Discussion Paper Series

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DP2016-19

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April 5, 2016

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Abstract

This paper proposes an empirical framework to explore the role of monetary policy communication. We develop an econometric methodology to impose restrictions for the identification of communication effects distinct from the effects of policy decisions. The empirical results support the hypothesis that both policy decision and communication factors are required to adequately capture the financial market reactions to monetary policy news. By applying a text mining approach focused on phrases that appear in press conferences on policy meeting days, we find that the communication factors identified are characterized by the policy intentions and preferences of the central bank.

JEL Classification: E52; E58; C30.

Keywords: monetary policy communication; policy surprise; financial market; event study; text mining.

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1 Introduction

A large literature from economists such as Bernanke (2004) and Blinder et al. (2008) argues that central bank communication with the market plays an important role whenever the central bank implements monetary policy. The literature holds that more communication may enhance the effectiveness of monetary policy and exert some level of control over the market expectations on the policy the central bank adopts. The central bank uses communication as a tool to issue signals on its monetary policy and reduce noise. Communication may allow the central bank to move asset prices in desired directions by enhancing the link between policy and asset prices and reducing the uncertainty underlying the financial market.

Why does communication matter for monetary policy? As Bernanke (2004) and Eusepi and Preston (2010) point out, policy may fail to stabilize macroeconomic dynamics when the condition of symmetric information does not hold, that is, when market participants are incompletely informed of the policy intentions because they lack access to all of the information the central bank uses in making policy decisions. In instances like this, communication plays a critical role in the central bank's implementation of monetary policy by helping the bank anchor market expectations. The same policy decision can move asset prices in different ways when the policy is communicated to the market in different ways.

In practice, the central bank conducts monetary policy through not only policy decisions, but also policy inclinations using communication tools. According to Blinder et al. (2008), the central bank communicates on four different aspects of a monetary policy: the policy goal or motive behind a particular policy decision, such as price stability; the current policy target for a policy variable over the intermeeting period; the future paths of policy variables; and the economic outlook. These pronouncements by the central bank move asset prices by influencing the expectations of public agents. The central bank can also use statements on forward guidance and commitments and other communication tools to stimulate the economy by managing expectations, even when it faces the zero lower bound on short-term policy interest rates (see Eggertsson and Woodford (2003), Bernanke and Reinhart (2004) and

Bernanke et al. (2004)).

The aim of this paper is to empirically assess the role of central bank communication. Specifically, we seek to obtain empirical evidence of the impact of monetary policy communication on the financial market alongside the impact of the actual policy action itself. We also try to identify the sources of this communication effect.

While the significant impact of monetary policy on asset prices has been amply shown, the task of decomposing the policy impact into the effect of the actual action and the effect of the communication is far from straightforward.[1] In one line of research employing the narrative approach, statements by the central bank are classified according to their content and the putative intentions behind them and then coded on a numerical scale (e.g., Jansen and De Haan (2005), Reeves and Sawicki (2007), and Ehrmann and Fratzscher (2007)). While this approach attempts to directly quantify the effects of communication on asset prices, the required classification is necessarily subjective.

Another line of research constructs indirect communication measures derived from financial market reactions. Kohn and Sack (2004), Bernanke et al. (2004), Gürkaynak et al. (2005), and Brand et al. (2010) point out that monetary policy surprises are explained not by a single factor but multiple factors. They thereupon suggest that the multidimensional indicators model is for examining the role of monetary policy in the financial market. In particular, they find that a policy path factor that is orthogonal to target changes (surprise changes in the policy target rate), what they regard to be a communication factor, has significant impacts on mid- and long-term bond yields. This implies that the central bank has the ability to influence financial market expectations through its forward guidance on its target policy for the short-term rate. Yet the effect of the policy path factor probably derives from

[1]For evidence on the financial market response to *conventional* monetary policy, see, for example, Cook and Hahn (1989), Thorbecke (1997), Evans and Marshall (1998), Kuttner (2001), Bernanke and Kuttner (2005), Miyao (2002), Braun and Shioji (2006), and Honda and Kuroki (2006). For evidence on the financial market responses to *unconventional* monetary policy in a low interest rate environment, see, for example, Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Joyce et al. (2011), Wright (2012), D'Amico and King (2013), Ueda (2012), Honda et al. (2013), Shibamoto and Tachibana (2013), Arai (2014), and Rogers et al. (2014).

the different sources of surprising news and depends on the reasons *why* people change the expected future policy path. As Ellingsen and Söderstrom (2001), Claus and Dungey (2012), Woodford (2012), and Campbell et al. (2012) argue, a policy change driven by a revision of economic foresight can cause different reactions in market yield than a policy change driven by shifts in the preferences of the monetary authorities.[2]

In this paper we construct communication measures distinct from actual policy actions to distinguish between their effects on financial market reactions to monetary policy news. We do so by considering an econometric model that specifies the structural indicators of monetary policy news related with policy decisions and policy communication based on the high-frequency changes of asset prices as unobservable common factors underlying them.

Japanese data from the 2000s serve as a good sample for testing our econometric framework for investigating the role of policy communication versus the role of the underlying policy actions. Over this period the Bank of Japan (BOJ) has actively used communication tools such as policy announcements and press conferences in efforts to enhance the effectiveness of monetary policy. By doing so the BOJ has attempted to compensate for the declining feasibility of overnight call market rate adjustments, the bank's conventional tool for monetary policy operation, due to the zero lower bound facing the bank since the end of the 1990s. The BOJ's active communication through press conferences also brings value to the Japanese data. The BOJ has held a press conference on every monetary policy meeting (MPM) day. The European Central Bank (ECB), in contrast, habitually omits press conferences, and the Federal Reserve (Fed) in the US only started holding press conferences in 2009. This institutional feature properly fits with the requirements of our econometric methodology described later to decompose the surprise components of monetary policy into policy communication and actual policy actions.

[2]Ellingsen and Söderstrom (2001) provide a theoretical model to describe the different reactions in market yield after a policy change when a change in monetary policy comes about for two reasons: the monetary authorities respond to new and possibly private knowledge about the economy, and their policy preference changes. Claus and Dungey (2012) provide empirical evidence that supports the theory proposed by Ellingsen and Söderstrom (2001). Also, Woodford (2012) and Campbell et al. (2012) argue that an optimal interest rate in a low interest rate environment will generally be state-contingent.

Several novel features of our analysis set this study apart from the existing literature. First, we develop an econometric methodology following the idea by Rigobon and Sack (2003, 2004), who introduce a method for identifying structural shocks through heteroscedasticity. Specifically, we use the institutional feature of the MPM day communications, where the central bank announces and explains policy decisions at two different points in time on every MPM day. Next, we use the differences of the co-movements of asset price returns among different points to identify the impacts of policy news that relate separately to the policy decision and communication dimensions. In a study closely related to this paper, Brand et al. (2010) focus on the timing of the ECB's MPM day communications. They provide a methodology for using intraday changes in money market forward rates to distinguish between the market reaction to the announcement of the decision and the market reaction to the forward-looking communication.[3] While they *assume* that the communication factor occurs only over the time span captured by the press conference window, we *test* the validity of the restrictions imposed on the models to examine whether high-frequency changes in asset prices after a policy announcement and press conference are adequately captured by a single surprise factor or by two factors, the policy decision factor and communication factor.[4]

Second, we provide empirical evidence about the impacts of monetary policy communication in a low interest rate environment. Kohn and Sack (2004), Gürkaynak et al. (2005), and Brand et al. (2010) use a principal components method to construct two common components describing interest rate movements around policy announcements. They use these two components to identify two structural factors: the surprise in the short-term policy target rate and the putative communication effect of the policy statement, which is orthogonal to the target surprise. Yet little information on the central bank's behavior is included in the short-term interest rate futures market data in a very low short-term interest rate environ-

[3]The ECB announces its decisions at 1:45 pm without any explanatory statements and then explains the decisions in detail in a press conference forty-five minutes later.

[4]Brand et al. (2010) define the communication factor as changes in contracts for 1 year interest rate futures prices during the press conference. They find that this factor exerts a significant impact on interest rates at longer maturities.

ment. As Bernanke et al. (2004) point out, current target changes extracted from short-term rate futures contracts (e.g., Euro-Yen 3-month TIBOR futures used in the case of Japan by Honda and Kuroki (2006)) have limited impacts on financial markets in a low interest rate environment.[5] On the other hand, the econometric methodology developed in this paper applies without relying on data like short-term rate futures contracts, even under a low interest rate environment.

Third, we use a text mining approach to explore the possible sources of the communication effect. While our econometric methodology enables us to identify both the policy communication factor and decision factor, we still have no way of ascertaining *why* the market participants react to the monetary policy news announced in the central bank communication. The text mining approach helps us overcome the limitation of econometric methodology by extracting salient features of the topic contents to which the market participants react and by clarifying differences between policy decisions and communications in the topic contents that elicit reactions. This information is extracted with as little subjectivity as possible. Specifically, we identify sets of keywords and co-occurring words that are diagnostic of identified policy decision and communication factors from various of phrases that appear in the press conferences held on MPM days.

This paper reports two main empirical findings. First, we find that two factors, one that can be structurally interpreted as a policy decision factor and one that can be interpreted as a communication factor, are required to capture the impacts of monetary policy news on asset prices. The policy decision factor has persistent impact on long-term bond yields

[5] Bernanke et al. (2004) construct the monetary policy news factors through a Cholesky decomposition of asset price changes during the MPM day and relate them to subjective measures of the tone of the BOJ statements. They then investigate the impacts of monetary policy news on short-term and long-term yields and stock prices in Japan's low interest rate environment. They find little evidence that the BOJ used its statements to influence near-term policy expectations during the quantitative easing policy period. In addition, they find that (i) unanticipated changes in the policy setting seem to be associated with statements that provide information on the future path of policy, (ii) the surprise announcements of the JGB purchases appear to be linked with long-term JGB yields, and (iii) the surprise announcements of the quantitative easing policy (the BOJ's surprise announcements of increases in current account balance targets) appear to provide a positive impetus to the stock market, with both current and future interest rate expectations held constant. However, as they note, serious problems arise from their small sample size.

but very temporary and less pronounced impact on exchange rate and stock prices. The communication factor has significant impacts on exchange rate and stock prices but less impact on long-term bond yields. Second, the text mining analysis in this paper suggests that, while the identified policy decision factor is closely related with the details of the actual policy implementations and the BOJ's economic outlook related to the policy objectives, the communication factor is characterized by the BOJ's policy intentions and preferences.

