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Article

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Did the expectations channel work? Evidence from quantitative easing in Japan, 2001–06

Chikashi Tsuji^{1*}

Abstract: The Japanese economy experienced a prolonged period of quantitative easing (QE) over the five years from March 2001 to March 2006. The purpose of this paper is to evaluate the direct and exclusive effects of this rather unconventional monetary policy on financial markets, economic activity, and labor markets in Japan empirically by employing exactly the same testing period with the QE period in most of our examinations. Using a range of variables, we first estimate vector error correction models (VECMs) that consider the cointegrating relations between the Japanese monetary base and other variables in our data-set. We also use Markov-switching dynamic regression (MSDR) models, Bayesian vector autoregressive (VAR) models, and causality analyses to test for robustness. Together, all the above analyses consistently provide a number of interesting findings. First, QE lowered short- and medium-term credit spreads and improved Japanese credit market conditions. Second, QE increased stock prices in Japan and improved market expectations. Third, the QE policy recovered labor market conditions and economic productivity in Japan. Finally, additional analyses of fund flows and economic survey data suggest that the primary transmission channel of this period of Japanese QE policy was the expectations channel.

ABOUT THE AUTHOR

Chikashi Tsuji is a professor of Economics and Finance at Chuo University in Tokyo, Japan. He commenced his academic career as an assistant professor at Ritsumeikan University in 2003, followed by an associate professorship at Tsukuba University in 2007 and a professorship at Chuo University in 2013. His research interests include asset pricing, corporate finance, applied econometrics, financial accounting, and monetary economics. He is also interested in engineering issues related to economics and finance. His published research includes forecasting asset returns and volatility, testing asset-pricing models, investigating financial risk, examining linkages between asset prices and macroeconomic variables, and testing the relations between corporate payout policy, capital structure, financial and accounting ratios, and stock returns. He has published widely in a range of international peer-reviewed journals including the *Journal of International Money and Finance*, *Quantitative Finance*, and *Applied Financial Economics*.

PUBLIC INTEREST STATEMENT

The Bank of Japan executed a quantitative easing (QE) monetary policy over the five-year period from March 2001 to March 2006. This work empirically evaluates the direct and exclusive effects of this rather unconventional monetary policy on financial markets, economic activity, and labor markets in Japan. Using a wide range of variables, the work yields a number of interesting findings. First, QE lowered short- and medium-term credit spreads and improved credit market conditions. Second, QE increased stock prices and improved market expectations. Third, the QE policy facilitated the recovery of labor market conditions and economic productivity. Finally, analysis of fund flows and economic survey data suggests that the primary transmission channel of this QE policy was the expectations channel. This study is noteworthy in that it is the first to reveal the working mechanisms of the expectations channel in Japanese QE from 2001 to 2006.

Subjects: Economics; Finance

Keywords: Bayesian VAR model; cointegration; expectations channel; Markov-switching dynamic regression model; portfolio substitution channel; quantitative easing monetary policy; signaling effect; vector error correction model

1. Introduction

In recent years, a number of major central banks around the world have conducted quantitative easing (QE) programs to counter the strong negative effects of the most recent financial crisis on economic activity. For instance, in an attempt to end Japan's current prolonged deflation and economic slump, known as the "Lost Two Decades," the Bank of Japan (BOJ) is currently executing an unconventional monetary easing policy referred to as quantitative–qualitative easing (QQE). However, this policy is ongoing, and it is difficult to fully assess its effectiveness at present. Similarly, the US Federal Reserve has also implemented successive QE monetary policies, known as QE1, QE2, and QE3, and sometimes referred to as large-scale asset purchase (LSAP) programs.¹ Evaluation of the effectiveness of QE policies like these is extremely important for policy-makers and other monetary policy stakeholders. Fortunately, aside from the current QQE policy in Japan, the BOJ also conducted a QE policy from March 2001 to March 2006. Because this program has now concluded, we can now evaluate its effects fully.

Regarding the effectiveness of QE, previous studies present two conflicting views. Concerning the first, traditional macroeconomic theory as Hicks (1937) suggested that when interest rates are at their lower bound, monetary injections into the economy are ineffective. In contrast, Eggertsson and Woodford (2003), Clouse, Henderson, Orphanides, Small, and Tinsley (2003), Bernanke and Reinhart (2004), and Bernanke, Reinhart, and Sack (2004) argued that central bankers could stimulate the economy, even when interest rates are at their lower bound, because QE monetary policy can stimulate the economy by changing market expectations or the composition and/or size of the central bank's balance sheet.

More recently, Glick and Leduc (2012), D'Amico and King (2013), and Neely (2015) examined the effects of QE in the US. Fujiwara (2006) used Markov-switching vector autoregressive (MSVAR) models to examine Japanese monetary policies empirically, including the partial period of QE from 2001 to 2006, and found that it had little effect. In contrast, Girardin and Moussa (2011), using an extended MSVAR model and factor analysis, found that it had in fact worked as expected. Using a structural VAR (SVAR) approach, Schenkelberg and Watzka (2013) also found evidence of the effectiveness of Japanese QE policy, as did Honda (2014) with simple VAR analysis. Given this mixed evidence, more comprehensive study is required on the effectiveness of QE in Japan from 2001 to 2006.

In this paper, we analyze the effects of Japan's QE program using vector error correction models (VECMs), Markov-switching dynamic regression (MSDR) models, Bayesian VAR models, and causality analyses to obtain robust evidence. Our paper has several noteworthy features. (i) First, we employ a comprehensive data-set to examine the effects of a wide range of economic and financial market variables on productivity, labor market conditions, bond markets, and stock markets in Japan. (ii) Second, we investigate the effects of QE by taking into account the bivariate cointegration between the monetary base and the other variables used in our analysis. The results are also carefully checked by additional analyses by MSDR models, Bayesian VAR models, and causality tests. (iii) Third, our study mainly focuses on the direct effects of the increases in the monetary base on the Japanese economy and financial markets. Nevertheless, we also attempt to identify the transmission channel that was effective during the QE period by examining important related data. We note that in identifying the effective channel, we focus on two important theoretical channels discussed later: the

expectations channel (Bernanke et al., 2004) and the portfolio substitution channel (e.g. Tobin, 1969). We also consider that signaling effects (Bernanke et al., 2004) are also important in the context of Japan's QE from 2001 to 2006. (iv) Fourth, this paper tests the QE effects employing exactly the same QE period except for the robustness checks by the MSDR model to clarify their precise and direct effects during the QE period. This is also one of the most noteworthy features of this study.

Using VECMs, MSDR models, Bayesian VAR models, and causality tests, we consistently obtain the following results. (i) First, QE lowered short- and medium-term credit spreads and improved Japanese credit market conditions. (ii) Second, QE increased stock prices and improved market expectations for future economic conditions. (iii) Third, QE stimulated and recovered economic productivity and labor market conditions in Japan. (iv) Finally, we find that it is the expectations channel that mainly worked in the Japan's QE from 2001 to 2006.

The remainder of the paper is organized as follows. Section 2 describes the QE conducted in Japan from 2001 to 2006, Section 3 reviews the existing literature, and Section 4 discusses the theoretical backgrounds of QE policy. Section 5 describes our data, Section 6 presents the results of the unit root and cointegration tests, and Section 7 discusses the specification of VECMs. Section 8 reports the empirical results from VECMs, Section 9 presents the results of MSDR models, Section 10 documents the results of robustness checks by Bayesian VAR and causality analyses, and Section 11 discusses the working channel in this QE. Section 12 further discusses the contributions and implications of our various empirical analyses and Section 13 concludes the paper.

2. Japanese QE from 2001 to 2006

The bubble economy burst in Japan in about 1990, followed by a prolonged economic depression. In response, the BOJ began reducing the uncollateralized overnight call rate as the target policy interest rate in Japan, and in February 1999, it decided to adopt a so-called zero interest rate policy (ZIRP), which was in place from April 1999 to August 2000. At first, this policy appeared to produce the required results, with the Japanese economy recovering from August 2000 and consumer prices becoming more stable. Consequently, the BOJ decided to discontinue the ZIRP in August 2000 and raised the uncollateralized overnight call rate.

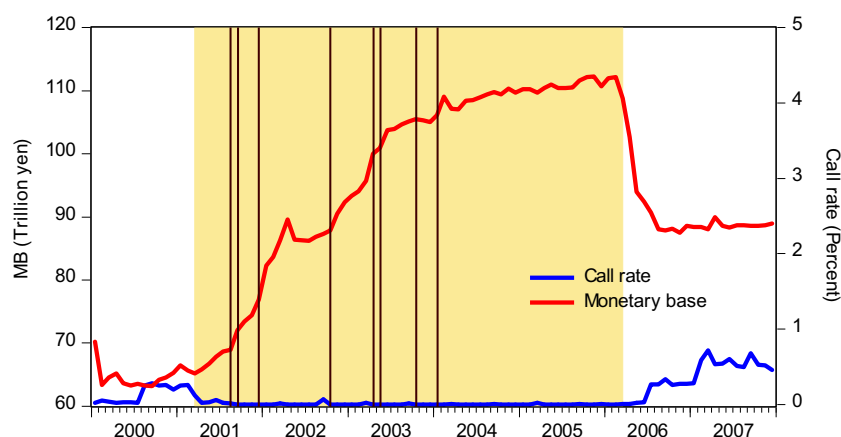
However, in late 2000, economic conditions again worsened, and concerns about deflation emerged in 2001. As a result, the BOJ again reduced the uncollateralized overnight call rate. Yet again, the ZIRP was unable to stimulate economic activity adequately. Hence, in March 2001, the BOJ undertook to employ a QE monetary policy. More specifically, on March 19, 2001, the BOJ altered its operating target from the uncollateralized overnight call rate to BOJ current account balances, with the BOJ supplying liquidity to the Japanese financial markets by increasing their current account balances.

During the period of QE, the BOJ raised the target range of its current account balances some eight times. In the first instance, the BOJ raised the target to 5–6 trillion yen in August 2001, then to in excess of 6 trillion yen in September 2001, and to 10–15 trillion yen in December 2001. Subsequently, the BOJ increased the target to 15–20 trillion yen in October 2002, 22–27 trillion yen in April 2003, 27–30 trillion yen in May 2003, 27–32 trillion yen in October 2003, and finally, in January 2004, to 30–35 trillion yen.²

After about five years, on 9 March 2006, the BOJ terminated this program of QE because (i) since October 2005, inflation as measured by the core consumer price index (CPI)³ had remained positive, and (ii) the BOJ was of the opinion that the inflation rate in Japan would remain positive for the foreseeable future. Figure 1 depicts the evolution of the Japanese monetary base and the call rate, with the shaded area identifying the period of QE. As shown, at least until about March 2006, the Japanese monetary base gradually increased following the adoption of QE.

Figure 1. Time-series evolution of the monetary base and the call rate during QE in Japan.

Notes: This figure exhibits the time-series evolution of the monetary base and the call rate in Japan, including the period of Japanese quantitative easing (QE). The Japanese monetary base is shown in trillion yen. Quantitative easing monetary policy in Japan was executed by the Bank of Japan (BOJ) for the period from 19 March 2001 to 9 March 2006. This figure is drawn for the period from January 2000 to December 2007 and the shaded area in this figure indicates the period of the Japan's QE. Furthermore, eight lines in this figure mean the date when the BOJ raised its targeting amount of current account balances.



3. Literature review

Although the focus of this paper is QE in Japan, we now briefly review the existing empirical literature, starting with QE in the US, followed by QE again in Japan from 2001 to 2006. To start with, Hancock and Passmore (2011) analyzed the purchase program for mortgage-backed securities (MBSs) conducted by the US Federal Reserve in 2008 by focusing on the effects of the purchase program on mortgage rates.⁴ More recently, Glick and Leduc (2012) examined the effects of the Federal Reserve's LSAPs since 2008 on financial markets in the US.⁵

Moreover, Kandrak and Schlusche (2013) confirmed the existence of "flow effects" in the prices of US Treasury securities during the initial stages of the LSAP program.⁶ Kandrak (2013) examined the impact of the MBS purchases by the Federal Reserve on market functions in the US and found that these purchases indeed disrupted markets, although the magnitude of the effects was small. Elsewhere, D'Amico and King (2013) considered the impact of the US Treasury securities purchase program by the Federal Reserve on yields. Lastly, using international data, Neely (2015) examined the effects of the Federal Reserve's QE announcements from 2008 to 2009 and found that these substantially lowered the yields of international long-term bonds and depreciated the spot price of the US dollar.

