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Japan's Monetary Policy: A Literature Review and Empirical Assessment*

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Abstract

This study reviews and assesses the monetary policy implemented by the Bank of Japan (BOJ), focusing on policies that employ short-term interest rates as the operational target. Our review of empirical studies on monetary policy that influenced the BOJ's policy reveals that they focused on (1) banking system and interest rate mechanisms, (2) financial deregulation and monetary aggregates, (3) the systematic reaction regarding the achievement of the ultimate goal, and (4) confirming how certain evidence serves as material for policy judgments and communication with the public. Our empirical results on the causal effect of monetary policy in the framework of a structural vector autoregressive model attest to the significant impact of Japan's monetary policy on the financial market and macroeconomy from the 1980s onward. Our counterfactual simulations affirm that the central bank should consistently shift its policy stance to achieve macroeconomic stability. Even small policy rate cuts in a low-interest-rate environment make significant contributions to economic recovery.

Keywords: Japanese macroeconomy, Short-term interest rate, Causal effect of monetary policy, Counterfactual simulation, Vector autoregressive model.

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1 Introduction

The empirical assessment of monetary policy transmission is a long-standing issue for contemporary policymakers and researchers in the field of quantitative monetary economics. While various studies examine how monetary policy affects the economy using real-world data, a consensus has yet to be reached. The economic impacts of a policy are challenging to assess through empirical means in any economy, including that of Japan. The difficulty of empirical policy assessment in Japan can be easily confirmed by the data, especially in recent years.

Monetary policy contributes to the rapid economic development of underdeveloped countries by supplying ample credit. Figure 1 shows that Japan experienced high economic growth and inflation in the three decades of economic development following the 1950s, with lulls during the oil shocks of 1973 and 1979. Japan still enjoyed good macroeconomic performance throughout the 1980s to the beginning of 1990; real GDP grew by approximately 5 percent per year, and inflation was mild. Japan's success in catching up to the advanced economies was supported by the provision of sufficient bank credit and money supply even when short-term interest rates were high. Table 1 shows that the rate of real GDP growth was strongly associated with the growth of money stock and bank credit during that period. The monetary policy of the Bank of Japan (BOJ) prior to and during the 1980s was successful in supplying credit for economic development.[1]

Table 1: Comparison of split-sample correlation coefficients for four-quarter growth of real money stock, bank credit, and GDP.

Sample period	1975Q1–1984Q4	1985Q1–1993Q4	1994Q1–2019Q1
Correlation between			
Money stock and Bank credit	0.96	0.94	0.09
	[0.00]	[0.00]	[0.35]
Money stock and GDP	0.73	0.81	0.13
	[0.00]	[0.00]	[0.20]
Bank credit and GDP	0.68	0.83	0.20
	[0.00]	[0.00]	[0.04]

Notes: This table reports the Pearson's correlation coefficients between two variables. The numbers in brackets are p-values for testing the null hypothesis that two variables are uncorrelated.

After becoming a major developed country in 1985, Japan experienced overheated economic

[1] As Shizume (2018) describes, the ultimate goal of monetary policy in Japan from the late 19th century through the 1970s was to provide credit for development.

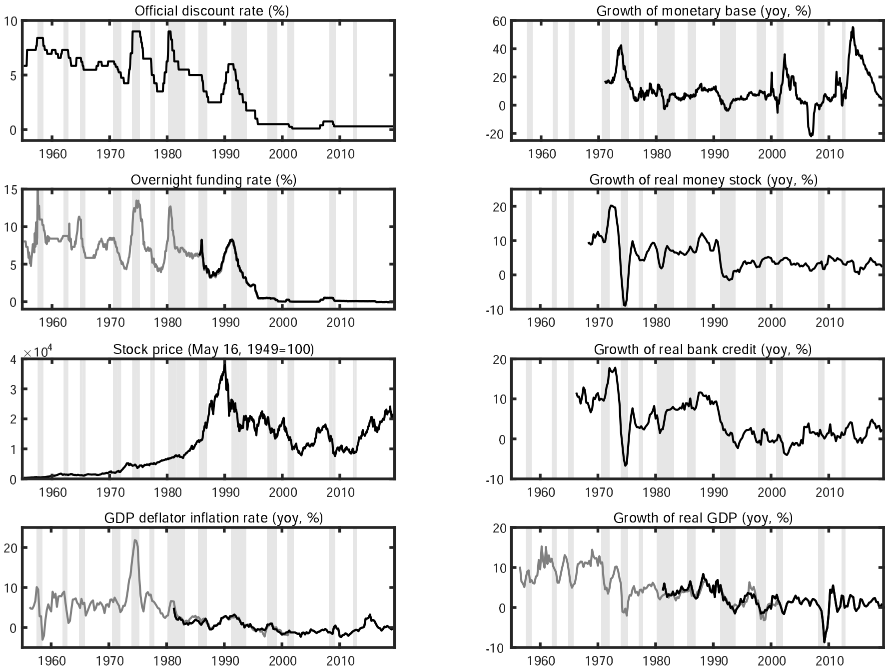

Figure 1: Financial market and macroeconomy in postwar Japan

Notes: The sample period depends on the data availability. The official discount rate is from January 1955 through March 2019. The growth of the monetary base is from January 1971 through March 2019. The collateralized and uncollateralized overnight funding rate (call market rate) is from January 1955 through April 2016 and July 1985 through March 2019, respectively. The growth of the money stock is from January 1968 through March 2019. The stock prices are from January 1955 through March 2019. The growth of bank credit is from the 1st quarter of 1964 through the 1st quarter of 2019. The GDP deflator inflation rate and the growth of the real GDP calculated based on the system of national accounts compiled according to 1968 SNA, 1993 SNA, and 2008 SNA are from the 1st quarter of 1956 through the 1st quarter of 2001 and the 1st quarter of 1981 through the 1st quarter of 2019, respectively. The dark gray lines in the middle left panel indicate the time series of the collateralized overnight call market rate and the black lines indicate the time series of the uncollateralized overnight call market rate. The dark gray lines in the panels on the lower left and right indicate the values based on the 1968 SNA and the black lines indicate the values based on the 1993 SNA and 2008 SNA. The shaded areas show periods of recession in Japan, as defined by the Cabinet Office.

activity, from an asset price bubble to a long-lasting economic stagnation with sluggish monetary conditions. The Japanese bubble expanded rapidly in the second half of the 1980s, culminating in the peaking of the Nikkei 225 Stock Index at almost 40,000 yen by the end of 1989. Then, the bubble burst, with a sudden collapse of stock prices at the beginning of 1990. The event was a hard hit to the monetary and macroeconomic conditions of Japan: growth rates of the real money stock, bank credit, and GDP sharply rose and fell together over the 1985–1993 period. Japan suffered through a long period of economic stagnation after the end of the recession caused by the bubble burst. The growth rates of real bank credit and GDP both average less than 1 percent, which was far below their levels before 1993. The relationship between monetary and macroeconomic conditions also seems to have vanished during the period of economic stagnation. Table 1 shows that correlation coefficients for four-quarter growth of real money stock, bank credit, and GDP after 1993 are only 0.09, 0.13, and 0.20, respectively, much less than what they were before 1993.

Moreover, the coexistence of economic boom/stagnation and a sequence of short-term interest rate hikes and cuts (see Figure 1) seems to raise concerns about the effectiveness of monetary policy.[2] Table 2 presents simple linear regressions of real money stock, bank credit, and GDP on the overnight funding rate using three subsamples: 1970 to 1984, 1985 to 2001, and 2001 to the end of the sample. The relationship between money stock, bank credit, real output, and the short-term interest rate before 1985 is consistent with what economic theory predict typically: the decrease in the short-term interest rate, which implies expansionary monetary policy, is associated with increases in the future money supply, bank credit, and real output. This relationship, however, has been unstable since 1985: the estimated coefficients of the short-term interest rate on the future money stock, bank credit, and real output are either contrary to the theory or statistically insignificant.

Table 2 does not necessarily demonstrate that monetary policy is no longer effective. The systematic policy response to economic conditions dramatically complicates efforts to discern the causal effects of policy on the economy. In practice, many central banks systematically decide their policy stance to maintain macroeconomic stability. Specifically, the BOJ lowered its short-term interest rate in response to the economic downturn caused by the bubble burst. If the monetary policy was effective, it could be expected to mitigate the fall in GDP growth. We also find that the short-term interest rate had either a positive association with real GDP growth or no association. To assess the effectiveness of the monetary policy, we specify the causal relationship between the policy actions and outcomes by thoroughly disentangling the systematic responses of the types and the other components (i.e., the so-called "shocks" of monetary policy). The empirical literature strives to advance the methodology for measuring the effect of a monetary policy "shock" in the presence of systematic responses to the economy.

[2]Empirical studies such as Miyao (2000), Fujiwara (2006), Inoue & Okimoto (2008), and Nakajima *et al.* (2011) note a structural change in the role of Japanese monetary policy during the 1990s and a loss of policy power due to a breakdown in the channel of transmission between short-term interest rate adjustments and the real economy. However, Honda & Kuroki (2006) and Shibamoto (2016) argue that we would underestimate the policy impacts if the empirical models failed to control for the market expectation of the monetary policy stance. Moreover, they find that Japan's monetary policy still influences the financial market and real economy significantly even after the 1990s.

Table 2: Comparison of coefficient estimates from split-sample linear regression models, regressing four quarters ahead of the real money stock, bank credit, and GDP on the overnight funding rate.

Sample period	1970Q1–1984Q4	1985Q1–2001Q1	2001Q2–2019Q1
Dependent: 4 quarters ahead of			
Money stock	-10.62	-3.48	-12.49
	(4.74)	(2.18)	(12.93)
Bank credit	-10.55	2.69	19.94
	(4.69)	(2.74)	(21.41)
GDP	-5.82	2.44	-20.37
	(2.01)	(2.93)	(10.79)

Notes: The dependent variable is four quarters ahead of the log of real money stock, real bank credit, and real GDP (1968SNA for sample 1970Q1-1984Q4 and 1993SNA/2008SNA for 1985Q1-2001Q1 and 2001Q2-2019Q1) times 400. The independent variable is the overnight funding rate (collateralized overnight call rate for 1970Q1-1984Q4 and 1985Q1-2001Q1, uncollateralized overnight call rate for 2001Q2-2019Q1). The constant and one- to four-quarter lags of each variable of interest and overnight funding rate are included as control variables in the linear regression model. The numbers in parentheses are Newey & West (1987) heteroskedasticity and autocorrelation robust standard errors for least squares with a four-quarter lag truncation. Coefficients and standard errors for the control variables are not reported.

This study aims to contribute to the empirical literature on Japan's monetary policy in two different ways. First, we introduce the historical background of empirical studies on Japan's monetary policy to researchers in broad-ranging fields, including computational social science. Next, we assess the recent development of monetary policy using the standard empirical methodology in the literature to stimulate further discussion on the role of monetary policy in developed countries that face policy response challenges in the aftermath of extraordinary shocks such as the bursting of the Japanese bubble economy or the 2008 global financial crisis in a low-interest-rate environment.

The rest of this paper is organized as follows. Section 2 reviews the empirical studies on Japan's monetary policy retrospectively and considers the historical and economic background of the study. Section 3 presents an overview of Japan's macroeconomy and monetary policy since the 1980s. Section 4 describes the empirical model employed to make causal inferences on the effect of monetary policy and reports the empirical results. Section 5 conducts counterfactual simulations based on our empirical model to provide lessons for monetary policy strategy according to Japan's experience since the 1980s. Section 6 concludes. The Appendix provides detailed definitions of the variables and data sources.