The remainder of the paper is structured as follows. Section 2 illustrates intraday financial market movements around the policy announcement and press conference on an MPM day to obtain an intuition corresponding to our econometric framework. Section 3 describes our econometric methodology for imposing restrictions for the identification of a policy communication effect distinguished from a policy decision effect. Section 4 provides the empirical results obtained using our econometric methodology. Section 5 describes our empirical framework using text mining analysis to explore the sources of the communication effect and provides the empirical results. In Section 6 we offer our concluding remarks. The Data Appendix at the end of this paper describes the data used in the paper.

2 Financial Market Responses to Policy Announcements and Press Conferences

By reporting its monetary policy decisions and inclinations to the public, the central bank enhances the effectiveness of its monetary policy and ensures its own accountability. Like other central banks such as the Fed and ECB, the BOJ usually announces its basic stance for monetary policy and its outlook for economic activity and prices.

On every MPM day, the BOJ holds two different events to communicate its monetary policy decision and thinking to the public. First, the BOJ announces its basic monetary policy stance just after the MPM adjourns. Specifically, the bank releases a public statement describing the policy decisions made at the MPM, guidelines for money market operations, and a brief summary of its assessments of economic activity and prices and its own thinking on the conduct of future monetary policy. The second event is a press conference held by the governor of the BOJ as the chairman of the Policy Board, about two or three hours after the MPM. The governor explains the policy decisions in further detail and apprises the press of the BOJ's thinking behind the decisions.

It will be instructive here to describe an episode illustrative of how the market participants react to monetary policy news around the BOJ's policy announcement and press conference. Specifically, we look at the intraday movement in asset prices on March 13, 2012. At the MPM held on that day, the BOJ left its key monetary policy unchanged but decided to increase the total amount of loans available through the Growth-Supporting Funding Facility by 2 trillion yen (from 3.5 to 5.5 trillion yen).

The upper, middle, and lower panels of Figure 1 show the minute-to-minute evolution of 10-year Japanese Government Bond (JGB) futures, yen/dollar exchange rate, and Nikkei 225 mini stock futures, respectively, from 12:30 to 17:59 (JST) on March 13, 2012. The shaded areas indicate the time of the BOJ's policy announcement and the time of the press conference.[6]

In Figure 1, we observe that the BOJ's announcement on its policy decision surprised financial markets and led to movements in asset prices. JGB yields were edging downward in the hours before the announcement. This was prompted by the gradual motion by some market participants into the expectation that the BOJ would enforce the expansionary policy it had announced in its last policy decision.[7] This was a reasonable expectation, because the BOJ did not announce its policy decisions until 14:00, somewhat later than its usual time for policy announcements, between 11:00 and 13:00. After the BOJ announced that it would keep its monetary policy stance on hold, JGB yields spiked upward, the exchange rate appreciated, and stock prices fell. This implies that the monetary policy decision not to

[6]See the Data Appendix for details on the source of the data, the time of the policy announcement, and the time of the press conference.

[7]On February 14, 2012, the BOJ decided to change its monetary policy stance: the targeted level of asset purchases was increased and the inflation goal was set at 1%.

change the monetary policy stance disappointed some market participants who expected the central bank to follow up on the easing of the previous month in another move to amplify its impact.

The market participants responded to the monetary policy news even during the press conference held by the BOJ's governor about two hours after the policy announcement. During the press conference, Mr. Masaaki Shirakawa, the former governor of the BOJ, described the BOJ's commitment to maintain and support financial conditions in order to escape from the currently dire economic circumstances. After the press conference the exchange rate suddenly depreciated back and stock prices suddenly rose back up, whereas JGB yields movements were stable.

The asset price movements over these hours of March 13, 2012 suggest that market participants may have reacted differently to the monetary policy news around the BOJ's policy announcement and press conference. Given that the market participants reacted to the policy news even at the press conference, several hours after they had learned of the policy decision itself, we speculate that the impacts of surprising monetary policy news on the BOJ's actual policy decisions may differ from those on the BOJ's policy communications. We need to rely on more sophisticated econometric methods, however, to definitively reveal such a gap in impacts between policy communications and policy decisions.

3 Econometric Framework

This section describes our econometric framework to examine the effects of monetary policy news on financial markets. Specifically, we consider a methodology to identify the effects of monetary policy news on asset prices using two types of econometric models that enable us to measure the impacts of monetary policy news on financial markets. First, we derive a single factor model with a framework for one-dimensional measurement of monetary policy news similar to the framework employed by many of the existing empirical studies on the effects of monetary policy surprises (e.g., Kuttner (2001), Cochrane and Piazzesi (2002), Bernanke and Kuttner (2005), and Honda and Kuroki (2006)). Second, we derive a multidimensional factor model consisting of two monetary policy factors: a policy decision factor and a communication factor wholly distinct from the policy decision factor. To identify the impacts of monetary policy news, we introduce the restrictions imposed on the models through the heteroscedasticity of structural factors.

First, we consider the specification in the framework for the one-dimensional measurement of monetary policy news. $\Delta Y_t = (\Delta ER_t, \Delta LB_t, \Delta SP_t)'$ denotes the vector consisting of asset price changes (Exchange Rate, Long-term Bond yield, and Stock Prices) over the time window being considered. To measure the effects of unexpected monetary policy actions on asset prices, we rely on the following regression:

$$\Delta Y_t = R_{MP} MP_t + \epsilon_t, \tag{1}$$

where MP_t denotes the surprise components of the monetary policy behavior as a one-dimensional measure of monetary policy news; $\epsilon_t = (\epsilon_t^{ER}, \epsilon_t^{LB}, \epsilon_t^{SP})'$ is a vector of the error terms, including other macroeconomic news factors that influence asset prices; and $R_{MP} = (\alpha_{MP}, \beta_{MP}, \gamma_{MP})'$, α_{MP}, β_{MP}, and γ_{MP} respectively represent the influences of monetary policy surprises on the exchange rate, long-term bond yields, and stock prices.

Next, we consider the model with two types of monetary policy surprises, the policy decision factor and communication factor. We measure the effects of these policy factors on asset prices by specifying the following model,

$$\Delta Y_t = R_{MPD} MPD_t + R_{MPC} MPC_t + \epsilon_t, \tag{2}$$

where MPD_t is the (unobservable) monetary policy decision factor; MPC_t is the (unobservable) monetary policy communication factor; $R_{MPD} = (\alpha_{MPD}, \beta_{MPD}, \gamma_{MPD})'$, $\alpha_{MPD}, \beta_{MPD}$, and γ_{MPD} respectively represent the influences of the policy decision factor on the exchange rate, long-term bond yields, and stock prices; $R_{MPC} = (\alpha_{MPC}, \beta_{MPC}, \gamma_{MPC})'$, and

$\alpha_{MPC}, \beta_{MPC}$, and γ_{MPC} respectively represent the influences of the policy communication factor on the exchange rate, long-term bond yields, and stock prices.

To identify the effects of monetary policy news on asset prices, we adopt an approach proposed by Rigobon and Sack (2003, 2004). Rigobon and Sack (2003, 2004) introduce a methodology for identifying the aforesaid effects through the heteroscedasticity of the structural shocks. Specifically, they look at differences of the co-movements of asset price returns when the variance of the shocks in the system is known to shift.

We use the institution knowledge of the central bank to separate the sample period into three subsamples, A, P and N, from the full sample data. Specifically, more news about monetary policy is likely to appear at the time of a policy announcement and the time of a press conference than at other times, although other shocks still take place when policy announcements and press conferences take place. We take the policy announcement times as set A and the press conference times as set P. For the set of non-policy times, N, we take 13:00 on days immediately preceding days included in sets A and P to minimize any effects arising from changes in the variances of the shocks over time.

First, we consider the assumptions for identifying the financial market responses to monetary policy surprises as a one-dimensional measure using a single factor model (1). $\sigma^{2A}_{MP}, \sigma^{2P}_{MP}$, and σ^{2N}_{MP} respectively denote the variance of the monetary policy news at policy announcement times, press conference times, and non-policy times, and $\sigma^{2A}_{\epsilon^i}, \sigma^{2P}_{\epsilon^i}$, and $\sigma^{2N}_{\epsilon^i}$ $(i = ER, LB, SP)$ respectively denote the variance of the error terms for the exchange rate, long-term bond yield, and stock price equations at policy announcement times, press conference times, and non-policy times. We assume that the variance of the monetary policy news increases in subsamples A and P, and that the variances of the error terms are the same as those in subsample N: $\sigma^{2A}_{MP}, \sigma^{2P}_{MP} > \sigma^{2N}_{MP}, \sigma^{2A}_{\epsilon^i} = \sigma^{2P}_{\epsilon^i} = \sigma^{2N}_{\epsilon^i}$ $(i = ER, LB, SP)$.

Under these assumptions, we obtain the moment conditions to identify the financial market responses to monetary policy surprises, R_{MP}, in single factor model (1) as follows:

$$\Sigma_A - \Sigma_N = R_{MP} R'_{MP}, \tag{3}$$

$$\Sigma_P - \Sigma_N = R_{MP} R'_{MP} \lambda, \tag{4}$$

$$\Sigma_A - \Sigma_P = R_{MP} R'_{MP} (1 - \lambda), \tag{5}$$

where Σ_A, Σ_P, and Σ_N are the covariance matrices of asset price changes ΔY_t within the announcement, press conference, and non-policy subsamples, respectively. Without loss of generality, we adopt the normalization that $\sigma^{2A}_{MP} - \sigma^{2N}_{MP} = 1, \sigma^{2P}_{MP} - \sigma^{2N}_{MP} = \lambda$, where we allow the variances of monetary policy surprises to differ between subsamples A and P. As (3), (4), and (5) clearly show, we can identify the parameters R_{MP} and λ from the restrictions on the differences of the covariance matrix. We implement the Generalized Method of Moments (GMM) method to obtain the estimate of the financial market responses to monetary policy surprises, $\hat{R}_{MP}$, and the difference in variance of policy surprises between subsamples A and P, $\hat{\lambda}$.

