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An Injection of Base Money at Zero Interest Rates: Empirical Evidence from the Japanese Experience 2001–2006*

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ABSTRACT

Many macroeconomists and policymakers have debated the effectiveness of further injection of base money at zero short-term interest rates. This paper takes up the Japanese experience of the quantitative monetary-easing policy (QMEP) that was conducted in 2001—2006. In particular we measure the effect of the QMEP on aggregate output and prices, and examine its transmission mechanism, based on the vector autoregressive (VAR) methodology. To ascertain the transmission mechanism, we include several financial market variables in the VAR system. The results show that the QMEP increased aggregate output through the stock price channel. This evidence suggests that further injection of base money is effective even when short-term nominal interest rates are at zero.

Keywords: Quantitative easing; Money injection; Portfolio rebalancing; Stock price channel; Vector autoregression

JEL Classification: E44; E52

1. Introduction

The bursting of bubble in U.S. housing markets, together with high leverage by financial institutions, triggered the instability of the financial system in 2008, and put credit conditions extremely tight in the U.S. The turmoil in financial markets was extended to the real sector of the economy especially after the bankruptcy of Lehman Brothers in September 2008, and the economy has weakened dramatically.

In order to cope with the deteriorating economic conditions, the Federal Reserve (Fed) decided to establish a target federal funds rate of 0 to 1/4 percent on December 16, 2008. The Fed also made it clear to purchase large quantities of agency debt and mortgage-backed securities to provide support to the mortgage and housing markets. The Fed called their operation "credit-easing policy", emphasizing their activity on the asset side of their balance sheet.

On the other hand, when the Bank of Japan (BOJ) continued to inject a massive quantity of base money to the economy for the period from March 2001 to March 2006 to overcome a long-lasting economic slump and deflationary pressures, the BOJ chose the current account balance (CABs) held at the BOJ as its operating target. Their operating target was on the liability side of their balance sheet. To this extent, the Fed's policy adopted on December 2008 was different from the BOJ's policy for the period from March 2001 to March 2006, but these two policies are very similar to each other in that they inject ample liquidity into the economy, even though short-term nominal interest rates are zero or almost zero. We call this policy of injecting a massive quantity of base money to the economy under zero or almost zero short-term interest rates quantitative monetary-easing policy (QMEP) in this paper.

The most serious question which the monetary authorities face in conducting QMEP is whether or not expanding monetary base is effective when short-term nominal interest rates fall to zero. There are two distinct views on this question. The first view at least dates back to Hicks (1937), who shows in his famous IS-LM model that an increase in money supply has no effect if the interest rate is at its lower bound, because money and bonds are perfect substitutes (that is, a liquidity trap happens in this case). Eggertson and Woodford (2003) also show the ineffectiveness of the QMEP by analyzing a dynamic general equilibrium model.

The second view, on the other hand, advocated by Bernanke and Reinhart (2004), Bernanke, Reinhart and Sack (2004), and Clouse, Henderson, Orphanides, Small, and Tinsley (2003), argues that, even when short-term nominal interest rates are at zero, increases in monetary base might be effective through the *portfolio rebalancing effect* and the *signaling effect* (we will explain these two effects in the next section).

Both of these two lines of thought are logically correct under their respective assumptions, and yet their conclusions are opposite to each other. The question is, therefore, an empirical matter. Unfortunately, however, there are little empirical data to test these two distinct hypotheses. The only exception is the recent Japanese experiences from March 2001 to March 2006. This paper will contribute to such arguments by empirically analyzing the Japanese experience in 2001–2006, which provides a good opportunity to examine the impact of the further injection of liquidity at zero interest rates.

In this paper, we use the standard vector auto-regressive (VAR) methodology. Since the purpose of this paper is to assess the effect of the QMEP, not to estimate and evaluate a macroeconomic model under zero interest rates, we choose a VAR approach rather than a dynamic, stochastic, general-equilibrium (DSGE) approach. The VAR approach allows us to gauge the effect of the QMEP with minimum restrictions on the macroeconomic model structure.

We first estimate a minimal VAR model, which consists only of output, prices, and the monetary policy instrument. This examination provides a preliminary assessment about the effect of the QMEP on the two key macroeconomic variables, aggregate output and prices. The estimation result shows that a quantitative-easing shock increases output, but it has little effect on the price level.

This result raises the question of the transmission mechanism through which the QMEP affected the output level. If the QMEP worked through the *portfolio rebalancing effect* or the *signaling effect*, financial market variables would play an important role in transmitting these effects. Therefore, we next add each of several financial variables to the above three-variable VAR to investigate the transmission mechanism of the QMEP. The financial variables we consider are short- to long-term nominal interest rates, stock prices, foreign exchange rates, and bank lending. From these four-variable VAR estimations, we find that the QMEP was effective through the stock price channel.

Furthermore, in order to check the robustness of the stock price channel, we control for the effects of several factors that the above four-variable VARs do not incorporate. The following four factors are considered: increases in the BOJ's outright purchase of long-term government bonds; introduction of the BOJ's purchase of stocks held by the commercial banks; large increases in the value of exports; and large decreases in the outstanding amount of nonperforming loans (NPLs) of the banking sector. They might have some effects on the economy, independent of increases in monetary base. Therefore, we include each of these four factors in the VAR model to control for their possible effects. The estimation results show that the stock price channel is robust even if we control for these effects.

The remainder of the paper is organized as follows. Section 2 gives an overview of the QMEP adopted in Japan for the 2001–2006 period, discusses the possible effects of the QMEP, and surveys the related empirical literature. Section 3 explains our VAR models, identification strategy and data. Section 4 reports the estimation results for the three- and four-variable VARs. Section 5 estimates alternative VAR specifications that control for the effects of the above-mentioned four factors. Section 6 offers concluding remarks.

2. Background

2.1. Overview of the QMEP

Even though the BOJ kept lowering the call rate during the 1990s and eventually adopted the zero-interest-rate policy in February 1999, the Japanese economy could not escape from the prolonged stagnation and deflationary pressures that occurred from the bursting of the asset price bubble in the early 1990s.[1,2] In March 2001, the BOJ introduced the QMEP to create a further monetary-easing environment under the situation where the call rate was almost zero. The BOJ changed its operating target from the call rate to the current account balances (CABs) held at the BOJ, and it continued to inject ample liquidity into the CABs beyond the level needed to maintain the call rates at zero.[3] The target level of the CABs was publicly announced immediately after every monetary policy meeting. Table 1 describes dates of policy changes (the left column) and announced targets of the CABs (the middle column). The CAB target increased eight times from 5 trillion yen at the introduction of the QMEP to 30–35 trillion yen in January 2004.

Table 1
Policy Changes during the QMEP Period

Dates of policy changes	Announced targets of the CABs (trillion yen)	Values of the CAB target variable (trillion yen)
19 March 2001	Introduction of QMEP	
19 March 2001	5	5 (March 2001 to July 2001)
14 August 2001	6	6 (August 2001)
18 September 2001	Above 6	8 (September 2001), 8.7 (October 2001), 9.3 (November 2001)
19 December 2001	10–15	12.5 (December 2001 to September 2002)
30 October 2002	15–20	17.5 (October 2002 to March 2003)
30 April 2003	22–27	24.5 (April 2003)
20 May 2003	27–30	28.5 (May 2003 to September 2003)
10 October 2003	27–32	29.5 (October 2003 to December 2003)
20 January 2004	30–35	32.5 (January 2004 to February 2006)
9 March 2006	Termination of QMEP	

On 1 April 2003, the BOJ raised the CAB target to 17–22 trillion yen for necessary adjustment due to the establishment of the Japan Post.