We next review extant studies of QE in Japan from 2001 to 2006, which is the focus period of our study. To start, Fujiwara (2006) used MSVAR models to analyze QE in Japan from January 1985 to December 2003, corresponding to only part of the QE sample period. However, the focus of that study was to confirm the existence of an economic structural break in Japan resulting from the BOJ's ZIRP.⁷ Furthermore, Fujiwara (2006) suggested that during the 1990s, monetary policy became less effective in Japan; consequently, QE after March 2001 had very little effect.

Conversely, Girardin and Moussa (2011) conducted empirical analysis of QE in Japan from 2001 to 2006 and found that QE was indeed effective. More specifically, using an extended MSVAR model and factor analysis, they showed that in Japan a significant economic regime change to a favorable state took place because of QE. On this basis, they concluded that QE was able to both prevent further recession and deflation and to stimulate output and prices substantially. Their analysis using factor analysis was also economy wide because it employed the extracted factors for (i) economic activity, (ii) prices, and (iii) interest rates from among several related series. However, their approach differs from the present analysis in that we examine the effects of QE on a variety of economic and financial variables, whereas their focus was only on output, prices, and interest rates. As we describe later in our discussion, this paper instead uses a wider range of specific variables and analyzes them individually to understand more clearly which variables were affected more directly and strongly by QE. Moreover, Girardin and Moussa (2011) did not examine the expectations channel or the portfolio substitution channel specifically, while this paper carefully considers these channels by inspecting actual data.

Using Japanese data after 1995, Schenkelberg and Watzka (2013) examined QE using a SVAR model to identify the effects of shocks in the zero-lower bound economy. They found that QE shocks lowered Japanese long-term interest rates and increased output and prices. We note that our study departs from this in that we analyze a number of additional variables. More precisely, Schenkelberg and Watzka (2013) analyzed the BOJ current account balances, CPI, industrial production, 10-year government bond yields, and exchange rates. Indeed, one of the main contributions of our paper is to obtain new evidence on the effects of the QE by specifying a wider range of variables in our analysis.⁸

Although Honda (2014) focused on QE in Japan from 2001 to 2006 and found that the policy had been effective, that study differs from our study in the following ways. First, Honda (2014) employed a longer sample period from January 1996 to March 2010 and examined the effects of QE from March 2001 to March 2006 using dummy variables identifying the QE period. Second, unlike Honda (2014), we also investigate the monetary base, the index of the capacity utilization ratio, the absolute unemployment rate, the short- and medium-term credit spreads, and the Nikkei 225 stock index price (the Nikkei). Third, Honda (2014) used standard VAR models instead of the VECMs that we employ in this study. The advantage of VECMs is that they consider the cointegrating relationship between the monetary base and the other economic and financial market variables.⁹ We also note that we check the results from VECMs by MSDR models, Bayesian VAR models, and causality analyses.

In summary, there is at present a lack of rigorous comprehensive empirical research concerning the effects of QE in Japan from 2001 to 2006. In response, we examine QE by considering the cointegrating relationships between the monetary base and other economic and financial market variables. Following this, and based on the theoretical discussion in the next section, we also attempt to identify the channel through which QE worked.

4. Theoretical discussion—effects and channels

This section discusses the potential effects and channels of QE, which work when short-term policy interest rates are at very low levels or even zero. The first is the expectations channel. This means that central banks can affect asset prices and economic activity by firstly influencing market participants' expectations of future short-term interest rates, as suggested by such studies as Svensson (2001), Eggertsson and Woodford (2003), and Woodford (2003). As Bernanke and Reinhart (2004) noted, these studies find that even when the nominal policy interest rate is zero or near zero, a central bank can stimulate the economy by committing to the public to maintain the short-term rate at a low level for even longer than previously expected. They also suggested that if this commitment is credible, it should affect other asset prices and stimulate real economy by changing market expectations.

The second is the portfolio substitution channel, as suggested by Tobin (1969), Brunner and Meltzer (1973), and Andrés, López-Salido and Nelson (2004). Specifically, if money is an imperfect substitute for other financial assets, large increases in the money supply will result in investors' portfolio rebalancing, and this will increase some non-money asset prices and decrease others. Consequently, through these portfolio substitution effects, economic activity will be stimulated, even in a lower-bound interest rate economy.

With Japanese QE after March 2001 facing a virtually zero-interest rate economy, by increasing its current account balances, the BOJ continued to inject more liquidity than needed to ensure a zero-call rate. As for the commitments in this policy, the BOJ at first promised that until the annual CPI change rate became stable at zero or above, it would continue QE. Afterwards, in October 2003, the BOJ supplied a more detailed description of its commitment. That is, it would continue QE (i) until the latest annual change in core CPI became zero or above and expected to continue as such in the future, and (ii) until the future core CPI inflation rate was not expected to fall below zero again. Hence, we understand that the BOJ's conditional commitments are equivalent to a commitment to

continue monetary easing until certain economic conditions are met, a policy discussed in the situation where the expectations channel is expected to work.

Moreover, we note that the BOJ's act of setting a high reserve target is more visible, and thus the commitment may be more credible than a purely verbal promise regarding future monetary policy. Once again, we regard the targeted current account balances as a clear visible policy signal, as suggested by Bernanke et al. (2004); thus, the so-called signaling effect is also expected in the context of Japan's QE.

Furthermore, with this form of QE executed from 2001 to 2006, the BOJ's current account balances increased roughly sevenfold over these five years, and the monetary base expanded from about 13 to 22% of nominal GDP over the same period. Given these unusual money injections, we also expect the portfolio substitution effect on non-money assets in Japanese financial markets, and through the effect, the Japanese economy would be stimulated.

Based on this theoretical discussion, we conduct a careful empirical analysis to clarify not only the effectiveness of this Japanese QE program but also the channels and mechanisms governing this QE during the policy period.

5. Data

This section describes the data and variables used in our analysis. In this study, we investigate the effects of the QE executed in Japan from March 2001 to March 2006. Accordingly, we mainly use Japanese monthly data over an identical period to analyze the direct and exclusive effects of the QE program. All data are from QUICK Corp. and the BOJ.

Our first variable group comprises macroeconomic variables. First, MB is the monetary base in Japan. Our interest is mainly on the effect of increases in MB through QE on the other variables. Second, IP is the most representative index of industrial production in Japan. Thus, IP represents overall productivity. Third, ICU is the capacity utilization ratio. This ratio indicates the degree of utilization of plant and equipment, and hence a higher ICU identifies greater economic activity in Japan. Lastly, UNE is a variable representing Japanese labor market conditions, as measured by the absolute unemployment rate in Japan. A lower UNE suggests an improvement in Japanese labor market conditions.

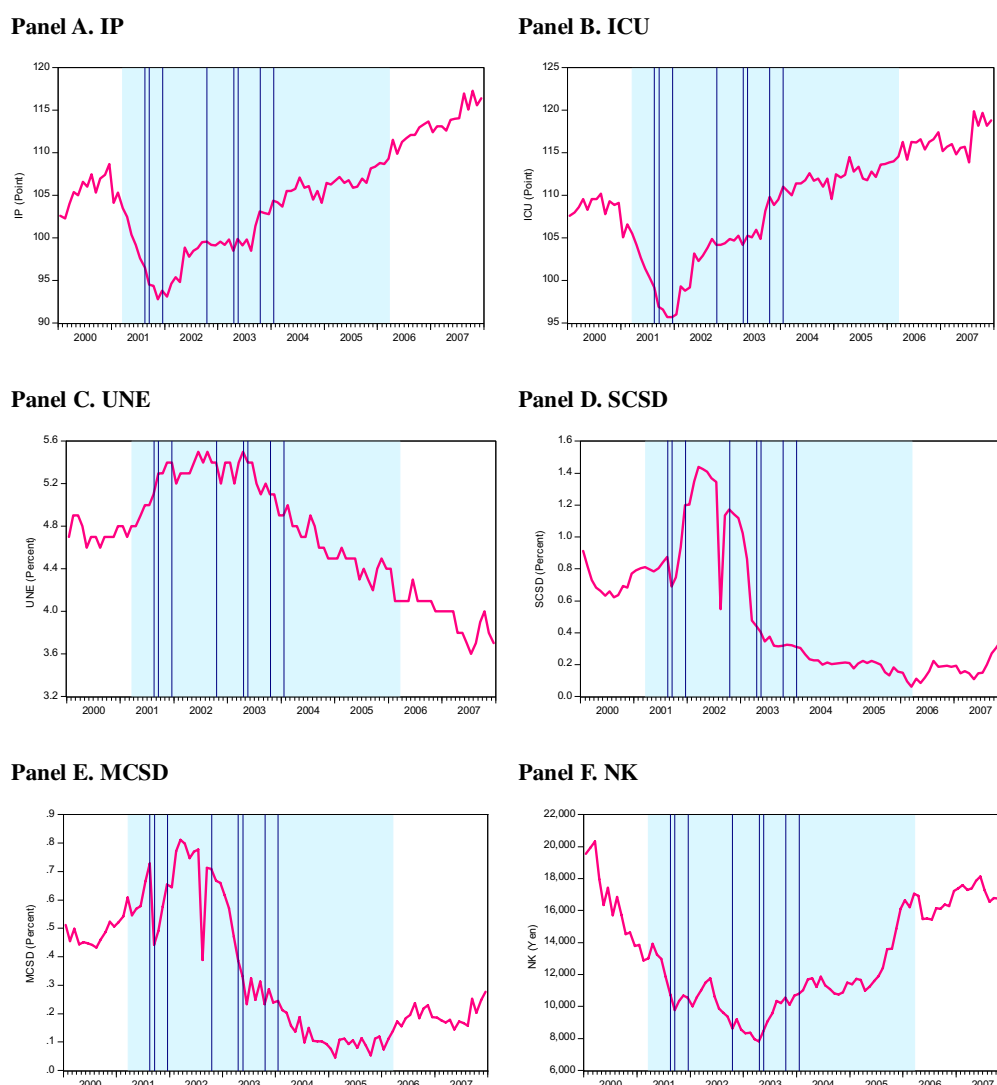
Our next group of variables reflects Japanese credit market conditions. First, SCSD is the short-term credit spread, being the difference between the short-term Nikkei bond index yield and the two-year Japanese government bond yield. Second, MCSD is the medium-term credit spread, which equals the medium-term Nikkei bond index yield minus the five-year Japanese government bond yield.¹⁰ We also consider that these credit spread variables are proxies for the risk aversion of market participants, such that lower values of SCSD and MCSD are associated with decreases in financial market risk aversion.

The final variable relates to the Japanese stock market. Namely, our variable NK indicates the Nikkei 225 stock price index (the Nikkei). The Nikkei is a well-known Japanese stock market index, mostly comprising large firms. We also consider that the prices of the Nikkei reflect the market expectations as to the future stock market and economic conditions.¹¹

Figure 2 plots the six economic and financial variables other than MB, with the shaded area designating the QE period. As shown, IP, ICU, and NK all generally increased during this period. In contrast, UNE, SCSD, and MCSD all decreased in general. Table 1 provides descriptive statistics for our variables, including the mean, median, maximum, minimum, standard deviation, skewness, and kurtosis. As shown, NK is right (or positively) skewed as the value of skewness is around one, while MB and ICU are left (or negatively) skewed. For the variable NK, the kurtosis value is more than three, suggesting fat-tailed (or leptokurtic) distributions with relatively many extreme observations. In

Figure 2. Time-series evolution of economic productivity, labor market, and financial market variables during QE in Japan.

Notes: This figure exhibits the time-series evolution of various variables as to economic productivity, labor market conditions, and the state of financial markets in Japan. This figure is drawn by including the period of Japanese QE from 2001 to 2006. More specifically, Panel A shows the evolution of IP; Panel B displays the time-series of ICU; Panel C exhibits the evolution of UNE; Panel D exhibits the time-series of SCSD; Panel E shows the evolution of MCSD; and Panel F indicates the time-series of NK. In this figure, IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread and this variable is constructed by subtracting the two-year Japanese government bond yield from the short-term Nikkei bond index yield; MCSD means the Japanese medium-term credit spread and this variable is constructed by subtracting the five-year Japanese government bond yield from the medium-term Nikkei bond index yield; and NK denotes the Nikkei 225 stock price index in Japan. This figure is drawn for the period from January 2000 to December 2007 and the shaded area indicates the period of the Japan's QE. Furthermore, eight lines in this figure mean the date when the BOJ raised its targeting amount of current account balances.



contrast, the values of the other six variables are all less than three, indicating thin-tailed (or platykurtic) distributions with relatively few extreme observations.