Next, we consider the assumptions for identifying the financial market responses to monetary policy decisions and communication using multidimensional factor model (2). $\sigma^{2A}_{MPD}, \sigma^{2P}_{MPD}$, and σ^{2N}_{MPD} respectively denote the variance of the policy decision factors at policy announcement times, press conference times, and non-policy times, while $\sigma^{2A}_{MPC}, \sigma^{2P}_{MPC}$, and σ^{2N}_{MPC} respectively denote the variance of the communication factors at policy announcement times, press conference times, and non-policy times. The variance of the policy decision factors is assumed to increase in subsample A because the market participants immediately know the central bank's policy decisions after the policy announcement: $\sigma^{2A}_{MPD} > \sigma^{2P}_{MPD} = \sigma^{2N}_{MPD}$. The variance of the policy communication factors, meanwhile, is assumed to increase in subsample P because, given the policy decision, the market participants understand why the central bank decides its policy stance and the extent to which the central bank signals its policy decisions to financial markets through the policy communication: $\sigma^{2P}_{MPC} > \sigma^{2A}_{MPC} = \sigma^{2N}_{MPC}$. We also assume that $\sigma^{2A}_{\epsilon^i} = \sigma^{2P}_{\epsilon^i} = \sigma^{2N}_{\epsilon^i}$ $(i = ER, LB, SP)$, just as we do in single factor model (1).

Under these assumptions, we obtain the moment conditions to identify the financial market responses to monetary policy decisions and communication factors, R_{MPD} and R_{MPC}, in multidimensional factor model (2) as follows:

$$\Sigma_A - \Sigma_N = R_{MPD}R^{'}_{MPD}, \tag{6}$$

$$\Sigma_P - \Sigma_N = R_{MPC}R^{'}_{MPC}, \tag{7}$$

$$\Sigma_A - \Sigma_P = R_{MPD}R^{'}_{MPD} - R_{MPC}R^{'}_{MPC}, \tag{8}$$

with the normalization that $\sigma^{2A}_{MPD} - \sigma^{2P,N}_{MPD} = 1, \sigma^{2P}_{MPC} - \sigma^{2A,N}_{MPC} = 1$ without loss of generality. We can identify the parameters R_{MPD} and R_{MPC} from the restrictions (6), (7), and (8) on the differences of the covariance matrix. Repeating the approach taken in single factor model (1), we implement the GMM method to obtain the estimates of the financial market responses to monetary policy decisions and communication, $\hat{R}_{MPD}$ and $\hat{R}_{MPC}$.

In practice we need to select a justifiable and relevant specification from possible models and moment conditions, because we can obtain several sets of the model parameters using two types of models (single factor model (1) or multidimensional factor model (2)) and their moment conditions. To check the validity of the identification assumptions we impose on the models, we use Sargan statistics to test whether or not over-identifying restrictions are satisfied. And to select an appropriate specification, we use two kinds of information criteria for GMM to assess the validity of different groups of moment conditions that satisfy the over-identified restrictions. One is a Model and Moment Selection Criterion ($MMSC$) derived by Andrews (1999) and the other is a Relevant Model and Moment Selection Criterion ($RMMSC$) by Hall et al. (2007).[8]

[8] Andrews (1999) develops an information criterion for GMM based on the orthogonality condition. He provides the familiar Akaike (AIC), Schwartz Bayesian (BIC) and Hanan-Quinn ($HQIC$) information criterion for GMM. The $MMSC$ uses the Sargan statistics to test over-identifying restrictions from which different penalty terms are subtracted, as is done with AIC, SBC, and $HQIC$. This paper reports the AIC criterion

A final point worth noting is how the implications of the differences between the single factor model (1) and 2 factor model (2) relate to our identification methodology. In particular, we focus on the information on the intraday movements of asset prices linked to the monetary policy news and look at the differences in the covariance of asset price returns implied by the BOJ's institutional practice of announcing and explaining policy decisions at two different points of time on every MPM day. Single factor model (1) captures differences in the variance-covariance of asset price returns between subsamples A and P as differences generated from changes in the variance of a single policy surprise, MP_t. On the other hand, 2 factor model (2) captures the differences as differences generated from variable reactions in the financial market to the two sources of surprising policy news, MPD_t and MPC_t.

4 Empirical Results using the Econometric Framework

In this section we provide the empirical results using our econometric framework. First, we confirm whether or not the covariance matrices of asset price changes differ among the subsamples A, P, and N, and thus fulfill the necessary condition to obtain the estimators through the heteroscedasticity of the structural factors that exist in high-frequency data. Second, we regress several specifications derived from possible models (single factor model (1) and 2 factor model (2)) and their moment conditions, and select a justifiable and relevant specification from the models to measure the impacts of monetary policy news on financial markets. Third, we report the empirical results using asset price changes over time windows of various durations. Fourth, we report the empirical results using an econometric model on which two alternative restrictions are imposed to identify the financial market responses to monetary policy decisions and policy communications.

(Section 4) because the BIC and $HQIC$ criteria tend to increase drastically as the number of over-identified restrictions increases. However, the results based on the BIC or $HQIC$ criteria are almost the same as a benchmark. Hall et al. (2007) provide an information criterion for model and moment selection based on the relevance condition.

4.1 Differences of covariance matrices of asset price changes among subsamples

In this subsection we confirm that the data used satisfies the identification condition applied in our econometric methodology: the covariance matrices of asset price changes differ among the subsamples A, P, and N. Specifically, we use the sample covariance matrices of asset price changes over a 60-minute window and calculate three test statistics, as follows:

$$[vech(\hat{\Sigma}_A - \hat{\Sigma}_N)]'[\hat{V}_A - \hat{V}_N]^{-1}[vech(\hat{\Sigma}_A - \hat{\Sigma}_N)] \text{ under the null hypothesis } \Sigma_A = \Sigma_N, \quad (9)$$

$$[vech(\hat{\Sigma}_P - \hat{\Sigma}_N)]'[\hat{V}_P - \hat{V}_N]^{-1}[vech(\hat{\Sigma}_P - \hat{\Sigma}_N)] \text{ under the null hypothesis } \Sigma_P = \Sigma_N, \quad (10)$$

$$[vech(\hat{\Sigma}_A - \hat{\Sigma}_P)]'[\hat{V}_A - \hat{V}_P]^{-1}[vech(\hat{\Sigma}_A - \hat{\Sigma}_P)] \text{ under the null hypothesis } \Sigma_A = \Sigma_P, \quad (11)$$

where $\hat{\Sigma}_A$, $\hat{\Sigma}_P$, and $\hat{\Sigma}_N$ within the announcement, press conference, and non-policy subsamples, respectively;[9] $\hat{V}_A$, $\hat{V}_P$, and $\hat{V}_N$ are estimates of the covariance matrices of $vech(\hat{\Sigma}_A)$, $vech(\hat{\Sigma}_P)$, and $vech(\hat{\Sigma}_N)$, respectively. Each test statistic follows the chi-square distribution with 6 degrees of freedom under each null hypothesis.

Table 1 presents the results of the test statistics in (9), (10), and (11). The null hypotheses that the covariance matrices of asset price changes are the same in the announcement, press conference, and non-policy subsamples are all rejected. Hence, the identification condition through the heteroscedasticity of structural factors is satisfied.

4.2 Validity of the econometric model and moment selection

In this subsection we test the validity of the restrictions imposed on the models to examine whether high-frequency changes in asset prices at policy announcement times and press conference times are adequately captured by a single monetary policy factor or by two factors, the policy decision and communication factors. Specifically, we regress the several specifications derived from the possible models (single factor model (1), multidimensional factor

[9] See the Data Appendix for detailed information about the data used.

model (2)) and their moment conditions. In this subsection we use the changes in asset prices over a 60-minute window.

Table 2 reports the estimates of model parameters for asset price changes and their corresponding standard error in parentheses. The upper half of Table 2 indicates the regression results for the single factor model (1) using several moment conditions. The lower half indicates the regression results for the 2 factor model (2). The table also reports Sargan test statistics (p-value in brackets) and two information criteria, $MMSC$ and $RMMSC$, to select a justifiable and relevant specification from the possible models and moment conditions.

While the single factor model (1) seems to perform well, it fails to adequately measure the immediate impact of monetary policy news on financial markets. The results in the upper half of Table 2 look reasonable, with all parameter estimates exhibiting their expected qualitative behaviors ($\hat{\alpha}_{MP} > 0, \hat{\beta}_{MP} < 0$, and $\hat{\gamma}_{MP} > 0$ imply that positive monetary policy surprises led to a depreciation of the yen/dollar exchange rate, a fall in JGB yields, and an increase in stock prices), but the Sargan statistics show that over-identifying restrictions are not satisfied across all specifications for the single factor model. There thus appears to be a misspecification in single factor model (1) for capturing the immediate financial market responses to monetary policy news.

Policy decision and communication factors in two factor model (2) significantly influence asset prices, which is consistent with the theory. In the lower half of Table 2 we find that the estimates $\hat{\alpha}_{MPD}, \hat{\alpha}_{MPC}, \hat{\gamma}_{MPD}$, and $\hat{\gamma}_{MPC}$ are positive and statistically significant, $\hat{\beta}_{MPD}$ is negative and statistically significant, and $\hat{\beta}_{MPC}$ is negative but statistically insignificant. This implies that positive surprising news in both the policy decision and communication led to a depreciation of the yen/dollar rate and an increase in stock prices immediately over the 60-minute time window, while positive surprising news in the policy decision alone led to a fall in JGB yields and positive surprising news in the policy communication alone had limited impacts on JGB yields.

We can plausibly impose our heteroscedasticity assumptions on 2 factor model (2) to characterize the impacts of monetary policy news using intraday financial data around the policy announcement and press conference. The Sargan statistics from the lower half of Table 2 indicates that we cannot reject the over-identifying restrictions of the 2 factor model with all possible moment conditions. The identification assumption we have imposed on 2 factor model (2) thus seems to be valid.

