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Myths and Observations on Unconventional Monetary Policy
—Takeaways from Post-Bubble Japan—

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Myths and Observations on Unconventional Monetary Policy

-- Takeaways from Post-Bubble Japan --

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Abstract

Reservations are sometimes raised regarding the effectiveness of unconventional monetary policy (UMP) due to the concerns about influences of impaired financial systems and low policy rates. To see if this is the case, we combine the local projection method of Jordà (2005) with shadow rates to estimate macroeconomic effects of monetary policy shocks during the implementation period of UMP, and test if effects of these shocks with the same magnitude differ across periods or states of the economy, using Japan's data from the 1980s to 2016. We find that monetary policy shocks during the implementation period of the UMP had statistically significant expansionary effects on the economy. We also find that an unexpected 100 basis point cut in shadow rates during the UMP yielded larger expansionary effects on key economic variables than it did during the conventional monetary policy (CMP), because of the following three reasons: (i) A cut in the shadow rates resulted in a larger reduction in the real interest rate, and affected a wider range of borrowing rates during the UMP; (ii) The effectiveness of monetary policy shocks was dampened when the financial system was significantly impaired, particularly during the CMP; (iii) Other things being equal, the effectiveness has been so far little affected by the level of policy rate. Our results show that UMP has been effective, but that the nature of monetary transmission is subject to change depending on financial conditions or other economic circumstances, and therefore monetary policy needs to be carefully implemented. Note also that our study only explores the effects of a one-unit shock to the monetary policy rule, and does not address the entire effects of monetary easing that are affected by the size of shocks as well.

JEL classification: F39; G15; G18

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1. Introduction

In the aftermath of the global financial crisis, central banks in a number of countries soon faced the zero lower bound of policy rates, and started to use a novel set of monetary policy measures commonly referred to as unconventional monetary policies (UMPs). These measures include forward guidance, quantitative and qualitative easing, and negative interest rate policies, and are thought to boost the economy through broader channels than conventional monetary policies (CMPs). However, there has been some natural skepticism about the effectiveness of these measures. This is partly because the economies in these countries have been slow in returning to their pre-crisis state, and more importantly, as pointed out by Borio and Hofmann (2017), because there are novel challenges in implementing UMPs that are not necessarily present when implementing CMPs.

The first challenge is the impairment of financial intermediation. In many advanced economies, UMPs were introduced to counter the adverse effects of the financial crisis, and their implementation therefore came hand-in-hand with an environment where the balance sheets of financial institutions, of banks in particular, were severely damaged and financial intermediation did not function well. Existing studies of jurisdictions that suffered from financial crises agree that such disruption in financial intermediation has an impact on monetary policy transmission.[1] For example, Nagahata and Sekine (2005) provide an empirical study of monetary policy transmission in Japan, and conclude that the credit channel of monetary policy did not function adequately during the time when the balance sheets of banks and non-financial firms were severely damaged.[2]

The second challenge is the level of the prevailing short-term interest rate. Short-term interest rates during a period of UMP are effectively zero or negative. Some studies argue that a further reduction in the policy rate when it is already low may

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[1] However, the literature does not agree regarding how this disruption affects monetary policy transmission. In contrast to the finding of Nagahata and Sekine (2005) and others listed below, Jimenez et al. (2017), using loan level data of Spanish banks, show that a monetary contraction has a greater effect on the loan granting of banks with lower capital.

[2] Relatedly, Hosono (2006) studies individual bank data and finds that the expansionary effect of monetary policy is attenuated if a bank is large, illiquid, and short of capital. See also Boeckx et al. (2017) which studies the effects of accommodative monetary policy in the euro area after the recent financial crisis. Authors show that monetary policy transmission, measured by its favorable effects on GDP in the member countries, was less evident in those countries where the banking sector had severe balance sheet problems.

reduce banks' lending instead of increasing it, thereby hampering monetary policy transmission. For example, if a further cut in the policy rate is straightforwardly translated into a reduction in banks' lending rates but not into a reduction of deposit rates, possibly because of the zero lower bound on the deposit rates, banks' retained earnings fall, resulting in damage to banks' balance sheets, a reduction in their risk taking activities and a general dampening of output. A theoretical work by Brunnermeir and Koby (2017) demonstrates that such a channel can manifest itself when banks with capital shortages are severely constrained by capital requirements. They coin the term "the reversal rate" to describe the maximum interest rate that yields such an adverse effect. Along similar lines, Borio and Gambacorta (2017) examine the data of large banks in 14 countries and report that banks' lending volume increases with a fall in the short-term interest rate when the rate is initially high, but it may otherwise decrease.[3]

While the presence of these challenges is undeniable, a quantitative assessment of these challenges, or the effectiveness of UMP relative to that of CMP, is yet to be concluded. Bernanke (2016) argues that "negative interest rates appear to have both modest benefits and manageable costs." Coeuré (2016) focuses on banks in the euro area and shows that a cut in the short-term interest rate increases banks' profits as the favorable effects arising from capital gains on banks' bond holding and a decline in the default risks of borrowers proves greater than the adverse effects of a decline in interest margins.[4]

In this paper, we empirically explore the quantitative impacts of these challenges and study if the effects of monetary policy are weakened under a UMP regime compared to those under a CMP regime, either by these challenges or by other factors. Based on the local projection (LP) method developed by Jordà (2005), and using the shadow rate metric constructed by Krippner (2015) as the measure of the policy rate, we propose a novel approach that tests statistically whether the effect on economic activity, prices, and financial variables of an unexpected one-unit cut in the policy rate, or

[3] See also the work by Borio et al. (2015) that empirically shows banks' profits are negatively correlated with the level of the short-term interest rate.

[4] Gilchrist et al. (2015), using data from the U.S., show that the efficacy of UMP in lowering real business borrowing costs is comparable to that of CMP and, depending on the metric used, can be larger than that of CMP. Ferrari et al. (2017), using the data of seven currencies, report that the responsiveness of exchange rates to shocks to monetary policy has monotonically increased over the years.

equivalently in the shadow rate, say a cut by 100 basis point, differs depending on the state of the credit cycle or the level of the short-term nominal interest rate, or between the two regimes. We then apply this approach to Japan's data.

Our sample period runs from the 1980s to 2016, and coincides with the period when these challenges were surfacing from time to time. From the 1990s to the early 2000s, following the bursting of the bubble economy in the early 1990s, Japan's economy experienced a financial crisis.[5] Banks found themselves burdened with an accumulation of bad loans, in particular those extended to the real estate and construction industries. Banks' balance sheets were increasingly damaged, leading to disruptions to financial intermediation. To tackle economic downturn following the financial crisis, the Bank of Japan (BOJ) first cut its policy rate successively to the point of the zero rate, and after started implementing the UMP measures. It set its policy rate at zero in 1999 and maintained the rate around that level, and in subsequent years launched a number of measures including Quantitative Easing (QE), Comprehensive Monetary Easing (CME), and Quantitative and Qualitative Monetary Easing (QQE).[6]

Did these two challenges hamper monetary policy transmission and weaken the expansionary effects of the UMP? The answer is both yes and no. On the one hand, we find that an unexpected 100 basis point cut in the shadow rate during the financial crisis period led to smaller accommodative effects on macroeconomic variables compared with the same size of rate cut during the normal period, in a statistically significant manner. On the other hand, we also found, based on the same metric of "effects induced by an unexpected 100 basis point cut in the shadow rate," that expansionary monetary policy shocks during the UMP regime boosted the economy greater than those under the CMP regime. The difference in expansionary effects across the regimes is statistically significant for various key macroeconomic variables, including GDP, consumer prices, and stock prices, as well as for financial variables like banks' lending. There are three reasons for this. First, while monetary policy transmission is hampered in a statistically significant manner when a financial crisis occurs, because the period of financial crisis in Japan overlapped longer with the period of CMP than UMP, the financial crisis

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[5] For instance, Hoshi and Kashyap (2010) describe the period from 1997 to 2002 as the acute period of the financial crisis. Reinhart and Rogoff (2011) date the banking crisis in Japan started in 1992 and ended in 2001.

[6] QQE here includes QQE with a Negative Interest Rate and QQE Yield Curve Control as well.

worked in the direction of reducing the relative effectiveness of monetary policy shocks under the CMP regime. Second, a low level of policy rates had little effect on monetary policy transmission. On macroeconomic variables, the level has no statistically significant effect on macroeconomic variables. Third, and most importantly, monetary policy shocks during the UMP regime were transmitted to real interest rates, stock prices, and exchange rates with a greater magnitude than during the CMP regime, giving rise to a possibly larger stimulus to the economy. In particular, our estimates show a decline in borrowing rates in a wider range of industry groups and larger investment responses for industry groups that are more susceptible to the benefits of low borrowing rates, such as durable goods producing firms, suggesting that the channel through real interest rates may be more pronounced during the UMP regime.

Our paper is built upon the two strands of literature relating to this topic. The first strand includes empirical works on the effectiveness of UMP, including Franta (2011), Baumeister and Benati (2013), Gambacorta et al. (2014), Gilchrist et al. (2015), Kimura and Nakajima (2016), and Panizza and Wypolsz (2016).[7] In particular, our paper is related to those that compare the effects of monetary policy shocks across CMP and UMP regimes using the common metric, such as Gilchrist et al. (2015) and Kimura and Nakajima (2016). The unique feature of our paper is that, thanks to the LP framework, it proposes a formal way to test if the differences in expansionary effects of monetary policy shocks that occur under the two regimes are statistically significant for macroeconomic variables, such as GDP and inflation rates, and bank-related variables, such as lending and interest margins.[8] The second strand of the literature includes works on the role of financial intermediation in monetary policy transmission, including Boeckx et al. (2017), Borio and Gambacorta (2017), Borio and Hoffmann (2017),

[7] For instance, Gambacorta et al. (2014) shows that, based on a panel regression that exploits the data of eight advanced countries, the effects of monetary policy shocks on output under UMP are similar to those of CMP, while the impact on price levels is weaker and less persistent under UMP.

[8] It is also notable that expansionary effects of the UMP in Japan estimated in our framework are far larger compared with those estimated by Kimura and Nakamura (2016). They use a shock to a bank reserve as a shock to the monetary policy rule during the UMP up to 2012, estimate its effects on variables using a structural VAR framework, and document that responses of the key variables, for instance inflation and the output gap, to the shock appear to be positive but highly uncertain. Two possible explanations why our results differ from theirs include the use of the shadow rates as the policy rate measure and the coverage of the sample periods. In particular, as shown in Appendix Figure B, there is some evidence that effects of monetary policy shocks are more pronounced during the period after 2013.

Brunnermeir and Koby (2017), Coeuré (2016), Jimenez et al. (2017), Nagahata and Sekine (2005), and Hosono (2006). Again, our contribution to this literature is of methodological relevance. We statistically test, using the LP framework, whether monetary policy shocks affect the economy less when the economy is hit by a financial crisis or when the policy rate is low. Our findings are in line with those studies that stress the role of financial intermediation in monetary policy transmission, but it contrasts with discussions such as Borio and Hoffmann (2017) over whether the level of policy rate matters to the transmission. Our findings on the role of impairment to financial intermediation has important implications for empirical studies of monetary policy shocks in Japan (Arai, 2017; Fujiwara, 2006; Kamada and Sugo, 2006; Miyao, 2000). These studies typically argue that the transmission of monetary policy is weakened during a period of UMP. For instance, Fujiwara (2006) argues, from estimation results based on the Markov switching model, that monetary policy became less effective after the mid-1990s, possibly due to the emergence of the zero lower bound. Our empirical findings are similar to his work, but our explanation rests on the impairment of financial intermediation, rather than the level of the policy rate.

The rest of this paper is organized as follows. Section 2 describes our econometric methodology. Section 3 presents our estimation results regarding the impact of monetary policy shocks on economic variables under the two regimes. Section 4 explores if and how much each of the challenges, financial intermediation malfunction and the level of the short-term interest rate, has hampered monetary policy transmission and resulted in differences in monetary policy transmission between CMP and UMP. Section 5 provides a discussion as to why the same size of policy rate cut has delivered a larger impact on various variables under the UMP. Section 6 presents our conclusions.

2. Methodology and Data

This section describes our estimation methodology and the data set used in the analysis.

2.1. Estimation Methodology

In estimating the effects of monetary policy shocks, we use the LP method proposed by Jordà (2005). This method is increasingly used in the analysis of monetary policy transmission.[9] The advantage of using LP is that it is flexible enough that the state dependency of the effects of monetary policy shock can be formally addressed.[10] Existing studies that exploit LP to study the effects of monetary policy shocks, including Tenreyro and Thwaites (2016) and Coibion et al. (2017), typically construct a monetary policy shock series following the narrative approach of Romer and Romer (2004) and use this series in the estimation. Unfortunately, such a series is not available for monetary policy shocks in Japan. To address this issue, therefore, we augment LP with the use of latent factors extracted from a large number of variables, following Bernanke et al. (2005) and Boivin et al. (2009), so as to correctly extract a shock to a monetary policy rule in the data-rich environment.

We start by describing our main estimation equation, shown below.

$$\Delta y_{i,t,t+h} = \alpha_{i,h} + \underbrace{\sum_{j=0}^{J}\left(\beta_{1,i,h,j}R_{t-j} + \beta_{2,i,h,j}d_{t-j}R_{t-j}\right)}_{\text{(a) policy rates}} + \underbrace{\sum_{j=0}^{J}\left(\gamma_{i,h,j}d_{R,t-j}R_{t-j}\right)}_{\text{(b) control variable I}} \tag{1}$$

$$+ \underbrace{\sum_{j=0}^{J}\sum_{k=1}^{K}\eta_{i,h,j,k}F_{k,t-j} + \sum_{j=0}^{J}\delta_{i,h,j}\Delta TFP_{t-j}}_{\text{(c) control variables II}} + \varepsilon_{i,h,t}, \quad \text{for} \quad h = 1, \dots, H.$$

Here $\Delta y_{i,t,t+h} \equiv y_{i,t+h} - y_{i,t}$ is the dependent variable, which is the growth rate of a variable of interest indexed by i from t to the horizon $t+h$. The right hand side consists of three components. The first component (a) consists of the current and lagged policy rates whose coefficients are the focus of our analysis. The second and third components (b) and (c) include a set of control variables. We use the same set of control variables throughout this paper unless otherwise noted. R_t is the policy rate, d_t is the dummy variable that takes unity if the UMP is implemented at t, and is zero otherwise. The

[9] Aside from the work of Jordà (2005), there are several empirical studies that estimate the effects of monetary policy shock using the LP method. For example, Tenreyro and Thwaites (2016) use the LP method to ask if the effects on the economy of monetary policy shock during expansions differ from those during recessions, and show that the effects of monetary policy are more powerful during expansions than during recessions.

[10] The LP method is also known to be robust to model miss-specification issues including those regarding the choice of explanatory variables and the number of lags.

variable $d_{R,t}$ included in the component (b) is a dummy variable that takes unity before $t \leq 1991\text{Q}2$, and zero in subsequent periods. We discuss the variable $d_{R,t}$ in more detail later in this section. The component (c) includes two types of factors that serve to extract a monetary policy shock, $F_{k,t}$, for k = 1, 2 and ΔTFP_t. Namely, our monetary policy shocks are captured as innovations in the policy rate R_t that are not explained by these factors. In particular, in our specification, information about variables that constitute a Taylor rule such as output gap and inflation is considered as included in the unobserved factors $F_{k,t}$. $F_{k,t}$ is a set of latent factors extracted from the panel of macroeconomic variables as the *k*-th largest principal component of these variables. ΔTFP_t is the growth rate of the measured Total Factor Productivity (TFP). We include the TFP series, since existing studies on the Japanese economy during our sample period, such as Hayashi and Prescott (2002), agree on the importance of TFP in accounting for the dynamics of macroeconomic variables in this period. Coefficients $\alpha_{i,h}$, $\beta_{1,i,h,j}$, $\beta_{2,i,h,j}$, $\gamma_{i,h,j}$, $\eta_{i,h,j,k}$, and $\delta_{i,h,j}$ are the parameters to be estimated, and $\varepsilon_{i,h,t}$ is the disturbance. Note that the parameter values change with the dependent variable i, the estimation horizon h, and the number of lags of the independent variable j.

Following Jordà (2005), we define the impulse response of a variable i to a 100 basis points change, or equivalently 1% change, in the policy interest rate as follows:

$$IR(\Delta y_{i,t,t+h}, u_R) = E(\Delta y_{i,t,t+h} | u_R = 1; F_{t-j}; TFP_{t-j}; R_{t-j})$$
$$-E(\Delta y_{i,t,t+h} | u_R = 0; F_{t-j}; TFP_{t-j}; R_{t-j}) \quad (2)$$
$$\text{for } j = 0, \dots, J.$$

where u_R is an exogenous change in the policy rate in period *t*. Using this definition and the estimation result of the equation (1), we can obtain the impulse response of a variable i at *h*th quarter horizon to a 1% shock in the policy rate at *t* straightforwardly:

$$IR(\Delta y_{i,t,t+h}, u_R) = \begin{cases} \beta_{1,i,h,0} & if \ 1991\text{Q3} \leq t \leq 1998\text{Q4 (CMP regime)} \\ \beta_{1,i,h,0} + \beta_{2,i,h,0} & if \ 1999\text{Q1} \leq t \text{ (UMP regime)} \end{cases} \quad (3)$$

for $h = 1, \ldots, H$.

That is to say, the response of a variable to an unexpected 100 basis point change in the policy rate during a period of CMP is given by the coefficient $\beta_{1,i,h,0}$ and during the UMP the response is given by the sum of the two coefficients $\beta_{1,i,h,0} + \beta_{2,i,h,0}$. The statistical significance of the difference between the effects of monetary policy shocks during the UMP and those during the period of CMP can be tested by the statistical significance of the estimated coefficient $\beta_{2,i,h,0}$. It is also notable that the equation (3) implicitly states that monetary policy shocks do not "contemporaneously" affect the control variables II, similarly to the way adopted in the standard VAR analysis where monetary policy shocks are identified by Cholesky decomposition as shocks that do not contemporaneously affect other variables. In Appendix C, we relax this assumption and estimate the equation (1) allowing monetary policy shocks to be contemporaneously correlated with the control variables II. The results are little changed.[11]

We choose the number of lag J of the independent variable in two steps. First, in estimating each variable of interest i, we calculate the optimal lag for each of the horizons $h = 1, \ldots, H$ following the Akaike Information Criterion (AIC). Next, we choose the optimal lag that appears most frequently among H lags. The number of the lag J therefore varies across dependent variables but is fixed across h. We choose the number of latent factor K equal to 2 throughout the analyses in the main text. We also conduct a sensitivity analysis with K = 3.[12] The confidence intervals of the impulse response functions are computed by constructing 10,000 samples and using them to conduct the bootstrap.[13] We report a 95% confidence interval, unless otherwise noted.

2.2. Data

Our data sample consists of three groups of variables: those used for extracting latent factors $F_{k,t}$, for K = 1, 2, those used as a dependent variable i, and a measure of the

[11] In doing this exercise, we formulate a separate VAR that consists of the shadow rate and four variables included in the control variable III and extract contemporaneous correlation between a monetary policy shock with other variables using the Cholesky decomposition.

[12] We confirmed that the results are little changed by increasing the number of latent factors from 2 to 3 in Appendix C.

[13] For the robust check, we test statistical significance of the coefficients using the standard errors based on Newey and West (1987) for all of the analyses. The results are little changed.

policy rate R_t. All of the data run from 1983Q2 to 2016Q4 throughout this analysis. Only exception is the case when a variable constructed from inflation expectation is used as the dependent variable. In this case, because the data of inflation expectation is only available from 1990Q2, the estimation period is also shortened accordingly.[14]

Latent factors $F_{k,t}$ are estimated from a balanced panel that contains 171 variables. All series are seasonally adjusted, where applicable, and transformed to the stationary series. They are all demeaned and standardized. See Table A for details. As shown in the equation (1), we include the measured TFP as a set of the control variable. Following Hayashi and Prescott (2002), we compute the measured TFP series from the logarithm of output growth less the weighted average of the logarithm of labor input and capital input growth. The time series of output and capital inputs are taken from the System of National Accounts, and that of labor input is obtained from the number of employees based on the Monthly Labor Survey.[15]

2.3. Choice of Policy rate and Monetary Policy Regimes

We define a UMP as a set of policy measures conducted after the introduction of the zero interest rate policy in 1999Q1 up to the present time, 2016Q4. The set includes the zero interest rate policy (ZIR), QE, CME, and QQE.[16] These policy measures were not necessarily implemented consecutively. We however include interval periods of these four regimes in the period of UMP, because the prevailing short-term nominal interest rates were already close to zero during these periods.[17]

[14] The panels (i) and (ii) in Figure 3(2) and Figure 10(1) are the only estimations that use inflation expectation in our analysis.

[15] There are two differences between our TFP series and that of Hayashi and Prescott (2002): (i) the output series that is used for constructing our TFP series is the GDP series, while the output series used for constructing their TFP is GNP less government capital consumption; and (ii) households' residential and foreign assets are not included in our capital stock series, while these two components are included by Hayashi and Prescott (2002).

[16] The implementation period of each policy is as follows: ZIR/1999M2-2000M8; QE/ 2001M3-2006M3, CME/2010M10-2013M4, QQE/2013M4-present.

[17] In contrast, Kimura and Nakajima (2016) defines the UMP based on the main operating target. In their definition, the UMP runs from 2001Q1 to 2006Q1 and from 2010Q1 to 2012Q3, and the interval period falls within the CMP, since the BOJ used the overnight call rate as the main operating target during the interval period from 2006Q2 to 2009Q4. We estimate the impulse response functions shown in Figures 2 and 3 using their definition of the UMP and confirm that the results are little changed.

The policy measures used by the BOJ under the UMP were not limited to the short-term nominal interest rate. The bank introduced various measures including direct lending to financial institutions, introduction of the price stability target, and the purchase of long-term bonds. In order to compare the effectiveness of monetary policy shocks between CMP and UMP, we use the shadow rate as the common metric of the monetary policy stance in both periods. The shadow rate is essentially equivalent to the prevailing short-term interest rate when it is above the lower bound, which is typically zero, and to what the short-term interest rate would be without the lower bound, when it is below the bound.[18] Following existing studies, including Wu and Xia (2016), we treat a shock to the shadow rate of the short-term nominal interest rate as a shock to the policy rate R_t and estimate the response of variables to this shock. Admittedly, one caveat of using shadow rates is that they are not observable. They need to be computed based on theoretical assumptions and the constructed series differ from each other depending on the assumptions. We therefore formulate the baseline analysis using the shadow rate constructed by Krippner (2015), and then conduct sensitivity analyses using two alternative measures of the policy rate, the shadow rate constructed by Ueno (2017), and the prevailing two-year government bond yield. Figure 1 shows the time path of these rates. The results of the sensitivity analysis are documented in Appendix C.