6. Unit root and cointegration tests

Before estimating the VECMs, we perform unit root and cointegration tests. Table 2 presents the results of the augmented Dickey–Fuller unit root tests. As shown, we conduct tests on both the levels and first differences of our seven variables. Table 2 shows that in levels, all variables have unit roots, while their first differences do not contain unit roots. Therefore, all seven variables are nonstationary in levels but stationary in first differences.

Table 3 shows the results of Johansen’s cointegration tests (Johansen, 1991, 1995) for the bivariate combinations of MB and the remaining six variables. Table 3 details the number of cointegrating relations for (i) no constant term in the cointegrating equation (CE) or in the VAR model (hereafter “model type 1”) and (ii) a constant term in the CE but no constant in the VAR model (“model type 2”). “Lag” in Table 3 indicates the lag order of each VAR model. The test results in Table 3 suggest that all six bivariate combinations have cointegrating relations. More specifically, Table 3 indicates that both the trace and maximum eigenvalue statistic tests suggest that in model type 1, MB and IP (Panel A) and MB and ICU (Panel B) have one cointegrating relation. Panels A and B also show that the lag orders of the VAR models for MB and IP and MB and ICU are two.

Table 1. Descriptive statistics of the variables for testing the effectiveness of Japanese QE from 2001 to 2006: statistics for the period from March 2001 to March 2006

	MB	IP	ICU	UNE	SCSD	MCSD	NK
Mean	97.1891	101.9705	107.0443	4.9295	0.5586	0.3575	11,233.6000
Median	105.0710	102.8000	108.2000	5.0000	0.3215	0.2491	11,008.9000
Maximum	112.2107	109.3000	114.6000	5.5000	1.4402	0.8112	17,059.6600
Minimum	65.2248	92.8000	95.7000	4.1000	0.0609	0.0462	7,831.4200
Std. Dev.	15.1082	4.5901	5.5864	0.4129	0.4320	0.2567	2,035.5990
Skewness	-0.8149	-0.2770	-0.4691	-0.2968	0.7666	0.4022	0.9662
Kurtosis	2.2900	1.9530	2.0634	1.8199	2.1085	1.5915	4.0859

Notes: This table presents the descriptive statistics of various variables as to the Japanese economy and financial markets. These seven variables are for testing the effectiveness of Japanese quantitative easing, which was executed from 2001 to 2006. Our samples are monthly, and the sample period for the statistics spans March 2001 to March 2006. In the table, Std. Dev. denotes the value of standard deviation. Regarding the variables more specifically, MB represents the amount of the monetary base in Japan (trillion yen); IP denotes the Japanese industrial production index (point); ICU means the capacity utilization ratio index in Japan (point); and UNE is the absolute unemployment rate in Japan (percent). In addition, SCSD denotes the Japanese short-term credit spread and this variable is constructed by subtracting the two-year Japanese government bond yield from the short-term Nikkei bond index yield (percent); and MCSD means the Japanese medium-term credit spread and this variable is constructed by subtracting the five-year Japanese government bond yield from the medium-term Nikkei bond index yield (percent). Finally, NK denotes the Nikkei 225 stock price index in Japan (yen).

Furthermore, the above two cointegration tests suggest that in model type 2, MB and UNE (Panel C), MB and SCSD (Panel D), MB and MCSD (Panel E), and MB and NK (Panel F) also have one cointegrating relation. The above four panels indicate that the VAR lag order of MB and UNE is four, the lag orders of MB and SCSD and MB and MCSD are six, and that of MB and NK is two. The details of the VECMs, as specified based on these results, are in the next section.

Table 2. Results of unit root tests: the cases of Japanese economic and financial market variables for the period of Japanese QE from March 2001 to March 2006

Panel A. Levels			Panel B. First differences		
Variable	t-statistic	p-value	Variable	t-statistic	p-value
MB	-0.1644	0.9925	MB	-5.7900***	0.0000
IP	-0.0739	0.9471	IP	-9.1679***	0.0000
ICU	-0.2202	0.9295	ICU	-9.0045***	0.0000
UNE	-0.2384	0.9271	UNE	-8.9833***	0.0000
SCSD	-1.1750	0.6798	SCSD	-9.3069***	0.0000
MCSD	-0.9133	0.7773	MCSD	-10.8956***	0.0000
NK	0.6065	0.9888	NK	-5.8514***	0.0000

Notes: This table displays the results of the augmented Dickey-Fuller (ADF) unit root tests for the levels and the first differences of our seven variables, which are related to economic productivity, labor markets, and financial markets in Japan. In this table, t-statistic means the test statistic for the ADF unit root tests. In our ADF tests, lag orders are determined by the Schwarz criterion. The sample period for the tests is from March 2001 to March 2006 and during this period, the BOJ executed QE. More specifically, Panel A shows the results for the level variables and Panel B exhibits the results for the first difference variables. In this table, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread and this variable is constructed by subtracting the two-year Japanese government bond yield from the short-term Nikkei bond index yield; MCSD means the Japanese medium-term credit spread and this variable is constructed by subtracting the five-year Japanese government bond yield from the medium-term Nikkei bond index yield; and NK denotes the Nikkei 225 stock price index in Japan.

***Statistical significance at the 1% level.

7. VECM analysis of the QE effects

This section documents the details of the VECMs estimated in this study. Based on the results in Panels A–F in Table 3, we specify the VECMs as follows.¹² First, for MB and IP, we apply a VECM(2) with a CE, $CE_{mb-ip} = MB_{t-1} + \psi_{mb-ip} IP_{t-1}$:

$$\Delta MB_t = \kappa_{1,mb-ip} CE_{mb-ip} + \sum_{p=1}^2 \xi_{1,p} \Delta MB_{t-p} + \sum_{q=1}^2 \phi_{1,q} \Delta IP_{t-q} + \eta_{1,t}, \quad (1)$$

Table 3. Results of cointegration tests: the cases of Japanese economic and financial market variables during Japanese QE from March 2001 to March 2006

Panel A. Cointegration tests of MB and IP

Assumed model	No intercept in the CE and no intercept in the VAR (Model type 1)			
Lag	2			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	17.8416**	0.0054	14.5504**	0.0126
At most 1	3.2912	0.0825	3.2912	0.0825

Panel B. Cointegration tests of MB and ICU

Assumed model	No intercept in the CE and no intercept in the VAR (Model type 1)			
Lag	2			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	17.8156**	0.0055	14.8827**	0.0109
At most 1	2.9329	0.1027	2.9329	0.1027

Panel C. Cointegration tests of MB and UNE

Assumed model	An intercept in the CE and no intercept in the VAR (Model type 2)			
Lag	4			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	28.2231**	0.0032	19.9133**	0.0110
At most 1	8.3098	0.0725	8.3098	0.0725

Panel D. Cointegration tests of MB and SCSD

Assumed model	An intercept in the CE and no intercept in the VAR (Model type 2)			
Lag	6			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	28.1974**	0.0033	20.6728**	0.0082
At most 1	7.5246	0.1014	7.5246	0.1014

Panel E. Cointegration tests of MB and MCSD

Assumed model	An intercept in the CE and no intercept in the VAR (Model type 2)			
Lag	6			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	33.5244**	0.0004	26.3378**	0.0008
At most 1	7.1865	0.1169	7.1865	0.1169

(Continued)

Table 3. (Continued)

Panel F. Cointegration tests of MB and NK

Assumed model	An intercept in the CE and no intercept in the VAR (Model type 2)			
Lag	2			
Test type	Trace test		Maximum-eigenvalue test	
Hypothesized number of CE	Trace statistic	p-value	Max-eigenvalue statistic	p-value
None	40.6452**	0.0000	35.8420**	0.0000
At most 1	4.8032	0.3057	4.8032	0.3057

Notes: This table presents the results of Johansen's cointegration tests (Johansen, 1991, 1995) for the combinations of MB and a variable from the other six variables as to economic productivity, labor markets, and financial markets in Japan. In this table, the results of the trace tests and those of the tests using the maximum eigenvalue statistic are exhibited. The sample period for the tests is from March 2001 to March 2006 and during this period, Japanese QE was conducted. More specifically, Panel A shows the results of MB and IP; Panel B displays the results of MB and ICU; Panel C exhibits those of MB and UNE; Panel D exhibits those of MB and SCSD; Panel E shows those of MB and MCSD; and Panel F indicates those of MB and NK. In this table, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan.

**Statistical significance for rejecting the hypothesized number of cointegrating equations in the null hypothesis at the 5% level and CE denotes the cointegrating equation.

$$\Delta IP_t = \kappa_{2,mb-ip} CE_{mb-ip} + \sum_{p=1}^2 \xi_{2,p} \Delta MB_{t-p} + \sum_{q=1}^2 \phi_{2,q} \Delta IP_{t-q} + \eta_{2,t}, \quad (2)$$

where ΔMB_{t-p} is the first difference of MB, and the lag order is p (the same hereafter); ΔIP_{t-q} is the first difference of IP, with lag order q .

For MB and ICU, we specify a VECM(2) with a CE, $CE_{mb-icu} = MB_{t-1} + \psi_{mb-icu} ICU_{t-1}$:

$$\Delta MB_t = \kappa_{1,mb-icu} CE_{mb-icu} + \sum_{p=1}^2 \tau_{1,p} \Delta MB_{t-p} + \sum_{q=1}^2 \lambda_{1,q} \Delta ICU_{t-q} + w_{1,t}, \quad (3)$$

$$\Delta ICU_t = \kappa_{2,mb-icu} CE_{mb-icu} + \sum_{p=1}^2 \tau_{2,p} \Delta MB_{t-p} + \sum_{q=1}^2 \lambda_{2,q} \Delta ICU_{t-q} + w_{2,t}, \quad (4)$$

where ΔICU_{t-q} is the first difference of ICU, with lag order q .

For MB and UNE, we employ a VECM(4) with a CE, $CE_{mb-une} = MB_{t-1} + \psi_{mb-une} UNE_{t-1} + h_{mb-une}$:

$$\Delta MB_t = \kappa_{1,mb-une} CE_{mb-une} + \sum_{p=1}^4 v_{1,p} \Delta MB_{t-p} + \sum_{q=1}^4 \beta_{1,q} \Delta UNE_{t-q} + m_{1,t}, \quad (5)$$

$$\Delta UNE_t = \kappa_{2,mb-une} CE_{mb-une} + \sum_{p=1}^4 v_{2,p} \Delta MB_{t-p} + \sum_{q=1}^4 \beta_{2,q} \Delta UNE_{t-q} + m_{2,t}, \quad (6)$$

where ΔUNE_{t-q} is the first difference of UNE, with lag order q .

For MB and SCSD, we specify a VECM(6) with a CE, $CE_{mb-scsd} = MB_{t-1} + \psi_{mb-scsd} SCSD_{t-1} + h_{mb-scsd}$:

$$\Delta MB_t = \kappa_{1,mb-scsd} CE_{mb-scsd} + \sum_{p=1}^6 \chi_{1,p} \Delta MB_{t-p} + \sum_{q=1}^6 \zeta_{1,q} \Delta SCSD_{t-q} + z_{1,t}, \quad (7)$$

$$\Delta SCSD_t = \kappa_{2,mb-scscd} CE_{mb-scscd} + \sum_{p=1}^6 \chi_{2,p} \Delta MB_{t-p} + \sum_{q=1}^6 \zeta_{2,q} \Delta SCSD_{t-q} + z_{2,t}, \quad (8)$$

where $\Delta SCSD_{t-q}$ is the first difference of SCSD, with lag order q .

For MB and MCSD, we use a VECM(6) with a CE, $CE_{mb-mcsd} = MB_{t-1} + \psi_{mb-mcsd} MCSD_{t-1} + h_{mb-mcsd}$ as follows:

$$\Delta MB_t = \kappa_{1,mb-mcsd} CE_{mb-mcsd} + \sum_{p=1}^6 \iota_{1,p} \Delta MB_{t-p} + \sum_{q=1}^6 \theta_{1,q} \Delta MCSD_{t-q} + l_{1,t}, \quad (9)$$

$$\Delta MCSD_t = \kappa_{2,mb-mcsd} CE_{mb-mcsd} + \sum_{p=1}^6 \iota_{2,p} \Delta MB_{t-p} + \sum_{q=1}^6 \theta_{2,q} \Delta MCSD_{t-q} + l_{2,t}, \quad (10)$$

where $\Delta MCSD_{t-q}$ is the first difference of MCSD, with lag order q .