Finally, the empirical results in this subsection propose 2 factor model (2) with moment conditions (6), (7), and (8) as a benchmark specification to measure the impacts of monetary policy news on asset prices around the policy announcements and press conferences. The model selection criteria $MMSC$ and $RMMSC$ from Table 2 indicate that the 2 factor model with moment conditions (6), (7), and (8) has the lowest values of the model selection criteria $MMSC$ and $RMMSC$ among the possible moment conditions for the 2 factor model. This suggests that 2 factor model (2) with moment conditions (6), (7), and (8) is the best specification among the possible models and moment conditions in terms of both the orthogonality and relevance conditions.

4.3 Results using asset price changes over various time windows

In this subsection we examine whether or not our benchmark specification obtains robust empirical results when using the asset price changes over time windows of various durations and explore the persistency of the impacts of monetary policy news on asset prices. Specifically, we regress 2 factor model (2) with moment conditions (6), (7), and (8) by using the asset price changes over time windows of 50, 60, 70, 80, 90, 100, and 110 minutes.[10] Table 3 reports the estimates of model parameters for asset prices (their corresponding standard

[10]If we use the asset price changes over a time window of more than 110 minutes, there are far too many cases where the asset price changes in subsample A cover the press conference as well as the policy announcement. This makes it difficult to use our econometric methodology because the asset price changes in subsample A are influenced by the information on the monetary policy news communicated at the press conference as well as the policy announcement. In the opposite direction, if we use the changes over a very tight window, e.g., a window of less than 30 minutes, the over-identifying restrictions of 2 factor model (2) are rejected. One way to interpret the test result using asset price changes over a very tight window is to assume that 2 factor model (2) is too simple to capture the asset price reactions with market microstructure noise such as the bid-ask bounce, price discreteness, etc.

errors in parentheses) and Sargan statistics (p-values in brackets) when using the asset price changes over the various time windows.

As Table 3 shows, the over-identifying restrictions of 2 factor model (2) are satisfied in all cases using the asset price changes over time windows of 50, 60, 70, 80, 90, 100, and 110 minutes. Our benchmark specification thus appears to robustly capture the high-frequency changes in asset prices at policy announcement times and press conference times even when the asset price changes are used over longer time windows.

Three other findings also emerge from this exercise. First, we find that $\hat{\beta}_{MPD}$ is negative and statistically significant even when the asset price changes are used over longer time windows. The decision effects on JGB yields thus prove to be persistent, which suggests that positive surprising news on a policy decision is closely related with JGB yields and later causes the yields to persistently fall.

Second, we find that the positive coefficients of the decision factors on the exchange rate and stock prices, $\hat{\alpha}_{MPD}$ and $\hat{\gamma}_{MPD}$ respectively, get smaller as asset price changes are used over longer time windows and cease to be significant in time windows of 90 minutes or longer. This tells us that the decision factors affect the exchange rate and stock prices for only about 90 minutes, even though the effects on JGB yields persist.[11]

Third, we find that $\hat{\alpha}_{MPC}$ and $\hat{\gamma}_{MPC}$ are positive and statistically significant even when using the asset price changes over longer time windows. The effects of communication factors on exchange rate and stock prices thus prove to be persistent, which suggests that positive surprising news on policy communication has an economically significant impact on the exchange rate and stock prices. We also find that $\hat{\beta}_{MPC}$ is negative and statistically significant

[11] This implies that the exchange rate depreciation and rising stock prices are not necessarily caused by the monetary expansion policy decision responsible for the fall in JGB yields. This finding is consistent with the previous studies by Ueda (2012), Arai (2014), and Rogers et al. (2014), who provide empirical evidence of the low policy pass-through from bond yields into the exchange rate, stock prices, and other asset prices under a low interest environment in Japan. Shibamoto et al. (2016) also identify two kinds of unconventional monetary policy shock, namely, *quantitative* easing shock and *qualitative* easing shock, under a low interest rate environment. They find that *qualitative* easing shocks have both a *positive* impact on stock prices and negative impact on long-term bond yields, while *quantitative* easing shocks have both a *negative* impact on stock prices and negative impact on long-term bond yields.

when using asset price changes over time windows of 80 minutes or longer, although the absolute size of their negative impact is smaller than that of the decision factor. This suggests that the policy communication has a significant effect on the long-term movement of rates.

4.4 Alternative Specifications

In this subsection we consider two alternative restrictions imposed on the 2 factor model to identify the financial market responses to monetary policy decisions and communication, and report the empirical results.

First, we consider the case where the variance of the policy communication factor increases in subsample A as well as subsample P: $\sigma^{2A}_{MPC} = \sigma^{2P}_{MPC} > \sigma^{2N}_{MPC}$, whereas the heteroscedasticity assumption for the policy decision factor is the same as the benchmark: $\sigma^{2A}_{MPD} > \sigma^{2P}_{MPD} = \sigma^{2N}_{MPD}$. This reflects the possibility that the market participants can understand the reasons behind the central bank's policy decision shortly after the policy decision is announced.[12]

Under these assumptions, we obtain the moment conditions to identify the financial market responses to monetary policy decisions and communication factors, R_{MPD} and R_{MPC}, as follows:

$$\Sigma_A - \Sigma_N = R_{MPD}R^{'}_{MPD} + R_{MPC}R^{'}_{MPC}, \tag{12}$$

$$\Sigma_P - \Sigma_N = R_{MPC}R^{'}_{MPC}, \tag{13}$$

$$\Sigma_A - \Sigma_P = R_{MPD}R^{'}_{MPD}, \tag{14}$$

with the normalization that $\sigma^{2A}_{MPD} - \sigma^{2P,N}_{MPD} = 1, \sigma^{2A,P}_{MPC} - \sigma^{2N}_{MPC} = 1$ without loss of generality.

Table 4 reports the empirical results under the identification restrictions: $\sigma^{2A}_{MPC} = \sigma^{2P}_{MPC} > \sigma^{2N}_{MPC}, \sigma^{2A}_{MPD} > \sigma^{2P}_{MPD} = \sigma^{2N}_{MPD}$. Specifically, it shows the estimates of the model parameters for asset price changes (corresponding standard errors in parentheses), a Sargan test statis-

[12]The BOJ's practice in policy announcements is to release a brief summary of its assessment of economic activity and prices and its thinking on the conduct of future monetary policy.

tics (p-value in brackets), and two kinds of information criteria, $MMSC$ and $RMMSC$, , to assess the validity of the model specification when using the four combinations of moment conditions (12), (13), and (14) and the asset price changes over time windows of 60 minutes and 110 minutes.

Table 4 suggests that the actual data justify the alternative assumption that the variance of the policy communication factor increases in subsample A as well as subsample P. We see from the table that the over-identified restrictions are satisfied under the specification, whereas the benchmark specifications are selected by $MMSC$ and $RMMSC$. More important, our findings under the benchmark specification prove to be robust even under this alternative assumption. In fact, the estimates of the parameters $\hat{R}_{MPD}$ and $\hat{R}_{MPC}$ are almost the same as the estimates under the benchmark specification.

The second alternative identification restriction is that the variance of the policy decision factor increases in subsample P as well as subsample A: $\sigma^{2A}_{MPD} = \sigma^{2P}_{MPD} > \sigma^{2N}_{MPD}$, whereas the heteroscedasticity assumption for the communication factor is the same as the benchmark: $\sigma^{2P}_{MPC} > \sigma^{2A}_{MPC} = \sigma^{2N}_{MPC}$. This reflects the possibility that the market participants fail to fully understand the contents of the policy decision shortly after it is announced but learn additionally valuable information about the contents of the policy decision during the detailed explanations provided at the press conference.

Under these assumptions, we obtain the moment conditions to identify the financial market responses to monetary policy decisions and communication factors, R_{MPD} and R_{MPC}, as follows:

$$\Sigma_A - \Sigma_N = R_{MPD}R^{'}_{MPD}, \tag{15}$$

$$\Sigma_P - \Sigma_N = R_{MPD}R^{'}_{MPD} + R_{MPC}R^{'}_{MPC}, \tag{16}$$

$$\Sigma_A - \Sigma_P = -R_{MPC}R^{'}_{MPC}, \tag{17}$$

with the normalization that $\sigma^{2A,P}_{MPD} - \sigma^{2N}_{MPD} = 1, \sigma^{2P}_{MPC} - \sigma^{2A,N}_{MPC} = 1$ without loss of generality.

Table 5 reports the empirical results under the identification restrictions: $\sigma^{2A}_{MPD} = \sigma^{2P}_{MPD} > \sigma^{2N}_{MPD}, \sigma^{2P}_{MPC} > \sigma^{2A}_{MPC} = \sigma^{2N}_{MPC}$. Specifically, it shows the estimates of the model parameters for asset price changes (corresponding standard errors in parentheses), a Sargan test statistics (p-value in brackets), and $MMSC$ and $RMMSC$ when using the four combinations of moment conditions (15), (16), and (17) and the asset price changes over time windows of 60 minutes and 110 minutes.

Table 5 indicates that the data used do not support the assumption that the variance of a policy decision factor increases around both the policy announcement and press conference. As the table shows, the over-identified restrictions under the corresponding identification assumption are not satisfied. This implies that policy decision factors play a limited role in the development of asset prices during press conferences.

5 Text Mining

In this section we explore the differences between the policy decision and communication factors in more detail. Specifically, we conduct a text mining analysis to examine the relation between the identified policy factors and the contents discussed during the BOJ press conference. First, we calculate the identified policy decision and communication factors based on the estimates obtained in the previous section from intraday movements of asset prices on MPM days to select specific event dates when the policy decision and communication factors fluctuate more. Second, we identify a set of phrases that are diagnostic of policy decision and communication factors from the various phrases that appear in the press conferences.

The upper and lower panels of Figure 2 show the identified policy decision and communication factors measured by our estimated 2 factor model (2) with moment conditions (6), (7), and (8) using the changes in asset prices over a 60-minute window. We plot the identified policy factors over time for two different events, a policy announcement plotted as solid bars and a press conference plotted as hollow bars. The findings from the figure contrast with those reported by Brand et al. (2010): the communication (policy decision) factor occurs even over the time span captured by the policy announcement window (press conference window), while fluctuation of the communication factors is larger at press conference times than at announcement times and the fluctuation of policy decision factors is larger at announcement times than at press conference times.