At first, the BOJ promised that it would continue the QMEP until the year-on-year rate of change in the consumer price index excluding perishables (core CPI) became stably zero or above. Then, in October 2003, the BOJ provided a more detailed description of the commitment: it would maintain the QMEP until (1) not only the most recently published core CPI inflation became zero or above, but also such tendency was confirmed over a few months, and (2) the future core CPI inflation was not be expected to register below zero percent.[4] Since October 2005, core CPI inflation rates have been zero or positive, which satisfied the first condition in the commitment statement. Furthermore, the BOJ judged that future inflation rates would remain positive due to a steady economic recovery at that time, which satisfied the second condition in the commitment statement. Under this environment, the BOJ terminated five years of the QMEP in March 2006.

2.2. Possible Effects of the QMEP and Related Empirical Literature

There are some empirical studies measuring the effect of the QMEP in Japan. Bernanke et al. (2004), Okina and Shiratsuka (2004), and Oda and Ueda (2007) show that the QMEP was effective in shifting the yield curve downward. In particular, Okina and Shiratsuka (2004) and Oda and Ueda (2007) argue that this downward shift of the yield curve was caused by the *policy-duration effect*.[5] The *policy-duration effect* means that the central bank's commitment to keeping the policy rate at zero can stabilize market expectations for the path of short-term interest rates and hence reduce long-term interest rates. Therefore, their findings suggest that the QMEP worked through the commitment to maintaining the zero-interest-rate policy.

Measuring only the *policy-duration effect*, however, is not enough to understand the effects of the QMEP completely. In the QMEP period, the BOJ had provided abundant money by increasing the CAB target several times, even though short-term nominal interest rates were already at the zero lower bound. As discussed in Bernanke and Reinhart (2004), Bernanke et al. (2004), and Clouse et al. (2003), such further expansions of base money might have an impact on economic activity through the *portfolio rebalancing effect* and the *signaling effect*.

The *portfolio rebalancing effect* stems from the assumption that there are several assets that are imperfect substitutes for each other. Even if short-term securities and money are perfect substitutes because of a zero short-term interest rate, money and other assets may be imperfect substitutes. Then, the additional supply of base money will cause investors to try to change their portfolios. This portfolio rebalancing will, in turn, raise prices (or reduce yields) of the assets, thereby stimulating economic activity. The idea of the *portfolio rebalancing effect* is based on the classic literature such as Brunner and Meltzer (1963) and Tobin (1969), in which multiasset models were used for the analysis of monetary policy. Although the *portfolio rebalancing effect* might occur even in normal times when nominal interest rates are positive, it would be more important in the low-interest-rate period because the *liquidity effect* would diminish or disappear under such a situation.

The *signaling effect* occurs if an increase in monetary base reinforces the signal about the central bank's intention of keeping short-term interest rates at zero. In this case, the QMEP can stabilize public expectations of the future paths of short-term interest rates and thereby decrease longer-term interest rates. The lower interest rates will, in turn, provide stimulus to economic activity. Note that the *signaling effect* plays a role in enhancing the *policy-duration effect* by increasing monetary base at zero interest rates.

The empirical literature investigating the effect of the further injection of monetary base under a zero-interest-rate environment includes Kimura and Small (2004), Oda and Ueda (2007), Kimura et al. (2002), and Fujiwara (2006).

Kimura and Small (2004) and Oda and Ueda (2007) limit their research to the effect on financial markets. Kimura and Small (2004) examine the *portfolio rebalancing effect* and find that the expansion of the CABs caused lower risk premiums on high-grade corporate bonds, while it had the adverse effects of raising risk premiums on stocks and low-grade corporate bonds. Oda and Ueda (2007) find that the expansion of the CABs was effective in lowering medium- to long-term yields of Japanese government bonds through the *signaling effect*, but it was ineffective through the *portfolio rebalancing effect*. However, these two studies do not measure the effect on macroeconomic variables.

Based on the VAR approach, Kimura et al. (2002) and Fujiwara (2006) examine the effect of increases in base money on the two key macroeconomic variables, aggregate output and prices. They show that an expansion of base money at zero interest rates only slightly increases the output and price levels, suggesting little evidence for the effectiveness of the QMEP.

This paper also investigates the effect of base money increases on aggregate output and prices, using the VAR methodology. However, our approach differs from Kimura et al. (2002) and Fujiwara (2006) in two points. First, our sample covers the whole QMEP period and excludes the pre-QMEP period (2001M3–2006M2 in our research, but 1985Q3–2002Q1 in Kimura et al. (2002) and 1985M1–2003M12 in Fujiwara (2006), where Q and M denote quarterly and monthly frequencies of data, respectively). Extending the sample period to the end of the QMEP allows us to obtain more accurate estimates for the effect of the QMEP. Excluding the pre-QMEP period would also lead to more accurate estimates because the QMEP is a different regime from the earlier monetary policy, in that the BOJ's operating target is changed from the call rate to the CABs. To avoid the issue of the regime change, Kimura et al. (2002) estimate a VAR with time-varying coefficients and Fujiwara (2006) adopts a Markov switching VAR method. In spite of these efforts, using only the implementation period of the QMEP seems to be the most appropriate approach for the investigation of the impact of additional money at zero interest rates.

Second, we examine the transmission mechanism of the QMEP more carefully and comprehensively. Other than the macroeconomic variables of prices, output, and the policy instrument (monetary base and call rate), no variable is included in Kimura et al. (2002) and only the yield on 10-year government bonds is included in Fujiwara (2006) (maybe because they obtain the result that the QMEP had no effect on output and prices, and there is no need to consider the transmission mechanism). If the QMEP was effective through the *portfolio rebalancing effect* or the *signaling effect*, then financial market variables would play an important role in transmitting these effects. For the *signaling effect*, short- to long-term nominal interest rates are key transmitting variables. For the *portfolio rebalancing effect*, those assets that are imperfect substitutes for money are all candidates for the transmitting variable. Therefore, we examine the transmission mechanism of the QMEP by including several financial variables in the VAR model.

3. VAR Model, Identification, and Data

Here we estimate two types of the VAR model to assess the effect of the QMEP. The first model is a minimal one that includes only output, prices, and the monetary policy instrument. This three-variable VAR provides a preliminary evaluation of the impact of a quantitative-easing shock on the two key macroeconomic variables, aggregate output and prices. As will be seen later, the estimated impulse response functions show that a quantitative-easing shock generates persistent increases in the output level.

However, its transmission mechanism is still unclear from the estimation of the three-variable VAR. To find out the transmission mechanism, we next estimate several four-variable VARs, each of which includes one of financial market variables as well as the above three variables. The financial variables we consider are short- to long-term nominal interest rates, stock prices, foreign exchange rates, and bank lending.[7] Through the *portfolio rebalancing effect* or the *signaling effect*, the QMEP might lower nominal interest rates, raise stock prices, or depreciate the yen, all of which would stimulate economic activity. In addition, commercial banks might increase their loans based on the additional money obtained by transactions with the BOJ in its open market operations. For these reasons, we adopt these financial variables as possible transmitting variables, and add them one-by-one to the VAR model.

