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THE EFFECTIVENESS OF NONTRADITIONAL MONETARY POLICY: THE CASE OF JAPAN*[1]

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The effectiveness of nontraditional monetary policy is controversial at least in Japan. Making use of data from the quantitative easing monetary policy period, this paper presents statistical evidence on the effectiveness of nontraditional monetary policy. We empirically demonstrate that quantitative easing monetary policy, adopted by the Bank of Japan for the period from March 2001 to March 2006, had a stimulating effect on investment and production at least through Tobin's q channel. We also provide a simple and operational model in which an injection of base money lowers the interest rate on bonds, reduces the required rate of returns from capital stocks, and depreciates the value of domestic currency.

Key Words: Quantitative Easing, Vector Autoregressions, Stocks, Tobin's q, Asset Markets

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1. Introduction

As soon as the new governor Haruhiko Kuroda and vice-governors took office at the Bank of Japan (BOJ) in April 2013, they started a new "quantitative easing" (QE) monetary policy in order to attain the targeted rate of inflation of 2% in around two years. Prior to this, the BOJ also adopted a QE strategy for the period from March 2001 to March 2006. We define "QE monetary policy" as injection of more new high-powered money into the economy by the central bank than is required for the short-term interest rate to reach 0%.

In an attempt to reverse the rapid deterioration of the US economy in December 2008, the Federal Reserve Board (FRB) also set the federal funds rate at 0–0.25%, and purchased large amounts of agency debt and mortgage-backed securities to support the US housing market. Ben Bernanke, chairman of the FRB, called this policy "Credit Easing (CE)", as the FRB's operating target was on the asset side, rather than the liability side, of its balance sheet. However, when the FRB purchases large amounts of securities, it expands not only the asset side but also the liability side of its balance sheet. Hence, the effect of the US CE policy obviously also includes the impact of QE.

The relevant question confronting central bankers is how effective QE or CE is in stimulating the real economy. If QE or CE is not effective, central bankers obviously want to avoid taking the risk of implementing unprecedented measures and incurring unpredictable disastrous side effects in the future.

Indeed, the former governor of the BOJ (Shirakawa, 2008) and the director in charge of monetary policy, Amemiya (Japanese Economic Association (JEA), 2012) are skeptical about the effectiveness of nontraditional monetary policy on macroeconomic variables. Kimura *et al*. (2002) and Fujiwara (2006), BOJ officials, also express the skepticism about the effectiveness of QE on macroeconomic variables, though the data in their empirical studies do not cover the entire QE period.

In the academic literature, there are two alternative views on the effectiveness of QE. The first view dates back to at least Hicks (1937). Hicks shows that, when the interest rate reaches the lower bound, money becomes a perfect substitute, and that pumping money into the economy under this condition has little effect in stimulating the economy. Eggertsson and Woodford (2003) and Curdia and Woodford (2010) also analyze dynamic general equilibrium models and reach similar conclusions.

Under a different set of assumptions, however, Bernanke and Reinhart (2004), Bernanke *et al*. (2004), and Clouse *et al*. (2003) argue that the central bank, even when facing very low interest rates, has at least three alternative monetary policy measures to stimulate the economy. The first measure is through "expectations" of the future path of short-term interest rates. Under normal circumstances, the central bank has a strong influence on the short end of the term structure of interest rates. Hence the central bank may make explicit or implicit commitments on the future path of monetary policy (some examples might include statements such as "The FRB will keep the current QE strategy until at least the end of year 2014" or "The BOJ will keep the current zero interest policy until concerns about possible deflation disappear"). By committing to expansionary monetary policy, the central bank may change market "expectations" of the future path of short-term interest rates, and lower longer-term interest rates today through arbitrage between short-term and the longer-term rates of interest. This is called the "time duration effect".

The second alternative measure is through changes in the composition of assets on the balance sheet of the central bank. In general, the long-term interest rate may be taken as the sum of the short-term interest, liquidity premium (premium paid for lack of liquidity), term premium (premium paid for the length of maturity), and risk premium (premium paid for default risk). Should a financial crisis occur, the risk premium on long-term interest rates would rise sharply. If the central bank should purchase large quantities of private securities, for example, as the FRB did in the face of the collapse of Lehman Brothers in September 2008, the central bank accepts the default risk of the private sector, mitigates the sharp rise in the risk premium, and thus lowers longer-term interest rates today.

The third alternative measure is a QE strategy, which has effects through changes in the size of the balance sheet of the central bank. While the second measure above focuses on the effects of changes in the asset side of the central bank's balance sheet, this third method pays close attention to the effects of changes in the liability side. Expanding the quantity of base money on the liability side of the balance sheet, the central bank induces the private sector to change their portfolios (called "portfolio rebalancing effects") and/or "expectations" of the future path of short-term interest rates (called "signaling effects"). When the central bank injects large quantities of base money into the economy, private investors holding the extra base money might purchase imperfect substitute assets, raise the price of these assets, and thus stimulate the real economy ("portfolio rebalancing effects"). The massive injection of base money into the economy by the central bank may signal an expansionary monetary policy stance to the market, lower expectations of the future path of short-term interest rates, and thus reduce longer-term interest rates today ("signaling effects").

The QE or CE monetary policy actually adopted in the US, UK, and Japan combines the above three alternative measures. An example of the second alternative measure is the adoption of a CE policy in December 2008 by the FRB involving the purchase of large amounts of private financial assets; however, it is also an example of the third measure in part as it involved the injection of a large quantity of high-powered money into the economy, expanding the size of the FRB balance sheet. The QE monetary policy that the BOJ adopted from March 2001 to March 2006, on the other hand, is an example of the third alternative measure; however, it is also an example of the second alternative in part as the BOJ purchased short- or long-term government securities, which might have different effects on the real economy.

Whether nontraditional monetary policy measures have real effects or not is controversial and still an ongoing question, largely because of a lack of sufficient data to identify the impacts of nontraditional monetary policy measures.

The JEA organized a panel discussion on the "Evaluation of Nontraditional Monetary Policy" at the 2011 Autumn Meeting of the Association, a summary of which was published as chapter 7 of JEA (2012). Some panelists were skeptical about the effectiveness of the nontraditional monetary policy measures on the macroeconomy. One panelist asserted that the QE monetary policy adopted by the BOJ for the period from March 2001 to March 2006 was effective in promoting the stabilization of the financial system rather than in stimulating the macroeconomy through portfolio rebalancing effects. Another panelist also asserted that it was nothing more than a placebo effect on the macroeconomy, should there be any, from nontraditional monetary policy measures.

However, these assertions were made with no or little empirical evidence. The purpose of this paper is to show that these assertions are in conflict with statistical data. Rather, the data suggest that QE monetary policy by the BOJ had significant impacts on production through changes in stock prices. Furthermore, Tobin's q was operating as a channel through which monetary policy shocks were transmitted to investment in the real sector.

The organization of the paper is as follows. In Section 2, we present the results of our vector autoregressions (VAR) models. Finding that stock prices play a key role in the empirical results, in Section 3 we briefly explain the four possible channels through which changes in stock prices are transmitted to the real macroeconomy. In Section 4, we examine the relationship between stock prices and the volume of newly issued stocks and the value of fixed investment, during the QE period. In Section 5, we discuss the impacts of QE monetary policy on bank lending and prices. In Section 6, we propose a simple and operational model that is consistent with the observed data. Section 7 summarizes our findings.

2. Vector autoregressions

This section summarizes the results of vector autoregression analysis in our two joint papers, Honda, Kuroki and Tachibana(2007; HKT hereafter), and Honda and Tachibana (2011; HT hereafter).

In assessing the effectiveness of monetary policy, it is common to include variables for production, prices, and the short-term interest rate in the VAR. During the QE period from March 2001 to March 2006, however, the BOJ used the total balance of bank reserves (TBBR) as their operating target, because the overnight call rate (the standard operating target) was stuck at virtually zero percent. Hence, if we restrict our data to the period March 2001 to March 2006, and if we replace the short-term interest rate by

TBBR, we can directly apply the above standard VAR method to analyze the effectiveness of nontraditional monetary policy during the QE period.