Finally, for MB and NK, we specify a VECM(2) with a CE, $CE_{mb-nk} = MB_{t-1} + \psi_{mb-nk} NK_{t-1} + h_{mb-nk}$:

$$\Delta MB_t = \kappa_{1,mb-nk} CE_{mb-nk} + \sum_{p=1}^2 \Gamma_{1,p} \Delta MB_{t-p} + \sum_{q=1}^2 \Lambda_{1,q} \Delta NK_{t-q} + s_{1,t}, \quad (11)$$

$$\Delta NK_t = \kappa_{2,mb-nk} CE_{mb-nk} + \sum_{p=1}^2 \Gamma_{2,p} \Delta MB_{t-p} + \sum_{q=1}^2 \Lambda_{2,q} \Delta NK_{t-q} + s_{2,t}, \quad (12)$$

where ΔNK_{t-q} is the first difference of NK, with lag order q .

8. Empirical results from the VECMs

This section documents our empirical results. In what follows, we explain the estimation results for the VECMs specified above. We then discuss the impulse response functions for our six variables given an increase in the monetary base. We note that these VECM analyses employ exactly the same QE period to clarify the direct and exclusive effects of Japan's QE during the QE period.

8.1. Estimation results for the VECMs

Table 4 presents the estimation results of our six VECMs as specified in the previous section. Panels A–C provide the results concerning the relations between the monetary base and the other economic variables. As shown, the estimated CEs of MB and IP, MB and ICU, and MB and UNE are statistically significant in explaining the dynamic evolution of ΔIP , ΔICU , and ΔUNE , respectively. In addition, the two-period lag of ΔMB statistically significantly explains the evolution of ΔIP with a positive sign (Panel A), and the one-period lag of ΔMB also statistically significantly explains the evolution of ΔICU with a positive sign (Panel B). Hence, our VECMs successfully capture the relations between MB and IP, MB and ICU, and MB and UNE. These results then well demonstrate that the QE program in Japan from 2001 to 2006 positively affected economic activity. During the QE period of March 2001 to March 2006, the IP recovered from a low of 92.8 points in November 2001 to 109.3 points in March 2006 and this is a 17.8% increase. In addition, ICU also recovered from a low of 95.7 points in November 2001 and December 2001 to 114.6 points in March 2006 and this is a 19.7% restoration.

Panels D and E of Table 4 provide the results for the monetary base and bond market variables. The results show that the CEs of MB and SCSD and MB and MCSD are statistically significant in explaining the evolution of $\Delta SCSD$ and $\Delta MCSD$, respectively. Moreover, the four-period lag of ΔMB statistically significantly explains the evolution of $\Delta SCSD$ with a negative sign (Panel D), and the

Table 4. Estimation results of the bivariate VECMs: the cases of Japanese QE from March 2001 to March 2006

Panel A. MB and IP			Panel B. MB and ICU		
Cointegrating equation			Cointegrating equation		
	Coefficients			Coefficients	
MB(−1)	1.0000		MB(−1)	1.0000	
IP(−1)	−1.0273***		ICU(−1)	−0.9717***	
p-value	0.0000		p-value	0.0000	
Error correction			Error correction		
	Variables			Variables	
	ΔMB	ΔIP		ΔMB	ΔICU
	Coefficients			Coefficients	
CE	−0.0584***	0.0345**	CE	−0.0649***	0.0424**
p-value	0.0024	0.0135	p-value	0.0020	0.0142
ΔMB(−1)	0.2246	0.0781	ΔMB(−1)	0.1717	0.2119*
p-value	0.1081	0.4433	p-value	0.2145	0.0684
ΔMB(−2)	0.0150	0.2286**	ΔMB(−2)	0.0612	0.1905
p-value	0.9132	0.0270	p-value	0.6652	0.1099
ΔIP(−1)	0.2580	−0.2348*	ΔICU(−1)	0.1100	−0.2116
p-value	0.1252	0.0592	p-value	0.4815	0.1079
ΔIP(−2)	−0.1081	0.3015**	ΔICU(−2)	0.0374	0.1162
p-value	0.5162	0.0163	p-value	0.8027	0.3533
Adj. R ²	0.1171	0.2369	Adj. R ²	0.0718	0.1290
Panel C. MB and UNE			Panel D. MB and SCSD		
Cointegrating equation			Cointegrating equation		
	Coefficients			Coefficients	
MB(−1)	1.0000		MB(−1)	1.0000	
UNE(−1)	14.8660**		SCSD(−1)	20.1558***	
p-value	0.0129		p-value	0.0000	
Intercept	−170.2329***		Intercept	−113.7593***	
p-value	0.0000		p-value	0.0000	
Error correction			Error correction		
	Variables			Variables	
	ΔMB	ΔUNE		ΔMB	ΔSCSD
	Coefficients			Coefficients	
CE	−0.0253	−0.0079***	CE	−0.0943***	−0.0083**
p-value	0.3248	0.0001	p-value	0.0090	0.0125
ΔMB(−1)	0.1573	−0.0048	ΔMB(−1)	0.0252	0.0067
p-value	0.2885	0.6419	p-value	0.8724	0.6407
ΔMB(−2)	0.1258	0.0072	ΔMB(−2)	0.0392	0.0003
p-value	0.3836	0.4739	p-value	0.7986	0.9803
ΔMB(−3)	0.3107**	−0.0070	ΔMB(−3)	0.2974*	0.0238*
p-value	0.0363	0.4936	p-value	0.0590	0.0985
ΔMB(−4)	0.0820	−0.0005	ΔMB(−4)	0.1075	−0.0547***

(Continued)

Table 4. (Continued)

Panel C. MB and UNE			Panel D. MB and SCSD		
<i>p</i> -value	0.5840	0.9613	<i>p</i> -value	0.5072	0.0006
Δ UNE(−1)	0.0193	−0.2496**	Δ MB(−5)	−0.0331	−0.0137
<i>p</i> -value	0.9914	0.0497	<i>p</i> -value	0.8535	0.4061
Δ UNE(−2)	−1.7160	−0.3711***	Δ MB(−6)	−0.0292	0.0116
<i>p</i> -value	0.3887	0.0098	<i>p</i> -value	0.8668	0.4703
Δ UNE(−3)	1.5295	−0.1419	Δ SCSD(−1)	0.9106	−0.0908
<i>p</i> -value	0.4573	0.3256	<i>p</i> -value	0.5601	0.5278
Δ UNE(−4)	2.0322	−0.4260***	Δ SCSD(−2)	1.0243	0.1338
<i>p</i> -value	0.3036	0.0031	<i>p</i> -value	0.5131	0.3540
			Δ SCSD(−3)	−1.0992	0.1547
			<i>p</i> -value	0.4136	0.2131
			Δ SCSD(−4)	−1.3713	0.0254
			<i>p</i> -value	0.3118	0.8375
			Δ SCSD(−5)	−1.1744	−0.0932
			<i>p</i> -value	0.3909	0.4587
			Δ SCSD(−6)	−0.0367	−0.0461
			<i>p</i> -value	0.9782	0.7087
Adj. R^2	0.0484	0.2856	Adj. R^2	0.0861	0.2911
Panel E. MB and MCSD			Panel F. MB and NK		
Cointegrating equation			Cointegrating equation		
	Coefficients			Coefficients	
MB(−1)	1.0000		MB(−1)	1.0000	
MCSD(−1)	29.7458***		NK(−1)	0.0043***	
<i>p</i> -value	0.0000		<i>p</i> -value	0.0015	
Intercept	−113.1759***		Intercept	−156.3180***	
<i>p</i> -value	0.0000		<i>p</i> -value	0.0000	
Error correction			Error correction		
	Variables			Variables	
	Δ MB	Δ MCSD		Δ MB	Δ NK
	Coefficients			Coefficients	
CE	−0.1033***	−0.0040**	CE	−0.0679***	19.8333***
<i>p</i> -value	0.0028	0.0231	<i>p</i> -value	0.0000	0.0001
Δ MB(−1)	−0.0154	0.0012	Δ MB(−1)	−0.0240	186.6508***
<i>p</i> -value	0.9227	0.8825	<i>p</i> -value	0.8526	0.0003
Δ MB(−2)	0.0728	−0.0099	Δ MB(−2)	−0.1737	132.4768**
<i>p</i> -value	0.6401	0.2299	<i>p</i> -value	0.2355	0.0175
Δ MB(−3)	0.2711*	0.0185**	Δ NK(−1)	0.0007*	−0.0119
<i>p</i> -value	0.0705	0.0201	<i>p</i> -value	0.0685	0.9321
Δ MB(−4)	0.0123	−0.0253***	Δ NK(−2)	0.0005	0.0305
<i>p</i> -value	0.9372	0.0033	<i>p</i> -value	0.1385	0.7960
Δ MB(−5)	0.0067	−0.0015			
<i>p</i> -value	0.9685	0.8669			
Δ MB(−6)	−0.0421	−0.0026			

(Continued)

Table 4. (Continued)

Panel E. MB and MCSD			Panel F. MB and NK		
<i>p</i> -value	0.7920	0.7575			
Δ MCSD(−1)	3.1077	−0.1645			
<i>p</i> -value	0.2389	0.2357			
Δ MCSD(−2)	2.0645	−0.0269			
<i>p</i> -value	0.4430	0.8486			
Δ MCSD(−3)	−3.0034	0.1977			
<i>p</i> -value	0.2025	0.1121			
Δ MCSD(−4)	−7.1151***	0.0152			
<i>p</i> -value	0.0040	0.9022			
Δ MCSD(−5)	−2.9506	−0.1833			
<i>p</i> -value	0.2633	0.1871			
Δ MCSD(−6)	−0.8479	−0.1618			
<i>p</i> -value	0.7194	0.1959			
Adj. R^2	0.2219	0.3292	Adj. R^2	0.2724	0.3319

Notes: This table exhibits the estimation results of the bivariate vector error correction models (VECMs) for the Japanese monetary base and one of the variables as to economic productivity, labor market conditions, and the state of financial markets in Japan. More specifically, Panel A shows the results of MB and IP; Panel B displays the results of MB and ICU; Panel C exhibits those of MB and UNE; Panel D exhibits those of MB and SCSD; Panel E shows those of MB and MCSD; and Panel F indicates those of MB and NK. In this table, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan. Moreover, MB(−*k*), IP(−*k*), ICU(−*k*), UNE(−*k*), SCSD(−*k*), MCSD(−*k*), and NK(−*k*) denote the *k*-month lagged variables of MB, IP, ICU, UNE, SCSD, MCSD, and NK, respectively. Moreover, Δ MB, Δ IP, Δ ICU, Δ UNE, Δ SCSD, Δ MCSD, and Δ NK denote the first differences of MB, IP, ICU, UNE, SCSD, MCSD, and NK, respectively. Further, Adj. R^2 means the adjusted R^2 value and CE denotes the cointegrating equation. The estimation period of our VECMs is from March 2001 to March 2006.

*Statistical significance at the 10% level.

**Statistical significance at the 5% level.

***Statistical significance at the 1% level.

four-period lag of Δ MB also statistically significantly explains the evolution of Δ MCSD with a negative sign (Panel E). Thus, our VECMs well capture the linkages between MB and SCSD and MB and MCSD. Hence, we can see that QE in Japan lowered short- and medium-term credit spreads, thereby decreasing risk aversion in Japanese bond markets.

Finally, Panel F of Table 4 displays the results for the monetary base and stock market variable. The results show that the CE of MB and NK is statistically significant in explaining the evolution of Δ NK. Moreover, the one- and two-period lags of Δ MB statistically significantly explain the evolution of Δ NK (Panel F) with all positive signs. Thus, our VECM again captures effectively the relations between MB and NK. Therefore, the results show that QE in Japan drove up stock prices, thereby improving expectations of the stock market and future economic conditions in Japan.

8.2. Analyzing impulse responses from the VECMs

In the previous subsection, we demonstrated that our bivariate VECM modeling of the direct effects of the increase in the monetary base on various economic and financial market variables was highly successful. In this subsection, we further examine the direction of these QE effects by analyzing the impulse response functions. Figure 3 depicts the responses of our six variables to a positive shock in the monetary base. In terms of the responses of the economic variables, Panels A and B show that IP and ICU respond positively to increases in the monetary base. Moreover, Panel C indicates that

UNE responds negatively to a positive shock in the monetary base. These results imply that from 2001 to 2006, QE boosted economic productivity and improved labor market conditions in Japan.

