Searching for the Effects of Unconventional Monetary Policy: The Case of the Bank of Japan

Yosuke Takeda
Sophia University
7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan
y-takeda@sophia.ac.jp

Yasuhide Yajima
NLI Research Institute
4-1-7 Kudankita, Chiyoda-ku Tokyo 102-0073, Japan

ABSTRACT

Despite numerous researches on the macroeconomic effects of unconventional monetary policy measures, as surveyed for example by Kozicki, et al. (2011) and Williams (2011), the empirical effectiveness is still unconvincing. Instead of an event-study method most of the previous studies took, we apply a simple time-series methodology of a Tobit or censored normal regression model. To capture the effects associated with the standard monetary policy rule, we take into account both non-linearity caused by a zero-bound of nominal interest rates (Benhabib, et al., 2002) and endogeneity of determinant variables in monetary policy rule. As relevant instrumental variables for the possibly endogenous variables in a non-linear Taylor-type rule augmented with financial asset prices, unconventional monetary policy measures are used. We consider the case of the Bank of Japan (BOJ), which has time-series variations in the ZIRP and QEP implemented on an intermittent basis since 1999. We also distinguish such three channels of the unconventional measures as summarized by Ueda (2012): either through providing funding liquidity for financial institutions, through enhancing market liquidity of financial assets, or through the central bank's balance sheet. Our comprehensive data-analysis suggests qualitative differences in the effectiveness among each channel. The effects of funding liquidity are as a whole restricted. While it is the policy via the market liquidity what is effective in reducing term spreads with fewer anomalies, it is via the central bank's balance sheet to decrease credit spread. Concerning the effects on output gap, a channel through the funding liquidity is though limitedly effective, but inflation rate is to the larger extent subject to the market liquidity or the central bank's balance sheet channel. These differential results on what kinds of assets and the amount to purchase in the open-market operations demonstrate how the central banks should effectively manage the unconventional measures and then develop exit strategy from them.

Keywords: Unconventional monetary policy; the Bank of Japan; Funding liquidity; Market liquidity; Central bank's balance sheet

JEL Classification: E43; E44; E52; E58

1. Introduction

Unconventional monetary policy has been implemented first and intermittently since 1999 by the Bank of Japan (BOJ), followed by the US Federal Reserve System (FRB) in 2008, the European Central Bank (ECB) and the Bank of England (BOE) in 2009. A variety of the policy measures have been designed by each central bank with a country-specific purpose of the credit expansions. For instance, the BOJ began to purchase commercial papers (CP), asset-backed CP and corporate bonds in 2008 in the aftermath of the Lehman shock, when the FRB initiated the Term Asset-Backed Securities Loan Facilities (TALF) which gave credit to asset-backed securities with original auto-loans, credit card loans and so forth. Although the details in the unconventional measures are different in each central bank, there are some common aspects in the measures.[1]

First, central banks have been forced to exercise the unconventional measures in the face of binding a zero lower bound of nominal interest rates, the conventional policy instruments. In the peace time immune to a financial crisis, the Taylor-type rule of monetary policy is implemented where both the output gap and target inflation rate determine a target policy rate. At the onset of binding a zero lower bound of nominal rates, when the standard Taylor-type rule became invalid, central banks as a result did nothing but the unprecedented policy measures.

Second, while the traditional role of central banks was still played as the lender of last resort, another role of "the asset purchaser of last resort[2]" has been expected there in financial markets. The new role could contribute to providing market liquidity for financial assets traded between financial intermediaries, as well as mitigating funding liquidity of financial institutions.

Third, as a consequence of the asset purchases, the balance sheet of central banks has heavily deteriorated due to increased credit risks associated with holding risky assets like ABS. Against the increasing credit risks, each central bank announced its policy of credit-risk managements. For instance, the BOJ made clear in 2004 three criteria for legitimate assets to be purchased: "soundness", "liquidity" and "neutrality". However, the actual sluggish responses of the financial markets might have accelerated the BOJ's choice of the unconventional measures beyond the criteria.

These aspects of unconventional monetary policy common to the major central banks raise questions on monetary policy, relevant for policy-makings and theoretically challenging for monetary economics. What assets should central banks purchase in the market, government bonds, stocks, commercial papers and so on?[3] What should be the optimal exit strategies from unconventional to normal monetary policy? Central bank's balance-sheet adjustments or interest rate hike, which one should be done prior to the other, in terms of minimizing social costs with the asset price fluctuations?[4]

In order to consider these questions, there remains so much uncertainty concerning empirical effectiveness of the unconventional monetary policy, despite numerous researches on the macroeconomic effects of unconventional monetary policy measures, as surveyed for example by Kozicki, et al. (2011) and Williams (2011).[5] Instead of an event-study methodology most of the previous studies took, we need an econometric framework of unconventional monetary policy, where the key issue is roles of asset prices in monetary policy-makings. This paper presents empirical evidence on the effects of unconventional monetary policy and the consequences of the exit strategies, taking the case of the BOJ.

In Japan, during and after the lost decade of economic stagnation when some policy failures are partly to blame for the sluggish doldrums (Posen, 2010), the BOJ experimented some unconventional measures intermittently. First, the zero interest rate policy (ZIRP) continued from February 1999 to August 2000. Second, the ZIRP started again on March 2001 associated with the quantitative easing policy (QEP) up to lifting on July 2006. Prior to lifting the ZIRP, then the BOJ decided to fordo the QEP on March 2006. The BOJ did the balance sheet adjustments prior to the interest rate hike. Third, on December 2008 the QEP was again introduced where purchase operations of CP, ABCP and corporate bonds were invented.[6]

A variety of the unconventional experiments in Japan thus gives a sample with enough data for us to estimate the effects of unconventional measures and the quantitative consequences of the exit strategies the BOJ actually adopted in 2006. Owing to the empirical advantage of the Japanese experience over another central bank, our empirical evidence provides some lessons for central banks when the exit policy will be conducted forthcoming.

How could we measure effects of the unconventional monetary policy? To achieve the practically and academically meaningful objective, the following two econometric issues must be solved. First, regarding the ZIRP that underlies QEP, the nominal interest rate is subject to a near-zero lower bound constraint (Benhabib, Schmitt-Grohe and Uribe, 2002).[7] In time series analysis such as the vector auto-regression (VAR) model which is normally applied to monetary policy analysis, there is difficulty handling the non-linearity caused by zero-bound nominal interest rates. Thus we must formulate an econometric model of a Taylor–type monetary policy rule augmented with non-linearity. In light of the non-linearity arising from zero-bound interest rates,[8] we apply two latent-variable models, the Tobit model or the censored normal regression model to estimate the non-linear Taylor rule for monetary policy.

Second, unconventional monetary policy can work through the route of asset prices. Not only in times of financial crisis such as the subprime loan crisis, but even in normal times when an asset bubble is gradually emerging, the monetary policy rule is thought to include the response to asset prices.[9]

Considering the response of asset prices under the monetary policy rule, an endogeneity problem arises between monetary policy and asset prices. In this paper, rather than directly addressing a simultaneity problem, we ask whether asset prices are an endogenous variable in the monetary policy rule. It is crucial in our analysis that the unconventional monetary policy measures which are thought to be a determinant of asset prices, can be used as instrumental variables for the possibly endogenous variables in a monetary policy rule with non-linear zero lower bound of nominal interest rates.

By resolving these two econometric issues, we present a general framework to empirically analyze the impact of unconventional monetary policy. Only through such a framework can we search for the effect of unconventional monetary policy.

Among three channels of the unconventional measures either through providing funding liquidity for financial institutions, through enhancing market liquidity of financial assets, or through the central bank's balance sheet, there are qualitative differences in the effects. The effects of funding liquidity are as a whole restricted. While it is the policy via the market liquidity what is effective in reducing term spreads with fewer anomalies, it is via the central bank's balance sheet to decrease credit spread. Concerning the effects on output gap, a channel through the funding liquidity is though limitedly effective, but inflation rate is to the larger extent subject to the market liquidity or the central bank's balance sheet channel. These results on what kinds of assets and the amount to purchase in the open-market operations demonstrate how the central banks should effectively manage the unconventional measures toward the current sluggish economy and then develop exit strategy from them.

The sections below are organized as follows: Section 2 describes the unconventional monetary policy measures adopted by the BOJ; Section 3 supposes a general empirical framework for analyzing the effects of unconventional monetary policy; Section 4 presents estimation results on the non-linear Taylor rule and the effects of unconventional measures on asset prices; finally, Section 5 summarizes our evaluation of the effects.

2. A Brief Review of Unconventional Monetary Policy by the BOJ

In March 2001, the Bank of Japan (BOJ) launched a monetary easing policy commonly known as "quantitative easing policy" (QEP) under historically rare deflationary conditions. As shown in Table 1, the BOJ not only began setting progressively higher targets for current account balances held at the Bank, but began outright purchases of long-term government bonds under the justification of facilitating the supply of the current account balances, purchases of ABS (including ABCP) as a temporary measure, and even stock purchases for the purpose of reducing the market risk of equities held by financial institutions.[10]

The zero-interest rate policy (ZIRP) was, after lifted in July 2006, reinstated in December 2008. Since then, the BOJ has set the uncollateralized overnight call rate target at 0.1%, with a help of an introduction of the complementary deposit facility which pays out interest on excess reserves. It has also continued outright purchases of JGBs since March 2001 in the quantitative easing phase. In addition, the BOJ initiated an interest rate auction method with eligible collateral for common collateralized funds supply and special corporate financing operations, and U.S. dollar funds-supplying operations. Moreover, at around the time when stock purchases were reinstated in February 2009, the BOJ implemented auction purchases with minimum yields set for CP and ABCP (a-1 or equivalent rating and remaining maturity of less than 3 months) which are eligible collateral, and auction purchases of A rated or equivalent corporate bonds with maturities of less than 1 year and minimum yield.

In this section, we discuss some concepts, though not rigorous theories, for the effects of the unconventional monetary policy adopted by central banks including the BOJ.[11] When central banks consider the unconventional monetary policy of ZIRP with zero lower bound of nominal interest rates and QEP expanding the central bank's liability, the central bank's policy concerns lies in how to decide what kinds of assets and how much the amount to purchase in open-market operations. With few exceptions, however, theoretical analysis on the policy issue has been stagnant, and any reliable analytical framework is unavailable. Here instead of a rigorous model where unconventional monetary policy can impact asset price formation, three channels from unconventional measures to asset pricing are described following typology of Ueda (2012)[12] funding liquidity of financial institutions; market liquidity of financial assets; and balance sheet of the central bank. The descriptions are associated with reviewing the Japanese financial data.

2.1. Funding Liquidity of Financial Institutions

The first channel by which unconventional monetary policy can affect asset prices, still as lender of last resort, the central bank can alleviate the funding liquidity of financial institutions, easing the liquidity restraint of investors, and having a positive impact on asset price formation.

As indicators of funding liquidity of financial institutions, Figure 1 shows outstanding banknotes issued and outstanding bank deposits (total amount of domestic banks, domestic branches of foreign banks, and shinkin banks) as a percentage of outstanding current account balances at the BOJ. The ratio of issued banknotes shows a stable trend (solid line, right axis), and the ratio of outstanding bank deposits, which corresponds to the reserve deposit ratio (dotted line, left axis), though of a different order of magnitude, show a similar pattern over time including the spikes corresponding to the Y2K problem (end of 1999), leap year (February 2000), and computer system

glitch of the Mizuho Bank merger (April 2002). During the QEP period from March 2001 to July 2006 (denoted between two dotted lines), the targeted current account balance level rose and fell sharply. In contrast, since the ZIRP was reinstated in December 2008, the BOJ current account balance has not increased conspicuously.

2.2. Market Liquidity of Financial Assets

As a second channel, the central bank can, through holding assets or collateral, increase the market liquidity of financial assets, reduce liquidity premiums, and cause asset prices to rise. During the financial crisis, to prevent investors from dumping or freezing assets with fire-sale prices, the central bank can serve as "market-maker of last resort."

As indicators of market liquidity, Figure 2 shows the Tokyo Stock Exchange (TSE) First Section turnover (billion yen; left axis, solid line), OTC turnover of interest bearing long-term JGBs (billion yen; left axis; dash line), implied volatility of 1-month yen/dollar rate option (percent; right axis, dotted line), and TSE 30-day historical volatility on the last trading day of the month (percent; right axis, dash dot line). As the graph shows, when the QEP was implemented, the turnover of long-term JGBs increased sharply. The growth pace continued even after the QEP was lifted, but plummeted in the subprime loan crisis. The TSE historical volatility index also shows a sharp increase around the time of the reinstatement of the ZIRP.

2.3. Balance Sheet of the Central Bank

The third channel by which unconventional monetary policy can affect asset prices is through the central bank's balance sheet. In general, while it is unclear how changes to the central bank's balance sheet can affect asset prices, Auerbach and Obstfeld (2005) and Eggertsson and Woodford (2003) suggest that a QEP based on outright purchases of government bonds can, through the accumulation of government debt on the central bank's balance sheet, trigger inflation. Higher inflation risk negatively affects nominal asset price formation. Inflation risk can also affect government bonds and other assets held by the central bank, further deteriorating the central bank's financial position.

Figure 3 plots two indicators of particular importance for balance sheet adjustment by the BOJ. One is regarding the "banknote rule" officially professed by the BOJ since outright purchases of long-term JGBs increased under the QEP. The banknote rule says that holdings of outstanding long-term JGBs are kept below the outstanding banknotes. The trends of banknotes (billion yen; left axis; dashed line) and long-term JGBs (billion yen; left axis; solid line) suggest that, in phases

when outright purchases of long-term JGBs increased under the QEP, the banknote rule as a constraint on the upper limit was likely to have binding force.

The other indicator is U.S. dollar lending operations of the BOJ, implemented to accommodate increased demand for U.S. dollar currency from domestic banks in the subprime loan crisis (100 million yen, right axis, dotted line). In the implementation of the operations, U.S. dollar accounts of the BOJ and domestic banks at the Federal Reserve Bank of New York were used based on a currency swap agreement with the U.S. Federal Reserve, and the domestic banks' accounts were treated as a separate balance sheet item from current account balances. Reflecting the strong demand for U.S. dollar currency, most of the lending was at fixed interest rates rather than interest rate auction method. The operation, which started in September 2008 after the Lehman shock and ended in February 2010, peaked in December 2008 with an outstanding amount of approximately USD 122.7 billion.

3. A Simple Econometric Model for Measuring the Effects of Unconventional Monetary Policy

This section presents a general framework for empirically analyzing the effects of unconventional monetary policy through the three channels of funding liquidity of financial institutions, market liquidity of financial assets, and the central bank's balance sheet. Using the Japanese data, we then explain a specific estimation method for the quantitative evaluation. Details of the actual estimation method and results are discussed in the next section.

3.1. Non-Linear Taylor Rule with Zero Lower Bound of Nominal Interest Rates

Monetary policy analysis must identify either side of 'cause and effect' relations between monetary policy and macroeconomic variables including asset prices. On one hand, the cause side can be expressed as a monetary policy rule known as the Taylor rule, in which the monetary policy target, or ultra-short-term interbank lending rate, is determined by the inflation rate and output gap. We analyze the non-linear Taylor rule that explicitly considers a zero lower bound of nominal interest rates.