We use the text mining method to find a set of phrases related with the monetary policy on MPM days respectively leading to large fluctuations of policy decision factors (MPD days) and communication factors (MPC days). Specifically, we begin by using the identified policy decision and communication factors to divide the MPM days into 10 upper and lower MPD days (UL, D), 10 upper and lower MPC days (UL, C), and other days $(O, D$ and $O, C)$, respectively. Second, using Japanese phrases that appear in the press conferences held on the MPM days, we identify a set of phrases that are highly diagnostic of the policy decision and communication factors.[13]

As a first step, we compute a vector that gives the number of times each phrase used in press conferences appears on each MPM day. To select a set of phrases that characterize the topic contents of press conferences related with policy decision and communication, we restrict attention to 234 keywords automatically selected by a term-extract algorithm proposed by Nakagawa (2000) and Nakagawa and Mori (2002), because the total number of phrases is quite large.[14]

We then take the following steps as a specific procedure to identify a set of keywords that are diagnostic of policy decision and communication factors.[15] Let $f_{i,UL,D}$ and $f_{i,O,D}$ denote the total number of times keyword i appears on the 10 upper and lower MPD days and on others days, respectively, and let $f_{i,UL,C}$ and $f_{i,O,C}$ denote the total number of times keyword i appears on the 10 upper and lower MPC days and on other days, respectively. Let $f_{\sim i,UL,D}$

[13]Specifically we compile in the text dataset summaries of speeches and public statements made by the BOJ's governor during the regularly scheduled press conferences after the MPMs (only available on the BOJ's website in Japanese, http://www.boj.or.jp/announcements/press/index.htm/).

[14]For details on the term extraction method, see Nakagawa (2000) and Nakagawa and Mori (2002).

[15]This procedure is similar to the automated procedure developed by Gentzkow and Shapiro (2010) to identify a set of English phrases diagnostic of a politician's ideology from among large numbers of phrases appearing in the *Congressional Record*.

and $f_{\sim i,O,D}$ denote the total occurrences of keywords other than keyword i on the 10 upper and lower MPD days and on other days, respectively, and let $f_{\sim i,UL,C}$ and $f_{\sim i,O,C}$ denote the total occurrences of keywords other than keyword i on the 10 upper and lower MPC days and on other days, respectively. Let $\chi^2_{i,D}$ and $\chi^2_{i,C}$ denote Pearson's χ^2 statistic for each keyword i, as follows:

$$\chi^2_{i,D} = \frac{(f_{i,UL,D} + f_{\sim i,O,D} + f_{i,O,D} + f_{\sim i,UL,D})(f_{i,UL,D} f_{\sim i,O,D} - f_{i,O,D} f_{\sim i,UL,D})^2}{(f_{i,UL,D} + f_{i,O,D})(f_{i,UL,D} + f_{\sim i,UL,D})(f_{i,O,D} + f_{\sim i,O,D})(f_{\sim i,UL,D} + f_{\sim i,O,D})} \quad (18)$$

$$\chi^2_{i,C} = \frac{(f_{i,UL,C} + f_{\sim i,O,C} + f_{i,O,C} + f_{\sim i,UL,C})(f_{i,UL,C} f_{\sim i,O,C} - f_{i,O,C} f_{\sim i,UL,C})^2}{(f_{i,UL,C} + f_{i,O,C})(f_{i,UL,C} + f_{\sim i,UL,C})(f_{i,O,C} + f_{\sim i,O,C})(f_{\sim i,UL,C} + f_{\sim i,O,C})} \quad (19)$$

We select more frequently occurring keywords, namely MPD keywords and MPC keywords, if their p-values calculated using a chi-square distribution with one degree of freedom are smaller than 0.01.

Both individual keywords and contextual information related to individual keywords are useful to further characterize the content of a press conference related to a policy decision and communication. We therefore identify informative co-occurring words for each of the keywords selected above out of 1,176 Japanese words that appear in the press conferences. Specifically, we compute two measures of co-occurrence, the mutual information score ($MIscore$) and T-score ($Tscore$), to determine whether a co-occurrence is significant. The mutual information between any given pair of words measures the strength of the word association by comparing the probability that the two words occur individually with the probability that they occur together as a joint event. We define the mutual information score as:

$$MIscore(i,j,D) = \log_2 \left(\frac{f_{i,j,UL,D} \sum_k^{1176} f_{k,UL,D}}{f_{i,UL,D} f_{j,UL,D}} \right) \quad (20)$$

$$MIscore(i,j,C) = \log_2 \left(\frac{f_{i,j,UL,C} \sum_k^{1176} f_{k,UL,C}}{f_{i,UL,C} f_{j,UL,C}} \right) \quad (21)$$

where $f_{i,j,UL,D}$ and $f_{i,j,UL,C}$ denote the number of co-occurrences of keyword i and its co-occurring word j on the 10 upper and lower MPD days and the 10 upper and lower MPC days, respectively. Pairs of words with high positive mutual information scores are more likely to constitute characteristic collocations than pairs with lower mutual information scores. The T-score, meanwhile, is a measure based on a t statistic to test the null hypothesis that the keyword i and its co-occurring word j are generated independently in the text. We define the T-score as:

$$Tscore(i,j,D) = \frac{f_{i,j,UL,D} - \frac{f_{i,UL,D} f_{j,UL,D}}{\sum_k^{1176} f_{k,UL,D}}}{\sqrt{f_{i,j,UL,D}}} \tag{22}$$

$$Tscore(i,j,C) = \frac{f_{i,j,UL,C} - \frac{f_{i,UL,C} f_{j,UL,C}}{\sum_k^{1176} f_{k,UL,C}}}{\sqrt{f_{i,j,UL,C}}} \tag{23}$$

Lacking any way to determine which measure is superior for assessing the notion of collocation explained by Church et al. (1991), we select informative words co-occurring with each MPD or MPC keyword based on both measures: for each keyword, (1) we restrict attention to co-occurring words with $Tscore$s larger than 2, (2) sort co-occurring words by their Mutual information $MIscore$s in descending order, and select them up to a maximum of 5.[16]

Tables 6 and 7 show more frequently appearing keywords and their informative co-occurring words on the 10 upper and lower MPD days and 10 upper and lower MPC days, respectively. These tables include selected Japanese keywords (sorted by their p-values in descending order) and their informative co-occurring words (with English translations of the words by the author in parentheses).

Table 6 offers possible details on the central bank's actual policy implementation and its economic outlook related to the policy objective as determinants of the fluctuation of the policy decision factor. In particular, empirical results from our text mining analysis indicate that many of the keywords identified in Table 6 are phrases that imply the clear

[16] In general, the T-score is far more likely to highlight frequently recurring words strongly associated with the keyword. On the other hand, the mutual information helps us decide what to look for in detail in a concordance, because pairs with very high mutual information values are generally quite strongly associated. Unhelpfully, however, the mutual information inflates the values for occurrences with low total frequencies in the text. Words with low frequencies in the text should be disregarded in the analysis when using the mutual information. For this reason, I believe the appropriate option is to use the T-score when assessing the significance of these low-frequency words selected based on the mutual information.

announcement of the BOJ's policy decision, e.g., '政策運営 (policy operation)', '政策変更 (policy change)', '残存期間 (remaining duration),' etc.,and its assessment and forecast of current and future inflation and economic activity, e.g., 'デフレ (deflation)' '需給ギャップ (output gap)', '予想インフレ率 (expected inflation rate)', '物価下落 (fall in price),' etc. In addition, many words co-occurring with the MPD keywords dimly hint at the BOJ's policy implementation and outlook for inflation and economic activity.

On the other hand, Table 7, meanwhile, suggests the central bank's policy inclinations and preference as determinants of the fluctuation of the policy communication factor. In particular, Table 7 lists a number of keywords and co-occurring words that imply the BOJ's intention on its policy stance; e.g., '金融緩和 (monetary easing)' + '推進 (promoting)' '強力 (powerful)' '包括 (comprehensive)' '一段 (further)', '明確化 (clarifying)' + '姿勢 (intention)' '成長 (growth)' '金融緩和 (monetary expansion)' '効果 (effect)', '量的緩和 (quantitative easing)' + '刺激 (stimulating)' '意味 (meaning),' etc. It also includes some keywords and co-occurring words related to preferences of the BOJ that have no direct relation with the BOJ's policy objective, e.g., '成長基盤 (foundation for economic growth)' + '強化 (strengthening)' '支援 (support)' '必要 (need)', '民間企業 (private company)' + '成長力 (growth potential)', '成長力 (growth potential)' + '不可欠 (essential)' '取り組む (tackle)' '強化 (strengthening)', '企業マインド (business sentiment)', '健全性 (soundness)' + '財務 (financial)' '信認 (confidence),' etc.

This exercise helps us understand how the asset price impact of monetary policy news differs between policy decisions and communication. On one hand, market reactions to surprising news on a policy decision take place in line with the current setting and future path of the interest rate and other policy instruments which are a systematic part of policy reaction to the output gap and inflation forecasts. These market reactions can directly affect the long-term interest rate through the term structure of the interest rate. On the other hand, market participants respond to policy news by revising their beliefs about the central bank's policy intentions and preferences, which can have an additional impact on asset prices.

6 Concluding Remarks

This paper proposed an empirical framework to assess the role of monetary policy communication. We developed an econometric methodology to measure the impact of a monetary policy communication distinguished from the impact of a policy decision. Specifically, we derived identification restrictions to estimate the impacts of monetary policy news that relate to policy decisions and communication motivated by the central bank's institutional practice of announcing and explaining policy decisions and the reasoning behind them at two different points in time on every policy meeting day. Using Japanese intraday financial data, we test the validity of these restrictions to examine whether these impacts are adequately captured by a single monetary policy surprise or by two surprises that can be structurally interpreted as a policy decision and communication. We found that two factors are required to explain the intraday movements in asset prices on policy meeting days, and that surprising news on policy communication has an economically significant impact on asset prices, especially the exchange rate and stock prices. This impact substantially differs from the impact of a policy decision, which largely centers on long-term bond yields. We also applied a text mining method to extract Japanese phrases that appeared in the press conferences held on MPM days by the BOJ governor. The text analysis shows a close relation between the policy decision factors with the details of the actual policy implementation and the BOJ's economic outlook related to the policy objectives, whereas the communication factors are characterized by the BOJ's policy intentions and preferences.