We next consider the responses of the Japanese bond market variables. Panels D and E show that SCSD and MCSD respond negatively to increases in the monetary base. Therefore, the above findings again indicate that QE reduced short- and medium-term credit spreads, decreasing risk aversion in Japanese bond markets. Finally, with regard to the Japanese stock market variable, Panel F reveals that NK responds positively to a positive shock in the monetary base. Thus, as these results show, QE pushed up stock prices and improved market expectations in Japan. Overall, the results from the various impulse response analyses demonstrate that from 2001 to 2006, Japan's QE had a clear positive effect on the economy and financial markets in Japan.

9. Further analysis using regime-switching models

9.1. Applying the MSDR models

In this section, we further investigate the effects of QE from 2001 to 2006 in Japan using MSDR models.¹³ For our robustness check, we use the annual percentage change (growth) rates of IP, ICU, UNE, and NK and the credit spread variables of SCSD and MCSD. Using these and two-regime MSDR models, we conduct robustness checks of our results in the previous section. In addition, to identify the effects of the QE policy in the period after its end, our robustness checks employ a longer sample period from January 1985 to November 2015, which includes the financial crisis periods represented by the US Lehman shock.¹⁴

In setting up the models, we assume that each of these four change rates and two credit spread variables follows a process that depends on the value of an unobserved state variable, s_t . We assume that there are $M = 2$ regimes, and hence when $s_t = m$, for $m = 1$ or 2 , the analyzed variable is in state or regime m in period t . More specifically, the two-regime MSDR model for the variable y is specified as follows:

$$y_t = \mu(m) + \sigma(m)\epsilon_t, \quad (13)$$

where ϵ_t follows an independent and identically distributed (*iid*) standard normal distribution. In addition, the expressions of the mean, $\mu(m)$, and the volatility, $\sigma(m)$, in model (13) indicate that μ and σ are regime dependent.

In the Markov-switching models, the probability of transitioning from regime i in period $t - 1$ to regime j in period t is expressed as follows:

$$P(s_t = j | s_{t-1} = i) \equiv p_{ij}(t), \quad (14)$$

and in our case of $M = 2$, the matrix of transition probabilities, $p(t)$ can also be written as follows:

$$p(t) = \begin{bmatrix} p_{11}(t) & p_{12}(t) \\ p_{21}(t) & p_{22}(t) \end{bmatrix}. \quad (15)$$

9.2. Evidence from the MSDR models

This subsection describes the results of the application of the MSDR models. We first present the estimation results for the MSDR models in Panels A–F in Table 5. All panels include the estimation results for the higher and lower regimes for the economic and financial market variables. As these results present, all model intercepts and the volatilities for the six variables are statistically significant at the 1% level. Therefore, we can see that all our MSDR models are very accurate.

Based on the results of our impulse response analyses, Figure 4 displays the probabilities that the annual percentage changes in IP, ICU, and NK are in the higher state, because these three variables respond positively to a positive shock in MB. In addition, we also present the probabilities that the

Table 5. Estimation results of the two-regime Markov-switching dynamic regression models: the cases of the Japanese economy and financial markets from January 1985 to November 2015

Panel A. Annual change rate of IP			Panel B. Annual change rate of ICU		
Higher regime			Higher regime		
	Estimates	p-value		Estimates	p-value
Intercept	3.0860***	0.0000	Intercept	2.1268***	0.0000
ln(σ)	1.0040***	0.0000	ln(σ)	1.2167***	0.0000
Lower regime			Lower regime		
	Estimates	p-value		Estimates	p-value
Intercept	−3.3784***	0.0011	Intercept	−4.8808***	0.0001
ln(σ)	2.3836***	0.0000	ln(σ)	2.5586***	0.0000
LL	−1105.523		LL	−1177.279	
Panel C. Annual change rate of UNE			Panel D. Level of SCSD		
Higher regime			Higher regime		
	Estimates	p-value		Estimates	p-value
Intercept	9.1027***	0.0000	Intercept	0.9453***	0.0000
ln(σ)	2.2307***	0.0000	ln(σ)	−0.9588***	0.0000
Lower regime			Lower regime		
	Estimates	p-value		Estimates	p-value
Intercept	−7.5020***	0.0000	Intercept	0.2591***	0.0000
ln(σ)	1.4018***	0.0000	ln(σ)	−2.0755***	0.0000
LL	−1233.346		LL	34.3678	
Panel E. Level of MCSD			Panel F. Annual change rate of NK		
Higher regime			Higher regime		
	Estimates	p-value		Estimates	p-value
Intercept	0.6403***	0.0000	Intercept	22.4539***	0.0000
ln(σ)	−1.4898***	0.0000	ln(σ)	2.7465***	0.0000
Lower regime			Lower regime		
	Estimates	p-value		Estimates	p-value
Intercept	0.1997***	0.0000	Intercept	−16.6450***	0.0000
ln(σ)	−2.4695***	0.0000	ln(σ)	2.5065***	0.0000
LL	222.6046		LL	−1545.436	

Notes: This table displays the estimation results of the two-regime Markov-switching dynamic regression (MSDR) models for the time-series of various Japanese variables. Specifically, we use two credit spread variables, SCSD and MCSD, and four annual change rates of IP, ICU, UNE, and NK. In this table, the rows of "Higher regime" indicate the estimation results for the higher state, while the rows of "Lower regime" show the estimation results for the lower state. The sample period for the estimations of our two-regime MSDR models is from January 1985 to November 2015, which includes the period of Japanese QE from March 2001 to March 2006, the Paribas shock, the Lehman shock, and the US government credit-rating downgrade shock. Further, IP denotes the Japanese industrial production index (Panel A); ICU means the capacity utilization ratio index in Japan (Panel B); and UNE is the absolute unemployment rate in Japan (Panel C). In addition, SCSD denotes the Japanese short-term credit spread (Panel D); MCSD means the Japanese medium-term credit spread (Panel E); and NK denotes the Nikkei 225 stock price index in Japan (Panel F). Moreover, LL denotes the log likelihood value; σ means the volatility for each regime.

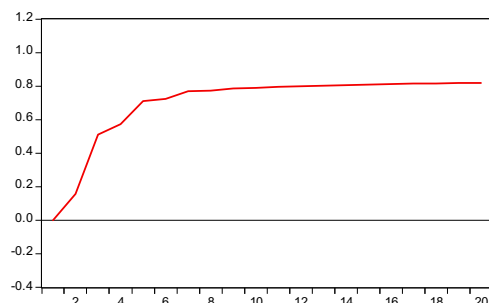
***Statistical significance of the estimates at the 1% level.

annual percentage changes for UNE and the credit spread variables SCSD and MCSD are in the lower state, as these three variables respond negatively to an increase in MB.

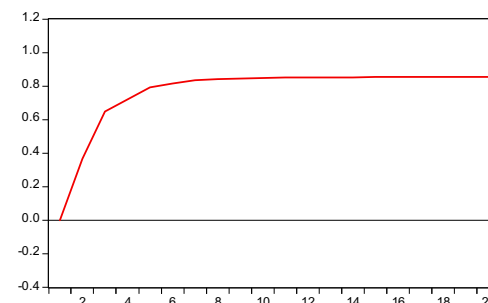
Figure 3. Impulse response functions from the VECMs: responses of economic and financial market variables to the increases in the monetary base in Japan.

Notes: This figure presents the responses of various variables to the positive shock to the Japanese monetary base. The analyzing period using the VECMs is from March 2001 to March 2006, in which the BOJ conducted QE policy. Panel A of this figure shows the response of IP to MB; Panel B displays the response of ICU to MB; and Panel C exhibits the response of UNE to MB. Moreover, Panel D shows the response of SCSD to MB; Panel E exhibits that of MCSD to MB; and Panel F displays that of NK to MB. Regarding variables, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan.

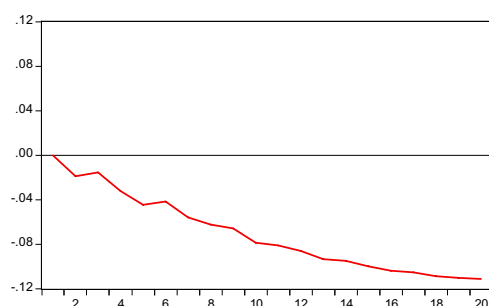
Panel A. Response of IP to MB



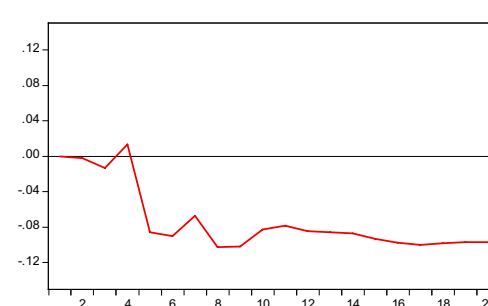
Panel B. Response of ICU to MB



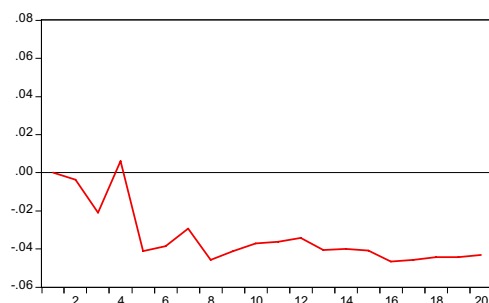
Panel C. Response of UNE to MB



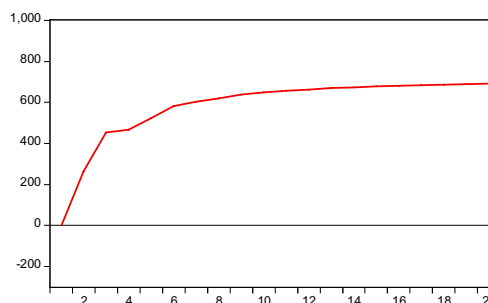
Panel D. Response of SCSD to MB



Panel E. Response of MCSD to MB



Panel F. Response of NK to MB



In terms of the economic variables, the growth rates of IP, ICU, and UNE are in the favorable regime during and well after the end of QE in March 2006 until around the Lehman shock in September 2008. Thus, these results suggest that productivity and labor market conditions in Japan kept recovering even after the end of QE. As for the Japanese bond market variables, SCSD and MCSD are in the lower regime state long after the implementation of QE. The credit spreads of SCSD and MCSD are in the lower state even after the end of QE; and they switched to the higher state around the Lehman shock in the US. These results suggest that QE decreased short- and medium-term credit spreads in Japan and continued to decrease risk aversion in Japanese bond markets, even after QE.

Finally, with regard to the stock market variable, after executing QE, the growth rate of NK moved to, and remained in, the higher regime even after the end of QE. The growth rate of NK remained in the higher state until the period immediately after the Paribas shock in August 2007. Thus, QE in Japan stimulated and continued to drive up stock prices even after the end of the QE program. Therefore, the above additional empirical analyses using MSDR models, which employ a longer sample period of January 1985 to November 2015, confirm the robustness of all our positive QE effects derived from the VECMs and impulse response functions.

10. Robustness checks using Bayesian VAR and causality analysis

10.1. Results from the Bayesian VAR models

To check further the robustness of our results, we next estimate Bayesian VAR models (Doan, Litterman, & Sims, 1984; Litterman, 1986) and plot the impulse responses from the models in Figure 5.¹⁵ This Bayesian VAR analysis also employs exactly the same sample period of the QE program to clarify the precise and direct effects of Japan's QE during the QE period. The results are almost identical to those exhibited in Figure 3. As to the responses of the economic variables, Panels A and B show that IP and ICU respond positively to the monetary base increases. Panel C also indicates that UNE responds negatively to a positive shock in the monetary base. These results therefore again imply that from 2001 to 2006, QE improved economic productivity and labor market conditions in Japan.