The problem with this approach is that the sample period is very short with only 60 months of data. Hence, we have to be parsimonious in our model specification. We start with the simplest three variable VAR model with indices of industrial production (y), consumer price index (p), and TBBR. All variables are in levels. The Akaike Information Criterion (AIC) suggests a lag of two months.

With the above three-variable VAR, the results are clear. TBBR affects production y. Then, we examine through which channel the variation in TBBR affects y. To be parsimonious in our model specification, we add just one variable at a time. As a fourth variable, we use various variables, including government bond rates of different maturities, stock prices, exchange rates; we found that stock prices have a significant influence on production. Therefore, we include stock prices as the fourth variable in our four-variable VAR model. As for the data on TBBR, the results are virtually the same, whether we use the realized balances of bank reserves or the target numbers officially announced by the BOJ.

The results for the four-variable VAR model indicate that changes in the TBBR target by the BOJ immediately lead to changes in stock prices and then to changes in production with a time lag. That is, changes in the operating target of TBBR are transmitted to production via changes in stock prices. Granger causality tests, impulse response analysis, and variance decompositions unanimously support these results. These are the main results in our first paper, HKT(2007). Our results largely agree with those in Wieland (2009). The weakness of HKT is that our sample size was so small that the results may not be robust.

To improve statistical inference, Honda and Tachibana(2011) extend the sample period: from March 2001–March 2006 to January 1996–March 2010, thereby increasing the sample size from 60 to 171 months. Introducing dummy variables into VAR, we fully exploit prior information that the central bank changed their operating target from the short-term interest rate to TBBR for the QE period. With the larger samples, the AIC leads us to choose four-month lag models.

We consider three kinds of VAR models in Table 1. Model (i) is a simple five-variable VAR, including prices (p), production (y), the overnight call rate (r), stock prices (s), and the actual TBBR (m) multiplied by the dummy variable ($d1$), where $d1$ takes the value 1 during the QE period, and 0 otherwise. In ordinary times, the BOJ set its operating target at the overnight call rate. With the overnight call rate at close to zero percent during the QE period, however, the BOJ used TBBR as their operating target. This is why we include the variable TBBR (m) during the QE period only in model (i). "c", "c_1", and "c_2" in Model (i) denote (5×1) vectors of intercept parameters.

<Table 1 around here>

Model (ii) is a six-variable VAR, including two dummy variables, $d1$ and $d2$, where the second dummy variable $d2$ takes the value 0 during the QE period, and 1 otherwise. Model (i) has the shortcoming of treating the QE period and other time periods asymmetrically, because the variable ($d1 \times m$) takes the value m during the QE period, and 0 otherwise. With the second dummy variable ($d2 \times m$) included, Model (ii) treats the QE period and other time periods symmetrically, and allows the variable TBBR (m) to have different dynamic effects on other variables during the QE period compared with the other time periods. Model (ii) has an advantage over Model (i) in that we can treat the QE period and other time periods symmetrically, but at the cost of reduced efficiency of estimation with an increased number of parameters.

Model (iii) assumes that the effects of TBBR on the other variables might be different between the three periods, the QE period, before the QE period, and after the QE period. Model (iii) includes three dummy variables, *d*1, *d*3, and *d*4, where *d*3 takes the value 1 during the pre-QE period only and 0 otherwise, and *d*4 takes the value 1 during the post-QE period only and 0 otherwise.

By increasing the sample size from 60 in HKT to 171 in HT, we can obtain more precise estimates of the relationships between the macroeconomic variables, and thereby increase the statistical power of the hypothesis tests on the effectiveness of QE. The qualitative results in HT (2011) are virtually the same as in HKT (2007).

Figure 1 reports the responses of prices (*p*), production (*y*), and stock prices (*s*) to a one standard deviation shock in TBBR (*m*). The dotted lines indicate the 90% confidence bounds, obtained by Monte Carlo simulation using 500 repetitions. In all three models, the responses in prices (core CPI) are negligible, but those in production (IIP) and stock prices are significantly different from zero. Stock prices react immediately but production reacts with a time lag, as expected.

<Figure 1 around here>

Bernanke and Reinhart (2004), and Bernanke *et al*. (2004) suggest that the central bank has at least three alternative monetary policy measures even when facing the zero bound constraint of short-term interest rates.

During the QE period, the BOJ set the operating target at TBBR, but at the same time took full advantage of other means explained by Bernanke and Reinhart (2004) and Bernanke *et al*. (2004). Therefore, the main message in HKT (2007) is that nontraditional monetary policy as a package has significant impacts on production through changes in stock prices.

Table 2 shows our estimates of an increase of 1 trillion yen in TBBR on prices, production, and stock prices evaluated at the mean value of TBBR. Although the impacts of policy shocks on stock prices and production are statistically significant, estimates vary across models probably because of the small samples in the QE period. The original estimates by HKT (2007) are much larger than those by HT (2011). The estimates in Model (iii) are the largest, while those in Model (i) are the smallest of the three models.

<Table 2 around here>

3. Alternative transmission channels through stock prices

HKT (2007) and HT (2011) suggest that stock prices play an important role in transmitting monetary shocks to the real sector even when short-term interest rates are very low. There are at least four possible channels through which financial shocks are transmitted to the real sector. The first is the channel of the well-known Tobin's q.

Second, increases or decreases in the value of stocks or real estate change the value of collateral when agents borrow money from markets. Higher stock prices make it easier for potential borrowers to obtain external funds from markets, and thus tend to increase investment (see, for example, Bernanke and Gertler (1989, 1995) and Kiyotaki and Moore (1997)).

Third, Japanese banks are allowed to hold up to 5% of the existing stock of a corporation. The difference between the purchase price and the market price of stocks is hidden reserves (*fukumi-eki* in Japanese). Tier II bank capital includes 45% of hidden reserves. Therefore, rises in stock prices increase banks' hidden reserves and thus Tier II bank capital. Increased bank capital in turn enables banks to make more loans, and thus tends to increase investment.

Finally, rises in stock prices make households wealthier, which increases consumption (called "wealth effects").

4. Transmission channel via Tobin's q

4.1 Stock prices and newly issued stocks

There are at least four possible channels through which changes in stock prices affect the real sector. Among these four channels, this paper only focuses on the first, the Tobin q channel, and finds that it plays a crucial role in transmitting financial shocks to the real sector. In particular, we demonstrate that firms are very sensitive to the value of stocks in issuing new stocks. That is, when stock prices rise, firms tend to issue larger amounts of new stocks, and are likely to spend more, which in turn increases physical investment.

4.1.1 Correlation

Figure 2 shows the changes in stock prices (Nikkei 225) and the corresponding amounts of newly issued stocks (including convertible bonds and warrants) during the QE period, March 2001 to March 2006.

<Figure 2 around here>

The Japanese government injected bank capital of about 1.8 trillion yen to Resona Bank in March 2003. The government rescued the bank to avoid the possibility of contagion effects spreading to the rest of the Japanese economy. March 2003 is clearly an outlier in our dataset, and we exclude this outlier from Figure 2 and also from our statistical analysis.

Figure 2 shows a downward trend in stock prices before March 2003, but an upward trend after that. Comparing the former period of 24 months (March 2001 to February 2003) with the latter period of 36 months (April 2003 to March 2006), we observe the tendency that the amount of newly issued stocks for the latter period is clearly larger than that in the former period. The average amount of newly issued stocks increased from 213 billion yen in the former period to 356 billion yen in the latter period, a rise of 67%. With a *t*-value of 2.55, we reject the null hypothesis at the 1% significance level that the means of the amounts of newly issued stocks are equal between the two subsamples.

Since the average stock price (Nikkei 225) increased from 10,699 yen in the former period to 11,608 yen in the latter, the data suggest that there is a positive correlation between stock prices and the amount of newly issued stocks. This assertion is also supported by the data. The correlation coefficient is 0.34 between stock prices and the amount of newly issued stocks.

