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Abstract

This paper assesses the effectiveness of unconventional monetary policy on the macro economy. It focuses on the Japanese economy during the Bank of Japan's quantitative easing policy period, and analyzes the effects of monetary policy shocks and systematic monetary policy using the vector autoregression model with simultaneous interaction between stock prices and policy decisions. The main finding is that unconventional monetary policy has a significant effect on the macro economy, which is closely in line with the existing evidence under the conventional monetary policy setting. The output effects work through the transmission linking the stock market and the real economy, while it plays a limited role in terms of the price effects. The analysis also suggests that the Bank of Japan's systematic policy responses mitigate severe downward pressure on the real economy generated from the stock market.

JEL Classification: E52; E58.

Keywords: unconventional monetary policy; vector autoregression model; interaction between monetary policy and stock market; effects of monetary policy shocks; systematic monetary policy responses.

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1 Introduction

Unconventional monetary policy is the policy adopted by central banks when the overnight interest rate cuts, conventionally conducted as the way of monetary policy stimulus, are no longer feasible due to its zero bound. Bernanke and Reinhart (2004), Bernanke, Reinhart, and Sack (2004) among others, divide unconventional monetary policy tools into three categories: (i) commitment to future policy stance, (ii) quantitative easing, and (iii) credit easing, and characterize unconventional monetary policy as a combination of these policy tools. As argued by Wright (2012), measuring the overall stance of unconventional monetary policy in this environment is in itself not a straightforward task unlike the conventional monetary policy setting, under which the short term interest rate, i.e., the federal funds rate for the U.S. and the uncollateralized overnight call market rate for Japan, provides a measure of the stance.

One of novel features in this study is to focus on the Japanese economy between March 2001 and March 2006. There is a validity that we consider the quantity of bank reserves, i.e., the current account balances (CABs), held at the Bank of Japan (BOJ) as a measure of the overall stance of unconventional monetary policy in Japan during that period. On 19 March 2001, the BOJ adopted an unconventional monetary policy that was officially referred to as the "quantitative easing policy (QEP)". The BOJ set the call rate at the zero lower bound and shifted the instrument of monetary policy from the policy rate to the CABs. The BOJ continued to inject ample liquidity into the CABs beyond the level needed to maintain the call rate at zero, and terminated five years of its policy on 9 March 2006. During the QEP period, the BOJ publicly announced the target level of the CABs soon after every Monetary Policy Meeting (MPM) day, and the market participants paid attention to these policy announcements.[1]

Most countries adopting an unconventional monetary policy have faced economic downturn generated by the stock market. Japan was confronted by a harsh economic and financial situation at the time of introduction of the QEP. The Japanese economy in the early 2000s suffered decreasing stock prices, deflationary pressures, and a significant fall in economic

[1]The BOJ controlled the amount of funds in the money market through various tools of policy operation, including policy commitment, the supply of money and the purchase of risky assets, to achieve its target CAB level. See Shiratsuka (2010) for the details.

activity due to the collapse of the global IT bubble. This fact is comparable to a common feature in business cycles, financial market dynamics, and the monetary policy conduct of several advanced countries after the collapse of Lehman Brothers in September 2008 provided by Gambacorta, Hofmann, and Peersman (2012).

This paper proposes using a structural vector autoregressive (VAR) model with simultaneous interaction between stock prices and policy decisions to measure the effects of monetary policy shocks and systematic monetary policy during Japan's QEP period. Essentially, we need to identify the policy-induced changes as monetary policy shocks in the VAR model and the systematic policy changes from the total changes in the CABs to assess the causal effects of monetary policy. In addition, there is an interdependent relation between stock prices and monetary policy. As argued by a growing literature on the effect of unconventional monetary policy on financial markets, including Gagnon, Raskin, Remache, and Sack (2011), D'Amico and King (2013), Krishnamurthy and Vissing-Jorgensen (2011), Joyce, Lasaosa, Stevens, and Tong (2011) and Wright (2012), the aggressive expansion of unconventional monetary policy seems to affect the stock market. On the other hand, monetary policy exerts a considerable influence on stock market.[2] In this environment, failing to take into account the simultaneous interaction between stock prices and policy decisions could seriously bias estimates of the stock market response to monetary policy and monetary policy reaction to the stock market.[3]

It seems peculiar that compared with extensive research efforts on the financial market effects of unconventional monetary policy, there exists only a small body of empirical literature quantifying its effects on the macro economy. Chung, Laforte, Reifschneider, and Williams (2012) and Chen, Curdia, and Ferrero (2012) use the structural macroeconomic model to conduct counterfactual simulations of how the economy would have performed in the absence of the actions of central banks.[4] However, they rely on models covering the pre-crisis

[2]As argued by Rigobon and Sack (2003, 2004), even if the central bank is not targeting stock market prices, movements in the stock market may importantly affect monetary policy decisions because the central bank systematically responds to stock market movements to the extent warranted by their impact on future output and prices.

[3]Bjørnland and Leitemo (2009) emphasize the need to allow for contemporaneous interaction between the monetary policy settings and the determination of stock prices in the context of conventional monetary policy shocks.

[4]Chung, Laforte, Reifschneider, and Williams (2012) and Chen, Curdia, and Ferrero (2012) carry out simulations using FRB/US macroeconomic model and the medium-sized DSGE model, and argue that the policy actions at that time mitigated severe economic recessions and deflationary risks.

period, which may not be adequate for assessing macroeconomic dynamics and monetary transmission at the zero lower bound. Also, as a criticism of these models by Sims (1980), the many over-identifying restrictions of the structural macroeconomic model may be both theoretically and empirically suspect, especially under the unconventional monetary policy setting. Baumeister and Benati (2012) and Kapetanios, Mumtaz, Stevens, and Theodoridis (2012) estimate a time-varying parameter structural VAR to investigate the macroeconomic impact of unconventional monetary policy shocks.[5] However, they impose sign restrictions, namely the output and prices do not decline in response to accommodative monetary policy shocks. An *a priori* restriction on output and prices aimed at eliminating the possibility of ineffectiveness on the real economy would be inappropriate for our purpose, which is to assess the effectiveness of unconventional monetary policy in protecting the macro economy from economic recessions and a deflationary pressure. Gambacorta, Hofmann, and Peersman (2012) estimate a panel VAR from eight advanced countries, including Japan, over a sample spanning the period since the onset of the recent global financial crisis. The motivation behind the identification strategy under their empirical framework is quite similar to ours in the sense that they only use the sample period where the central banks conduct the unconventional monetary policy, and rigorously disentangle exogenous monetary policy shifts and the endogenous reaction of central bank from the global financial crisis.[6] However, it might not be clear whether exogenous expansions in central bank balance sheets can be interpreted as total unconventional monetary policy shocks given that policy makers including the Fed, the ECB, and the BOJ have emphasized policy implementation combining unconventional monetary policy tools since the global financial crisis.[7] We strongly believe that the assessment of whether Japanese unconventional monetary policy during the QEP period was effective on macroeconomic conditions will serve as a useful guide for central banks not only in Japan but

[5]Baumeister and Benati (2012) and Kapetanios, Mumtaz, Stevens, and Theodoridis (2012) identify narrowing long-short spreads of government bonds as the unconventional monetary policy shocks, which rely on the empirical evidences in Gagnon, Raskin, Remache, and Sack (2011), D'Amico and King (2013) and Joyce, Lasaosa, Stevens, and Tong (2011).

[6]Gambacorta, Hofmann, and Peersman (2012) identify the unconventional monetary policy shocks by imposing a mixture of zero and sign restrictions such that an exogenous increase in central bank balance sheets at the zero lower bound has contemporaneously no impact on output and prices, and immediately mitigates financial market uncertainty measured by VIX.

[7]For example, Chairman Bernanke explicitly denied that the Fed's first planned program of asset purchases constituted QEP (Bernanke, 2009). See also subsection 2.1 for the BOJ and Trichet (2009) for the ECB.

also in other advanced countries in their conduction of unconventional monetary policy.

There are two empirical questions we focus on in this paper. The first is to examine whether there exists a monetary policy transmission linking the stock market and the real economy. According to previous literature on the effect of unconventional monetary policy on financial markets in Japan, the consensus view is that Japanese unconventional monetary policy during the QEP period had a significant impact on financial markets.[8] However, it is not clear whether this policy aimed to influence macroeconomic conditions. Honda, Kuroki, and Tachibana (2007) argue that an expansion of central bank balance sheets at the zero lower bound has a positive effect on not only the stock market but also the macro economy, but Kimura, Kobayashi, Muranaga, and Ugai (2003), Fujiwara (2006), and Nakajima, Kasuya, and Watanabe (2011) report evidence against this.[9] While these studies do not explicitly investigate the effectiveness of the transmission effects linking the stock market and the real economy, we quantitatively measure them within the VAR framework.

Second, we investigate the role of systematic monetary policy during the QEP period. Although it is an important task to measure the effects of monetary policy shocks under a zero policy interest rate environment, a substantial part of the observed movement in CABs might be explained by macroeconomic conditions, given the BOJ's policy objective of macroeconomic stabilization.[10] Especially in the early 2000s, a sharp decline in stock prices could cause the CABs to rise. This systematic policy reaction might play a critical role in avoiding a further

[8] Ueda (2012) examine the daily responses of asset prices to the BOJ's policy changes since March 2001 motivated by the empirical literature of Gagnon, Raskin, Remache, and Sack (2011), D'Amico and King (2013), Krishnamurthy and Vissing-Jorgensen (2011), and Joyce, Lasaosa, Stevens, and Tong (2011), and find that the effects of the BOJ's unconventional monetary policy measures on asset prices have been broadly similar between Japan and the advanced countries. Okina and Shiratsuka (2004) and Oda and Ueda (2007) report that the QEP, which committed itself to the actual performance of the CPI, had a significant effect on lowering the yield curve.

[9] Shirakawa (2010) mentioned the QEP effects on aggregate demand and prices as follows:

> Empirical studies on Japan mostly show that quantitative easing produced significant effects on stabilizing the financial system, while it had limited effects on stimulating economic activity and prices.

Ugai (2007) also concludes in his comprehensive survey of empirical studies of the effects of the QEP that the QEP's effects in raising aggregate demand and prices were not detected or were small.

[10] A lot of empirical studies regarding the effects of monetary policy, e.g., Bernanke, Gertler, and Watson (1997), Christiano, Eichenbaum, and Evans (1999), and Sims and Zha (2006), find that identified monetary policy shocks are a minor source of economic fluctuations, and most of the observed movement in the instruments of monetary policy is endogenous. In fact, our identified unconventional monetary policy shocks in subsection 4.3 explain less than 20% of the overall variation in output and prices.

severe economic recession. In order to understand the role of systematic monetary policy responses, we conduct a counterfactual simulation of what would have happened to the macro economy in the absence of the BOJ's actions in the face of stock price shocks.

The main result that emerges from the empirical analysis is that the unconventional monetary policy during Japan's QEP period had a significant effect on the macro economy, which is closely in line with the existing evidence under the conventional monetary policy setting. The output effects work through the transmission linking the stock market and the real economy, while it plays limited role in terms of price effects. Counterfactual simulation suggests that the BOJ's systematic policy responses mitigate severe downward pressure on the real economy generated by the stock market.