2 A historical review of empirical studies that affected the BOJ's monetary policy

This section considers the empirical studies on Japan's monetary policy retrospectively to clarify how the studies examined the effectiveness of the monetary policy. It primarily considers studies by researchers who worked for or with the BOJ. While a wider range of research was conducted in academia, we consider studies that seem to have a relatively significant influence on the BOJ's policies. Our survey also considers the historical and economic background of the studies.[3]

Active empirical research on monetary policy has been conducted in Japan since the late 1960s. Intriguingly, the focus of early research was on aspects of banking behavior, such as how the BOJ's policies affected bank lending and interest rate mechanisms. By the 1980s, the mainstream focus of empirical research on monetary policy centered on the role of the money supply. While the methodology changed with techniques such as regression analysis and time series analysis, the analysis consistently focused on three variables: monetary aggregates, real GDP, and prices. Bank behavior ceased to be the explicit topic of interest in the research. On the other hand, a pioneering study was conducted on the goal of monetary policy and its policy reaction function. Currently, the BOJ has utilized empirical analyses to confirm evidence that serves as material for actual policy judgments and communication with the public.

2.1 Empirical analysis of window guidance: Special features of Japan's financial structure and effectiveness of monetary policy before the 1980s

Patrick (1962) had a significant impact in the early stages of analyzing Japan's monetary policy. Regarding Japan's financial structure, he noted that (1) banks heavily borrowed from the BOJ, (2) businesses relied on borrowing from banks, and (3) interest rates were rigid.[4] Thus, he concluded that monetary policy was effective by (1) and (2) but not necessarily by (3). Royama (1971) highlighted that simply applying a Keynesian macroeconomic model was misleading in situations where indirect finance was overwhelming, and interest rates were rigid.

[3]See also Ito & Hoshi (2020) on the history of the Japanese financial market and monetary policies.

[4]Japanese commercial banks consist of a small number of large city banks based in urban areas and a large number of relatively medium-sized regional banks based in rural areas. Until the 1970s, industrialization in Japan took place predominantly in urban areas and funds flowed from rural areas into urban areas which supported economic development in Japan. As Japan was a bank-dominant financial system, funds also flowed from regional banks into city banks. The city banks then financed large corporations as the main bank. For more detailed discussion on the institutional background of the banking sector in Japan, see, for example, Takahashi (2012).

The empirical analysis at that time revolved around the effectiveness of the BOJ's window guidance, a policy instrument that directly regulated bank loan volume.[5] Royama (1971) also pointed out that the Japanese business cycle relied on corporate capital investment, which in turn relied exclusively on bank loans. Hence, the appropriate approach for analyzing monetary policy effects was thought to be the bank sector model rather than the conventional macroeconomic model. Research on Japan's monetary policy emphasized direct control channels by the BOJ while de-emphasizing the interest rate mechanism (Komiya, 1964; Tachi, 1965).

However, the empirical analysis of the BOJ economist Suzuki (1966) emphasized the role of the interest rate mechanism by focusing on the interbank market (call market), where interest rates moved relatively freely. Suzuki's work made an important contribution by empirically demonstrating the effectiveness of monetary policy through the interest rate mechanism of interbank rate fluctuations, using data from 1954 to 1964. If window guidance had been the most effective monetary policy instrument, city bank lending, an activity subject to window guidance, would have fluctuated more widely. Suzuki found, however, that the lending volume of regional banks moved more flexibly than that of city banks because the interbank rate was flexible. He argued that the monetary policy at that time was affected to some extent by the interest rate mechanism. However, his findings only partially showed that the interest rate mechanism was working and did not refute the effectiveness of window guidance. These observations led Suzuki and other BOJ economists to assert that window guidance was *complementary to interest rate policy*.

In fact, subsequent empirical studies gave a negative evaluation of the effectiveness of Japan's window guidance as *an independent policy instrument*. Horiuchi (1977, 1980) emphasized the importance of a general equilibrium, rather than a partial equilibrium, perspective and reported that the effectiveness of window guidance was not significant.[6] Horiuchi's results sparked controversy over the effectiveness of window guidance because denying the effectiveness of window guidance denied the BOJ's policies at the time in the sense that the window guidance played

[5]Window guidance was a complementary measure for the BOJ's interest policy from the 1960s to the 1970s. Even within voluntary practices, city banks submitted lending plans every quarter to be approved by the BOJ, and the results were carefully monitored. However, since the 1980s, the demand for funds from large corporations has decreased due to a decline in the economic growth rate. This has caused the situation to change. See Appendix 4 in Itoh *et al.* (2015) on the development of window guidance in Japan.

[6]Horiuchi (1977, 1980) constructed a general equilibrium model where the monetary economy was divided into sectors (BOJ, government, private banks, and non-private banks) and assets (cash, government bonds, BOJ loans, interbank loans, deposits, securities, and bank loans). His empirical analysis covered the effectiveness of window guidance from 1963 to 1974. Bank lending volume was used as the dependent variable, and the interbank rate and window guidance were used as the explanatory variables.

a critical role in controlling the market interest rate. Another BOJ economist, Eguchi (1977), argued that window guidance, along with other policies, curbed lending. A dispute on this point, the so-called "Horiuchi-Eguchi Controversy," arose between academics and the BOJ. An empirical study by Furukawa (1981) on the effect of the interbank rate on bank reserves empirically showed that bank reserves were sensitive to the interbank rate, and window guidance was effective as a complementary tool to support interest rate policy.

The argument that the BOJ sought to stabilize the market interest rate by using discount window lending, as well as the open-market operation, was supported by the view that the BOJ rationed discount window lending among private banks and regulated the quantity of borrowing.[7] Credit rationing by window guidance came under renewed focus in an empirical disequilibrium analysis developed from Keynesian disequilibrium economics. In such an analysis on credit rationing in the Japanese bank loan market, Iwata & Hamada (1980) found evidence in support of the credit rationing view on the BOJ's discount-window policy.[8]

2.2 Empirical studies that influenced monetary policy in the 1980s: Emphasis on monetary aggregates and policy analysis with time-series model

The move towards empirical analysis progressed significantly in the 1980s. Several important changes took place in the course of financial liberalization and deregulation. (1) Interest rates were progressively liberalized. (2) The supply of much-needed funds in the corporate sector brought induced major changes in the money flow. (3) Corporate financing expanded beyond bank loans as the capital markets developed. These changes increased the effectiveness of the analysis in conventional macroeconomic models, and empirical analysis replaced standard macroeconomic analysis.

The most important study on monetary policy in the 1980s, given its influence, was conducted by the Bank of Japan (1975). With a sample spanning 1957 to 1974, divided into three sub-sample periods, the BOJ study showed that changes in the money stock (M2+CD) preceded

[7]Shinohara & Fukuda (1982) argued that the guidance measure could be a complementary tool to ensure a stable supply of money and bank credit because the BOJ, which sought to stabilize the market interest rates, did not practice rigid monetary base control in situations with an unstable demand for bank reserves in the short run.

[8]In the measurement period from 1960 to 1973, Iwata & Hamada (1980) found a disequilibrium in the Japanese loan market and determined that lending rates were also affected by regulatory interest rates. Furukawa (1979), however, employed data from 1960 to 1977 to show the result of denying disequilibrium. Comparing the U.S. and Japanese lending markets, Ito & Ueda (1981) found disequilibrium in both markets and determined that interest rate adjustments were slower in Japan than in the U.S.

GDP and price changes in each period. This result provided the basis for the money supply target policy, which emphasized money stock as an intermediate target in monetary policy. In fact, the BOJ has also targeted the money stock as an implicit target since 1978. For a policy targeting money stock to be effective, the demand for money must be stable. As a supplement, the Bank of Japan (1975) measured the money demand function over the 1964–1974 period.[9]

The BOJ's finding that money preceded GDP and prices was based on simple time-lagged correlations. Using a methodology proposed by Sims (1972) to test a concept of causality based on prediction, Oritani (1979) reported that changes in the money stock preceded changes in nominal GDP over the 1962–1976 period.[10] Moreover, Oritani (1981) used a three-variable time-series model of money stock, real GDP, and prices to show that changes in the money stock preceded changes in real GDP and prices over the 1956–1979 period.[11] Oritani's time series analysis thereafter leads to the vector autoregressive (VAR) analysis.

2.3 Empirical analysis of systematic monetary policy: Changes in the policy reaction function

To the best of our knowledge, the first empirical investigation of the BOJ's reaction function was a study by Kaizuka (1967) using data from the 1956–1963 sample period. The final goal of the monetary policy at the time could have been outcomes such as inflation, the economic growth rate, and the balance of payments (Dewald & Johnson, 1963). In addition to the money stock, Kaizuka (1967) also used the interbank rate, bank loan volume, and other factors. His results indicated that the BOJ conducted monetary policy by controlling the interbank rate and adjusted the interbank rate, considering the balance of payments. Moreover, its policy goal at the time was to balance the balance of payments. This result was consistent with the findings from the aforementioned study by Suzuki (1966), and the goal of balancing the balance of payments was consistent with the rules of the game under fixed exchange rates.

Subsequent empirical studies noted that the BOJ's reaction function changed in the 1970s

[9] To the best of our knowledge, the first empirical study on Japan's money demand function was Ichimura (1962). Eguchi & Sawa (1979) measured the money demand function respectively by the household and corporate sectors, considering special features of the Japanese financial structure such as the indirect financial advantage and interest rate regulation.

[10] Oritani (1979) also used the total expenditure function of the St. Louis Fed to report the precedence of the money stock to nominal GDP.

[11] Miyao (2005) employs an econometric methodology similar to that of Oritani (1981) with data extending to the end of 2003 to re-examine whether the money stock (M2+CDs) can predict future economic activity and prices. He finds that the linkage between M2 and income or prices has been unstable since the 1990s.

as the focus of its policy goal began to shift toward macroeconomic stability. When Seo & Takahashi (1982) divided the measurement period into the 1960s and 1970s, for example, they found that the bank initially had a reaction function that emphasized the external balance of payments in the 1960s. The bank then emphasized domestic factors such as the GDP and prices in the 1970s.[12]

Upon finding that the economic conditions well explained the shifts in policy stance, researchers were intrigued by the possibility that systematic and predictable monetary policy affected the economy in an important way.[13] In response to the Lucas-Sargent-Wallace (LSW) hypothesis that an anticipated change in monetary policy would not affect real output,[14] Seo & Takahashi (1982) reported a statistically significant effect of anticipated changes in monetary policy.[15] For further discussion on the LSW hypothesis, see, for instance, Hamada & Hayashi (1985), in addition to Seo & Takahashi (1982).

2.4 Empirical analysis *at battlefield* since the 1990s: Materials for policy judgment and communication

The BOJ has used market functions in implementing monetary policies under the progress of financial liberalization and deregulation since the 1980s. In practice, their progress gradually undermined the need for window guidance in Japan. Given liberalization, the BOJ can adjust the overnight funding rate freely determined in the market simply through open-market operations. The BOJ ultimately terminated window guidance in 1991. Following this, the BOJ *officially* changed monetary policy measures from those based on regulated interest rates, i.e., the official discount rates, to those based on market operation with the use of money markets and flexible interest rates. It began to guide the short-term market interest rates as an operating target for market operations in 1995, and decided to use the uncollateralized overnight call rate as a specific target for market operations in 1998.[16]

[12]Clarida *et al.* (1998), Bernanke & Gertler (1999), Jinushi *et al.* (2000), and Shibamoto (2008) describe the BOJ's behavior from the 1970s to the early 2000s by estimating the reaction function where the short-term policy rate depends on the output gap and inflation.

[13]Bernanke *et al.* (1997) and Sims & Zha (2006) propose a methodology to explore the effects of systematic monetary policy on the economy within a structural VAR framework.

[14]The term "LSW hypothesis" has been in common use since Gordon (1982).

[15]Regarding their proof, a problem of multicollinearity was highlighted (Okina, 1986).

[16]The short-term market interest rates such as the uncollateralized overnight call rate remained above the official discount rate until June 1995 due to regulatory interest rates and the BOJ's discount-window policy. In July 1995, the BOJ adopted the new framework for its operating procedures where it expected the short-term interest rates to remain below the discount rate and supplied funds to the market.