4.1.2 Causality from stock prices to newly issued stocks

A comparison between the two subsamples shows that the rate of increase in the average amount of newly issued stocks of 67% is far greater than the corresponding rate of increase in stock prices of 8.5%. This finding supports Tobin’s q, suggesting causality from stock prices to newly issued stocks. That is, the higher stock prices induce firms to issue larger amounts of stocks. The ordinary least squares (OLS) estimates of the relationship between stock prices s_t and the amount of newly issued stocks a_t are:

$$a_t = -188{,}975 + 43.366\, s_t. \quad (1)$$

(1.06) (2.77)

Figure 3 shows a scatter plot and the fitted OLS line. The sample period covers March 2001 to March 2006 with the outlier of March 2003 excluded. The *t*-values of the estimates are in parentheses and indicate that stock prices s_t affect the amount of newly issued stocks a_t at the 1% significance level, consistent with the hypothesis that Tobin's q is working as a transmission channel from the financial to the real sector.

<Figure 3 around here>

4.2 Stock prices and investment

Was the increase in newly issued stocks the cause of the increased investment in the latter half of the QE period? In this subsection, we address this question, making use of both monthly and quarterly data. We use "Machinery Orders", a prominent leading indicator for monthly data, and "Fixed Investment" data for quarterly data.

4.2.1 Stock prices and machinery orders

Figure 4 is a scatterplot diagram of stock prices and machinery orders for the period from March 2001 to March 2006, excluding March 2003. The estimated equation is:

$$b_t = 868{,}548 + 105.16\, s_t, \quad (2)$$

(1.75) (2.40)

where b_t denotes machinery orders, and the *t*-values are in parentheses. Equation (2) shows that a rise in stock prices increases machinery orders significantly at the 1% level.

<Figure 4 around here>

To avoid possible simultaneous equation bias, we also regress machinery orders on stock prices with a lag of one month, s_{t-1}, and find results similar to those of equation (2) with the *t*-value of the coefficient estimate of s_{t-1} significant at the 5% level.

4.2.2 Stock prices and fixed investment

Now we turn to quarterly data. Using three-month-average data of stock prices, S_t, and regressing fixed investment I_{t+4} on stock prices, S_t, we obtain the following OLS estimates and *t*-values:

$$I_{t+4} = 12517.13 + 0.42\, S_t. \qquad (3)$$

$$(5.74) \qquad (2.18)$$

The sample period covers the first quarter of 2001 to the first quarter of 2006, for a sample of only 21 observations. The sample size is too small to identify the effects of other variables accurately. Hence, we should be cautious about the interpretation of estimation results in equation (3). Nevertheless, the *t*-value of the estimate of stock prices S_t is statistically significant at the 5% level.

The results for both the monthly data and quarterly data above are consistent with the hypothesis that higher stock prices induced firms to issue larger amounts of new stocks, which in turn lead to increases in fixed investment and production.

5. Deleveraging and prices

In the previous sections, we analyzed firm behavior in the stock market for the QE period. In this section, we now examine firm and bank behavior in lending markets for this period.

Figure 5 depicts the total amount of bank loans for the QE period. The total balance of bank loans starts at around 469 trillion yen in March 2001 and declines almost monotonically until January 2004 at a rate of 21.4 trillion yen per year. Over this period, it was believed that there were three excesses in the economy, excess capital stock, excess stock of labor, and excess debt balance. Banks were collecting money back from customers and firms were repaying loans. The lending channel had virtually shut down. The impacts of this deleveraging were enormous. The decline in bank loans of 21.4 trillion yen per year is large relative to 3.9 trillion yen of newly issued stocks per year (monthly average of 61 samples, from March 2001 to March 2006 with an outlier of March 2003 included, multiplied by 12). They had contractionary and deflationary effects on the national economy. The QE strategy adopted in March 2001 and the seven subsequent increases in the operating targets by the BOJ could not prevent this downward trend in bank lending immediately. However, pumping large amounts of base money into the economy seems also to have had effects in bank loan markets, and raising the operating target to 30–35 trillion yen in January 2004 seems to have stopped the downward deleveraging trend.

<Figure 5 around here>

As shown in Figure 5, the total balance of bank loans reached a low of about 388 trillion yen in June 2005, and subsequently increased slightly. However, the BOJ suddenly abandoned its QE strategy in March 2006. We believe that this sudden exit from QE was probably too early for lending markets to return to normal, and for the Japanese economy to commence a strong recovery. This is why we find that expansionary nontraditional monetary policy during the QE period had no significant impact on prices in our VAR analysis in previous sections.

6. A simple analytic model

In this section, we propose a simple and operational model that is consistent with the statistical evidence presented in previous sections. The model we employ is an extension of Tobin (1969) and Yabushita (2009).

Before we proceed to our model, recall that bank loan markets were virtually not operating during the QE period. Taking this fact into account, we assume for purely analytic convenience that there are no bank loan markets. That is, we discard bank loans and deposits from our analysis in the following model. "Money" is the central bank money and does not include deposits in our discussion in this section.

6.1 Four-asset model

Following Tobin, for analytical purposes we regard the income account variables as exogenous data for portfolio choice behavior, and find equilibrium in the markets for stocks of assets conditional upon assumed values of outputs, incomes, and other flow variables. This strategy is the same as the one we employ when constructing the "LM curve" in macroeconomics. The key behavioral assumption here is that spending decisions and portfolio decisions are independent.

Yabushita (2009) constructs two types of financial market models, both of which are composed of three asset markets. Given the importance of stock prices, as we see in previous sections, and given the significance of foreign exchange rates, as we find in Hamada *et al*. (2010), we extend Yabushita's models to one with four assets; money, bonds, capital stocks, and foreign assets.

6.2 Demand for assets

The respective demand for money (M), bonds (B), stocks (V), and foreign assets (F) depends on their relative asset yields, GDP (Y), and wealth (W^S):

$$\begin{aligned} &\text{Money:} && M = M(i, r, z, Y, W^S) \\ &\text{Bonds:} && B = B(i, r, z, Y, W^S) \\ &\text{Stocks:} && V = V(i, r, z, Y, W^S) \\ &\text{Foreign Assets:} && F = F(i, r, z, Y, W^S). \end{aligned} \tag{4}$$

We assume that bonds, stocks, and foreign assets yield returns of interest rate (i), stock returns (r), and foreign asset returns (z), but that money yields no return.

The expected rate of return from holding foreign assets z is the sum of two components, the interest rate on foreign bonds and the expected rate of change in the exchange rate $E[\Delta e/e]$, where $E[*]$ denotes the expectation operator. We assume z is exogenous throughout the paper.

We also assume that the assets are "gross substitutes" in standard microeconomics terminology: the demand for each asset varies directly with its own rate of return and inversely with other rates. In symbols, the own derivatives of the respective demand functions:

$$(\partial B/\partial i, \partial V/\partial r, \partial F/\partial z),$$

are positive and the cross-derivatives are nonpositive.

Just as there is a budget constraint in standard microeconomics, we have a balance sheet constraint: the total demand for the four assets sums to the total demand for wealth in the economy W:

$$W = M(i, r, z, Y, W^S) + B(i, r, z, Y, W^S) + V(i, r, z, Y, W^S) + F(i, r, z, Y, W^S). \tag{5}$$

When any one of the returns ($j = i, r, z$) changes, the demand for each asset reacts to this, but the sum of the changes in the demand for each asset is assumed to be zero. That is:

$$M_j + B_j + V_j + F_j = 0 \text{ for } j = i, r, z, \tag{6}$$

where subscript j denotes partial derivatives with respect to $j = i, r, z$.

When exogenous total wealth increases, we have:

$$M_W + B_W + V_W + F_W = 1, \tag{7}$$

where subscript w denotes a partial derivative with respect to total wealth W^S.

6.3 Supply of assets

The central bank exogenously supplies the money stock, M^S. The government and firms jointly determine the supply of bonds, $P^B B^S$, where P^B and B^S denote the price and the quantity of bonds outstanding, respectively.

Firms provide the supply of stocks, qK^S, where q and K^S denote the market-value price of one unit of physical capital and the stock of physical capital, respectively, or alternatively, the stock price and the total number of stocks outstanding, respectively. The reproduction cost of one unit of physical capital is assumed to be one, and remains constant throughout the discussion.