On the other hand, the effects of monetary policy are expressed as the channels through which the interest rate set by the central bank affect macroeconomic indicators such as asset prices, inflation rate and output gap, under nominal rigidity and financial market frictions. We do not explicitly address a structural model regarding any mechanism of the monetary policy effect.

Figure 4 tracks the uncollateralized overnight call rate (in percent), the monetary policy target of the BOJ except during the QEP phase. The call rate hovers near the zero floor three times: from February 1999, when the ZIRP was initiated, until it was lifted in August 2000; from March 2001,

when the policy was reinstated together with the QEP, until it was lifted in July 2006; and from December 2008, when it was reinstated a second time. In this last phase, however, the call rate floor is 0.1% due to the complementary lending facility set up in November 2008, which pays out a 0.1% interest rate on the excess reserves held in the Bank's current account balances.

Figure 5 illustrates the non-linear Taylor rule expressed in Equation (1). Here, $\underline{i}$ denotes the floor of the BOJ policy target, which is the nominal call rate i_t (uncollateralized overnight call rate, in percent). As in Figure 4, the call rate floor $\underline{i}$ was 0.1% in phase one of the ZIRP and QEP, and 0.2% is thought to be an appropriate level in the second phase.

$$\begin{cases} i_t = \max\{\underline{i}, \quad i_t^*\} \\ i_t^* = \rho i_{t-1} + \alpha \pi_t + \beta y_t + \varepsilon_t \end{cases} \tag{1}$$

For the explanatory variables for a latent variable i_t^* in the non-linear Taylor rule, output gap y_t is defined as the rate of divergence of the monthly index of industrial production (IIP) data from the potential IIP derived by smoothing the IIP using the Hodrick and Prescott (HP) filter. The inflation rate π_t is defined as the year-on-year change in the general consumer price index (CPI). Also, to express the central bank's nominal-interest-rate smoothing in the Taylor rule, we add the previous month's call rate i_{t-1} as an explanatory variable.

In our estimations in the next section, as well as a Tobit model with a nominal interest rate floor of 0.1% or 0.2%, we estimate a censored normal model that allows the nominal interest rate floor $\underline{i}_t$ to change over time.

$$\begin{cases} i_t = \max\{\underline{i}_t, \quad i_t^*\} \\ i_t^* = \rho i_{t-1} + \alpha \pi_t + \beta y_t + \varepsilon_t \end{cases} \tag{2}$$

We regard $\underline{i}_t$ as time-varying, since as noted earlier, when the ZIRP was reinstated the second time in December 2008, the complementary lending facility introduced a month earlier in November paid out a 0.1% interest rate on reserve deposits, and this level came to function as the call rate floor.

3.2. Policy Response to Asset Price Fluctuations

There are a variety of operational proposals for improvement in the U.S. Fed's monetary policy effects, looking back on its response to the sub-prime loans crisis (Leamer, 2007; Farmer, 2009; Taylor, 2008; Cúrdia and Woodford, 2009). Among the monetary policy behaviors of the U.S. Fed, what grave doubt has been cast on is the efficacy of the "Greenspanism" named after a fact that the former Chairman Alan Greenspan and the Chairman Ben Bernanke advocated (Bernanke, 2002; Greenspan, 2004; Takeda and Yajima, 2009).[13] The Fed following "lean-against-the-bubble strategy" has been criticized for both overestimating costs of "aggressive bubble popping" and underestimating costs of reconstructing dysfunctional financial system after asset bubble collapses. In addition to the criticism against the Greenspanism, the BIS economists show a different view that the Fed could have predicted the asset bubble in housing and stock prices, with some index combining numerous financial variables (Borio and Lowe, 2002).

Incorporating the responses to asset bubble and the prevention of financial crisis into monetary policy's objectives, we consider a role of asset prices in monetary policy rule as "information variables".[14]

$$\begin{cases} i_t = \max\{\underline{i}, \quad i_t^*\} \\ i_t^* = \rho\, i_{t-1} + \alpha\, \pi_t + \beta\, y_t + \gamma\, a_t + \varepsilon_t \end{cases} \tag{3}$$

Considering some policy debates concerning the informational roles of asset prices in the BOJ's monetary policy, we choose as comprehensive a list of asset prices as possible: foreign exchange rates (dollar/yen rate), stock prices, the Japanese Government Bond yield, credit spreads, term spreads, crude oil Dubai price, and J-REIT Index. The details of the policy debates in Japan will be described in Appendix.

3.3. Endogeneity of Determinants in the Monetary Policy Rule

As noted above, the fluctuation of asset prices is considered in monetary policy decisions. However, since asset price fluctuation is itself an endogenous variable which is subject to monetary policy, there arises the simultaneity problem with the monetary policy decision expressed in the nominal interest rate. Simultaneity would raise the identification problem associated with a structural equation of the monetary policy rule.[15] Instead of directly addressing the simultaneity problem, we assume as in Equation (4) that asset prices is endogenous but depends on an exogenous lag component , which is also another policy target variable with a purpose of interest rate smoothing.

$$\begin{cases} i_t = \max\{\underline{i}, \quad i_t^*\} \\ i_t^* = \rho i_{t-1} + \alpha \pi_t + \beta y_t + \gamma a_t + \varepsilon_t \\ a_t = \delta i_{t-1} + \xi_t \end{cases} \tag{4}$$

Here, monetary policy and asset prices are determined by the relationship shown in Figure 6.[16] Moreover, in the monetary policy rule, not only asset price but also macroeconomic indicators such as inflation rate and output gap can be endogenous. In this case, we can express the structure as in Equation (5), where and Ξ_t are vectors respectively of the coefficient of the lag endogenous variable of the monetary policy instrument and of error terms in the endogenous variable.

$$\begin{aligned} & i_t = \max\{\underline{i}, \quad i_t^*) \\ & i_t^* = \rho i_{t-1} + \alpha \pi_t + \beta y_t + \gamma a_t + \varepsilon_t \\ & \begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix} = \Delta i_{t-1} + \Xi_t \end{aligned} \tag{5}$$

3.4. Unconventional Monetary Policy as Instrumental Variables

Here, even if Equation (4) or Equation (5) is estimated using a Tobit model or censored normal regression model, the structural equation of the monetary policy rule cannot be identifiable from the rank conditions. In this paper, we use indicators of unconventional monetary policy as an instrument of the candidate endogenous variables $\begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix}$. The relevancy as instrumental variables of unconventional monetary policy indicators is thought to be high. Because as noted earlier, unconventional monetary policy is not adopted in normal times, when the monetary policy target is the nominal interest rate, the correlation with the monetary policy rule error term is zero, while the correlation with the error term of asset prices and other endogenous variables Ξ_t is thought to be high whether in times of normalcy or financial crisis. As a result, we must obtain

$$Cov\left(\begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix}, \mathrm{q}_t\right) = 0.$$

In this case, identification of the structural equation of the monetary policy rule become possible due

to the fluctuation of endogenous asset prices resulting from the unconventional monetary policy .[17]

$$
\begin{aligned}
& i_t = \max\{\underline{i}, \quad i_t^*\} \\
& i_t^* = \rho\, i_{t-1} + \alpha\, \pi_t + \beta\, y_t + \gamma\, a_t + \varepsilon_t \\
& \begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix} = \Delta\, i_{t-1} + \Phi q_t + \Xi_t
\end{aligned}
\tag{6}
$$

In the next section, for estimation of the Tobit model with endogenous variables shown in Equation (6), we use Newey's (1987) minimum chi-square estimation to obtain the two-step estimates which consists of the structural equation of endogenous variable candidate $\begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix}$ as the first step, and the structural equation of the non-linear Taylor rule as the second step.[18] For the endogenous variable candidate $\begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix}$, due to the correlation between the monetary policy rule error term and endogenous variable error term Ξ_t, we test the endogeneity of each variable using the Wald statistic, and specify the structural equation. Finally, under the specified structural equation, we empirically explain the effect of unconventional monetary policy by confirming the significance level of the effect of unconventional monetary policy indicators as control variables on the endogenous variables.

4. Estimation Results on the Non-Linear Taylor Rule and the Effects of Unconventional Measures on Asset Prices

This section presents estimation procedures to which the econometric methods above are applied.[19] First, in order to set variables of inflation rate and output gap used in the estimation on the basis of log-likelihood function, the variable choice of which will be fixed in later estimations, we estimate the non-linear Taylor rule with the standard specification. The explanatory variables only consist of inflation rates and output gaps as well as the lagged policy instrument rate. Second we include in the non-linear rule each asset price alternately, which is considered as the information

variable. Third, we test endogeneity of the explanatory variables in the non-linear rule, which the acceptance would lead us to taking advantage of unconventional measures as instrumental variables.

On the basis of data availability with monthly frequency, our sample period starts on April 1999 and ends on September 2009, if not otherwise specified. Among the 126 valid samples, 35 observations are left uncensored with the 0.2% floor of the policy instrument rate.

4.1. Non-Linear Taylor Rule Estimated

We set variables of the inflation rate and output gap determining the monetary policy rule on the basis of the estimated log-likelihood function. Our candidates are eight (2 by 4) combinations of both determinants. Inflation variable is a year-to-year percentage change of either the Consumer Price Index (CPI), general or the core CPI, general excluding fresh food. Output gap is defined as a deviation rate of the Index of Industrial Production (IIP) from the potential output calculated with the Hodrick-Prescott filter. The IIP variable is either one among the original, the seasonally adjusted, the utilization-adjusted original, and the utilization and seasonally adjusted series.

We estimate the non-linear Taylor rule with three regression models: two Tobit models with an explicit floor of nominal interest rate 0.1% (Table 2) or 0.2% (Table 3); and a censored normal model with the floor changing over time (Table 4). In a case of the Tobit model with the 0.1% floor, the sample after December 2008 when the ZIRP had again restarted cannot be censored as a period during when the lower bound is binding, since the complementary deposit facility allowed the BOJ to add interest 0.1% to excess reserve deposits in November 2008.

In either case, above all the coefficients on the lagged policy instrument rate indicate the interest rate smoothing is noticeable. Comparisons of two cases of the 0.1% or 0.2% floor rate suggest (in) significance of the output gap variables in the (former) latter case. In the censored normal regression model, both determinants of the inflation rates and the output gaps are also significant. In terms of the estimated log-likelihood functions, among the eight combinations of the inflation and output gap variables, it is likely to be a pair of the CPI, general and the IIP original series, that the most adequately explains the non-linear Taylor rule. In the later estimations, the CPI, general and the original IIP series will be used, and the floor rate of the policy instrument will be set with 0.2% in the Tobit case.

4.2. Asset Prices in the Monetary Policy Rule

We incorporate into the non-linear Taylor rule each variable of asset prices, the fluctuation of which the BOJ has ever responded to. We select a list of the informational variables, covering FX rates,

stock price indexes, the JGB yield, credit and term spreads, the crude oil price, and the J-REIT index.[20] Table 5 indicates predicted signs of a coefficient on each variable in the Taylor rule.

4.2.1. FX Rate

We pick up a year-to-year percentage change in the FX rates, either dollar-yen exchange rate or nominal effective exchange rate of yen. The former is a rate in home currency. The latter rate in foreign currency is an index of the weighted geometric average exchange rates for yen to other major currencies according to the volume of trade between Japan and the partner countries. Consequently, the predicted signs of a coefficient on each FX rate are positive and negative, respectively. Table 6 shows all the variables except but the inflation rate are significant with the predicted signs.

4.2.2. Stock Price Index

We also pick up a year-to-year percentage change in two stock price indexes differing in both brand coverage and calculation method. The Nikkei Stock Average is an arithmetic average of 225 brands. The TOPIX is also an index of total current value of all stocks in the Tokyo Stock Exchange's PSection. Table 7 shows significance and sign conditions of all the variables.

4.2.3. Government Bond Yield

The 10-year JGB yield is predicted to have a negative coefficient in the estimated Taylor rule, since the central bank intends to keep stable prices of long-term government bonds. Deterioration in the government bond price then leads to monetary easing. Contrary to the good results in the cases of FX rate or stock price index, Table 8 shows insignificance of the inflation rate and the output gap. It also indicates significance but wrong signs on the JGB yield, a possibility of endogeneity problem in the JGB yield case.

4.2.4. Credit Spread

We address measurement of credit risk, which is evaluated in terms of credit-ratings by an agency Moody's; secondary market performance of public offering bonds by business companies relative to government bonds; or interbank market offered rates in Tokyo relative to London.

One measure of credit risk is yield spreads of bonds classified by the ratings Aaa, Aa, A, or Baa of a rating agency Moody's. Remaining terms of the bonds are 1, 3, 5, or 10 years. There are some missing data on the bond yields. To ensure as long a time series data as possible, we choose the following eight combinations of the ratings with help of the 10-year JGB yield: for 1 year remaining

term, Baa to A and Baa to Aa; for 3 years, Baa to A and Baa to Aa; for 5 years, A to Aa; and for 10 years, A to Aa, A to the 10-year JGB and Aa to the 10-year JGB. The second measure is based on the Nomura BPI (Bond Performance Index), an index of investment returns of the publicly offered industrial and government bonds in the Japanese secondary markets. Investment periods are short-, medium- or long-term. Spreads in the BPI of the industrial and government bonds for each investment period reflect credit risk associated with industrial activities in general operated by private companies. The third measure is the so-called "Japan premium", that is a spread of 1-, 3- or 6-month Japanese yen TIBOR (Tokyo Interbank Offered Rate) or 3-month CD rate to Japanese yen LIBOR (London Interbank Offered Rate). The spread reflects credit risk the Japanese banks face in the interbank markets.

Coefficients on these credit spreads in the estimated rule are predicted to be negative. Table 9 shows results of the spreads on the basis of the credit ratings. Though significance of the inflation rate and the output gap disappears with a few exceptions, there observe significant coefficients on the credit spreads with correct signs in the cases of the short- to medium-terms. However, the credit spreads of either the industrial bonds (Table 10) or the Japan premium (Table 11) have insignificant coefficients or significant ones but with wrong signs. The results remind us of the endogeneity problem in these credit spread cases.

4.2.5. Term Spread

We are concerned with term spread on which the QEP could have the duration effects through term structure of interest rates. We define the term spread as a difference between 1-, 3-, or 6-month Japanese yen TIBOR and the unsecured call rate. Table 12 shows significance and correct sign (negative) of the term spread coefficients only in the Tobit model.

4.2.6. Miscellaneous: Crude Oil Price and REIT Index

Finally, we pick up a year-to-year percentage change in miscellaneous asset prices, the crude oil Dubai price and the Tokyo Stock Exchange REIT index (Real Estate Investment Trust; thereafter, J-REIT). Only in the case of the J-REIT index with scarce data-availability, our estimation period starts on March 2004, the number of valid samples equal to 67 (the 29 uncensored observations). Table 13 indicates only significance and correct sign (positive) of the J-REIT.