The remainder of the paper is organized as follows. In Section 2, we offer the overview of the BOJ's QEP and the Japanese economy between 2001 and 2006. In Section 3, we describe our empirical model. In Section 4, we report our benchmark empirical results. In Section 5, we report empirical results from alternative specifications to examine the robustness of our benchmark results. In Section 6, we provide some implications from our empirical results. Section 7 concludes the paper. Data Appendix describes the data we use in this paper.

2 Overview of the BOJ's QEP and Japanese Economy from 2001 to 2006

In section 2.1, we offer an overview of the QEP implemented from 2001 to 2006 and then discuss what is the best indicator of monetary policy and why our analysis focuses on the 2001–2006 period. In section 2.2, we describe the Japanese economic situation at that time and point out the potential problems associated with the empirical analysis.

2.1 Characteristics of the BOJ's 2001–2006 QEP

The BOJ adopted its QEP in March 2001 under severe economic circumstances that had begun with the collapse of the asset price bubble in the early 1990s and had been aggravated by the collapse of the global IT bubble in 2000.[11] As explained in Ugai (2007) and Shiratsuka (2010), the QEP during the 2001–2006 period consisted mainly of three pillars: (i) the BOJ changed its main operating target for money market operations from the uncollateralized overnight call rate[12] to the outstanding current account balances (CABs) held by financial institutions at the BOJ. (ii) The BOJ made a commitment that the QEP would continue until the consumer price index (excluding perishables, the core CPI hereafter) inflation became stably zero or above. (iii) To smoothly achieve the CAB target, the BOJ gradually increased its outright purchases of long-term Japanese government bonds.[13]

It is natural to consider the CABs as the best indicator of the BOJ's policy stance during the QEP period, and hence we include the CABs, instead of the call rate, in our VAR framework as a monetary policy instrument. Table 1 describes the CAB targets decided by the Policy Board of the BOJ at the MPMs, and Figure 1 plots the actual amount of the CABs along with the CAB targets and the call rate. The BOJ progressively raised the CAB target in response to the deterioration of the economy (also see Figure 2 for movements of macroeconomic and stock price variables in the QEP period). The actual amount of the CABs also increased in line with increases in the CAB target. Sometimes the BOJ provided ample liquidity exceeding the ceiling of the CAB target when it deemed that financial institutions faced a shortage of liquidity, for example, at the end and midway point of the fiscal year. On the other hand, the call rate was kept at virtually zero percent, meaning that it contains no additional information about the BOJ's policy stance during the QEP period.

Our analysis focuses on the 2001–2006 period, not extending the estimation period to recent years, since the BOJ changed its operating target after the termination of the QEP. When terminating the QEP in March 2006, the BOJ restored its operating target to the call rate again. And then in October 2010, the BOJ adopted a new QEP called "a comprehensive monetary easing policy" in the face of economic downturn caused by the world financial crisis in 2008. Under this new policy regime, the BOJ did not adopt the CABs as its operating

[11] Before adopting the QEP, the BOJ implemented the zero interest rate policy from February 1999 to August 2000.

[12] The call rate is an interbank overnight rate in Japan like the federal funds rate in the US. Miyao (2002) concludes that the call rate can be regarded as the best indicator of monetary policy in Japan for his estimation period 1975–1998.

[13] See Ugai (2007) and Shiratsuka (2010) for more detailed explanation about the BOJ's 2001–2006 QEP.

target. Instead, the BOJ established a new fund to purchase several types of financial assets, and it increased the total size of the fund when pursuing further monetary easing. Therefore, if the CABs were used as the monetary policy indicator with the sample period including the post-2006, then shocks to the CABs identified by the VAR analysis might not be interpreted as monetary policy shocks.

2.2 Japanese Economy during the QEP Period

Figure 2 shows the time series of real output, goods price, and stock price as well as the CABs from the early 2000s to 2006. We use the index of industrial production (IIP) as a proxy of real output, the core CPI as a proxy of goods prices, and the Nikkei 225 average index as a proxy of stock prices.

In the first half of the period, output, goods prices, and stock prices were severely declining due, in part, to the burst of the global IT bubble. In response to this rapid deterioration of the economy, the BOJ increased its provision of liquidity to the CABs. From mid-2003, output and stock prices began gradually increasing, while the core CPI stopped declining temporarily but it began to decline again from 2005.

There are three points we should take note of in Figure 2 before formally analyzing the effect of the QEP. First, the figure shows a negative correlation between macroeconomic and stock price variables and the CABs in the early phase of the QEP. One interpretation of the negative relationship is that the QEP had no effect on the Japanese economy. The other interpretation is that the QEP could not reverse the decline of the economy but was at least able to mitigate that decline. To see which hypothesis is true, we conduct a counterfactual analysis in subsection 4.4, in which we examine what would have happened if the BOJ had not increased the CABs in response to the economic downturn.

Second, it is also seen from the figure that the IIP and stock prices have been positively correlated with the CABs since the mid-2003. The Japanese economic recovery reflected in the IIP and stock prices may be attributable not only to the influence of the QEP but to other macroeconomic factors including the improvement of the financial situation and the resolution of the non-performing loan problems following the nationalization of the Resona

Bank (May 2003), or to the increase in exports during the period. Therefore, in section 5, in which several robustness analyses are conducted, we estimate the VAR specifications that control for the latter two possible effects.

Third, each of the variables in the figure can be regarded as following a unit root process. Thus we use the growth rate of stock prices and the CABs in the benchmark model while the IIP and the CPI remain in level. Further, in section 5 we estimate an alternative specification with the first log difference of the IIP and the CPI.

3 Econometric Framework

This section describes the econometric framework employed in this paper. The framework follows that of previous studies in that it combines high-frequency financial market data with monthly VARs to achieve identification, such as in Cochrane and Piazzesi (2002), Faust, Swanson, and Wright (2004), and D'Amico and Farka (2011). In particular, the idea of our identification is similar to one developed by D'Amico and Farka (2011). We first run a high-frequency regression of stock returns on policy shocks outside the VAR to obtain the stock market response to policy actions, and then, in the second step, estimate the monetary policy reaction to stock prices by directly imposing the first-step estimate in the monthly VAR. By doing so, we isolate the financial markets response to monetary policy and the monetary policy reaction to financial markets, and assess the effectiveness of unconventional monetary policy in Japan from the viewpoint of the real economic effects of not only monetary policy shocks but also systematic monetary policy.

However, we cannot directly follow the D'Amico and Farka's (2011) technique to analyze the unconventional monetary policy.[14] In contrast with the analysis under the conventional monetary policy setting, we cannot directly measure surprise changes in the CABs as a proxy of the unconventional monetary policy stances during Japan's QEP period because there is no market-based proxy to gauge the policy expectations on the target level of the CABs.

[14] As in Kuttner (2001), among others, D'Amico and Farka (2011) use the changes in the current month federal funds futures rate in a narrow window around FOMC announcements as a direct measure of monetary policy shocks under the conventional monetary policy setting, and run the ordinary least squares regression of changes in stock price futures on policy shocks to estimate the stock market response to policy actions.

So, as in Wright (2012), we employ the methodology of Rigobon and Sack (2004) to measure the stock market responses to monetary policy shocks with a daily frequency. This is an identification strategy using heteroscedasticity in daily-frequency data under which we assume that the variance of monetary policy shocks is higher on days of monetary policy board meetings when a larger portion of the news hitting markets is about monetary policy.[15]

One of novel features of our econometric framework unlike the previous VAR studies, such as Christiano, Eichenbaum, and Evans (1999) and Honda, Kuroki, and Tachibana (2007), is that identification does not depend on the restriction that the central bank endogenously and contemporaneously responds to financial markets. We show that we should take into account the interdependence between stock market and monetary policy decisions to isolate the financial markets' response to monetary policy and the monetary policy reaction to financial markets, and discuss its importance when we assess the effectiveness of unconventional monetary policy in the following section reporting our empirical results.

3.1 VAR model

X_t is given by $(Y_t^{'}, SR_t, \Delta CAB_t)^{'}$, where Y_t is a vector of $n-2$ macroeconomic variables, and SR_t and ΔCAB_t denote stock returns and the changes of the CABs as a proxy of the BOJ's behavior during the QEP period as described in the previous section, respectively. Suppose the economy is described by a following structural form VAR:

$$A_0 X_t = A(L) X_t + \epsilon_t, \tag{1}$$

and its reduced form counterpart $X_t = \phi(L)X_t + u_t$, where $A(L), \phi(L)$ are matrix polynomials in lag operator L, $\epsilon_t = (\epsilon_t^{y'}, \epsilon_t^{SR'}, \epsilon_t^{MP'})^{'}$ is an $(n \times 1)$ vector of zero-mean structural shocks with diagonal variance-covariance matrix D, $u_t = R\epsilon_t$ is a vector of reduced form innovations, the diagonal elements of A_0 are equal to one, and $R = A_0^{-1}$. Note that the matrix of

[15] As shown by Rigobon and Sack (2004), the estimators under heteroscedasticity are generalized to ones under an event-study approach, which is applied by Gagnon, Raskin, Remache, and Sack (2011), D'Amico and King (2013), Krishnamurthy and Vissing-Jorgensen (2011), Joyce, Lasaosa, Stevens, and Tong (2011), and Ueda (2012) to examine the daily financial market responses to unconventional monetary policy.

contemporaneous coefficients A_0 of the form:

$$A_0 = \begin{bmatrix} A^m_{0M} & A^m_{0F} \\ A^f_{0M} & A^f_{0F} \end{bmatrix}. \tag{2}$$

We assume that macroeconomic variables such as output and prices respond with lag to policy actions and stock price shocks. This assumption is reflected by $A^m_{0F} = 0$. This assumption is common in the VAR literatures, for e.g., Christiano, Eichenbaum, and Evans (1999), among others.

We allow for simultaneous responses between ΔCAB and SR. In other words, suppose that the A^f_{0F} block can be written as $A^f_{0F} = \begin{pmatrix} 1 & -\alpha \\ -\beta & 1 \end{pmatrix}$ because the diagonoal elements of A_0 are equal to 1; then we do not impose the restriction of either no instantaneous impact of monetary policy, $\alpha = 0$, or no contemporaneous monetary policy reaction to stock returns, $\beta = 0$, to identify the system.

3.2 Instantaneous impacts of monetary policy on stock returns

We think of structural shocks ϵ_t as cumulative shocks in daily series over the course of a month $\epsilon_t = \sum_{d=1}^{D} \epsilon_{t,d}$, where d indexes the days within the month. We assume that the same relationship between structural and reduced form errors applies at high-frequency as it does in monthly data. Under this assumption, we represent the contemporaneous relationship between $SR_{t,d}$ and $\Delta CAB_{t,d}$ at the time t, d as follows;

$$SR_{t,d} = \alpha \Delta CAB_{t,d} + \gamma \epsilon^y_{t,d} + \epsilon^{SR}_{t,d} \tag{3}$$

$$\Delta CAB_{t,d} = \beta SR_{t,d} + \delta \epsilon^y_{t,d} + \epsilon^{MP}_{t,d}. \tag{4}$$

Equation (3) is the stock price equation at a daily frequency, which allows the SR to be affected by the CABs and also by the other macroeconomic shocks (news) $\epsilon^y_{t,d}$. Equation (4) represents a monetary policy reaction function at the daily frequency that captures the expected response of policy to the SR and $\epsilon^y_{t,d}$.