We denote the supply of foreign assets by eF^S, where e and F^S are the exchange rate measured in yen per unit of foreign currency, and the total balance of foreign assets measured in foreign currency, respectively. The exchange rate e is endogenous, but F^S is assumed to be determined exogenously.

6.4 Inverse relations between market prices and returns

We assume that there is an inverse relation between bond price, P^B, and interest rate, i:

$$dP^B/di < 0. \tag{8}$$

Similarly, we also assume that an inverse relation:

$$dq/dr < 0, \tag{9}$$

also holds for capital stocks.

One simple intuitive explanation for inequalities (8) and (9) is as follows. Consider consols that produce one yen per year. The market value of these consols P^B is given by $P^B = 1/i$. There is indeed an inverse relation between the price of bonds P^B and the interest rate i.

In a similar manner, consider one unit of physical capital that produces real return R (assumed to be exogenous) per year. Then, the market value of this physical capital q is given by $q = R/r$. An inverse relation holds again in this case between stock prices q and the rate of return on capital stocks r, where r is the rate of return on stocks required for market investors to be induced to hold capital stocks in their portfolios.

6.5 Market equilibrium

The market equilibrium conditions are given by the four equations:

$$M^S = M(i, r, z, Y, W^S), \tag{10}$$

$$P^B B^S = B(i, r, z, Y, W^S), \tag{11}$$

$$qK^S = V(i, r, z, Y, W^S), \tag{12}$$

$$eF^S = F(i, r, z, Y, W^S), \tag{13}$$

but one of these conditions is automatically satisfied when the other three conditions are met because of the balance sheet constraint:

$$M^S + P^B B^S + qK^S + eF^S = W^S = W, \tag{14}$$

where W^S denotes the total supply of wealth. Therefore, we only have to consider any three equations of the above four; we choose equations (10), (11), and (13). The three endogenous variables are the interest rate i, returns on capital stocks r, and the foreign exchange rate e. Variables P^B, q, and W^S are also endogenous because of conditions (8), (9), and (14), respectively. The remaining variables in the system (10) through (13) are exogenous.

Substituting equation (14) into equations (10), (11), and (13), we have:

$$M^S = M(i^*, r^*, z, Y, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{15}$$

$$P^B(i^*)B^S = B(i^*, r^*, z, Y, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{16}$$

$$e^*F^S = F(i^*, r^*, z, Y, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{17}$$

where superscript * indicates the equilibrium value.

6.6 The effects of an increase in money supply

We are interested in the effects of an exogenous increase in money supply M^S on the equilibrium endogenous variables (i^*, r^*, e^*). We consider two kinds of comparative statics. The first is the examination of the effects of a simple exogenous increase in money supply M^S. In this case, the government and the central bank collaborate and print the new money, and distribute it to individuals in the nation, similar to the case of tax cuts. The most primitive case corresponding to this in the real world is the case where the government issues new government bonds, and purchases goods and services with the newly printed money. As we are interested in the pure effects of an increase in the money supply, we consider the situation where the government reduces its spending on other activities by the same amount as the newly printed money.

The direct purchase of government bonds by the central bank is of course prohibited by law in Japan today. If the government issues new bonds, and if the central bank purchases the same amount of older bonds from the markets, however, the result is the same as in the case of the direct sale of government bonds by the government to the central bank.

Furthermore, note that this case of a simple exogenous increase in the money supply corresponds to the case of an increase in the money supply in the well-known IS–LM model.

Appendix A shows that an increase in the money supply lowers the interest rate, $di^*/dM^S < 0$, reduces the required rate of returns from stocks, $dr^*/dM^S < 0$, and depreciates the value of the domestic currency, $de^*/dM^S > 0$.

The second case is the effects of an open market operation (OMO). What are the effects if the central bank purchases government bonds from the market? Appendix B shows that an increase in the money supply by OMO lowers the interest rate, $di^{**}/dM^S < 0$, reduces the required stock return, $dr^{**}/dM^S < 0$, and depreciates the value of the domestic currency, $de^{**}/dM^S > 0$.

6.7 Limitations of the model

6.7.1 Banks

There are neither deposits nor bank loans in our model. This is clearly a bold simplification. However, the significance of our model lies in the demonstration of the existence of the transmission mechanism of nontraditional monetary policy even in such a primitive model as one with no bank loans. We have shown in our model that an increase in the money supply M^S lowers the interest rate on bonds i, reduces the required rate of return from stocks *r*, and depreciates the exchange rate of the domestic currency *e*. This implies that even if lending channels are completely shut down, there are still other channels through which monetary policy shocks may be transmitted to the real sector. Indeed this was what happened in Japan for the QE period, as we saw in Sections 4 and 5.

6.7.2 Expectations

Variables in financial markets are forward-looking, and expectations play an important role in the real world. However, our model ignores the role of expectations for the sake of simplicity.

For example, our model shows that the purchase of government bonds by the central bank reduces the equilibrium interest rate. However, this might not be the case in the real world because of expectations among market participants. When the central bank purchases government bonds, and when portfolio managers believe that such a policy stimulates the economy and that the inflation rate will be higher in the future, then portfolio managers are likely to increase the share of stocks and decrease that of bonds in their portfolios. (This is because stocks are believed to be a better device than bonds for hedging against future inflation.) The decline in the demand for bonds might raise the equilibrium rate of interest, contrary to the prediction of the above simple model.

When expectations change as in the above example, they might shift demand for assets in the equations in (4). Strictly speaking, therefore, when we wish to analyze the effects of OMO, we should specify demand for bonds *B* and stocks *V* as:

$$B = B(i, r, z, Y, W^S, \varphi^B(M^S)), \tag{18}$$

$$V = V(i, r, z, Y, W^S, \varphi^V(M^S)), \tag{19}$$

instead of the corresponding equations in (4), where $\varphi^B(M^S)$ and $\varphi^V(M^S)$ denote the impacts of an increase of the money supply on the demand for bonds and stocks, respectively, through changes in expectations among market participants. In such a complicated model with expectations, our standard results obtained, $di^*/dM^S < 0$ or $di^{**}/dM^S < 0$, may no longer hold. This is all the more likely to happen under a low interest rate environment, where the liquidity effect is weak, or almost disappears.

As in the above example, our simple model with no expectations has some limitations for analyzing the real world. Nevertheless, our simplified model is still relevant because people form their expectations carefully. They usually base their expectations on logical thinking or a simple operational model such as the one in this paper. In this case, our simple model with no expectations might still be a good approximation to the real world in many situations.

7. Concluding remarks

We summarize our findings in this paper. First, the two different VAR analyses, HKT (2007) and HT (2011), provided the same qualitative results. That is, changes in the TBBR target affect IIP through changes in stock prices. Second, the estimates of the impacts of nontraditional monetary policy in HT (2011) are smaller than those in HKT (2007). Third, monetary policy shocks during the QE period increased IIP at least through the Tobin q channel. However, our empirical results do not exclude possible effects through changes in foreign exchange rates.

Why did stock prices rise when the BOJ raised their operating targets for TBBR during the QE period? There are at least two reasons. The first is a simple substitution effect between money and stocks, as shown in our simple model in the previous section.

The second is that the "expected rate of inflation" in the market rises. Indeed, the break-even inflation rate (the nominal yield on standard government bonds with a 10-year maturity minus the real yield on the corresponding government bonds of the same maturity adjusted for future rates of inflation) rose from about 0.2% in March 2004 to nearly 1.0% in August 2004, and remained roughly there for the rest of the QE period (data were obtained from Nihon Sogo Securities in Japan).[1] Taking into account that there is an upper bound on the returns from bonds, whereas there is no such bound on the returns from stocks, some market investors might have shifted their portfolios from bonds to stocks, and stock prices increased.

A rise in stock prices in turn induces corporate managers to collect more funds from stock markets and to spend more on their physical capital investment. Hence, investment, and thus production increase.