4.3. Endogeneity and the Effects of Unconventional Monetary Policy

We are now ready to measure the effects of unconventional monetary policy with a Tobit/ censored normal regression model, where the non-linear Taylor rule is in an econometrics sense identified by

instrumental variables of the unconventional measures. As described in Section 2, three channels of the unconventional measures' effects are considered, via either funding liquidity of financial intermediations, market liquidity of financial assets, or the central bank's balance sheet. In line with each channel, data transformation is consciously devised. A variable list is Table 14.

There are two indicators of funding liquidity of financial institutions: outstanding current account balances at the BOJ and US dollar denominated loans (converted into yen with dollar-yen exchange rate each present month). The former is the usual transaction account. The latter payment and receipt of US dollar between the Bank and the counterparties was made through the accounts at the Federal Reserve Bank of New York (FRBNY) on the basis of a US dollar-yen swap agreement with the FRBNY. We transform the indicators into the ratios of outstanding bank deposits (total amount of domestic banks, domestic branches of foreign banks and shinkin banks). The ratios mean the financial institutions' demand for funding liquidity.

For enhancing market liquidity of the concerned financial assets, there are some unconventional operations: specifically, outright purchases of JGB; outright purchases of ABS; stock purchasing plan; fund-supplying operations against pooled collateral; special funds-supplying operations to facilitate corporate financing; US dollar funds-supplying operations against pooled collateral; outright purchases of CP and ABCP (a-1 rating and 3-month maturity or shorter); and outright purchases of corporate bonds (A rating or higher and 1-year maturity or shorter). Raw turnovers of these purchases are used as the measures for the market liquidity.[21] Data before the start of the unconventional policy is assigned with zero values.

Among the BOJ accounts, we pick up the unconventional balances: outstanding current deposits at the BOJ; US dollar loans balance (converted into yen); long-term JGBs; ABS; pecuniary trusts (stocks held as trust property); loans made by way of funds-supplying operations against pooled collateral and special funds-supplying operations to facilitate corporate financing; CPs; and corporate bonds. Each BOJ balance data is transformed into ratios relative to issued BOJ banknote balance, with reference to the "banknote rule" officially professed by the BOJ.

4.3.1. Two-Step Estimator of Newey (1987)

We apply the two-step estimator of Newey (1987) to the Tobit model with endogenous regressors. The estimator takes two steps, first to estimate the reduced form of the endogenous variables

$\begin{pmatrix} a_t \\ \pi_t \\ y_t \end{pmatrix}$ by OLS to generate the Ξ_t residuals , and second to estimate a standard Tobit of the non-linear Taylor rule on the endogenous variables and the residuals Ξ_t.

Table 15 indicates significant but wrong signed coefficients on the inflation rate and the dollar-yen exchange rate in a case where the FX rate and output gap are endogenous variables. In the other cases, no measures for funding liquidity matter with the yen nominal effective exchange rate. What cause yen to depreciate are the outright purchases of JGBs for market liquidity, and the ratio of pecuniary trusts (stocks held as trust property) to issued banknote balance. It is the ratios of long-term JGB, loans made by way of funds-supplying operations against pooled collateral and special funds-supplying operations to facilitate corporate financing and corporate bonds, that cause yen to appreciate.

We have in Table 16 no cases excluded for the inference on the effects of the unconventional measures. The BOJ current deposits for funding liquidity and the outright purchases of JGBs for market liquidity are both liable to decline in the stock price indexes. In spite of the neutrality criterion the BOJ has ever stated, the ratio of pecuniary trusts (stocks held as trust property) to issued banknote balance raises directly concerned asset prices, the stock price indexes. The stock price indexes also decrease anomalously in response to the balance ratio of the long-term JGBs.

Table 17 suggests the 10-year JGBs yield cases where, differently from the estimation without concerns about endogeneity problems in Table 8, the coefficient on the JGBs yields in the monetary policy becomes significant and correct signed. The endogeneity bias turns out to be from the inflation rate and the output gap.

Table 18 and 19 (credit spreads on the credit-rating basis), Table 20 (ones of the industrial bonds) and Table 21 (the Japan premium) indicate there are many cases in which some of the endogenous variables have wrong signs on the coefficients in the monetary policy rule: where the endogeneity is not rejected for the output gap and each credit spread variable for either the 5-year remaining A-Aa ratings, 10-year A-Aa ratings or 10-year A rating-JGB; medium-term industrial bonds; where neither for a credit spread of the medium-term industrial bonds; and where neither for the output gap and each credit spread variable for the 3-month TIBOR-LOBOR or 3-month CD-LIBOR Japan premium.

As for the effects of unconventional monetary policy, there are no effective measures for the funding liquidity. Among the measures for the market liquidity, the outright purchases of CPs with the a-1 rating and ones of corporate bonds with the A rating or higher increase the credit spreads through

only decreasing credit risk in highly rated securities. The example means that the BOJ's measures exceed its neutrality criterion. While the ratios of the pecuniary trusts (stocks held as trust property) and the CPs to the BOJ banknotes balance decrease the credit spreads, the ratio of the corporate bonds does also increase the credit spreads. The anomaly casts doubt on the financial soundness, one of the criteria the BOJ follows.

When the term spread variables are introduced into the non-linear Taylor rule, the second-step estimations in Table 22 show wrongly signed coefficients on the determinant variables in all the cases where the endogeneity of the term spread variables are not reject. When the miscellaneous asset prices (the crude oil Dubai price or the J-REIT index) are also introduced, Table 23 indicates no case where the coefficients on the determinant variables are correctly signed. Consequently, we can say nothing significant about the effects of the unconventional measures on the term spreads, the oil prices or the REIT index.

We report finally the estimation results in Table 24 concerning the macroeconomic effects on the inflation rate and the output gap. Among the market liquidity measures, the US dollar funds-supplying operations against pooled collateral increase the inflation rate. The inflation rate also responds positively to the ratio of the pecuniary trusts (stocks held as trust property) to the BOJ banknotes balance, and negatively though anomalous, to the corporate bonds ratio in the BOJ balance. On the other hand, concerning the effects on the output gap, the outright purchases of the JGBs or the ABS for the market liquidity are depressive, while effective are the US dollar funds-supplying operations against pooled collateral for the funding liquidity.

5. Conclusion

We measured the effects of the unconventional monetary policy on either a variety of the asset prices, the inflation rate or the output gap. The econometric model considered the non-linearity of the Taylor rule and the endogeneity of the determinant variables there. Then the unconventional measures can be relevant instrumental variables, since the correlation is, while probably non-zero with the determinant variables, by definition zero with the latent variable of the monetary policy instrument. We thus estimated the Tobit/ censored normal regression model for the Japanese data covering the intermitted periods of the ZIRP and the QEP.

A brief summary of the estimated effects on asset prices are depicted in Table 25. Among three channels of the unconventional measures either through providing funding liquidity of financial institutions, enhancing market liquidity of financial assets, or through the central bank's balance sheet, there are qualitative differences in the effects. The effects of funding liquidity are as a whole restricted. While it is the policy via the market liquidity what is effective in reducing

term spreads with fewer anomalies, it is via the central bank's balance sheet to decrease credit spread. Concerning the effects on output gap, a channel through the funding liquidity is effective, but inflation rate is to the larger extent subject to the market liquidity or the central bank's balance sheet channel. These results on what kinds of assets and the amount to purchase in the open-market operations demonstrate how the central banks should effectively manage the unconventional measures and then develop exit strategy from them.

NOTES

*The authors wish to thank Hiroshi Aketa, Shin-ichi Fukuda, Koichi Hamada, Toshiki Jinushi, Masayuki Keida, Daisuke Miyakawa, Masanori Ono, James Parker, Masaya Sakuragawa, Daichi Shirai, and participants in Asian-Pacific Economic Association 2011 at Pusan University, Korea, and Seikei University, Japan, for their helpful comments and editorial assistance.

1. The classical Modigliani-Miller irrelevance of choices in open-market operations is supposed by Wallace (1981), while Broaddus and Goodfriend (2001) raised the institutional and historical issues on the US Fed from practical central- banker's eyes.
2. See a theoretical paper on the issue, Schmitt-Grohe and Uribe (2010).
3. Recent researches have been intensively pursued on the effectiveness of the US Fed large-scale asset purchases, such as D'Amico and King(2011), Gagnon, Raskin, Remache and Sack (2011), Glick and Leduc (2011), Krishnamurthy and Vissing-Jorgensen (2011), Meaning and Zhu (2011), Neely (2011), and Swanson(2011). There are a few papers including Joyce, Lasaosa, Stevens and Tong (2011) for the Bank of England, and Peersman (2011) for the European Central Bank. As for the Bank of Japan, we can list some previous studies: Iwata and Wu (2006); Lam (2011); Schenkelberg and Watzka (2011); and Ueda (2012).
4. Shiratsuka (2010) contains a comprehensive treatment of unconventional monetary policy in Japan.
5. A theoretical study of the zero-interest rate bound Taylor rule, Benhabib, Schmitt-Grohe and Uribe (2002) suggests that while a non-linear Taylor rule with zero interest rate bound has a local equilibrium satisfying the "Taylor principle" that a 1% increase in inflation rate causes the nominal interest rate to rise more than 1%, there also contains a peril of generating a globally stable "deflationary" equilibrium.
6. In the literature of VAR models, there are a few exceptions which address binding zero-restriction on nominal interest rates in monetary policy analysis. Iwata and Wu (2006) propose a non-linear structural VAR model, where a policy interest rate is a censored variable. The paper alternates each of two identification regimes, 'standard' or 'monetary targeting' in a non-linear VAR model. In the former identification, central bank 'fully accommodates money demand shocks', while in the latter

one money growth 'is only affected contemporaneously by the exogenous monetary policy shock'. However, in their VAR estimation, the zero lower bound does not switch identification regime from the former to the latter, but it is considered that either regime realizes regardless of the zero lower bound. Another VAR model on the zero-bound of nominal interest rates is Schenkelberg and Watzka (2011), where sign restrictions are used to identify monetary policy shocks when at the zero lower bound. In the AD-AS-model-based structural VAR, however, responses of the policy interest rate to supply shock or 'quantitative easing' one are restricted within a neighborhood of zero, while the policy rate can presumably respond to demand shock without zero-bound. The latter sign restriction should depend on magnitude of demand shock, as an IS-LM Keynesian cross would indicate. Similarly, Peersman (2011) holds the same problem as Schenkelberg and Watzka (2011).

7. There are some papers addressing informational roles of asset prices in monetary policy (Amato, Morris and Shin, 2002), where central banks cannot utilize an asset prices' role of the Grossman-Stiglitz type information aggregation in the face of unconventional monetary policy. Unlike the standard Taylor rule, there are also some advocates for the augmented Taylor rule with asset prices as target variables in monetary policy rule (Leamer, 2007; Farmer, 2009; Taylor, 2008; Curdia and Woodford, 2009). Following the theoretical legitimacy and empirical relevancy, we augment some asset prices to the non-linear Taylor rule.
8. Concerning the Bank's basic approach to a balance sheet management implemented in the ZIRP and QEP measures, the BOJ Planning Office (2004; authors' translation) stated in June 2004 that assets held at the Bank must satisfy three criteria of financial soundness, liquidity, and neutrality. To maintain financial soundness, the Bank "strives to ensure that the assets held and collateral received are highly creditworthy. (p. 23)" Suppose the Bank aims at revive the market liquidity of financial assets with the outright purchase of the concerned assets. If the outright purchase anomalously deteriorates prices of the assets, then credit risk would be borne associated with the assets held by the Bank. Also to ensure asset liquidity, "With consideration of balanced maturity dates of the assets held, the BOJ strives to keep the overall outstanding maturity from increasing and to keep the assets readily disposable whenever necessary. (p.24)" On the other hand, the Bank is anticipated purchasing financial assets with small market liquidity in order to buoy up prices of the assets. Moreover, neutrality is addressed as follows. "The BOJ strives so that our own asset holdings do not influence price formation in the respective asset markets. If the BOJ were to concentrate its holdings on a specific financial asset, depending on the size of the market, the BOJ would affect price formation in the market and risk impeding the neutrality of asset allocation. To ensure neutrality, for its open market purchases the BOJ in principle chooses highly liquid financial assets with deep markets (p. 24)." Suppose the Bank purchases outright the Japanese government bonds

(JGB). If no effects of the purchasing plan would be observed but in lower JGB yields, then the outright purchase of JGBs turns out to infringe the neutrality. The neutrality requires the market operations to work uniformly price formations of as many assets as possible.

9. A comprehensive survey of the effect of the BOJ's QEP is Ugai (2007).
10. Ueda (2012) presents typology of policy options near the zero lower bound: managing expectations about future levels of the policy rate; targeted asset purchases; and quantitative easing. In the terminology used in the literature, the effect of the first option is called "signaling effect"; one of the second option is "portfolio balance effect"; and the third one is "expansionary fiscal effect" whereby the central bank holding government debt replaces the expected future tax liability for the public with an inflation tax (Bernanke and Reinhart, 2004).
11. Takeda and Yajima (2009) use the real-time data available for the Fed Chairmen Greenspan and Bernanke, to estimate mean-reversion models of growth rates of the stock index or the REIT index. The estimation results show that the stock-price changes can be predicted with the dividend-price ratio, while the REIT-price changes, a proxy for the housing-price changes follow the efficient market hypothesis.
12. Roles of information variables in monetary policy have been analyzed in the VAR models for effects of monetary policy. In many cases of the VAR estimates, there remains the "price puzzle" that in response to a contractionary monetary policy shock, inflation rate initially rises in the impulse response function. To solve the empirical puzzle, information variables in the VAR models are included by some researchers including Sims (1992). They interpret the price puzzle as a delayed response of inflation to preemptive monetary contraction by central bank predicting inflationary pressure through information variables.
13. See Rigobon and Sack (2004) for research that resolves the identification problem caused by the simultaneity of the monetary policy interest rate target and asset prices by using the heteroscedasticity between the policy rates on the decision date and on the previous day.
14. In Figure 6, while the latent variable of the monetary policy rule i_t^* is assumed to be an increasing function of asset a_t price , the sign condition does not in any way constrain the argument that follows.
15. As shown in Figure 7, the exit strategy to transition from the zero-interest rate policy to a normal monetary policy is possible in our framework due to the three endogenous variables of asset prices, inflation rate, and demand-supply gap. Figure 7 corresponds to an exit strategy wherein asset price fluctuations push up the nominal interest rate. Figure 8 corresponds to an exit strategy wherein the inflation rate or demand-supply gap rises. In either case, based on the estimate of the structural

equation, we can estimate the average scale of unconventional monetary policy necessary for the exit strategy. We leave this matter for future work.

16. Chapter 16 of Wooldridge (2002) contains a detailed explanation of the Tobit model and other censored regression models.
17. From space constraint, some statistics of standard errors or R-squares will be omitted from tables.
18. See the data description in Appendix.
19. Changes in outstanding current deposits at the BOJ would be a likely denominator of a ratio of the purchase turnovers, but no components in the changes (banknotes, Treasury funds and others, or BOJ loans and market operations) can consistently standardize the turnover variables. Consequently, we use the raw turnover data.

REFERENCES

Amato, J. D., Morris, S. & Shin, H. S. (2002). Communication and Monetary Policy. *Oxford Review of Economic Policy, 18*(4), 495-503.

Auerbach, A. J. & Obstfeld, M. (2005). The Case for Open-Market Purchases in a Liquidity Trap. *American Economic Review, 95*(1), 110–137.