As seen from equations (3) and (4), we cannot necessarily obtain a consistent estimate of the impacts of monetary policy on stock returns using ordinary least square (OLS) due to the presence of both endogeneity and omitted variable bias.[16] In particular, if we regress (3) by the OLS, the estimate would be biased below its true value α in cases where the central banks countercyclically responds to stock returns, which imply a negative relation between the CABs and stock returns ($\beta < 0$).

In order to estimate the impact of monetary policy on stock returns α, we follow the methodology introduced by Rigobon and Sack (2004). Their idea is to look at changes in the co-movements of monetary policy measures and asset prices when the variance of one of the shocks in the system is known to shift. They use the institutional knowledge of the central bank to separate the sample period into two subsamples, PD and NPD. Specifically, days of the policy announcement are likely to contain a greater amount of news about monetary policy than other days, although other shocks still take place on these days. Following Rigobon and Sack (2004), we take those dates as the set of dates PD, or policy dates, to indicate that the variance of the policy shock is elevated. For the set of non-policy dates NPD, we take the set of days immediately preceding those included in subsample PD, which minimizes any effects arising from changes in the variances of the shocks over time.

The identifying assumption is that the variance of the policy shocks increases in subsample PD, while the stock price shocks and the other shocks are assumed to occur with the same intensity as in subsample NPD. Let Ω_{PD} and Ω_{NPD} denote the variance-covariance matrices of the variables, $SR_{t,d}, \Delta CAB_{t,d}$, on the subsamples, PD and NPD, respectively. Under the above identification assumption, we obtain

$$\Delta\Omega = \Omega_{PD} - \Omega_{NPD} = \frac{(\sigma^{PD}_{\epsilon MP} - \sigma^{NPD}_{\epsilon MP})}{(1-\alpha\beta)^2} \begin{bmatrix} \alpha^2 & \alpha \\ \alpha & 1 \end{bmatrix}, \tag{5}$$

where $\sigma^{PD}_{\epsilon MP}$ and $\sigma^{NPD}_{\epsilon MP}$ represent the variances of monetary policy shocks in subsamples PD and NPD, respectively. As is evident from equation (5), two parameters, α and $\lambda \equiv$

[16]In fact, we can obtain a consistent estimate of α only if $\Delta CAB_{t,d}$ is predetermined when stock price and other macroeconomic shocks occur ($\beta = 0, \delta = 0$), or the variance of monetary policy shocks, $\sigma^2_{\epsilon MP}$, is infinitly larger than stock price shocks, $\sigma^2_{\epsilon SR}$, and other macroeconomic shocks, $\sigma^2_{\epsilon y}$ ($\sigma^2_{\epsilon MP}/\sigma^2_{\epsilon SR} \to \infty, \sigma^2_{\epsilon MP}/\sigma^2_{\epsilon y} \to \infty$). See Rigobon and Sack (2004) for details.

$\frac{(\sigma^{PD}_{\epsilon MP} - \sigma^{NPD}_{\epsilon MP})}{(1-\alpha\beta)^2}$, can be identified from three restrictions on the change in the covariance matrix.

In practice, we implement the Generalized Method of Moments (GMM) approach to estimate α.[17] In order to check the validity of the identification assumption that we have imposed on the model, we use a standard Sargan statistics to test whether the over-identifying restrictions for the equation (5) are satisfied or not.

We compare the estimates under a heteroscedasticity-based approach $\hat{\alpha}_{het}$ to the OLS estimates $\hat{\alpha}_{OLS}$. Specifically, in order to test the null hypothesis that the OLS estimate $\hat{\alpha}_{OLS}$ is consistent and efficient, we use the following Hausman (1978) type test statistics:

$$|\hat{\alpha}_{het} - \hat{\alpha}_{OLS}|[Var(\hat{\alpha}_{het}) - Var(\hat{\alpha}_{OLS})]^{-1}|\hat{\alpha}_{het} - \hat{\alpha}_{OLS}|, \tag{6}$$

which asymptotically follow the chi-square distribution with one degree of freedom under the null hypothesis.

3.3 Contemporaneous monetary policy reaction to stock returns

First, we directly impose the estimated coefficient $\hat{\alpha}$ from the high-frequency regression in the monthly VAR. Next, we consider the following system regression model:

$$\begin{bmatrix} 1 & -\hat{\alpha} \\ -\beta & 1 \end{bmatrix} \begin{bmatrix} SR_t \\ \Delta CAB_t \end{bmatrix} = A^f_{0Y} Y_t + A^f(L) X_t + \begin{bmatrix} \epsilon^{SR}_t \\ \epsilon^{MP}_t \end{bmatrix}. \tag{7}$$

We can estimate the contemporaneous policy responses to a stock price shock under system (7) by considering the interdependent relation between the stock market and monetary policy. Let $\hat{\epsilon}^{SR}_t$ denote the residuals from the first regression in equation (7). We estimate the second regression by regressing the monetary policy variable, ΔCAB_t, on contemporaneous and lagged values of all variables, using residuals $\hat{\epsilon}^{SR}_t$ as an instrument for SR_t, and obtain the estimate of the parameter on ΔCAB_t, $\hat{\beta}$. In this way, we can complete the identification of the monthly VAR system.

[17] Rigobon and Sack (2004) suggest two different approaches to estimate α; one implemented the instrumental variables regression by using $w_m \equiv [\Delta CAB^{PD} - \Delta CAB^{NPD}]$ as the instruments and the other implemented it using the GMM apprach. We also implement the instrument variables regression and obtain the similar results as the following benchmark ones.

4 Benchmark Results

This section provides the empirical results using our econometric framework. First, we estimate the instantaneous impact of monetary policy shocks on stock returns α using the assumption that monetary policy shocks have especially high variance on days of policy announcements, while there is nothing unusual about these days from the perspective of any other shocks to the economy. Second, we estimate the monetary policy response to stock return β. Third, we estimate the impulse responses of monetary policy shocks on output, prices, stock prices, and CABs to examine the dynamic causal effects of monetary policy, and quantitatively measure the transmission effects linking the stock market and real economy within the VAR framework. Finally, we estimate the impulse responses of stock price shocks to examine the influences of stock prices on the CABs and the macro economy and conduct the counterfactual simulation of what would have happened to the macro economy in the absence of systematic policy actions in the face of stock price shocks.

4.1 Instantaneous impacts of unconventional monetary policy on stock returns

Table 2 reports the statistics on daily changes in ΔCAB and in stock returns. ΔCAB and stock returns are first log differences of CABs and stock prices, respectively, multiplyed by 100. The first to third columns of Table 2 indicate the standard deviation of asset prices using full samples, non policy dates, and policy dates, respectively. The fourth to sixth columns of Table 2 indicate the covariance with the ΔCAB using full sample, non policy dates, and policy dates, respectively.

In Table 2, we find that the standard deviation of ΔCAB rises substantially on the days with higher variance of policy shocks, as expected. More importantly, a positive relationship between these variables becomes evident on the policy dates, as the higher variance of the policy shocks on those days tends to move the observations along the stock price response function, whereas there is no clear relationship between stock prices and the CAB on full sample and non-policy dates, as evidenced by the relatively small covariance between them.

Table 3 reports the estimates of the parameter on stock returns α for equation (3). The first row in this table indicates the estimate obtained using heteroscedasticity assumptions, $\hat{\alpha}_{het}$. The second row indicates the simple OLS estimate $\hat{\alpha}_{OLS} = Cov(\Delta CAB, SR)/(std(\Delta CAB) \times std(SR))$ using the full sample. The third row indicates a Sargan statistics to test whether or not the over-identifying restrictions for equation (5) are satisfied. The fourth row indicates a Hausman-type test statistics to test the null hypothesis that the OLS estimate $\hat{\alpha}_{OLS}$ is consistent and efficient.

There are three empirical findings we should mention from Table 3. First, the central banks can have an impact on stock markets even under a zero short-term interest rate. In the first row of Table 3, we find that the estimate under the heteroscedasticity-based approach $\hat{\alpha}_{het}$ is positive and statistically significant. This means that the aggressive policy-induced rise of the CABs led to an increase in stock prices immediately during the QE period. This is consistent with the findings in Ueda (2012).

Second, it is a plausible way to impose the heteroscedasticity assumptions to identify the effects of monetary policy shocks at a zero short-term interest rate lower bound. In the third row of Table 3, a Sargan statistics indicates that we cannot reject the over-identifying restrictions of the model. This implies the validity of the identification assumption that we have imposed on the model.

Third, interdependence between stock market and monetary policy plays a critical role in estimating the impact of monetary policy on stock prices. In the second row of Table 3, the OLS estimate $\hat{\alpha}_{OLS}$ is very small and statistically insignificant. In the fourth row of Table 3, a Hausman-type test statistics shows that the null hypothesis that the OLS estimate $\hat{\alpha}_{OLS}$ is consistent and efficient is rejected. This implies that the simple OLS estimates underestimate the monetary policy effects on stock returns due to an endogenous and omitted variables bias.

4.2 Contemporaneous responses of unconventional monetary policy to stock returns

In this subsection, we examine the contemporaneous responses of monetary policy to stock returns. First, we estimate a 4-variable reduced-form VAR model using monthly data. As a benchmark, we consider the VAR model containing the logarithm of the IIP multiplied by 100 as a proxy of output, the logarithm of core CPI multiplied by 100 as a proxy of goods prices, the first log difference of the Nikkei 225 index or TOPIX multiplied by 100 as a proxy of stock return, and the first log difference of CABs multiplied by 100. We set the lag length to four in the reduced-form VAR estimation, which is sufficient to capture the system dynamics.[18] Next, we impose the estimate under the heteroscedasticity-based approach $\hat{\alpha}_{het}$ into equation (7) and estimate the contemporaneous monetary policy reaction to stock returns β. Table 4 shows the estimate of policy reaction to stock returns $\hat{\beta}$ when we impose the estimate of contemporaneous stock returns effects of monetary policy shocks $\hat{\alpha}_{het} = 0.16$.

The central bank endogenously and simultaneously responds to the stock market. In Table 4, we find that the estimate $\hat{\beta}$ is negative and statistically significant. This means that the BOJ took immediate accommodative policy stances in response to severe downward pressure on the stock market during the QE period.

The result in Table 4 also implies that we reject the usual assumption that the central bank does not respond to the financial market movements contemporaneously ($\beta = 0$). This assumption, which is imposed by a large VAR literature including Christiano, Eichenbaum, and Evans (1999), Honda, Kuroki, and Tachibana (2007) to analyze the monetary policy, ignores, at least in part, the influences of the actual systematic policy actions to stabilize the macroeconomic conditions.

4.3 Dynamic causal effects of unconventional monetary policy

We first highlight the impulse responses to a monetary policy shock. Figure 3 displays the impulse responses for all the variables with respect to one standard error monetary policy shock for a period of up to 48 months.[19] The solid lines represent the point estimates of the responses, and shaded areas represent 16th and 84th percentile error bands calculated by the bias-adjusted bootstrap method proposed by Kilian (1998) with 10000 replications. The responses for the SR and the ΔCAB are displayed as the cummulative responses, which

[18]We perform a modified likelihood ratio test proposed Sims (1980) to check whether taking four lags is sufficient. Here the null of four lags is tested against the alternative of six lags or ten lags. The chi-square statistics indicate that the null is not rejected by conventional significance levels for each of the models considered.

[19]We only report the results using Nikkei 225 average as a proxy of stock price. In using TOPIX, we obtain nearly the same results as the benchmark.

reflect the responses in levels.