Since the end of the 1990s, the BOJ has been compelled to manage policies under low interest rates. The BOJ adopted the zero-interest rate policy (ZIRP) from February 1999 to August 2000, under which it lowered an overnight call rate to be almost zero. The BOJ adopted a quantitative monetary easing (QME) policy from March 2001 to March 2006, which is characterized as follows; it fixed the overnight call rate at almost zero percent, set the target level of the current account balances held by financial institutions at the BOJ, and committed to maintaining the policy until the CPI registers at a stable zero percent or an increase year-on-year. While it had returned to the use of the overnight funding rate as its instrument from March 2006, the BOJ adopted a comprehensive monetary easing (CME) policy in October 2010, under which it began purchasing ETFs, J-REITs, and other assets in an asset purchasing program at an overnight call rate of 0% to reduce various risk premiums. The BOJ took monetary easing one step further by introducing quantitative and qualitative monetary easing (QQE) policy in April 2013. In February 2016, the BOJ took further steps, and started a negative interest rate policy (NIRP) where it set the target level of the overnight call rate at a negative value. In September 2016, the BOJ introduced QQE with Yield Curve Control (YCC)–a program that targets both short-term and long-term policy interest rates.

The BOJ has been putting an effort to follow the development in academia to carry out empirical analyses which address the important features of the macroeconomy and monetary policies in reality. Since the 1990s, empirical research at the BOJ has been conducted by incorporating standard macroeconometric models, such as Dynamic Stochastic General Equilibrium (DSGE) models, VAR models, and finance models, as well as traditional macroeconometric models. For example, the BOJ completed a new macroeconomic model in 2003; The Japanese Economic Model (JEM). JEM is a DSGE-type econometric model that includes long-term equilibrium and short-term dynamics (Fujiwara *et al.*, 2005). This has been used for economic forecasting for policy decisions of the Bank. Additionally, the BOJ has utilized JEM and other macroeconometric models to analyze important topical issues related to its policy decisions and in preparing its economic outlook.[17]

Empirical studies using econometrics methodologies are also being conducted on ZIRP and the subsequent unconventional monetary policies by BOJ economists. For example, Ugai (2007)

[17] The Outlook for Economic Activity and Prices (the Outlook Report) presents the BOJ's outlook for developments in economic activity and prices, empirically assesses upside and downside risks, and outlines its views on the future course of monetary policy. `https://www.boj.or.jp/en/mopo/outlook/index.htm/` (Accessed November 18, 2020)

concludes in his comprehensive survey of empirical studies on QME policy from March 2001 to July 2006, that while the QME policy contributed to lowering the yield curve, the effects of QME policy in raising aggregate demand and prices were uncertain. Specifically, Ugai (2007) classifies the effects of QME policy into those on financial variables and those on real variables. Regarding the effects of the former, Baba *et al.* (2005), for example, examined the effects of commitment on financial variables by using a macro-finance model that combined a small macroeconomic model consisting of aggregate demand and supply equations and a monetary policy rule with a term structure of interest rates. They found that a commitment to maintaining a zero-interest rate for a long period affected the entire yield curve.[18] Regarding the effects of the latter in contrast, Kimura *et al.* (2003) and Fujiwara (2006) examined the QME policy effects on real economic variables by using the VAR model and argue that the effect of the increase in base money on prices, GDP, and industrial production was undetectable or was small. These empirical analyses can cause the BOJ to hesitate to inject excess reserves with fixed policy rates as a means to influence macroeconomic conditions up until the policy by the BOJ governor Mr. Haruhiko Kuroda.[19]

Currently, the BOJ has acknowledged that it is crucial to present empirical evidence to the public in conveying its intentions of the policy decisions as well as its economic outlook. In particular, regarding the QQE policy, the BOJ released a "Comprehensive Assessment" of monetary easing based on empirical analysis in September 2016 (the Bank of Japan, 2016). In this report, the BOJ expressed its view on the effectiveness of the reduction of real interest rates as a main transmission channel of QQE and the causes of the sluggish inflation and its expectations during the QQE period by using macroeconometric models including a new type of JEM, Q-JEM, and its counterfactual simulation.[20] Then, the BOJ decided to introduce the YCC policy and "inflation-overshooting commitment" where the BOJ committed itself to

[18] Additionally, Okina & Shiratsuka (2004) and Oda & Ueda (2007) report that the QME policy, which committed itself to the actual movement of the CPI, had a significant effect on lowering the yield curve.

[19] In fact, Mr. Masaaki Shirakawa, the former governor of the BOJ, mentioned the QME policy effects on aggregate demand and prices as follows (Shirakawa, 2010):

> Empirical studies on Japan mostly show that quantitative easing produced significant effects on stabilizing the financial system, while it had limited effects on stimulating economic activity and prices.

[20] The Bank of Japan (2016) pointed out that (1) the reduction of real interest rates due to QQE programs was effective in alleviating deflation, (2) exogenous factors, such as the decline in crude oil prices, the weakness in demand following tax hikes in April 2014, and the slowdown in emerging economies and volatile global financial markets have lowered the observed inflation, and (3) inflation expectations weakened because expectations formation in Japan is largely backward-looking. See also Kan *et al.* (2016) and Hirakata *et al.* (2019) for details.

keeping an accommodative monetary policy stance until the CPI inflation exceeds the price stability target of 2 percent and stays above the target in a stable manner.

3 Japan's conventional monetary policy

This section describes Japanese time-series data to present an overview of the macroeconomy and monetary policies since the 1980s. Specifically, we briefly summarize final and operational targets for monetary policies. Additionally, we provide evidence of the stable money demand relationship to show that the BOJ can affect the money market conditions by changing short-term policy rates in the implementation of conventional monetary policy.

3.1 Final and operational targets for Japan's monetary policy since the 1980s

The BOJ, like the central banks in many other advanced countries, implements monetary policy to maintain price stability. Both academics and policymakers share the belief that stable prices play a critical role in enhancing both economic growth and economic stability. As Shizume (2018) reports in his review, the primary goal of Japan's monetary policy is to maintain macroeconomic stability since the country achieved industrialization and became a leading economic power in the 1980s.

To begin explaining the evolution of macroeconomic stability in Japan, we consider the behavior of the output gap and inflation during the last 40 years. The left panel of Figure 2 shows the time series of the real GDP gap, defined as a percentage difference between the actual level of the real GDP and the potential level estimated by the Cabinet Office from 1980 to 2019. The right panel shows the time series of core consumer price index (CPI; all items less fresh food) inflation, a measure the BOJ refers to as a metric for price stability. The shaded areas show periods of recession in Japan, as defined by the Cabinet Office.

The Japanese economy rapidly expanded in the 1980s following the great inflation by the oil crisis. It then underperformed from the early 1990s up to the middle of the 2000s. Japan's real GDP level fell below its potential at the end of 1992, several years after the burst of the bubble economy, and remained stagnant with little recovery in sight (left panel of Figure 2). Meanwhile, other advanced countries experienced sustained economic growth under the Great Moderation.[21] The long-lasting negative or low output gap moved in step with the downward

[21] The Great Moderation was a sharp reduction in the volatility of both inflation and output growth in developed

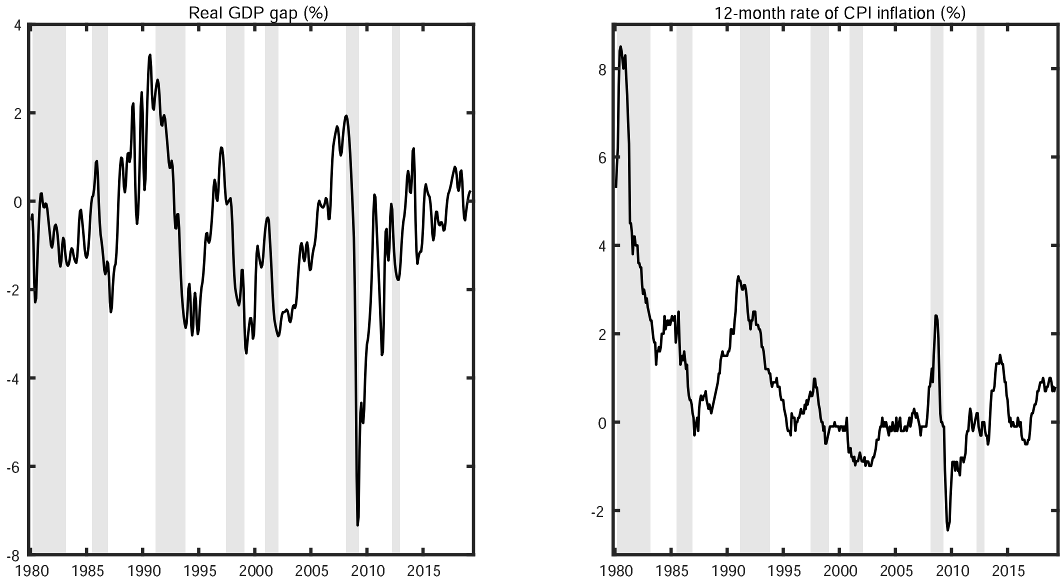

Figure 2: Real GDP gap and core CPI inflation in Japan since the 1980s

Notes: Real GDP gap (percent, left panel) and core CPI inflation (percent, right panel) from January 1980 to March 2019. The shaded areas show periods of recession in Japan, as defined by the Cabinet Office.

trend in CPI inflation. CPI inflation fell sharply from three percent at the end of 1990 to below 1 percent after 1994, and the decline persisted to the end of the decade, pausing only briefly in around 1996 (right panel of Figure 2).[22] We can see that the BOJ failed to achieve its objective of price stability throughout this protracted downturn.

Japan's economic recovery in the mid-2000s came to a dramatic halt with the outbreak of the global financial crisis in 2008. However, the economy rebounded from the downturn more quickly than it did from the long-lasting recession after the burst of the bubble in the 1990s. Japan's real GDP level fell below its potential in the fourth quarter of 2008 and troughed at almost seven percent below the potential in the first quarter of 2009, thus showing its largest decline since 1980 (left panel of Figure 2). The duration of the recession, however, was moderate in comparison with the great depth of the downturn. Real GDP stayed around the level of potential after the 2nd quarter of 2009, with only two interruptions: the Great East Japan Earthquake

countries, such as the U.S., the Euro area, and the U.K., from the mid-1980s to the global financial crisis in 2007. In their investigation of the sources of volatility changes in economic activity in the G7, Stock & Watson (2005) suggest that a significant portion of the widespread reduction in volatility is associated with a reduction in the magnitude of the common international shocks in all of the G7 economies but Japan. They find that the cyclical fluctuations in the Japanese GDP during the 1980s and 1990s are almost detached from those of other G7 economies, with domestic shocks explaining almost all movements.

[22]This period is often termed as the "great recession" (Kuttner & Posen, 2001) and "lost decade" (Hayashi & Prescott, 2002).

and tsunami in 2011 and a temporary economic downturn in 2012.[23][24] These features of the recession following the global financial crisis diverge from those seen in the post-bubble recession of the 1990s. CPI inflation fell sharply to less than minus two percent in mid-2009 but bounced back to zero in the middle of 2011. This behavior suggests that the BOJ may have significantly contributed to early recovery from the severe economic downturn.

Next, we consider the behavior of the short-term policy rate as an operational target for conventional monetary policy. As Okina (1993), Ueda (1993), Miyao (2002a) and others note in their institutional discussions, the BOJ has attempted to control the overnight funding rate in the interbank market (overnight call market rate).