Our findings have important implications for the literature on the effects of monetary policy surprises on asset prices. Many of the previous empirical studies that examine the effect of monetary policy focus on the impact of surprise components of policy indicators, i.e., short-term policy rates such as the federal funds rate in the US or the call market rate in Japan, extracted from futures contracts on the short-term rate (see, for example, Kuttner (2001), Kohn and Sack (2004), Bernanke and Kuttner (2005), Gürkaynak et al. (2005), Honda and Kuroki (2006), and Brand et al. (2010)). Our empirical evidence, however, supports the existence of surprise components of monetary policy communication that has an additional impact on asset price movements even when the current level and expectations on the future level of policy instruments stay unchanged.

The impact of monetary policy communication identified in this paper is of crucial importance for assessing the effect of monetary policy. As pointed out by Bernanke (2004), there would be no marginal benefit to communication if the conditions of symmetric information as well as systematic policymaking and financial market efficiency all held. Yet the influences of monetary policy on the market through communication manifest in the way market participants not only respond to the policy decisions on the current settings and future path of policy instruments, but also revise their beliefs on the central bank's intentions and preferences. As such, the effect of monetary policy should depend on what people think: the same policy move, or even the same statement by the central bank, can have very different implications if interpreted differently by people.

While central bank communication can lead to a *self-induced paralysis* of monetary policy, it can serve as an important and powerful policy tool to enhance the effectiveness of monetary policy. If, on the one hand, the central bank overemphasizes the risk of it monetary policy and the economic situation remotely related to its policy objective, the public is likely to respond by assuming that the central bank is unwilling to fulfill its own objective. This kind of central bank communication with the market can weaken the effectiveness of monetary policy by leading to unstable or indeterminate outcomes.[17] *Effective* communication, on the other hand, can help to avoid this undesirable situation by conveying the policy intention to the public, because the central bank can use its power as a mover of financial markets to improve the public's potential to achieve macroeconomic stability. As such, the communication can be a useful instrument for the central bank in implementing monetary policy.

[17]Bernanke (2000) describes the BOJ's hesitance to cut interest rates and failure to commit to aggressively expansionary policy, especially in the early 1990s, as a case of *self-induced paralysis.* Kuttner (2014) argues that the BOJ's communication from the 1990s emphasized the risks of expansionary policies and not the benefits, and that the BOJ's policy was characterized by conservatism and inaction, at least up until the policy under the BOJ governor Mr. Haruihiko Kuroda.

Data Appendix

- ΔER_t: yen/dollar Exchange Rate. Data source: *Bloomberg*; 100 times first log change over the time window under consideration on MPM day t (%).

- ΔLB_t: 10-year Japanese Government Bond futures. Data source: *JPX Data Cloud*; 100 times yield change over the time window under consideration on MPM day t (basis point).

- ΔSP_t: Nikkei225 mini stock futures. Data source: *JPX Data Cloud*; 100 times first log change over the time window under consideration on MPM day t (%).

- We calculate the asset price changes from 5 minutes before each of the events corresponding to sabsamples A, P, N to the time window (50, 60, 70, 80, 90, 100, and 110 minutes) afterwards.

- The event days and times of the policy announcements and press conferences are obtained from the BOJ's website (http://www.boj.or.jp/en/index.htm/). Note that the event corresponding to subsample P is set as the time frame from the closing time to the closing time plus the interval of the press conference itself, because news providers such as Bloomberg broadcasted announcements and news on the BOJ's press conference after the press conference ended. In some cases occurring in the first half of the sample period, when the markets for 10-year government bond futures and/or Nikkei225 mini futures had closed by the time the press conference ended, we calculate the asset price changes from 5 minutes before the end of the press conference to the opening price on the following day of trading.

- The sample period covers all but a few of the days when monetary policy announcements were provided after the MPMs from August 2006 through to March 2012. The days when policy coodination took place with the Fed, ECB, etc., namely, September 18, 2008, September 29, 2008, and November 30, 2011, are excluded from the the sample because some of the moves taken addressed purposes for other than monetary policy. The MPM day just after the Tohoku earthquake on March 14, 2011 is also excluded from the sample because other exogenous macro-shocks are presumed to have been very large at that time.

- The sample size is 82 in each of the subsamples A, P, and N. (The BOJ usually held the MPMs once or twice a month.)

Acknowledgements

I thank Takeo Hoshi and Takashi Kamihigashi for their encouraging comments and suggestions. I am also grateful for the helpful comments and discussions from: Kosuke Aoki, Yi Chen, Mardi Dungey, Hitoshi Inoue, Tokuo Iwaisako, Masayo Kani, Myung-Jig Kim, Kenneth N. Kuttner, Yusuke Kinari, Nobuhiro Kiyotaki, Junko Koeda, Teruyoshi Kobayashi, Chim Lau, Yoichi Matsumoto, Keiichi Morimoto, Kiyotaka Nakashima, Urike Schaede, Takakazu Seki, Etsuro Shioji, Koji Takahashi, Wataru Takahashi, Yasuo Takatsuki, Yoshiro Tsutsui, and Iichiro Uesugi; seminar participants at the University of California, San Diego, Hitotsubashi University, Osaka University, Kobe University, and University of Tokyo; and conference participants at the 1st Hangyan-Kobe-Nanyang Conference in Economics, the 9th annual conference of Asian Pacific Economic Association, the 11th International Conference of Western Economic Association International, and the 2015 Kobe-Peking Joint Conference on Economics. This study received financial support in the form of a Grant-in-Aid from the Japanese Ministry of Education and the Ishii Memorial Securities Research Promotion Foundation.

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Table 1: Specification test of the hypotheses: $\Sigma_A = \Sigma_P = \Sigma_N$

Null hypothesis	Test stat.
$\Sigma_A = \Sigma_N$	13.062
	[0.042]
$\Sigma_P = \Sigma_N$	13.355
	[0.038]
$\Sigma_A = \Sigma_P$	19.440
	[0.003]

Notes: Values in brackets are p-values.

Table 2: Model and moment selection for the examination of the impact of monetary policy news on asset price changes (60-minute time window)

Moment Condition	Parameter Estimates						Test of O.I. rest	MMSC	RMMSC
Single factor model	α_{MP}	β_{MP}	γ_{MP}	λ					
(3) and (4)	0.114**	-0.787**	0.190*	0.308*			15.299	-0.701	2.357
	(0.033)	(0.222)	(0.093)	(0.129)			[0.054]		
(3) and (5)	0.106†	-0.832**	0.188	0.254*			18.924	2.924	3.429
	(0.037)	(0.257)	(0.128)	(0.110)			[0.015]		
(4) and (5)	0.111**	-0.955**	0.192*	0.185†			16.542	0.542	1.534
	(0.029)	(0.192)	(0.086)	(0.108)			[0.035]		
(3), (4), and (5)	0.123**	-0.821**	0.218*	0.269**			22.026	-5.974	2.243
	(0.029)	(0.194)	(0.084)	(0.097)			[0.078]		
Multi-factors model	α_{MPD}	β_{MPD}	γ_{MPD}	α_{MPC}	β_{MPC}	γ_{MPC}			
(6) and (7)	0.100**	-0.970**	0.148†	0.189**	-0.064	0.197†	4.767	-7.233	-0.877
	(0.030)	(0.192)	(0.085)	(0.035)	(0.152)	(0.105)	[0.574]		
(6) and (8)	0.105**	-0.929**	0.170†	0.186**	-0.056	0.184*	5.520	-6.480	0.005
	(0.030)	(0.196)	(0.089)	(0.031)	(0.095)	(0.082)	[0.479]		
(7) and (8)	0.098**	-1.003**	0.101	0.177**	-0.115	0.133	4.043	-7.957	-0.504
	(0.034)	(0.202)	(0.102)	(0.027)	(0.119)	(0.087)	[0.671]		
(6), (7), and (8)	0.105**	-0.926**	0.159†	0.186**	-0.060	0.176**	6.071	**-17.929**	**-0.981**
	(0.030)	(0.180)	(0.084)	(0.023)	(0.080)	(0.065)	[0.912]		

Notes: Values in parentheses are standard errors. **, *, † indicates significance at the 1, 5, and 10% levels, respectively. Values in brackets are p-values. Values in bold are the minimum values of the MMSC and the RMMSC over all candidate models and moments.

Table 3: The impacts of policy decisions and communication on asset price changes over various time windows

Time window	Parameter Estimates						Test of O.I. rest
	α_{MPD}	β_{MPD}	γ_{MPD}	α_{MPC}	β_{MPC}	γ_{MPC}	
50m	0.101**	-0.921**	0.126	0.155**	-0.111	0.118†	16.022
	(0.036)	(0.226)	(0.077)	(0.019)	(0.115)	(0.061)	[0.190]
60m	0.105**	-0.926**	0.159†	0.186**	-0.060	0.176**	6.071
	(0.030)	(0.180)	(0.084)	(0.023)	(0.080)	(0.065)	[0.912]
70m	0.083**	-1.001**	0.084	0.195**	-0.060	0.260**	13.576
	(0.030)	(0.180)	(0.096)	(0.021)	(0.072)	(0.055)	[0.329]
80m	0.071*	-0.997**	0.090	0.169**	-0.174*	0.208**	10.245
	(0.030)	(0.183)	(0.091)	(0.019)	(0.085)	(0.063)	[0.594]
90m	0.044	-1.180**	0.035	0.158**	-0.264*	0.144*	9.244
	(0.030)	(0.181)	(0.095)	(0.023)	(0.112)	(0.065)	[0.682]
100m	0.033	-1.242**	0.018	0.168**	-0.267*	0.150*	6.951
	(0.032)	(0.183)	(0.093)	(0.023)	(0.110)	(0.073)	[0.861]
110m	0.018	-1.244**	0.022	0.178**	-0.189*	0.223**	7.474
	(0.037)	(0.169)	(0.091)	(0.025)	(0.094)	(0.086)	[0.825]

Notes: Values in parentheses are standard errors. **, *, † indicates significance at the 1, 5, and 10% levels, respectively. Values in brackets are p-values.