The impulse response patterns for a monetary policy shock are closely in line with the existing evidence under the conventional monetary policy setting. The left upper chart in Figure 3 indicates that output rises for one year or so up to an expanding monetary policy shock, which is statistically significant, and then goes back to steady state level. The maximum estimated positive effect in response to a one-standard-deviation monetary policy shock is about 0.45, which is comparable with the monetary policy effect on output under the conventional monetary policy setting in Japan obtained by West (1993), Shioji (2000), Miyao (2002) and Braun and Shioji (2006).[20] [21] The right upper chart in Figure 3 indicates that the rises in core CPI are also statistically significant for about two years after a policy shock.[22] Overall, monetary policy shocks had a significant effect on the real economy during Japan's QEP period. The left lower chart in Figure 3indicates that the responses of stock returns jump initially above the steady state, and remain persistent. This suggests that the monetary transmission via stock returns is operating to that degree. This finding is consistent with the results under the conventional monetary policy setting in Miyao (2002), and supports the arguments of the effectiveness of the unconventional monetary policy through the stock price channel by Honda, Kuroki, and Tachibana (2007). The left lower chart in Figure 3 indicates that the responses of CAB jump initially above the steady state, and then

[20] West (1993), Shioji (2000), Miyao (2002) and Braun and Shioji (2006) all study the role of Japan's monetary policy with their selected policy variable and identification framework. West (1993) adopts the nonrecursive identification framework to Japan's innovations in the money supply (M2) equation as monetary policy shocks. Shioji (2000) uses the nonrecursive identification framework with some monetary policy variables (the Bank of Japan loan and high-powered money), and concludes that a model based on the view that the central bank controls the total amount of high-powered money is better for describing Japanese monetary policy than one based on the view that it controls only a specific component of high-powered money. Miyao (2002) argues that the institutional features of the Bank of Japan's operating procedures under the conventional policy setting fit a simple recursive identification approach similar to Sims (1992) and Christiano, Eichenbaum, and Evans (1999), where disturbances in the short-term interest rate equation are viewed as the exogenous part of monetary policy and the interest rate is placed before monetary aggregates in the ordering. Braun and Shioji (2006) use the two alternative sign restrictions where a surprise tightening in monetary policy increases short-term nominal interest rate and lowers output, prices, monetary aggregates on the one hand, and a surprise tightening in monetary policy lowers short-term nominal interest rate and lowers output, prices, monetary aggregates on the other hand, and argue that under the latter assumption, monetary policy has large and persistent effects on the economy.

[21] This is also comparable with the evidence in other countries obtained by, e.g., Kim (1999), Christiano, Eichenbaum, and Evans (1999), and D'Amico and Farka (2011).

[22] The size of core CPI responses to monetary policy shocks is quite small. One possible reason is its small fluctuation during the QEP period. In fact, when we estimate the price effects of monetary policy shocks using the CGPI as a proxy of prices, the size is much larger than one using the core CPI. See the empirical results in section 5.

go back to the steady state level in 6 months. This implies that the monetary policy shocks have only transitory, not persistent, effects on the level of CABs.

Next, we measure the quantitative effects of the QEP worked through the transmission linking the stock market and the real economy. Specifically, we calculate the effects of the monetary policy shocks identified from the restricted VAR model in which we include the stock returns SR as an exogenous variable. This exercise reflects a case where stock returns do not respond to monetary policy shocks endogenously, that is, a case of the shut down of the impacts on the stock returns. Then, we compare the benchmark ones with the ones obtained from this exercise.

Figure 4 shows a comparison of the impulse responses to a one-standard-deviation monetary policy shock for different VAR specifications. The solid lines with + symbols in Figure 4 show the effects of the monetary policy shocks identified from the restricted VAR model in which stock returns are included as an exogenous variable.

As seen in left upper chart of Figure 3, the output effects disappear in the absence of the monetary policy impacts on stock prices. This implies that the stock price channel can account for a large portion of the QEP effects on output. Price responses are almost the same as the benchmark (the solid lines), which implies that the stock price channel plays limited role in terms of the QEP effects on prices.

Finally, we analyze the quantitative influences if we specify the VAR model in which we impose an assumption that the central bank does not respond to contemporaneous stock price shocks. Specifically, we compare the benchmark results with the effects of monetary policy shocks identified based on the recursive assumption, which is employed by VAR studies such as Honda, Kuroki, and Tachibana (2007). The dotted lines in Figure 4 show the effects of the policy shocks identified under the recursive assumption.

Even if we include stock returns in the VAR system as an endogenous variable, we would obtain biased estimates of the QEP effects. The left upper chart in Figure 4 indicates that the output impact of the policy shocks identified under the recursive assumption is about a half smaller than the benchmark, while the price response is almost the same as the benchmark. The stock price responses are much smaller (immediate response is about 0.03) than the benchmark (immediate response is 2.20). These results imply that, when we ignore the contemporaneous policy response to stock price shocks, we underestimate the monetary policy effects on stock returns and the real economy due to an endogenous variable bias.

4.4 Systematic unconventional monetary policy responses to a stock price shock

In this subsection, we analyze the role of the systematic policy actions in response to stock price shocks. We focus primarily on stock price shocks for two reasons. First, there is a consensus that a sharp decline of the stock prices especially in the early 2000s triggered an economic recession and deflationary pressures and thus, at least in part, systematically caused the CABs to rise. Second, we can rigorously identify stock price shocks in our econometric framework to the extent that we specify the simultaneous interaction between stock prices and policy decisions. We first estimate the impacts of the stock price shock on macroeconomic variables. Second, we illustrate what would happen if the systematic component of monetary policy were different from the actual policy.

Figure 5 displays the impulse responses for all the variables with respect to a negative-one-standard-deviation stock price shock for a period of up to 48 months, together with the 16th and 84th percentile error bands. As in Figure 3, we display the responses for SR and ΔCAB as the cumulative responses.

The results of figure 5 look reasonable, with all variables exhibiting their expected qualitative behaviors. The upper charts in Figure 3 indicate that a negative shock to stock returns is followed by a fall in output for about one year or so, despite the limited impact on the price. This implies that a sharp decline in stock prices leads to an economic recession. The right lower chart in Figure 3 indicates that a negative shock to stock prices is followed by a statistically significant rise in the CAB, as expected, and the response is permanent. This implies that the BOJ systematically accommodated a sharp decline in stock prices and eased the monetary condition permanently.

Next, we obtain a quantitative measure of the importance of the systematic component of monetary policy by comparing the historical behavior of the economy with its behavior under a hypothesized alternative policy reaction function. We employ counterfactual simulations within the VAR framework suggested by Bernanke, Gertler, and Watson (1997) and Sims and Zha (2006).[23] Specifically, as a hypothesized alternative policy reaction function, we consider a case in which the monetary authority holds ΔCAB fixed in the face of stock price shocks.

In figure 5, we also show impulse responses for a system in which the model's estimated monetary policy reaction function is replaced by one in which ΔCAB is completely unresponsive to other variables in the system (solid lines with + symbols). The difference between the total effect of a stock price shock on the system variables (the estimates under baseline model, solid lines) and the calculated effect when ΔCAB is unresponsive is then interpreted as a measure of the contribution of the endogenous policy response.[24]

As seen in Figure 5, the absence of an endogenous monetary policy results in the larger decline of the stock prices and Core CPI and more volatile output fluctuations to a negative stock return shock than the presence of an endogenous policy. This implies that, if the monetary authority reacted to a stock price shock by holding ΔCAB fixed instead of, as it did historically, expanding CAB to offset the downward pressure of the stock prices, the result would be more depressing effects of the shock on the macro economy.

The analysis also helps to reveal the BOJ's relative weight on output and inflation variability in its preferences during the QEP period. Quantitatively, a systematic monetary policy suffices to eliminate most of the price effect of a stock price shock. This suggests that the BOJ strongly focuses on inflation stabilization under the unconventional monetary policy setting, which is consistent with the findings for the monetary policy reaction function under the conventional monetary policy setting in Japan by Clarida, Gali, and Gertler (1998), Jinushi, Kuroki, and Miyao (2000), and Shibamoto (2008).[25]

[23]West (1993) also performs counterfactual simulations in a VAR context to examine the effects of systematic monetary policy under several money supply rules.

[24]In this exercise, all other equations of the system are held fixed, which implies that we are ignoring changes in the dynamics of the private sector that would occur as private agents modified their algorithms for forecasting the economy under the new policy. That is, we are ignoring the Lucas critique. We think that this is nonetheless an interesting exercise, for practical purposes probably even more interesting than an exercise that takes into account the Lucas critique via the unreasonable assumption that the policy change is immediately and fully understood and that the public has no doubt that it is permanent.

[25]Clarida, Gali, and Gertler (1998), Jinushi, Kuroki, and Miyao (2000), and Shibamoto (2008) estimate the Taylor (1993) type monetary policy reaction function, where the behavior of an overnight call market interest rate as a monetary policy instrument depends on the (expected) output gaps and (expected future) inflation, and report that the BOJ has placed somewhat more weight on controlling inflation relative to output

5 Empirical Results from Alternative Specifications

Because any empirical analysis might have some tentativeness, it is important to examine several alternative frameworks and check robustness in some detail. In this section we report on several robustness checks carried out in order to evaluate the sensitivity of the empirical results reported in the previous section.

We re-estimated the instantaneous impacts of monetary policy on stock returns α to examine the robustness of the estimates using the high-frequency model. Specifically, we consider two alternative specifications for the high-frequency model; (i) we allow for lags in equations (3) and (4) and perform the same analysis on the reduced-form residuals; (ii) we follow Wright (2012) and estimate the effects of monetary policy shocks on stock returns and the CABs by using the daily VAR model consisting of the CABs, stock return, and differences between long-term and short-term interest rates which reflects, to some extent, the expectation of the future monetary policy stance. These results are nearly identical, and hence we do not report them.

Next, we re-estimated the dynamic effects of monetary policy and stock price shocks to check the robustness of the benchmark results using the VAR model. We modify the benchmark VAR specification to take into account four dimensions: (i) the choice of the measures of output and price levels; (ii) the influences of the presence of alternative contributors to the real economy; (ii) the possibility that identified monetary policy shocks are contaminated by a sudden rise in the CABs due to the liquidity demand of financial institutions; (iv) the possibility of the misspecification of the benchmark model due to the unit root process of output and prices.

Tables 5 and 6 report some summary from alternative specifications of our VAR system. Specification [1] of tables 5 and 6 report results for the composite index of coincident economic indicators (CI) as a proxy of output, whereas specification [2] report results for corporate goods price index (CGPI) as a proxy of price level. Specification [3] reports results from the model in which we include the dummy variables as exogenous variables that take values of one from May 2003 onward where we check whether our benchmark results are influenced by other

stabilization.

macroeconomic factors including, for example, the improvement of the financial condition and the resolution of the non-performing loan problems following the nationalization of the Resona Bank. Specification [4] reports results from the VAR model in which we include the commodity price index as an endogenous variable, where we follow Sims (1992) and Christiano, Eichenbaum, and Evans (1999) and include information about future inflation that was available to the BOJ. Specification [5] and [6] report results from the VAR model in which we include the export volume as an endogenous variable and 1 to 4 lags of the IIP in the US as an exogenous variable, respectively, where we control the exogenous increases in the values of exports due to strong overseas economic performance. Specification [7] reports results from the model in which we include the dummy variables as exogenous variables that take values of one on March and September every year when the BOJ deemed that financial institutions faced a shortage of liquidity. Specification [8] reports results from the model with the first log difference of IIP and Core CPI. Values in bold indicate the point estimates significantly different from zero based on the bootstrapped confidence intervals in the same manner as figures 3 and 5. Table 5 also shows the differences between the baseline specification and the results obtained from the VAR model in which stock returns are included as an exogenous variable, whereas Table 6 shows the differences between the baseline specification and the results obtained under the hypothesized policy reaction, in which the CAB is fixed at its baseline value. Values in bold indicate that the confidence interval for the baseline specification do not contain the effects obtained under the restricted VAR model in which SR is included as an exogenous variable in Table 5 and the counterfactual assumption in which the CAB is held fixed in Table 6.