In practice, the overnight funding rate can be considered a *de facto* policy instrument through the market mechanism. *Technically* it is uncertain whether the overnight funding rate can be considered a policy instrument as the lever under the BOJ's *direct* control. The call market is the interbank market where financial institutions transact their reserves at the BOJ. Therefore, the call market rate is determined by a supply-demand equilibrium in the market. This is different from other policy instruments, such as window guidance, official discount rate, the interest rate on reserves, the reserve supply, and the asset purchases the BOJ *directly* control. However, the BOJ has a strong influencing power on the call market rate by adjusting the reserve supply through open market operation[25] and establishing the corridor by the official discount rate at the ceiling and the interest rate on (part of) excess reserves at the floor. The market participants in the interbank market fully acknowledge this power and have the expectation with confidence that, if the call market rate deviated from its operational target, the BOJ would intervene in the market to achieve the target. This implies that the BOJ influences the demand in the reserve market as well as the reserve supply. As a result, it is possible for the BOJ to *indirectly* control the call market rate by preventing large and persistent deviations from the target through the open *mouth* operation with the help of its strong power and the expectation, not necessarily through the open *market* operation.[26]

[23]The Great East Japan Earthquake and the resulting tsunami hit the Tohoku area on March 11, 2011, which triggered the meltdown at the Fukushima Daiichi nuclear power plant. This disaster caused serious damage over multiple prefectures; the Cabinet Office estimated the direct financial damage from the disaster, as of June 2011, to be approximately 16.9 trillion yen. `https://www.reconstruction.go.jp/english/topics/GEJE/` (Accessed November 16, 2020)

[24]The Economic and Social Research Institute within the Cabinet Office determined that the Japanese economy fell into recession from May to November 2012 based on the coincident index of the business condition indicators.

[25]See Hayashi (2001) and Uesugi (2002) for the empirical evidence that supports the existence of liquidity effects in the call market in Japan.

[26]See Guthrie & Wright (2000) and Friedman & Kuttner (2010) for more discussion on how central banks set

While it has multiple policy instruments in implementing monetary policy, the BOJ has adjusted the overnight funding rate as a key policy instrument to signal its stance of conventional monetary policy. In particular, the BOJ *officially* used the uncollateralized overnight call rate as a policy instrument from September 9, 1998 to March 19, 2001; July 14, 2006 to October 5, 2010; and from February 2016 to the end of the sample period. On the other hand, the BOJ often uses other instruments; The BOJ mainly used the official discount rate from the 1970s to September 8, 1995. The BOJ used the current account balances it holds as a QME scheme from March 19, 2001 to July 13, 2006. The BOJ used the number of unconventional asset purchases as a CME program from October 5, 2010 to April 4, 2013. The BOJ used the amount of monetary base and unconventional asset purchases as a QQE program from April 5, 2013 to the present. Also, the BOJ used the 10-year Japanese government bond yield from September 21, 2016 to the end of the sample period. In practice, however, the BOJ has generally controlled the overnight funding rate with a great deal of precision over time. This control implies that the overnight funding rate can be regarded as a useful indicator of the monetary policy stance in Japan.

In fact, the overnight funding rate is a good measure of the monetary policy stance over time. Figure 3 shows the time series of the overnight funding rate (uncollateralized overnight call rate) in Japan from 1980 through 2019. The dark- and light-shaded areas respectively show months that coincide with policy decisions to tighten and expand monetary conditions. Regardless of the different policy instruments, we can confirm that the overnight funding rate rises and falls immediately after the tightening and expanding decisions by the BOJ.

As previous studies such as Clarida *et al.* (1998), Bernanke & Gertler (1999), Jinushi *et al.* (2000), and Shibamoto (2008) argue, the BOJ systematically changes the overnight funding rate target in response to the economic condition. In particular, the BOJ lowered the overnight funding rate from eight to 0.5 percent over the period from July 1991 to September 1995, thus maintaining an accommodative policy stance in response to the economic recession following the burst of the bubble economy. The BOJ also implemented a monetary easing policy in the wake of the global financial crisis at the end of 2008. However, there was only a small change in the overnight funding rate from 0.5 to 0.1 percent, with little room to cut the rate in the low-interest-rate environment.

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the policy rate.

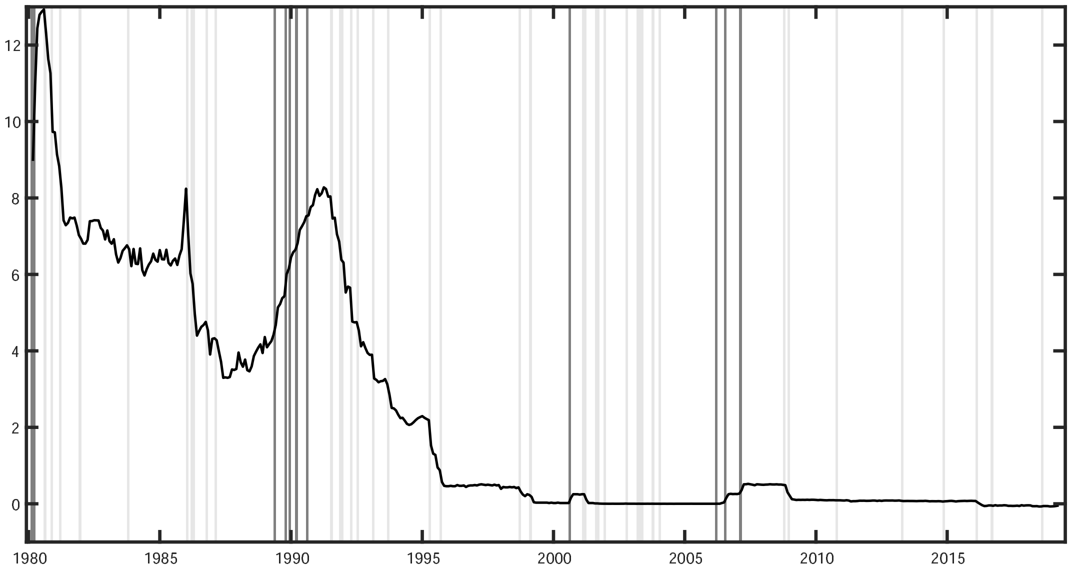

Figure 3: Overnight funding rate in Japan

Notes: Uncollateralized overnight funding (call market) rate (monthly average, percent) from January 1980 to March 2019. We calculate it backward for the period before June 1985 using the monthly change in the collateralized overnight call rate from February 1980 to July 1985. The dark- and light-shaded areas show the months coinciding with tightening and easing policy decisions, respectively.

Two caveats are notable when dealing with the overnight funding rate as a measure of the monetary policy stance in Japan. First, the overnight funding rate should be regarded as a measure of the *conventional* monetary policy stance. In addition to pursuing a conventional short-term interest rate policy, the BOJ eased monetary conditions further using *unconventional* policy instruments such as excess reserve injections and large-scale unconventional asset purchases since the beginning of the 2000s. Figure 3 shows that some of the changes in the policy stance are not necessarily reflected in the overnight funding rate over the following periods: the QME period from March 2001 to July 2006, the CME period from October 2010 to March 2013, and the QQE period from April 2013 to the end of the sample period. In the next section, we empirically assess the role of the conventional monetary policy by quantifying the causal effect of the short-term interest rate policy.

Second, as Figure 3 shows, the fluctuation in the short-term rate from the end of the 1990s was relatively small compared with that before. When dealing with the macroeconomic data from the 1980s to the end of the sample period, we consider the specification of the econometric model to account for the non-linear relationship between the macroeconomic variables and the short-term interest rate stemming from the low-interest-rate environment.

3.2 Role of short-term interest rate in the money market

Conventional monetary policy plays an essential role in the money market. Central banks can make monetary policy by managing the short-term interest rates representing money market conditions, rather than controlling the quantity of the money stock.[27] They can allow the money stock to fluctuate in response to the current state of the economy. Given a level of operational targets of the short-term policy rates, the money stock can be adjusted to restore a long-run equilibrium in the money market when unpredictable fluctuations hit the economy.[28] Changes in the interest rate target can lead to changes in the conditions for equilibrium in the money market.

In this subsection, we provide time-series evidence in the money market related to Japan's monetary policy. Specifically, following Miyao (2002b), Bae *et al.* (2006), and Nakashima (2009), we show some empirical results that suggest there exists a stable long-run relationship between the short-term policy rate, the money stock, the real output, and the price level over the period including the low-interest-rate environment.[29]

Although commercial banks themselves create it, central banks can influence the quantity of money stock by changing the price of money, that is, interest rates. As described in standard textbooks in economics, such as Mankiw (2010), the liquidity preference theory allows the demand for money held to depend on the interest rate. It is based on the assumption that households allocate their wealth either to an interest-bearing asset (bonds) or to a non-interest-bearing asset (money). Since holding wealth as money requires forgoing the returns on other assets, such as bonds, the nominal interest rate is the opportunity cost of holding money. Consequently, by raising the cost of holding money, an increase in the nominal interest rate will lead people to economize on their cash holdings.

The liquidity preference theory suggests the following function relating the demand for

[27] In practice, especially since the 1990s, the BOJ has not considered monetary aggregates as an instrument and neither as a final or operational target for monetary policy, including the period under a low-interest-rate environment.

[28] On the other hand, as Poole (1970) theoretically describes, if money demand is highly volatile, fixing the money stocks under the target would result in much variability in the real interest rate, and this will translate into more variance in the real economy.

[29] Miyao (2002b), Bae *et al.* (2006), and Nakashima (2009) find a stable long-run relationship between the real money-income ratio and the log of the short-term interest rate during their sample periods, including when the low-interest-rate period that persisted in Japan from 1995 onward is included.

money stock, MS^d, to income, Y, and (short-term) nominal interest rate SR,

$$MS^d = PM^d(Y_{(+)}, SR_{(-)}), \tag{1}$$

where P refers to the price level. The M^d function increases with Y since a greater volume of transactions requires more money and decreases with SR reflecting the tendency to move out of money and into alternative assets such as bonds as the interest rate rises. P enters multiplicatively which implies that changes in the price level are assumed to have a one-for-one effect on the demand for nominal money stocks. Therefore, the M^d function can be interpreted as the demand for real money stocks, MS/P. *In equilibrium*, money demand will be equal to the quantity of money supplied by the banking system ($MS^s = MS^d$).

Following Miyao (2002b), among others, we analyze the log-log specification of an equilibrium money demand relation such that:

$$\log(MS_t) - \log(CPI_t) = \beta_y \log(Y_t) + \beta_{sr} \log(SR_t + 0.2) + \beta_1 + e_t, \tag{2}$$

where MS_t, CPI_t, Y_t, and SR_t denote nominal monetary aggregates (here M2), price level (here the consumer price index for all items except fresh foods), real output (here the industrial production index), and nominal short-term interest rate (here the overnight funding rate), respectively. β_y and β_{sr} denote income elasticity and interest elasticity, respectively. e_t is the money demand residual. In this specification, the relationship between real money stock and short-term interest rate is non-linear but linearized after taking the logarithm of the short-term interest rate as well as the other variables to estimate interest elasticity β_{sr}. We add 0.2 to the short-term interest rate to avoid the log of a short-term rate that is too volatilely near zero percent.[30]

First, we investigate whether cointegrating relation exists in the money stock, price level, output, and the short-term interest rate.[31] Specifically, we calculate the augmented Dickey &

[30]We obtain qualitatively similar results when we use the formula $\log(SR_t + 0.1), \log(SR_t + 0.3)$, or $\log(SR_t + 0.4)$.

[31]We performed the augmented Dickey & Fuller (1979) (ADF) test of the unit root process against the stationary process for the money stock, price level, output, and the short-term interest rate, and obtained empirical results that imply the money stock, price level, output, and the short-term interest rate can follow non-stationary processes. When neither has a causal effect on the other, a *spurious* relation estimated by OLS can occur due to the presence of a stochastic trend in these variables. On the other hand, when the variables are cointegrated in that a linear combination of the variables is stationary, the relation is not spurious.

Table 3: Cointegration test for money demand function

	PO test	GH test
ADF Statistics	-2.09	-5.83
lag selected	3	7
Unknown level shift	No	Yes

Notes: The sample period is January 1971 through March 2019. ADF statistics are t-statistics for the first order autoregressive coefficient in the autoregressive model without/with a level shift that equals to one. Critical values of ADF statistics for the residuals of the money demand function (2) with no level shift at the 10 percent, the 5 percent, and the 1 percent level of significance, tabulated by Phillips & Ouliaris (1990), are −3.53, −3.84, and −4.50, respectively (PO test). Critical values of ADF statistics for the residual of the money demand function (2) with level shift at the 10 percent, the 5 percent, and the 1 percent level of significance, tabulated by Gregory & Hansen (1996), are −4.69, −4.92, and −5.44, respectively (GH test). The lag lengths in the autoregressive model used in the PO and GH test regressions are chosen by general to specific reduction (from twelve lags) proposed by Hall (1994).