In order to make a fair comparison of the effectiveness of monetary policy shocks between periods of CMP and UMP, we control the effects of the alternative monetary policy measures called window guidance (WG) and regulations on the interest rate system. Before the 1990s, monetary policy was conducted through changes in the official discount rate and WG under the regulated interest rate framework. As described in Sonoda and Sudo (2016), WG is a set of guidelines regarding lending volume that each bank is expected to extend. It was released by the BOJ to banks and used repeatedly as a supplementary policy tool in monetary policy implementation.[19] From

[18] Shadow rates are increasingly used in studies of monetary policy implementation under the zero lower bound. For instance, Wu and Xia (2016) construct the shadow federal funds rate and estimate the impulse response of macroeconomic variables to a shock to the shadow rate and find that, similarly to a negative shock to the federal funds rate, a negative shock to the shadow federal funds rate increases production activity and decreases the unemployment rate.

[19] In general, it specified the total amount of lending volume that an individual bank could extend within a certain period of time by asking the bank to make adjustments to its own lending plans.

the late 1980s, the BOJ gradually shifted its monetary policy measures from "those based on a regulated interest rate framework to those based on market operation with good use of money market and flexible interest rates" (Itoh et al., 2015). As part of this process, WG was ended in July 1991. Financial regulations on the interest rate system that were effective up to the early 1990s also have the potential to affect monetary policy transmission. As described in Hoshi and Kashyap (2000) and Itoh et al. (2015), regulations on interest rates once present have been lifted gradually since the early 1980s, and all of the interest rate system, except deposit rates for small accounts, was decontrolled by the end of the 1980s.

We control the effects arising from WG and financial deregulation by including a dummy variable $d_{R,t}$ in the estimation equation (1). This variable takes unity until the period $T-1$ and zero in subsequent periods. Here, T is the period when the effects of WG and financial regulation on monetary policy transmission became economically insignificant. However, we do not know the period T. In order to pin down the dividing period T that separates the period before and after the ending of WG and deregulation, we follow Bai and Perron (2003) and estimate the following equation for i = GDP.

$$\begin{aligned}\Delta y_{i,t,t+h} &= \alpha_{i,h} + \sum_{j=0}^{J} \beta_{1,i,h,j} R_{t-j} + \sum_{j=0}^{J}\sum_{k=1}^{K} \eta_{i,h,j,k} F_{k,t-j} \\ &+ \sum_{j=0}^{J} \delta_{i,h,j} \Delta TFP_{t-j} + \varepsilon_{i,h,t}, \quad \text{for} \quad h = 1, \dots, \mathrm{H}.\end{aligned} \tag{4}$$

Note that the last two terms are the same as the term (c) in the equation (1) and here, we focus on the coefficient $\beta_{1,i,h,0}$. We statistically test if there has been a structural break for this coefficient, and ask if so, when. As shown in Table 2, while the estimated division points differ across the horizon h, the results agree that a structural break occurred in the early 1990s. Taking the average of the results, we set T=1991Q3 in all of the analysis below.[20] This date coincides with the period when WG was abolished.[21]

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[20] In Appendix C, we conduct a sensitivity analyses using different dates for T, and find that results are little changed.

[21] The decision to abolish WG was made in June 1991, and became effective in 1991Q3.

3. Testing the Difference in Monetary Policy Transmission

3.1. Response of GDP components and labor market variables

Figure 2 shows the impulse response of the major GDP components and of labor market variables to an unexpected 100 basis points cut in the policy rate R_t. Responses are estimated using the equation (1). The solid line is the point estimate of the response of a variable i to a negative 100 basis point shock under the UMP regime, namely the sum of the coefficients $-\beta_{1,i,h,0} - \beta_{2,i,h,0}$ for $h = 1, \dots, 20$ in the equation (1), and the shaded area is the confidence interval of 95%. The dashed line is the point estimate of the response of the same variable i under the CMP regime, namely $-\beta_{1,i,h,0}$ for $h = 1, \dots, 20$, and the dotted line is its confidence interval. In order to tell the difference of effects of monetary policy shocks across policy regimes statistically, we introduce a criterion. We determine that the impulse response of a variable i to a shock under the UMP is more positive (less positive) than a shock under the CMP when all of the following three conditions are met: (i) when $-\beta_{2,i,h,0}$ is positive (negative) at the 95% significant level at least one quarter h for $h = 1, \dots, 20,$ (ii) given that the condition (i) is met, when $-\beta_{2,i,h,0}$ is not negative (positive) at the 95% significant level in any quarter h for $h = 1, \dots, 20,$[22] and (iii) when the 2.5% percentile of the estimated value of $-\beta_{2,i,h,0}$ is positive (negative) on average in 20 quarters. In the figure, a variable with "+" ("–") is a variable that exhibits a more positive (less positive) response to a negative shock to the policy rate under UMP than under CMP based on this criterion.

Two observations are notable. First, under both regimes, the cut in the policy rate boosts the economy. GDP, consumption, and investment increase after the shock in a statistically significant manner. The unemployment rate falls and the number of people in employment increases. These results are in line with existing studies that empirically estimate the effects of monetary policy shocks, such as Bernanke et al. (2005) for CMP, and Gambacorta et al. (2015) for UMP. Second and more importantly, for all the variables listed in the figure, except consumption, a policy rate cut under UMP leads to a quantitatively larger expansionary impact than does a cut of the same size under CMP.

[22] In other words, we do not conclude the "sign" if the sign flips over 20 quarter horizon.

3.2. Response of prices and financial intermediation

The four panels at the top of Figure 3 show the impulse response function of prices. An expansionary monetary policy shock that occurs during either regime increases the price level and nominal wage, and short- and long-term inflation expectations in a statistically significant manner. In addition, for these four variables, a 100 basis point cut in the policy rate has a statistically significant larger impact under UMP than under CMP.

The four panels at the bottom of the figure show the impulse response of variables related to banks. There is no indication that banks' lending activities or their balance sheet conditions suffer more in response to an expansionary monetary policy shock during the period of UMP than CMP. Under both regimes, an expansionary monetary policy shock reduces net interest margins and the number of bankruptcies, and increases domestic lending and banks' profits. In addition, during a period of UMP, the decline in net interest margins is less pronounced, the decline in the number of defaulting entities is larger, and the increase in domestic lending is larger.[23] In this respect, our findings are in line with those reported in Coeuré (2016) for banks in the euro area.

4. Two Challenges and Effects of Monetary Easing

In order to see why economic variables react differently under the two different policy regimes, we first study how the two challenges, impairment of financial intermediation and the low level of the policy rate, have influenced monetary policy transmission.

4.1. Impairment in Financial Intermediation

Japan's economy experienced a bubble burst in the early 1990s and a banking crisis in the late 1990s. As documented in detail by Hoshi and Kahaysp (2011), these crises led to an accumulation of bad loans, in particular loans to the real estate industry, severe impairment of banks' balance sheets and disruption to financial intermediation. Figure 4 shows the time path of the credit cost ratio of Japanese banks and the credit-to-GDP

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[23] Banks' lending volume increases more during the UMP, but the increase in banks' profit is not statistically different across the policy regimes. This is partly because the portfolio share of lending at banks during the UMP is smaller than that during the CMP. Based on the Flow of Funds Accounts, the portfolio share of lending at domestic banks was about 10% smaller during the 2000s than the 1990s.

ratio from the 1980s to the present, together with the crisis period specified by Hoshi and Kasyhap (2010) and Reinhart and Rogoff (2011).[24] Credit costs started gradually to rise in the early 1990s, reached a peak around 1998, and then subsequently declined. The amount of financial intermediation plummeted during the late 1990s and remained at a low level until the mid-2000s.

Existing studies such as Hosono (2006) and Nagahata and Sekine (2005) argue that monetary policy transmission was hampered during this period. We first examine if this is the case, based on the LP framework. We compare the responses of variables to a monetary policy shock during a financial crisis with those during normal times, using a dummy variable. We specify the dates of the financial crisis as running from 1997 to 2002, following the work of Hoshi and Kasyhap (2011), and construct a dummy series denoted as $d_{FC,t}$ that takes unity when t is in the crisis period, and zero if otherwise, and we modify the equation (1) by incorporating the dummy variable as follows.

$$\Delta y_{i,t,t+h} = \alpha_{i,h} + \underbrace{\sum_{j=0}^{J}\left(\beta_{1,i,h,j}R_{t-j} + \beta_{2,i,h,j}d_{t-j}R_{t-j}\right)}_{\text{(a) policy rates}} + \underbrace{\sum_{j=0}^{J}\left(\gamma_{i,h,j}d_{R,t-j}R_{t-j}\right)}_{\text{(b) control variable I}}$$

$$+ \underbrace{\sum_{j=0}^{J}\sum_{k=1}^{K}\eta_{i,h,j,k}F_{k,t-j} + \sum_{j=0}^{J}\delta_{i,h,j}\Delta TFP_{t-j}}_{\text{(c) control variable II}} + \underbrace{\sum_{j=0}^{J}\left(\theta_{i,h,j}d_{FC,t-j}R_{t-j}\right)}_{\text{(d) control variable III}} \tag{5}$$

$$+\varepsilon_{i,h,t}, \qquad \text{for} \quad h = 1, \dots, H.$$

We first examine the properties of the coefficients of the dummy variable $\theta_{i,h,0}$ for selected variables related to financial intermediation. The upper panels in Figure 5 show the coefficients multiplied by -1, namely, $-\theta_{i,h,0}$. More negative values for $-\theta_{i,h,0}$ indicate that the variable i increases less (or equivalently, declines more) in

[24] We follow the dating of the crisis period as in Hoshi and Kashyap (2010), the dates of what they refer to as the "acute period" of the Japanese financial crisis. During this period, a good number of financial institutions collapsed, including Hokkaido Takushoku Bank and Yamaichi Securities. This period also coincides with a period when a large "Japan premium" was evident in interbank markets. The crisis period of Reinhart and Rogoff (2011) is that of the banking crisis in their paper.

response to an expansionary shock to the policy rate when the shock occurs during a period of financial crisis. The response of lending attitude is more severe, that of financial position is tighter, and that of credit-to-GDP is less positive when an expansionary monetary policy shock occurs in a crisis period. These results suggest that this dummy is related to factors that hamper financial intermediation activities. For the robustness check analysis, we do the same exercise using the dummy variable that is constructed following the dating of the financial crisis by Reinhart and Rogoff (2011), which runs from 1992 to 2002, and obtain qualitatively similar results.

Next, we study the properties of the coefficients further by looking at the responses of lenders and borrowers at a more disaggregated level. The second and third panels of the figure show the distribution of the response of lending extended by 79 Japanese banks and that of the response of investment of 38 industry groups.[25] The solid line is the median of responses $-\theta_{i,h,0}$ for $h = 1, \dots, 20,$ and the shaded area is the 25-75th percentile interval of the responses across banks and industry groups. Clearly, banks' loans and industry groups' investments respond less positively to an expansionary monetary policy shock, similar to the responses of the aggregate variables.

As documented above, impairment to banks' balance sheets is considered the key underlying cause of the financial crisis, and how badly balance sheets were damaged depends on the banks' asset composition before and during the crisis. In other words, at the micro level, the financial crisis dummies of a bank's extended loans should correlate negatively with the bank's creditworthiness. To see this, we investigate whether variations in coefficients of dummy variable across banks can be explained by variations in banks' creditworthiness.

$$-\theta_{L_b,h,0} = \omega_{L_b,h} + \phi_{L_b,h}(\text{bank } b'\text{s creditworthiness}) + \varepsilon_{L_b,h} \qquad \text{for } h = 0, \dots, 20. \tag{6}$$

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[25] Our sample of individual banks includes Japanese domestic banks that have not seen a merger or acquisition, and whose figures for the total amount of lending throughout the sample period are obtainable. The data is taken from the annual reports of each bank. Because the data is on a yearly basis, we linearly interpolate the series to obtain the quarterly series. Our sample of industry groups is categorized by the industry (19 industries) and the size in terms of capital (less than 1 billion yen, or above). The data is taken from the Corporate Statistics released by the Ministry of Finance.

In the equation (6), the dependent variable $-\theta_{L_b,h,0}$ is the estimate of the coefficient of the financial crisis dummy variable of a bank b's lending, the explanatory variables are the constant and a measure of a bank's creditworthiness during the period of the financial crisis, and $\omega_{L_b,h}$ and $\phi_{L_b,h}$ are the coefficients to be estimated. $\varepsilon_{L_b,h}$ is the error term.[26]

As a measure of "a bank b's creditworthiness," we use three variables: the bank's equity holding as of 1989, the bank's lending amount outstanding to real estate industry as of 1989, and the bank's capital adequacy ratio in the late 1990s. We choose the first variable following the discussion in Bayoumi (2001) and Ito and Sasaki (2002),[27] each of which underscores the importance of the stock price plummet that came together with the bubble burst in eroding banks' balance capital and hampering their risk taking during the crisis period. We choose the second variable following the discussion in Ueda (2000) and Hoshi (2001), where real estate lending extended prior to the bubble burst is considered the key cause of impairments to banks' balance sheets during the financial crisis. The third variable is the gap between the actual book-based capital ratio (BCAR) and its target ratio constructed by Watanabe (2006). This gap is a proxy of the degree of balance sheet constraints banks faced as a result of the Basel capital requirements. When the actual capital ratio exceeds the target, banks are sufficiently creditworthy and the capital constraints cease to bite, while the opposite is also true.[28]

The upper panels (1) in Figure 6 show the coefficient $\phi_{L_b,h}$ for $h = 1, \ldots, 20$, for each of the three measures of a bank's creditworthiness: the bank's equity holding, the banks' lending to the real estate industry, and the BCAR in the estimation equation (6). The estimated signs are consistent with the story that a bank's capital shortage hampers monetary policy transmission during the financial crisis period. A bank with larger

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[26] This estimation procedure is an application of the methodology by Dedola and Lippi (2005) that explores the relationship between the responsiveness of output of a specific sector to a monetary policy shock and the characteristics of the sector by cross-sectional regression.

[27] Based on the data of individual banks during the early 1990s, Ito and Sasaki (2002) empirically show that a fall in stock price at that time wiped out the capital gains of large banks that were subject to the capital requirements of the Basel accord, causing them to reduce lending.

[28] For the BCAR, we use the values during the late 1990s because rigorous self-assessment of banks' asset quality, upon request of the Ministry of Finance, was only conducted from 1998 and beyond. In Figure 6, we report the case when BCAR as of 1998 is used as the explanatory variable in the estimation equation (6). Our estimate results are, however, little changed when BCAR in 1997 or 1999 are used instead.

equity holding prior to the bubble burst, or with a larger capital deficit in the late 1990s, tends to see more negative values for the coefficient $-\theta_{L_b,h,0}$ in a statistically significant manner, which in turn indicates that the bank's response of lending to an expansionary monetary policy shock becomes less positive.

We also look from the perspective of non-financial firms at the properties of the coefficients on dummy variable of financial crisis. Using data from 38 industry groups, we run a cross-industry regression shown in the equation (7) below. We now use as the dependent variable the coefficient $-\theta_{I_m,h,0}$ of the financial crisis dummy where I_m is the investment by an industry group m. This coefficient itself is estimated in the regression equation (5) in which I_m is the dependent variable. The explanatory variables are those that represent the degree of reliance of the industry group on external finance. Here, we use two variables, (i) the amount of debt divided by the total liability, and (ii) a dummy variable that represents the role of the size of the industry group, which takes unity if the group's capital is less than 10 billion yen, and zero if otherwise.[29] We expect the financial crisis dummy $-\theta_{I_m,h,0}$ to be more negative if an industry group m borrows more or has limited access to financial markets due to its size, as the financial crisis is considered to affect the "supply side" of monetary policy transmission in particular through disruption to financial intermediation.

$$-\theta_{I_m,h,0} = \omega_{I_m,h} + \phi_{I_m,h}(\text{industry group } m'\text{s characteristics}) + \varepsilon_{I_m,h} \qquad \text{for } h = 0, \dots, H. \tag{7}$$

The lower panels (2) in Figure 6 show the coefficient $\phi_{I_m,h}$ for $h = 1, \dots, 20,$ of amount of debt and the size of industry group m. The estimated sign of the coefficients is significantly negative, suggesting that monetary policy transmission during the financial crisis is attenuated for industry groups that rely more on external finance or have less access to capital markets.

The upper panels of Figure 7 show how financial crises affect the macroeconomic impact of monetary policy shocks. Again, the upper panels show the values for

[29] In addition to the two variables, we control the effects of durability of goods and services produced by the industry group and land asset holding of the industry group. See explanations in Section 5.3 for those variables.

$-\theta_{i,h,0}$ for $h = 1, \ldots, 20$. The figures show that an expansionary monetary policy shock during a crisis period yields a smaller accommodative effect on the key variables compared with a shock during normal times, at a statistically significant level for all four variables except for GDP.

The next question is whether a financial crisis hampers monetary policy transmission more during UMP than CMP. In fact, the answer is no. The lower panels show the impulse response of variables to an unexpected 100 basis point cut in the policy rate during periods of CMP and UMP, when the effects of a financial crisis are controlled. The responses during CMP are calculated by $-\beta_{1,i,h,0}$ and those during UMP are calculated by $-\beta_{1,i,h,0} - \beta_{2,i,h,0}$ for $h = 1, \ldots, 20$ in the equation (5). Theoretically, while the estimated responses shown in Figures 2 and 3 are a mix of the responses to shocks to the policy rate during a financial crisis and those during normal times, the estimated responses shown in Figure 7 are responses to shocks that occur during normal times exclusively. It is evident that the estimated effects of expansionary monetary policy shocks under UMP remain larger than those under CMP. In other words, the estimated value of the coefficient $\beta_{2,i,h,0}$ is little changed by the inclusion of the financial crisis dummies in the estimation equation. Instead, the value of the coefficient $-\beta_{1,i,h,0}$ estimated in the equation (5) is noticeably more positive than that estimated in the equation (1). This indicates that, on average, financial crises hampered monetary policy transmission during the period of CMP more than during the period of UMP, possibly because a period of financial crisis overlapped with the period of CMP for longer than the period of UMP.

4.2. Level of Policy Rates

We now estimate the effects of the level of the policy rate by extending the equation (1) as follows.

$$\Delta y_{i,t,t+h} = \alpha_{i,h} + \underbrace{\sum_{j=0}^{J}\left(\beta_{1,i,h,j}R_{t-j} + \beta_{2,i,h,j}R_{t-j}^2\right)}_{\text{(a) policy rates}} + \underbrace{\sum_{j=0}^{J}\left(\gamma_{i,h,j}d_{R,t-j}R_{t-j}\right)}_{\text{(b) control variable I}}$$

$$+ \underbrace{\sum_{j=0}^{J}\sum_{k=1}^{K}\eta_{i,h,j,k}F_{k,t-j} + \sum_{j=0}^{J}\delta_{i,h,j}\Delta TFP_{t-j}}_{\text{(c) control variable II}} + \underbrace{\sum_{j=0}^{J}\left(\theta_{i,h,j}d_{FC,t-j}R_{t-j}\right)}_{\text{(d) control variable III}} \quad (8)$$

$$+\varepsilon_{i,h,t}, \qquad \text{for} \quad h = 0, \dots, H.$$

This equation (8) differs from equation (5) only in the specification of the term (a), while the other three terms are equivalent to those in equation (5).[30] Under this specification, the impulse response function to an unexpected 100 basis point decline in the policy rate in the period t, denoted as u_R, when the policy rate in the period $t-1$ is R_{t-1}, is obtained as follows.

$$\begin{aligned} IR(h, R_t, u_R) &= \{\hat{\beta}_{1,i,h}\,(R_{t-1} + u_R) + \hat{\beta}_{2,i,h}(R_{t-1} + u_R)^2\} \\ &\quad - \{\hat{\beta}_{1,i,h}R_{t-1} + \hat{\beta}_{2,i,h}R_{t-1}^2\} \\ &= \hat{\beta}_{1,i,h}u_R + \hat{\beta}_{2,i,h}(2R_{t-1}u_R + u_R^2) \end{aligned} \quad (9)$$

The estimated impulse response function changes with the level of policy rate R_{t-1}, for example whether $R_{t-1} = 1$, namely 100 basis points, or R_{t-1}= 0, namely 0 basis point.

Figure 8 shows the impulse response of variables to a monetary policy shock in the period t when the policy rate one period before the arrival of the shock, is 100 basis points ($R_{t-1} = 1$) and zero ($R_{t-1} = 0$), respectively. The response is not affected by the level of the policy rate for most of the variables. The exceptions are variables related to banks. The deposit rate, lending rate, and interest margin all fall less when $R_{t-1} = 0$ than when $R_{t-1} = 1$, possibly because there was more room for banks to reduce their lending rates following a cut in the policy rate R_t when the rates were high. By

[30] Note that the level of the policy rate is somehow related to whether the economy is in financial crisis, as the BOJ lowered its policy rate following the start of the financial crisis during the 1990s. In order to control for the effects of a financial crisis on monetary policy transmission and focus on the effects of the level of the policy rate alone, we include the term associated with it (term (d)) in the explanatory variables.

contrast, lending rates were already about 170 basis points at the start of the period of UMP, fell below 100 basis points around 2012, and reached 70 basis points at the end of 2016, making it difficult for banks to further cut their lending rates. Because lending rates fall less, despite the fact that deposit rates fall less, interest margins also fall less during a period of UMP. Consequently, banks' profits are not adversely affected by an accommodative monetary policy shock even when the policy rate is low.

Admittedly, what matters to the agents in the economy, in particular banks, may be the prevailing nominal short-term interest rate rather than the shadow rate. To consider this possibility, we replace the term (a) in the equation (8) with the term shown below, and estimate the response again.

$$\sum_{j=0}^{J}\left(\beta_{1,i,h,j}R_{t-j}+\beta_{2,i,h,j}R_{t-j}V_{t-j}\right) \tag{10}$$

Here, V_{t-j} is the prevailing nominal short-term interest rate. Figure 9 shows the impulse response function of variables to a monetary policy shock of 100 basis point when the prevailing short-term nominal interest rate is $V_{t-j}=1$ (namely, 100 basis point) and $V_{t-j}=0$ (namely, 0 basis point). The estimated results are qualitatively similar to those shown in Figure 8, confirming that monetary policy transmission is not affected by the level of the prevailing short-term nominal interest rate.

5. What Makes the Effects of UMP More Expansionary?

Based on our metric "effects induced by a 100 basis point cut in the policy rate," monetary policy transmission in Japan during the period of UMP is larger than during the period of the CMP. In this section, we explore the causes of this phenomenon.

5.1. Response of real interest rates and firms' borrowing costs

We start by analyzing the response of real interest rates to a shock to the policy rate R_t. As stated in the Comprehensive Assessment of the BOJ's QQE that was released by the BOJ in 2016 (Bank of Japan, 2016), the real interest rate is considered the key transmission channel of monetary policy. If the policy rate cut under UMP exerts greater pressure on the real interest rate, it should enhance various transmission mechanisms, including intertemporal substitution effects and the financial accelerator mechanisms, thereby boosting economic activity.