The point estimates reported in table 5 are consistent with the findings discussed in figures 3 and 4. In particular, the baseline estimates show that a monetary policy shock raises output, price level, and stock prices, by magnitudes that are reasonably comparable across all specifications. The differences in output effects are significantly positive in all cases, which implies the output effects of monetary policy shocks in the baseline are much larger than in the case of a shut down of the impacts on the stock returns, whereas the differences in price effects of monetary policy shocks are quite small. Again, as reported in Table 6, we see quantitatively similar results as the findings discussed in figure 5. These results suggest that our benchmark model adequately captures the important features regarding the effects of the unconventional monetary policy on the macro economy during Japan's QEP period.

We note some additional findings from alternative specifications. First, there are large differences in the price effects between core CPI and CGPI. Specification [2] in Table 5 indicates that the size of CGPI responses are significantly larger than that of the core CPI in the benchmark. Specification [3] in Table 5 also indicates that the size of ComP responses are significantly larger than that of the core CPI. This suggests that the QEP had a stronger impact on raw material, primary and intermediate goods prices than on final goods prices. Second, as shown in Specification [5], expanding monetary policy shocks lead to a statistically significant rise in exports, which suggests that the QEP promoted exports. Third, with first differences specification in Specification [8], the estimated impulse responses of output and prices to monetary policy and stock price shocks are long-lasting.[26] One reason is that we might not impose possible co-integrated relations in our VAR system, which means that it may not be a stationary VAR system. Therefore, it is desirable to estimate the benchmark VAR model including output and prices in levels.[27]

6 Discussion

In this section, we discuss some implications from our analysis and the differences between our findings and those of previous literature. Our analysis has several novel features that can differentiate this study from the existing literature. First, we distinguish between the effects of exogenous shocks to the CABs and systematic endogenous policy responses. Second, we explicitly measure the monetary transmission effects linking the stock market and the real economy within the VAR framework. Third, we focus on the role of the CABs as a measure of the overall stance of unconventional monetary policy during the QEP period in Japan. We

[26] Miyao (2002) estimates the VAR consisting of call rate, monetary base, stock prices, and output in Japan, all in first differences, and reports that the estimated responses of output to monetary policy shocks do not die out toward zero.

[27] Sims, Stock, and Watson (1990) show that the estimated coefficients of a VAR in levels are consistent and the distribution of individual estimated parameters is asymptotically normal even when variables have unit roots and there are some variables that form co-integration relationships.

conduct the discussion along the lines of these features.

There are the policy-induced changes identified as monetary policy shocks and systematic policy changes along with the monetary policy reaction function behind the total changes in CABs. Our results show that the policy-induced changes identified as monetary policy shocks result in a temporal rise in CABs, whereas systematic policy changes in response to stock price shocks result in a permanent rise in CABs. This implies that a substantial part of the observed increase in CABs reflects systematic policy movements in response to negative shocks hitting the Japanese economy in the early 2000s when there was a massive and gradual rise in CABs as explained in section 2.1.

The fact that there was a strong negative correlation between macroeconomic and stock price variables and CABs in the early phase of the QEP as shown in subsection 2.2 does not mean the QEPs were ineffective on the real economy. Our counterfactual simulations in subsection 4.4 suggest that the BOJ avoided a more serious economic recession by systematically accommodating the financial condition more than we observed in the early 2000s.

However, this do not imply that systematic monetary policy actions reverse the expectations of low economic growth and deflation. Okina and Shiratsuka (2004) and Oda and Ueda (2007) find that the accommodative monetary policy actions during the QEP period resulted in reducing longer-term interest rates and flattening the yield curve by the monetary policy effect, but that it failed to reverse deflationary expectations in financial markets. They argue that this is because the transmission channel linking the financial and non-financial sectors remained blocked. In contrast, we argue that this reflects that a substantial part of the massive increase in the CABs was mainly due to systematic policy responses which stimulate no additional aggregate demand, whereas the QEP through its transmission linking the stock market and the real economy reported in subsection 4.3 is still effective on the real economy even under the decline of the financial intermediary functions of banks burdened by nonperforming loans and corporate balance sheet adjustments.

If we ignored the existence of the stock price channel, we would reach a different conclusion regarding the QEP's effects on the real economy. In contrast with our findings, a large volume of the previous literature, such as Kimura, Kobayashi, Muranaga, and Ugai (2003), Fujiwara

(2006), and Nakajima, Kasuya, and Watanabe (2011), provides empirical results showing that their identified monetary policy shocks have limited impacts on stimulating economic activity. However, these studies do not explicitly take into account the transmission linking stock market responses and the real economy. In fact, as shown in subsection 4.3, a large portion of the QEP effect on output is due to its transmission.

Finally, we should emphasize that our analysis focuses on the total effect of unconventional monetary policy on the stock market and the real economy during the QEP period. In contrast with our findings, Gambacorta, Hofmann, and Peersman (2012) report the empirical results that the output responses to Japan's expanding monetary base shocks after the collapse of Lehman Brothers in September 2008 are hardly statistically different from zero. However, monetary base shocks might not be interpreted as unconventional monetary policy shocks. In fact, the BOJ did not adopt the CABs as its operating target but implemented a policy combining the unconventional monetary policy tools, that is, commitment to future policy stance, quantitative easing, and credit easing, in response to the world financial crisis. The difference between the findings in ours and Gambacorta, Hofmann, and Peersman (2012) might mean that the effects of providing ample liquidity to realize the target level of the CABs in excess of the required reserves play a limited role on the real economy.

7 Conclusion

This paper has attempted to assess the effectiveness of unconventional monetary policy on the macro economy. We have focused on the characteristics of the BOJ's QEP, and have argued that the CABs held at the BOJ serve as a measure of the overall stance of unconventional monetary policy during that period. We have also proposed a plausible empirical framework to examine the effects of monetary policy and stock price shocks. Our results using daily data have indicated that we should take into account the interdependence between stock market and monetary policy to isolate the financial market responses to monetary policy and the monetary policy reaction to financial markets. Using a structural VAR model with simultaneous interaction between stock prices and policy decisions, we have obtained reasonably precise impulse response results to monetary policy and stock price shocks during Japan's

QEP period. The main finding is that unconventional monetary policy during Japan's QEP period had a significant effect on the real economy, which is closely in line with the existing evidence under the conventional monetary policy setting. The output effects work through the transmission linking the stock market and the real economy, while it plays a limited role in terms of the price effects. Our analysis also suggests that the BOJ's systematic policy responses mitigate severe downward pressure on the real economy generated by the stock market.

The analysis in this paper does not explicitly assess the effectiveness of different types of unconventional monetary policy tools. We focus on assessing the total effect of unconventional monetary policy in a similar way as previous VAR studies that examine the effects of conventional monetary policy. However, the BOJ could impact the financial market and the real economy through the expansion of the size of the BOJ's balance sheet and also in other ways, such as by changing expectations for the future path of the policy interest rate and the composition of the balance sheet. The effectiveness of monetary transmission on the real economy might depend on the differences among unconventional monetary policy tools. Addressing this issue is beyond the scope of this paper, but is worthy of future research.

Data Appendix

This Appendix describes the data series used in this paper. All data are from the NIKKEI NEEDS-Financial Quest by Nikkei Media Marketing.

Daily series

The basic stance of monetary policy is decided by the Policy Board at the MPMs. At the MPMs, the Policy Board discusses the economic and financial situation, decides the guidelines for money market operations and the Bank's monetary policy stance for the immediate future, and announces decisions immediately after the meeting concerned. Based on the guidelines, the Bank sets the amount of daily money market operations and chooses the types of operational instruments, and provides and absorbs funds in the market.

We define the policy date as the day when the BOJ announces the policy decision after the

MPMs. The target level of the CABs is publicly announced immediately after every MPM day. We naturally think that the policy announcement affects the financial markets later in the day. However, on 19 March 2001 and 18 September 2001, the MPMs ended at 17:27 and 18:48, respectively, by which time the Tokyo Stock Exchange market had already closed. So, we set the next trading day as the policy date.

Our full sample is from March 19, 2001 to March 9, 2006–the QEP period. Our sample includes 80 policy dates. Non-policy dates are taken to be the day before each policy date.

Stock Price (1)	Nikkei 225 stock average, closing price, yen.
Stock Price (2)	Tokyo stock price index, closing price, 4 January 1968= 100.
CABs	Current account balances, closing price, yen.
Spread	Spread between the long-term yields of government bonds (10 years) and tokyo interbank offered rate (3 months).

Monthly series

We use monthly observations for the period between March 2001 and March 2006.

Call Rate	Uncollateralized overnight call market rate, monthly average, percent
IIP	Index of industrial production, seasonally adjusted series, 2005 average = 100.
Core CPI	Consumer price index, excluding fresh foods, seasonally adjusted series, 2005 average = 100.
Stock Price (1)	Nikkei 225 stock average, end of month, yen.
Stock Price (2)	Tokyo stock price index, end of month, 4 January 1968= 100.
CABs	Current account balances, end of month, yen.
EX	Export volume, seasonally adjusted series, yen.
CI	Composite Index of Coincident Economic Indicators, 2005 average = 100.
CGPI	Domestic Corporate Goods Price Index, the average price level for a fixed basket of capital and consumer goods paid by producers, 2005 average = 100.
comP	Nikkei commodity price index (42 items), 1970 average = 100.
USIIP	U.S. industrial production index, seasonally adjusted series, 2005 average = 100

References

Baumeister, C., and L. Benati (2012): “Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound,” *Bank of Canada Working Papers*, (12-21).

Bernanke, B. S. (2009): “The Crisis and the Policy Response,” A Speech at the Stamp Lecture, London School of Economics, London, England.

Bernanke, B. S., M. Gertler, and M. W. Watson (1997): “Systematic Monetary Policy and the Effects of Oil Price Shocks,” *Brookings Papers on Economic Activity*, pp. 91–142.

Bernanke, B. S., and V. R. Reinhart (2004): “Conducting Monetary Policy at Very Low Short-Term Interest Rates,” *American Economic Review*, 94(2), 85–90.

Bernanke, B. S., V. R. Reinhart, and B. P. Sack (2004): “Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment,” *Brookings Papers on Economic Activity*, 35(2), 1–100.

Bjørnland, H. C., and K. Leitemo (2009): “Identifying the Interdependence between US Monetary Policy and the Stock Market,” *Journal of Monetary Economics*, 56(2), 275–282.

Braun, R. A., and E. Shioji (2006): “Monetary Policy and the Term Structure of Interest Rates in Japan,” *Journal of Money, Credit and Banking*, 38(1), 141–162.

Chen, H., V. Curdia, and A. Ferrero (2012): “The Macroeconomic Effects of Large-Scale Asset Purchase Programmes,” *Economic Journal*, 122(564), F289–F315.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (1999): “Monetary Policy Shocks: What Have We Learned and to What End?,” in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, vol. 1, pp. 65–148. North-Holland, Amsterdam.