Fuller (1979) (ADF) statistics for the residual of the linear regression (2), $\hat{e}_t$, and use Phillips & Ouliaris (1990) distribution to test the null of no cointegration against cointegration (PO test). Moreover, we employ a test procedure proposed by Gregory & Hansen (1996) and calculate the ADF statistics of no cointegration against cointegration with a possible level shift in an unknown timing (GH test). We select the lag length in the autoregressive model used in the PO and GH test regressions by general to specific reduction (from twelve lags) proposed by Hall (1994).

Table 3 reports the cointegration test results. Using a PO test, we cannot detect cointegration. However, when we allow for the possibility of a level shift in an unknown timing, a GH test detects cointegration with the logged real output and the logged overnight funding rate. This implies that, if we take into account a possible level shift of it, there exists a cointegrating money demand relation over the sample period even including a low-interest environment after the second half of the 1990s in Japan, which is consistent with the findings by Miyao (2002b), Bae *et al.* (2006), and Nakashima (2009).

Next, given that cointegration in money stock exists, we then investigate whether there would indeed be a level shift in the cointegrating relation. We perform a SupF test developed by Hansen (1992) under the null of a stable constant in the cointegrating vector against the alternative of a level shift in an unknown timing. We obtain the SupF statistics of 311.40, which indicate that there was a significant level shift in the cointegrating vector. Additionally, the data point with the largest F-statistic is November 2008. These results suggest that a

Table 4: Estimation results for money demand function in Japan

Model	(3)	(3)	(2)	(2)
$\hat{\beta}_y$	1.39	1.38	1.42	1.38
	(0.01)	(0.04)	(0.02)	(0.04)
$\hat{\beta}_{sr}$	-0.106	-0.107	-0.111	-0.123
	(0.003)	(0.006)	(0.011)	(0.030)
$\hat{\beta}_1$	4.48	4.53	4.37	4.59
	(0.07)	(0.17)	(0.08)	(0.22)
$\hat{\beta}_d$	0.35	0.33		
	(0.01)	(0.02)		
Controls	n.a.	12 leads and lags of $\Delta\log(Y_t), \Delta\log(SR_t + 0.2)$	n.a.	12 leads and lags of $\Delta\log(Y_t), \Delta\log(SR_t + 0.2)$
Adj-R^2	0.99	0.99	0.97	0.98
Sample start	January 1970	January 1971	January 1970	January 1971
Sample end	March 2019	March 2018	March 1995	March 1995

Notes: The numbers in parentheses are Newey & West (1987) heteroskedasticity and autocorrelation robust standard errors for least squares with a 5-month or 7-month lag truncation for the period, January 1970 (1971)-March 1995 and January 1970 (1971)-March 2019 (2018), respectively.

permanent shift in money demand has occurred after the global financial crisis although income and interest elasticities are stable.

Finally, we estimate the parameters of money demand relation by allowing a level shift. We regress the following money demand function by allowing a level shift in November 2008 which corresponds to the data point with the largest F-statistic for structural break test:

$$\log(MS_t) - \log(P_t) = \beta_y \log(Y_t) + \beta_{sr} \log(SR_t + 0.2) + \beta_1 + \beta_d d_t + e_t, \tag{3}$$

where d_t refers to the dummy variable that is set to one after November 2008 and zero elsewhere. We use the standard OLS procedure and dynamic OLS procedure developed by Stock & Watson (1993) which involves adding twelve leads and lags of the first difference of the logged real output and the logged overnight funding rate to obtain the estimates of the parameters together with the Newey & West (1987) heteroskedasticity and autocorrelation robust standard errors with a 7-month lag truncation. Then, we estimate the parameters of money demand relation (2) using the sample which ends in March 1995 when the SR was more than 2%, in order to check whether we indeed regard the parameters for income and interest elasticities, β_y, β_{sr}, as time-invariant even under a low interest rate.

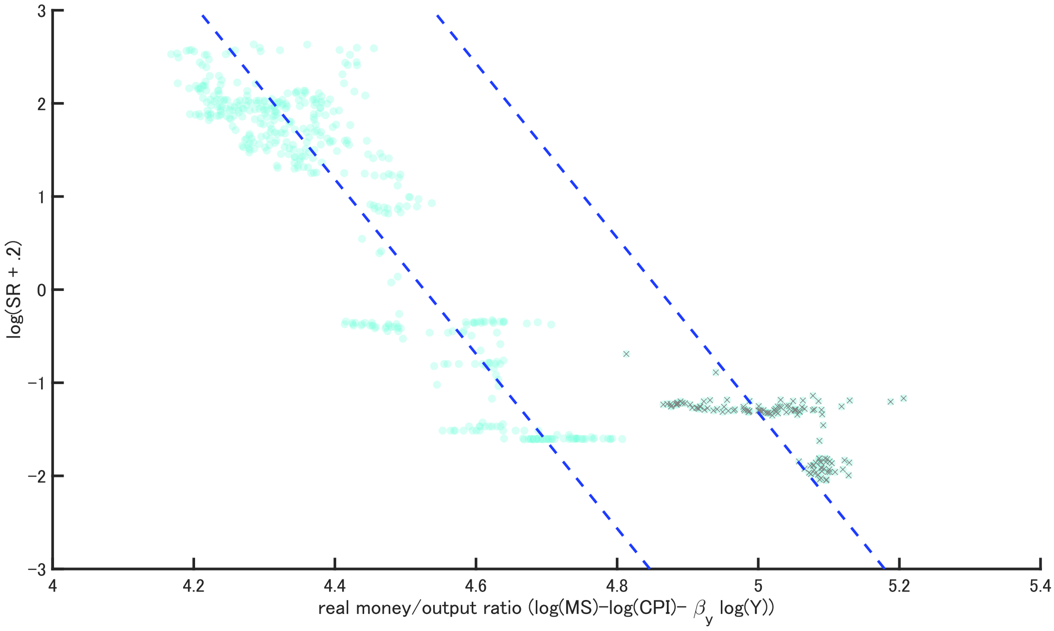

Figure 4: Interest elasticity of money demand in Japan

Notes: The sample period is January 1970 through March 2019. Scatter plots of real money/output ratios $(\log(MS_t) - \log(CPI_t) - \beta_y \log(Y_t))$ where $\beta_y = 1.38$ based on Dynamic OLS estimation using sample from January 1971 to March 2018 and a log of short-term policy rates $(\log(SR_t + 0.2))$. Two dashed lines indicate the fitted value for money demand with and without a level shift (0.33) based on Dynamic OLS estimation using sample from January 1971 to March 2018. The symbol x indicates the scatter plot for the period after November 2008.

Table 4 presents the estimation results. The estimated interest elasticity β_{sr} is about -0.1, which is comparable with the findings in previous studies such as Miyao (2002b), Bae *et al.* (2006), and Nakashima (2009). Additionally, we turn out a substantial increase in money demand from November 2008 at the 1% level of significance. Figure 4 shows scatter plots of real money/output ratio $(\log(MS) - \log(CPI) - \beta_y \log(Y))$ and logs of short-term policy rates $(\log(SR + 0.2))$, which can graphically confirm the plausibility of the log-transformation of the short-term interest rate.

Figure 5 displays the time series of money demand calculated using the estimated parameters with the subsample up to March 1995 and the level shift that occurred in November 2008, compared with that of actual money stock. As shown in the figure, stable money demand can explain the actual behavior of money stock in Japan over time. This suggests that our model applies a simple and parsimonious linear specification of money demand using the log of short-term interest rate as an independent variable and sufficiently captures the high-interest semi-elasticity of money demand when interest rates are extremely low from 1995 onward.

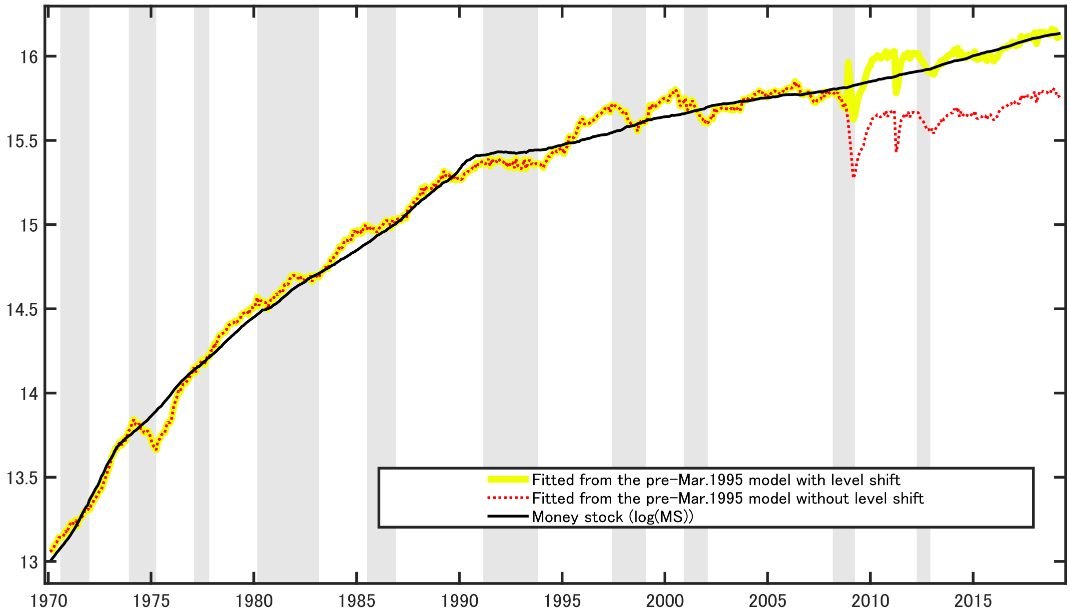

Figure 5: Money stock and the value implied by money demand

Notes: The sample period is January 1970 through March 2019. The solid line indicates the actual behavior of the log of money stock ($\log(MS_t)$). The dotted line indicates the fitted value for money demand based on OLS estimation of (2) using data from January 1970 to March 1995 ($\log(CPI_t)+1.42\log(Y_t)-0.11\log(SR_t+0.2)+4.37$). Bold lines indicate the fitted value with a level shift of 0.35 in November 2008 ($\log(CPI_t) + 1.42\log(Y_t) - 0.11\log(SR_t + 0.2) + 4.37 + 0.35d_t$). The shaded areas show periods of recession in Japan as defined by the Cabinet Office.

Our empirical results support the view that the BOJ has controlled money market conditions, not the quantity of the money stock, for a long time even in a low-interest-rate environment by setting the target level of the short-term nominal policy rate that is related to the opportunity cost of holding money. A change in the overnight funding rate has led to changes in the conditions for equilibrium in the money market, which has influenced the quantity of the money stock. Additionally, a small change in the funding rate has sufficed to influence money market equilibrium due to the highly sensitive interest and semi-elasticity of money demand in a low-interest-rate environment.

4 Measuring the effect of interest rate policy

Since the work of Sims (1980), the structural VAR methodology has been widely applied to address issues when measuring the effects of monetary policy in quantitative monetary economics. As a methodology consisting of multiple equations with multiple time series, a VAR model provides a systematic way to capture rich macroeconomic dynamics from a general equilibrium perspective. It also provides a coherent approach to structural inference and policy evaluation as well as macroeconomic forecasting.