The lag length is set equal to two months for all VAR models, which is selected based on the Akaike information criterion for the baseline three-variable VAR (the maximum lag length is set equal to six months).[8]

To identify monetary policy shocks, we use a recursive strategy (that is, the Cholesky decomposition). This is the simplest identification scheme and hence has been used in several studies in the VAR literature. As described in the previous section, this paper is the first attempt to deal with the whole QMEP period and to investigate the transmission mechanism comprehensively. Thus, it seems to be plausible to employ this widely used identification strategy for our VAR models. For the three-variable VAR, we place the variables in order of output, prices, and the monetary policy instrument. This ordering assumes that the BOJ sees current output and prices when it sets the policy instrument, but that output and prices only respond to a policy shock with one lag. For the four-variable VAR, each financial variable is ordered last, implying that financial markets respond to a policy shock with no lag. This ordering is essentially the same as Christiano et al. (1996), Edelberg and Marshall (1996), Evans and Marshall (1998), and Thorbecke (1997), which place the VAR variables in order of macroeconomic variables, monetary policy variables, and financial variables.[9]

The frequency of our data is monthly and the sample period is from March 2001 to February 2006.[10] The measure of output is the index of industrial production (IIP). The measure of prices is the core CPI, which is the most crucial variable in the BOJ's commitment statement to maintain the QMEP.[11] As the measure of the monetary policy instrument, we use the BOJ's target of the CABs. See the right column in Table 1 for values of the CAB target variable. When the announced target of the CABs is a range rather than a level (six cases out of nine policy changes), we take a middle point of the range as a value of the CAB target variable. For the period from September 2001 to November 2001 when the announced target of the CABs is "above 6 trillion yen", we use the monthly average of the actual daily CABs (8 trillion yen in September 2001, 8.7 trillion yen in October 2001, and 9.3 trillion yen in November 2001).[12] We also use the monthly average of the actual daily CABs for the period before March 2001, which serve as the initial data for the VAR estimation (4.8 trillion yen in January 2001 and 4.3 trillion yen in February 2001). Our data of nominal interest rates are the London Interbank Offered Rates (LIBOR) with maturities of 1, 3, 6, and 12 months and the swap rates with maturities of 2, 3, 5, 7, and 10 years. The measures of stock prices, foreign exchange rates, and bank lending are, respectively, the Nikkei Stock Average, the real effective exchange rate, and the total amount of loans and discounts of all banks.[13] All data except for nominal interest rates are transformed in logarithm and multiplied by 100.[14] More detailed information about the data is provided in the appendix. Finally, Figure 1 displays the time series of the data used in this paper.

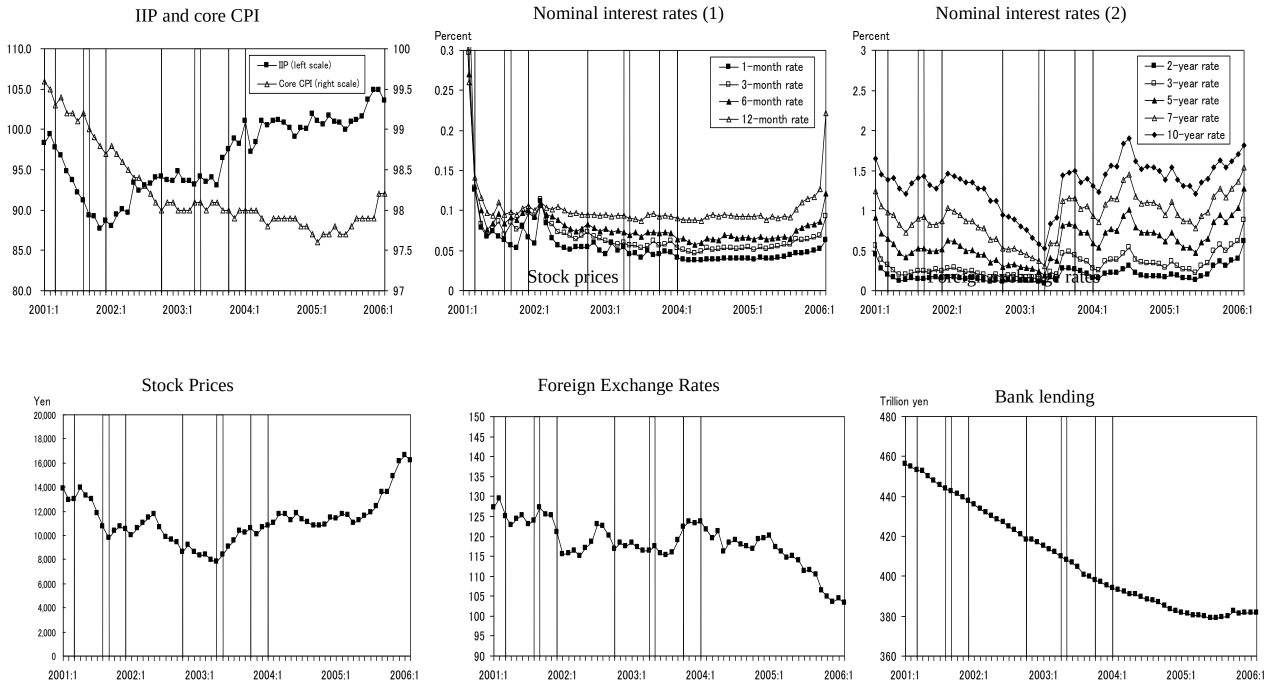

Figure 1
Time Series Data

The figure displays the time series of the data used in the estimation. The vertical lines indicate the months when the BOJ changed the CAB target.

4. Empirical Results

4.1. A Three-variable VAR

We first estimate the simplest three-variable VAR that consists of IIP, core CPI, and the CAB target. Figure 2 displays all estimated impulse responses to a one-standard-deviation shock to each variable. The first to third columns represent the dynamic responses of the three variables to an IIP shock, a CPI shock, and a quantitative-easing shock, respectively. The solid lines represent the point estimates of impulse response functions, and the dotted lines denote plus and minus two-standard-error bands computed by Monte Carlo simulation with 500 repetitions.

There are three interesting points to be noted in Figure 2. First, a quantitative-easing shock generates persistent increases in output. In response to a quantitative-easing shock, IIP begins to increase from the second month and then peaks at the eighth month (the response of IIP at the first month is negative, but very small and insignificant). Notably, the positive response of IIP is statistically different from zero at the seventh and eighth months. In the next subsection, we will examine the transmission mechanism through which the policy shock increases the output level. Second, the response of core CPI to a quantitative-easing shock is very small and not statistically different from zero throughout the period. Although the BOJ introduced the QMEP in order to escape from deflationary environment, we cannot see the statistical evidence that it succeeded in raising general prices. Third, the CAB target increases (decreases) in response to a negative (positive) core CPI shock, while it hardly reacts to an IIP shock, implying that the BOJ placed more emphasis on prices rather than output. This result is consistent with the BOJ's commitment statement, in which the two necessary conditions to terminate the QMEP refer only to the recent and expected future rates of inflation, but do not refer to real economic activity.