Chung, H., J.-P. Laforte, D. Reifschneider, and J. C. Williams (2012): “Have We Underestimated the Likelihood and Severity of Zero Lower Bound Events?,” *Journal of Money, Credit and Banking*, 44, 47–82.

Clarida, R., J. Gali, and M. Gertler (1998): “Monetary Policy Rules in Practice Some International Evidence,” *European Economic Review*, 42(6), 1033–1067.

Cochrane, J. H., and M. Piazzesi (2002): “The Fed and Interest Rates - A High-Frequency Identification,” *American Economic Review*, 92(2), 90–95.

D’Amico, S., and M. Farka (2011): “The Fed and the Stock Market: An Identification Based on Intraday Futures Data,” *Journal of Business and Economic Statistics*, 29(1), 126–137.

D’Amico, S., and T. B. King (2013): “Flow and Stock Effects of Large-Scale Treasury Purchases: Evidence on the Importance of Local Supply,” *Journal of Financial Economics*, forthcoming.

Faust, J., E. T. Swanson, and J. H. Wright (2004): “Identifying VARs Based on High Frequency Futures Data,” *Journal of Monetary Economics*, 51(6), 1107–1131.

Fujiwara, I. (2006): “Evaluating Monetary Policy When Nominal Interest Rates Are Almost Zero,” *Journal of the Japanese and International Economies*, 20(3), 434–453.

Gagnon, J., M. Raskin, J. Remache, and B. Sack (2011): “The Financial Market Effects of the Federal Reserve’s Large-Scale Asset Purchases,” *International Journal of Central Banking*, 7(1), 3–43.

Gambacorta, L., B. Hofmann, and G. Peersman (2012): “The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis,” *BIS Working Papers*, (384).

Hausman, J. A. (1978): “Specification Tests in Econometrics,” *Econometrica*, 46(6), 1251–71.

Honda, Y., Y. Kuroki, and M. Tachibana (2007): “An Injection of Base Money at Zero Interest Rates: Empirical Evidence from the Japanese Experience 2001-2006,” Discussion Papers in Economics and Business 07-08, Osaka University, Graduate School of Economics and Osaka School of International Public Policy (OSIPP).

Jinushi, T., Y. Kuroki, and R. Miyao (2000): "Monetary Policy in Japan Since the Late 1980s: Delayed Policy Actions and Some Explanations," in *Japan's Financial Crisis and Its Parallels to U.S. Experience*, ed. by R. Mikitani, and A. Posen. Institute for International Economics, Washington D.C.

Joyce, M. A. S., A. Lasaosa, I. Stevens, and M. Tong (2011): "The Financial Market Impact of Quantitative Easing in the United Kingdom," *International Journal of Central Banking*, 7(3), 113–161.

Kapetanios, G., H. Mumtaz, I. Stevens, and K. Theodoridis (2012): "Assessing the Economy-Wide Effects of Quantitative Easing," *Economic Journal*, 122(564), F316–F347.

Kilian, L. (1998): "Small-Sample Confidence Intervals For Impulse Response Functions," *Review of Economics and Statistics*, 80(2), 218–230.

Kim, S. (1999): "Do Monetary Policy Shocks Matter in the G-7 Countries? Using Common Identifying Assumptions about Monetary Policy across Countries," *Journal of International Economics*, 48(2), 387–412.

Kimura, T., H. Kobayashi, J. Muranaga, and H. Ugai (2003): "The Effect of the Increase in the Monetary Base of Japan's Economy at Zero Interest Rates: An Empirical Analysis," in *Monetary Policy in a Changing Environment*, pp. 276–312. Bank for International Settlements, Basle.

Krishnamurthy, A., and A. Vissing-Jorgensen (2011): "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy," *Brookings Papers on Economic Activity*, 43(2), 215–287.

Kuttner, K. N. (2001): "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market," *Journal of Monetary Economics*, 47(3), 523–544.

Miyao, R. (2002): "The Effects of Monetary Policy in Japan," *Journal of Money, Credit, and Banking*, 34(2), 376–392.

Nakajima, J., M. Kasuya, and T. Watanabe (2011): "Bayesian Analysis of Time-Varying Parameter Vector Autoregressive Model for the Japanese Economy and Monetary Policy," *Journal of the Japanese and International Economies*, 25(3), 225–245.

Oda, N., and K. Ueda (2007): "The Effects of The Bank of Japan's Zero Interest Rate Commitment and Quantitative Monetary Easing on the Yield Curve: A Macro-Finance Approach," *Japanese Economic Review*, 58(3), 303–328.

Okina, K., and S. Shiratsuka (2004): "Policy Commitment and Expectation Formation: Japan's Experience under Zero Interest Rates," *The North American Journal of Economics and Finance*, 15(1), 75–100.

Rigobon, R., and B. Sack (2003): "Measuring the Reaction of Monetary Policy to the Stock Market," *Quarterly Journal of Economics*, 118(2), 639–669.

——— (2004): "The Impact of Monetary Policy on Asset Prices," *Journal of Monetary Economics*, 51(8), 1553–1575.

Shibamoto, M. (2008): "The Estimation of Monetary Policy Reaction Function in a Data-Rich Environment: The Case of Japan," *Japan and the World Economy*, 20(4), 497–520.

Shioji, E. (2000): "Identifying Monetary Policy Shocks in Japan," *Journal of the Japanese and International Economies*, 14(1), 22–42.

Shirakawa, M. (2010): "Uniqueness or Similarity?–Japan's Post-Bubble Experience in Monetary Policy Studies–," Keynote Address at Second IJCB Fall Conference entitled "Monetary Policy Lessons from the Global Crisis" hosted by the Institute for Monetary and Economic Studies.

Shiratsuka, S. (2010): "Size and Composition of the Central Bank Balance Sheet: Revisiting Japan's Experience of the Quantitative Easing Policy," *Monetary and Economic Studies*, 28, 79–106.

Sims, C. A. (1980): "Macroeconomics and Reality," *Econometrica*, 48(1), 1–48.

——— (1992): "Interpreting the Macroeconomic Time Series Facts : The Effects of Monetary Policy," *European Economic Review*, 36(5), 975–1000.

Sims, C. A., J. H. Stock, and M. W. Watson (1990): "Inference in Linear Time Series Models with Some Unit Roots," *Econometrica*, 58(1), 113–44.

Sims, C. A., and T. Zha (2006): "Does Monetary Policy Generate Recessions?," *Macroeconomic Dynamics*, 10(02), 231–272.

Taylor, J. B. (1993): "Discretion Versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.

Trichet, J.-C. (2009): "The ECB's Enhanced Credit Support," Keynote address at the University of Munich.

Ueda, K. (2012): "The Effectiveness of Non-Traditional Monetary Policy Measures: The Case of the Bank of Japan," *Japanese Economic Review*, 63(1), 1–22.

Ugai, H. (2007): "Effects of the Quantitative Easing Policy: A Survey of Empirical Analyses," *Monetary and Economic Studies*, 25(1), 1–48.

West, K. D. (1993): "An Aggregate Demand-Aggregate Supply Analysis of Japanese Monetary Policy, 1973–1990," in *Japanese Monetary Policy*, ed. by K. J. Singleton, pp. 161–189.

Wright, J. H. (2012): "What does Monetary Policy do to Long-Term Interest Rates at the Zero Lower Bound?," *Economic Journal*, 122(564), F447–F466.

Table 1: Policy changes during the QEP period

Date	CAB target
March 19, 2001	¥5 trillion
August 14, 2001	¥6 trillion
September 18, 2001	above ¥6 trillion
December 19, 2001	¥10–15 trillion
October 30, 2002	¥15–20 trillion
March 5, 2003	¥17–22 trillion
April 30, 2003	¥22–27 trillion
May 20, 2003	¥27–30 trillion
October 10, 2003	¥27–32 trillion
January 20, 2004	¥30–35 trillion
March 9, 2006	Termination of the QEP

Table 2: Standard deviations and covariances on full samples, non-policy and policy dates

	Std. dev. of asset prices			Covar. with CAB		
	Full	NPD	PD	Full	NPD	PD
CAB	4.044	3.497	5.238	1	1	1
Nikkei225	1.440	1.621	1.517	0.101	0.771	3.537
TOPIX	1.243	1.289	1.299	0.089	0.268	3.103

Notes: The table uses 100 times daily log differences for CAB and stock prices.

Table 3: Estimates of the instantaneous effects of monetary policy on stock returns from one-day changes in CAB and stock prices.

	Nikkei225		TOPIX	
	Estimate	S.E	Estimate	S.E
$\hat{\alpha}_{het}$	0.162	(0.052)	0.161	(0.048)
$\hat{\alpha}_{OLS}$	0.006	(0.010)	0.006	(0.009)
	Stat.	p-value	Stat.	p-value
Test of O.I. rest	1.260	[0.262]	1.057	[0.304]
Hausman type Test	6.235	[0.012]	10.623	[0.001]

Table 4: The contemporaneous reaction of monetary policy to stock returns

	Nikkei 225		TOPIX	
	Estimate	S.E	Estimate	S.E
$\hat{\beta}$	-2.777	(0.942)	-3.668	(1.240)

Table 5: Dynamic responses to monetary policy shocks: Benchmark and alternative specifications

Specification	Output		Price		SR		ΔCAB		ComP		EX	
Steps (in months)	6	12	6	12	0	12	0	12	6	12	6	12
Benchmark	**0.452**	0.047	**0.028**	**0.019**	**2.197**	**3.967**	**13.561**	0.121				
Difference	**0.491**	**0.147**	0.010	0.006			**-1.960**	**-8.759**				
[1]	**0.377**	0.064	**0.024**	**0.015**	**2.166**	**3.443**	**13.369**	1.178				
Difference	**0.489**	**0.200**	0.009	0.004			**-2.322**	**-8.447**				
[2]	**0.618**	**0.179**	**0.113**	**0.121**	**2.253**	**4.749**	**13.910**	0.307				
Difference	**0.599**	**0.142**	0.130	0.131			**-1.535**	**-8.447**				
[3]	**0.314**	-0.021	**0.031**	**0.021**	**2.160**	**3.009**	**13.334**	1.655				
Difference	**0.378**	0.058	0.013	0.008			**-2.184**	**-7.248**				
[4]	**0.499**	0.073	**0.026**	0.017	**2.179**	**4.190**	**13.454**	-0.691	**0.446**	0.300		
Difference	**0.491**	0.103	0.009	0.011			**-2.273**	**-9.019**	0.222	0.278		
[5]	**0.466**	0.037	**0.034**	0.016	**2.085**	**3.380**	**12.869**	1.442			**0.665**	-0.098
Difference	**0.436**	-0.001	0.018	0.007			**-1.771**	**-6.096**			**0.682**	-0.076
[6]	**0.392**	0.029	**0.032**	**0.028**	**2.164**	**3.318**	**13.357**	0.428				
Difference	**0.377**	0.073	0.019	**0.022**			**-1.941**	**-7.379**				
[7]	**0.381**	0.021	**0.026**	**0.016**	**1.779**	**3.243**	**10.983**	0.068				
Difference	**0.413**	0.109	0.009	0.004			**-0.934**	**-7.483**				
[8]	**0.403**	**0.437**	**0.018**	**0.020**	**2.240**	**4.136**	**13.827**	**4.206**				
Difference	**0.307**	**0.342**	0.008	0.010			-2.595	**-5.163**				

Notes: For benchmark and eight different specifications (see text), the table shows the point estimates of impulse responses in 6 and 12 months for output, prices, comP, and EX, and in 0 and 12 months for SR and ΔCABs (cumulative responses) resulting from a one-standard-deviation monetary policy shock. Values in bold indicate the point estimates significantly different from zero based on the bootstrapped confidence intervals. Also shown are the differences in output, prices, ΔCABs, comP, and EX effects from the restricted VAR model in which stock returns are includeds as an exogeneous variable. Values in bold indicate that the confidence interval for the baseline specification do not contain the effects obtained under the restricted VAR model.