The upper three panels of Figure 10 show the impulse response of three measures of real interest rates to an unexpected 100 basis point cut in the policy rate based on the estimation model (1).[31] The three panels agree that a cut in the policy rate during a period of UMP is followed by a large decline in real interest rates in a statistically significant manner. By contrast, a decline in the real interest rate following the same shock under a period of CMP is either insignificant or less pronounced.

Other things being equal, a larger decline in the real interest rate should lead to a greater decline in the borrowing rates facing firms and increased borrowing by these firms. To see this, similar to the exercise shown in Figure 5, we estimate the response of borrowing rates and real debts for 38 industry groups to an expansionary monetary policy shock during periods of CMP and UMP. The middle panels of Figure 10 show the distribution of responses of industry groups. The shaded area represents the range where the 20-80th and 5-95th highest responding industry groups fall for borrowing rates and real debts. While the median of response is comparable across the policy regimes, the second or higher moment of response exhibits a clear difference. For example, regarding borrowing rate, 95% of industry groups see a decline greater than −0.67 points four years after the impact period under UMP, whereas the same portion of groups sees a decline greater than only −0.33 points at the same horizon under CMP. In other words, a decline in borrowing rate and real debts spreads over a wider range of industry groups under UMP than CMP.

5.2. Response of asset prices and exchange rates

Real interest rates are not the only channel of monetary policy transmission. Existing studies, such as Bernanke and Kuttner (2005), Barbon and Gianinazzi (2017), and Ferrari et al. (2017), also focus on developments in asset prices or exchange rates. Figure 11 shows the estimated impulse response of stock prices, land prices, and nominal and real

[31] Our measures include the long-term nominal interest rate minus the inflation expectation rate, the call rate minus the inflation expectation rate, and the call rate minus the realized inflation rate. For the data on inflation expectations, we use figures reported in the Consensus Forecasts, since they are the only measures of inflation expectations for which long-run time series are present.

exchange rates to an unexpected 100 basis points policy rate shock under the two policy regimes. For all these variables, except for residential land prices, the accommodative effect of a shock is more pronounced when the response is estimated under a period of UMP rather than CMP, suggesting that channels other than the interest rate channel, such as the wealth effects of asset prices, may also be operating on a larger scale under UMP.

5.3. Determinants of investment response of industry groups

How are these larger responses in real interest rates, asset prices, and exchange rates translated into firms' investment decisions? To see this, we again use the industry group data used in Section 4.1, and estimate the equation (7) with the same set of explanatory variables. Now the dependent variable is the response of investment of each industry group m, h-th quarter after a monetary policy shock occurs, and "industry group's characteristics" include four variables that represent industry features: (i) the amount of debt divided by the total liability; (ii) the dummy variable that takes unity if the capital of the industry group is less than 1 billion yen, and zero if otherwise; (iii) the land asset holdings divided by the total assets; and (iv) the dummy variable that takes unity if the products of the industry group are durables. The first three variables are included so as to capture financial factors behind investment decisions. Other things being equal, a decline in the real interest rate leads to a lower borrowing rate, and the benefits of low borrowing rates should be greater for industry groups that largely rely on external finance. The variable (iii) is intended to capture the effects of a change in the collateral value. According to statistics released by the Bank of Japan, an average of about 21% of total lending was secured by real estate and floating mortgages during our sample period. A policy-induced rise in land prices may therefore enhance borrowers' creditworthiness, leading to a larger response of investments. The last variable (iv) is intended to capture the demand side of the real interest rate channel. As theoretically shown in Barsky et al. (2006), since durables expenditure is considered more sensitive to a change in the real interest rate induced by a policy rate shock, the coefficient of this dummy variable should be larger when the size of the interest rate channel is greater.

Figure 12 shows the estimated coefficient of each industry feature when the response of investment to a monetary policy shock of each industry group is regressed on these features. There is evidence that real interest rates play a certain role in enhancing investment responses. The amount of debt, firm size, and durability are three features that all affect positively the difference in investment response between UMP and CMP. In contrast, under UMP, an industry group with larger land asset holdings exhibits no clear difference in its investment response from that of a group with smaller land asset holdings, suggesting that an increase in land price accounts little for the different effects of monetary policy shocks across regimes.

5.4. Relative significance of each underlying factor that enhances monetary policy transmission during UMP

The net impact of monetary easing is determined by several different factors. In order to quantitatively pin down the key factors that enhance monetary policy transmission of shocks under UMP, we adopt some simplifying assumptions and decompose the discrepancy of effects of monetary policy shocks on GDP between the two policy regimes into the contribution of five underlying factors: impairment of financial intermediation, the level of the policy rate, real interest rates, the wealth effects of asset prices, and other factors.

The results are shown in Figure 13.[32] The grey bars at the top and the bottom are the response of GDP to an expansionary monetary policy shock under CMP and UMP regimes, respectively. The white bars between the two gray bars are the contributions of each factor. Among these factors, the effects arising from real interest rates stand out. The real interest rates are, however, not the dominant factor. Only about one third of the discrepancy is accounted for by real interest rates. Impairment of financial intermediation and wealth effects are the second and third factors that increase the response of GDP to a shock under UMP. Not surprisingly, the contribution of the level of the policy rate is minimal.

The bottom panel shows the decomposition of the discrepancy between the two policy regimes regarding the effects of a monetary policy shock on the inflation rate. Here, the discrepancy is decomposed into the component explained by the difference in the response of GDP and other factors. The latter component, by definition, should

[32] The assumptions we employ in computing the contributions are listed in the footnote to Figure 13.

contain the effects of any factors that influence inflation rates independently of real economic activity, such as exogenous changes in expected inflation or those in the slope of the Phillips curve. This panel shows that while the effects of expansionary monetary policy shocks on inflation rates are enhanced during a period of UMP, the expansionary effects on output are transmitted less to inflation rates, as shown in the negative contribution of “others” in the decomposition.[33]

6. Conclusion

Is unconventional monetary policy (UMP) ineffective, or less effective than conventional monetary policy (CMP)? Do the impairment of financial intermediation and low policy rates matter to effectiveness of monetary policy shocks? To answer these questions, we use the local projection model developed by Jordà (2005) combined with the shadow rates constructed by Krippner (2015) and propose an novel approach that statistically tests the difference in impact of one unit shock to the policy rate across states that differ in terms of the monetary policy regime or other economic conditions. We then apply this approach to Japan’s data from the 1980s to 2016.

We find that the expansionary effects of monetary policy shocks during the period of the UMP are statistically significant, and that these effects are in fact larger than during the period of the CMP over a broad range of variables in a statistically significant manner. There are three reasons for this. The first is that while the financial crisis in Japan during the 1990s significantly dampened the effectiveness of monetary policy shocks, the crisis had a greater effect on monetary policy transmission during the period of CMP. This may be due to the fact that the financial crisis in Japan overlapped longer with the period of CMP than the period of UMP. The second is that the level of policy rate had little impact on monetary policy transmission, at least as far as the data up to 2016 is concerned. Consequently, low prevailing policy rates during the UMP did not themselves hamper the effectiveness of monetary policy shocks. The third is that under the UMP, a cut in the policy rate was translated into a larger fall in the real interest rate

[33] One possible explanation for this weakening transmission of real economic activity on inflation rates may be a change in the slope of the Phillips curve. Kaihatsu et al. (2017) discuss the possibility that a decline in trend inflation rates in the mid-1990s in Japan flattened the Phillips curve both theoretically and empirically.

and a fall in the borrowing rates of a wider range of firms, including small enterprises. Our analysis suggests, among other things, that the real interest rate reacts to a shock to the shadow rate greater during the period of the UMP enhancing the accommodative effects of monetary policy shocks on macroeconomic variables.

There are three caveats to be noted regarding our analysis. First, while we do not find supporting evidence for the existence of a "reversal rate" based on the sample period that runs to 2016Q4, our findings do underscore the importance of financial environment in monetary policy transmission. We find that the accommodative effects of expansionary monetary policy shocks are hampered during the period of financial crisis, and poorly capitalized banks and firms with the heavy dependence on the external finance are affected greater by the financial crisis. Second, our study only compares the effects on economic variables of an unexpected policy rate cut of the same size across the two policy regimes. It does *not* however compare the overall effects of monetary policy easing across the regimes, as our paper does not address the implications of the magnitude of a monetary policy shock. Given that the prevailing short term nominal interest rate during the period of UMP was mostly floored by the zero lower bound, it is possible that, in practice, the size of monetary policy shocks during the period of UMP may be smaller than the previous period.[34] Third, our paper implicitly assumes that the effects of shocks to the shadow rate occur equally across the four different UMP regimes. We choose this treatment since we intend to compare the impact of monetary policy shocks under UMP and CMP regimes. It is possible that the size of the effects of shocks may vary over time within a UMP regime, given the variety of policy measures adopted during the period.[35] Relatedly, our measure of policy rates, the shadow rate, is constructed solely from the yield curve of government bonds, and in theory may not

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[34] In the linear model, the overall effect of monetary policy shocks can be gauged as the product of the effects induced by one unit size of monetary policy shock and the size of the monetary policy shock. In Appendix A, we estimate the time path of monetary policy shocks from the 1980s to the present in Japan, using a vector autoregression system that consists of the same set of variables used in the main text, the shadow rate, the measured TFP, and latent macroeconomic factors. We find that the magnitude of monetary policy shocks during the period of UMP has become somewhat limited compared with previously.

[35] In Appendix B, we relax the assumption that the effects of a shock to the policy rate are unchanged across periods and estimate how the effects change across UMP policy regimes. There is some evidence that on six key variables the effects of monetary policy shocks were larger during the period of QQE, compared with the period of CMP. See also Miyao and Okimoto (2017) that obtain a qualitatively similar finding to ours using a VAR framework.

reflect the effects of some policy measures included in the UMP, such as those of the purchase of risky assets that may not necessarily influence the yield curve. In this sense, our results gauge the lower bound of the accommodative effects of monetary policy shocks under the UMP, if not all.

Finally, it is important to stress that while the current paper focuses on Japan’s data exclusively, the approach proposed in this paper can serve for the analysis of monetary policy transmission in other jurisdictions where UMP is being, or has been implemented. Such a direction is left for the future research.

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Appendix A

In this appendix, we use the VAR framework to estimate the time path of shocks to the policy rate from the 1980s to the present. We do this so as to tentatively assess the overall effect of shocks to the policy rate, whereas in the main text we focus our analysis on measuring the effects of one-unit shocks to the policy rate. We formulate the VAR that consists of the growth rate of measured TFP ΔTFP_t, the unobservable factors $F_{k,t}$ for $K = 1$ and 2, and the policy rate R_t, and identify shocks to the policy rate by computing the Cholesky decomposition with the order of the variables above. The number of lags of the VAR is set to 2 based on the AIC, and the sample period runs from 1983Q2 to 2016Q4. We use the shadow rate of Krippner (2015) as the policy rate R_t.

Appendix Figure A shows the time path of the identified shocks to the policy rate. Two observations are notable. First, there is a stark difference in the magnitude and impact of shocks across the four UMP policy regimes. In particular, realizations of the policy shocks during the period of QQE were on average more negative than those during the other three policy regimes, including the period of CME. Other things being equal, therefore, this result indicates that shocks to the policy rate R_t have had a comparatively large accommodative impact on the economy during the period of QQE. Second, the magnitude of shocks to the policy rate R_t was greater during the period of CMP than the period of UMP. For both expansionary and contractionary shocks, the size of shocks often exceeded 100 basis points during the 1980s and the early 1990s. Such large shocks have rarely been seen during the period of UMP.

Appendix B

In this appendix, we investigate whether monetary policy transmission has changed during QQE. To see this, we relax the assumption that the coefficients that appear in the estimation equation (1) are unaltered across the period, and conduct a rolling estimate of the equation (1) with different sample periods.

Appendix Figure B shows the impulse response of six key variables to an expansionary shock to the policy rate R_t over a varying sample period. Each impulse response of a variable i is computed using the sample period that runs for 10 years ending in the period specified on the vertical axis of the panels, and stands for the level of a variable i four quarters after the impact period. Points with a black circle (white circle) indicate that they are (are not) different from zero at a statistically significant level of 10%.

There are signs that the accommodative effects of an expansionary monetary policy shock on the economy have become more pronounced in recent years. For the six key variables listed in the figure, the expansionary effects are either quantitatively larger or attain a statistical significance when more recent data is used for the estimation.

Appendix C

In this appendix, to check robustness, we estimate the response of key macroeconomic variables to an expansionary shock to the policy rate R_t under UMP and CMP using settings that are different from those adopted in the main text. We then compare the estimated impulse functions with those shown in Figure 4.

Setting 1: Each of the two alternative measures of the policy rate R_t, the shadow rate constructed by Ueno (2017) and the two-year government bond rate, is used instead of the shadow rate constructed by Krippner (2015) used in the main text.

Setting 2: The number of unobserved factors $F_{k,t}$ included in the estimation equation (1) is set to 3, instead of 2 as in the main text.

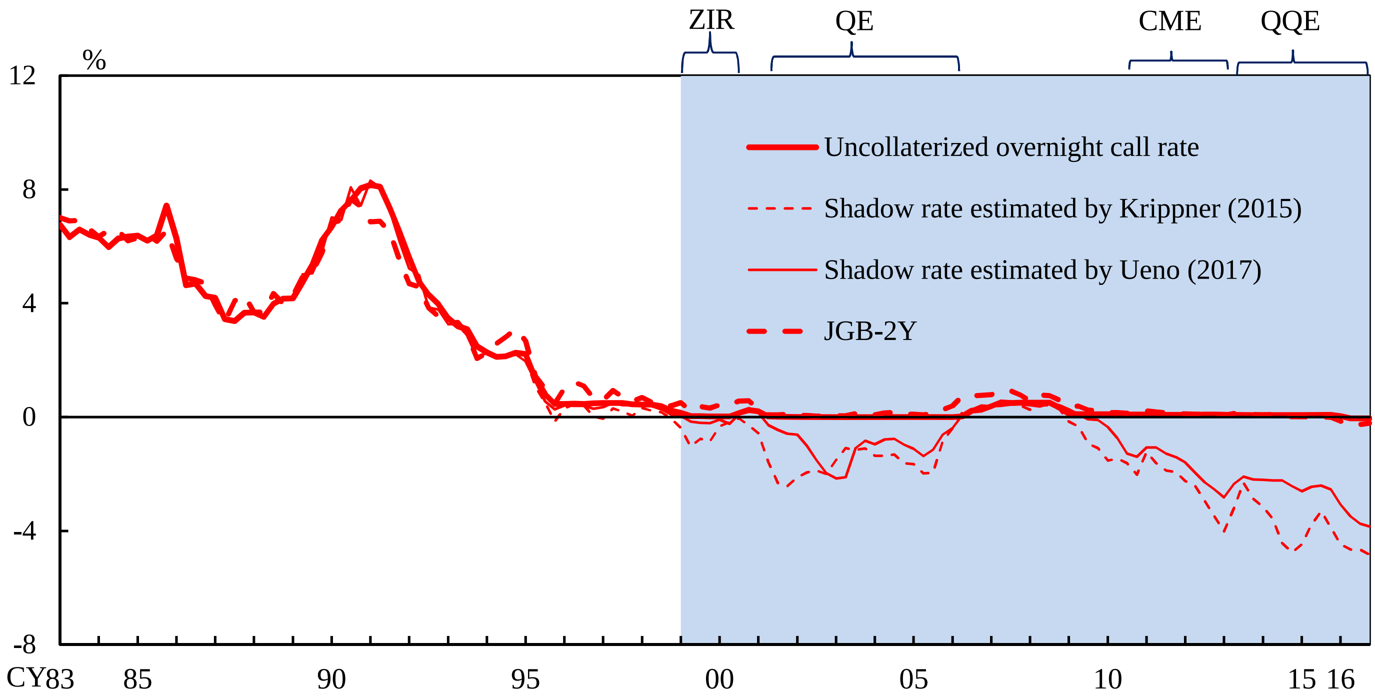
Setting 3: The alternative dividing point T is used to control the effects of WG and the regulations on the interest rate system, instead of $T = 1992Q2$ that is used in the main text.

Setting 4: The alternative method is used for the identification of monetary policy shocks. Monetary policy shocks are assumed to contemporaneously correlated with $F_{k,t}$ and ΔTFP_t while they are assumed to be contemporaneously uncorrelated with these variables in the baseline setting.

Setting 1 is intended to study the robustness of the results to the choice of policy rate measure, and the estimation results are shown in Appendix Figures C1, and C2. Setting 2 is intended to study the robustness of the results to the number of unobserved factors used to extract shocks to the policy rate, and the estimation results are shown in Appendix Figure C3. Setting 3 is intended to study the robustness of the results to the choice of sample period when the CMP started, in particular the robustness of the estimated responses of variables to a shock to the policy rate under the CMP regime. The estimation results are shown in Appendix Figure C4. Setting 4 is intended to study the robustness of the results to the identification scheme of monetary policy shocks, and the estimation results are shown in Appendix Figure C5.

The estimated impulse responses in Appendix Figure C are little changed from those shown in Figure 4, indicating that the estimation results shown in the main text are robust to the issues described above.

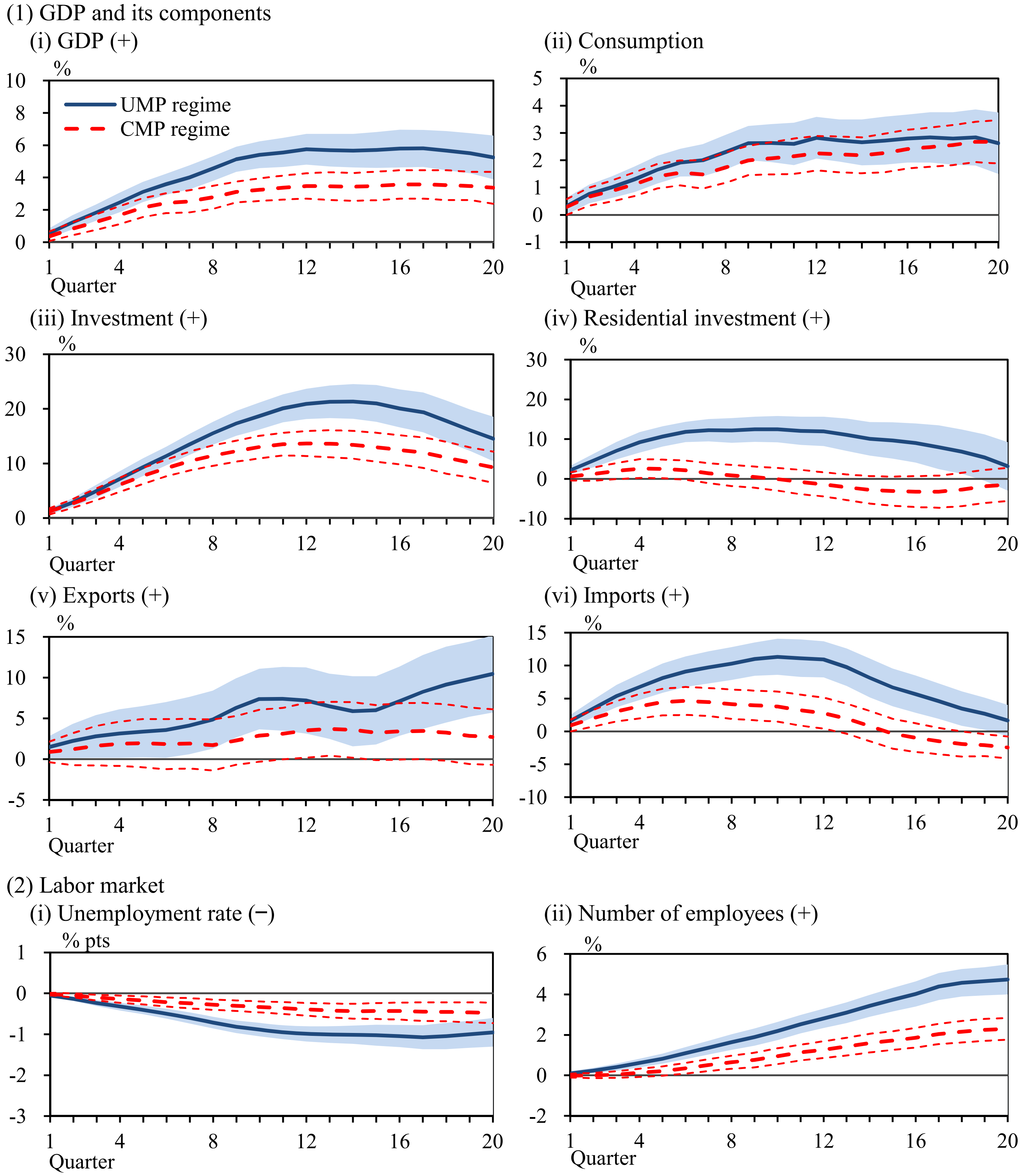
Figure 1: Shadow Rates in Japan



Key: ZIP: Zero Interest Rate Policy; QE: Quantitative Easing; CME: Comprehensive Monetary Easing;
QQE: Quantitative and Qualitative Monetary Easing.

Sources: Bloomberg, Bank of Japan, Krippner (2015), Ueno (2017).

Figure 2: Effects of Monetary Easing (1)

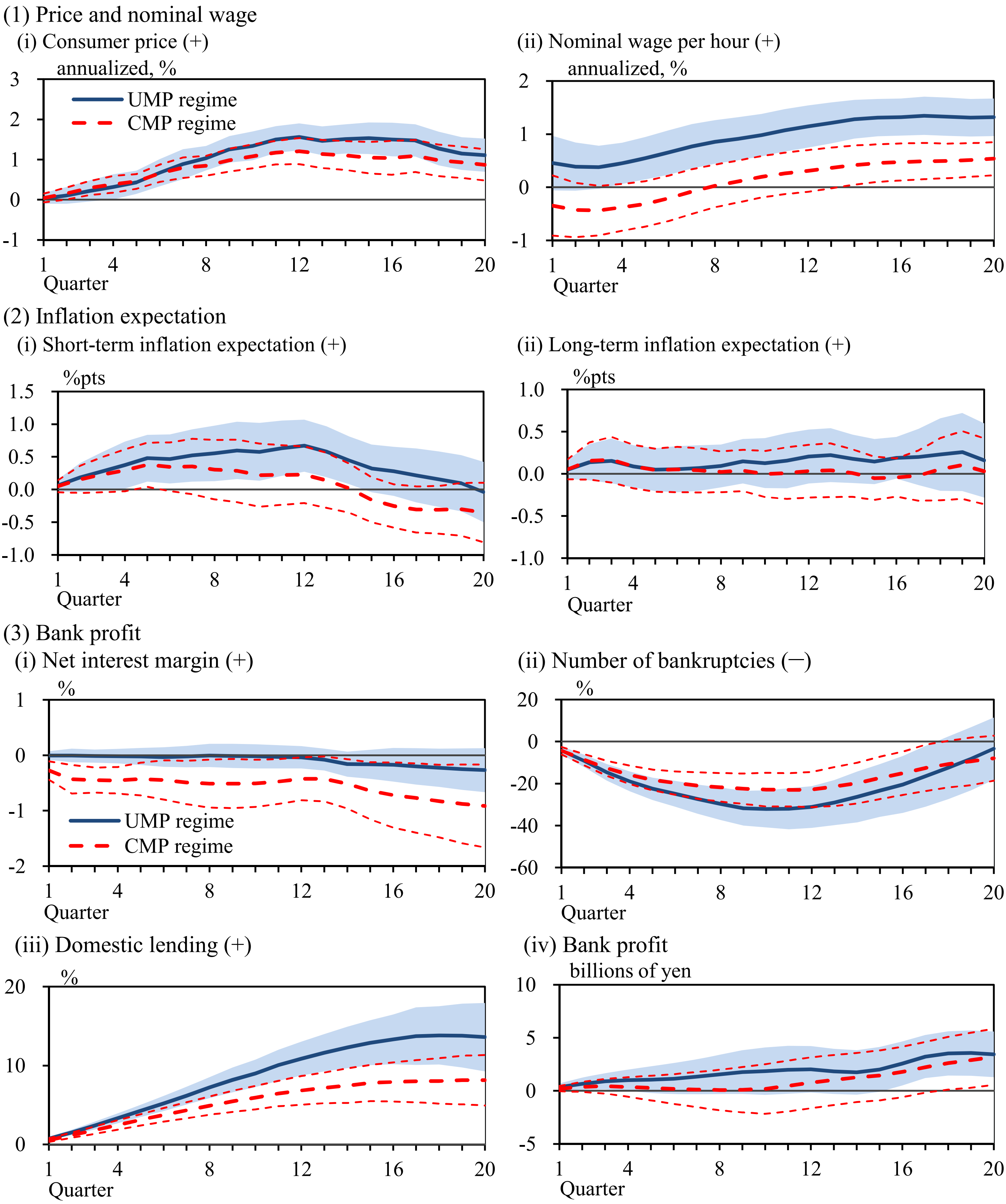


Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence interval of the estimates regarding a response to a shock during the CMP period.