Baba, N., Nakashima, M., Shigemi, Y., & Ueda, K. (2006). The Bank of Japan's Monetary Policy and Bank Risk Premiums in the Money Market. *International Journal of Central Banking, 2* (1), 105–135.

Bank of Japan. (2004). Monetary Operations and Balance Sheet of the Bank of Japan. Retrieved from http://www.boj.or.jp/type/ronbun/ron/research/data/ron0406b.pdf in Japanese.

Bank of Japan. (2004). Japanese Government Bond Markets and the Bank of Japan. Retrieved from http://www.boj.or.jp/type/ronbun/ron/research/data/ron0404b.pdf in Japanese.

Benhabib, J., Schmitt-Grohe, S., & Uribe, M. (2002). Avoiding Liquidity Traps. *Journal of Political Economy, 110*(3), 535-563.

Bernanke, B. (2002). Asset-Price "Bubbles" and Monetary Policy, Remarks by Governor Ben S. Bernanke, Before the New York Chapter of the National Association for Business Economics, New York, October 15, 2002.

Bernanke, B. & Gertler, M. (1999). Monetary Policy and Asset Volatility. *Federal Reserve Bank of Kansas City Economic Review,* 84 (4th Q), 17-51.

Bernanke, B. & Gertler, M. (2001). Should Central Banks Respond to Movements in Asset Prices? American Economic Review, 91(2), 253-257.

Borio, C. & Lowe, P. (2002). Asset Prices, Financial and Monetary Stability: Exploring the Nexus. *BIS Working Paper*, No. 114.

Broaddus, J. A., Jr. & Goodfriend, M. (2001). What Assets Should the Federal Reserve Buy? *Federal Reserve Bank of Richmond Economic Quarterly, 87*(1), 7-22.

Brunnermeier M. K. (2009). Deciphering the Liquidity and Credit Crunch 2007-2008. *Journal of Economic Perspectives, 23*(1), 77-100.

Buiter, W. H. (2008). Central banks and financial crises, paper presented at the Federal Reserve Bank of Kansas City's symposium on "Maintaining Stability in a Changing Financial System", at Jackson Hole, Wyoming, on August 21-23, 2008.

Cúrdia, V. & Woodford, M. (2009). Credit Spreads and Monetary Policy. *NBER Working Papers*, 15289.

D'Amico, S. & King, T. (2010). Flow and Stock Effects of Large-Scale Treasury Purchases. *Board of Governors of the Federal Reserve System Finance and Economics Discussion Series* No. 2010-52.

Eggertsson, G. & Woodford, M. (2003). The Zero Bound on Interest Rates and Optimal Monetary Policy. *Brookings Papers on Economic Activity, 1*, 139–211.

Farmer, R. (2009). What Keynes Should Have Said. VoxEU.org

Fukuda, S. (2009). Financial Market Turmoil and Monetary Policy after the Asset Bubble Collapse in Japanese, Chapter 7 in *Deflationary Economy and Monetary Policy in Japan*, edited by H. Yoshikawa, Keio University Press.

Gagnon, J., Raskin, M., Remache, J., & Sack, B. (2011). The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases. *International Journal of Central Banking, 7*, 3-43.

Glick R. & Leduc, S. (2011). Central Bank Announcements of Asset Purchase and the Impact on Global Financial and Commodity Markets. *Federal Reserve Bank of San Francisco Working Paper Series*, 2011-30.

Greenspan, A. (2004). Risk and Uncertainty in Monetary Policy. *American Economic Review Papers and Proceedings, 94*(2), 33-40.

Hamada, K. & Okada, Y. (2009). Monetary and International Factors behind Japan's Lost Decade. *Journal of the Japanese and International Economies, 23*(2), 200-219.

Ireland, P. N. (1996). Long-Term Interest Rates and Inflation: A Fisherian Approach. Economic Quarterly, Federal Reserve Bank of Richmond, winter, 21-36.

Ito, T. & Harada. K. (2005). Japan Premium and Stock Prices: Two Mirrors of Japanese Banking Crises. *International Journal of Finance & Economics, 10*(3), 195-211.

Iwata, S. & Wu, S. (2006). Estimating Monetary Policy Effects When Interest Rates are Close to Zero. *Journal of Monetary Economics 53*, 1395-1408.

Joyce, M., Lasaosa, A., Stevens, I., & Tong, M. (2010). The Financial Market Impact of Quantitative Easing in the United Kingdom. *International Journal of Central Banking, 7*, 113-161.

Kozicki, S., Santor, E., & Suchanek, L. (2011). Unconventional Monetary Policy: The International Experience with Central Bank Asset Purchases. *Bank of Canada Review*.

Krishnamurthy, A. & Vissing-Jorgensen, A. (2011). The Effects of Quantitative Easing on Lon-Term Interest Rates. *Brookings Papers on Economic Activity*.

Lam, W. R. (2011). Bank of Japan's Monetary Easing Measures: Are They Powerful and Comprehensive? *IMF Working Paper*, WP/11/264.

Lansing, K. J. (2008). Monetary Policy and Asset Prices. *FRBSF Economic Letter*, No.2008-34.

Leamer, E. E. (2007). Housing is the Business Cycle. *NBER Working Paper*, No. 13428.

McCulley, P. & Toloui, R. (2008). Chasing the Neutral Rate Down: Financial Conditions, Monetary Policy, and the Taylor Rule. Global Central Bank Focus, PIMCO.

Meaning, J. & Zhu, F. (2011). The Impact of Recent Central Bank Asset Purchase Programmes. *BIS Quarterly Review*, 73-83.

Neely, C. (2010). The Large-Scale Asset Purchases Had Large International Effects. *Federal Reserve Bank of St. Louis. Working Paper No. 2010-018C*.

Newey, W. K. (1987). Efficient Estimation of Limited Dependent Variable Models with Endogenous Explanatory Variables. *Journal of Econometrics, 36*(3), 231-250.

Okina, K., Shirakawa, M., & Shiratsuka, S. (2001). The Asset Price Bubble and Monetary Policy: Japan's Experience in the Late 1980s and the Lessons: Background Paper. *Monetary and Economic Studies, Institute for Monetary and Economic Studies (Bank of Japan), vol. 19*(S1), 395-450.

Peersman, G. (2011). Macroeconomic Effects of Unconventional Monetary Policy in the Euro Area. *CESifo Working Paper*, No. 3589.

Posen, A. S. (2010). The Realities and Relevance of Japan's Great Recession. STICERD public lecture, May 2010.

Reis, R. (2009). Where Should Liquidity Be Injected During a Financial Crisis? Presented at the NBER Summer Institute 2009.

Rigobon, R. & Sack, B. (2004). The Impact of Monetary Policy on Asset Prices. *Journal of Monetary Economics, 51*(8), 1553-1575.

Schenkelberg, H. & Watzka, S. (2011). Real Effects of Quantitative Easing at the Zero-Lower Bound: Structural VAR-Based Evidence from Japan. *CESifo Working Paper Series*, No. 3486.

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, Institute for Monetary and Economic Studies (Bank of Japan), 28*, 79-106.

Sims, C. A. (1992). Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy. *European Economic Review, 36*(5), 975-1000.

Swanson, E. (2011). Let's Twist Again: A High-Frequency Event-Study Analysis of Operation Twist and Its Implications for QE2. *Brookings Papers on Economic Activity*.

Taylor, J. B. (2008). Monetary Policy and the State of the Economy" Testimony before the Committee on Financial Services, U.S. House of Representatives, February 26, 2008.

Taylor, J. B. (2009). *Getting Off Track: How Government Actions and Interventions Caused, Prolonged, and Worsened the Financial Crisis*. Hoover Institution Press.

Tobin, J. (1963). An Essay on the Principles of Debt Management. From Fiscal and Debt Management Policies, *Commission on Money and Credit*, 143-218.

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, Institute for Monetary and Economic Studies(Bank of Japan), 25*(1), 1-48.

Wallace, N. (1981). A Modigliani-Miller Theorem for Open-Market Operations. *American Economic Review, 71*(3), 267-274.

Williams, J. C. (2011). Unconventional Monetary Policy: Lessons from the Past Three Years. *FRBSF Economic Letter*, 2011-31.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

A. Appendix

We describe asset price data used in this paper, each of which is considered as the information variables in the monetary policy process. We refer to some literatures on the information roles of each asset price in the BOJ's policy.

A.1. FX Rate

There are some chronologies on dollar-yen exchange rate depicted in Figure A-1. The BOJ followed monetary expansion during the second half of the 1980s, with a purpose of such an international policy coordination as the Plaza Agreement for aiming at dollar's depreciations in 1985 and the Louvre Agreement for preventing excessive yen's appreciations in 1986. The expansion resulted in the asset price bubbles in stock and land prices in Japan (Okina, Shirakawa and Shiratsuka, 2000). Around 1990, on the rebound, the BOJ turned into monetary contraction for a purpose of leaning against the asset bubbles.

Figure A-1 Policy Response to Asset Price Fluctuations: FX Rate

Source: the Bank of Japan

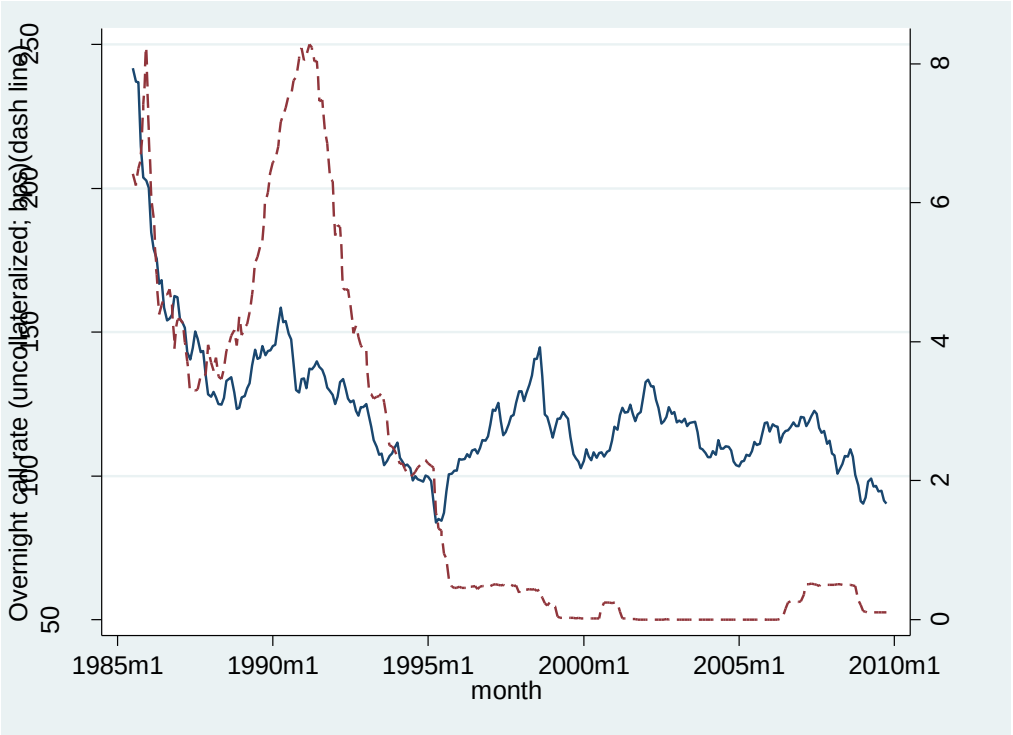


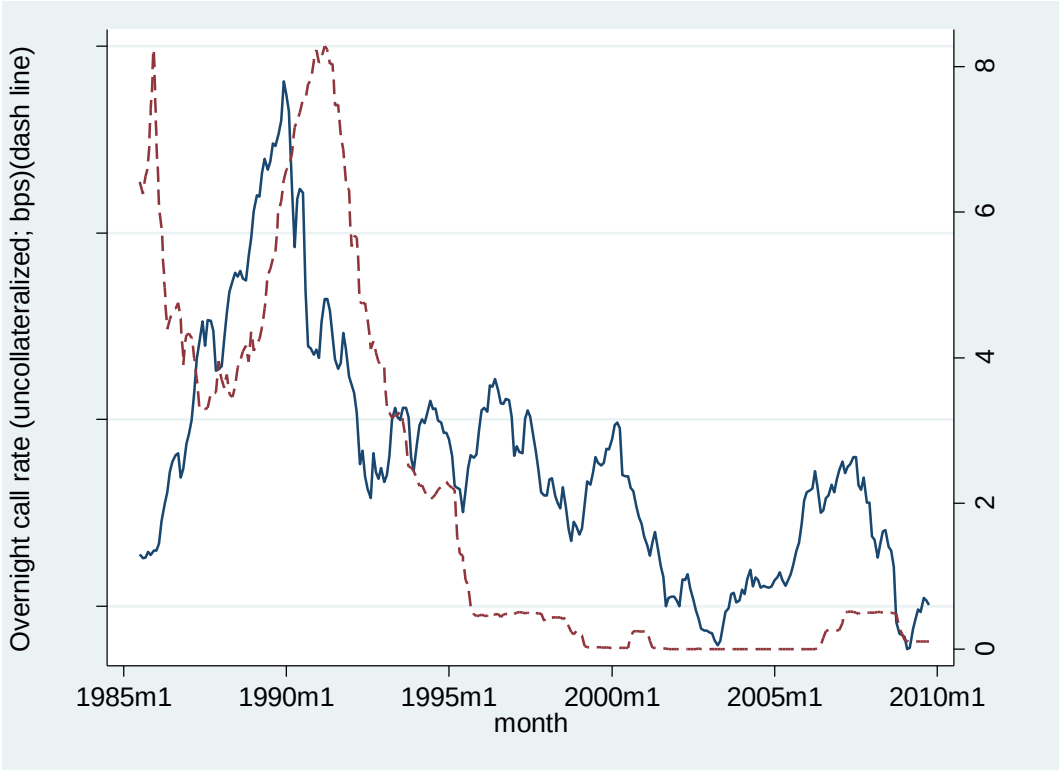
Figure A-1X suggests that since the mid-1995 when the overnight call loans rate became below the then official rate 0.5%, the yen was depreciating for a while. Thereafter in the long-run, the yen is moving

toward a direction of the appreciation. During the QEP period, there was also a policy debate concerning how effective unsterilized FX intervention policy was (Hamada and Okada, 2009).

A.2. Stock Price Index

Figure A-2X indicates the Nikkei average index, the Japanese representative stock price had gone boom since the mid-1980s and went bust in 1991. Focusing on the then monetary policy the BOJ operated, Bernanke and Gertler (1999; 2001) advocated that the stock price targeting policy-rule impaired macroeconomic stability, and that the stock prices could not be useful for the monetary policy only until the stock prices played an informational role in predicting inflation rate and output gap.

Figure A-2 Policy Response to Asset Price Fluctuations: Stock Price Index
Source: Nikkei; the Bank of Japan



In recent years, the stock price targeting policy is reevaluated as a pragmatic policy choice by Lansing (2008) and Farmer (2009). Lansing (2008) shows that a Taylor rule incorporating year-to-year percentage change of the S&P500 Stock Price Index, can well explain the actual US FF rate, except for 2003-2005 when as Taylor (2009) criticized the Fed for the housing bubble, the FF rate was extraordinarily at lower levels. On the other hand, Farmer (2009) proposes a stock-price-index targeting of monetary policy rule for a reason of controlling fluctuations in employment through expectations, in which the stock prices are considered as playing a crucial role.