4.1 VAR specification

To analyze the dynamic relationship among macroeconomic variables, we construct the following k-variable reduced-form VAR model:

$$X_t = a_0 + A_1 X_{t-1} + \cdots + A_p X_{t-p} + u_t, \quad (4)$$

which can be expressed as

$$A(L)X_t = a_0 + u_t, \quad (5)$$

where X_t is a k-by-one vector of time series variables of interest, a_0 is a k-by-one constant vector, $A(L) = I - A_1 L - \cdots - A_p L^p$ is a pth order lag polynomial of a k-by-k coefficient matrix $A_j (j = 1, \cdots, p)$ and u_t is a k-by-one vector of serially uncorrelated innovations with a mean of zero and a covariance matrix of Σ_u.

Specifically, we consider the following variables in constructing the VAR model. We let the first variable in X_t be the log of the short-term policy rate (SR) plus 0.2, which we denote by $X_{S,t}$. We use this as a measure of the monetary policy stance in the implementation of the conventional monetary policy in the same manner as described in subsection 3.2. We check whether our VAR, including the log-transformation of the SR, is stable over the entire sample period. In addition to the measure of the monetary policy stance, we also include five macroeconomic variables: three financial market variables (the long-term rate [LR], stock price index [SP], and money stock [MS]), one real economic variable (the real GDP gap [GGAP]), and one price indicator (the core CPI [CPI]).[32] See the Appendix for more detailed information on the aforesaid variables in the VAR. The variables, $X_{\mathrm{SP},t}$, $X_{\mathrm{MS},t}$, and $X_{\mathrm{CPI},t}$ are expressed in logarithm and multiplied by 100.

The reduced-form monthly VAR model is estimated over the period from January 1985 through January 2016. Our dataset for the VAR estimation covers the period when the BOJ controlled the overnight funding rate mainly through open-market operations to influence the

[32] When we use the log-transformation of LR plus 0.2, we obtain qualitatively similar results.

formation of the market interest rates that started around the mid-1980s.[33] We omit the period since February 2016 where the BOJ implemented the NIRP.[34]

Following Friedman & Kuttner (1992), for instance, the lag length p in the reduced-form VAR estimation is set to twelve. We confirm that taking twelve lags is sufficient to capture the system dynamics.[35]

As described above, we check the possibility of a structural shift in the dynamics of our model before proceeding with the estimation of the effects of monetary policy. From the end of the 1990s, in particular, the BOJ implemented not only conventional policy but also unconventional policies such as the ZIRP (in February 1999) and the QME policy (in March 2001). In September of 2008, the global financial crisis sent the Japanese economy into a severe economic downturn. These episodes induced a significant structural shift in the dynamic system in our VAR model.

To test the structural stability of the VAR model, we confirm whether any structural break can be found in the parameters of our reduced-form VAR system defined by (5). The procedure tests whether the overall parameter values are unchanged between the two periods before and after a given possible break date. Thus, we test the null hypothesis that all of the model parameters are the same, as against the alternative of a structural shift. We begin by estimating the following reduced-form system:

$$A(L)X_t + A^d(L)X_t d_t = a_0 + a_0^d d_t + v_t, \tag{6}$$

where d_t is a dummy variable set to one after a given break date, a_0^d is a k-by-one constant vector, $A^d(L) = I - A_1^d L - \cdots - A_p^d L^p$, and v_t is a vector of innovations with a mean of zero and a covariance matrix of Σ_v. The test statistics are $(T - 2(kp+1))(\log|\Sigma_u| - \log|\Sigma_v|)$, where T is the number of observations. Under the null hypothesis, $a_0^d = 0, A_1^d = A_2^d = \cdots = A_p^d = 0$,

[33] Itoh *et al.* (2015) described the situation in detail using materials from the BOJ Archive. In the mid-1980s, the BOJ fully recognized the need to reform monetary policy implementation due to the progress in financial deregulation toward the effective use of freely determined market interest rates.

[34] The BOJ decided to adopt a NIRP on January 29, 2016, cutting the short-term policy rate by 20 basis points into negative territory. It charged banks 0.1 percent of a small portion of their excess reserves on February 16, which incurred an additional and direct cost for banks. This situation brought concerns regarding a substantial difference in the monetary transmission of interest rate changes between the conventional monetary policy and the negative interest rate policy.

[35] The Bayesian information criterion selects three lags, and the Akaike information criterion selects five lags. We perform a modified likelihood ratio test proposed by Sims (1980) to check whether taking three or five lags is sufficient. The chi-square statistics indicate that the null hypothesis of three or five lags is rejected at the one percent significance level against the alternative of 12 lags. However, they also indicate that conventional significance levels do not reject the null of 12 lags, as against the alternative of 13 lags. Moreover, we confirm that the estimated impulse responses are insensitive when more than 12 lags are used.

the test statistic is asymptotically chi-squared with degrees of freedom equal to $k(kp + 1)$.

Table 5 shows the stability test results reporting chi-squared statistics with p-values. The following are set as possible break dates: February 1999, when the BOJ launched the ZIRP; March 2001, when the BOJ launched the QME; and September 2008, when the Lehman Brothers Bankruptcy triggered the global financial crisis. The chi-squared statistics in this table indicate that conventional significance levels do not reject the null of structural stability, as against the alternative of structural shifts. The test results suggest that our VAR model is stable throughout the entire sample period.

Table 5: Stability test results for the VAR model

Break date	February 1999	March 2001	September 2008
Test statistics	472.97	464.20	458.85
	[0.12]	[0.19]	[0.24]

Notes: This table reports the chi-squared statistics that tests the null hypothesis, which states that the overall parameters of the reduced-form VAR system defined by (5) are unchanged between the two periods before and after a given break date (shown in the first row of the table) when estimated over the period from January 1985 to January 2016. The numbers in brackets are p-values for the test.

Figure 6 shows the prediction values of X using the estimated parameters from January 1985 to January 1999 (before ZIRP), such that $\hat{X}_t^{85-99} = \hat{a}_0^{\text{85-99}} + \hat{A}_1^{\text{85-99}} X_{t-1} + \cdots + \hat{A}_p^{\text{85-99}} X_{t-p}$. From February 1999 to January 2016, $\hat{X}_t^{\text{85-99}}$ is the one-step forecast conditioning on $X_{t-1}, \cdots, X_{t-p}$ based on the estimated parameters $\hat{a}_0^{\text{85-99}}, \hat{A}(L)^{\text{85-99}}$ from January 1985 to January 1999 (before ZIRP was launched). We find that the predicted values in Figure 6 sufficiently explain the time-series pattern of the short-term policy rate and other macroeconomic variables from 1999, although the prediction of the long-term rate over-fluctuates to a slight degree. This result suggests that the proposed VAR model and the chosen parameters remain stable over the sample period.

4.2 Identification of the causal effects of the interest rate policy

When quantifying the monetary policy effect, we examine whether the *policy-induced* changes in the monetary stance have an impact on the economy. A central bank, however, systematically changes its policy stance in response to economic conditions. Therefore, we must distinguish between the policy-induced changes and systematic changes from the observed policy stance in investigating the causal effect of monetary policy.

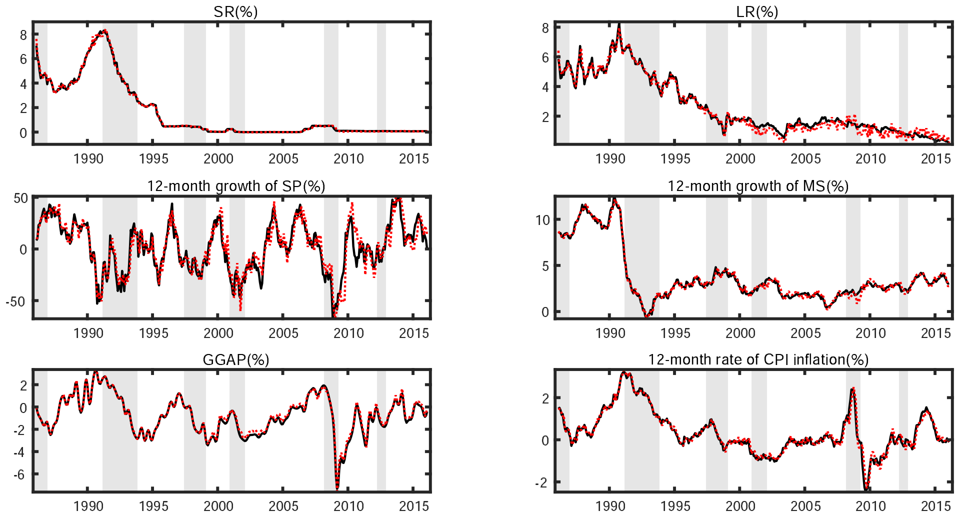

Figure 6: Financial market, output gap, and inflation in Japan

Notes: Sample period from January 1985 to January 2016. Solid lines: actual values. Dotted lines: one-step VAR forecasts conditional on $X_{t-1}, \cdots, X_{t-12}$, which is based on the estimated parameters over the sample from January 1985 to January 1999. The shaded areas show periods of recession in Japan as defined by the Cabinet Office. SR: short-term policy rate, LR: long-term rate, SP: stock price, MS: money stock, GGAP: GDP gap, CPI: core consumer price index.

Let us consider the monetary policy reaction function to understand better how a central bank systematically adjusts its policy stance in response to various elements in a macroeconomy. On the premise that the current and lags of X_t include sufficient information on the macroeconomy, the reaction function is expressed as follows:

$$X_{S,t} = f(X_t^{-S}, X_{t-1}, \cdots, X_{t-p}) + \epsilon_{MP,t}. \tag{7}$$

The function $f(X_t^{-S}, X_{t-1}, \cdots, X_{t-p})$, where X_t^{-S} is a subvector of X_t derived with $X_{S,t}$ dropped, represents how the policy stance measure $X_{S,t}$ systematically responds to the information set. The random variable $\epsilon_{MP,t}$ with a mean of zero and a variance of σ_{MP}^2 represents the nonsystematic component of the reaction of $X_{S,t}$, which is often referred to as a "monetary policy shock." In interpreting the policy shocks, we can speculate that (1) $\epsilon_{MP,t}$ reflects emergent changes in the preferences of monetary policy authorities, where the BOJ decides to get tough on macroeconomic conditions; or (2) monetary policy authorities contemplate in retrospect of making something it should not have, where the BOJ keeps its policy stance even if the economy worsens.[36]

[36]See Christiano *et al.* (1999) for more detail on the interpretation of monetary policy shocks.

A key question in the literature is how to identify monetary policy shocks to measure the dynamic causal effects of monetary policy. Several studies (e.g., West (1993); Shioji (2000); Miyao (2002a); Nakashima (2006); and Braun & Shioji (2006)) estimate the macroeconomic effects of monetary policy shocks in Japan by developing VAR models with *internal* restrictions, such as the short-run restrictions proposed by Sims (1992), Bernanke & Blinder (1992), Bernanke & Mihov (1998), and Christiano *et al.* (1999) and the sign restrictions proposed by Uhlig (2005). West (1993) adopts the non-recursive identification framework in conjunction with the innovations in the money stock (M2) equation as monetary policy shocks in Japan. Shioji (2000) uses the non-recursive identification framework with several monetary policy variables (the BOJ loan and high-powered money).[37] Miyao (2002a) argues that the institutional features of the BOJ's operating procedures under the conventional policy setting fit a recursive identification approach that is similar to that of Bernanke & Blinder (1992), Sims (1992), and Christiano *et al.* (1999), where disturbances in the short-term interest rate equation are viewed as the policy shocks and the interest rate is placed before monetary aggregates in the ordering. Nakashima (2006) develops the structural VAR approach proposed by Bernanke & Mihov (1998) to model the Japanese reserve market with the BOJ's operation procedures from January 1975 to June 1995, a period when the overnight funding rate remained above the official discount rate.[38] Braun & Shioji (2006) use two alternative sign restrictions, one where a surprise tightening in monetary policy *increases* the short-term nominal interest rate and lowers output, prices, and monetary aggregates, and another where it *lowers* the short-term nominal interest rate and lowers output, prices, and monetary aggregates.[39] Others, such as Rudebusch (1998) and Nakamura & Steinsson (2018), however, note that serious concerns may arise regarding the reliability of the identifying restrictions internally imposed in the VAR model.