2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications, "Labour Force Survey," etc.

Figure 3: Effects of Monetary Easing (2)



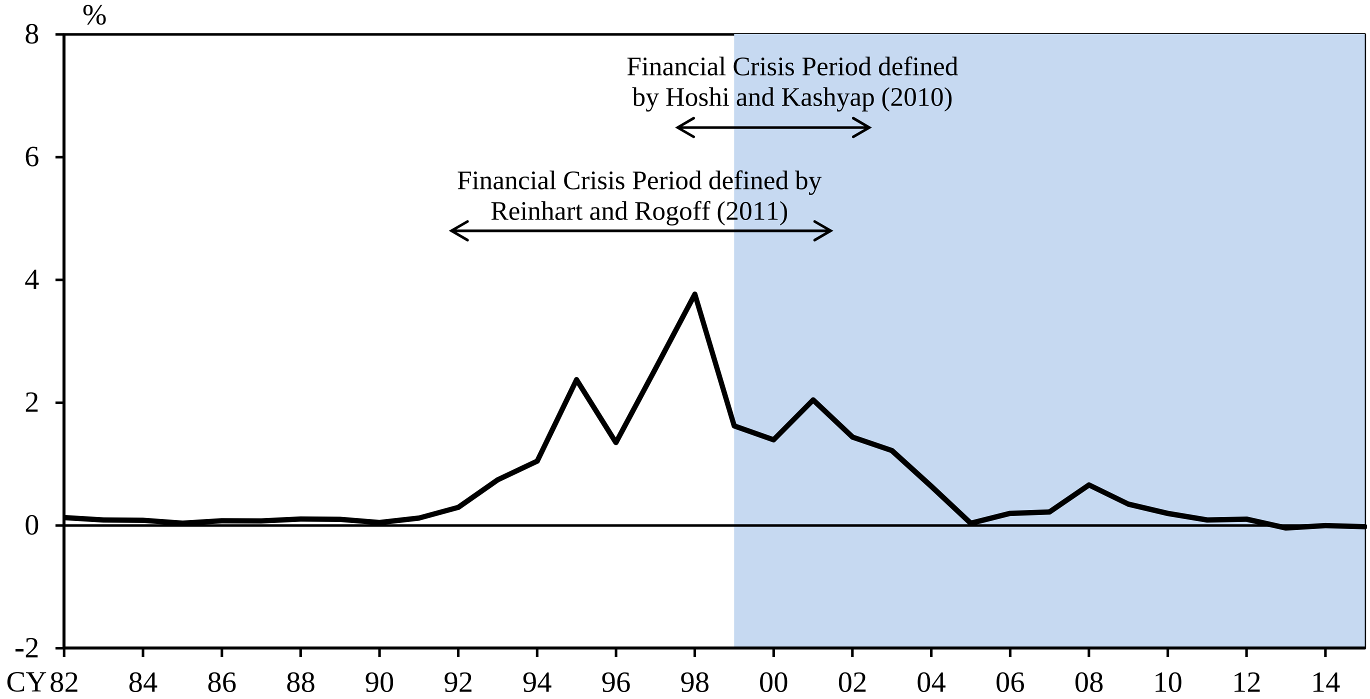
Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid line is the point estimate and the shaded areas are the 95% confidence intervals of the estimate regarding a response to a shock during the UMP period. The bold dashed line in red is the point estimate and the light dotted lines show the 95% confidence interval of the estimate regarding a response to a shock during the CMP period.

2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

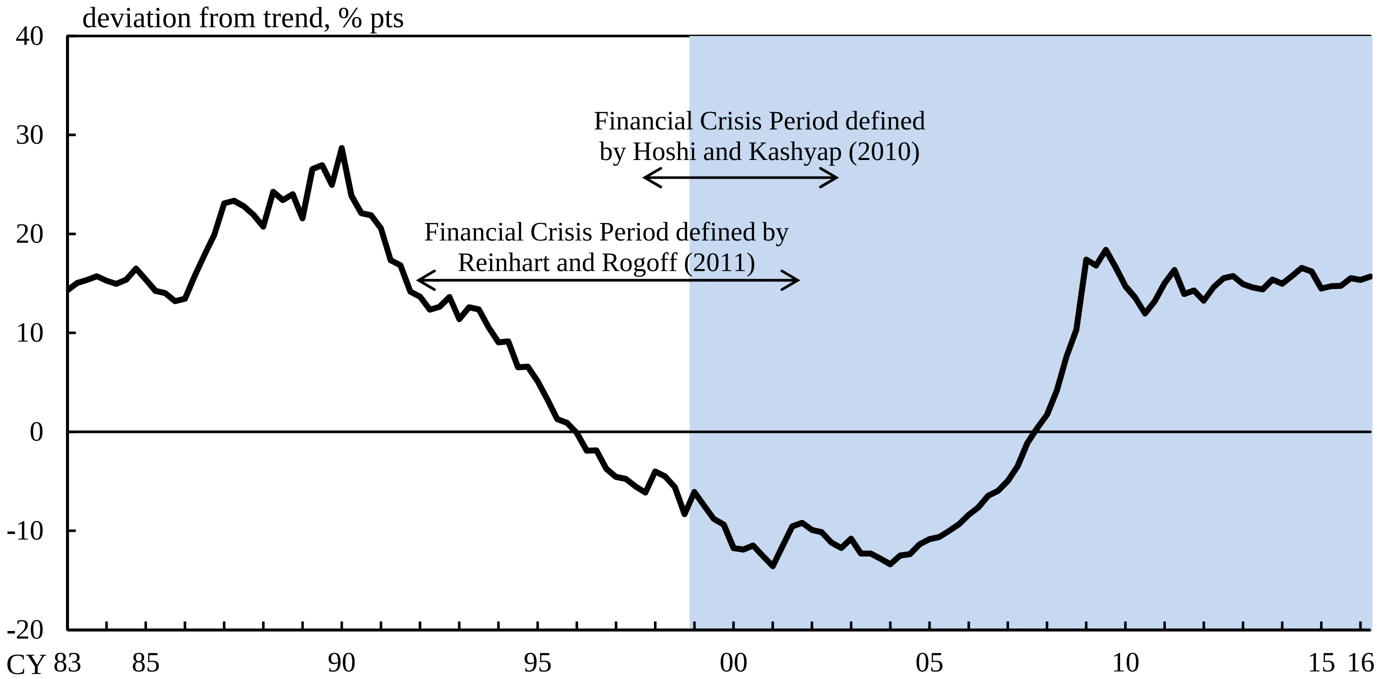
Sources: Ministry of Internal Affairs and Communications, “Consumer Price Index”, Consensus Economics Inc., “Consensus Forecasts”; Bank of Japan, etc.

Figure 4: Financial Crisis in Japan

(1) Credit Cost Ratio of Japanese banks



(2) Credit to GDP ratio



Note: 1. The financial crisis period defined by Hoshi and Kashyap (2010) runs from 1997 to 2002, and by Reinhart and Rogoff (2011) from 1992 to 2001.

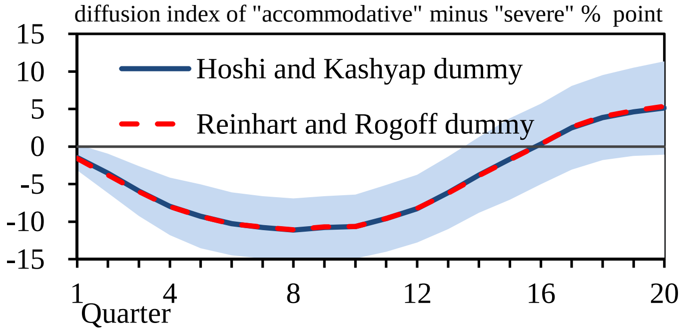
2. The shaded area indicates the period when the unconventional monetary policy was implemented.

Sources: Cabinet Office, the Bank of Japan, Hoshi and Kashyap (2010), Reinhart and Rogoff (2011) .

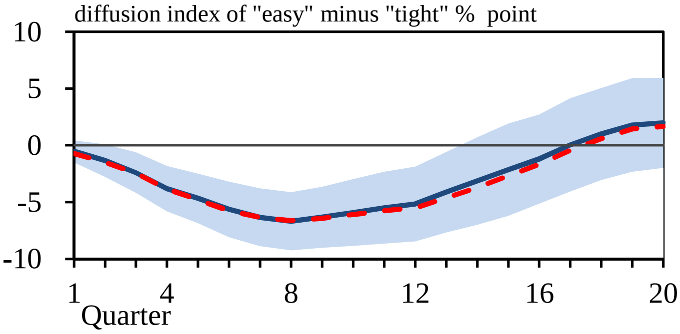
Figure 5: Nature of Financial Crisis Dummy (1)

(1) Coefficient of financial crisis dummies for financial variables

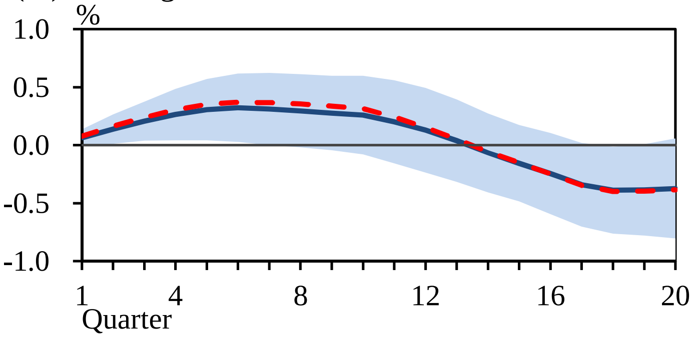
(i) Lending attitude of financial intermediaries



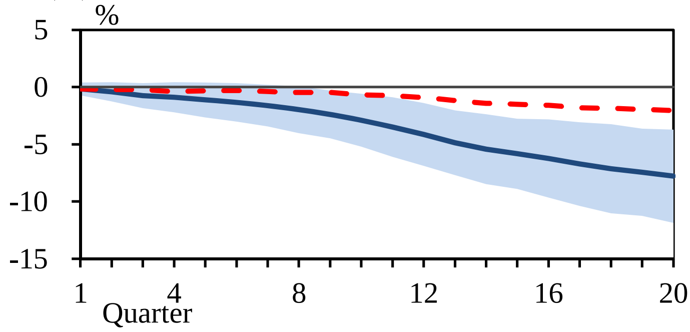
(ii) Financial position of non-financial firms



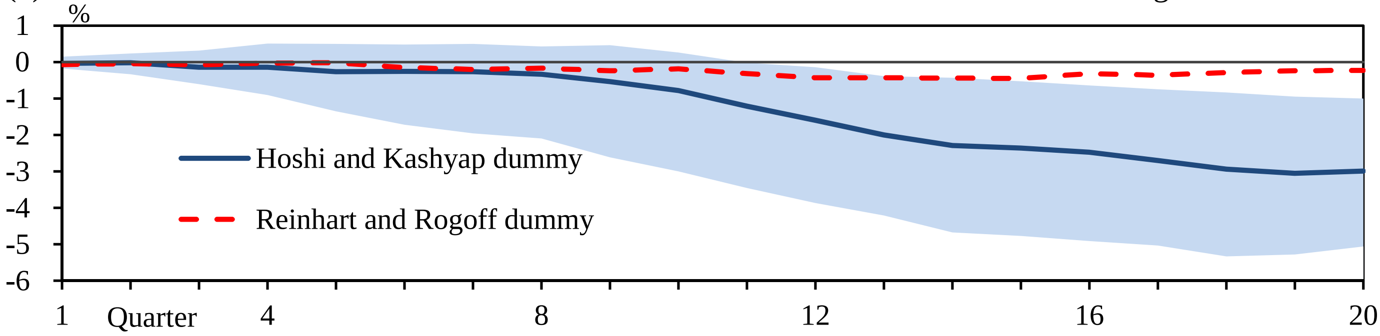
(iii) Lending rate



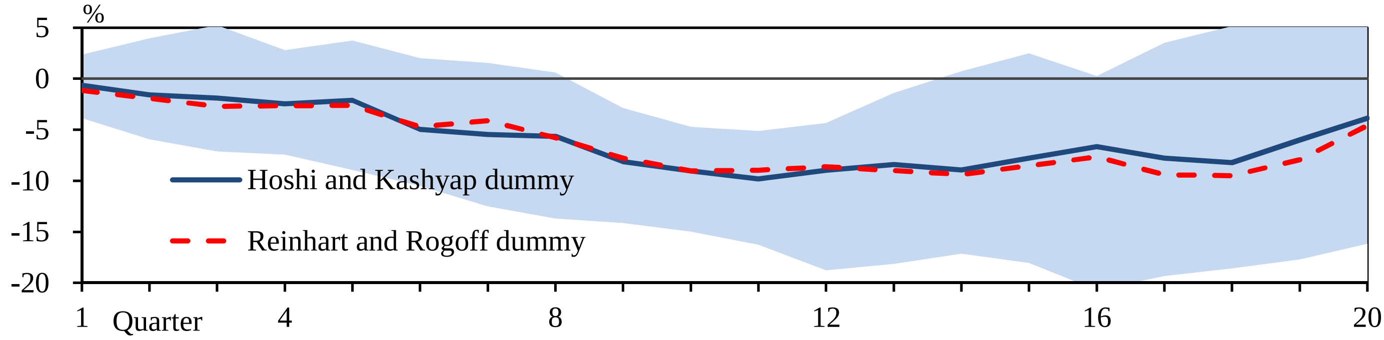
(iv) Credit to GDP ratio



(2) Distribution of coefficient of financial crisis dummies for an individual bank's lending



(3) Distribution of coefficient of financial crisis dummies for an industry group's investment



Notes: 1. The figure shows the estimated coefficient of financial crisis dummies when the response of a variable listed above to an expansionary monetary policy shock is estimated.

2. The shaded areas in panel (1) are the 95% confidence intervals of the estimates of the coefficient of the dummy variable based on Hoshi and Kasyhap (2010). The estimated coefficients are multiplied by -1 as an expansionary monetary policy is considered.
The red dashed line is the point estimate of the coefficient when the dummy variable is constructed based on Reinhart and Rogoff (2011).

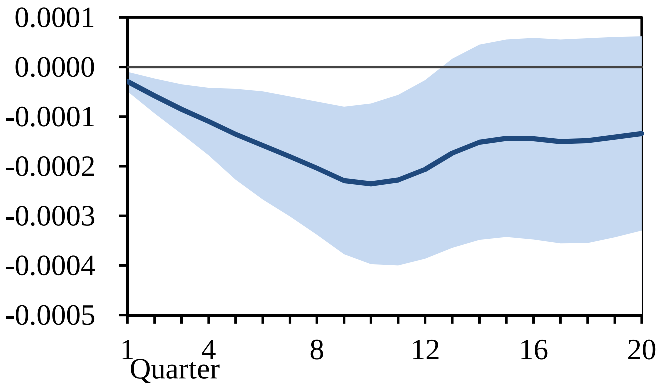
3. The shaded areas in panels (2) and (3) show the range of distribution where the 25-75th percentile of response of sampled banks and industry groups fall. The blue solid line and red dashed line show the median of impulse responses of lending among banks when either of the two dummy variables is used.

Sources: Bank of Japan, “Short-term Economic Survey of Enterprises in Japan”; Cabinet Office, “National Accounts”; Ministry of Finance, “Financial Statements Statistics of Corporations by Industry”; Nikkei Inc., etc.

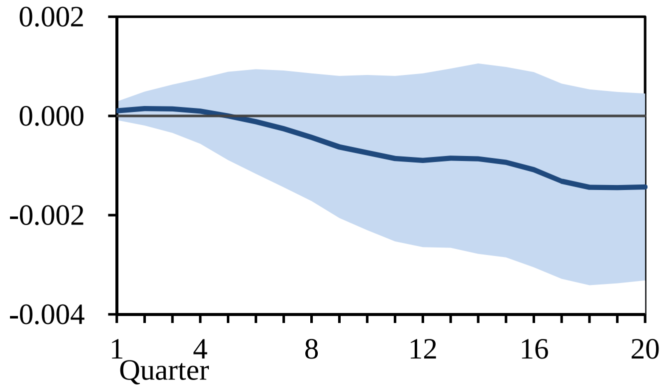
Figure 6: Nature of Financial Crisis Dummy (2)

(1) Relationship between financial crisis dummies and creditworthiness of an individual bank

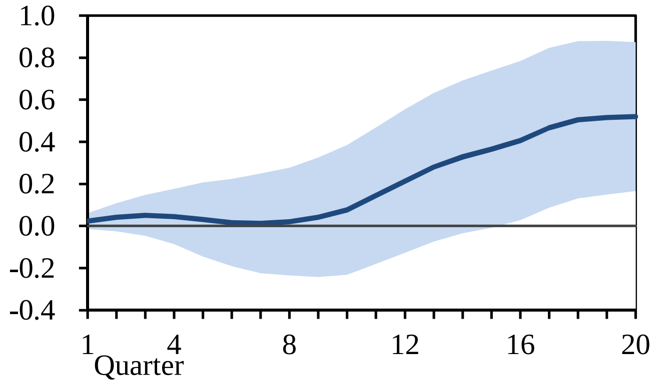
(i) Equity holding in 1989



(ii) Real estate lending in 1989

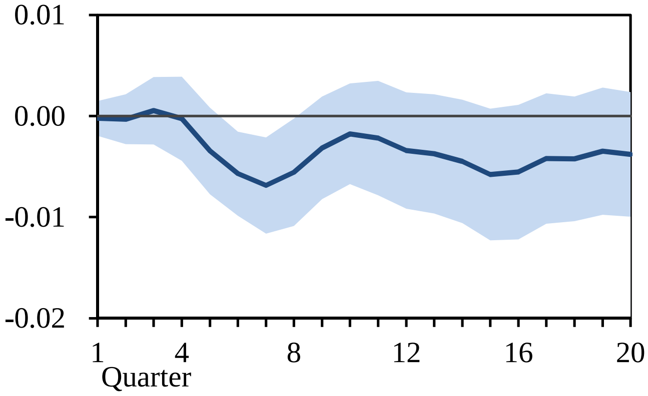


(iii) Bank's capital adequacy

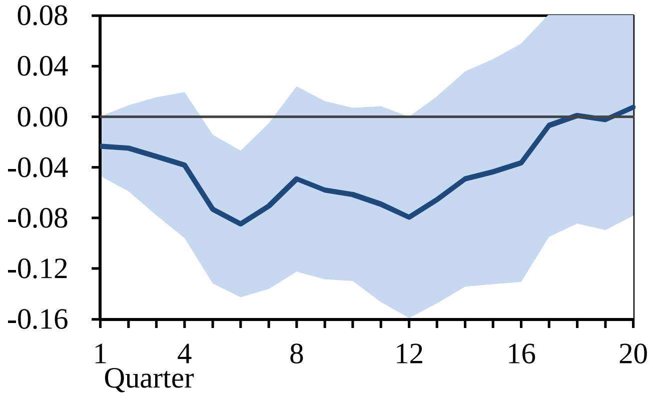


(2) Relationship between financial crisis dummies and characteristics of an industry group

(i) Amount of borrowing



(ii) Firm size



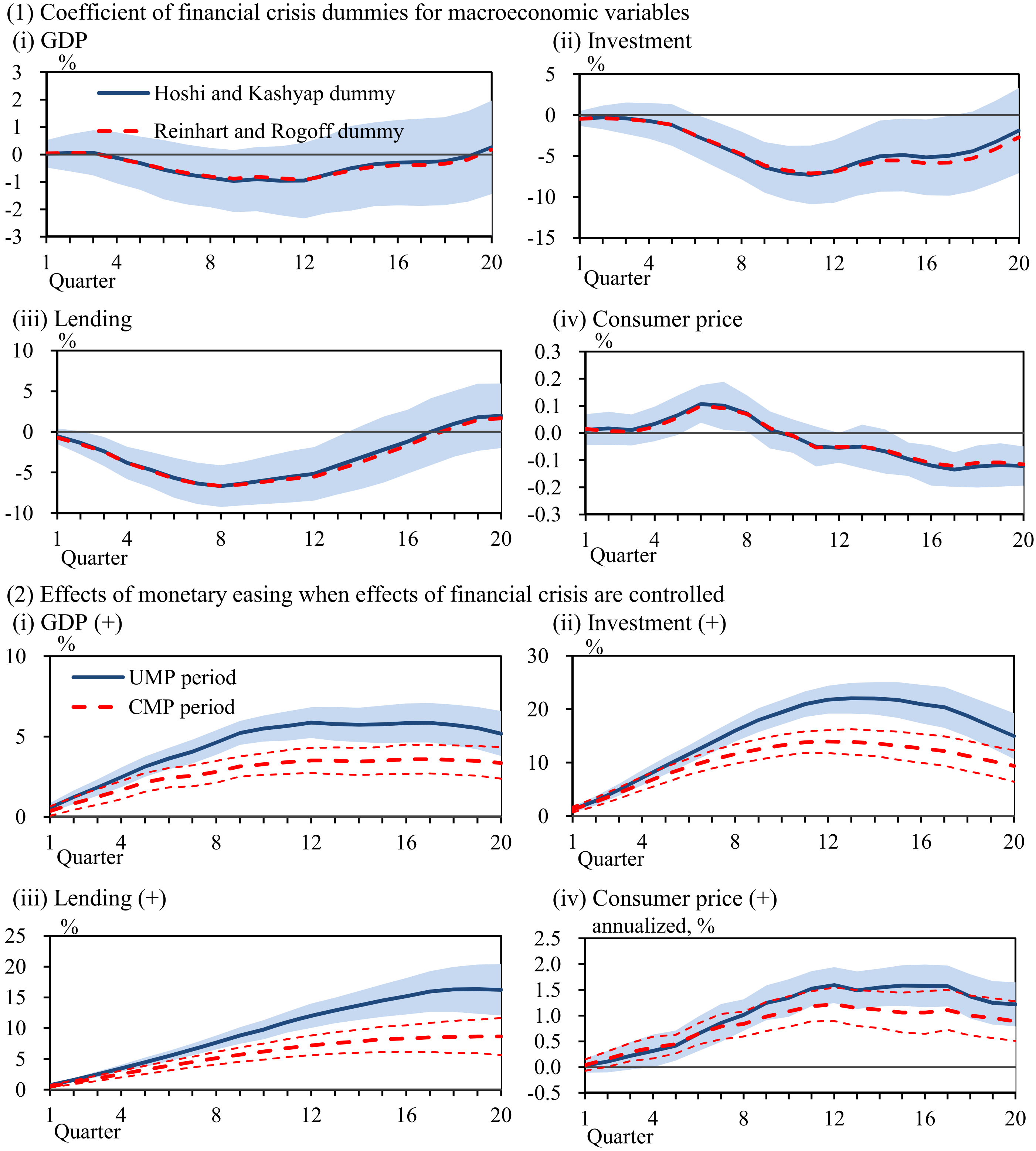
Notes: 1. The panels (1) show the results of estimation where the dependent variable is the coefficient of financial crisis dummy of an individual bank's total amount of loan at *h* and the explanatory variables are those of the bank listed above. (i) and (ii) are the result of estimation where both equity holding and real estate lending (and constant) are the independent variable, and (iii) is the result of estimation where the capital adequacy (and constant) is the independent variable.