A.3. Government Bond Yield

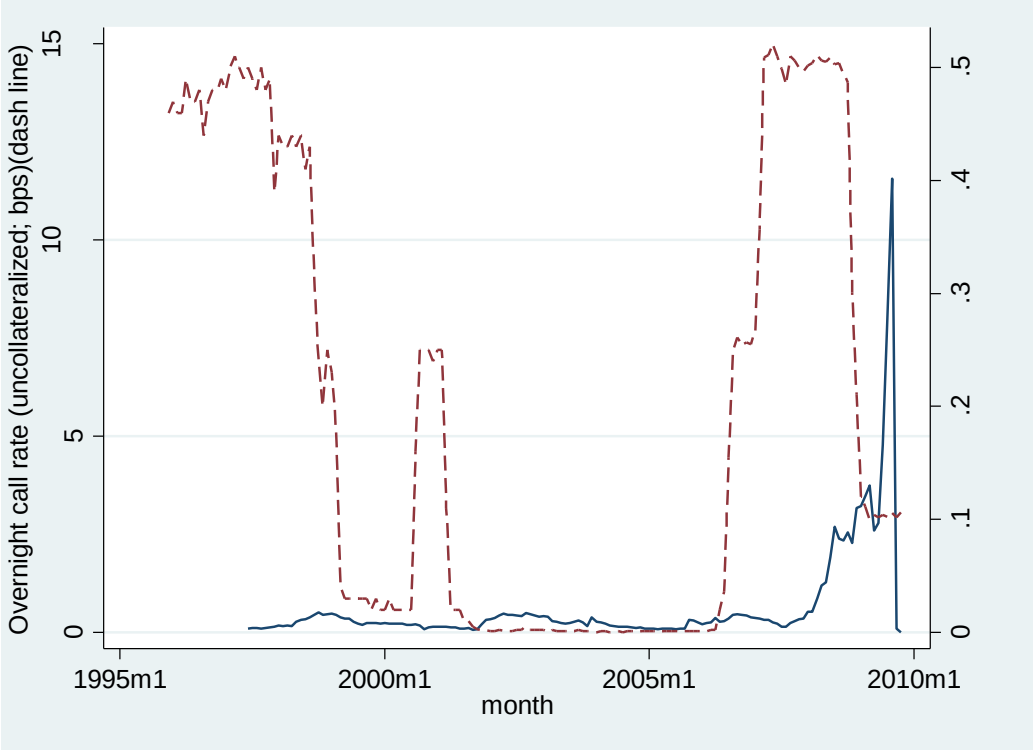
Ireland (1996) for the US and Takeda and Yajima (2006) for Japan empirically showed it was a premium for inflation risk that dominated the long-term government bond rates. Takeda, Komaki and Yajima (2005) also analyzed the daily effects of changes in the QEP policy on the JGB yield structure, suggesting increases in the outright purchases of the JGBs were immediately followed by rises in the estimated premiums, especially in the inflation risk premium. In the BOJ's monetary policy, indeed the JGB markets with high turnovers, as Figure 2 indicates, are consider as playing a role of information source in monetary policy decision-making, as well as roles of both interest rates free from credit risk and instruments of money market operations (Financial Markets Department, the BOJ, 2004).

A.4. Credit Spread

Figure A-3X depicts a credit spread in the 3-year remaining yield differential between Baa and A Moody's ratings, showing a spike at 11.6% in August 2009 after the spread had been gradually heightened since the sub-prime loans problem became an issue in April 2008.

Figure A-3 Policy Response to Asset Price Fluctuations: Credit Spreads (Moody's Rating)

Source: Japan Securities Dealers Association; Moody's; the Bank of Japan



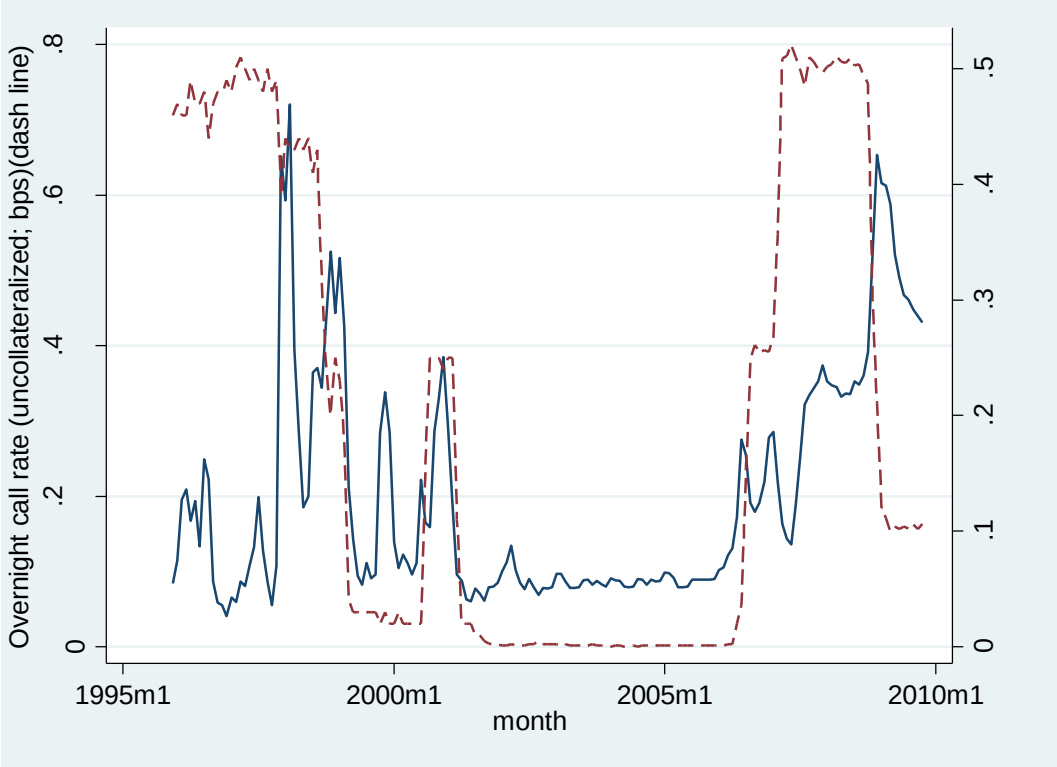
In the face of the credit spread in the financial markets, it has been researched what is a role of credit spread in monetary policy. In theory, Cúrdia and Woodford (2009) analyze how much a Taylor rule together with a credit spread can improve social welfare, showing in the New Keynesian model, optimal monetary policy does not cancel out fully an increase in the credit spread. Some empirical studies also support a credit-spread augmented Taylor rule (Talyor, 2008; McCulley and Toloui, 2008).

A.5. Term Spread

Figure A-5X depicts some notable spikes of term spread, defined as the 3-month Japanese yen TIBOR minus the unsecured overnight call loans rate. Timing of the spikes corresponds to liquidity events like the Y2K problem at the year end of 1999; the 9.11 shock in September 2001; and the Lehman shock in September 2008. The duration effect of the ZIRP and the QEP reducing term spreads in Japan was also empirically shown by Baba, Nakashima, Shigemi and Ueda (2006) or Takeda, Komaki and Yajima (2005).

Figure A-5 Policy Response to Asset Price Fluctuations: Term Spread

Source: The Bank of Japan, and other sources



A.6. Miscellaneous: Crude Oil Price and REIT Index

Finally, we pick up two asset prices: the crude oil Dubai price and the J-REIT index. The crude oil price has been considered as an important information variable of the monetary policy, especially for the BOJ which experienced domestic rampant inflation transmitted through imported-goods pricing by the oil shocks in 1973 and 1979. As for the US Fed which is accused of having disregarded the housing price bubble until housing prices collapsed and the sub-prime loans problem was invited, the REIT index is informative to monetary policy of the BOJ which experienced the real estate boom and bust for the mid-80s to 1992, too.

Figure A-6X depicts the representative price, the crude oil Dubai price. On November 25, 2009, from the so-called Dubai shock the crude oil price went bust after going boom. The shock as a result, caused capital flight of the oil money invested into the oil-producing countries to the Japanese yen, rapidly appreciating up to 1 US dollar=90 yen.

Figure A-6 Policy Response to Asset Price Fluctuations: Crude Oil Price

Source: The Bank of Japan, and other sources

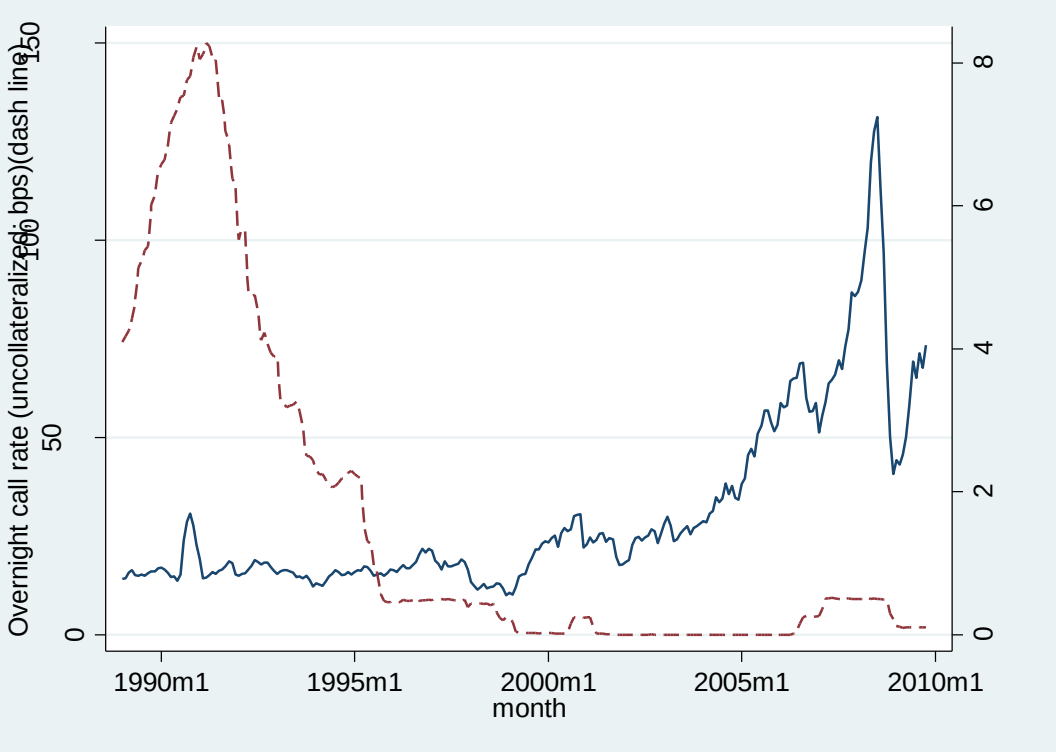
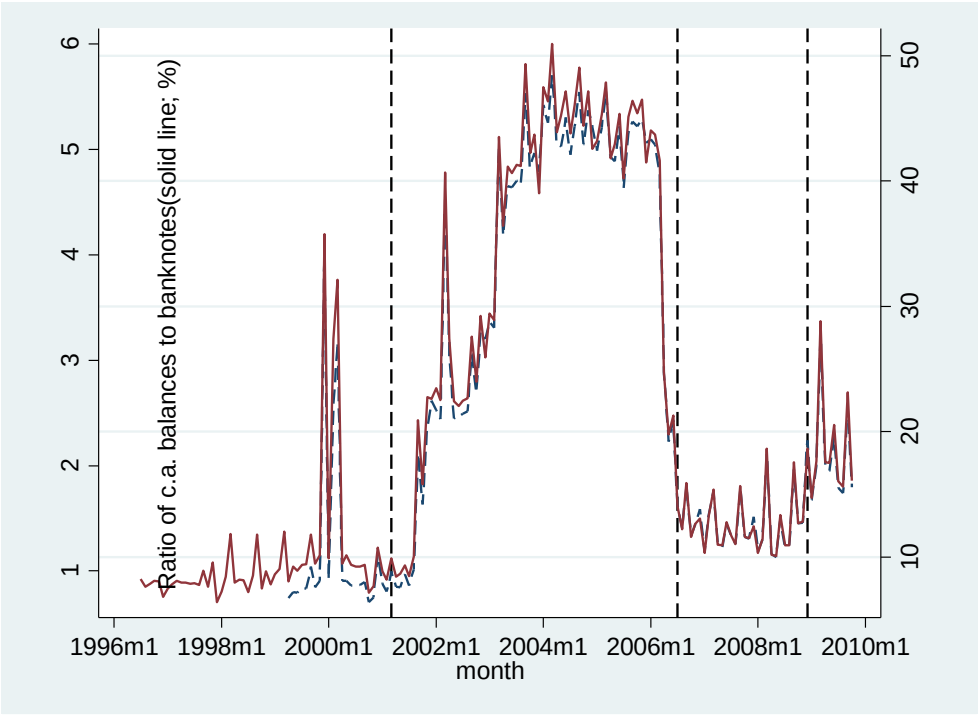


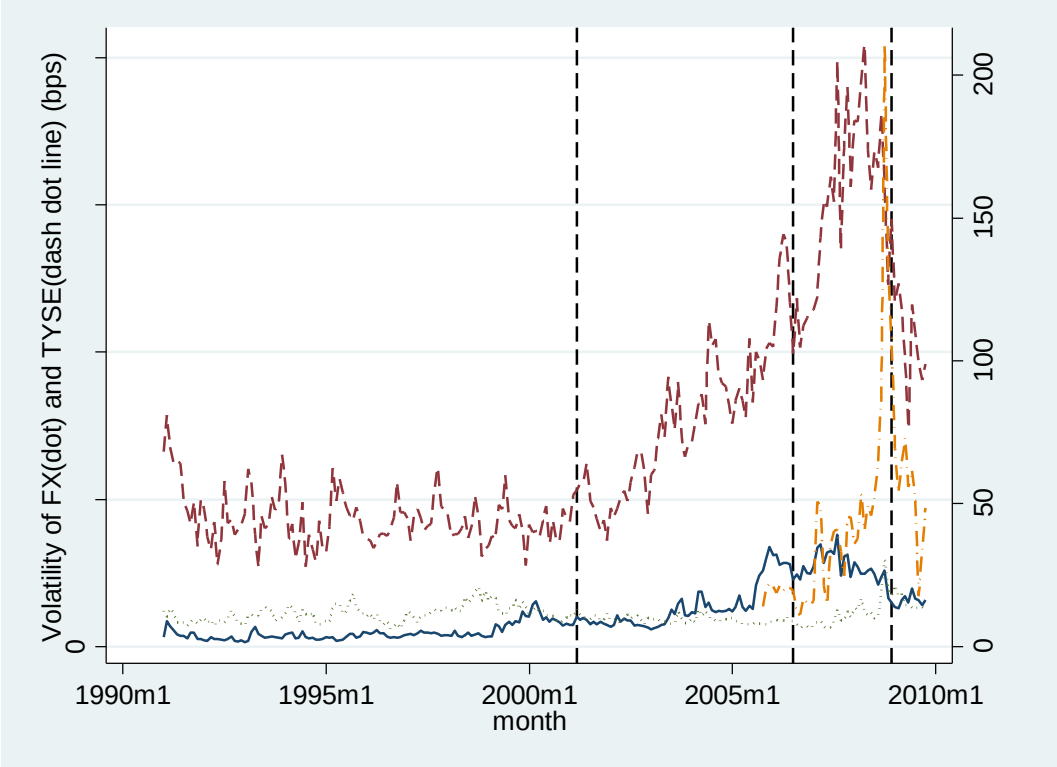
Figure 1 Current Account Balances at the Bank of Japan