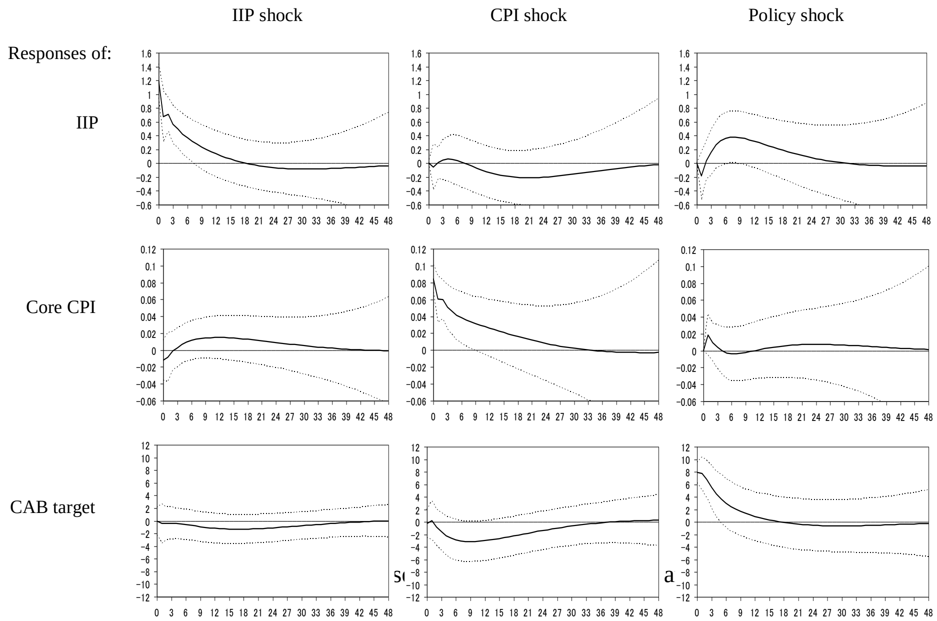

Figure 2
Impulse Response Functions for the Three-variable VAR

The figure displays the estimated impulse response functions for the three-variable VAR, consisting of IIP, core CPI, and the CAB target. The dotted lines denote two-standard-error bands.

4.2. Transmission Mechanism

Although we have found that the QMEP was effective in increasing the output level, the transmission mechanism is still an open question. We here investigate the transmission mechanism by estimating several four-variable VARs, each of which includes one of financial market variables.

Figure 3 displays the dynamic response of each financial variable to a quantitative-easing shock. Charts A to I present the estimated dynamic responses of nominal interest rates with various maturities and Charts J to L provide those of stock prices, foreign exchange rates, and bank lending, respectively. First note that standard-error bands become extremely wide from a certain period in most charts. This would be due to a small number of observations relative to the large number of parameters to be estimated in the four-variable VAR. Nonetheless, standard-error bands appear to be relatively narrow for a short period of time (within about a year after a policy shock), implying that our empirical results are reliable at least about the short-run effect of the QMEP. Therefore, we will hereafter focus our discussion on the short-run impact of the policy shock.

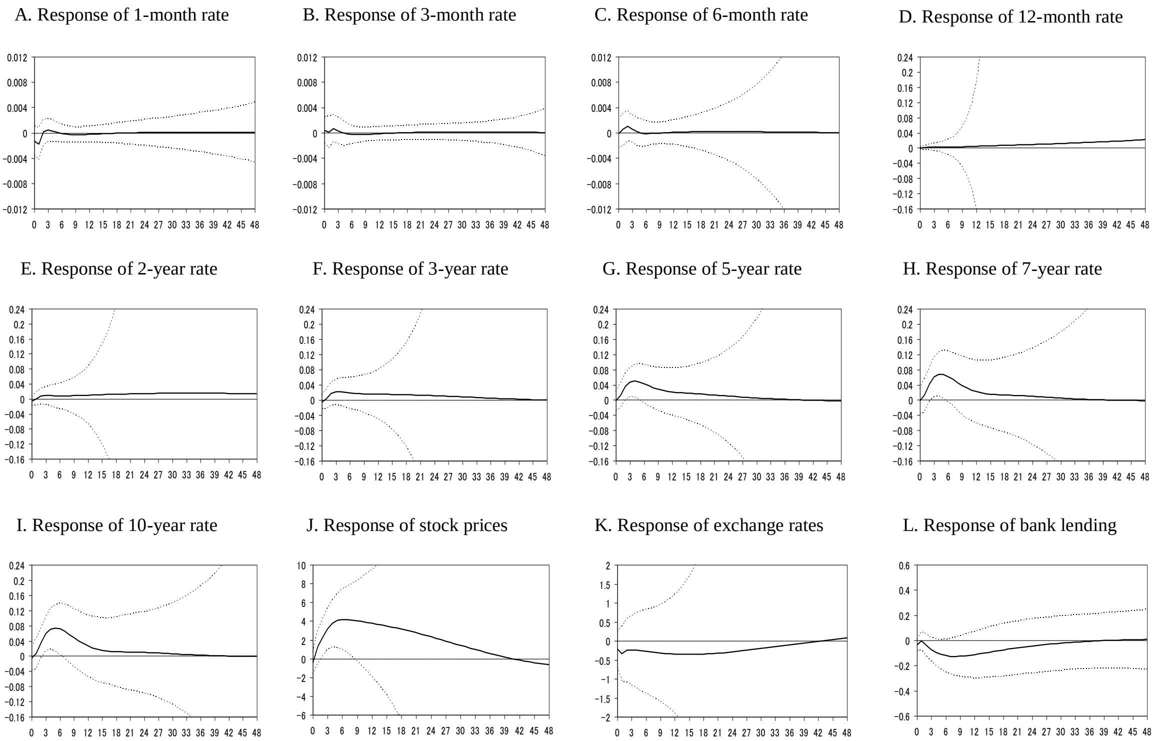

Figure 3
Effects of Quantitative Easing Shocks on Financial Variables

Each chart displays the dynamic effects of a quantitative easing shock on a financial variable. The impulse response function is estimated from the four-variable VAR, consisting of IIP, core CPI, the CAB target, and a financial variable. Financial variables used include nominal interest rates with various maturities, stock prices, foreign exchange rates, and bank lending. The dotted lines denote two-standard-error bands.

The most notable result in Figure 3 is that a quantitative-easing shock raises stock prices persistently (see Chart J). The positive response of stock prices is statistically different from zero for between the second and eighth months. Hence, it is likely that the QMEP was effective through the stock price channel (we will later report all impulse response functions for the four-variable VAR with stock prices included and discuss the existence of the stock price channel). On the other hand, Charts A to I show that nominal interest rates do not decline in response to a quantitative-easing shock (only the 1-month rate declines in the first two months, but the effect is very small and insignificant). Rather, positive responses are observed for long-term interest rates, and the longer the maturity is, the larger the positive response is. In Chart K, a quantitative-easing shock depreciates the yen (note that declines in effective exchange rates imply the depreciation of the yen). However, the depreciation is not statistically significant throughout the period. In Chart L, bank lending decreases rather than increases in response to a quantitative-easing shock.

Summarizing these results, a quantitative-easing shock significantly raises stock prices and slightly depreciates the yen, both of which would stimulate economic activity, while the policy shock raises nominal interest rates and decreases bank lending, which provide no stimulus.

At first glance, these results seem to be strange because short- to long-term interest rates do not decline and bank lending does not increase in response to a quantitative-easing shock. However, these results are consistent with the idea of the *portfolio rebalancing effect* and can be interpreted as follows.[15] With additional money from the BOJ, investors (including banks) intended to decrease an interest-bearing asset component (including bank lending) in their portfolios, increase an equity component considerably, and increase a foreign asset component slightly. Such investors' behavior can be explained by the Japanese financial market conditions for the QMEP period: the yields (prices) of interest-bearing assets were near zero (at very high levels); stock prices were at the lowest levels since the late 1980s; domestic financial assets yielded lower returns than foreign assets; and the banking sector suffered from the NPL problem. Under these circumstances, investors might feel that holding interest-bearing assets had a higher risk than holding equities or foreign assets, and therefore they might seek to rebalance their portfolios in such a way that they held more equities and foreign assets, and held less interest-bearing assets, when they received further liquidity from the BOJ. In addition, the result that the response of interest rates is larger at the longer end of maturities implies that investors intended to sell more long-term interest-bearing assets than short-term assets, because of the concern about rises in the future interest rates.