We next check the responses of the Japanese credit spread variables. Panels D and E show that SCSD and MCSD respond negatively to the increase in the monetary base. Slightly differently from the results in Panels D and E of Figure 3, the responses of SCSD and MCSD in Figure 5 are rather rapid and smooth. Hence, the above results again indicate that QE reduced short- and medium-term credit spreads and decreased the degree of risk aversion in Japanese credit markets. Finally, as for the Japanese stock market variable, Panel F of Figure 5 again exhibits that NK responds positively to a positive shock in the monetary base. Thus, the results again indicate that through QE, Japanese stock

Table 6. Results of the Granger causality tests: monetary base and other economic and financial market variables in Japan

		IP	ICU	UNE	SCSD	MCSD	NK
Panel A. Causing variable: MB							
Lag = 2	F-stat.	19.7009***	16.351***	5.7173***	3.2848**	3.7201**	12.7672***
	p-value	0.0000	0.0000	0.0056	0.0451	0.0306	0.0000
Lag = 3	F-stat.	7.4419***	9.3316***	5.1736***	2.5640*	2.3807*	8.7048***
	p-value	0.0003	0.0001	0.0034	0.0648	0.0804	0.0001
Lag = 4	F-stat.	4.6561***	6.3350***	2.8527**	3.3329**	3.3366**	6.6168***
	p-value	0.0029	0.0004	0.0336	0.0173	0.0172	0.0003
Lag = 5	F-stat.	3.2466**	5.9012***	3.8064***	5.2326***	3.6934***	4.7392***
	p-value	0.0138	0.0003	0.0058	0.0007	0.0069	0.0015
Panel B. Caused variable: MB							
Lag = 2	F-stat.	2.2408	1.4760	1.2773	0.0574	0.1545	4.5272**
	p-value	0.1162	0.2376	0.2871	0.9443	0.8572	0.0152
Lag = 3	F-stat.	2.5163	1.1020	1.6221	0.3985	0.7507	4.2314***
	p-value	0.0685	0.3569	0.1957	0.7547	0.5270	0.0096
Lag = 4	F-stat.	1.5667	0.7614	0.8331	0.5074	0.4402	2.5500*
	p-value	0.1984	0.5556	0.5109	0.7305	0.7789	0.0511
Lag = 5	F-stat.	1.1957	0.7048	0.7230	0.7045	1.9148	1.8747
	p-value	0.3266	0.6228	0.6097	0.6230	0.1106	0.1177

Notes: This table exhibits the results of the pairwise Granger causality tests. In this table, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan. Moreover, F-stat. means the F-statistic for the causality tests and our testing period is from March 2001 to March 2006.

*Statistical significance at the 10% level.

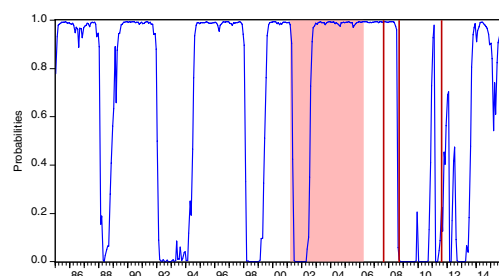
**Statistical significance at the 5% level.

***Statistical significance at the 1% level.

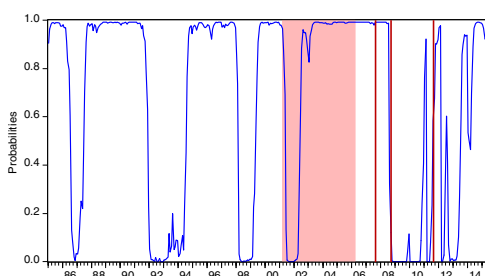
Figure 4. Probabilities in the higher or lower state derived from the two-regime MSDR models.

Notes: This figure displays the probabilities for six variables to stay in the higher or lower state and the probabilities are derived from the two-regime Markov-switching dynamic regression (MSDR) models. Specifically, regarding IP, ICU, and NK, the probabilities for the variables to stay in the higher state are displayed. On the other hand, as for UNE, SCSD, and MCSD, the probabilities for the variables to stay in the lower state are exhibited. These probabilities are shown for the period from January 1985 to November 2015, which includes the period of Japanese QE from March 2001 to March 2006 (shaded area). Further, three red lines in this figure mean the Paribas shock (August 2007), the Lehman shock (September 2008), and the US government credit-rating downgrade shock (August 2011), respectively. Moreover, IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. Further, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan.

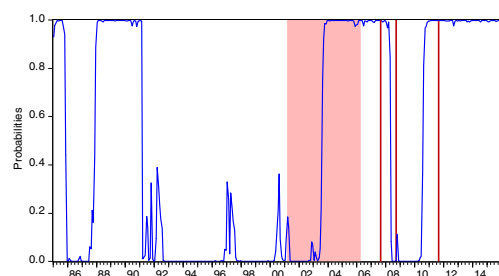
Panel A. Probabilities for the annual percentage change rate of IP in the higher state



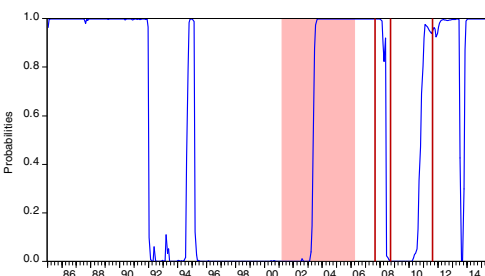
Panel B. Probabilities for the annual percentage change rate of ICU in the higher state



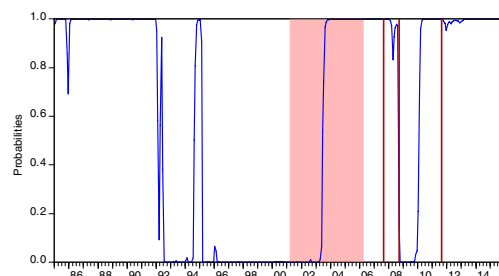
Panel C. Probabilities for the annual percentage change rate of UNE in the lower state



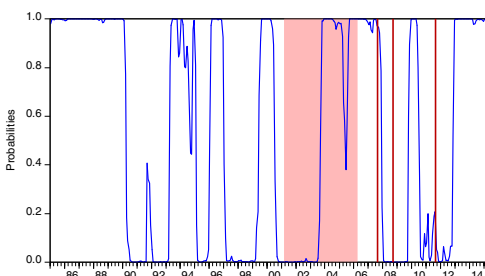
Panel D. Probabilities for the level of SCSD in the lower state



Panel E. Probabilities for the level of MCSD in the lower state



Panel F. Probabilities for the annual percentage change rate of NK in the higher state



prices increased. In sum, the impulse responses from the Bayesian VAR models again demonstrate that from 2001 to 2006, QE had a positive effect on the Japanese economy and financial markets.

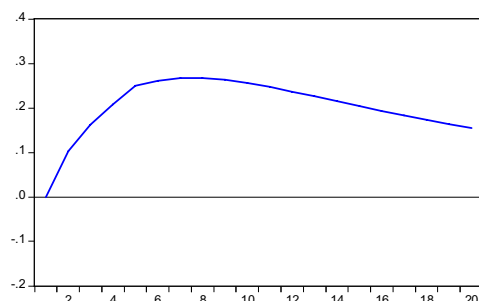
10.2. Results of causality analysis

We next employ Granger causality analysis, with the results shown in Table 6. Again, this Granger causality analysis also uses exactly the same QE period to clarify the exclusive and direct effects of this Japanese QE during the QE period. Panel A provides the results of causality tests from MB to other six variables, while Panel B shows the results of the causality tests from these other six variables to MB. The results in Table 6 clearly show that the causal relationships are unidirectional only; that is, MB Granger-causes the other variables and except for some weak causality from NK to MB, MB is not Granger-caused. This analysis therefore again demonstrated that Japanese QE from 2001 to 2006 had a positive causal effect on Japanese financial markets and the economy. That is, we consider this evidence of unidirectional causal relationships from MB to various Japanese economic and financial market variables in the QE period from March 2001 to March 2006 means that the exogenous increases of MB by the BOJ's QE drove the actual recovery of Japanese economy during this QE period.

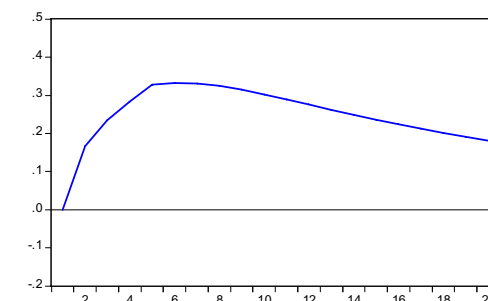
Figure 5. Impulse response functions from the Bayesian VAR models: responses of economic and financial market variables to the increases in the monetary base in Japan.

Notes: This figure presents the responses of various variables to the positive shock to the Japanese monetary base. The analyzing period using the Bayesian VAR(4) models is from March 2001 to March 2006, in which the BOJ conducted QE policy. Panel A of this figure shows the response of IP to MB; Panel B displays the response of ICU to MB; and Panel C exhibits the response of UNE to MB. Moreover, Panel D shows the response of SCSD to MB; Panel E exhibits that of MCSD to MB; and Panel F displays that of NK to MB. Regarding the variables more specifically, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan.

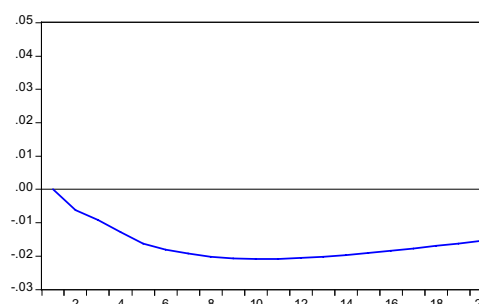
Panel A. Response of IP to MB



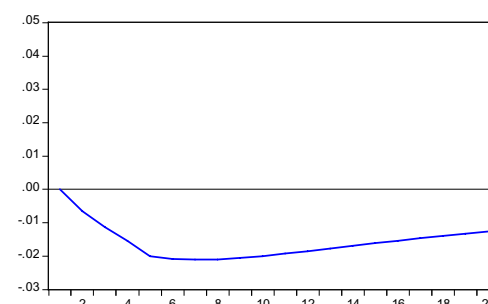
Panel B. Response of ICU to MB



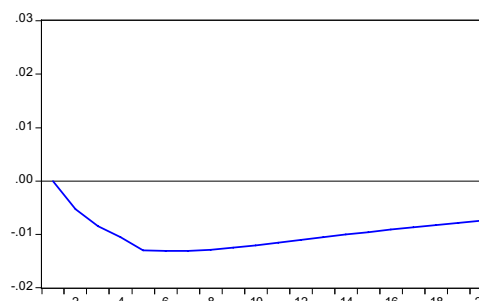
Panel C. Response of UNE to MB



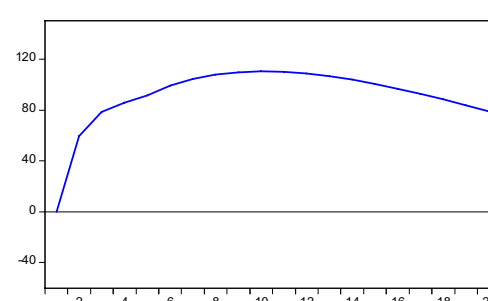
Panel D. Response of SCSD to MB



Panel E. Response of MCSD to MB



Panel F. Response of NK to MB



11. What channel worked?—Interpreting the results

The next important question is through what channel did QE affect Japanese financial markets and the Japanese economy? In order to respond to this question, we conduct several specific Granger causality tests and present the results in Table 7. The results show that there are unidirectional causal effects from SCSD to NK, from MCSD to NK, from SCSD to UNE, from MCSD to UNE, from UNE to NK, from NK to ICU, and from NK to IP. We provide a more careful interpretation later, but these results statistically indicate that the (i) decreases in credit spreads led to stock price increases, that the (ii) decreases in credit spreads led to declines in the unemployment rate, that (iii) declines in the unemployment rate led to stock market increases, and that (iv) stock market recoveries led to improvements in industrial production and capacity utilization in Japan.