Why, then, has the Japanese economy been trapped with deflation even after the QE monetary policy from March 2001 to March 2006? We conjecture there are at least two reasons for this. One, the strength of the recovery from the serious recession was weak and slow. Two, it was too early for the BOJ to abandon nontraditional monetary policy and send a contractionary financial shock to the market. This contractionary monetary

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[1] Some doubt about the reliability of the break-even inflation rate in Japan as an indicator of future inflation due to the thinness of the market. However, the total balance of inflation indexed bonds outstanding at that time roughly corresponds to the total issued stocks outstanding of one of largest corporations listed at Tokyo Stock Exchange, and we conjecture that the market was thick enough for arbitrage to fully work. (Sekine et al.(2008) report that the total balance of inflation indexed bonds was 8.4 trillion yen at the end of March 2008.)

policy shock in March 2006 might have hampered the strong recovery of the real economy.

Fourth, the impacts of deleveraging were enormous. Lending channels were virtually shut down during the QE period. Fifth, raising the operating target of TBBR to 30–35 trillion yen at January 2004 seems to have halted the trend of deleveraging.

Sixth, this paper has an implication for analytic economic models. The well-known IS–LM model is based on the assumption that there are two asset classes, money and bonds. Arguments regarding the "liquidity trap", which Hicks (1937) discussed, break down if there are more than three assets in the model. Our empirical findings suggest that stock prices play a crucial role in transmitting financial shocks to the real sector. Therefore, it is not the two-asset model, but the n-asset model, as in Tobin (1969), that is relevant for describing the real world today. It is not the interest rate alone as in the IS–LM model that transmits financial shocks to the real sector. Changes in the central bank's policy stance are transmitted to the real sector through the prices of all assets, including the term structure of interest rates (prices of bonds), stock prices, and foreign exchange rates (prices of foreign currencies).[2]

2. Kiyotaki and Moore(2012) also discuss the role of monetary policy in a framework of multiple assets.

Appendix A: Effects of an exogenous increase in money supply

There are three endogenous variables, (i, r, e), and three equations. Differentiating equations (15), (16), and (17) with respect to M^S, we have:

$$\begin{bmatrix} 1-\mathrm{M}_5 \\ -\mathrm{B}_5 \\ -\mathrm{F}_5 \end{bmatrix}$$

$$= \begin{bmatrix} \mathrm{M}_1+\mathrm{M}_5\mathrm{B}^{\mathrm{S}}(\mathrm{dP}^{\mathrm{B}}/\mathrm{di}) & \mathrm{M}_2+\mathrm{M}_5\mathrm{K}(\mathrm{dq}/\mathrm{dr}) & \mathrm{M}_5\mathrm{F}^{\mathrm{S}} \\ \mathrm{B}_1+(\mathrm{B}_5-1)\mathrm{B}^{\mathrm{S}}(\mathrm{dP}^{\mathrm{B}}/\mathrm{di}) & \mathrm{B}_2+\mathrm{B}_5\mathrm{K}(\mathrm{dq}/\mathrm{dr}) & \mathrm{B}_5\mathrm{F}^{\mathrm{S}} \\ \mathrm{F}_1+\mathrm{F}_5\mathrm{B}^{\mathrm{S}}(\mathrm{dP}^{\mathrm{B}}/\mathrm{di}) & \mathrm{F}_2+\mathrm{F}_5\mathrm{K}(\mathrm{dq}/\mathrm{dr}) & (\mathrm{F}_5-1)\mathrm{F}^{\mathrm{S}} \end{bmatrix} \begin{bmatrix} (\mathrm{di}^*/\mathrm{dM}^{\mathrm{S}}) \\ (\mathrm{dr}^*/\mathrm{dM}^{\mathrm{S}}) \\ (\mathrm{de}^*/\mathrm{dM}^{\mathrm{S}}) \end{bmatrix}, \quad \text{(A1)}$$

where M_j, B_j, V_j, and F_j (j = 1, 2, 3, 4, 5) denote the partial derivatives of demand for money M, bonds B, stocks V, and foreign assets F, with respect to the j-th argument, respectively. Solving this system of equations, we obtain:

$$\frac{\mathrm{di}^*}{\mathrm{dM}^{\mathrm{S}}} = \mathrm{F}^{\mathrm{S}}[-\mathrm{B}_2(1-\mathrm{F}_5-\mathrm{M}_5)-\mathrm{B}_5(\mathrm{M}_2+\mathrm{F}_2)-\mathrm{B}_5\mathrm{K}(\mathrm{dq}/\mathrm{dr})]/\Delta, \quad \text{(A2)}$$

$$\frac{\mathrm{dr}^*}{\mathrm{dM}^{\mathrm{S}}} = \mathrm{F}^{\mathrm{S}}$$

$$[\mathrm{B}_1(1-\mathrm{M}_5-\mathrm{F}_5-\mathrm{B}_5)+\mathrm{B}_5(\mathrm{M}_1+\mathrm{F}_1+\mathrm{B}_1)+(\mathrm{B}_5+\mathrm{F}_5+\mathrm{M}_5-1)\mathrm{B}^{\mathrm{S}}(\mathrm{dp}^{\mathrm{B}}/\mathrm{di})]/\Delta,$$

(A3)

$$\frac{\mathrm{de}^*}{\mathrm{dM}^{\mathrm{S}}} = [\mathrm{F}_1\{-\mathrm{M}_2\mathrm{B}_5-\mathrm{B}_2(1-\mathrm{M}_5)\}+\mathrm{F}_2\{\mathrm{B}_1(1-\mathrm{M}_5-\mathrm{B}_5)-\mathrm{B}_5(\mathrm{V}_1+\mathrm{F}_1)\}-$$

$$\mathrm{F}_5(\mathrm{M}_1\mathrm{B}_2-\mathrm{M}_2\mathrm{B}_1)+\{-\mathrm{F}_2(1-\mathrm{M}_5-\mathrm{B}_5)-\mathrm{F}_5(\mathrm{B}_2+\mathrm{M}_2)\}\mathrm{B}^{\mathrm{S}}(\mathrm{dp}^{\mathrm{B}}/\mathrm{di})+(\mathrm{B}_1\mathrm{F}_5-$$

$$\mathrm{B}_5\mathrm{F}_1)\mathrm{K}(\mathrm{dq}/\mathrm{dr})-\mathrm{F}_5\mathrm{B}^{\mathrm{S}}\mathrm{K}(\mathrm{dp}^{\mathrm{B}}/\mathrm{di})(\mathrm{dq}/\mathrm{dr})]/\Delta, \quad \text{(A4)}$$

where Δ denotes the determinant of the (3 × 3) matrix on the right-hand side of equation (A1), and is given by:

$$\Delta = \mathrm{F^S[M_1\{B_2(F_5-1)-B_5F_2\}+M_2\{B_5F_1+B_1(1-F_5)\}+M_5(B_1F_2-B_2F_1)}$$

$$\mathrm{+\{M_5(-B_2+B_2F_2-B_5F_2-F_2)+M_2(B_5+F_5-1)\}B^S(dp^B/di)}$$

$$\mathrm{+(-B_5M_1+B_1M_5)K(dq/dr)-M_5B^SK(dp^B/di)(dq/dr)]}$$

$$= \mathrm{F^S[M_1\{B_2(F_5-1)-B_5F_2\}+M_2\{B_5(F_1+}B_1\mathrm{)+B_1(}L_5+V_5\mathrm{)\}}$$

$$\mathrm{+M_5(B_1F_2-B_2F_1)}$$

$$\mathrm{+\{M_5(-B_2+B_2F_2-B_5F_2-F_2)+M_2(}-M_5-V_5\mathrm{)\}B^S(dp^B/di)}$$

$$\mathrm{+(-B_5M_1+B_1M_5)K(dq/dr)-M_5B^SK(dp^B/di)(dq/dr)]}. \quad \text{(A5)}$$

Making use of equations (6), (7), and the assumption of gross substitutes among the demand for assets, we can show that the terms in square brackets are positive on the right-hand side of equation (A2), positive on the right-hand side of equation (A3), and negative on the right-hand side of equation (A4), respectively. Noting that

$$1-F_5 = M_5+B_5+V_5 \; and \; F_1+B_1 = -V_1-M_1 > 0,$$

we also obtain an inequality Δ < 0. Therefore, we have:

$$\frac{\mathrm{di^*}}{\mathrm{dM^S}} < 0, \frac{\mathrm{dr^*}}{\mathrm{dM^S}} < 0, and\; \mathrm{de^*/dM^S} > 0.$$