(Ratios of Issued Banknotes and Bank Deposits)



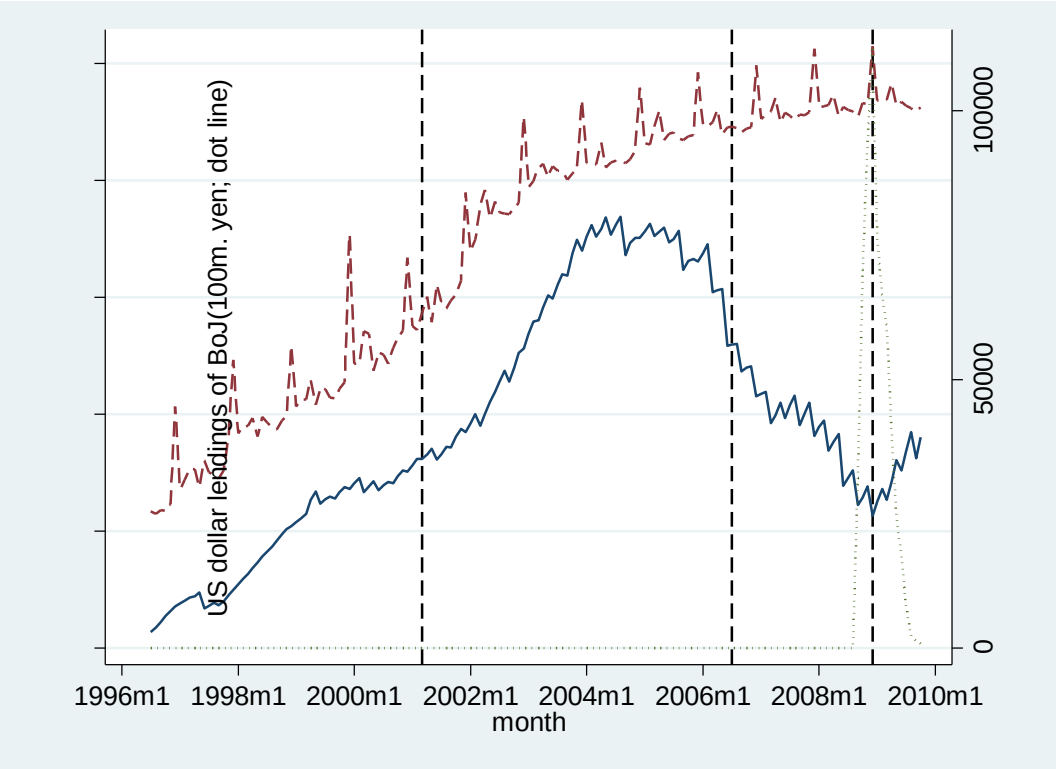
Source: The Bank of Japan.

Figure 2 Turnover and Volatility



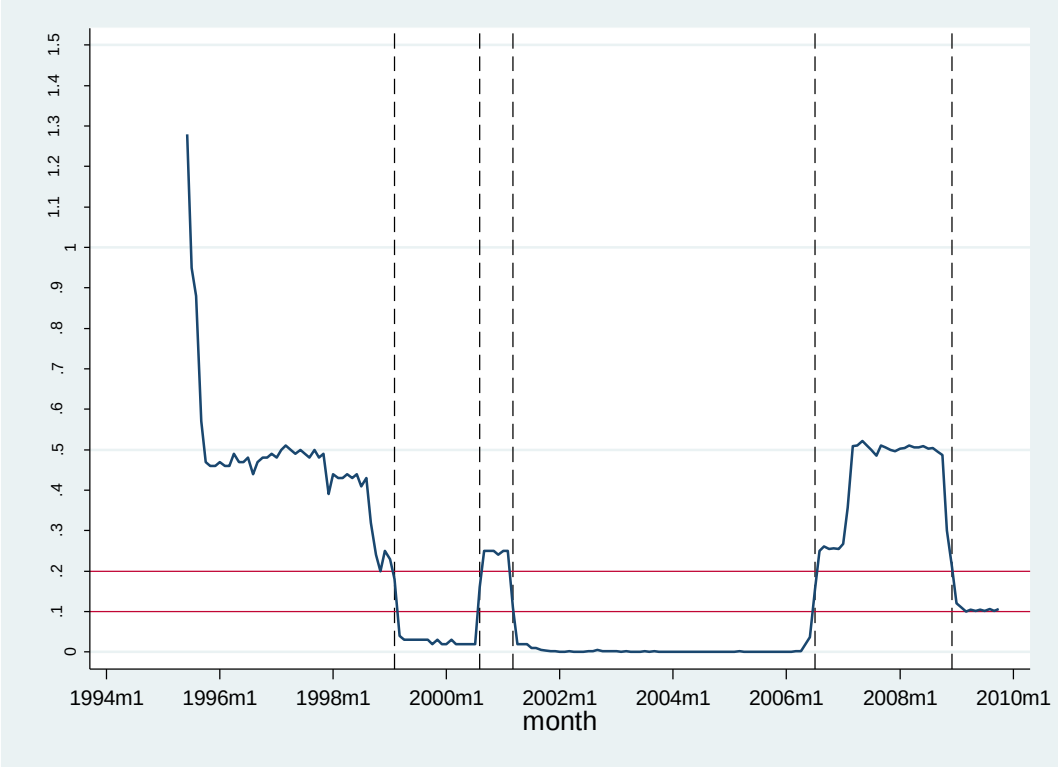
Sources: The Bank of Japan, Tokyo Stock Exchange, Japan Securities Dealers Association, and Bloomberg.

Figure 3 Balance Sheet of the Bank of Japan



Source: The Bank of Japan

Figure 4 Uncollateralized Overnight Call Rate Floor and the Zero-Interest Rate Policy



Source: The Bank of Japan.

Table 1 History of the Zero-Interest Rate and Quantitative Easing Policies

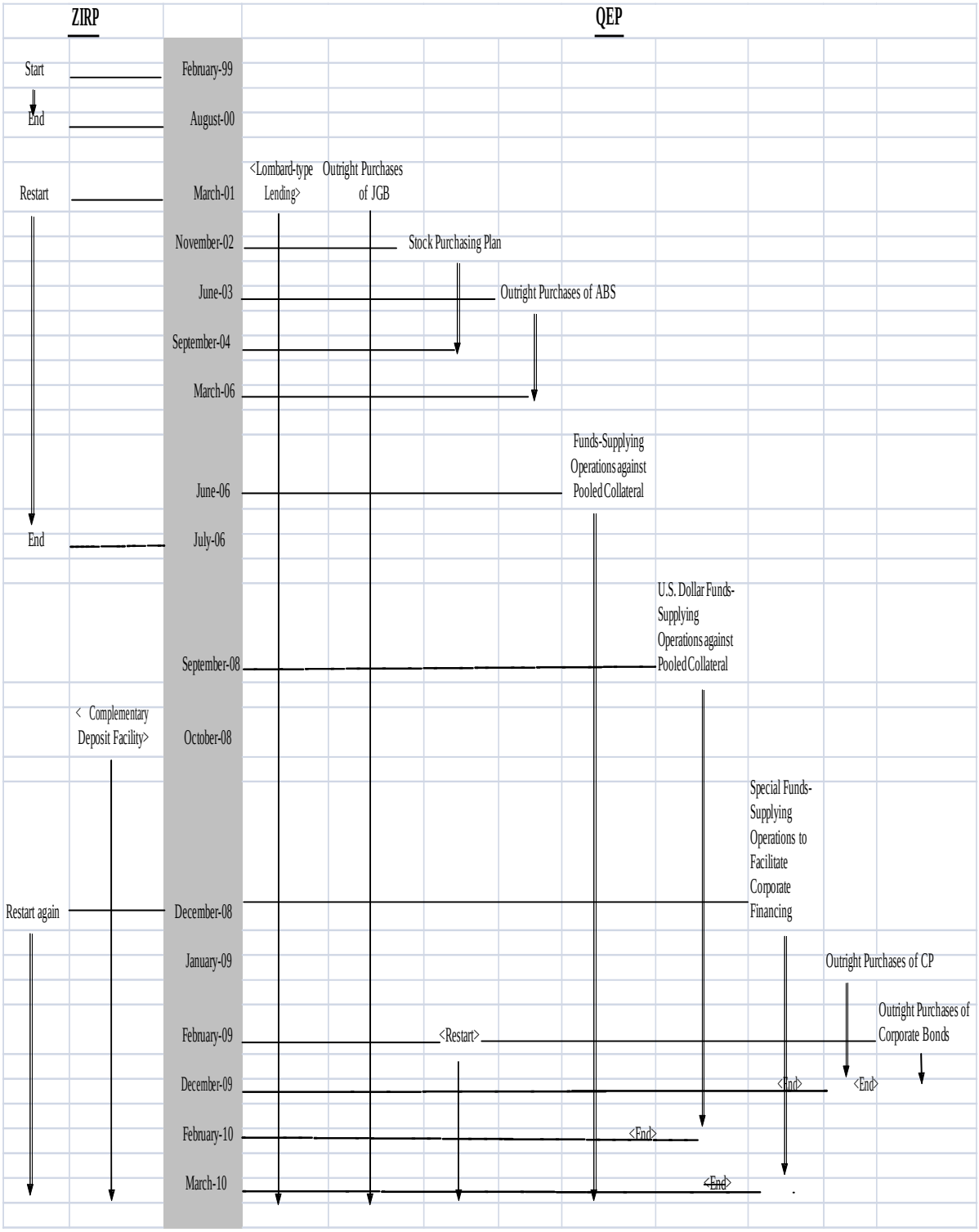


Table 2 Non-Linear Taylor Rule Estimated (Tobit Model with the Floor 0.1%)

Floor 0.1%(the # of Censored 80)	Tobit Model (Significance Level 10%*, 5%**, 1%			
(Inflation, Output): Log-Likelihood	Const.	Lagged Call Rate	Inflation	Output
(CPI General, IIP Original); −14.87	−.08***	.99***	.03**	4.46E-03**
(CPI General, IIP Seasonally Adjusted); −16.65	−.08***	.99***	.04**	3.47E-03
(CPI General, IIP Utilization Adjusted Original); −16.18	−.08***	.99***	.04**	3.37E-03*
(CPI General, IIP Utilization Seasonally Adjusted); −17.03	−.08***	.99***	.04**	2.77E-03
(Core CPI General, IIP Original); −15.71	−.08***	1.00***	.03	4.81E-03**
(Core CPI General, IIP Seasonally Adjusted); −17.54	−.08***	1.00***	.03	4.28E-03
(Core CPI General, IIP Utilization Adjusted Original); −17.12	−.08***	1.00***	.03*	3.76E-03*
(Core CPI General, IIP Utilization Seasonally Adjusted); −18.00	−.08***	1.00***	.03*	3.49E-03

Table 3 Non-Linear Taylor Rule Estimated (Tobit Model with the Floor 0.2%)

Floor 0.2%(the # of Censored 93)	Tobit Model (Significance Level 10%*, 5%**, 1%			
(Inflation, Output): Log-Likelihood	Const.	Lagged Call Rate	Inflation	Output
(CPI General, IIP Original); −10.06	−.08***	.99***	.04**	.01*
(CPI General, IIP Seasonally Adjusted); −12.15	−.08***	1.00***	.03*	.01
(CPI General, IIP Utilization Adjusted Original); −10.85	−.08***	.99***	.04*	.01*
(CPI General, IIP Utilization Seasonally Adjusted); −11.65	−.08***	1.00***	.03	.01**
(Core CPI General, IIP Original); −10.76	−.09***	1.00***	.03	.01*
(Core CPI General, IIP Seasonally Adjusted); −12.69	−.09***	1.00***	.03	.01*
(Core CPI General, IIP Utilization Adjusted Original); −11.54	−.08***	1.00***	.03	.01**
(Core CPI General, IIP Utilization Seasonally Adjusted); −12.11	−.09***	1.00***	.02	.01**

Table 4 Non-Linear Taylor Rule Estimated (Censored Normal Regression Model)

Floor 0.1% or 0.2%	Censored Normal Regression Model (Significance Level 10%*, 5%**, 1%***)			
(Inflation, Output): Log-Likelihood	Const.	Lagged Call Rate	Inflation	Output
(CPI General, IIP Original); −28.80	−.13***	1.00***	.05***	.01***
(CPI General, IIP Seasonally Adjusted); −29.94	−.13***	1.00***	.04**	.01***
(CPI General, IIP Utilization Adjusted Original); −29.96	−.13***	1.00***	.05***	.01***
(CPI General, IIP Utilization Seasonally Adjusted); −29.97	−.13***	1.00***	.04**	.01***
(Core CPI General, IIP Original); −29.70	−.13***	1.00***	.04**	.01***
(Core CPI General, IIP Seasonally Adjusted); −30.55	−.13***	1.00***	.04*	.01***
(Core CPI General, IIP Utilization Adjusted Original); −30.86	−.13***	1.00***	.04**	.01***
(Core CPI General, IIP Utilization Seasonally Adjusted); −30.55	−.13***	1.00***	.04***	.01***

Table 5 Predicted Signs of a Coefficient on Each Asset Price in the Taylor Rule

Asset Prices	Predicted Signs
Dollar-Yen FX Rate	+
Nominal Effective FX Rate of Yen	−
Stock Price Indexes	+
10-year JGB Yield	−
Credit Spreads	−
Term Spreads	−
Crude Oil Dubai Price	+
J-REIT Index	+

Table 6 Asset Prices in the Monetary Policy Rule (FX Rates)

		Asset Price: FX Rate (Year-to-Year Percentage Change)	
Models	Explanatory Variables	Dollar-Yen Rate	Nominal Effective FX Rate of Yen
Tobit Model (Floor 0.2%)	Const.	−.08***	−.07***
	Lagged Call Rate	1.01***	1.00***
	Inflation	.02	.02
	Output	.01***	.01***
	Asset Price	3.98E-03***	−3.81E-03***
Censored Normal Regression Model	Const.	−.13***	−.12***
	Lagged Call Rate	1.01***	1.01***
	Inflation	.03*	.04**
	Output	.01***	.01***
	Asset Price	3.81E-03***	−3.32E-03**

Table 7 Asset Prices in the Monetary Policy Rule (Stock Price Indexes)