2. The panels (2) show the results of estimation where the dependent variable is the coefficient of financial crisis dummy of an industry group's investment at *h* and the explanatory variables are those of the industry group listed above.

3. The y-axis denotes the estimated coefficient, and the shaded areas in the panels stand for the 90% confidence intervals of the estimates.

Sources: Ministry of Finance, "Financial Statements Statistics of Corporations by Industry"; Nikkei Inc.; Watanabe (2006), etc.

Figure 7: Effects of Financial Crisis



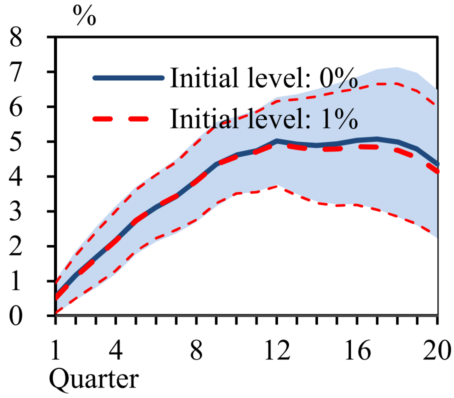
Notes: 1. The panels (1) show the estimated coefficient of financial crisis dummies when a response of a variable listed above to an expansionary monetary policy shock is estimated.
2. The dark area in panel (1) are 95% confidence interval of the estimates of the coefficient of the dummy variable based on Hoshi and Kasyhap (2010). The estimated coefficients are multiplied by -1 as an expansionary monetary policy is considered. The red dotted line is the point estimate of the coefficient when the dummy variable is constructed based on Reinhart and Rogoff (2011).
3. "+" ("−") in the panel (2) denote that a response of the variable to a monetary policy shock during the period of the UMP regime is significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level, when effects of financial crisis are controlled.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications, "Consumer Price Index"; Bank of Japan, etc.

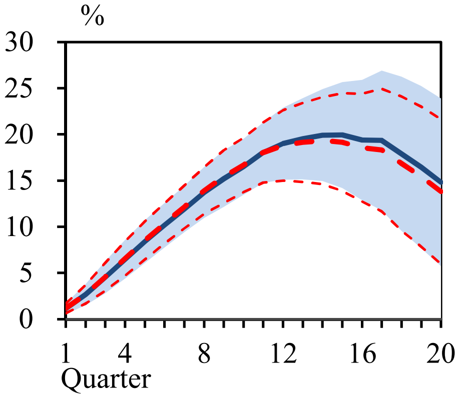
Figure 8: Effects of the Level of Policy Rate

(1) GDP and its components

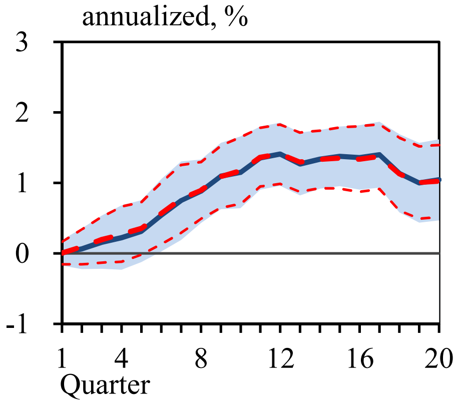
(i) GDP



(ii) Investment

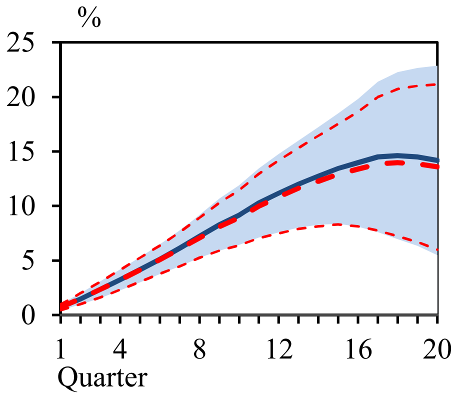


(2) Consumer price

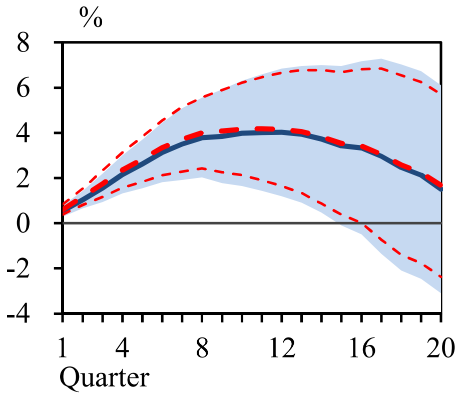


(3) Variables related to Financial Intermediation

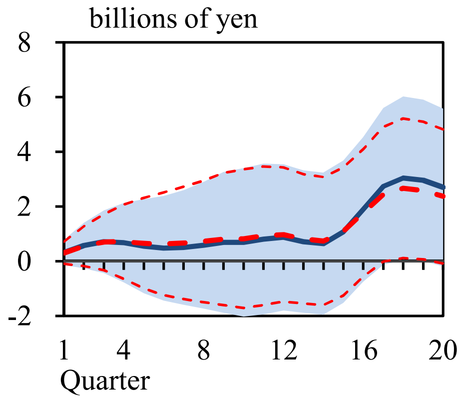
(i)Lending



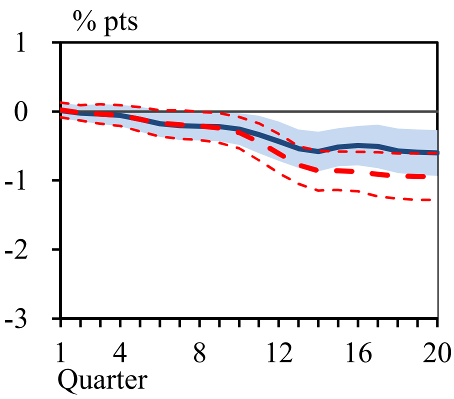
(ii) Deposit



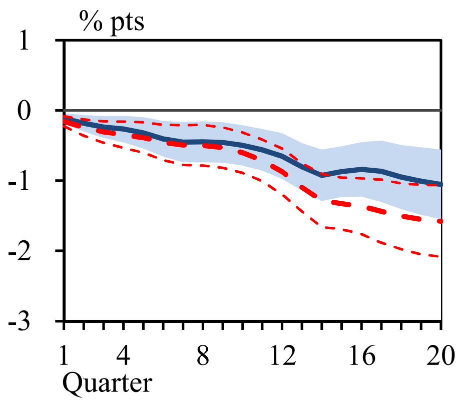
(iii) Net profit



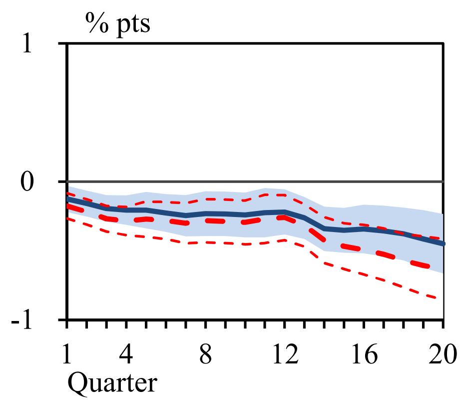
(iv) Deposit rate (+)



(v) Lending rate (+)



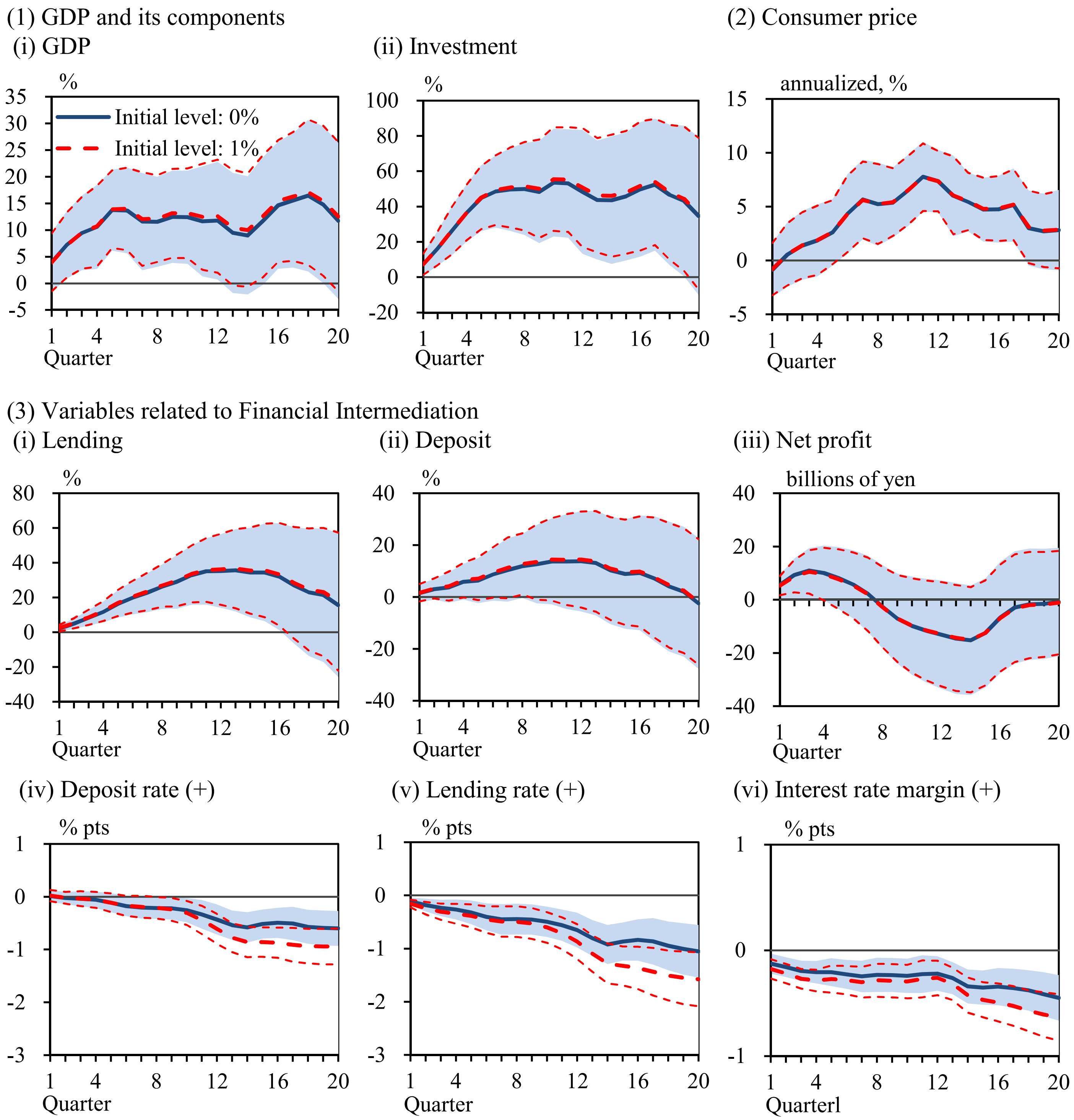
(vi) Interest rate margin (+)



Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock.
The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs.
The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding response to a shock when the policy rate in the previous period is 0 basis.
The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock when the rate in the previous period is 100 basis.
2. "+" ("−") denotes that the response of the variable to a monetary policy shock when the policy rate in the previous period is 0 basis is significantly more positive (less positive) than the case when the policy rate in the previous period is 100 basis at a 5% significance level.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications, "Consumer Price Index"; Bank of Japan, etc.

Figure 9: Effects of the Level of Call Rate



Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock when the prevailing short-term nominal interest rate in the previous period is 0 basis. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock when the rate in the previous period is 100 basis.

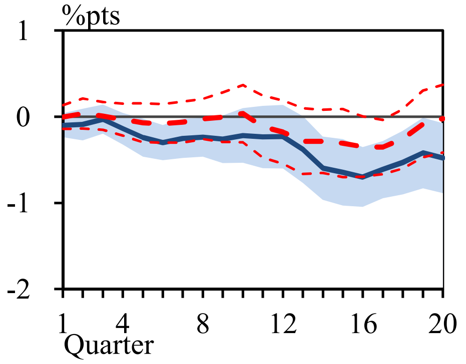
2. "+" ("−") denotes that the response of the variable to a monetary policy shock when the prevailing short-term nominal interest rate in the previous period is 0 basis is significantly more positive (less positive) than the case when the rate in the previous period is 100 basis at a 5% significance level.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications,"Consumer Price Index"; Bank of Japan, etc.

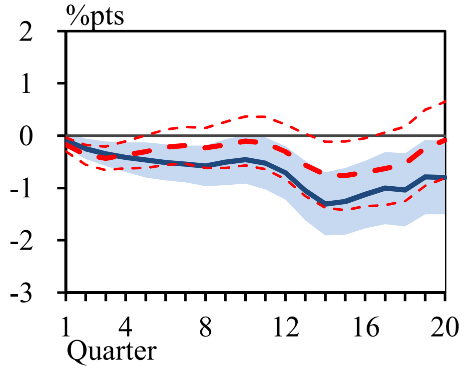
Figure 10: Transmission Channels of UMP (1)

(1) Impulse response of various measures of real interest rates

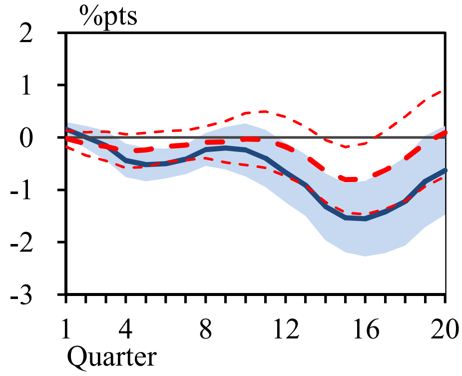
(i) Long-term real interest rate (−) deflated using inflation expectation



(ii) Short-term real interest rate (−) deflated using inflation expectation

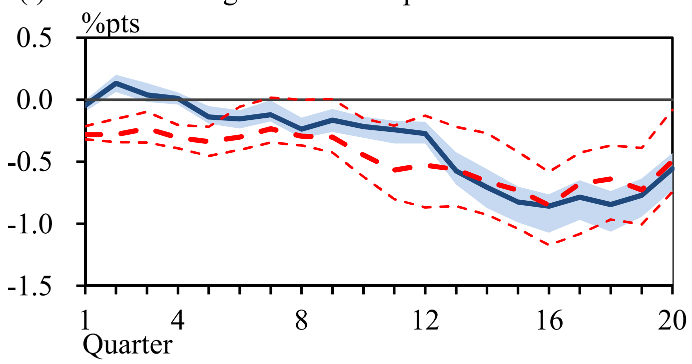


(iii) Short-term real interest rate (−) deflated using actual inflation rate

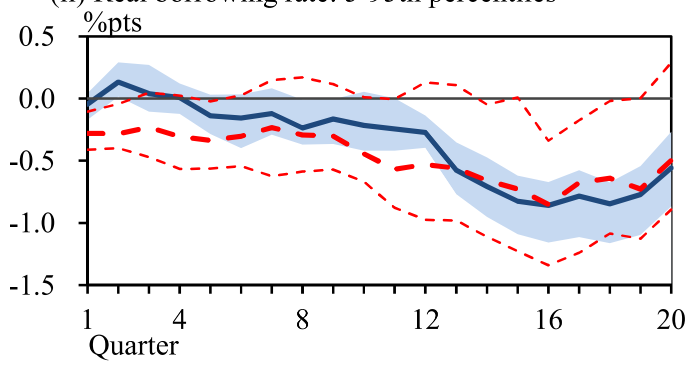


(2) Distribution of responses across 38 industry groups

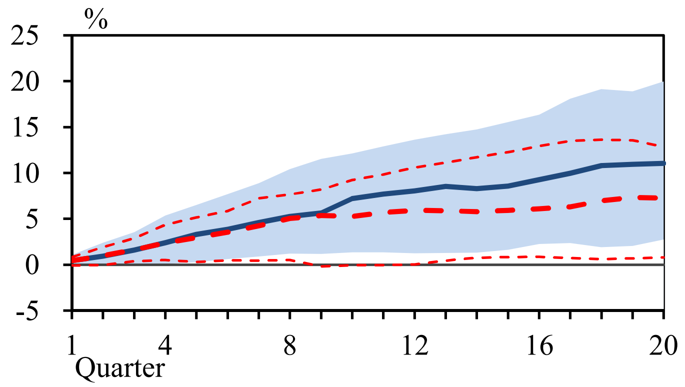
(i) Real borrowing rate: 20-80th percentiles



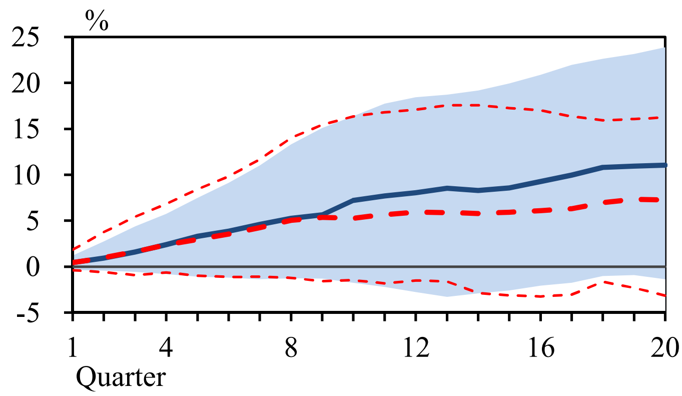
(ii) Real borrowing rate: 5-95th percentiles



(iii) Real debt: 20-80th percentiles



(iv) Real debt: 5-95th percentiles



Note: 1. The figures in panel (1) show the impulse responses of financial variables to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are the 95% confidence intervals of the estimate for the UMP period. The bold dashed line in red is the point estimate and the light dotted lines show the 95% confidence intervals of the estimate for the CMP period.

2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

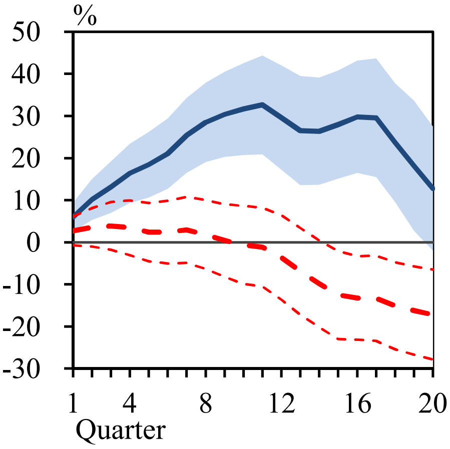
3. The figures in panel (2) show the distribution of impulse responses of borrowing rates and debt to an expansionary monetary policy shock among 38 industry groups. The shaded and dotted areas in panel (2) stand for the range where 60% and 90% of industry groups fall for an impulse response under UMP and CMP, respectively. The blue solid line and red dashed line stand for the median of impulse responses of industry groups to shocks under the two policy regimes.

Sources: Consensus Economics Inc., “Consensus Forecasts”; Ministry of finance, “Financial Statements Statistics of Corporations by Industry”; Bank of Japan, etc.