Table 4: The impacts of policy decisions and communication on asset price changes. Alternative identification restriction: $\sigma^{2A}_{MPD} > \sigma^{2P}_{MPD} = \sigma^{2N}_{MPD}, \sigma^{2A}_{MPC} = \sigma^{2P}_{MPC} > \sigma^{2N}_{MPC}$

Moment Condition	Parameter Estimates						Test of O.I. rest	MMSC	RMMSC
60m window	α_{MPD}	β_{MPD}	γ_{MPD}	α_{MPC}	β_{MPC}	γ_{MPC}			
(12) and (13)	0.158**	-0.836**	0.187†	0.150**	-0.188	0.100	4.070	-7.930	-2.134
	(0.035)	(0.243)	(0.110)	(0.028)	(0.150)	(0.101)	[0.667]		
(12) and (14)	0.058†	-1.111**	0.072	0.125**	-0.128	0.218**	10.129	-1.871	-0.659
	(0.031)	(0.177)	(0.089)	(0.031)	(0.154)	(0.074)	[0.119]		
(13) and (14)	0.058†	-1.101**	0.073	0.195**	0.019	0.266**	9.452	-2.548	-0.998
	(0.031)	(0.182)	(0.093)	(0.038)	(0.149)	(0.099)	[0.150]		
(12), (13), and (14)	0.059†	-1.072**	0.053	0.135**	-0.134	0.217**	14.886	-9.114	-1.048
	(0.031)	(0.171)	(0.086)	(0.028)	(0.126)	(0.064)	[0.248]		
110m window									
(12) and (13)	0.122**	-1.270**	0.097	0.155**	-0.443**	0.168†	10.479	-1.521	-1.607
	(0.042)	(0.217)	(0.104)	(0.030)	(0.142)	(0.090)	[0.106]		
(12) and (14)	0.002	-1.298**	0.010	0.137**	-0.257	0.089**	11.279	-0.721	1.323
	(0.038)	(0.191)	(0.095)	(0.036)	(0.197)	(0.110)	[0.080]		
(13) and (14)	0.002	-1.361**	-0.012	0.216**	-0.268*	0.242**	10.072	-1.928	-0.240
	(0.036)	(0.178)	(0.092)	(0.033)	(0.136)	(0.084)	[0.122]		
(12), (13), and (14)	-0.005	-1.369**	-0.031	0.156**	-0.280†	0.144**	16.009	-7.991	0.155
	(0.033)	(0.155)	(0.087)	(0.030)	(0.150)	(0.079)	[0.191]		

Notes: Values in parentheses are standard errors. **, *, † indicates significance at the 1, 5, and 10% levels, respectively. Values in brackets are p-values.

Table 5: The impacts of policy decisions and communication on asset price changes. Alternative identification restriction: $\sigma^{2A}_{MPD} = \sigma^{2P}_{MPD} > \sigma^{2N}_{MPD}, \sigma^{2P}_{MPC} > \sigma^{2A}_{MPC} = \sigma^{2N}_{MPC}$

Moment Condition	Parameter Estimates						Test of O.I. rest	MMSC	RMMSC
60m window	α_{MPD}	β_{MPD}	γ_{MPD}	α_{MPC}	β_{MPC}	γ_{MPC}			
(15) and (16)	0.092*	-0.067	0.395**	0.152**	0.086	0.017	10.370	-1.630	1.760
	(0.042)	(0.264)	(0.128)	(0.044)	(0.168)	(0.140)	[0.110]		
(15) and (17)	0.093**	-0.120	0.285*	0.157**	-0.034	0.017	12.159	0.159	1.251
	(0.048)	(0.263)	(0.116)	(0.043)	(0.169)	(0.131)	[0.059]		
(16) and (17)	0.096	0.063	0.347*	0.145**	0.035	0.024	9.970	-2.030	2.608
	(0.105)	(0.337)	(0.136)	(0.047)	(0.147)	(0.153)	[0.126]		
(15), (16), and (17)	0.089†	-0.072	0.274*	0.149**	-0.008	0.017	14.041	-9.959	0.921
	(0.048)	(0.258)	(0.112)	(0.035)	(0.146)	(0.108)	[0.298]		
110m time window									
(15) and (16)	0.089	-0.353	0.112	0.192**	-0.074	0.184	20.210	8.210	3.443
	(0.060)	(0.347)	(0.177)	(0.033)	(0.196)	(0.115)	[0.003]		
(15) and (17)	0.083	-0.408	0.132	0.176**	-0.091	0.114	16.123	4.123	3.526
	(0.056)	(0.294)	(0.151)	(0.040)	(0.221)	(0.129)	[0.013]		
(16) and (17)	0.116	-0.242	0.133	0.171**	-0.060	0.155	18.043	6.043	4.917
	(0.095)	(0.418)	(0.237)	(0.041)	(0.254)	(0.138)	[0.006]		
(15), (16), and (17)	0.080	-0.321	0.101	0.183**	-0.067	0.153	20.860	-3.140	3.200
	(0.061)	(0.339)	(0.174)	(0.027)	(0.188)	(0.099)	[0.052]		

Notes: Values in parentheses are standard errors. **, *, † indicates significance at the 1, 5, and 10% levels, respectively. Values in brackets are p-values.

Table 6: More frequently occurring keywords and their co-occurring words at the 10 upper and lower MPD days

Keyword	Co-occurrence words
買入 (purchasing)	残存期間 (remaining duration), 異例 (unusual), 長期国債 (long-term governemt bond), 資産買入 (asset purchase), 金融商品 (financial products)
量的緩和 (quantitative easing)	当座預金 (current account), ターゲット (target), 制約 (constraint), 定義 (definition), 残高 (balance)
デフレ (deflation)	脱却 (exit), 物価下落 (fall in price), 定義 (definition), 記者 (press), 粘り強い (patient)
リスクプレミアム (risk premium)	市場金利 (market interest rate), 縮小 (reduction), 資産 (asset), 基金 (fund), 国債 (government bond)
為替相場 (exchange rate quote)	ドル (dollar), コメント (comment), 反映 (reflection), 示す (show), 上昇 (rise)
基準改定 (revision of standard)	物価指数 (price index), 指数 (index), 新しい (new), 消費者物価 (consumer price), 変わる (change)
伸び率 (growth rate)	銀行貸出 (bank lending), 企業 (company), 思う (think)
市場金利 (market interest rate)	資産買入 (asset purchasing), 基金 (fund), 縮小 (reduction), 対象 (target), 国債 (government bond)
政策運営 (policy operation)	置く (place), 各国 (each country), 感じ (feel), 持続 (sustain), 与える (give)
長期国債 (long-term government bond)	銀行券 (banknote), オペ (operation), 国債 (government bond), 保有 (hold)
需給ギャップ (output gap)	プラス基調 (positive trend), 超過 (excess), マクロ (macro), 生鮮食品 (fresh food), 需要 (demand)
為替レート (exchange rate)	影響 (influence), 思う (think)
予想インフレ率 (expected inflation rate)	繰り返し (repeated), 上がる (rise), 中長期的 (mid and long term), 変化 (change), 要因 (factor)
金融緩和 (monetary easing)	臨時 (unscheduled), 推進 (promote), 資産買入 (asset purchase), 一段 (further), 包括 (comprehension)
情勢判断 (judgement situation)	踏まえる (based on), 維持 (maintain), 考える (consider), 思う (think)
財政政策 (fiscal policy)	金融システム (financial system), 大事 (important), 必要 (need), 政策 (policy), 経済 (economy)
展望レポート (outlook for economic activity and prices)	中間評価 (interim assessment), 示し (show), 沿う (in line), シナリオ (scenario), 循環 (cycle)
金利水準 (interest rate level)	政策金利 (policy interest rate), 余地 (room), 低い (low), 極めて (extremely), 水準 (level)
政策変更 (policy change)	分析 (analysis), 持つ (have), 経済物価 (economic activity and price), 市場 (market), 経済 (economy)
固定金利 (fixed rate)	共通 (common), オペ (operation), 資金供給 (fund supply), 担保 (mortgage)
固定金利オペ (fixed-rate operation)	長め (longer), 導入 (introduce), 促す (promote), 低下 (fall), 金利 (interest rate)
残存期間 (remaining duration)	国債 (government bond), 検討 (examine), 買入 (purchasing), 行う (conduct)
物価下落 (fall in price)	定義 (definition), デフレ (deflation), 緩やか (moderate), 景気 (economic activity), 物価 (price)

Notes: Terms in parentheses are English translations of Japanese keywords by the author. More frequently occurring keywords (sorted by their p-values in descending order) are selected if their p-values are smaller than 0.01.