Our results also imply that the *portfolio rebalancing effect* dominates both the *liquidity effect* and the *signaling effect* for the QMEP period, because if either of the latter two effects occurs, nominal interest rates decline in response to a quantitative-easing shock. If nominal interest rates deviate from the lower bound as in normal times, the *liquidity effect* would dominate and the yields (prices) of several assets would move in the same direction in response to a monetary policy shock. However, we have found that the yields (prices) of several assets moved in the different direction in response to a quantitative-easing shock. This suggests that the *liquidity* *effect* diminishes or disappears, and the *portfolio rebalancing effect* becomes significant in the low-interest-rate period.[16]

Our findings with regard to the effect of the QMEP on financial markets are different from Kimura and Small (2004) and Oda and Ueda (2007). Kimura and Small (2004) obtain the result that the QMEP raised risk premiums on stocks (lowered stock prices) through the *portfolio-rebalancing effect*. Oda and Ueda (2007) find that the expansion of the CABs lowered medium- to long-term interest rates through the *signaling effect*. These conflicting results stem from the differences in sample period, data frequency, and estimation method. Kimura and Small (2004) use daily data and regress risk premiums of stocks on the CABs and other relevant variables for the period 1/21/2000–6/30/2003 (or 1/21/2000–3/31/2004). Oda and Ueda (2007) estimate a simple macroeconomic model for the period 1980Q1–1999Q1 and use a macro-finance approach to decompose nominal interest rates into expectations and risk premium components for the period 1995Q1–2005Q1. And then, they regress a variable indicating the commitment effect for each component, on the CABs and other relevant variables for the period 1995Q1–2005Q1 (or 1996Q3–2005Q1).

We have found that it is better to include stock prices in the VAR model to capture the dynamics of the Japanese economy for the QMEP period. Figure 4 displays all impulse response functions for the four-variable VAR, which consists of IIP, core CPI, the CAB target, and stock prices. Interestingly, IIP shows a slower response than the stock price response: in response to a quantitative-easing shock, IIP begins to increase from the second month and peaks at the ninth month, while stock prices begin to rise from the first month and peak at the sixth month. This result suggests that there exists the stock price channel for the QMEP period. There are four possible channels through which higher stock prices boost the output level: an increase in consumption through a rise in households' wealth (the wealth effect); an increase in investment through higher Tobin's q; an increase in bank lending through a decline in the external finance premium of borrowers (the balance sheet effect); and an increase in bank lending through an improvement in the banks' capital-to-asset ratios. Considering the result that a quantitative-easing shock does not increase bank lending (see Chart L in Figure 3), we suspect that the last two channels might have been weak and either or both of the first two channels mainly worked in the QMEP period.

There are three other remarkable findings in Figure 4. First, a quantitative-easing shock raises core CPI, but the response is very small and insignificant throughout the period as with the case of the three-variable VAR, suggesting that the QMEP had little effect on the price level. Second, the CAB target increases (decreases) not only in response to a negative (positive) core CPI shock but also in response to a negative (positive) stock price shock. Third, a positive shock to stock prices raises IIP with the statistical significance in the second and third months.

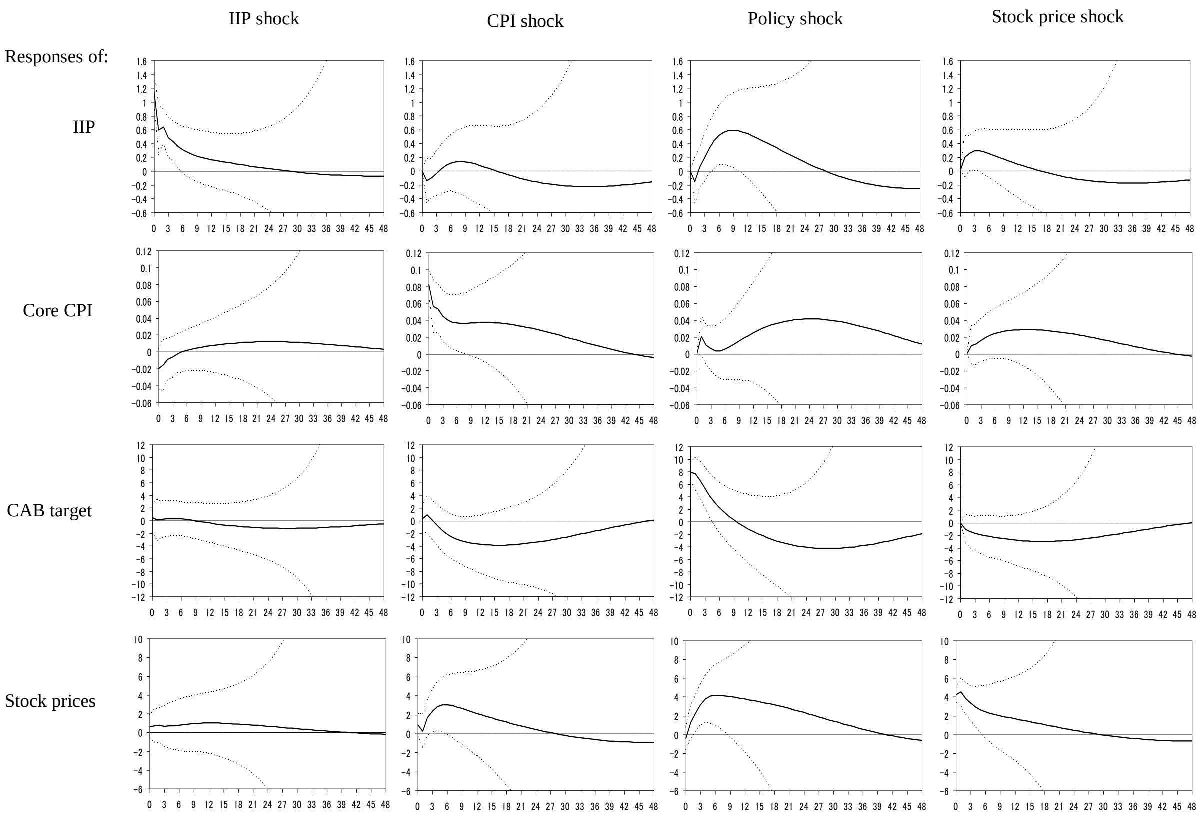

Figure 4
Impulse Response Functions for the Four-variable VAR

The figure displays the estimated impulse response functions for the four-variable VAR, consisting of IIP, core CPI, the CAB target, and stock prices. The dotted lines denote two-standard-error bands.

Table 2
Percentage of Forecast Error Variance Explained by Monetary Policy Shock

	Period		
Variable	2	6	12
IIP	1.14 (2.71)	16.48 (10.82)	40.89 (16.11)
Core CPI	3.75 (4.65)	2.79 (5.82)	6.67 (9.39)
CAB target	97.38 (6.06)	86.91 (11.53)	61.20 (17.40)
Stock prices	10.51 (8.42)	34.40 (13.19)	45.59 (14.34)

The table reports the percentage of the variance of the 2-, 6-, and 12-months-ahead forecast errors in IIP, core CPI, the CAB target, and stock prices that are accounted for by monetary policy shocks. The variance decomposition is conducted for the four-variable VAR, consisting of IIP, core CPI, the CAB target, and stock prices. The standard errors are reported in parentheses.