In addition, we provide further evidence of the recovery of market expectations during QE in Japan. Figure 6 plots the changes in the short-term economic survey of enterprises in Japan.¹⁶ Specifically, Panel A shows the year-on-year percentage changes in terms of future business conditions, and Panel B displays future business condition survey changes from the previous quarter. Both panels provide details of the changes in expectations of manufacturing, nonmanufacturing, and all-industry firms in Japan. This figure clearly suggests that market expectations clearly recovered

Table 7. Inspecting the expectations channel of QE in Japan: results of additional Granger causality tests

		SCSD to NK	MCSD to NK	SCSD to UNE	MCSD to UNE
Lag = 2	F-stat.	3.3959**	4.4329**	4.1416**	7.1992***
	p-value	0.0408	0.0165	0.0212	0.0017
Lag = 3	F-stat.	2.7641*	2.2023*	4.3061***	6.4208***
	p-value	0.0513	0.0991	0.0088	0.0009
Lag = 4	F-stat.	2.0743*	1.4832	3.1528**	3.9315***
	p-value	0.0988	0.2220	0.0222	0.0077
Lag = 5	F-stat.	1.7078	1.1556	3.4666***	3.9785***
	p-value	0.1523	0.3457	0.0098	0.0045
		NK to SCSD	NK to MCSD	UNE to SCSD	UNE to MCSD
Lag = 2	F-stat.	0.4031	1.0832	1.4461	0.2853
	p-value	0.6702	0.3458	0.2445	0.7529
Lag = 3	F-stat.	0.3912	1.2915	1.0019	0.1883
	p-value	0.7598	0.2874	0.3996	0.9039
Lag = 4	F-stat.	1.8585	1.2400	0.9172	0.1421
	p-value	0.1331	0.3066	0.4617	0.9656
Lag = 5	F-stat.	2.3496*	1.0936	1.0007	0.6123
	p-value	0.0560	0.3771	0.4283	0.6909
		UNE to NK	NK to ICU	NK to IP	
Lag = 2	F-stat.	3.1777**	1.7249	2.6324*	
	p-value	0.0496	0.1879	0.0811	
Lag = 3	F-stat.	2.3072*	2.0949	3.1316**	
	p-value	0.0876	0.1124	0.0335	
Lag = 4	F-stat.	2.0602	3.0231**	3.3314**	
	p-value	0.1008	0.0265	0.0174	
Lag = 5	F-stat.	1.4237	5.0775***	4.1059***	
	p-value	0.2341	0.0009	0.0037	
		NK to UNE	ICU to NK	IP to NK	
Lag = 2	F-stat.	0.0014	1.9043	1.4664	
	p-value	0.9987	0.1588	0.2398	
Lag = 3	F-stat.	0.6707	1.0606	0.8963	
	p-value	0.5740	0.3740	0.4495	
Lag = 4	F-stat.	1.4870	0.8218	0.6703	
	p-value	0.2209	0.5177	0.6158	
Lag = 5	F-stat.	1.6609	0.7937	0.6613	
	p-value	0.1636	0.5599	0.6546	

Notes: This table exhibits the results of the pairwise Granger causality tests. In this table, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan. Moreover, F-stat. means the F-statistic for the causality tests and our testing period is from March 2001 to March 2006.

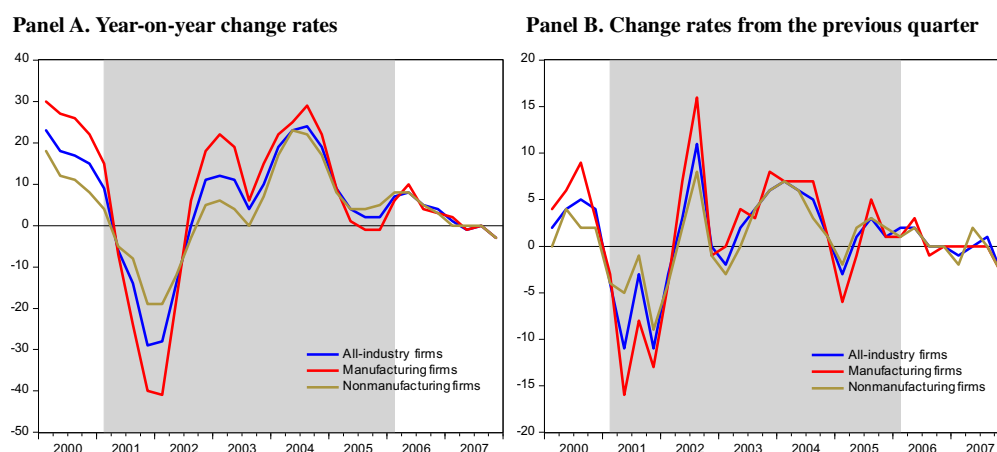
*Statistical significance at the 10% level.

**Statistical significance at the 5% level.

***Statistical significance at the 1% level.

Figure 6. Time-series evolution of changes in expectations in terms of future business conditions: evidence from the short-term economic survey of enterprises in Japan.

Notes: This figure exhibits the percentage change rates of expectations as to Japanese future business conditions, which are obtained from the BOJ's short-term economic survey of enterprises in Japan. Panel A of this figure shows the year-on-year percentage change rates of the future expectations of manufacturing, nonmanufacturing, and all-industry firms in Japan. Panel B exhibits the percentage change rates from the previous quarter regarding the future expectations of manufacturing, nonmanufacturing, and all-industry firms in Japan. Japanese QE policy analyzed in this study was executed from 19 March 2001 to 9 March 2006 (shaded area) and this figure is drawn for the period from January 2000 to December 2007.



during the QE in Japan, linked to the exogenous MB increases by this BOJ's QE as seen in Figure 1. This supports our interpretation of the effectiveness of the expectations channel in this Japanese QE program. We consider that this linkage between Japan's QE and expectation improvements was driven by the BOJ's commitment and forward guidance in the QE. Namely, in this QE, as we documented in the Theoretical discussion section, the BOJ committed to continuing to increase current account balances until the Japanese core CPI stably remains positive for the foreseeable future.

Therefore, taking into consideration the expectation recovery suggested in Figure 6, we interpret our empirical results as follows. First, (i) through QE, risk aversion in bond markets decreased and stock markets rose because of the recovery in financial market expectations; second, (ii) following the decline in risk aversion in Japanese bond markets, the recovery of expectations in corporations decreased unemployment rates; and third, (iii) the stock market recovery associated with changes in market expectations boosted industrial production and capacity utilization. Hence, we consider that the recovery of the Japanese economy during the QE period was mainly through the expectations channel.

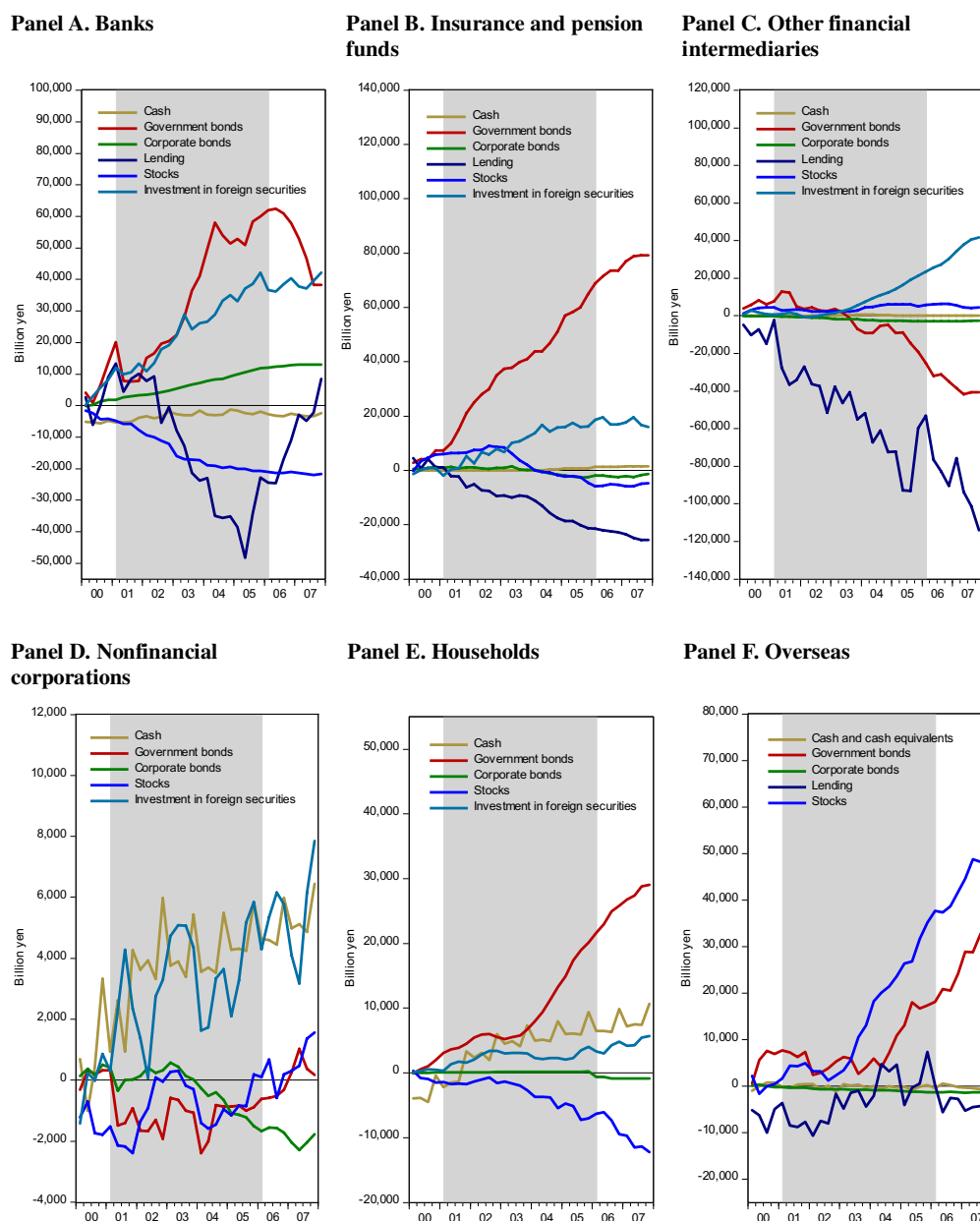
We now turn to discuss the next possibility; namely, the portfolio substitution channel. To investigate this, we further examine funds flow data in several economic sectors.¹⁷ More specifically, we calculate the accumulated fund flows for banks (Panel A), insurance and pension funds (Panel B), other financial intermediaries (Panel C), nonfinancial corporations (Panel D), households (Panel E), and overseas (Panel F) in Figure 7. The accumulated fund flows in this figure are from January 2000 to December 2007 and include funds in the form of cash, government bonds, lending, corporate bonds, stocks, and investment in foreign securities.

Given the context of our analysis, we focus on the fund flows of stocks and corporate bonds. To start, Figure 7 shows that the fund flows into stocks increased only in the overseas sector (Panel F), whereas in other economic sectors, they decreased or were almost unchanged during the QE period. As to corporate bond fund flows, these increased in banks only very slightly, whereas in all other sectors, they decreased. Thus, during QE, only the overseas sector bought Japanese stocks, and almost no sector bought Japanese corporate bonds. Hence, we cannot find the evidence suggesting that portfolio rebalancing by investors boosted stock prices and decreased corporate bond yields in the period of QE.

In light of these results, we suggest that the primary channel for QE in Japan was not the portfolio substitution channel but the expectations channel. Figure 8 depicts the mechanisms underpinning the effects of the expectations channel in Japan's QE from 2001 to 2006.

Figure 7. Portfolio rebalancing during Japan's QE: accumulated fund flows in six economic sectors.

Notes: This figure exhibits the time-series evolution of the accumulated fund flows of cash (and cash equivalents), government bonds, corporate bonds, lending, stocks, and investment in foreign securities for six economic sectors. Specifically, Panels A–F exhibit the fund flows for banks, insurance and pension funds, other financial intermediaries, nonfinancial corporations, households, and overseas, respectively. Japanese QE analyzed in this study was executed from 19 March 2001 to 9 March 2006 (shaded area) and this figure is drawn for the period from January 2000 to December 2007.



12. Further discussion

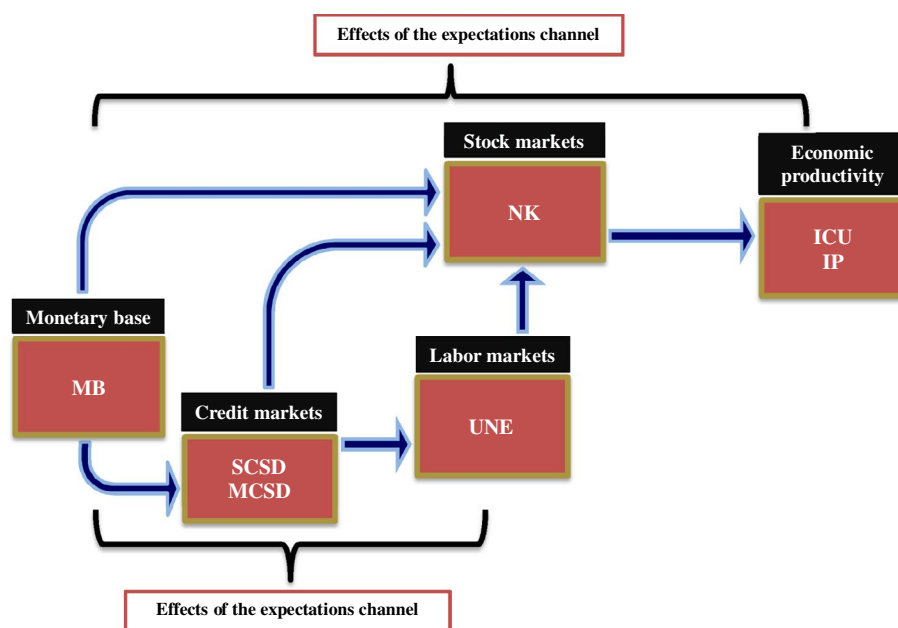
12.1. Contribution

This study has several advantages over previous studies. First, our study used a sample period for estimation that corresponded exactly with the QE implementation period from March 2001 to March 2006. In contrast, previous studies have investigated QE in Japan using longer sample periods that only partially include the actual QE period. Thus, our study provides evidence that is associated exclusively with QE in Japan from 2001 to 2006.