Table 7: More frequently occurring keywords and their co-occurring words at the 10 upper and lower MPC days

Keyword	Co-occurrence words
固定金利オペ (fixed-rate operation)	拡充 (expanding), 貸出 (lending), 長め (longer), 増額 (increasing), 大幅 (large extent)
金融緩和 (monetary easing)	推進 (promoting), 強力 (powerful), 包括 (comprehensive), 一段 (further), 資産買入 (asset purchasing)
リスクプレミアム (risk premium)	縮小 (reduction), 長め (longer), 資産 (asset), 低下 (fall), 効果 (effect)
明確化 (clarifying)	姿勢 (intention), 成長 (growth), 金融緩和 (monetary expansion), 安定 (stability), 効果 (effect)
意見交換 (exchange opinion)	総裁 (governer), 決定会合 (policy meeting), 具体 (specifying), 行う (implement), 中央 (central)
量的緩和 (quantitative easing)	刺激 (stimulating), 意味 (meaning), 政策 (policy), 質問 (question), 効果 (effect)
資金供給 (fund supply)	固定金利 (fixed-rate), オペレーション (operation), 資産買入 (asset purchasing), 潤沢 (ample), 方式 (method)
成長基盤 (foundation for economic growth)	成長基盤強化 (strengthening the foundation for economic growth), 強化 (strengthening), 検討 (examine), 支援 (support), 必要 (need)
固定金利 (fixed rate)	方式 (method), 共通 (common), 残高 (balance), オペ (operation), 担保 (mortgage)
政策措置 (policy action)	思う (think)
執行部 (executive)	指示 (order), 報告 (report), 受ける (receive), 検討 (examine), 政策決定 (policy decision)
意思疎通 (communication)	政府 (government), 行う (do), 思う (think)
民間企業 (private company)	成長力 (growth potential), 強化 (strengthening), 政府 (government), デフレ (deflation), 金融機関 (financial institution)
金利政策 (interest rate policy)	実質 (reality), 理解 (understanding), 言う (say), 含める (include), 金融 (finance)
政策委員 (policy board member)	メンバー (member), 責任 (responsibility), 健全 (soundness), 日本銀行法 (Bank of Japan Act), プロセス (process)
日本銀行法 (Bank of Japan Act)	国民経済 (national economy), 健全 (soundness), 発展 (development), 責任 (responsibility), 資する (serve)
上昇率 (inflation rate)	指数 (index), 消費者物価 (consumer price), デフレ (deflation), 示す (show), 物価 (price)
成長力 (growth potential)	不可欠 (essential), 取組む (tackle), 強化 (strengthening), 構造 (structure), 民間企業 (private company)
政策決定 (policy decision)	会合 (meeting), 開催 (holding), 執行部 (executive), 決める (decide), 調節方針 (operation guideline)
短期金融市場 (short-term money market)	緊張 (stress), 流動性 (liquidity), 機能 (function), 各国 (each country), 低下 (loss)
民間金融機関 (private financial institution)	取り組み (effort), 検討 (examine), 支援 (support), 様々(various), 行う (implement)
証券化商品 (securitized product)	金融機関 (financial institution), 市場 (market), 思う (think)
主要国 (principal country)	ドル (dollar), 比べる (compare), 金融市場 (financial market), 含める (include), 銀行 (bank)
企業マインド (business sentiment)	円高 (yen appreciation), 経済物価 (economic activity and price)
国民経済 (national economy)	健全 (soundness), 発展 (development), 日本銀行法 (Bank of Japan Act), 資する (serve), 目的 (purpose)
市場金利 (market interest rate)	基金 (fund), 資産 (asset), 促す (promote), 目的 (purpose), 買入 (purchasing),
健全性 (soundness)	財務 (financial), 信認 (confidence), 低下 (loss), 中央 (central) , 銀行 (bank),

Notes: Terms in parentheses are English translations of Japanese keywords by the author. More frequently occurring keywords (sorted by their p-values in descending order) are selected if their p-values are smaller than 0.01.

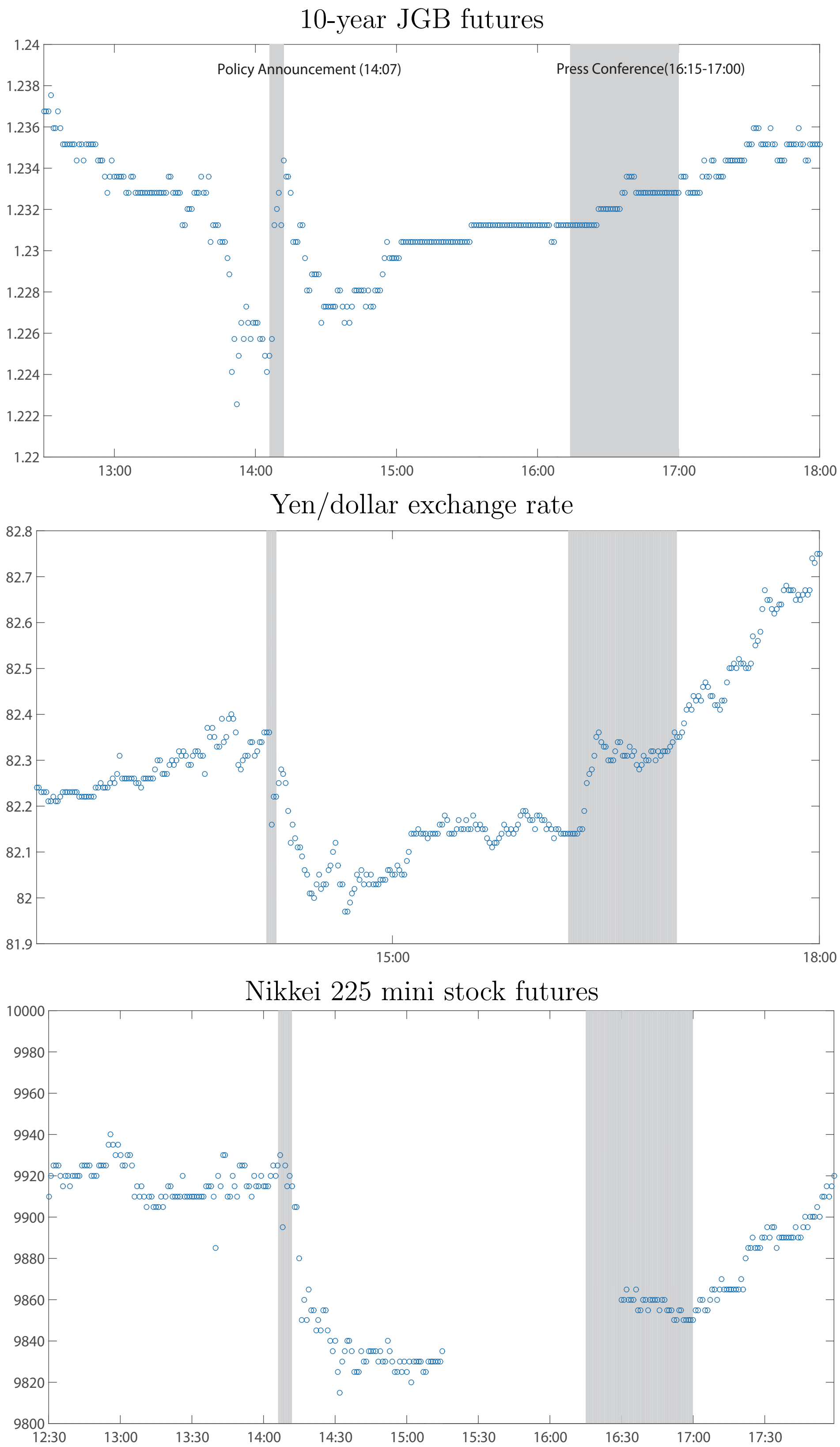

Figure 1: Intraday movements in asset prices on March 13, 2012. The shaded areas indicate the times of the Bank of Japan's policy announcement and press conference.

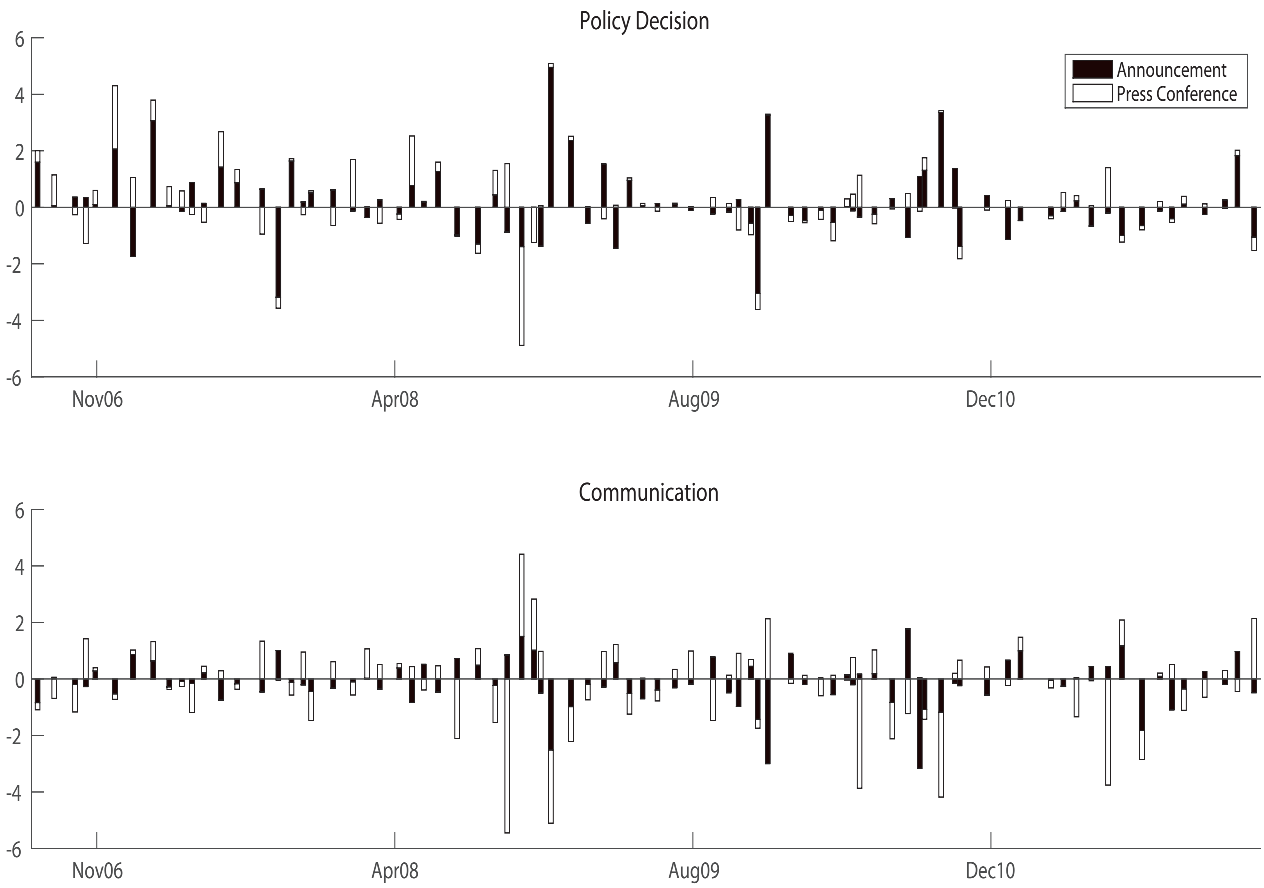

Figure 2: Identified monetary policy decision and communication factors