Next, we conduct the variance decomposition analysis. Table 2 reports the results for the four-variable VAR with stock prices included. The value in the table denotes the percentage of the variance of the 2-, 6-, and 12-months-ahead forecast errors that are accounted for by monetary policy shocks. The standard errors, computed by Monte Carlo simulation with 500 repetitions, are reported in parentheses. Monetary policy shocks account for a significant part of the volatility of IIP and stock prices (41% and 46% of the 12-months-ahead forecast error variance of IIP and stock prices, respectively). On the other hand, monetary policy shocks account for only a small part of the volatility of core CPI (only 7% of the 12-months-ahead forecast error variance of core CPI). Thus, monetary policy shocks are a major contributor to fluctuations of aggregate output and stock prices, but they are unimportant for explaining the fluctuation of general prices.

Table 3
P-value for Granger Causality Test

From CAB target to:		From stock prices to:	
IIP	0.21	IIP	0.05
Core CPI	0.06	Core CPI	0.24
Stock prices	< 0.01	CAB target	0.39

The table reports p-values for the Granger causality test. The test is performed for the four-variable VAR, consisting of IIP, core CPI, the CAB target, and stock prices. The left column presents p-values for the test of the null hypothesis that the CAB target does not Granger-cause IIP, core CPI, and stock prices. The right column presents p-values for the test of the null hypothesis that stock prices do not Granger-cause IIP, core CPI, and the CAB target.

Finally, we perform the Granger causality test. Table 3 reports the results of the Granger causality test (F-test) for the four-variable VAR including stock prices. The left column presents *p*-values associated with the test of the null hypothesis that the CAB target does not Granger-cause IIP, core CPI, and stock prices. The right column provides *p*-values for the test of the null hypothesis that stock prices do not Granger-cause IIP, core CPI, and the CAB target. In the left column, the null hypothesis that the CAB target does not Granger-cause stock prices can be rejected at the 1% significance level, suggesting that there is a Granger-causality from the CAB target to stock prices. In the right column, the null hypothesis that stock prices do not Granger-cause IIP can be rejected at the 6% significance level, suggesting that there is a Granger-causality from stock prices to IIP. Therefore, the results of the Granger causality test complement evidence of the stock price channel found from the estimated impulse response functions.

5. Alternative Specifications

5.1. Controlling for the Effects of Alternative Policy Tools

In the QMEP period the BOJ conducted two unconventional policies other than expanding the CABs. One is the increases in the outright purchase of long-term government bonds (OPLTGBs). The target amount of the OPLTGBs per month was gradually increased from 400 billion yen to 600 billion yen in August 2001, to 800 billion yen in December 2001, to 1 trillion yen in February 2002, and to 1.2 trillion yen in October 2002. The other policy is the purchase of stocks held by commercial banks. This policy was conducted from November 2002 to September 2004, and the value of purchased stocks amounted to about 2 trillion yen in September 2004. According to the public announcement, the BOJ did not aim to stimulate economic activity directly by introducing these two policies. In fact, the BOJ expanded the amount of the OPLTGBs to achieve the increased CAB target smoothly. The BOJ also began to purchase the stocks held by commercial banks to reduce the risk pertaining to the shareholdings of the banks, who suffered from the serious NPL problem. However, in spite of such BOJ's intentions, these two policies might have effects on output, prices or stock prices, independent of the increases in the CAB target. Thus, in this subsection, we control for such possible effects so as to check the robustness of our results obtained in the previous section.

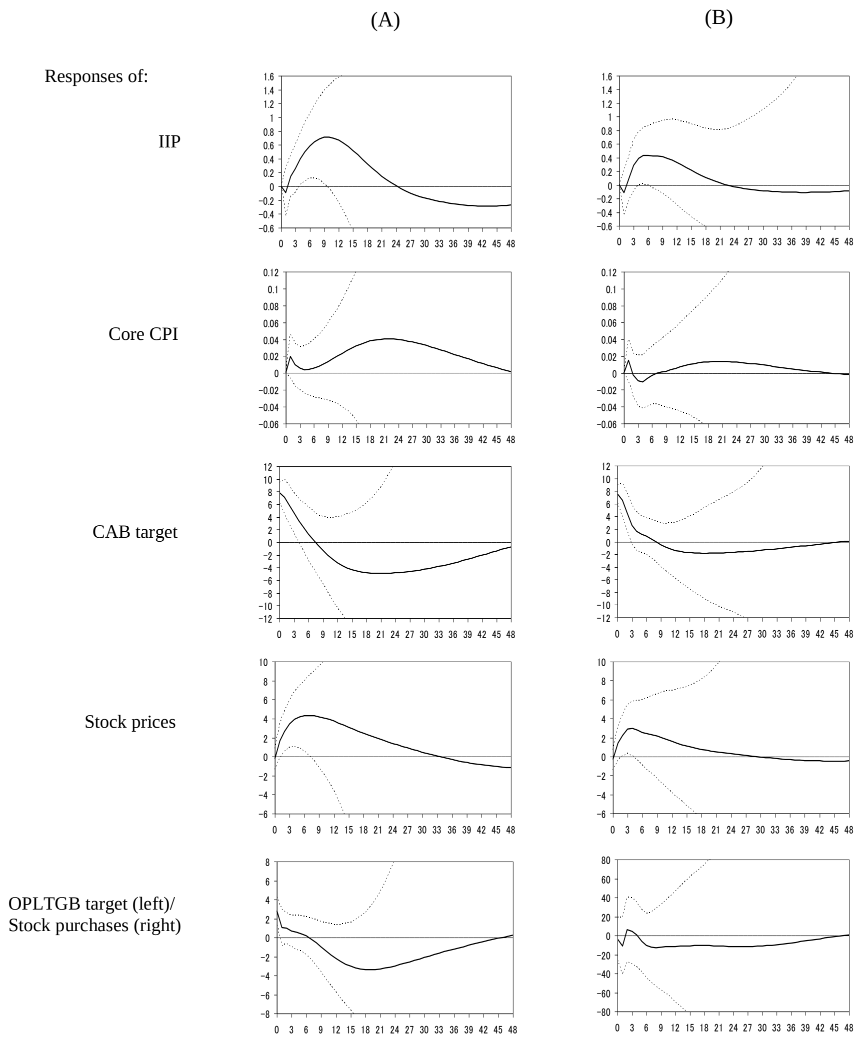

Figure 5
Effects of Quantitative Easing Shocks with Two Alternative Policy Measures Included

Column (A) displays the dynamic effects of a quantitative easing shock estimated from the five-variable VAR, consisting of IIP, core CPI, the CAB target, stock prices, and the OPLTGB target. Column (B) displays those estimated from the five-variable VAR, consisting of IIP, core CPI, the CAB target, stock prices, and BOJ's stock purchases. The dotted lines denote two-standard-error bands.