Table 6: Dynamic responses to stock price shocks: Benchmark and alternative specifications

Specification	Output		Price		SR		ΔCAB		ComP		EX	
Steps (in months)	6	12	6	12	0	12	0	12	6	12	6	12
Benchmark	**-0.303**	-0.116	0.008	0.006	**-4.529**	**-3.329**	**6.479**	**9.049**				
Difference	**0.363**	**0.263**	**0.040**	**0.053**	**1.050**	**6.194**						
[1]	**-0.389**	**-0.164**	0.006	0.007	**-4.422**	**-3.087**	**7.091**	**9.859**				
Difference	**0.302**	0.204	**0.035**	**0.041**	**1.149**	**4.985**						
[2]	**-0.361**	-0.004	**-0.099**	**-0.076**	**-4.765**	**-3.590**	**4.974**	**8.849**				
Difference	**0.402**	**0.509**	0.054	**0.139**	**0.806**	**6.058**						
[3]	**-0.237**	-0.067	0.007	0.005	**-4.388**	**-2.561**	**6.812**	**8.200**				
Difference	**0.264**	0.053	**0.046**	**0.047**	**1.104**	**3.881**						
[4]	**-0.322**	-0.123	0.010	-0.001	**-4.747**	**-3.548**	**6.402**	**10.171**	-0.126	-0.261		
Difference	**0.506**	**0.436**	**0.046**	**0.061**	**1.037**	**8.075**			**0.703**	**0.905**		
[5]	**-0.220**	-0.013	0.000	-0.002	**-4.451**	**-3.404**	**6.323**	**8.331**			-0.138	0.029
Difference	**0.359**	**0.312**	**0.042**	**0.043**	**1.024**	**5.213**					**0.592**	0.323
[6]	-0.201	-0.042	-0.002	-0.008	**-4.228**	**-2.525**	**6.663**	**8.233**				
Difference	**0.355**	**0.225**	**0.040**	**0.055**	**1.079**	**5.227**						
[7]	**-0.360**	-0.107	0.002	0.003	**-4.708**	**-3.790**	**4.150**	**8.573**				
Difference	**0.287**	**0.261**	**0.034**	**0.050**	**0.672**	**5.454**						
[8]	**-0.382**	**-0.416**	-0.008	-0.009	**-4.453**	**-5.373**	**7.723**	**8.995**				
Difference	**0.326**	**0.403**	**0.018**	**0.022**	**1.251**	**3.355**						

Notes: For benchmark and eight different specifications (see text), the table shows the point estimates of impulse responses in 6 and 12 months for output, prices, comP, and EX, and in 0 and 12 months for SR and ΔCABs (cumulative responses) resulting from a one-standard-deviation stock price shock. Values in bold indicate the point estimates significantly different from zero based on the bootstrapped confidence intervals. Also shown are the differences in output, prices, SR, comP, and EX effects from the counterfactual simulation under the hypothesized policy reaction, in which the CAB is fixed. Values in bold indicate that the confidence interval for the baseline specification do not contain the effects obtained from the counterfactual simulation.

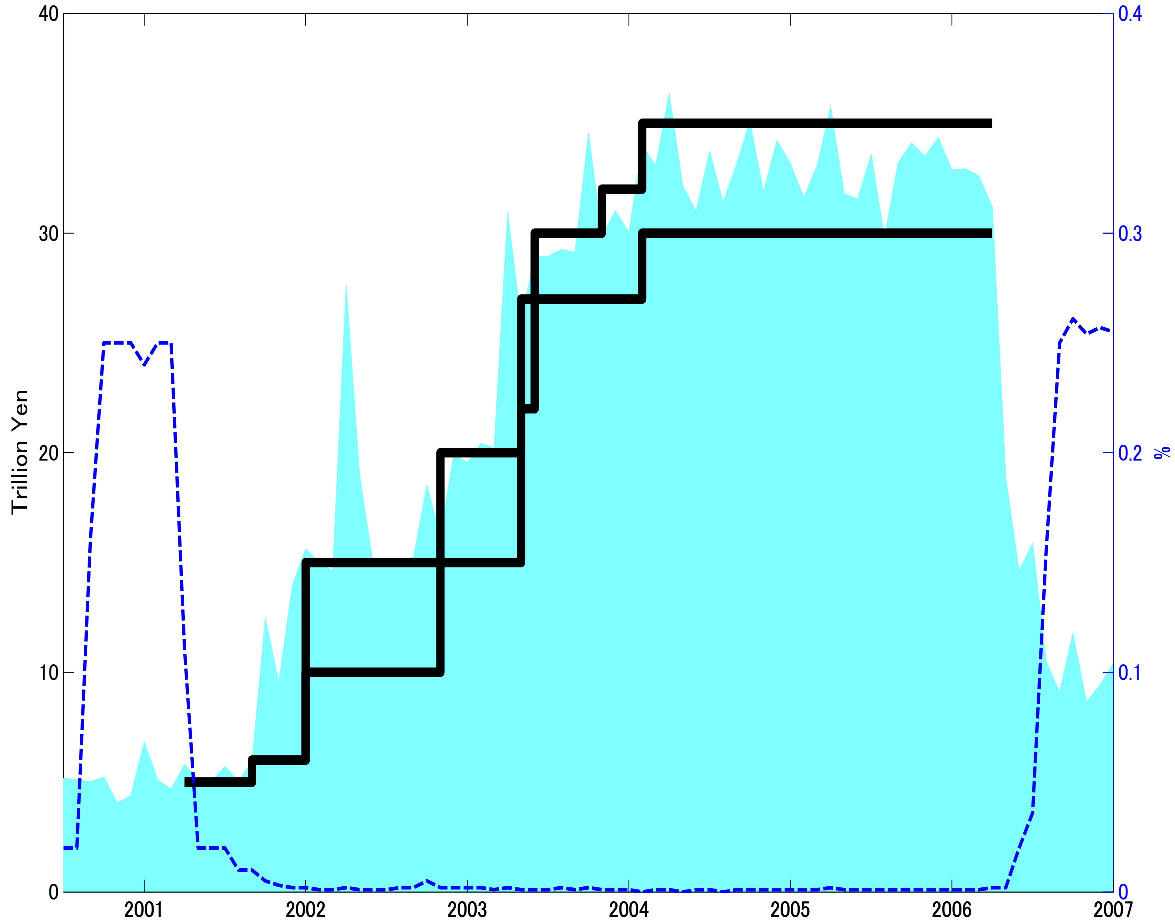

Figure 1: The actual amount and policy target of CABs and the actual level of overnight call rate

Note: The shade areas represent the actual amount of the CABs (left axis). The bold lines indicate the CAB targets during the QEP period (left axis). The dotted lines represent the actual level of the uncollateralized overnight call market interest rate (right axis).

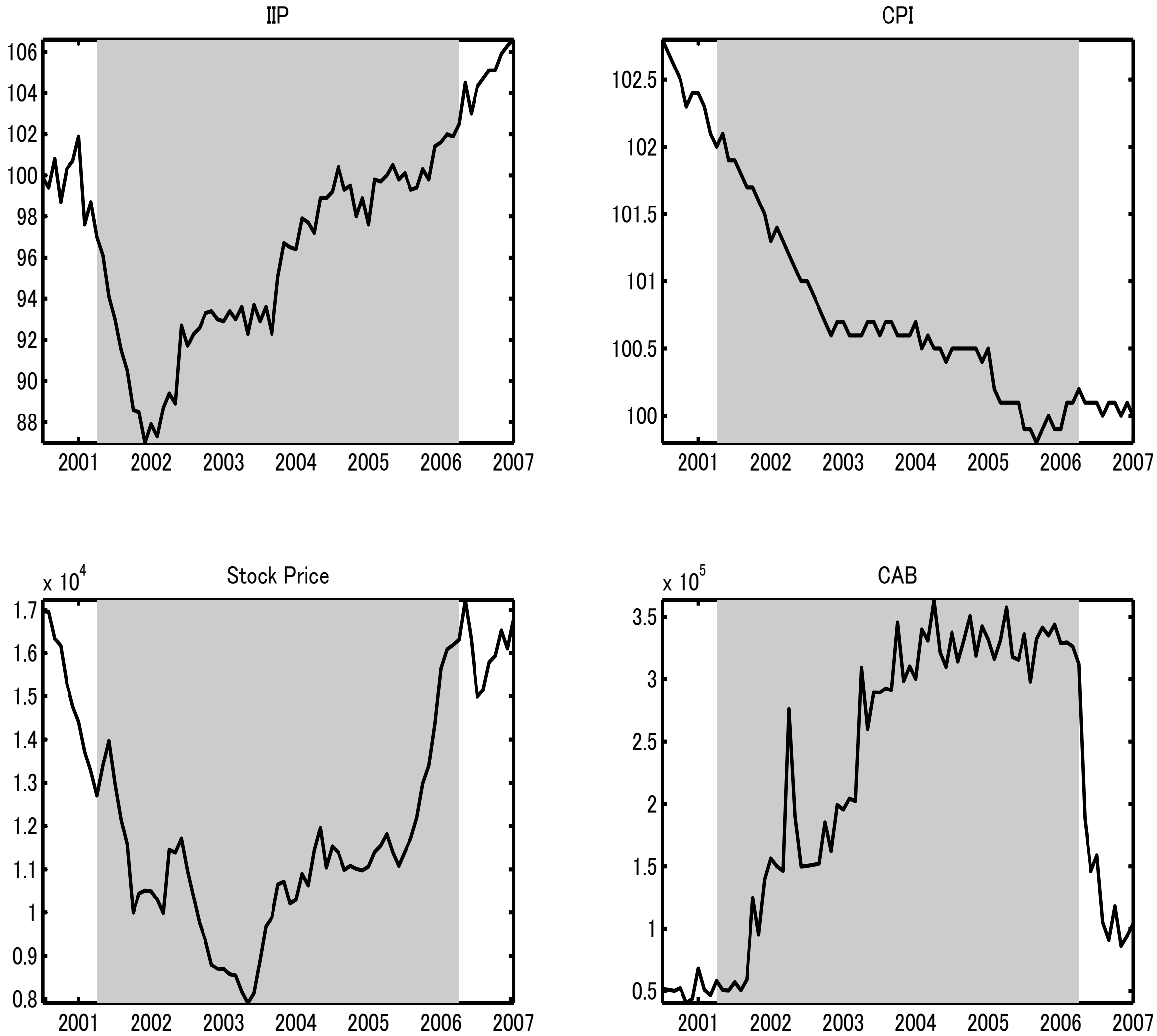

Figure 2: Macroeconomic conditions, stock market and monetary policy

Note: The shade areas indicate the QEP period.