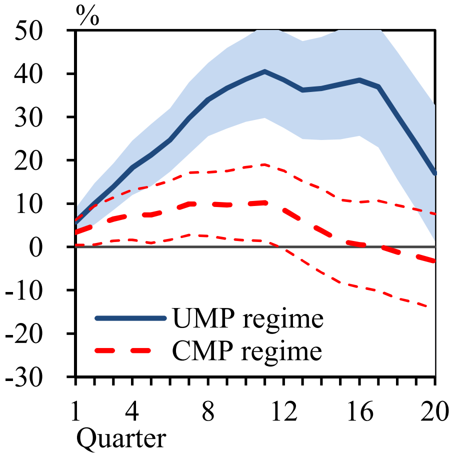
Figure 11: Transmission Channels of UMP (2)

(1) Impulse response of stock prices

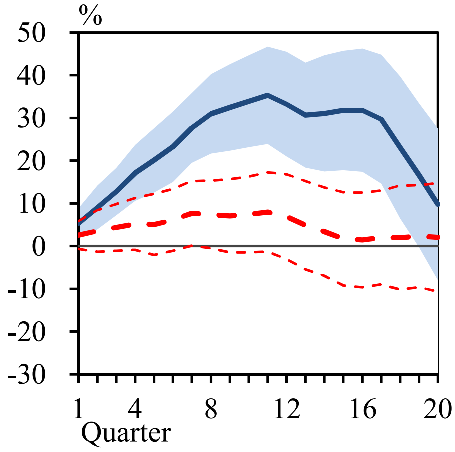
(i) Large firms (+)



(ii) Middle sized firms (+)

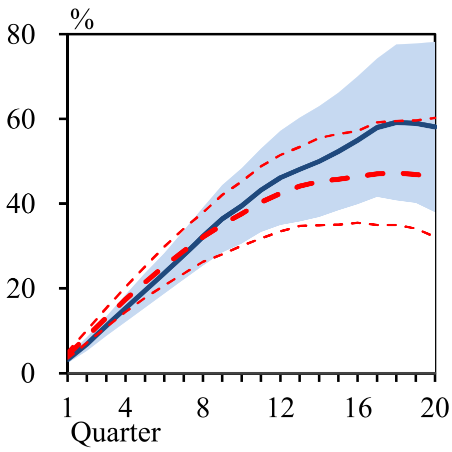


(iii) Small firms (+)

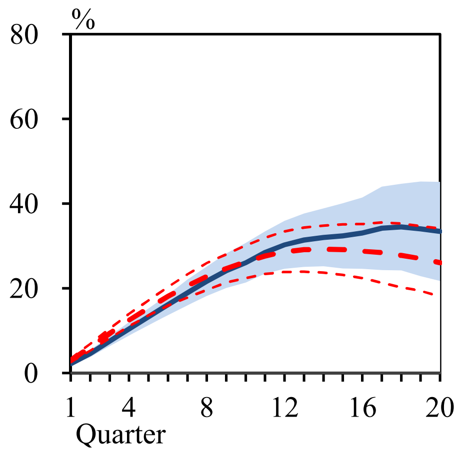


(2) Impulse response of land prices

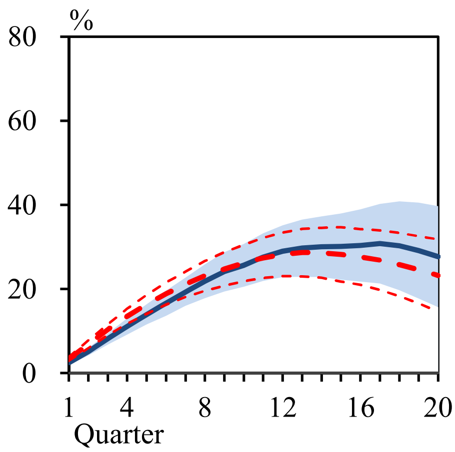
(i) Commercial (+)



(ii) Industrial (+)

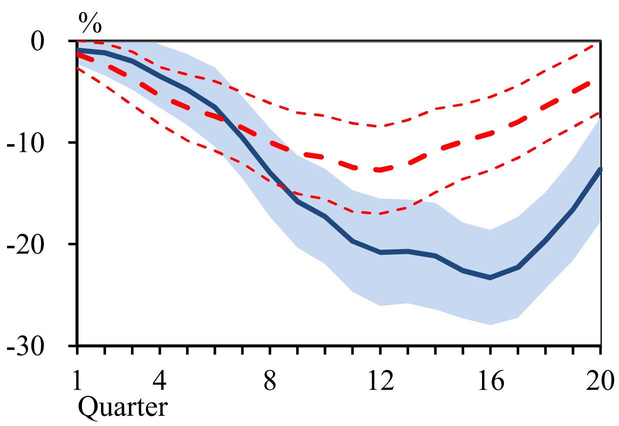


(iii) Residential

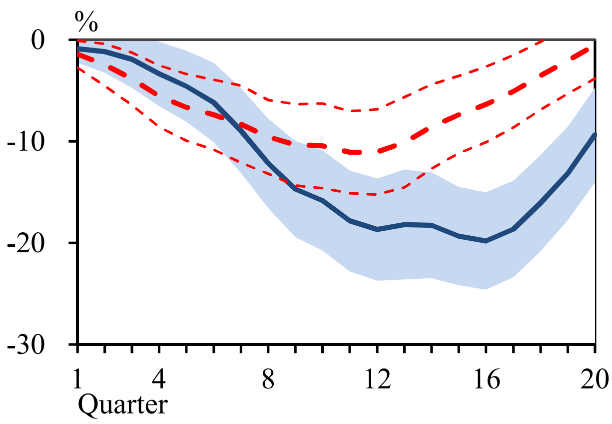


(3) Impulse response of exchange rates

(i) Nominal exchange rate (−)



(ii) Real exchange rate (−)



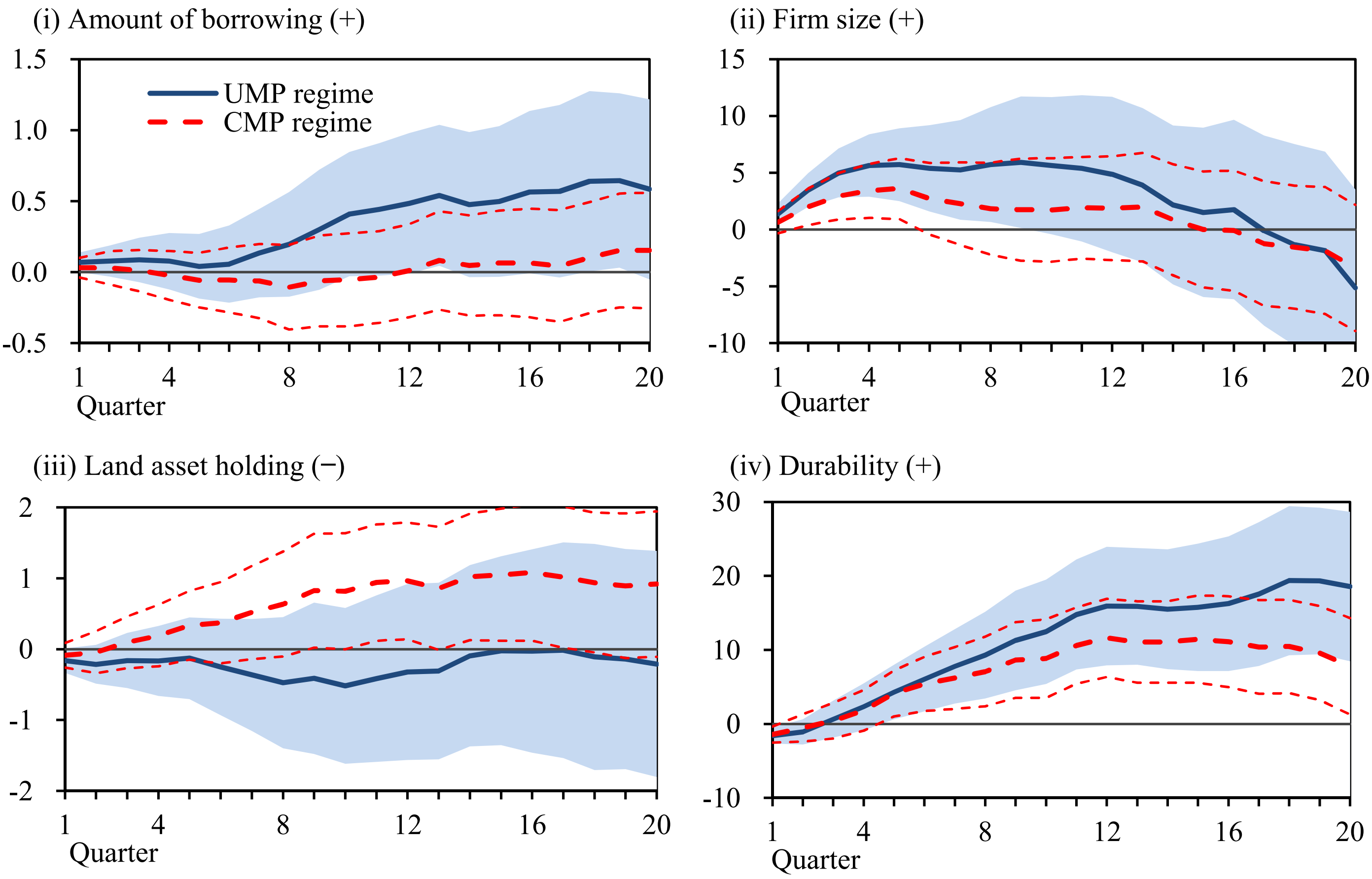
Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid line is the point estimate and the shaded areas are the 95% confidence intervals of the estimate regarding a response to a shock during the UMP period. The bold dashed line in red is the point estimate and the light dotted lines show the 95% confidence intervals of the estimate regarding a response to a shock during the CMP period.

2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: HAVER,etc.

Figure 12: Transmission Channels of UMP (3)

Relationship between an industry's characteristics and the impulse response



Notes: 1. The figure shows the result of the regression where an impulse response of investment to an expansionary monetary policy shock for 38 industry groups is used as the dependent variable and their features (i) ~ (iv) are used as the independent variable. Note that "firm size" captures the effects of the industry group being small enterprises. Each panel shows the estimated coefficient of an industry group's characteristic when *h*-th quarter response of the investment is the dependent variable.

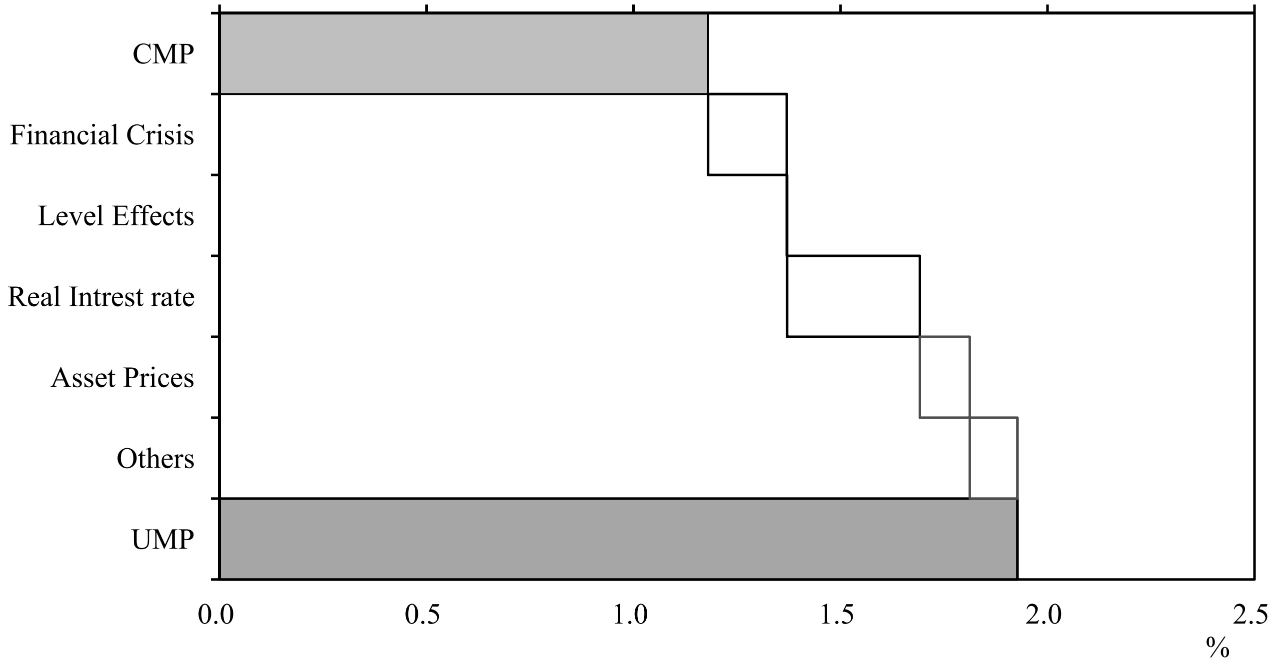
2. The solid line is the point estimate and the shaded areas are the 90% confidence intervals of the estimates of responses to a shock that occurs during the UMP period. The bold dashed line in red is the point estimate and the light dotted lines are the 90% confidence intervals of the estimates of responses to a shock that occurs during the CMP period.

3. "+" ("−") denotes that the characteristic contributes positively (negatively) at a 90% significant level to the difference of an investment response to a monetary policy shock between the period of the UMP regime and CMP regime.

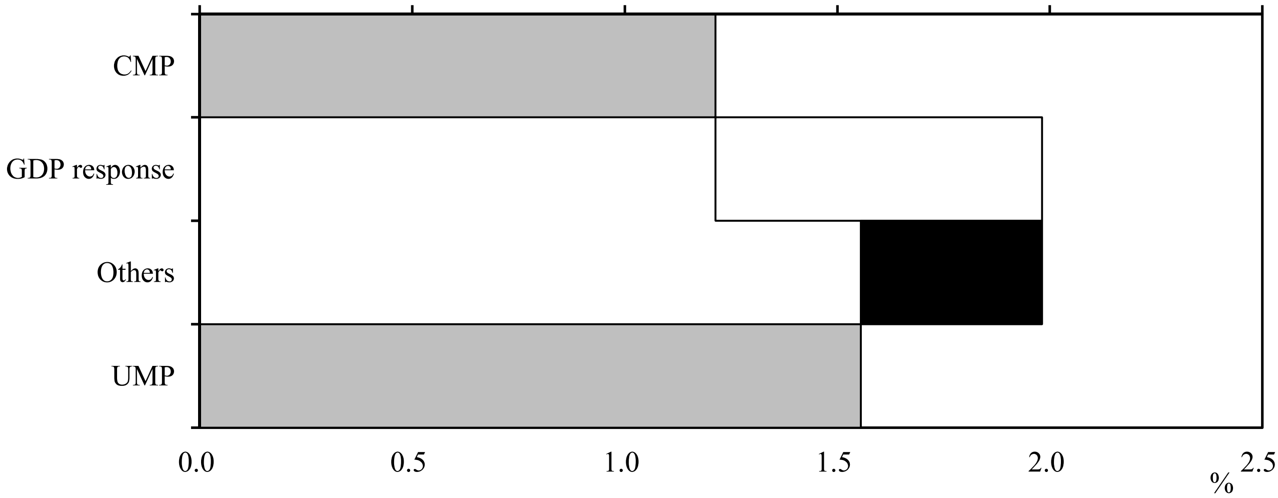
Sources: Ministry of Finance, “Financial Statements Statistics of Corporations by Industry,” etc.

Figure 13: Differences in Monetary Policy Transmission and Contributing Factors

(1) Factors contributing to the difference in GDP response



(2) Factors contributing to the difference in the consumer price response



Note: 1. Contributing factors to the difference in GDP are calculated as follows.

CMP: 12 quarters ahead response of GDP to an expansionary monetary policy shock in the CMP period.

Financial Crisis: The coefficient of the financial crisis dummy that is constructed based on Hoshi and Kashap (2010) at h = 12.

Level effects: The coefficient of the interaction term between the interest rate level and the policy rate at h = 12.

Real interest rate: 12 quarters ahead response of a real interest rate to an expansionary monetary policy shock in the UMP period − those in the CMP period (Note that a change in real interest rate is straightforwardly translated to a one-for-one increase in GDP in both of the two regimes).

Asset prices: 12 quarters ahead response of stock prices to an expansionary monetary policy shock in the UMP period multiplied by the size of wealth effects estimated by Horioka (1999) and the average value of consumption share of GDP over the sample period.

Others: Residuals.

UMP: 12 quarters ahead response of GDP to an expansionary monetary policy shock in the UMP period.

2. Contributing factors to the difference in the consumer price are calculated as follows.

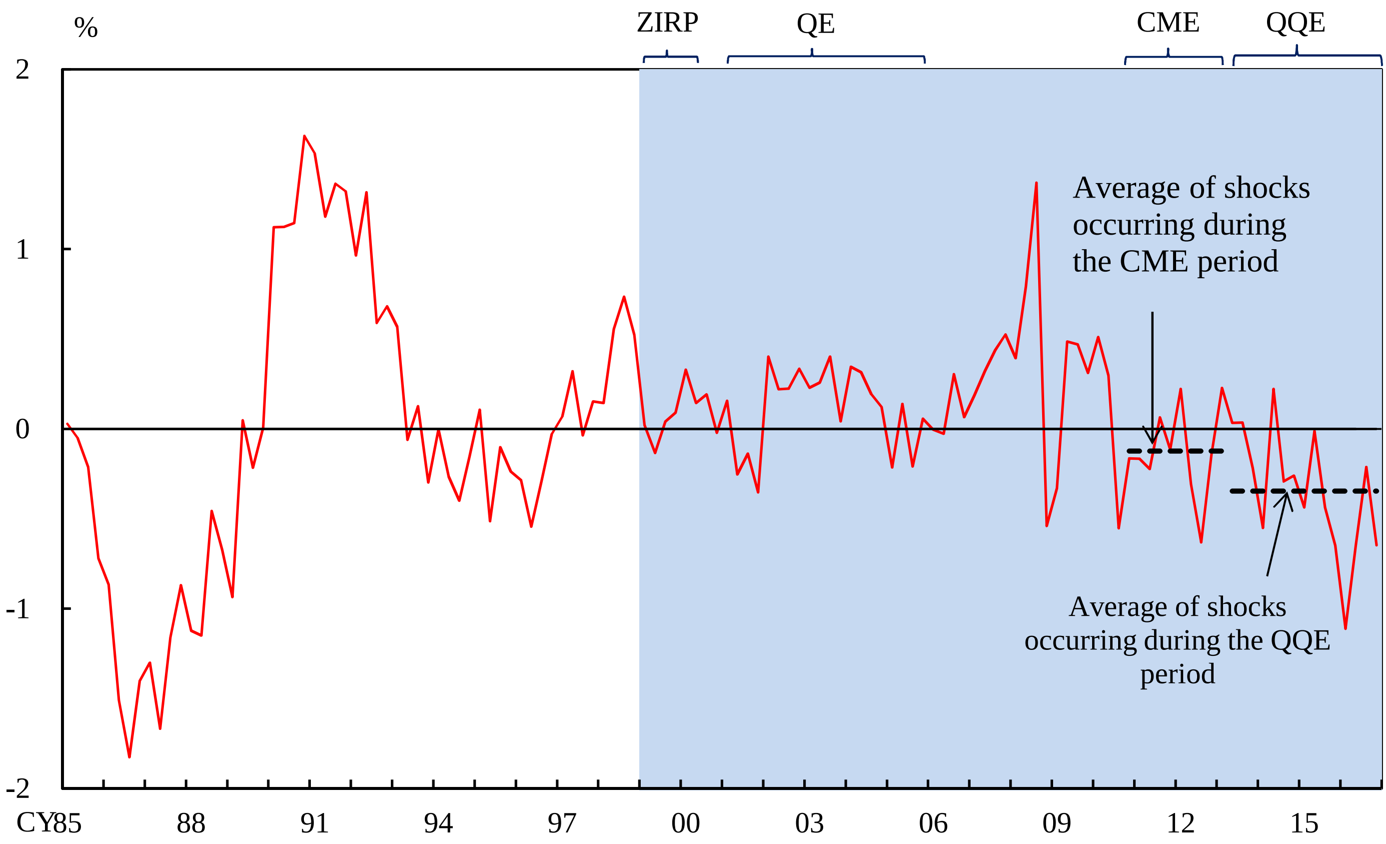
CMP: 12 quarters ahead response of the price level to an expansionary monetary policy shock in the CMP period.

GDP response: 12 quarters ahead response of the price level during the CMP period, multiplied by 12 quarters ahead response of GDP during the UMP period, divided by that of GDP during the CMP period.

Others: Residuals.

UMP: 12 quarters ahead response of the price level to an expansionary monetary policy shock in the UMP period.

Appendix Figure A: Size of Monetary Policy Shocks

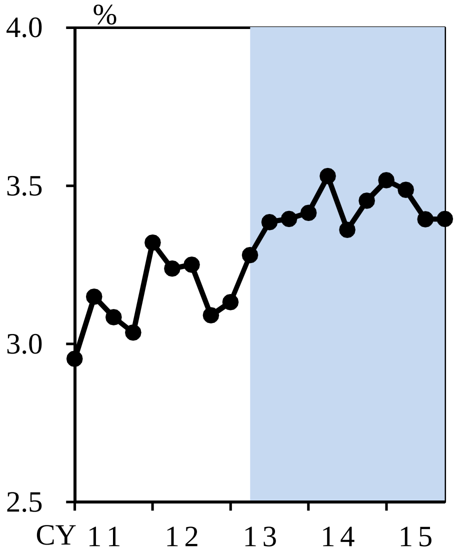


Note: 1. The figure shows the time series of shocks to the shadow rate that are estimated using the vector autoregression. The sample period runs from 1983Q2 to 2016Q4.
2. The shaded area represents the period when UMP was implemented.

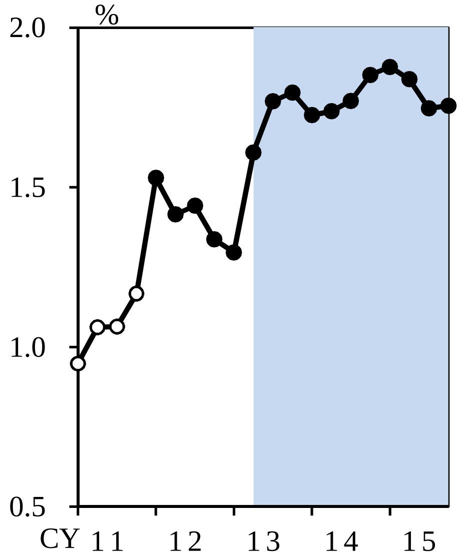
Appendix Figure B: Developments in Monetary Policy Transmission

(1) GDP and its components

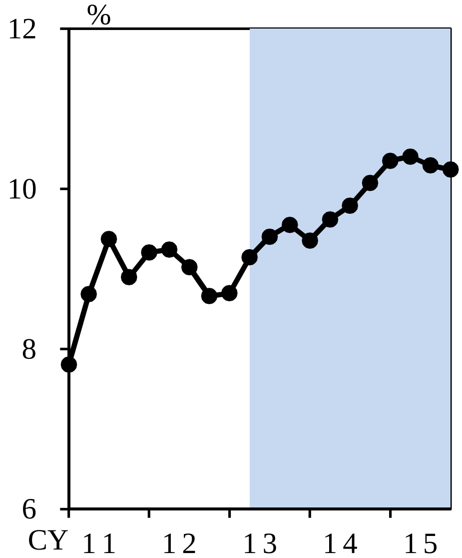
(i) GDP



(ii) Consumption

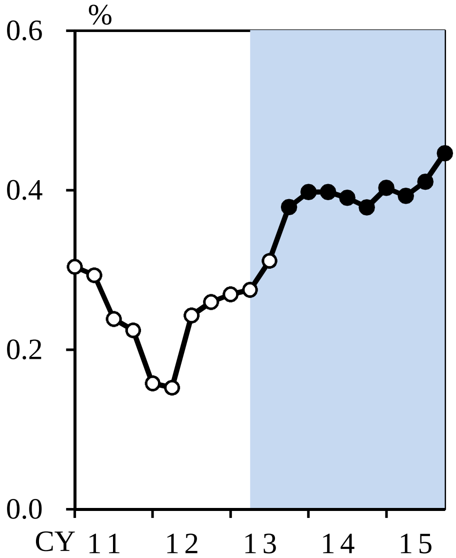


(iii) Investment

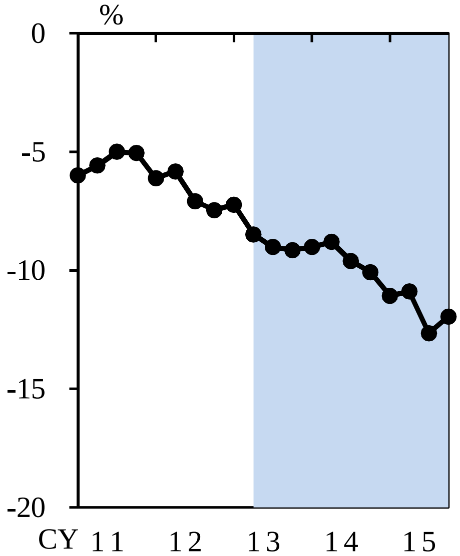


(2) Price and asset price

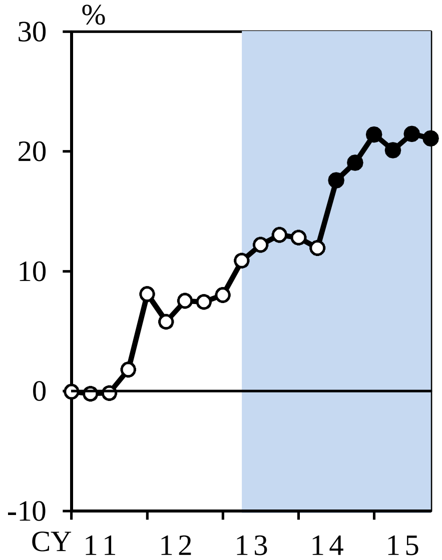
(i) Price level



(ii) Nominal exchange rate



(iii) TOPIX



Note: 1. The figure shows the estimate of the impulse response of *h*=4 of a variable based on the different sample period with the length of 120 months ending at the period on the horizontal axis.