To this end, either the target amount of the OPLTGBs or the total amount of the purchased stocks (both transformed in logarithm and multiplied by 100) is added to the four-variable VAR with stock prices.[17] In each VAR model, an additional variable of the alternative policy measure is ordered just after the CAB target. Column (A) in Figure 5 displays the dynamic responses of the VAR variables to a quantitative-easing shock for the five-variable VAR model, which consists of IIP, core CPI, the CAB target, stock prices, and the OPLTGB target. We find that the shapes of the impulse response functions do not change compared with those in the third column in Figure 4, and that there is still evidence of the stock price channel. Column (B) in Figure 5 displays the corresponding results for the five-variable VAR in which the OPLTGB target is replaced by the total amount of the purchased stocks. Inclusion of the purchased stocks appears to change the shapes of the impulse response functions. In particular, the positive responses of IIP and stock prices become much smaller. Nevertheless, they are statistically different from zero for some periods, and stock prices show an earlier response than IIP. Therefore, we can still see evidence of the stock price channel even in this case.[18,19]

5.2. Controlling for the Effects of Alternative Contributors to Economic Recovery

The economic recovery experienced in the QMEP period seems to be attributable not only to the QMEP of the BOJ but also to the following two alternative factors: the large increases in the values of exports due to strong overseas economy; and the large decreases in the outstanding amount of NPLs of the banking sector. In this subsection, we control for the possible effects of these two factors to check the robustness of our results. For this purpose, we add to the four-variable VAR with stock prices either the export values or the outstanding amount of NPLs (both transformed in logarithm and multiplied by 100).[20] The measure of exports is ordered first since it depends on foreign economic activities (that is, treated as most exogenous), and the measure of the outstanding amount of NPLs is ordered last since it is a financial sector variable (that is, treated as most endogenous).

Column (A) in Figure 6 displays the dynamic responses of the VAR variables to a quantitative-easing shock for the five-variable VAR with exports included, and column (B) displays the corresponding results for the five-variable VAR with NPLs included. The estimated impulse response functions are somewhat different from the third column in Figure 4: in column (A), the response of core CPI is larger and the response of stock prices is more persistent; and in column

(B), the responses of IIP, core CPI, and stock prices are smaller. However, for both VAR specifications, the positive responses of IIP and stock prices are statistically different from zero for some periods and stock prices exhibit an earlier response than IIP. Therefore, we can still see evidence of the stock price channel even if we control for the effects of exports and NPLs.[21]

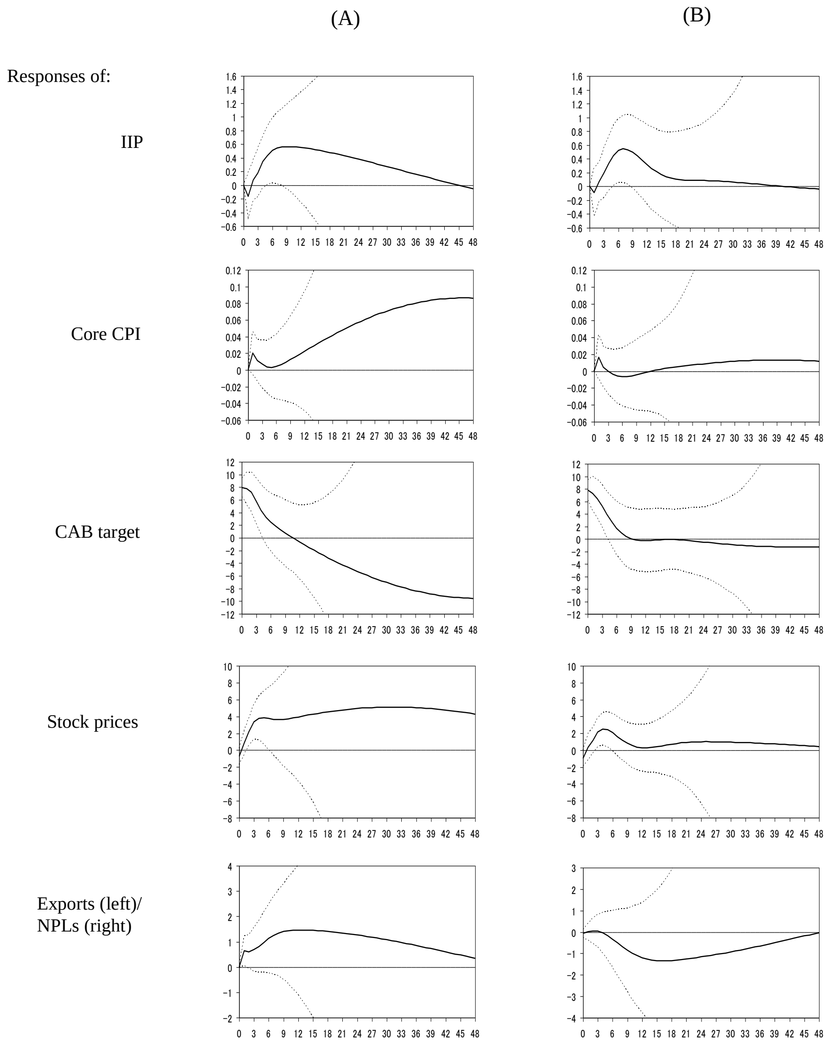

Figure 6
Effects of Quantitative Easing Shocks with Exports and NPLs Included

Column (A) displays the dynamic effects of a quantitative easing shock estimated from the five-variable VAR, consisting of IIP, core CPI, the CAB target, stock prices, and exports. Column (B) displays those estimated from the five-variable VAR, consisting of IIP, core CPI, the CAB target, stock prices, and NPLs. The dotted lines denote two-standard-error bands.

There are two other interesting findings from Figure 6. First, in column (A), a quantitative-easing shock increases exports persistently (but the response is not statistically significant throughout the period, except for the first month after a policy shock). As seen in Chart K of

Figure 3, a quantitative-easing shock depreciates the yen (but the depreciation is also insignificant). Therefore, the QMEP might be effective through the exchange rate channel, though the evidence is not strong enough to be supported statistically.[22] Second, in column (B) a quantitative-easing shock generates persistent declines in NPLs (but the response is insignificant throughout the period). Interestingly, the negative response of NPLs appears to be slower than the IIP response, suggesting that the QMEP contributed to the decreases in NPLs by boosting the Japan's real economy.

6. Concluding Remarks

Many macroeconomists and policymakers have discussed whether the further injection of monetary base at zero interest rates is effective. This paper has addressed this issue by examining the effect of the QMEP implemented in Japan for the 2001–2006 period. Using the VAR approach, we have found that the QMEP stimulated real economic activity through the stock price channel: in the impulse response function analysis, a quantitative-easing shock firstly raises stock prices and then increases the output level; in the variance decomposition analysis, monetary policy shocks account for a significant part of the volatility of output and stock prices; and in the Granger causality test, the target level of the CABs Granger-causes stock prices, and stock prices in turn Granger-cause the output level. All of the above results suggest the existence of the stock price channel.

We have also found that evidence of the stock price channel is robust, even if we control for the effects of two alternative policies of the BOJ (the increases in the outright purchase of long-term government bonds and the introduction of the purchase of stocks held by commercial banks) and even if we control for the effects of two alternative contributors to the economic recovery (the large increases in exports and the large declines in NPLs).