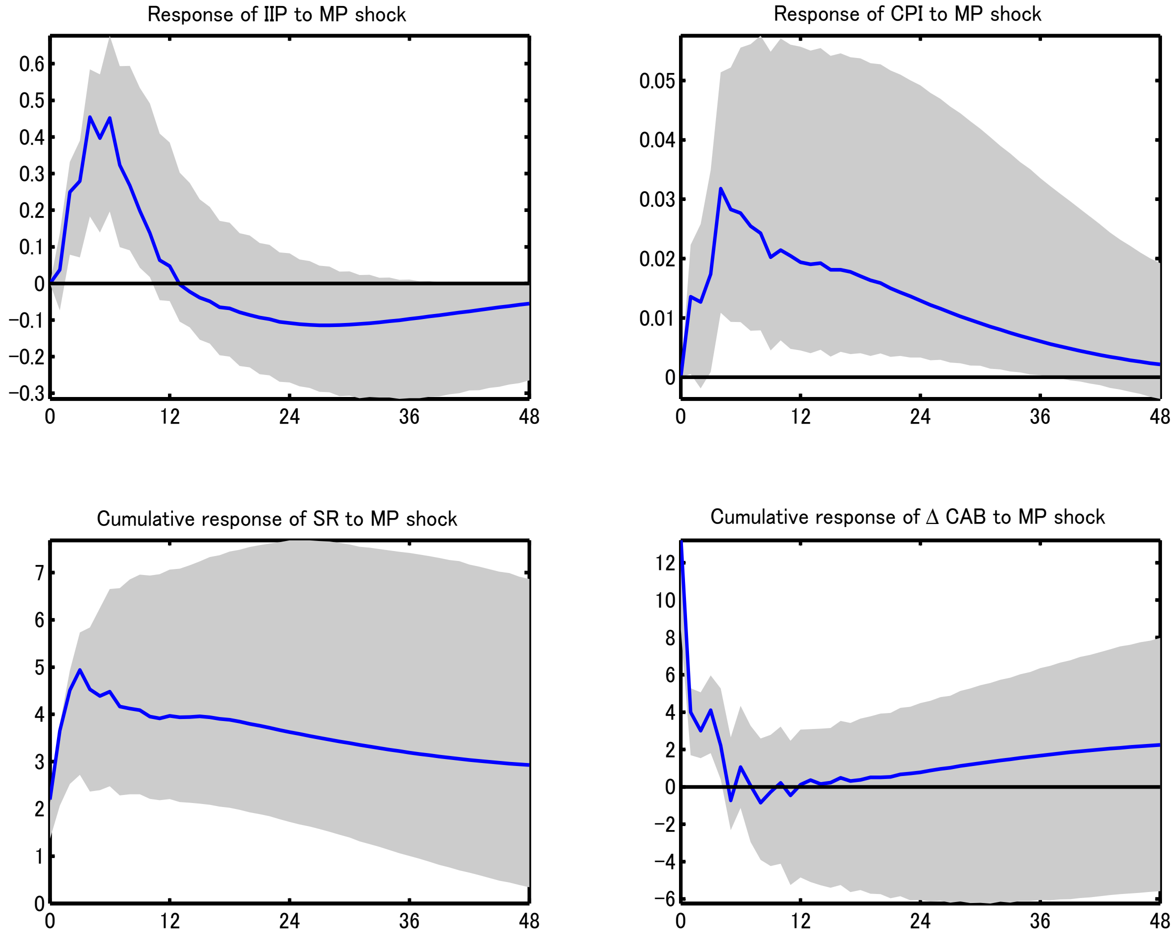

Figure 3: Impulse responses to a monetary policy shock

Note: The solid lines represent the point estimates of the impulse responses to a monetary policy shock in the baseline VAR model. The shaded areas represent 16th and 84th percentile error bands calculated by the bias-adjusted bootstrap method with 10000 replications.

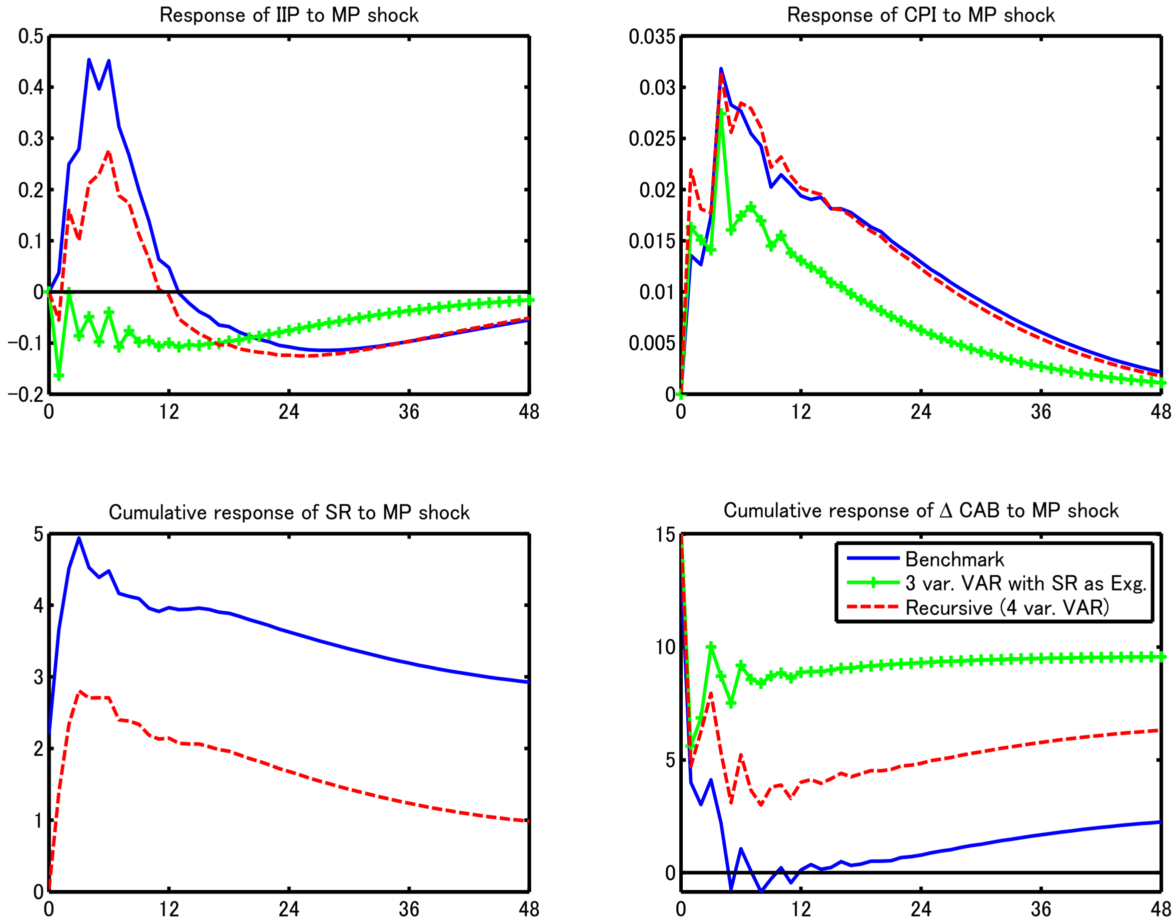

Figure 4: Impulse responses comparison

Notes: The solid lines represent the point estimates of the impulse responses to a monetary policy shock in the baseline VAR model. The solid lines with + symbols represent the effects of the monetary policy shocks identified from the restricted VAR model in which stock returns are included as an exogenous variable. The dotted lines represent the effects of the policy shocks identified from the restricted VAR model under the recursive assumption.

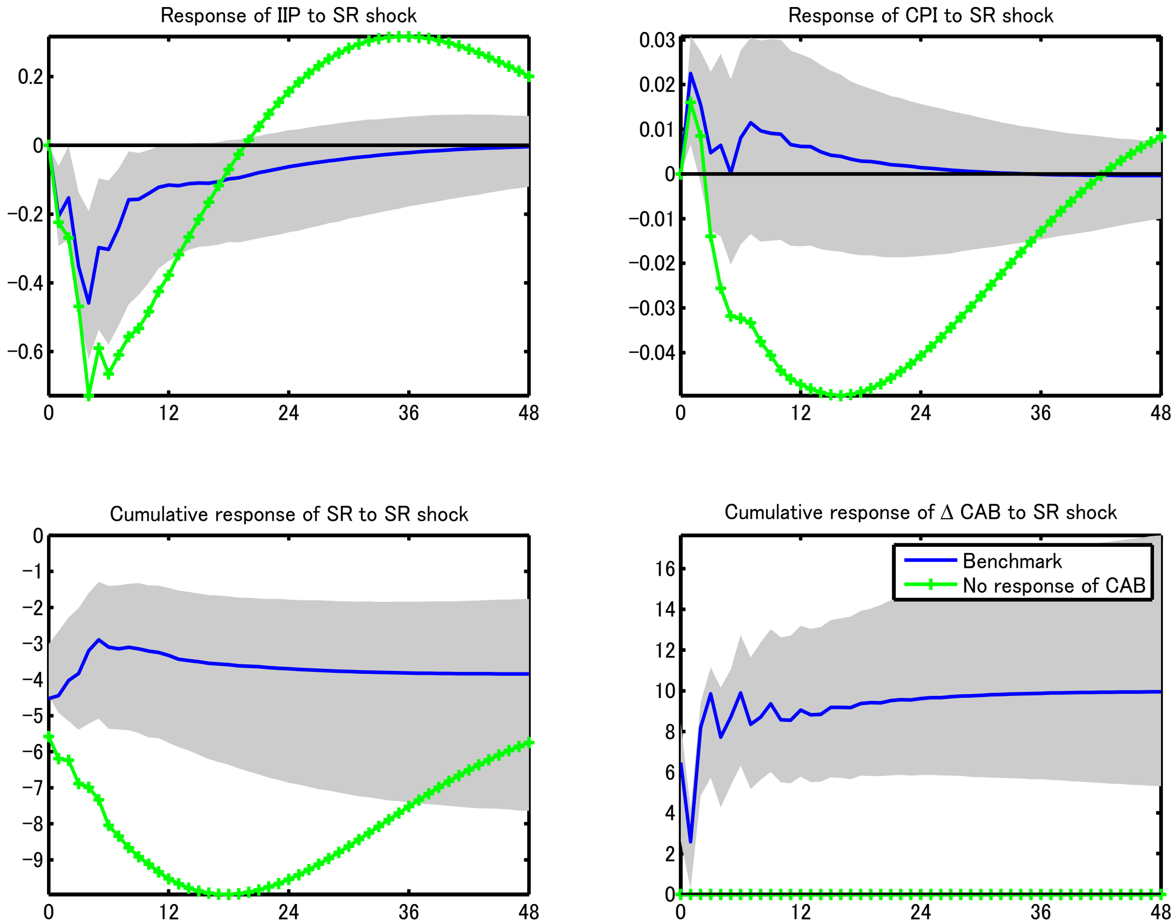

Figure 5: Impulse responses to a stock price shock: baseline and no policy response

Note: The solid lines represent the point estimates of the impulse responses to a negative-one-standard-deviation stock price shock in the baseline VAR model. The shaded areas represent 16th and 84th percentile error bands calculated by the bias-adjusted bootstrap method with 10000 replications. The solid lines with + symbols represent the impulse responses for a system in which the model's estimated monetary policy reaction function is replaced by one in which ΔCAB is completely unresponsive to other variables in the system.