Appendix B: Effects of an open market operation

In mathematical terminology, the central bank's purchase of government bonds is an increase in the money supply M^S with a simultaneous decrease in the supply of bonds B^S. In this appendix, therefore, the supply of bonds B^S is endogenous and a function of the money supply M^S. The system is now composed of the following four equations:

$$M^S = M(i^{**}, r^{**}, z, Y, M^S + p^B(i^{**})B^S(M^S) + q(r^{**})K^S + e^{**}F^S), \quad \text{(A6)}$$

$$p^B(i^{**})B^S(M^S) = B(i^{**}, r^{**}, z, Y, M^S + p^B(i^{**})B^S(M^S) + q(r^{**})K^S + e^{**}F^S), \quad \text{(A7)}$$

$$e^{**}F^S = F(i^{**}, r^{**}, z, Y, M^S + p^B(i^{**})B^S(M^S) + q(r^{**})K^S + e^{**}F^S), \quad \text{(A8)}$$

$$\frac{d[p^B(i^{**})B^S(M^S) + M^S]}{dM^S} = 0, \quad \text{(A9)}$$

where superscript ** denotes the equilibrium value. Equation (A9) expresses that an increase in the money supply M^S is equal to the simultaneous reduction in the supply of bonds $P^B B^S$ in absolute value.

There are four endogenous variables (i, r, e, B^S) in the model. Solving equation (A9) for (dB^S/dM^S), we have:

$$\frac{dB^S}{dM^S} = -\{1/p^B(i^{**})\} - \{B^S/p^B(i^{**})\}\{dp^B(i^{**})/di^{**}\}(di^{**}/dM^S). \quad \text{(A10)}$$

Substituting equation (A10) into equations (A6), (A7), and (A8), we have the system of three equations:

$$\begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix} = \begin{bmatrix} M_1 & M_2 + M_5K(dq/dr) & M_5F^S \\ B_1 & B_2 + B_5K(dq/dr) & B_5F^S \\ F_1 & F_2 + F_5K(dq/dr) & (F_5 - 1)F^S \end{bmatrix} \begin{bmatrix} di^{**}/dM^S \\ dr^{**}/dM^S \\ de^{**}/dM^S \end{bmatrix}. \quad \text{(A11)}$$

Solving this system of equations (A11), we have:

$$\frac{di^{**}}{dM^S} = \frac{F^S\left[(M_2 + B_2)(F_5 - 1) - (B_5 + M_5)F_2 - (B_5 + M_5)K\left(\frac{dq}{dr}\right)\right]}{\Delta^o}, \quad \text{(A12)}$$

$$\frac{dr^{**}}{dM^{S}} = \frac{F^{S}[-V_5F_1 - V_1(1 - F_5)]}{\Delta^{o}}, \tag{A13}$$

$$\frac{de^{**}}{dM^{S}} = \frac{\left[-V_1F_2 + V_2F_1 + \{-V_1F_5 - (1 - V_5)F_1\}K\left(\frac{dq}{dr}\right)\right]}{\Delta^{o}}, \tag{A14}$$

where Δ^{o} is the determinant of the (3×3) matrix in the right-hand side of equation (A11), and is given by:

$$\begin{aligned}\Delta^{o} = F^{S}[&M_1B_2(F_5 - 1) + M_5B_1F_2 - M_5B_2F_1 - M_1B_5F_2 \\ &+ M_2\{-B_5(M_1 + V_1) + B_1(M_5 + V_5)\} \\ &+ (M_5B_1 - M_1B_5)KF^{S}(dq/dr)].\end{aligned} \tag{A15}$$

Using conditions (6), (7), and the assumption of gross substitutes among the demand for assets, we can show that the terms in square brackets are positive on the right-hand side of equations (A12), positive on the right-hand side of equation (A13), negative on the right-hand side of equation (A14), and negative on the right-hand side of equation (A15), respectively. Therefore, we obtain:

$$\frac{di^{**}}{dM^{S}} < 0,\ \frac{dr^{**}}{dM^{S}} < 0,\ \text{and}\ \frac{de^{**}}{dM^{S}} > 0.$$

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TABLE 1

VAR models

VAR Model (i)

$Y = (p, y, r, d1 \times m, s)'$, $c = c_1 + (c_2 \times d1)$

VAR Model (ii)

$Y = (p, y, r, d1 \times m, d2 \times m, s)'$, $c = c_1 + (c_2 \times d1)$

VAR Model (iii)

$Y = (p, y, r, d1 \times m, d3 \times m, d4 \times m, s)'$, $c = c_1 + (c_2 \times d1) + (c_3 \times d4)$

HT (2011)

TABLE 2

Effects of an increase of one trillion yen in operating target

	Model (i)	Model (ii)	Model (iii)	HKT (2007)
Core CPI	0.004%	0.005%	0.003%	0.021%
IIP	0.031%	0.067%	0.177%	0.303%
Stock Prices	0.200%	0.341%	0.918%	2.142%

HKT (2007)

HT (2011)

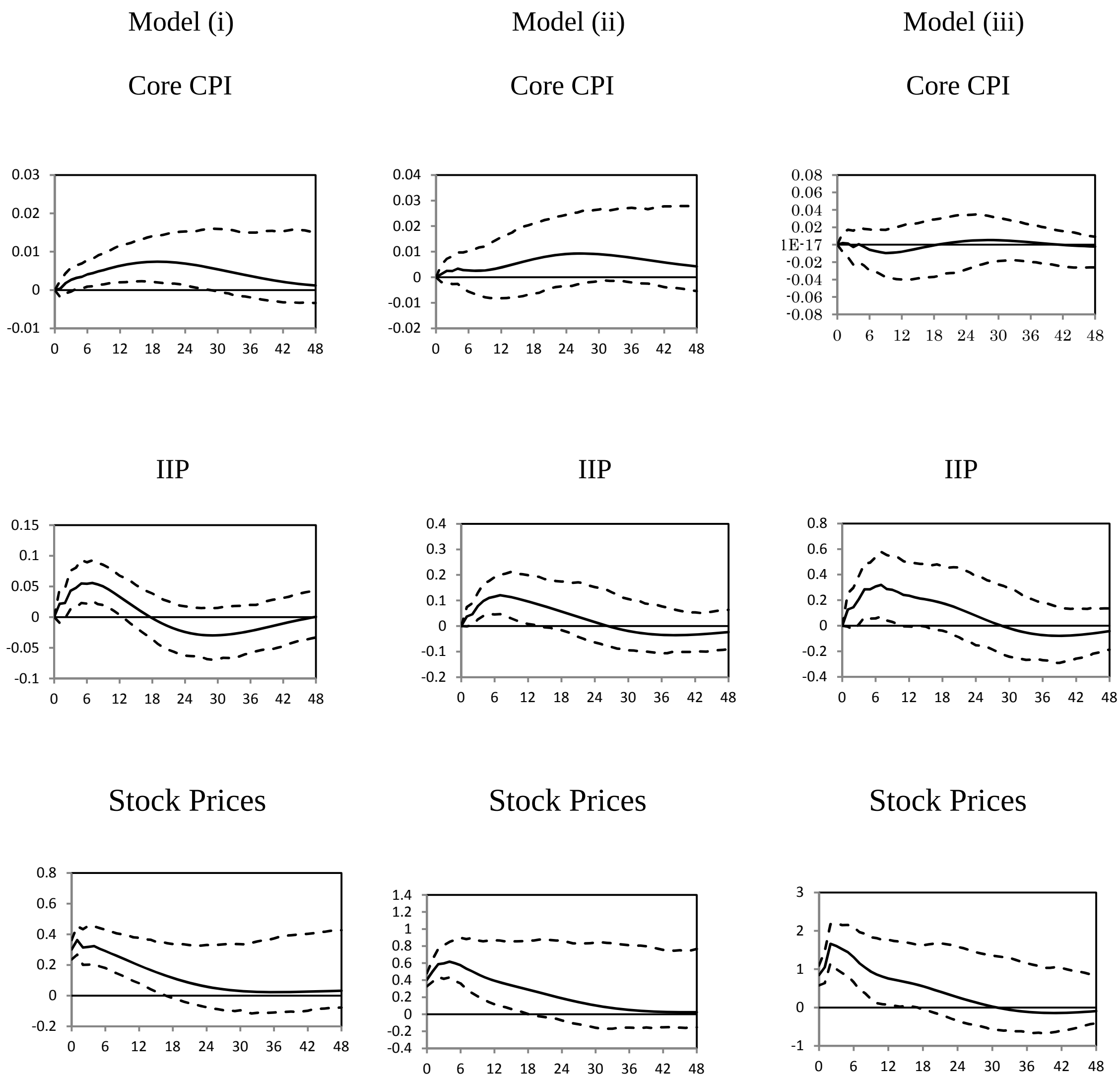


FIGURE 1. Impulse responses to a quantitative easing policy shock

Notes: Solid and dotted lines are the point estimates and 90% confidence bounds, respectively. The horizontal axis measures months after the policy shock. The units of measurement on the vertical axis are the natural logarithm of the variable in levels multiplied by 100.