The results obtained in this paper have two implications. First, multiasset models would be useful when we discuss the effectiveness of monetary policy under the situation of low interest rates. Usual two-asset models such as the IS-LM model include only money and bonds. Such two-asset models implicitly assume that the yields (prices) of several assets move in the same direction in response to a monetary policy shock. However, we have found that the yields (prices) of several assets moved in the different direction in response to a quantitative-easing shock. This finding implies that the *portfolio rebalancing effect* becomes significant in the low-interest-rate period. For this reason, we need to build and use multiasset models that take into account the *portfolio rebalancing effect*, in order to examine the effect of monetary policy in the low-interest-rate period.[23]

Second, the Japanese economy might not have fallen into a *liquidity trap* in the QMEP period. *Liquidity trap* is defined as the situation where people spend no money to purchase non-monetary assets and thus money demand is infinitely elastic, when the nominal interest rate is at its lower bound. Our empirical evidence is consistent with the liquidity trap hypothesis in that people did not spend injected money to purchase bonds. However, our findings also imply that people used injected money for the purchase of stocks, which is inconsistent with the liquidity trap hypothesis. Therefore, even if short-term interest rates are zero, it does not necessarily mean that a *liquidity trap* occurs. At least in the recent Japanese case, there was room for monetary easing, even though short-term interest rates were zero.

Data Appendix

Variable	Description	Source
IIP	Seasonally adjusted series, 2000 average = 100	Website of Ministry of Economy, Trade and Industry
Core CPI	Seasonally adjusted series, 2000 average = 100	Website of Ministry of Internal Affairs and Communications
LIBOR (1, 3, 6, 12 months)	JPY, end of month	Website of British Bankers' Association
Swap rates (2, 3, 5, 7, 10 years)	Yen–yen, average of offered and bid rates, end of month	NEEDS Financial QUEST
Nikkei Stock Average	End of month	Website of BOJ
Real effective exchange rate	March 1973 = 100	Website of BOJ
Bank lending	Loans and discounts of banks, seasonally adjusted by using Census X-12	Website of BOJ
BOJ's stock purchases	Total amount of purchased stocks reported in BOJ's accounts, end of month	Website of BOJ
Exports	Balance of payments, seasonally adjusted series	Website of Ministry of Finance
NPLs	Based on the definition in the Financial Reconstruction Law, all banks	Website of Financial Services Agency

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NOTES

1. The call rate is a short-term interbank rate, like the federal funds rate in the United States. The BOJ has used the uncollateralized overnight call rate as a policy instrument except for the QMEP period.
2. In August 2000, the BOJ terminated the zero-interest-rate policy with the judgment that deflationary pressures receded due to the economic recovery, and it raised the call rate to 0.25. However, faced with the subsequent deterioration in Japan's economy, the BOJ lowered the call rate to 0.15 in February 2001.
3. The CABs include not only reserve balances but also deposits of other financial institutions (e.g. securities companies) that are not subject to the Reserve Requirement System.
4. The BOJ also stated that these two conditions were the necessary condition and that, even if these two conditions were fulfilled, it might maintain the QMEP depending on the economic situation.
5. Fujiki and Shiratsuka (2002), Okina and Shiratsuka (2004), and Oda and Ueda (2007) also report evidence of the presence of the *policy-duration effect* for the period of the zero-interest-rate policy (from February 1999 to August 2000).
6. When the central bank supplies money to the private sector, the nominal interest rate declines until supply and demand of money rebalance. This effect is called "liquidity effect" in this paper.
7. There is little VAR literature studying the impact of the Japanese monetary policy on financial markets even for the period when short-term nominal interest rates are positive. Braun and Shioji (2006) investigate the relationship between monetary policy and the yield curve. Miyao (2000) includes foreign exchange rates in the VAR system while Miyao (2002) uses stock prices.
8. Using alternative lag lengths of one, three, and six months did not essentially change the results, but impulse response functions with six lags showed jagged shapes, suggesting that the number of parameters to be estimated is too large relative to the number of observations.
9. We obtained similar results even when four-variable VARs were estimated with alternative six orderings, (P, Y, M, F), (Y, P, F, M), (M, Y, P, F), (M, F, Y, P), (F, Y, P, M), and (F, M, Y, P), where P, Y, M, and F denote prices, output, the monetary policy instrument, and a financial variable, respectively.
10. We exclude March 2006 from the sample period because the QMEP was implemented for only a short time in this month (it terminated on March 9, 2006).
11. The Ministry of Internal Affairs and Communications started to release the 2005-base CPI from August 2006, instead of the 2000-base CPI. The 2005-base CPI surprised markets due to a large downward revision of the CPI inflation rate for July 2006. The differences between the two measures also seem to be large for the QMEP period. For example, the inflation rate for February 2006 computed from the 2000-base (seasonally adjusted) core CPI is 0.6 percent, but that computed from the 2005-base is 0.0 percent. We here use the 2000-base core CPI, because the BOJ and market participants perceived it as a true measure of general prices for the QMEP period and they behaved based on it (for example, if the 2005-base CPI had been available to the BOJ in March 2006, the QMEP would not have been terminated in this month).
12. The daily data of the CABs are obtained from the Financial QUEST of Nikkei Economic Electronic Databank System (NEEDS).
13. We checked the robustness of our results to the use of alternative measures, which include the *actual* level of the CABs, yields on 10-year government bonds, the Tokyo Stock Price

Index (TOPIX), *real* stock prices (deflated by core CPI for both Nikkei Stock Average and TOPIX), *nominal* effective exchange rates, and *real* bank lending (deflated by core CPI). Even when we estimated the VARs using them one-by-one instead of a baseline measure, we obtained similar results.

14. We estimate the VAR in levels, since it yields consistent estimates even if each variable is nonstationary (see Hamilton (1994, pp. 651–653)).
15. There are alternative interpretations for the responses of interest rates and bank lending. The positive responses of interest rates may reflect an increase in inflation expectation (the *Fisher effect*). For the negative responses of bank lending, the QMEP did not increase bank lending, but it might have mitigated the downward pressure on bank lending. In fact, bank lending had decreased for the entire QMEP period (see Figure 1), which was caused by the weak demand (due to excess debt, excess capacity and excess employment on firms) and by the weak supply (due to the NPL problem and low capital-to-asset ratios on banks).
16. Note that our results do not necessarily deny the existence of the *policy-duration effect* found by Okina and Shiratsuka (2004) and Oda and Ueda (2007). The yield curve shifted downward through the *policy-duration effect*, but our results imply that "increases in base money" could not move the yield curve further down.
17. The BOJ reports the total amount of the purchased stocks for the period from December 2002 to September 2004. We set its values before this period equal to zero (in logarithm). We also set the values after this period equal to the value in September 2004, because the BOJ did not sell the stocks during the QMEP period.
18. With regard to the impacts of these two alternative policy measures on output, prices, and stock prices, we could not find clear evidence indicating the presence of their effects.
19. To save space, here we do not report the results of the variance decomposition and the Granger causality test in table form. However, these results support the existence of the stock price channel for both five-variable VARs: in the variance decomposition analysis, monetary policy shocks account for at least more than 20% of the 12-months-ahead forecast error variance of IIP and stock prices; in the Granger causality test, we can reject the null hypothesis that the CAB target does not Granger-cause stock prices and also reject the null hypothesis that stock prices do not Granger-cause IIP at conventional significance levels.
20. Since the NPL data are only available for end-March and end-September in each year, we use the interpolation method to construct the monthly data of NPLs.
21. The results of the variance decomposition and the Granger causality test also support the presence of the stock price channel, except for one case (the null hypothesis that stock prices do not Granger-cause IIP cannot be rejected even at the 10% significance level for the five-variable VAR with exports).
22. Even when the exchange rate was added to this five-variable VAR, we obtained results suggesting the existence of the exchange rate channel (but the evidence is not strong enough to be supported statistically).
23. Andrés et al. (2004) develop a multiasset model which includes both short- and long-term bonds.

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