Moreover, unlike previous papers, our study implemented a more comprehensive analysis with regard to the effects of QE in Japan using a wider range of economic and financial variables. That is, we examined the effects of QE on (i) productivity, (ii) labor market conditions, (iii) credit spreads, and (iv) equity index prices in Japan. From the viewpoint of data analysis, the use of factor analysis is also

Figure 8. The mechanisms of the expectations channels of QE in Japan from 2001 to 2006.

Notes: This figure depicts the mechanisms underpinning the effects of the expectations channels in Japan's QE from 2001 to 2006. In this figure, MB denotes the amount of the monetary base in Japan; IP denotes the Japanese industrial production index; ICU means the capacity utilization ratio index in Japan; and UNE is the absolute unemployment rate in Japan. In addition, SCSD denotes the Japanese short-term credit spread; MCSD means the Japanese medium-term credit spread; and NK denotes the Nikkei 225 stock price index in Japan. Moreover, the arrows in this figure indicate unidirectional causal relations.



interesting, as in Girardin and Moussa (2011). They constructed and analyzed three kinds of extracted factors: a real activity factor, a price factor¹⁸, and an interest rate factor. This is an interesting method because it enables the analysis of much more information through examining the extracted factors. We instead used a wider range of specific variables, which we individually analyzed in order to yield much more clear evidence in terms of the QE's effects and works. This approach enables us to understand more clearly which variables were affected more directly and strongly by QE. Clarification of these issues is one of the main contributions of this study.

Furthermore, our study also examined the direct effects of QE while taking into consideration the cointegrating linkages between the policy variable, the monetary base, and the other variables using bivariate VECMs. Bivariate VECMs are highly effective in identifying the direct connection between QE and various economic and financial market variables during the policy period. This is a significant advantage of this study. We note that deriving robust evidence of the effectiveness of QE is important for future monetary policy and research. Careful repeated robustness checks using univariate two-regime MSDR models, Bayesian VAR models, and causality tests is another of the main contributions of this study.

Finally, the most important contribution of this study is the clarification of the mechanism and transmission channel of Japan's QE. Our additional analysis of causality, survey, and funds flow data suggests that regarding Japan's QE, the main effective channel was not portfolio substitution but expectations.¹⁹ We note that stock prices and credit spreads both strongly relate to expectations regarding the future evolution of financial markets and the macroeconomy. We consider that our careful attempt to inform our empirical analysis with theory regarding the potential QE effect mechanism is our most significant contribution.

12.2. Implications

This subsection discusses several implications of our results by comparing them with those of other studies. For example, Schenkelberg and Watzka (2013) documented that the success of the QE experiment in Japan was only temporary. In early 2007, only one year after the end of QE in Japan, the subprime crisis happened and the following Lehman shock in the US negatively affected the Japanese economy. Thus, it is not easy to assess whether the actual effects of the QE were only temporary.

To measure the duration of the effectiveness of QE in the real world, we consider that the univariate MSDR approach adopted in this paper is superior to the application of MSVAR models elsewhere. Univariate MSDR models enable us to specify more precisely the time points for regime changes because of their higher estimation accuracy when compared with multivariate models. Nevertheless, the application of the Markov-switching factor-augmented VAR model estimated by Girardin and Moussa (2011) is technically interesting. Our application of the univariate MSDR models demonstrated that industrial production and the capacity utilization ratio in Japan remained in the higher regime beyond the Paribas shock and until around the Lehman shock.

Moreover, our MSDR analyses also show that the unemployment rate in Japan remained in the lower regime beyond the Paribas shock and until just before the Lehman shock. These results imply that the above economic productivity and unemployment rate variables do not support the suggestion that the success of the QE experiment in Japan was temporary. Therefore, it is very important to monitor the duration of these effects and the exit strategy for the QQE program currently conducted by the BOJ.

Furthermore, our empirical results suggested that the recovery in expectations was a key factor for stimulating economic activities and improving labor market conditions. Hence, we stress the crucial role of expectations management in practical monetary policy, as suggested by such theoretical studies as Krugman (1998)²⁰ and Eggertsson and Woodford (2003). Thus, the most important implication of our study is that in unconventional monetary policy, the key is whether successful expectations management is accomplished. This is a crucial implication for the current QQE by the BOJ and the monetary policy in Europe, for example.

We also note that in the case of Japanese QE from 2001 to 2006, the targeted amount of BOJ current account balances was a clear policy target and that this setting of a visible signal was effective, not only for obtaining the signaling effect (Bernanke et al., 2004) but also for achieving better expectations management. We consider that policy regime changes (e.g. Sargent, 1982) through clear signals and credible commitments supplied by central banks are also important for successfully managing expectations in conducting monetary policy.

13. Summary and conclusions

In this paper, we investigated the effects of Japanese QE, which was executed by the BOJ from March 2001 to March 2006. We empirically examined the effects of this unconventional monetary policy on a range of variables in Japan including economic activity, labor and credit market conditions, and stock market evolution. The findings and contributions from our VECMs, MSDR models, Bayesian VAR models, causality tests, and other important data analyses are as follows.

- First, QE improved Japanese credit market conditions by lowering short- and medium-term credit spreads. We suggest that this was because of favorable declines in risk aversion through the QE program.
- Second, QE increased stock prices, as measured by the Nikkei 225 stock price index in Japan. We consider this means that market expectations for future economic conditions and financial markets recovered through QE.
- Third, QE improved labor market conditions in Japan. In particular, the Japanese unemployment rate remained lower for much longer, even after the end of QE. Our MSDR model suggested that the improved regime continued until just before the Lehman shock in the US.
- Fourth, QE had a positive effect on economic activity in Japan. Japanese industrial production and the utilization of plant and equipment increased both during and after the end of the QE program. The recovery in these measures continued until about the time of the Lehman shock in the US.
- Fifth, other than VECMs, MSDR models, Bayesian VAR models, and Granger causality tests also supported all of the above positive effects of the Japan's QE. We therefore consider our findings to be robust.

- Sixth, our empirical study clarified the mechanism and channel for Japan's QE. Additional analyses suggested that the primary channel was expectations. Moreover, as stock prices and credit spreads both strongly relate to expectations regarding future financial markets and the macro-economy, our results demonstrate the importance of expectations, as reflected in asset prices, for monetary policy to be effective.
- Finally, our empirical inspections revealed the working mechanism and channel for Japan's QE, which will provide valuable feedback for the theoretical research. Our results suggest that building a theoretical monetary policy model including the effects of market expectations changes will be an important future research topic in economic theory.

As already emphasized, there are few comprehensive empirical studies of the effects of QE in Japan from 2001 to 2006. Thus, the rigorous and comprehensive empirical evidence derived from this study is important for deepening our understanding of the actual effects of unconventional monetary policies on the economy and financial markets. As we noted, we analyzed the QE effects by using exactly the same QE period except in the MSDR analyses to reveal the exclusive and direct effects of Japan's QE during the QE period. We again emphasize that this is one of the most noteworthy features of this study.

Overall, our empirical evidence shows the importance of expectations management, the signaling effect, and regime changes through monetary policy. Hence, we consider that our findings will be useful in designing future monetary policies in a rapidly changing and highly integrated global economy. As such, our evidence concerning Japan's experience of QE from 2001 to 2006 will also be of benefit for other countries. This likewise suggests important research for the future, including the effects of Japanese QQE, LSAPs in the US, and QE in Europe.

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Notes

1. QE1 operated from November 2008 to June 2010, QE2 from November 2010 to June 2011, and QE3 from September 2012 to October 2014.
2. Initially, the main type of assets purchased by the BOJ to attain the target current account balances was long-term Japanese government bonds. Subsequently, the BOJ increased the range of purchased assets to include asset-backed securities, asset-backed commercial paper, and private assets held by private banks. Girardin and Moussa (2011) argue that we can consider these subsequent purchases by the BOJ as a form of credit provision to small- and medium-size corporations.
3. The Japanese core CPI (carefully watched by the BOJ in its conduct of monetary policy) does not include food prices but does include volatile energy prices.
4. They concluded that the MBS purchase program decreased US mortgage rates.
5. Their analyses revealed that announcement of the LSAPs lowered long-term interest rates and that on the announcement days, the US dollar depreciated and commodity prices decreased.
6. In their study, the “flow effects” were the effects on the prices and liquidity of securities on days corresponding to LSAP transactions. They concluded that the economic significance of the effects was small.
7. Okina and Shiratsuka (2004) is one of very few empirical studies to consider the ZIRP in Japan, the others being Iwata and Wu (2006) and Kim and Mizen (2010).
8. Bowman, Cai, Davies, and Kamin (2015) also analyzed Japanese QE from 2001 to 2006. However, unlike our analysis, their focus was on the effects of QE on bank lending.
9. Honda (2014) specified the BOJ current account balances, industrial production, stock prices, CPI, and overnight call rate in levels in a standard VAR framework. We believe that while the use of the BOJ current account balances is suitable in that context, the monetary base is more appropriate in analyzing the overall economy and financial markets.
10. The Nikkei bond indices include both Japanese government and corporate bonds.
11. The units of measurement are as follows: MB is in trillions of yen, NK is in yen, IP and ICU are indices, UNE, SCSD, and MCSD are percentages.
12. Recent VECM applications include Hoesli and Oikarinen (2012), Kim (2012), Menezes, Dionisio, and Hassani (2012), Kalantzis and Milonas (2013), Wang and Wu (2013), Wang, Yang, and Yang (2013), Bekiros (2014a, 2014b, 2014c), Cunado and de Gracia (2014), Giuliadori and Rodriguez (2015), Gossé and Serranito (2014), Hou and Li (2014), and Olmo and Sanso-Navarro (2015). However, no previous study has investigated the effects of QE in Japan from 2001 to 2006 using VECMs.

13. Examples of the application of Markov-switching models include Hamilton (1989), and more recently, Chen (2013), Pan and Li (2013), Klein (2013), Kocaaslan (2013), Zheng and Zuo (2013), Kim, Roh, Min, and Byun (2014), Avino and Nneji (2014), Chen and Lin (2014), Martins and Gabriel (2014), Moore (2014), Wang, Zheng, and Zhu (2014), Jiang and Fang (2015), and Kaufmann (2015).
14. From a methodological perspective, longer sample periods are generally suitable for empirical tests by regime-switching models such as the MSDR model. Thus, in this paper, only the robustness checks using the MSDR model employ a longer sample period than the exact period of Japan's QE.
15. Our estimations in this section are only for the purpose of further robustness checks. Hence, we uniformly specify four lags in all our models.
16. This important BOJ survey is known as "Tankan," both within and outside Japan. More concretely, as in Figure 6, the expectations data of future business conditions can be obtained from the BOJ's short-term economic survey data provided by Japanese enterprises. Using the data, as Panels A and B of Figure 6 show, we can understand the changes in the future business condition expectations of manufacturing, nonmanufacturing, and all-industry firms in Japan. In this "Tankan" survey, higher values mean higher expectations of the future business conditions by manufacturing, nonmanufacturing, and all-industry firms in Japan.
17. We used the BOJ's flow of fund account statistics.
18. Their price factor represents inflation extracted from related series including consumer prices and the prices of corporate goods and services.
19. We consider that the channel relates to exchange rates. However, during the QE period from 2001 to 2006, the Japanese yen-US dollar exchange rate did not change significantly.
20. A key insight highlighted in Krugman (1998) is the role of expectations in a liquidity trap world, as experienced by Japan during the QE period. Krugman (1998) suggested that if a central bank's commitment to monetary policy is credible, expectations for the future economy can be controlled, and even a zero-lower bound interest rate economy can escape from the trap by executing expansionary monetary policy.

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