HT (2011)

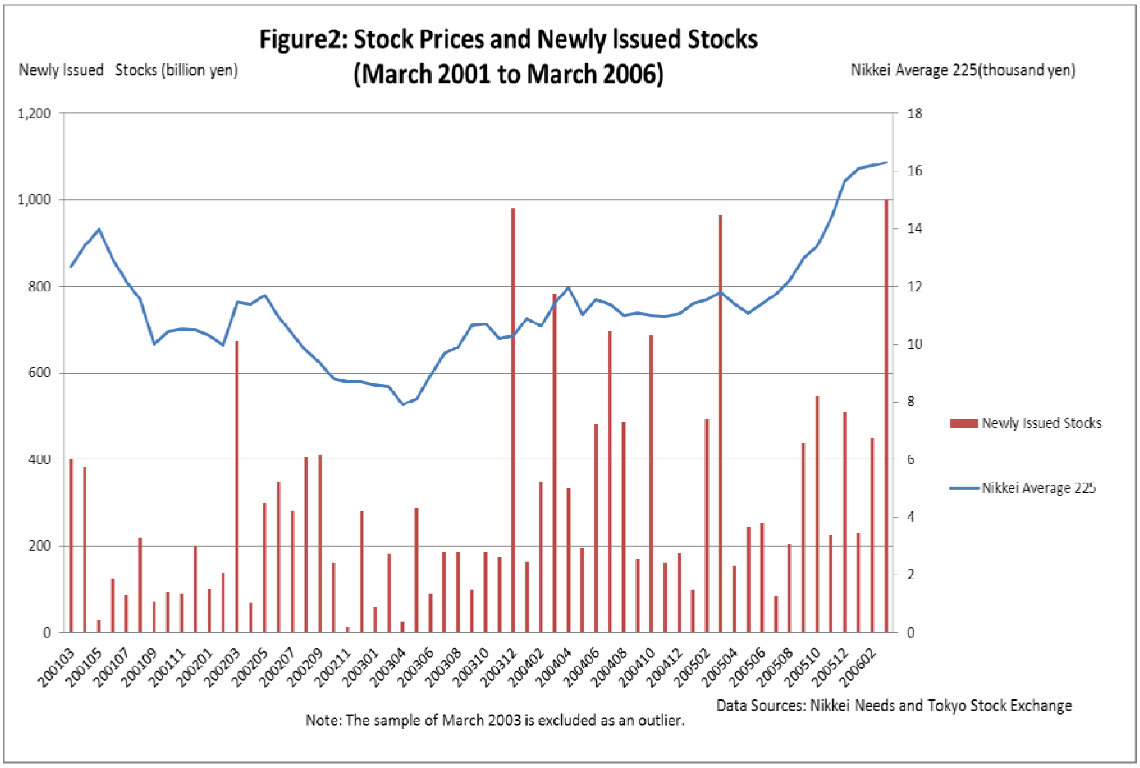
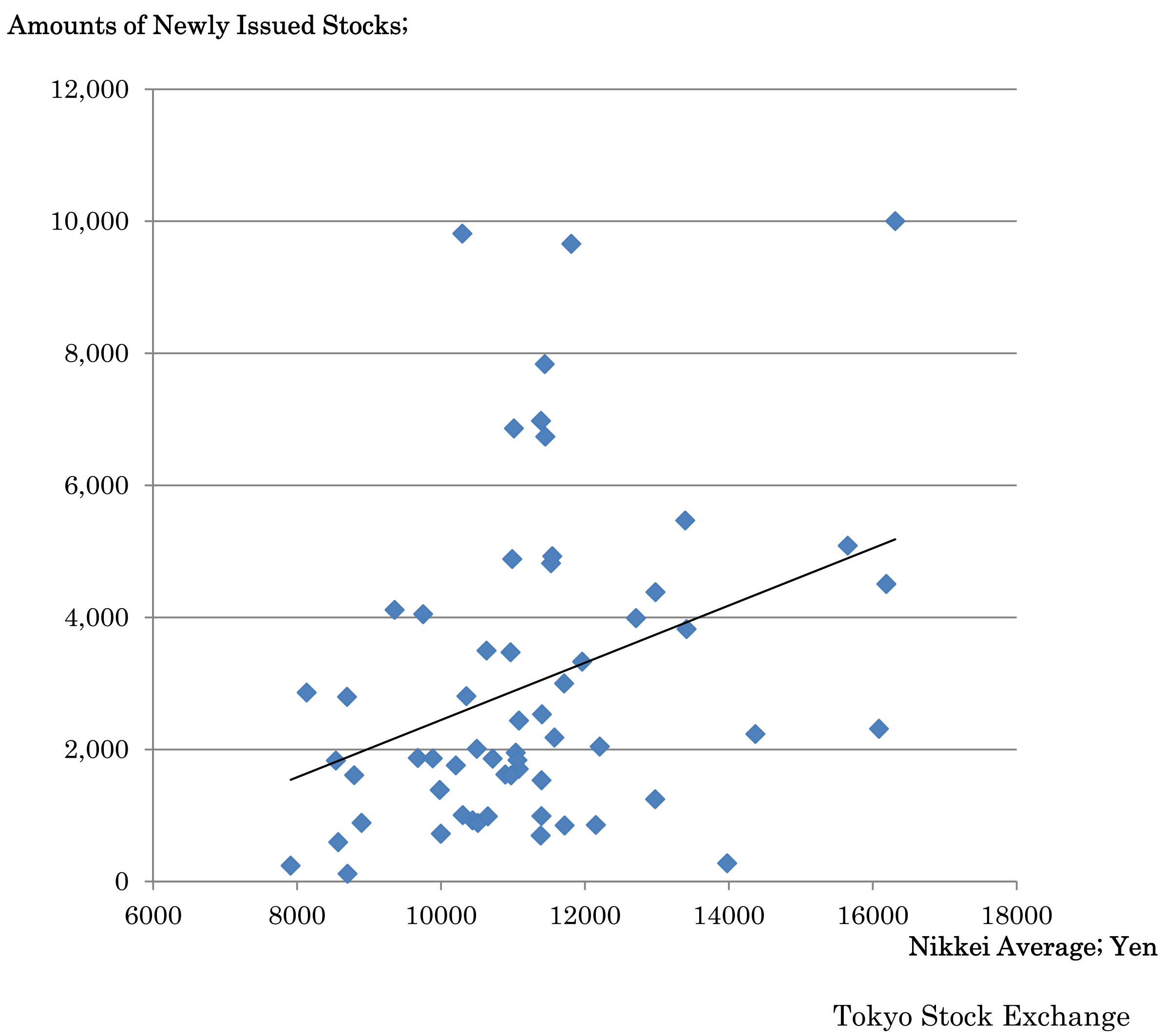


Figure2: Stock Prices and Newly Issued Stocks
(March 2001 to March 2006)
Newly Issued Stocks (billion yen)
Nikkei Average 225(thousand yen)
Newly Issued Stocks
Nikkei Average 225
Data Sources: Nikkei Needs and Tokyo Stock Exchange
Note: The sample of March 2003 is excluded as an outlier.