		Asset Price: Stock Price Indexes (Year-to-Year Percentage Change)	
Models	Explanatory Variables	Nikkei Stock Average	TOPIX
Tobit Model (Floor 0.2%)	Const.	−.09***	−.09***
	Lagged Call Rate	.99***	.99***
	Inflation	.06***	.05***
	Output	.01***	.01***
	Asset Price	2.08E-03***	1.52E-03**
Censored Normal Regression Model	Const.	−.13***	−.13***
	Lagged Call Rate	.99***	.99***
	Inflation	.06***	.06***
	Output	.01***	.01***
	Asset Price	1.82E-03***	1.23E-03*

Table 8 Asset Prices in the Monetary Policy Rule (Government Bond Yield)

Models	Explanatory Variables	Asset Price: 10-Year JGB Yield
Tobit Model (Floor 0.2%)	Const.	−.02
	Lagged Call Rate	.89***
	Inflation	−9.24E-04
	Output	1.69E-03**
	Asset Price	.03***
Censored Normal Regression Model	Const.	−.14***
	Lagged Call Rate	1.12***
	Inflation	−1.72E-03
	Output	1.30E-03
	Asset Price	.04***

Table 9 Asset Prices in the Monetary Policy Rule (Credit Spreads [1])

		Asset Price: Credit Spreads							
		Moody's Credit Ratings							
	Remaining Terms	1 Year		3 Years		5 Years	10 Years		
Models	Explanatory Variables	Baa-A	Baa-Aa	Baa-A	Baa-Aa	A-Aa	A-Aa	A-10yr JGB	Aa-10yr JGB
Tobit Model (Floor 0.2%)	Const.	.04*	.05**	.03	.04*	.06***	.05*	.05*	.05*
	Lagged Call Rate	.90***	.90***	.90***	.90***	.90***	.88***	.88***	.88***
	Inflation	.01	.01	.01	.01	.01	2.74E-03	3.48E-03	4.43E-03
	Output	1.57E-03*	1.20E-03	1.55E-03*	1.43E-03*	−.1.27E-05	1.26E-03	1.19E-03	1.29E-03
	Asset Price	−.03***	−.04***	−.02**	−.02***	−.15***	−.07	−.04	−.05
Censored Regression Model Normal	Const.	−.08***	−.07***	−.08***	−.07***	−.05***	−.09***	−.09***	−.09***
	Lagged Call Rate	1.18***	1.18***	1.17***	1.18***	1.20***	1.18***	1.17***	1.16***
	Inflation	.01	.01	.01	.01	.01	1.82E-03	2.16E-03	2.13E-03
	Output	9.77E-04	6.21E-04	9.87E-04	8.23E-04	−5.25E-04	1.30E-03	1.47E-03	1.59E-036
	Asset Price	−.04**	−.04***	−.02**	−.02**	−.17***	−.02	−6.85E-04	.02

Table 10 Asset Prices in the Monetary Policy Rule (Credit Spreads [2])

		Asset Price: Credit Spreads		
		Nomura BPI: Industrial -Government Bonds (Maturities)		
Models	Explanatory Variables	Short-Term	Medium-Term	Long-Term
Tobit Model (Floor 0.2%)	Const.	−.09***	−.08***	−.08***
	Lagged Call Rate	1.00***	1.00***	1.00***
	Inflation	.03	.03	.03
	Output	.01***	.01***	.01***
	Asset Price	.01**	3.14E-03	6.61E-04
Censored Normal Regression Model	Const.	−.13***	−.13***	−.13***
	Lagged Call Rate	1.00***	1.00***	1.00***
	Inflation	.04**	.04**	.04**
	Output	.01***	.01***	.01***
	Asset Price	.01**	3.12E-03	4.59E-04

Table 11 Asset Prices in the Monetary Policy Rule (Credit Spreads [3])

		Asset Price: Credit Spreads			
		Japan Premium			
		1 Month	3 Months		6 Months
Models	Explanatory Variables	Japanese Yen TIBOR - Japanese Yen LIBOR	Japanese Yen TIBOR - Japanese Yen LIBOR	CD - Japanese Yen LIBOR	Japanese TIBOR - Japanese Yen LIBOR
Tobit Model (Floor 0.2%)	Const.	.02	.03	.03	.02
	Lagged Call Rate	.90***	.89***	.91***	.92***
	Inflation	7.04E-04	1.32E-03	1.76E-03	2.17E-03
	Output	2.75E-03***	2.68E-03**	2.81E-03**	2.82E-03**
	Asset Price	.14	.04	.12	.11
Censored Normal Regression Model	Const.	−.11***	−.12***	−.09***	−.12***
	Lagged Call Rate	1.20***	1.23***	1.25***	1.25***
	Inflation	2.84E-03	5.12	3.73E-03	6.84E-03
	Output	2.30E-03*	2.95E-03**	2.56E-03*	2.69E-03**
	Asset Price	.15	.29*	.27	.34**

Table 12 Asset Prices in the Monetary Policy Rule (Term Spreads)

		Asset Price: Term Spreads		
Models	Explanatory Variables	Japanese Yen TIBOR 1 Month − Call Rate	Japanese Yen TIBOR 3 Months − Call Rate	Japanese Yen TIBOR 6 Months − Call Rate
Tobit Model (Floor 0.2%)	Const.	.07***	.07***	.07***
	Lagged Call Rate	.88***	.89***	.90***
	Inflation	4.42E-03	4.01E-03	2.5E-03
	Output	1.19E-03**	9.47E-04	9.93E-04
	Asset Price	−.14***	−.11***	−.11***
Censored Normal Regression Model	Const.	−.07***	−.07***	−.08***
	Lagged Call Rate	1.15***	1.15***	1.15***
	Inflation	1.31E-03	6.88E-04	2.32E-04
	Output	1.20E-03	1.20E-03	1.29E-03
	Asset Price	−.05	−.02	−6.33E-03

Table 13 Asset Prices in the Monetary Policy Rule (Miscellaneous Asset Prices)

		Miscellaneous Asset Prices (Year-to-Year Percentage Change)	
Models	Explanatory Variables	Crude Oil Dubai Price	J-REIT Index
Tobit Model (Floor 0.2%)	Const.	−.07***	.04
	Lagged Call Rate	.98***	.84***
	Inflation	.03**	.03*
	Output	3.56E-03*	2.88E-03**
	Asset Price	4.55E-04	1.14E-03***
Censored Normal Regression Model	Const.	−.10***	−.08***
	Lagged Call Rate	.98***	1.09***
	Inflation	.05***	.03
	Output	.01***	2.25E-03
	Asset Price	−1.55E-04	1.16E-03***

Table 14 Variable List of Unconventional Monetary Policy Measures

Channels of the Effects of Unconventional Measures	Variables
Funding liquidity of financial intermediations	Ratio of outstanding current account balances at the BOJ to outstanding bank deposits (total amount of domestic banks, domestic branches of foreign banks and shinkin banks); %.
	Ratio of US dollar denominated loans (converted into yen with dollar-yen exchange rate each present month) to outstanding bank deposits; %.
Market liquidity of financial assets	Outright purchases of JGB; hundred million yen.
	Outright purchases of ABS; hundred million yen.
	Stock purchasing plan; hundred million yen.
	Sum of fund-supplying operations against pooled collateral and special funds-supplying operations to facilitate corporate financing; hundred million yen.
	US dollar fund-supplying operations against pooled collateral; converted into hundred million yen.
	Outright purchases of CP and ABCP (a-1 rating and 3-month maturity or shorter); hundred million yen.
	Outright purchases of corporate bonds (A rating or higher and 1-year maturity or shorter); hundred million yen.
Central bank's balance sheet	Ratio of outstanding current account balances at the BOJ to issued BOJ banknote balance; %.
	Ratio of US dollar loans balance (converted into yen) to issued BOJ banknote balance; %.
	Ratio of long-term JGBs to issued BOJ banknote balance; %.
	Ratio of ABS to issued BOJ banknote balance; %.
	Ratio of pecuniary trusts (stocks held as trust property) to issued BOJ banknote balance; %.
	Ratio of loans made by way of fund-supplying operations against pooled collateral and special fund-supplying operations to facilitate corporate financing, relative to issued BOJ banknote balance; %.
	Ratio of CPs to issued BOJ banknote balance; %.
	Ratio of corporate bonds to issued BOJ banknote balance; %.

Table 15 Two-Step Estimator of Newey (1987): FX Rates

Two Steps	Asset Price: FX Rates (Year-to-Year Percentage Change)	Dollar-Yen FX Rate	Nominal Effective FX Rate of Yen
1st stage	BOJ CA balances/ total bank deposits	7.806243	-7.65254
	US dollar loans/ total bank deposits	-51.50641	5.434943
	Outright JGB purchases	0.0006315	-0.0013802**
	Outright ABS purchases	0.0014911	-0.0016408
	Stock purchasing plan	-0.0025553**	0.0023931**
	Fund-supplying operations, etc.	0.0000766**	-0.000066**
	US dollar fund-supplying operations	-7.37E-08	-0.0001792
	Outright CPs purchases	-0.001099	0.0012349
	Outright CB purchases	-0.0179678	0.0240998
	BOJ CA balances/ BOJ banknotes	-1.101823	1.050408
	US dollar loans/ BOJ banknotes	4.387717	3.130758
	Long-term JGBs/ BOJ banknotes	-0.7460176***	0.5540955**
	ABS/BOJ banknotes.	-2.984005	11.94343
	Stocks/ BOJ banknotes	2.866271	-2.249499
	Loans of fund-supplying operations, etc./ BOJ banknotes	-0.8822291***	0.7122123***
	CPs/BOJ banknotes.	11.38187	-11.06794
	CB/ BOJ banknotes	0.1810926	42.60823
2_{nd}stage	Inflation	0.0460089***	0.0659704***
	Output	0.0090699***	0.0141397***
	Asset Price	0.0004648	-0.0009081
	Lagged Call Rate	0.5065141***	0.317304***
	Const.	0.1208257***	0.155273***
Wald Test of Exogeneity(chi-square; p-value)		4.03; 0.2586	3.54; 0.3158

Table 16 Two-Step Estimator of Newey (1987): Stock Price Indexes

Two Steps	Asset Price: Stock Price Indexes(Year-to-Year Percentage Change)	Nikkei	TOPIX
1st stage	BOJ CA balances/ total bank deposits	-58.48699***	-61.23015***
	US dollar loans/ total bank deposits	108.8709	61.90563
	Outright JGB purchases	-0.0020557*	-0.0039959***
	Outright ABS purchases	-0.0014446	-0.0017342
	Stock purchasing plan	-0.0034815	-0.0026487
	Fund-supplying operations, etc.	0.0000393	0.0000404
	US dollar fund-supplying operations	0.0002092	0.0002002
	Outright CPs purchases	-0.0014034	-0.0015552
	Outright CB purchases	-0.0331098	-0.0262539
	BOJ CA balances/ BOJ banknotes	6.248825***	6.684186***
	US dollar loans/ BOJ banknotes	-17.53572	-11.67505
	Long-term JGBs/ BOJ banknotes	-1.027627**	-1.116281**
	ABS/BOJ banknotes.	38.16432	41.90509
	Stocks/ BOJ banknotes	22.99605***	24.3801***
	Loans of fund-supplying operations, etc./ BOJ banknotes	-0.2192593	-0.1721215
	CPs/BOJ banknotes.	1.827278	2.087422
	CB/ BOJ banknotes	-40.94447	-23.20402
2_{nd}stage	Inflation	0.082979***	0.0793369***
	Output	0.0178091***	0.0192787***
	Asset Price	-0.0003966	-0.001376**
	Lagged Call Rate	0.1774484**	0.0877699
	Const.	0.1726205***	0.1914312***
Wald Test of Exogeneity (chi-square; p-value)		3.15; 0.3695	2.79; 0.4251

Table 17 Two-Step Estimator of Newey (1987): 10-year JGB Yield

Two Steps	Asset Price: Government Bond Yield	10-year JGB Yield
1st stage	BOJ CA balances/ total bank deposits	-1.030493***
	US dollar loans/ total bank deposits	0.8448906
	Outright JGB purchases	-0.0000321**
	Outright ABS purchases	-0.0001257***
	Stock purchasing plan	-0.0000823***
	Fund-supplying operations, etc.	1.20E-06
	US dollar fund-supplying operations	5.65E-06
	Outright CPs purchases	-0.0000243
	Outright CB purchases	-0.0002758
	BOJ CA balances/ BOJ banknotes	0.1042305***
	US dollar loans/ BOJ banknotes	-0.1596163
	Long-term JGBs/ BOJ banknotes	-0.0273593***
	ABS/BOJ banknotes.	1.8247***
	Stocks/ BOJ banknotes	0.248427***
	Loans of fund-supplying operations, etc./ BOJ banknotes	-0.0096471**
	CPs/BOJ banknotes.	0.1493555
	CB/ BOJ banknotes	0.0989824
2_{Nd}stage	Inflation	0.0730645***
	Output	0.0220827***
	Asset Price	-0.4085503***
	Lagged Call Rate	0.130793*
	Const.	0.8185367***
Wald Test of Exogeneity (chi-square; p-value)		3.24; 0.3563

Table 18 Two-Step Estimator of Newey (1987): Credit Spreads[1 - 1]

Two Steps	Asset Price: Credit Spreads (Moody's Credit Rating)	1-Year Remaining Baa-A	1-Year Remaining Baa-Aa	3-Year Remaining Baa-A	3-Year Remaining Baa-Aa
1st stage	BOJ CA balances/ total bank deposits	0.0153844	-0.0269624	-0.1822636	-0.2619546
	US dollar loans/ total bank deposits	-1.398486	-0.4394598	1.310112	1.871119
	Outright JGB purchases	0.0000191	0.0000253	0.0000529	0.0000585
	Outright ABS purchases	-0.0000452	-0.0000478	-0.0000454	-0.000052
	Stock purchasing plan	-0.0000223	-0.0000219	-0.000036	-0.0000235
	Fund-supplying operations, etc.	4.91E-07	3.06E-07	1.48E-07	-9.38E-07
	US dollar fund-supplying operations	0.0000202	0.0000198	1.58E-06	5.08E-06
	Outright CPs purchases	0.0005284***	0.0005158***	0.0007548***	0.0007563***
	Outright CB purchases	0.0144123***	0.0140047***	0.0188413***	0.0188002***
	BOJ CA balances/ BOJ banknotes	0.0009628	0.006699	0.0235943	0.0343749
	US dollar loans/ BOJ banknotes	0.1771097	0.075013	0.0011264	-0.0520951
	Long-term JGBs/ BOJ banknotes	0.0039228	0.0039363	-0.0080976	-0.0081864
	ABS/BOJ banknotes.	0.5387242	0.6167361	0.78774	0.9465732
	Stocks/ BOJ banknotes	-0.181321	-0.2553505**	-0.1977363	-0.2864007*
	Loans of fund-supplying operations, etc./ BOJ banknotes	0.019277	0.0216347	0.0174527	0.0256638
	CPs/BOJ banknotes.	-3.716221***	-3.593331***	-5.032348***	-4.97441***
	CB/ BOJ banknotes	3.170407*	4.398408**	2.95647	4.05436
2_{nd}stage	Inflation	0.0270194**	0.0223081*	0.041942***	0.0411671***
	Output	0.0128085***	0.0119048***	0.0128037***	0.0119353***
	Asset Price	-0.0535326***	-0.0527135***	-0.0341314***	-0.0332921***
	Lagged Call Rate	0.5192118***	0.5406687***	0.4850667***	0.5092652***
	Const.	0.1331661***	0.1376414***	0.1343228***	0.137891***
Wald Test of Exogeneity (chi-square; p-value)		3.84; 0.279	3.55; 0.3148	3; 0.3913	2.94; 0.4004