2. The black circles indicate that the estimates are statistically significant at the 10% level, while the white circles indicate that they are not statistically significant. The standard errors are computed from autocorrelation robust standard errors based on Newey-West's method.

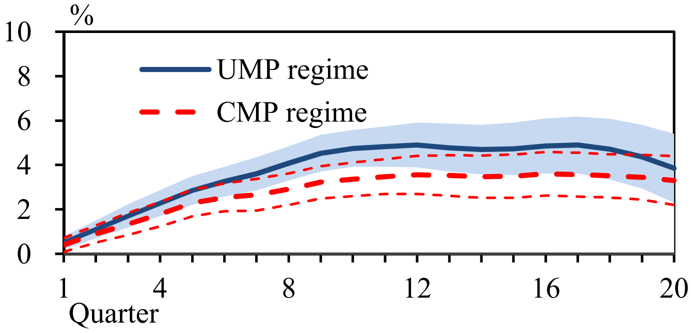
3. The shaded areas represent the period when QQE was implemented.

Sources: Cabinet Office, “National Accounts”; Ministry of Internal Affairs and Communications, “Consumer Price Index”; HAVER, etc.

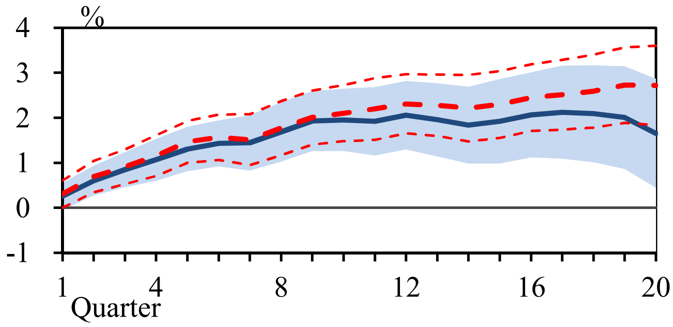
Appendix C1: Estimation with Shadow Rates of Ueno (2017)

(1) GDP and its components

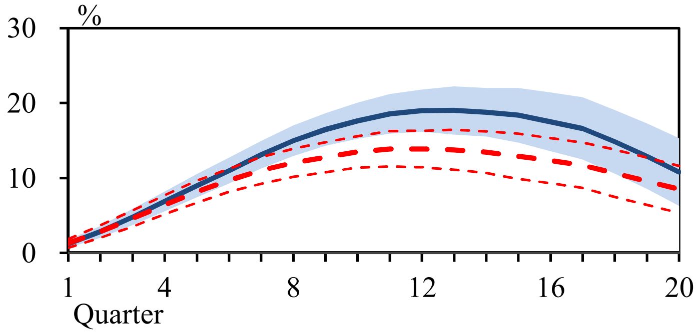
(i) GDP (+)



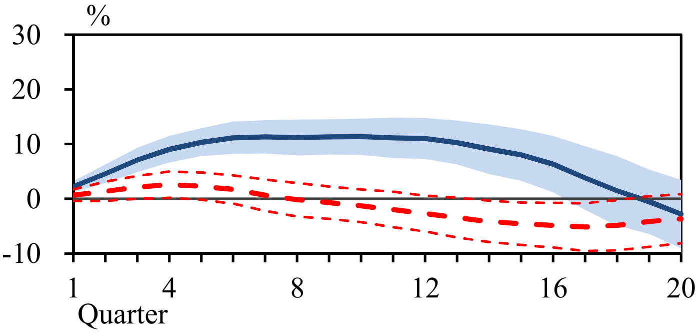
(ii) Consumption (−)



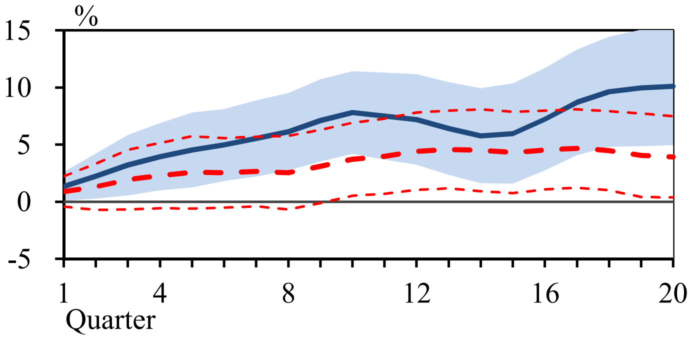
(iii) Investment (+)



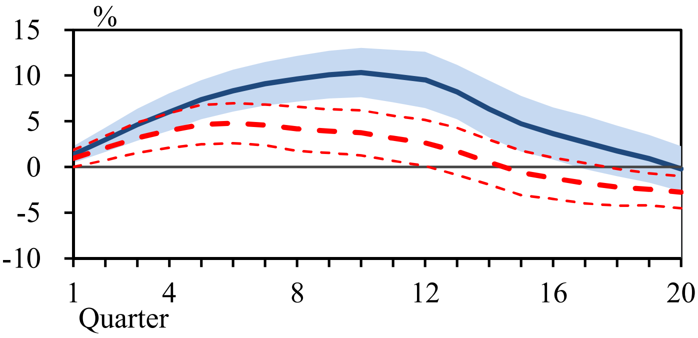
(iv) Residential Investment (+)



(v) Exports

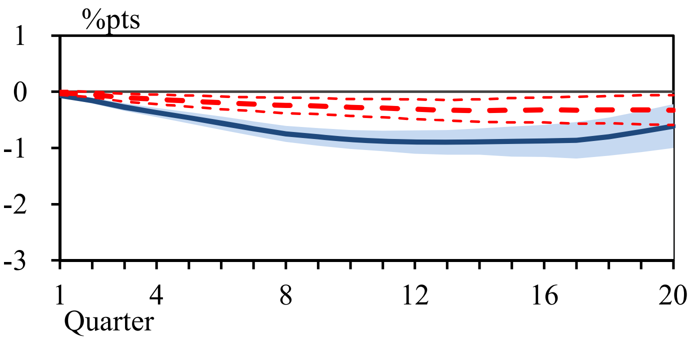


(vi) Imports (+)

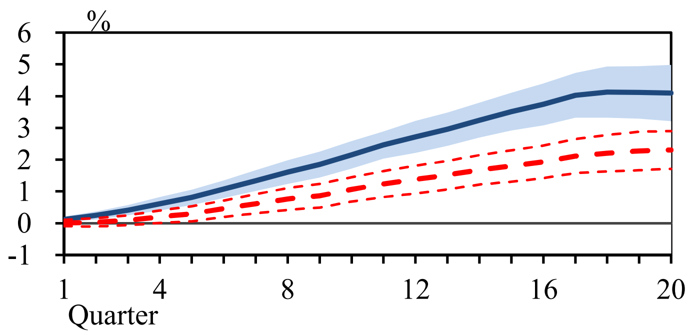


(2) Labor market

(i) Unemployment rate (−)



(ii) Number of Employees (+)



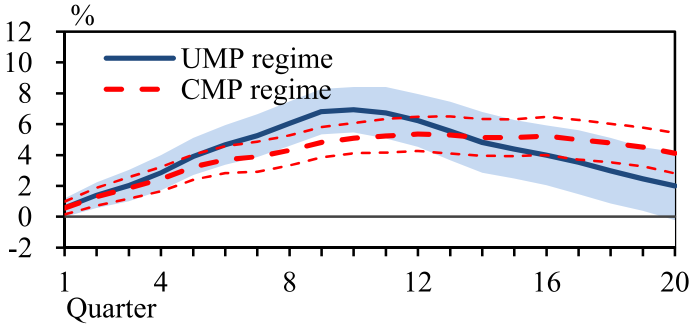
Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock.
The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs.
The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock during the CMP period.
2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is, on average over 20 quarters, significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications, "Labour Force Survey," etc.

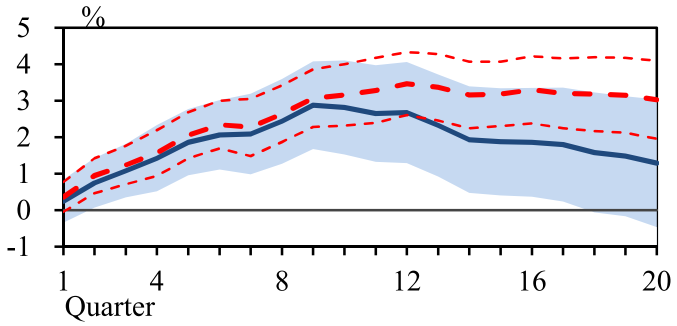
Appendix Figure C2: Estimation with 2 yr Bond Yield

(1) GDP and its components

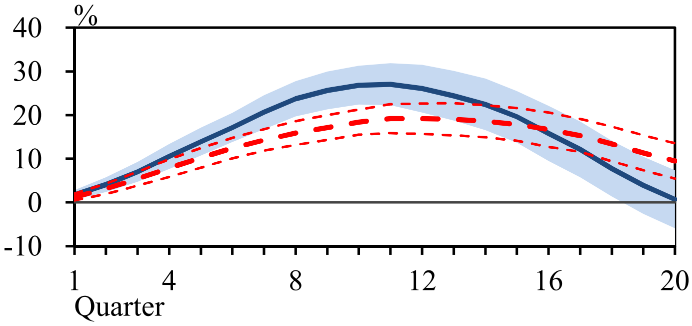
(i) GDP (+)



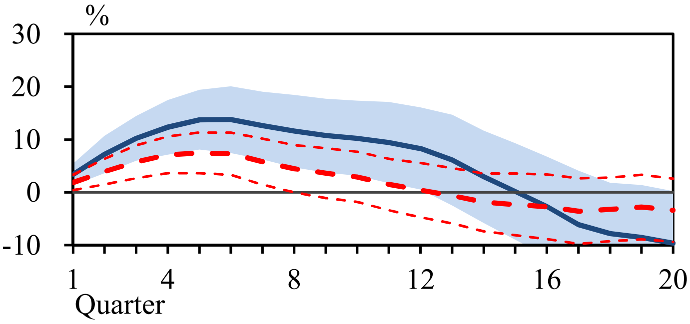
(ii) Consumption (−)



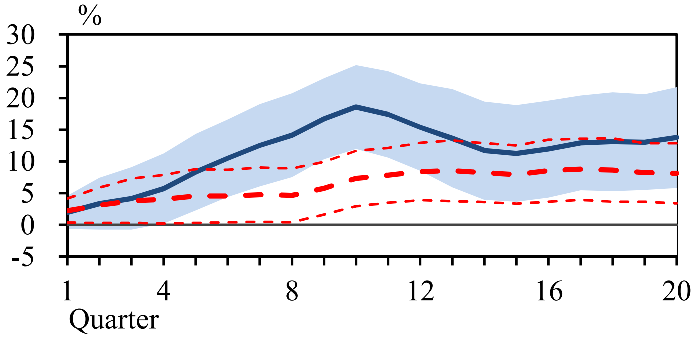
(iii) Investment (+)



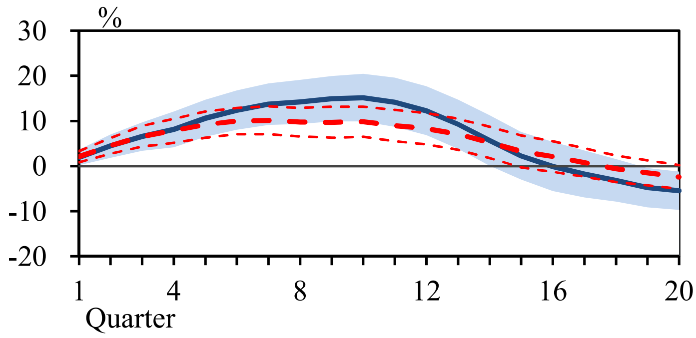
(iv) Residential Investment (+)



(v) Exports (+)

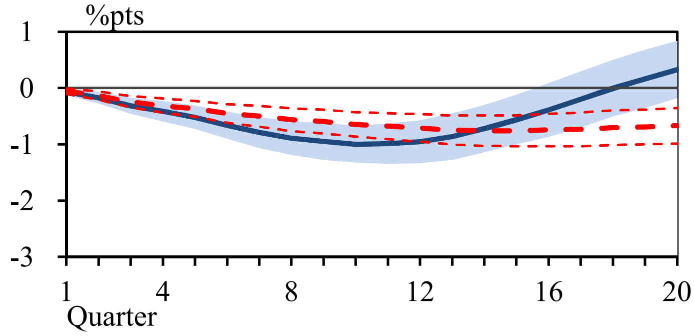


(vi) Imports (+)

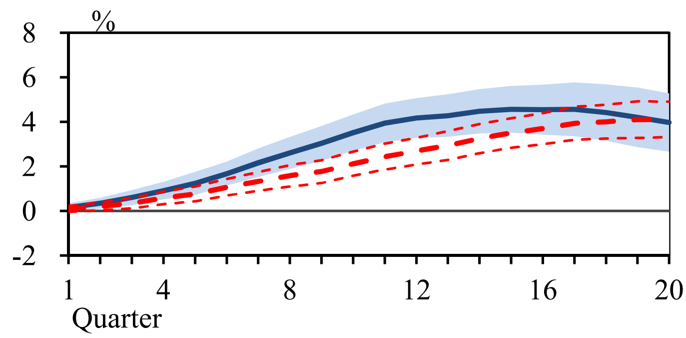


(2) Labor market

(i) Unemployment rate (−)



(ii) Number of Employees (+)



Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock during the CMP period.

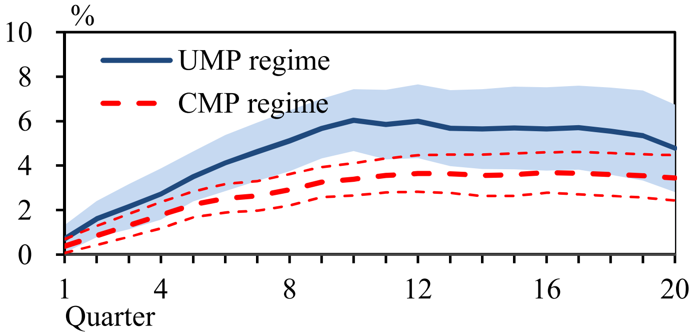
2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is, on average over 20 quarters, significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, “National Accounts”; Ministry of Internal Affairs and Communications,“Labour Force Survey,” etc.

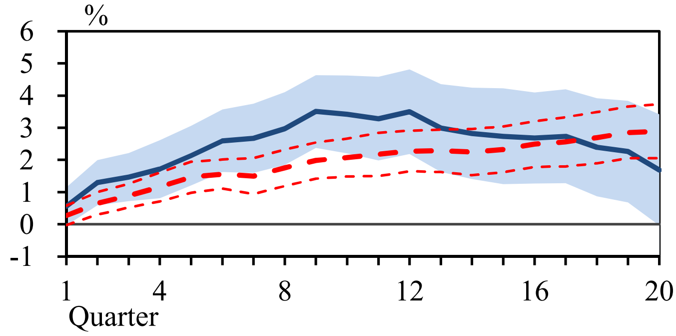
Appendix Figure C3: Estimation with 3 Unobservable Factors

(1) GDP and its components

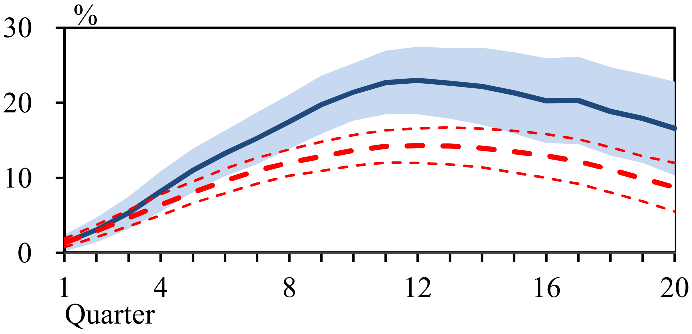
(i) GDP (+)



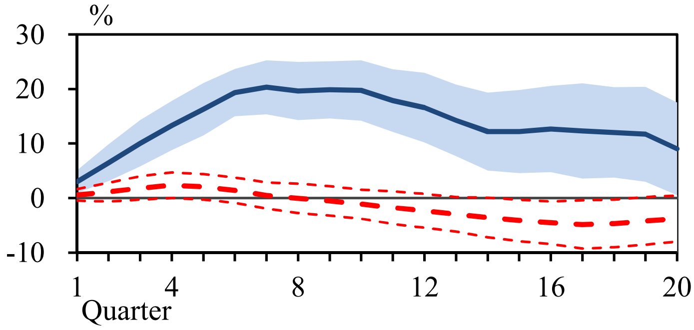
(ii) Consumption (+)



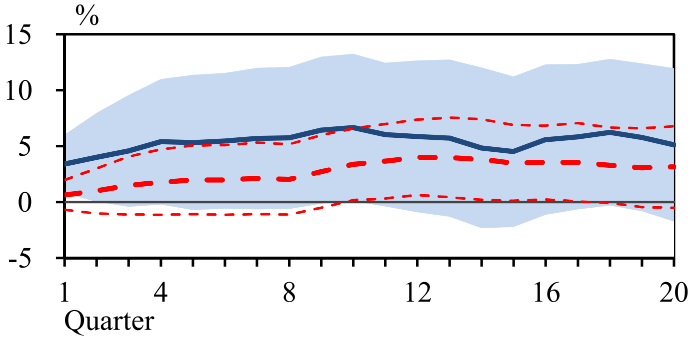
(iii) Investment (+)



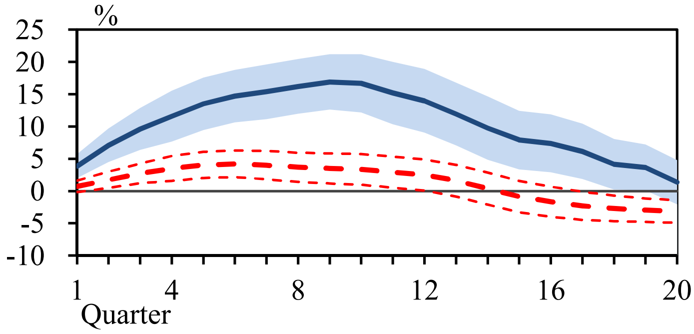
(iv) Residential Investment (+)



(v) Exports (+)

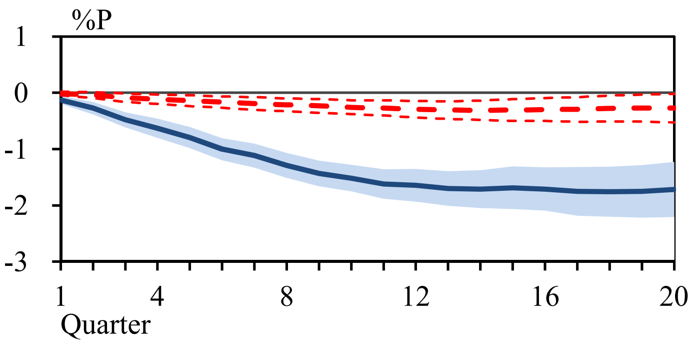


(vi) Imports (+)

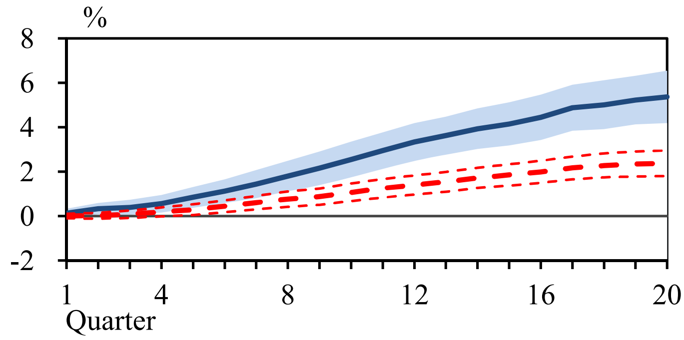


(2) Labor market

(i) Unemployment rate (−)



(ii) Number of Employees (+)



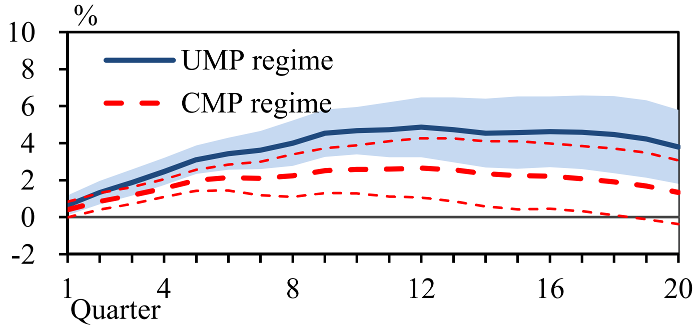
Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock.
The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs.
The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock during the CMP period.
2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is, on average over 20 quarters, significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, “National Accounts”; Ministry of Internal Affairs and Communications,“Labour Force Survey,” etc.