Figure 3: Scattered Diagram on Stock Prices and Newly Issued Stocks(2001/3 to 2006/3 with data of 2003/3 Excluded as an Outlier)



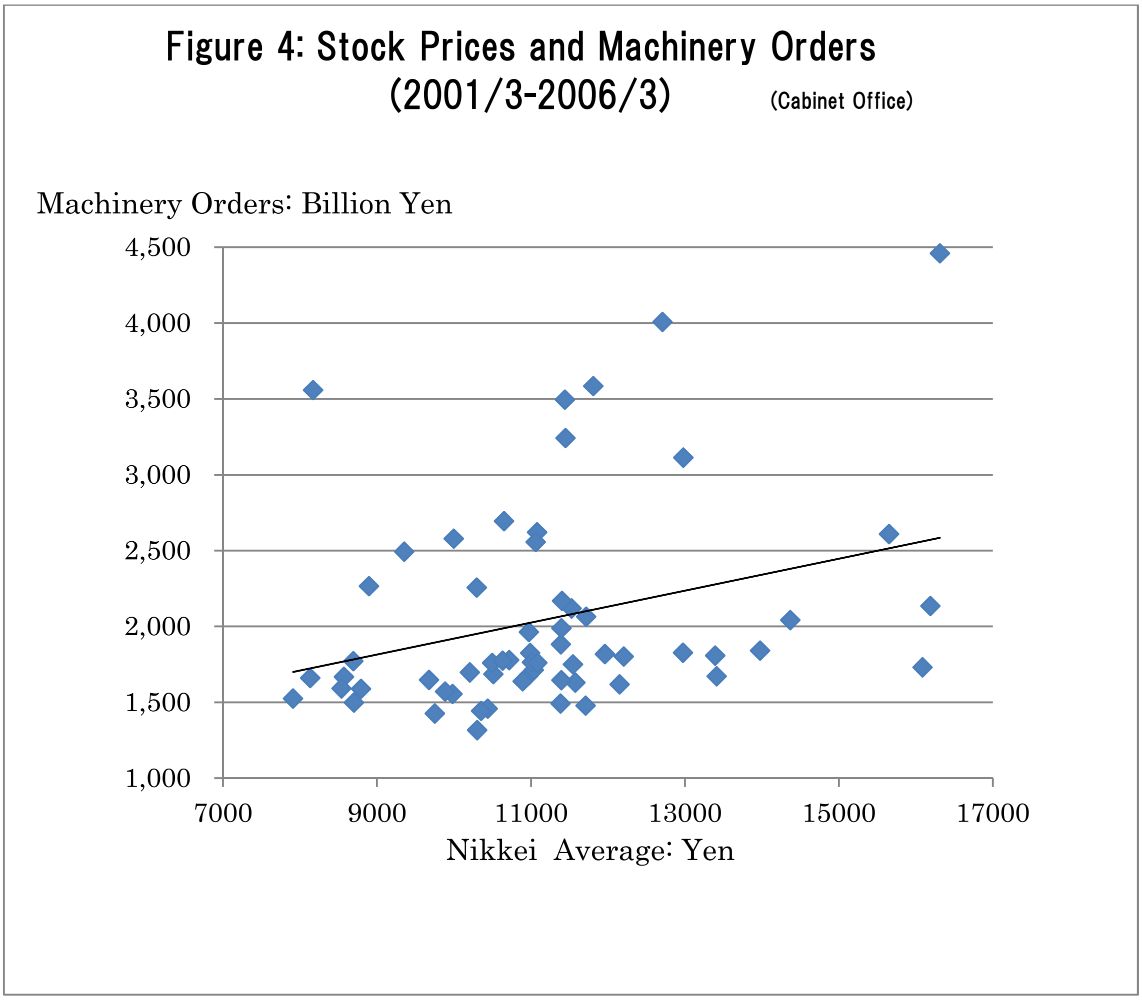


Figure 4: Stock Prices and Machinery Orders
(2001/3-2006/3)
(Cabinet Office)
Machinery Orders: Billion Yen
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
7000
9000
11000
13000
15000
17000
Nikkei Average: Yen

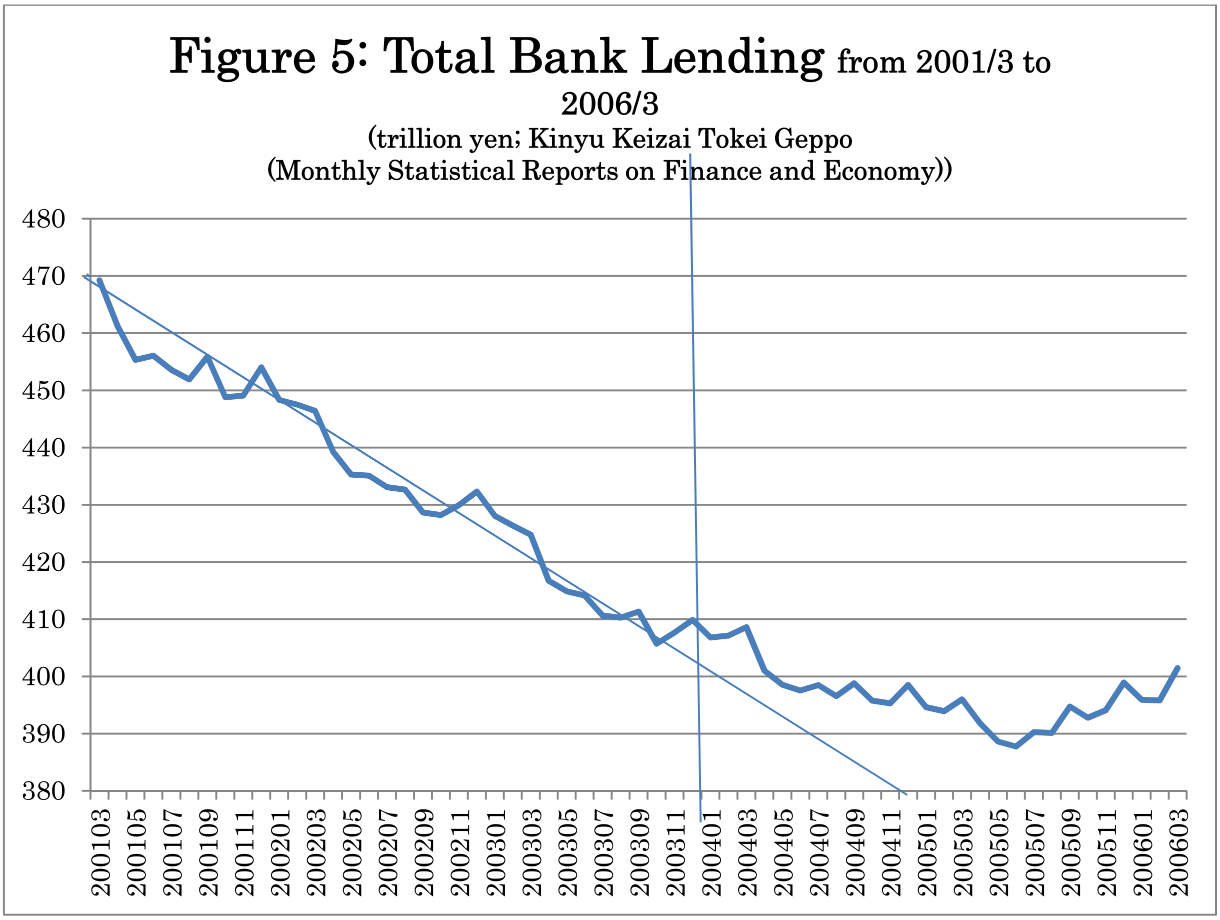


Figure 5: Total Bank Lending from 2001/3 to 2006/3
(trillion yen; Kinyu Keizai Tokei Geppo
(Monthly Statistical Reports on Finance and Economy))
480
470
460
450
440
430
420
410
400
390
380
200103
200105
200107
200109
200111
200201
200203
200205
200207
200209
200211
200301
200303
200305
200307
200309
200311
200401
200403
200405
200407
200409
200411
200501
200503
200505
200507
200509
200511
200601
200603