Following the argument by Rudebusch (1998) and Nakamura & Steinsson (2018), we attempt to identify conventional monetary policy shocks in Japan using an *external* instrument from the VAR system that captures exogenous variation in the policy stance. Here, we follow the methodology developed by Stock & Watson (2012, 2018).

[37]Shioji (2000) concludes that Japanese monetary policy is better described when the model assumes that the central bank controls the total amount of high-powered money rather than only a specific component of high-powered money.

[38]Until June 1995, Nakashima (2006) argues that the BOJ aimed to stabilize the overnight funding rate using not only open market operations but also discount window lending.

[39]Under the assumption where a surprise tightening in monetary policy lowers the short-term nominal interest rate and lowers output, prices, and monetary aggregates, Braun & Shioji (2006) argue that monetary policy has large and persistent effects on the economy.

In a structural VAR, the innovations u_t in (5) are assumed to be linear combinations of the "structural" shocks:

$$u_t = \Theta \epsilon_t, \tag{8}$$

where ϵ_t is a k-by-one vector of structural shocks, which are assumed to be independent of each other, and Θ represents the impact matrix for the responses of the VAR variables X_t to the shocks ϵ_t. (5) and (8) yield a moving average representation regarding the structural shocks as follows:

$$X_t = b_0 + B(L)\Theta \epsilon_t, \tag{9}$$

where $b_0 = A(L)^{-1}a_0$ and $B(L) = A(L)^{-1}$. Let $\epsilon_{MP,t}$ and $\epsilon_{\text{-}MP,t}$ be a monetary policy shock and a vector of the structural shocks other than the policy shock, respectively, such that $\epsilon_t = (\epsilon_{MP,t}, \epsilon_{\text{-}MP,t}^{'})^{'}$. Moreover, let Θ_1 represent the impact vector for the responses of the VAR variables X_t to the policy shock and $\Theta_{\text{-}1}$ represent the impact matrix for the responses of the VAR variables X_t to the other shocks, such that $\Theta = (\Theta_1, \Theta_{\text{-}1})$. We can express impulse response functions of X_t to a monetary policy shock $\epsilon_{MP,t}$ as $B(L)\Theta_1$.

To identify $\Theta_1 = (\Theta_{11}, \cdots, \Theta_{k1})^{'}$, we adopt the approach proposed by Stock & Watson (2012, 2018). Suppose there is an instrument z_t for the policy shock that satisfies the following conditions:

$$E[\epsilon_{MP,t} z_t] \neq 0, \text{ and} \tag{10}$$

$$E[\epsilon_{\text{-}MP,t} z_t] = 0. \tag{11}$$

Assume also that a unit increase in $\epsilon_{MP,t}$ increases $X_{S,t}$ by one unit $\Theta_{11} = 1$. We use the instrumental variable (IV) regression to yield a consistent estimate of Θ_{i1}:

$$u_{i,t} = \Theta_{i1} u_{1,t} + \epsilon_{i,t}^{\text{-}MP}, \tag{12}$$

using the instrument z_t, where $\epsilon_{i,t}^{\text{-}MP} = \Theta_{i\text{-}1}\epsilon_{\text{-}MP,t}$.

The instrument z_t is the change in the three-month euro-yen TIBOR futures on the monetary policy board meeting (MPM) dates as a proxy of the unanticipated changes in the short-term policy rate. Specifically, up to December 1997, when the BOJ had yet to announce the MPM dates officially, we use the daily series of surprise change measures provided by Honda and

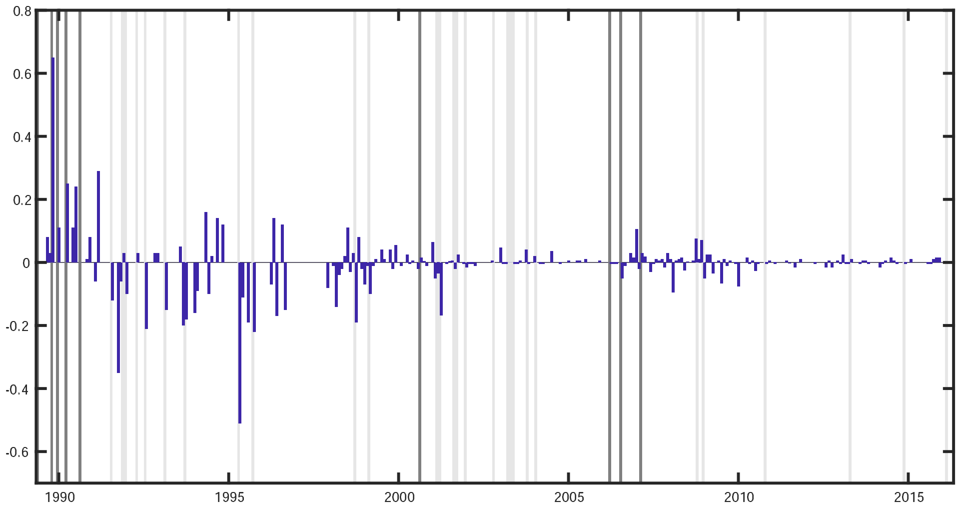

Figure 7: Monthly measure of unanticipated changes in the three-month euro-yen TIBOR futures on the monetary policy board meeting dates, z_t

Notes: Sample period from July 1989 to January 2016. The dark and light shaded areas show the month of tightening and easing policy decision, respectively.

Kuroki (2006, Table 1).[40] From January 1998, when the BOJ started to announce the MPM dates officially, we calculate the changes in euro-yen futures over two-day periods when the BOJ made policy decisions (from the days before the public statements to the days after the statements) to duly cover both the timing of the public statements and the time it took for the news to be sufficiently recognized, as in Ueda (2012) and Nakashima *et al.* (2019). We then sum up the daily series to construct unanticipated monthly changes in the short-term policy rate. Figure 7 plots our calculation of the monthly measure of unanticipated changes in the three-month euro-yen TIBOR futures on the MPM dates, z_t, over time. To verify the robustness of the proposed instrument, we compute the F-statistic from the first-stage regression of the VAR innovation of the policy stance measure $u_{1,t}$ on the instrument z_t.[41]

The IV regression estimating the impact effect of the policy shock is estimated over the period from July 1989 to January 2016.[42] The starting date of our sample for the IV regression

[40] Honda & Kuroki (2006) identify the event dates of the policy rate target changes and the target levels (or ranges) by carefully reading the articles in the *Nikkei News Paper*. They then measure the changes in three-month TIBOR futures over the events as the surprise components of the policy rate.

[41] One may be concerned about a structural break of the validity of the external instrument for identifying monetary policy shocks. In particular, unanticipated policy change measures before and after 1998 seem to behave differently as the BOJ has implemented a low-interest rate policy since 1998; the variations in the policy rate themselves were relatively small compared with those before. However, we confirm the stability in the first-stage regression of the VAR innovation of the policy stance measure $u_{1,t}$ on the instrument z_t; we do not statistically detect a structural break in the regression coefficient after January 1998.

[42] The reason why we employ monthly estimations is that we identify the monetary policy shocks in the VAR model as rigorously as possible, in addition to the availability of financial market data and CPI. The monetary

is the day the instrument variable, z_t, becomes available.

4.3 Estimation of the dynamic causal effects of the change in the short-term policy rate on the macroeconomy

The estimated impulse response functions are summarized in Figure 8. The instrument is strong, with a heteroskedasticity-robust first-stage F-statistic of 10.44.[43] As described above, a monetary policy shock is normalized to produce a one-unit increase in the log of the short-term policy rate (SR) on impact. The solid line indicates the estimated response for each of the variables in levels up to 60 months. The shaded areas denote one-standard-error bands calculated using 1000 bootstrap samples.

Overall, this figure shows that the Japanese monetary policy has a plausible effect, as compared to the monetary policy effects discussed in the macroeconomic literature by Boivin *et al.* (2011), for instance. Figure 8 shows that the tightening monetary policy shock leads to a persistent decrease in the GGAP and the CPI. GGAP declines to its lowest values (about 3.5 percent) approximately two years after a monetary tightening and gradually works its way back up to zero.[44] The CPI price stays flat for roughly one and a half years due to price rigidity then declines steadily for two years to its minimum (about 1.5 percent), with long-lasting effects. The monetary tightening, meanwhile, leads to an immediate reduction in the SP, an immediate increase in the LR, and a persistent fall in the MS. These responses imply that the BOJ stimulates the financial market and macroeconomy through a policy-induced change in the short-term policy rate.

5 Policy evaluations based on counterfactual simulations

This section employed our econometric model to empirically assess cases where the BOJ conducted expansionary monetary policy in response to economic conditions. Specifically, we con-

policy surprises we use as an external instrument to identify the shocks in the VAR model randomly occur at monthly frequencies because the BOJ decides on policies at monetary policy board meetings which were held once or twice a month, at least, until the end of our sample period. In order to identify the shocks using the monetary policy surprises in the manner as (12) and estimate the dynamic causal effect of the shocks, $B(L)\Theta_1$, it should be more appropriate to use monthly estimations, rather than quarterly estimations.

[43] To be confident that a weak instrument problem is not present, Stock *et al.* (2002) and Stock & Yogo (2005) recommend the rule of thumb that requires that the F-statistic from the first stage regression of the two-stage least squares should exceed ten.

[44] When we use the log of the index of industrial production as a proxy of real output instead of the real GDP gap, we obtain qualitatively similar results.

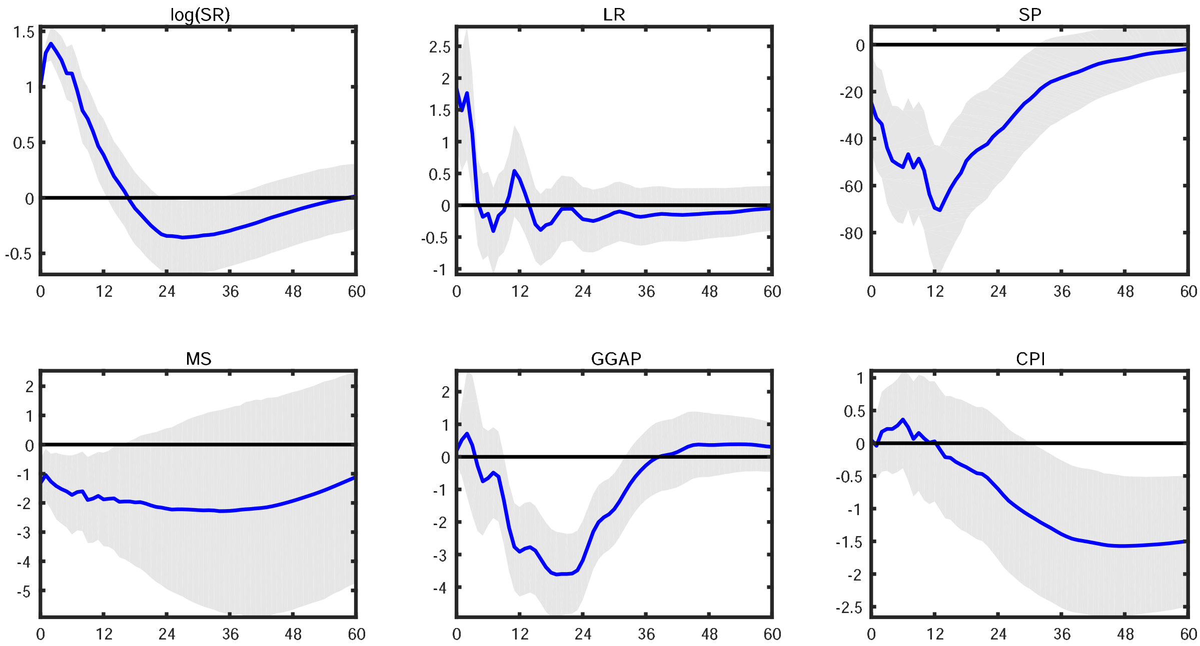

Figure 8: Estimated responses to a monetary policy shock

Notes: The monetary policy shock increases the log of the short-term policy rate by one unit. The instrument for the monetary policy shock is the monetary policy surprise measures compiled by Honda & Kuroki (2006) from July 1989 through December 1997 and the changes in the three-month euro-yen TIBOR futures before and after the BOJ's policy decisions over the two-day period (from the day before the public statement to the day after the statement) from January 1998 through January 2016. Estimation samples span January 1985 through January 2016 for the VAR and July 1989 through January 2016 for the monetary policy shock IV regression. The solid lines represent the point estimates of the impulse responses to a monetary policy shock. All the responses, except those of the log of the short-term policy rate, are expressed in percentage points. The shaded areas denote one standard error bands calculated using 1000 bootstrap samples. We set the lag length to twelve in the reduced form VAR estimation. SR: short-term policy rate, LR: long-term rate, SP: stock price, MS: money stock, GGAP: GDP gap, CPI: core consumer price index.

ducted *ex-post* assessments of policy responses to two extraordinary shocks: the burst of the bubble economy and the outbreak of the global financial crisis.