Table 19 Two-Step Estimator of Newey (1987): Credit Spreads[1‐2]

Two Steps	Asset Price: Credit Spreads (Moody's Credit Rating)	5-Year Remaining A-Aa	10-Year Remaining A-Aa	10-Year Remaining A-JGB	10-Year Remaining Aa-JGB
1st stage	BOJ CA balances/ total bank deposits	-0.0964213	-0.0383753	-0.2232712	-0.1848959*
	US dollar loans/ total bank deposits	-1.631779	-0.282062	-1.03912	-0.7570579
	Outright JGB purchases	4.80E-07	-3.10E-06	-0.0000161	-0.0000129*
	Outright ABS purchases	-9.22E-06	1.62E-06	6.77E-07	-9.41E-07
	Stock purchasing plan	5.15E-06	0.0000192*	0.000024	4.77E-06
	Fund-supplying operations, etc.	-5.58E-07	-1.91E-07	-3.79E-07	-1.88E-07
	US dollar fund-supplying operations	-8.29E-06**	-1.48E-06	-7.42E-06	-5.93E-06*
	Outright CPs purchases	-6.47E-06	0.000036***	0.0000416**	5.58E-06
	Outright CB purchases	0.0001405	0.0013041***	0.0014443***	0.0001403
	BOJ CA balances/ BOJ banknotes	0.0113917	0.0035307	0.0232124	0.0196817*
	US dollar loans/ BOJ banknotes	0.276716	0.0465604	0.1803373	0.1337769
	Long-term JGBs/ BOJ banknotes	-0.0005292	0.0047286**	0.00544	0.0007114
	ABS/BOJ banknotes.	0.1877779	-0.1282812	-0.1914503	-0.0631691
	Stocks/ BOJ banknotes	-0.0782718***	-0.081252***	-0.0626012**	0.0186508
	Loans of fund-supplying operations, etc./ BOJ banknotes	0.0047362*	0.0013276	0.0042952	0.0029677
	CPs/BOJ banknotes.	0.3330835***	-0.3136482***	-0.3119458**	0.0017024
	CB/ BOJ banknotes	0.8328919**	0.4959279*	0.9785529**	0.482625
2_{nd}stage	Inflation	0.0650304***	0.0323731	-0.0550603***	0.0187653
	Output	-0.0012694	0.009595***	0.0135622***	0.0064901***
	Asset Price	-0.6831758***	-0.001199	-0.791543***	-1.305487***
	Lagged Call Rate	0.7131732***	0.5646785***	0.3768703***	0.5520527***
	Const.	0.2449543***	0.0979922***	0.4591798***	0.4439211***
Wald Test of Exogeneity (chi-square; p-value)		2.89; 0.4087	4.04; 0.2575	3.47; 0.3247	3.54; 0.3158

Table 20 Two-Step Estimator of Newey (1987): Credit Spreads [2]

Two Steps	Asset Price: Credit Spreads (Nomura BPI; Industrial-Government Bonds)	Short-Term	Medium-Term	Long-Term
1st stage	BOJ CA balances/ total bank deposits	-0.9851496	-2.185094	-3.263165
	US dollar loans/ total bank deposits	-8.122841	-4.178261	-186.2188***
	Outright JGB purchases	0.0001413*	0.0002033	-0.0000663
	Outright ABS purchases	-0.0001873	-0.0001953	-2.62E-06
	Stock purchasing plan	0.0001781	0.0003607	0.000582
	Fund-supplying operations, etc.	-3.52E-06	-8.61E-06	-0.0000105
	US dollar fund-supplying operations	-0.0000814**	-0.0001262*	-0.0002334**
	Outright CPs purchases	-0.0002879**	-0.000615**	-0.000446
	Outright CB purchases	0.0014813	-0.0013954	0.0043842
	BOJ CA balances/ BOJ banknotes	0.0657768	0.1774088	0.3387391
	US dollar loans/ BOJ banknotes	1.17548	0.926714	22.34469***
	Long-term JGBs/ BOJ banknotes	0.0613012*	0.1231034**	0.0038978
	ABS/BOJ banknotes.	1.822536	1.164644	2.177385
	Stocks/ BOJ banknotes	-0.3024597	-0.2880866	0.0802956
	Loans of fund-supplying operations, etc./ BOJ banknotes	0.0205755	0.0458989	0.0179615
	CPs/BOJ banknotes.	1.239703	3.133662	-0.1548377
	CB/ BOJ banknotes	-3.410838	-3.52421	1.544524
2nd stage	Inflation	0.06741***	0.0737331***	0.0538868***
	Output	0.0198035***	0.0187863***	0.0231071***
	Asset Price	-0.0514394***	-0.0343555***	-0.0227495***
	Lagged Call Rate	0.0896	0.0853116	0.0841566
	Const.	0.1942082***	0.1904938***	0.1807678***
Wald Test of Exogeneity (chi-square; p-value)		3.7; 0.2957	4.49; 0.2129	3.1; 0.3765

Table 21 Two-Step Estimator of Newey (1987): Credit Spreads [3]

Two Steps	Asset Price: Credit Spreads (Japan Premium)	1-Month TIBOR-LIBOR	3-Month TIBOR-LIBOR	3-Month CD-LIBOR	6-Month TIBOR-LIBOR
1st stage	BOJ CA balances/ total bank deposits	-0.0077366	0.0199833	0.0166732	0.0391311
	US dollar loans/ total bank deposits	0.2447844	-0.1933976	-0.110369	-0.0632005
	Outright JGB purchases	8.16E-07	-1.38E-07	5.94E-06***	-2.87E-06
	Outright ABS purchases	-6.94E-06	1.18E-07	-4.09E-06	1.13E-06
	Stock purchasing plan	-4.06E-07	1.99E-06	8.16E-07	6.05E-07
	Fund-supplying operations, etc.	-1.73E-08	1.67E-07*	1.49E-07	1.04E-07
	US dollar fund-supplying operations	-4.65E-06***	-2.97E-06***	-2.02E-06**	-1.64E-06*
	Outright CPs purchases	1.82E-08	2.88E-07	-1.17E-06	-4.37E-06
	Outright CB purchases	-0.0000603	-0.0001186	-0.0001486*	-0.0002261**
	BOJ CA balances/ BOJ banknotes	0.00126	-0.002706	-0.0025126	-0.0048405
	US dollar loans/ BOJ banknotes	-0.0100897	0.0382693	0.0235094	0.0122811
	Long-term JGBs/ BOJ banknotes	0.0012973*	0.001623**	0.0026032***	0.0026176***
	ABS/BOJ banknotes.	0.0250684	-0.0014939	0.0419396	-0.0314324
	Stocks/ BOJ banknotes	-0.0068153	0.0027782	-0.0074395	0.0010577
	Loans of fund-supplying operations, etc./ BOJ banknotes	0.0001364	-0.0009376	-0.0014918**	-0.0005807
	CPs/BOJ banknotes.	0.0349619	0.0419862*	0.0508005*	0.0694626**
	CB/ BOJ banknotes	0.4861606***	0.6945142***	0.468454***	0.5194348***
2nd stage	Inflation	0.0176473	-0.0046935	0.0729129***	0.0969469***
	Output	0.0181331***	0.014532***	0.017374***	0.0175489***
	Asset Price	-1.130543***	-1.482781***	0.0477386	0.5146029
	Lagged Call Rate	0.2627974***	0.2569313***	0.245141***	0.2839096***
	Const.	0.1340435***	0.140145***	0.1635552***	0.1609108***
Wald Test of Exogeneity (chi-square; p-value)		5.84; 0.1199	4.63; 0.2013	4.09; 0.2522	4.11; 0.2494

Table 22 Two-Step Estimator of Newey (1987): Term Spreads

Two Steps	Asset Price: Term Spreads	TIBOR 1 Month - Call Rate	TIBOR 3 Months - Call Rate	TIBOR 6 Months - Call Rate
1st stage	BOJ CA balances/ total bank deposits	0.0832151	0.0026024	-0.081551
	US dollar loans/ total bank deposits	1.613923*	0.1129525	0.1011901
	Outright JGB purchases	-0.0000223***	-7.94E-06*	-5.97E-06
	Outright ABS purchases	0.0000148	1.40E-06	-1.52E-06
	Stock purchasing plan	2.04E-06	-6.73E-07	-4.84E-06
	Fund-supplying operations, etc.	2.49E-07	2.69E-07	1.76E-07
	US dollar fund-supplying operations	-4.34E-06**	-6.76E-06***	-6.28E-06***
	Outright CPs purchases	-4.81E-06	-1.51E-06	-2.88E-06
	Outright CB purchases	0.0000205	-9.01E-06	-0.0000291
	BOJ CA balances/ BOJ banknotes	-0.0052544	-0.0005725	0.0068619
	US dollar loans/ BOJ banknotes	-0.1486168	0.0459482	0.0436934
	Long-term JGBs/ BOJ banknotes	-0.0080267***	-0.0038744**	-0.0039525**
	ABS/BOJ banknotes.	-0.0324529	0.0593953	0.0336068
	Stocks/ BOJ banknotes	0.0170696	0.0172535	0.0370154***
	Loans of fund-supplying operations, etc./ BOJ banknotes	-0.0005824	0.0006384	0.0013914
	CPs/BOJ banknotes.	0.0554609	0.0323608	0.0410496
	CB/ BOJ banknotes	0.6108865***	0.836894***	0.9148746***
2nd stage	Inflation	0.0552988***	0.0399971***	0.0400669***
	Output	0.0121981***	0.0049039*	0.0042794*
	Asset Price	-0.473635***	-0.7059813***	-0.7113407***
	Lagged Call Rate	0.5017345***	0.8790653***	0.905056***
	Const.	0.1828779***	0.2076046***	0.2353547***
Wald Test of Exogeneity (chi-square; p-value)		3.06; 0.3824	2.23; 0.5261	2.51; 0.4733

Table 23 Two-Step Estimator of Newey (1987): Miscellaneous (Crude Oil Dubai Price and J-REIT Index)

Two Steps	Asset Prices: Miscellaneous (Year-to-Year Percentage Change)	Crude Oil Dubai Price	J-REIT Index
1st stage	BOJ CA balances/ total bank deposits	-63.17299*	72.89214**
	US dollar loans/ total bank deposits	81.78978	98.1699
	Outright JGB purchases	-0.0065081***	0.0064085
	Outright ABS purchases	-0.0108192	-0.0000334
	Stock purchasing plan	0.0050343	-0.0071433
	Fund-supplying operations, etc.	-0.0000124	-0.0000294
	US dollar fund-supplying operations	0.0008912	-0.0007456
	Outright CPs purchases	-0.0010102	0.0005673
	Outright CB purchases	-0.0068714	0.0038835
	BOJ CA balances/ BOJ banknotes	8.298916**	-8.766642**
	US dollar loans/ BOJ banknotes	-22.05403	-7.195148
	Long-term JGBs/ BOJ banknotes	-1.61643*	-0.1161022
	ABS/BOJ banknotes.	119.4662	11.69217
	Stocks/ BOJ banknotes	5.952681	129.4714***
	Loans of fund-supplying operations, etc./ BOJ banknotes	1.178684	0.079864
	CPs/BOJ banknotes.	-7.568874	6.165071
	CB/ BOJ banknotes	-203.0602*	139.9983
2nd stage	Inflation	0.0436832***	-0.2701649***
	Output	0.0056381	-0.0041094***
	Asset Price	0.0020558***	-0.0028796***
	Lagged Call Rate	0.5939713***	1.144991***
	Const.	0.0503759***	0.1487595***
Wald Test of Exogeneity (chi-square; p-value)		4.2; 0.2409	0.69; 0.8746

Table 24 Estimated Effects on the Inflation Rate and the Output Gap

	Inflation		Output	
BOJ CA balances/ total bank deposits	-3.453E-01		-8.956E+00	
US dollar loans/ total bank deposits	-1.011E+00		7.338E+01	
Outright JGB purchases	7.980E-06		-1.260E-03	***
Outright ABS purchases	-1.496E-04		-4.226E-03	***
Stock purchasing plan	7.160E-05		4.340E-04	
Fund-supplying operations, etc.	-1.070E-06		2.100E-06	
US dollar fund-supplying operations	5.210E-05	***	6.054E-04	***
Outright CPs purchases	-6.760E-05		9.240E-05	
Outright CB purchases	-4.785E-04		3.494E-03	
BOJ CA balances/ BOJ banknotes	3.166E-02		1.271E+00	*
US dollar loans/ BOJ banknotes	-1.498E-01		-1.314E+01	
Long-term JGBs/ BOJ banknotes	-6.175E-03		-3.757E-01	**
ABS/BOJ banknotes.	1.689E+00		3.468E+00	
Stocks/ BOJ banknotes	2.034E-01	**	2.685E+00	**
Loans of fund-supplying operations, etc./ BOJ banknotes	2.754E-02	**	-2.035E-02	
CPs/BOJ banknotes.	4.307E-01		-1.350E+00	
CB/ BOJ banknotes	-9.886E+00	***	-1.037E+01	

Table 25 Summary of the Estimated Effects on Asset Prices

	Funding Liquidity		Market Liquidity							Central Bank's Balance Sheet							
Asset Prices	BOJ CA balances/ total bank deposits	US dollar loans/ total bank deposits	Outright JGB purchases	Outright ABS purchases	Stock purchasing plan	Fund-supplying operations, etc.	US dollar fund-supplying operations	Outright CPs Purchases	Outright CB purchases	BOJ CA balances/ BOJ banknotes	US dollar loans/ BOJ banknotes	Long-term JGBs/ BOJ Banknotes	ABS/ BOJ banknotes.	Stocks/ BOJ banknotes	Loans via fund-supplying operations, etc./ BOJ banknotes	CPs/ BOJ banknotes.	CB/ BOJ banknotes
Dollar/Yen					−	+						−			−		
Yen Effective			−		+	−						+			+		
Nikkei	−		−							+		−		+			
TOPIX	−		−							+		−		+			
JGB	−		−	−	−					+		−	+	+	−		
1Baa-A								+	+							−	+
1Baa-Aa								+	+					−		−	+
3Baa-A								+	+							−	
3Baa-Aa								+	+					−		−	
5A-Aa							−							−	+	+	+
10A-Aa					+			+	+			+		−		−	+
10A-JGB								+	+					−		−	+
10Aa-JGB	−		−				−			+							
BPI Short-			+				−	−				+					

Medium-							−	−				+					
Long-term		−					−				+						
1T-L							−					+					+
3T-L						+	−					+				+	+
3CD-L			+				−		−			+			−	+	+
6T-L							−		−			+				+	+
1T-Call		+	−				−					−					+
3T-Call			−				−					−					+
6T-Call							−					−		+			+
Dubai	−		−							+		−					−
JREIT	+									−				+			