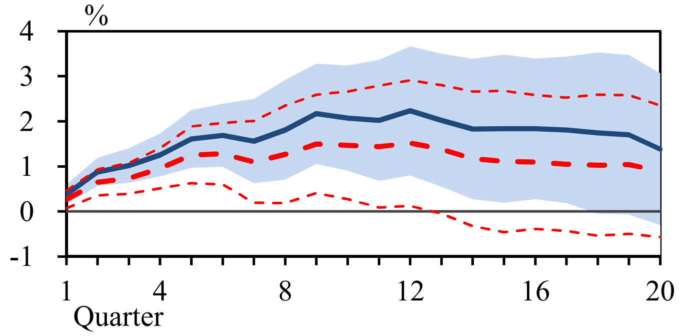
Appendix Figure C4: Estimation with Alternative *T*

(1) GDP and its components

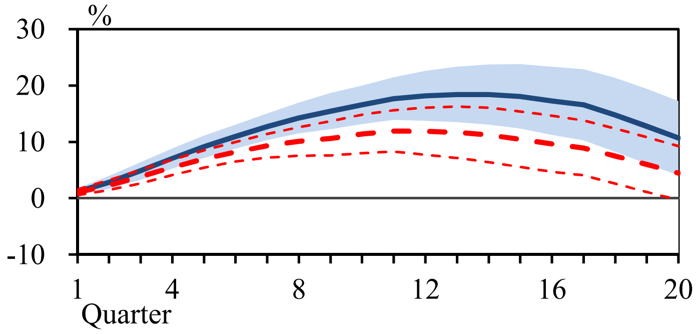
(i) GDP (+)



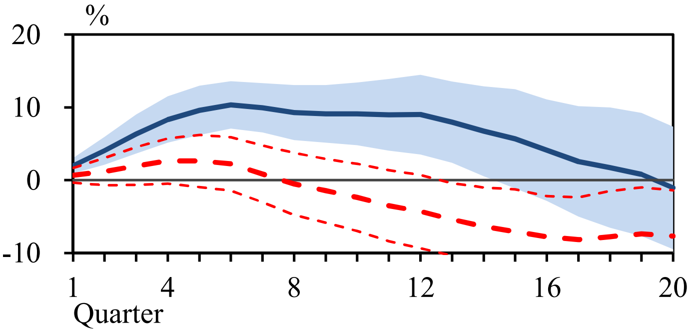
(ii) Consumption (+)



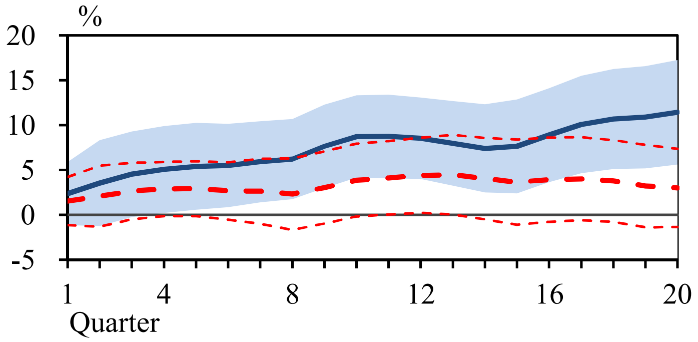
(iii) Investment (+)



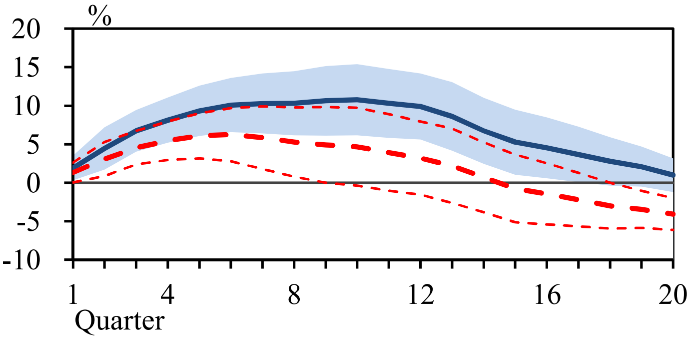
(iv) Residential Investment (+)



(v) Exports (+)

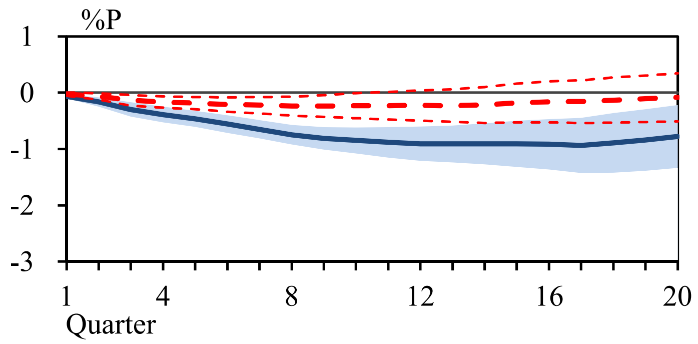


(vi) Imports (+)

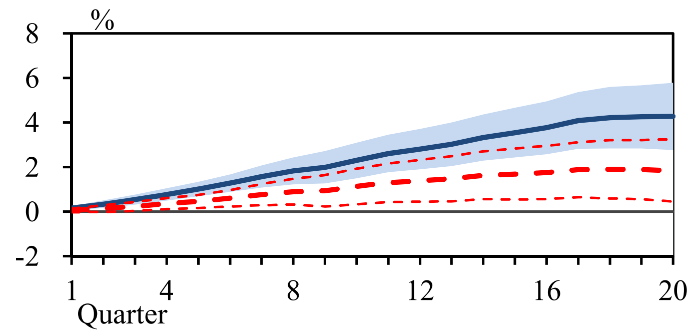


(2) Labor market

(i) Unemployment rate (−)



(ii) Number of Employees (+)

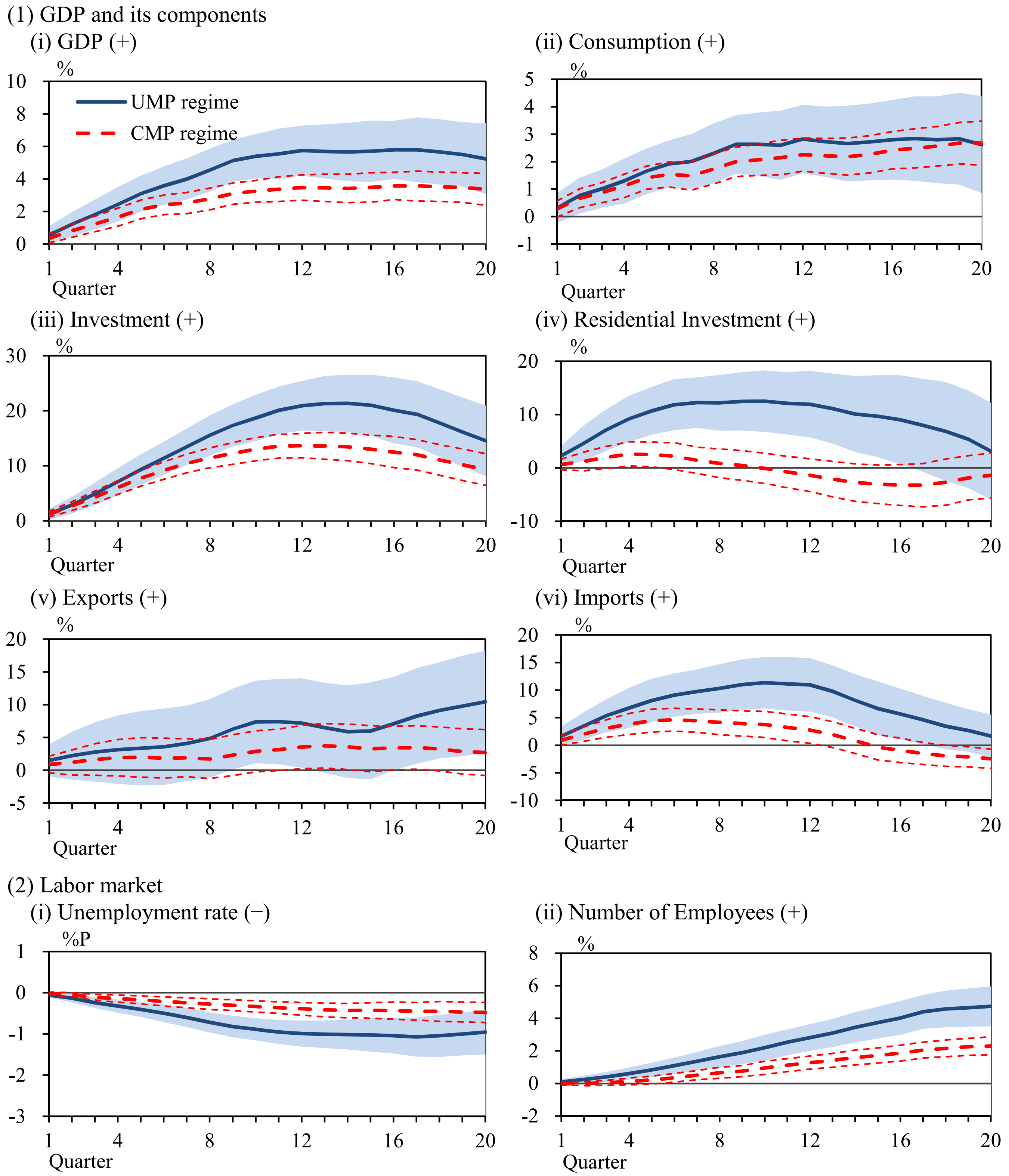


Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs. The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock during the CMP period.

2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is, on average over 20 quarters, significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, "National Accounts"; Ministry of Internal Affairs and Communications,"Labour Force Survey," etc.

Appendix Figure C5: Estimation with Other Identification Assumption



Notes: 1. The figure shows the impulse response of a variable to an expansionary monetary policy shock.
The vertical axis denotes the percentage deviation of the variable after a monetary policy shock occurs.
The solid lines are the point estimates and the shaded areas are the 95% confidence intervals of the estimates regarding a response to a shock during the UMP period. The bold dashed lines in red are the point estimates and the light dotted lines are the 95% confidence intervals of the estimates regarding a response to a shock during the CMP period.
2. "+" ("−") denotes that the response of the variable to a monetary policy shock during the period of the UMP regime is, on average over 20 quarters, significantly more positive (less positive) than that under the period of the CMP regime at a 5% significance level.

Sources: Cabinet Office, “National Accounts”; Ministry of Internal Affairs and Communications,“Labour Force Survey,” etc.

Table A: List of Variables Used for Extracting Latent Factors

Descriptions appearing in the table are as follows:
"Trans" -The transformation code.
The transformation codes are: 0 - no transformation; 1 - first difference of logarithm;
"SA" - Seasonal adjustment code (1=seasonally adjusted, 0=not adjusted)

No.	Data Description	Trans	SA
Real output and income			
1	GDP, Real gross domestic expenditure (GDE=GDP)	1	1
2	GDP, Private final consumption expenditure	1	1
3	GDP, Private residential investment	1	1
4	GDP, Private non-residential investment	1	1
5	GDP, Government final consumption expenditure	1	1
6	GDP, Public fixed capital formation	1	1
7	GDP, Real exports	1	1
8	GDP, Real imports	1	1
9	GDP gap	0	1
10	Industrial Production, Production (2010=100)	1	1
11	Industrial Production, Shipment (2010=100)	1	1
12	Industrial Production, Inventories (2010=100)	1	1
13	Industrial Production, Capacity utilization	1	1
14	Industrial Production, Production by industry, Iron and steel	1	1
15	Industrial Production, Production by industry, Nonferrous metals	1	1
16	Industrial Production, Production by industry, Fabricated metals	1	1
17	Industrial Production, Production by industry, Transport equipment	1	1
18	Industrial Production, Production by industry, Chemicals	1	1
19	Industrial Production, Production by industry, Foods and Tobacco	1	1
20	Industrial Production, Production by industry, Textiles	1	1
21	Industrial Production, Capacity utilization by industry, Iron and steel	0	1
22	Industrial Production, Capacity utilization by industry, Nonferrous metals	0	1
23	Industrial Production, Capacity utilization by industry, Fabricated metals	0	1
24	Industrial Production, Capacity utilization by industry, Transport equipment	0	1
25	Industrial Production, Capacity utilization by industry, Chemicals	0	1
26	Industrial Production, Capacity utilization by industry, Textiles	0	1
Consumption			
27	Consumption of households, Durable goods	1	1
28	Consumption of households, Semi-durable goods	1	1
29	Consumption of households, Non-durable goods	1	1
30	Consumption of households, Services	1	1
Housing starts			
31	Housing starts	1	1
Labor inputs			
32	Labor Force Survey, Labor force population	1	1
33	Labor Force Survey, Number of employed	1	1
34	Labor Force Survey, Number of employee	1	1
35	Labor Force Survey, Unemployment rate	0	1
36	Employment referrals for general workers, Active job openings-to-applicants ratio	0	1
Earnings			
37	Monthly labor survey, Total cash earnings (deflated by the GDP deflator)	1	1
38	Monthly labor survey, Scheduled cash earnings (deflated by the GDP deflator)	1	1
39	Monthly labor survey, Non-scheduled cash earnings (deflated by the GDP deflator)	1	1

No.	Data Description	Trans	SA
Price indices			
40	Urban land price index of six large city areas, Commercial (deflated by the GDP deflator)	1	0
41	Urban land price index, Nationwide, excluding six large city areas, Commercial (deflated by the GDP deflator)	1	0
42	Urban land price index of six large city areas, Residential (deflated by the GDP deflator)	1	0
43	Urban land price index, Nationwide, excluding six large city areas, Residential (deflated by the GDP deflator)	1	0
44	Urban land price index; Nationwide, Commercial (deflated by the GDP deflator)	1	0
45	Urban land price index; Nationwide, Residential (deflated by the GDP deflator)	1	0
46	GDP deflator	1	1
47	GDP, Private final consumption expenditure deflator	1	1
48	GDP, Private housing investment deflator	1	1
49	GDP, Real Private non-residential investment deflator	1	1
50	GDP, Real Government final consumption expenditure deflator	1	1
51	GDP, Public fixed capital formation deflator	1	1
52	GDP, Exports deflator	1	1
53	GDP, Imports deflator	1	1
54	Corporate goods price index	1	1
55	CGPI export price index (contract currency basis)	1	1
56	CGPI Import Price Index (contact currency basis)	1	1
57	CGPI by stage of demand and use, Raw materials	1	1
58	CGPI by stage of demand and use, Intermediate materials	1	1
59	CGPI by stage of demand and use, Final goods	1	1
60	CPI, overall	1	1
61	CPI excluding fresh food	1	1
62	CPI excluding imputed rent	1	1
63	CPI excluding energy and food	1	1
64	CPI, Food	1	1
65	CPI, Housing	1	1
66	CPI, Household durable goods	1	1
67	CPI, Clothes and footware	1	1
68	CPI, Medical care	1	1
69	CPI, Transportation and communication	1	1
70	CPI, Culture and recreation	1	1
71	CPI, Miscellaneous	1	1
72	The Nikkei commodity index	1	0
73	The Nikkei commodity index, Fiber	1	0
74	The Nikkei commodity index, Steel materials	1	0
75	The Nikkei commodity index, Nonferrous metals	1	0
76	The Nikkei commodity index, Lumber and wood products	1	0
77	The Nikkei commodity index, Chemicals	1	0
78	The Nikkei commodity index, Petroleum	1	0
79	The Nikkei commodity index, Pulp and papers	1	0
80	The Nikkei commodity index, Food	1	0
81	The Nikkei commodity index, Other	1	0
Stock prices			
82	Nikkei 225 (deflated by the GDP deflator)	1	0
83	TOPIX (deflated by the GDP deflator)	1	0
84	TOPIX Large-sized stocks index (deflated by the GDP deflator)	1	0
85	TOPIX Medium-sized stocks index (deflated by the GDP deflator)	1	0
86	TOPIX Small-sized stocks index (deflated by the GDP deflator)	1	0
Exchange rate			
87	Nominal effective exchange rate	1	0
88	Real effective exchange rate	1	0
Interest rate			
89	Overnight call rate	0	0
90	JGB 1-year	0	0
91	JGB 5-year	0	0
92	JGB 9-year	0	0

No.	Data Description	Trans	SA
93	JGB 9-year － JGB 1-year	0	0
94	Basic loan rate	0	0
95	Ordinary deposits and savings rate	0	0
96	Short-term prime lending rates of banks	0	0
97	Long-term prime lending rates of banks	0	0
98	Average contract rate on Total loans, discounts, City banks	0	0
99	Average contract rate on total loans, discounts, Regional banks	0	0
100	Average contract rate on total loans, Discounts, Regional banks II	0	0
101	Average contract rate on total loans, discounts, Shinkin banks	0	0
102	Average contract interest rates on loans and discounts, Domestically licensed bank, short-term	0	0
103	Average Interest Rates on Time Deposits by Maturity, 3-month	0	0
104	Net interest margin (defined as the difference between 102 - 103)	0	0
Money and credit quantity aggregates			
105	Monetary base (deflated by the GDP deflator)	1	1
106	Monetary stock, M1 (average amounts outstanding, deflated by the GDP deflator)	1	1
107	Monetary stock, M2 (average amounts outstanding, deflated by the GDP deflator)	1	1
108	Tokyo Shoko Research, LTD, Corporate bankruptcies, Number of cases	1	1
109	Tokyo Shoko Research, LTD, Corporate bankruptcies, Amount of liabilities (deflated by the GDP deflator)	1	1
110	Loans and Discounts Outstanding by Sector, Total	1	1
111	Loans and Discounts Outstanding by Sector, Construction	1	1
112	Loans and Discounts Outstanding by Sector, Electricity, gas, heat supply, and water	1	1
113	Loans and Discounts Outstanding by Sector, Real estate	1	1
114	Loans and Discounts Outstanding by Sector, Manufacturing	1	1
Business conditions			
115	TANKAN, Business conditions, Large enterprises, Manufacturing, Actual result	0	0
116	TANKAN, Business conditions, Medium-sized enterprises, Manufacturing, Actual result	0	0
117	TANKAN, Business conditions, Small enterprises, Manufacturing, Actual result	0	0
118	TANKAN, Business conditions, Large enterprises, Nonmanufacturing, Actual result	0	0
119	TANKAN, Business conditions, Medium-sized enterprises, Nonmanufacturing, Actual result	0	0
120	TANKAN, Business conditions, Small enterprises, Nonmanufacturing, Actual result	0	0
121	TANKAN, Business conditions, All enterprises, All industries	0	0
122	TANKAN, Business conditions, All enterprises, Manufacturing, Actual result	0	0
123	TANKAN, Business conditions, All enterprises, Textiles, Actual result	0	0
124	TANKAN, Business conditions, All enterprises, Lumber & wood products, Actual result	0	0
125	TANKAN, Business conditions, All enterprises, Pulp & paper, Actual result	0	0
126	TANKAN, Business conditions, All enterprises, Chemicals, Actual result	0	0
127	TANKAN, Business conditions, All enterprises, Petroleum & Coal products, Actual result	0	0
128	TANKAN, Business conditions, All enterprises, Ceramics, Stone & Clay, Actual result	0	0
129	TANKAN, Business conditions, All enterprises, Iron & Steel, Actual result	0	0
130	TANKAN, Business conditions, All enterprises, Nonferrous metals, Actual result	0	0
131	TANKAN, Business conditions, All enterprises, Food & Beverages, Actual result	0	0
132	TANKAN, Business conditions, All enterprises, Processed metals, Actual result	0	0
133	TANKAN, Business conditions, All enterprises, Electrical machinery, Actual result	0	0
134	TANKAN, Business conditions, All enterprises, Transportation machinery, Actual result	0	0
135	TANKAN, Business conditions, All enterprises, Other manufacturing, Actual result	0	0
136	TANKAN, Business conditions, All enterprises, Nonmanufacturing, Actual result	0	0
137	TANKAN, Business conditions, All enterprises, Construction, Actual result	0	0
138	TANKAN, Business conditions, All enterprises, Real estate, Actual result	0	0
139	TANKAN, Business conditions, All enterprises, Wholesaling & Retailing, Actual result	0	0
140	TANKAN, Business conditions, All enterprises, Wholesaling, Actual result	0	0
141	TANKAN, Business conditions, All enterprises, Transport & Postal activities, Actual result	0	0
142	TANKAN, Business conditions, All enterprises, Electric & Gas utilities, Actual result	0	0
143	TANKAN, Business conditions, All enterprises, Mining & Quarrying of stone and gravel, Actual result	0	0
Financial conditions			
144	TANKAN, Lending attitude, Large enterprises, Manufacturing, Actual result	0	0
145	TANKAN, Lending Attitude, Large enterprises, Nonmanufacturing, Actual result	0	0

No.	Data Description	Trans	SA
146	TANKAN, Lending Attitude, Medium-sized enterprises, Manufacturing, Actual result	0	0
147	TANKAN, Lending Attitude, Medium-sized enterprises, Nonmanufacturing, Actual result	0	0
148	TANKAN, Lending Attitude, Small enterprises, Manufacturing, Actual result	0	0
149	TANKAN, Lending Attitude, Small enterprises, Nonmanufacturing, Actual result	0	0
150	TANKAN, All Enterprises, Financial Institution Loan Policy, Actual result	0	0
151	TANKAN All Enterprises, Financial Position, Actual result	0	0
Financial statements of financial institutions			
152	Flow of Funds, Liabilities, Equity and investment fund shares, Domestically licensed banks, Stock	1	0
Financial statements of nonfinancial institution			
153	Liabilities, Equity and investment fund shares, Private nonfinancial corporations, Stock	0	1
154	Financial statements statistics of corporation, Large enterprises, Manufacturing, Investment, Sales	0	1
155	Financial statements statistics of corporation, Medium and small enterprises, Manufacturing, Investment, Sales	0	1
156	Financial statements statistics of corporation, Large enterprises, Nonmanufacturing, Investment, Sales	0	1
157	Financial statements statistics of corporation, Medium and small enterprises, Nonmanufacturing, Investment, Sales	0	1
158	Financial statements statistics of corporation, Large enterprises, Manufacturing, Current profit, Sales	0	1
159	Financial statements statistics of corporation, Medium and small enterprises, Manufacturing, Current profit, Sales	0	1
160	Financial statements statistics of corporation, Large enterprises, Nonmanufacturing, Current profit, Sales	0	1
161	Financial statements statistics of corporation, Medium and small enterprises, Nonmanufacturing, Current Profit, Sales	0	1
162	Financial statements statistics of corporation, Large enterprises, Manufacturing, Borrowings, Total assets	0	1
163	Financial statements statistics of corporation, Medium and small enterprises, Manufacturing, Borrowings, Total assets	0	1
164	Financial statements statistics of corporation, Large enterprises, Nonmanufacturing, Borrowings, Total assets	0	1
165	Financial statements statistics of corporation, Medium and small enterprises, Nonmanufacturing, Borrowings, Total assets	0	1
166	Financial statements statistics of corporation, Large enterprises, Manufacturing, Interest rate and discounting expenses, Borrowings	0	1
167	Financial statements statistics of corporation, Medium and small enterprises, Manufacturing, Interest rate and discounting expenses, Borrowings	0	1
168	Financial statements statistics of corporation, Large enterprises, Nonmanufacturing, Interest rate and discounting expenses, Borrowings	0	1
169	Financial statements statistics of corporation, Medium and small enterprises, Nonmanufacturing, Interest rate and discounting expenses, Borrowings	0	1

Table B: Results of Structural Break Test

h =2	h =4	h =8	h =12	h =16	h =20	Avg.
1992Q4	1995Q4	1990Q2	1990Q1	1990Q1	1990Q1	1991Q3

Note: Results of the structual test of Bai and Perron (2003), under the assumption that there exists one structural break during the sample period.