Following Bernanke *et al.* (1997), Sims & Zha (2006), and Eberly *et al.* (2019), for instance, we use VAR models to conduct counterfactual simulations to assess how the Japanese economy would have performed under alternative monetary policies.[45][46] Specifically, we measure the

[45]An alternative approach is to use New Keynesian DSGE models (e.g., Bernanke & Gertler, 1999; Fujiwara *et al.*, 2005; Kan *et al.*, 2016; Hirakata *et al.*, 2019), which have gained popularity during the past two decades. In this study, we use a more traditional econometric approach.

[46]Our counterfactual simulations do not necessarily meet the Lucas (1976) critique; if the central bank changed the systematic policy reactions, decision rules of the private sector would vary systematically with changes in the policy, and thus any change in policy would systematically alter the structure of traditional macro-econometric models. Our simulations are conducted under a situation where the systematic policy reaction, as well as the decision rules of the private sector, should be the same as the actual and the counterfactual policy paths which are derived by deviations from the systematic policy action. This implies that the private sector has no incentive to change its decision rules because the systematic policy reaction is invariant under the counterfactual policy paths. However, as Bernanke *et al.* (1997) describe, our simulations are not completely invulnerable to the Lucas

counterfactual values of the variables in the VAR model by taking four steps. In step 1, we compute the difference between a specified path of the policy stance measure $\tilde{X}^{CS}_{S,t+h}$ and its actual path $X_{S,t+h}$, such that $\check{X}_{S,t+h} = \tilde{X}^{CS}_{S,t+h} - X_{S,t+h}$ for $h = 0, \cdots, H$. In step 2, we compute the sequence of monetary policy shocks $\{\check{\epsilon}_{MP,t}, \check{\epsilon}_{MP,t+1}, \cdots, \check{\epsilon}_{MP,t+H}\}$ where the policy stance measure explained by the current and lags of the policy shocks (i.e., the first element of a vector of $\hat{B}(L)\hat{\Theta}_1\check{\epsilon}_{MP,t+h}$), is equal to $\check{X}_{S,t+h}$ for all $h = 0, \cdots, H$, given $\check{\epsilon}_{MP,t-1} = \check{\epsilon}_{MP,t-2} = \cdots = 0$. In step 3, we compute the ensuing contribution of the sequence of monetary policy shocks:

$$\check{X}_{t+h} = \hat{A}_1\check{X}_{t+h-1} + \cdots + \hat{A}_{12}\check{X}_{t+h-12} + \hat{\Theta}_1\check{\epsilon}_{MP,t+h}, \text{ for } h = 0, \cdots, H, \tag{13}$$

given $a_0 = 0$ and the initial value $\check{X}_{t-1} = \check{X}_{t-2} = \cdots = \check{X}_{t-12} = 0$. In step 4, we add this contribution $\check{X}_{t+h}$ to the observed value of X_{t+h}, such that $\tilde{X}^{CS}_{t+h} = \check{X}_{t+h} + X_{t+h}$ for $h = 0, \cdots, H$.[47]

For comparison, we also consider the counterfactual values of the variables in the VAR model in the case where no structural shocks take place ($\epsilon_{t+h} = 0$ for all $h = 0, \cdots, H$) over the period of the counterfactual simulation:

$$\tilde{X}^{\text{-}\epsilon}_{t+h} = \hat{a}_0 + \hat{A}_1\tilde{X}^{\text{-}\epsilon}_{t+h-1} + \cdots + \hat{A}_{12}\tilde{X}^{\text{-}\epsilon}_{t+h-12} \text{ for } h = 0, \cdots, H, \tag{14}$$

given the initial value $\tilde{X}^{\text{-}\epsilon}_{t-1}, \cdots, \tilde{X}^{\text{-}\epsilon}_{t-12}$ is equal to their actual values. This reflects the counterfactual path of the policy rate and the economy conditioning on the information up to the month before the beginning of the period of the simulation. In addition to the actual path, we use this as baselines to quantitatively assess alternative monetary policies.

5.1 *More aggressive* policy rate cuts after the bubble collapse in the 1990s

The Japanese economy suffered from a sustained recession from the burst of the bubble economy at the beginning of the 1990s onwards, even though the BOJ lowered the policy rate repeatedly. Japan's GDP gap declined by more than five percent during the recession over the half-decade from February 1991 (the starting date of the recession phase just after the bubble collapse in the

critique because the private sector might change its expectation for policy rule and its decision rules when it repeatedly has seen deviations from the reaction.

[47] Note that our counterfactual simulations rely on *ex-post* data that were unavailable to the BOJ in real time. It might, therefore, be difficult to say that the BOJ should have or could have made different decisions in real time.

1990s). Moreover, the CPI inflation gradually declined to almost zero percent year-on-year in 1995, from three percent before the recession. The BOJ cut the official discount rate nine times in July 1991, November 1991, December 1991, April 1992, July 1992, February 1993, September 1993, April 1995, and September 1995. The short-term policy rate fell drastically from eight to 0.5 percent during this period, albeit at a slow pace. Some studies, such as Bernanke (2000), Jinushi *et al.* (2000), and Kuttner (2014), argue that the policy rate cuts in the first half of the 1990s were not as expansionary as they would appear at first glance.[48]

Our first counterfactual simulation supposes that the BOJ had implemented *more aggressive* policy rate cuts, as compared with its own policy rule implied in the VARs, in reaction to the economy's deterioration after the burst of the bubble economy in the first half of the 1990s. Specifically, we define *more aggressive* policy rate cuts at the beginning of the 1990s as the following policy rate path: the actual value in June 1991 (about eight percent) to seven percent in July 1991, six percent in November 1991, five percent in December 1991, 3.5 percent in April 1992, two percent in July 1992, 1.5 percent in February 1993, and 1 percent in February 1993. This situation is comparable to the measures taken by the Federal Reserve (Fed) in response to the recession in the U.S. (e.g., from 8.25 to 3 percent from June 1990 to September 1993, from 6.5 to one percent from December 2000 to June 2003, and from 5.25 percent to almost zero percent from August 2007 to December 2008).

The simulation results are summarized in Figure 9. The figure depicts the actual (solid lines) and counterfactual paths of the following macroeconomic variables with the alternative policy (i.e., *more aggressive* policy rate cut (dotted lines), and those with no monetary policy shocks (dashed lines)): the short-term policy rate, the 12-month growth of stock price, the 12-month growth of money stock, GDP gap, and the 12-month rate of CPI inflation from February 1991 to February 1996. The upper-right panel in this Figure plots the actual (solid lines) and simulated values (dotted line) of monetary policy shock $\epsilon_{MP,t+h}$ for $h = 0, \cdots, H$, which is implied by the counterfactual paths with *more aggressive* policy rate cuts shown in the upper-left panel.

It is essential for a central bank to consistently shift to an immediate and massive stimulus to achieve price stability in response to any serious decline in real output and falling inflation

[48] Bernanke (2000) show that money growth was weak in the first half of the 1990s despite the large reduction of the broader nominal interest rates. Jinushi *et al.* (2000) show that the Japanese monetary policy actions during the first half of the 1990s were delayed compared with their "good" Taylor-style policy rule, which was estimated over the pre-bubble period from 1975–1985. Kuttner (2014) shows that the actions were not as decisive as the measures taken by the Fed during the recessions beginning in 2000 and 2007.

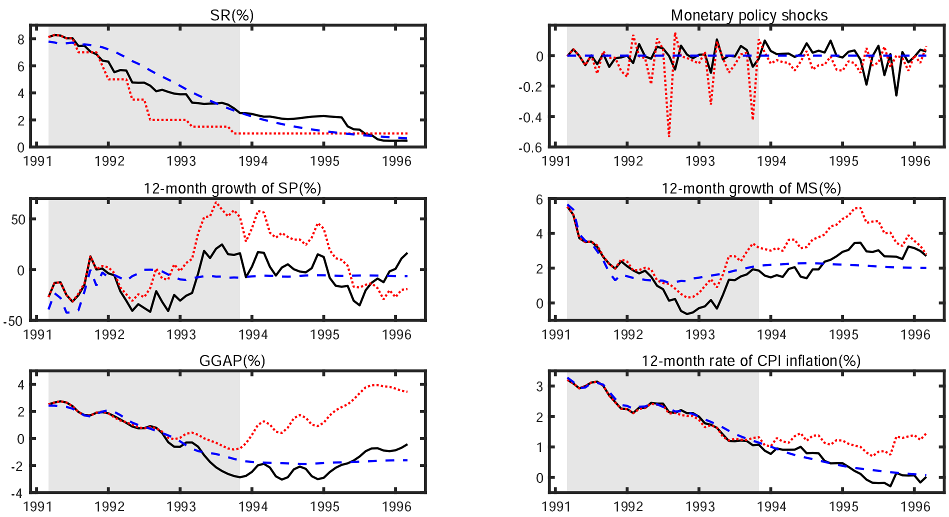

Figure 9: Counterfactual simulation of macroeconomic variables: *More aggressive* policy rate cuts at the beginning of 1990s

Notes: Solid lines indicate actual values. Dotted lines indicate simulated values obtained by setting the simulated monetary policy shocks so that the simulated short-term policy rate follows the *more aggressive* policy rate cut. Dashed lines indicate simulated values in the case without monetary policy shocks over the period of the counterfactual simulation (February 1991 to February 1996). The shaded areas show periods of recession in Japan, as defined by the Cabinet Office. SR: short-term policy rate, SP: stock price, MS: money stock, GGAP: GDP gap, CPI: core consumer price index.

due to an extraordinary economic shock. Figure 9 shows that with *more aggressive* policy rate cuts from eight to one percent for two years, the GDP gap would not have fallen below zero and risen after the recession period. CPI inflation would have declined only mildly and stably remained above one percent after the recession. Financial conditions such as the stock price and money growth would have recovered from the severe setback triggered by the burst of the bubble economy in the middle of the recession period. These results suggest that the BOJ's reluctance to cut policy interest rates in response to the post-bubble downturn significantly contributed to the long-lasting recession of the 1990s.

5.2 *No* policy rate cuts after the global financial crisis

After the outbreak of the global financial crisis in 2008, the BOJ was forced to take prompt actions to ensure price and financial market stability. Japan was hit hard by the global financial crisis. The Japanese stock market began to fall sharply after a drop in the U.S. market, and the GDP gap decreased dramatically with severe deflation. The BOJ cut the interest rate from 0.5 to 0.3 percent on October 31, 2008 and decreased further to 0.1 percent on December 19, 2008, albeit with some confusion and concerns that the small rate cuts would have limited impact or the extremely low-interest rate would cause financial markets to malfunction (Minutes of the Monetary Policy Meeting on October 31, 2008 and December 18 and 19, 2008).[49] Considering the serious damage to the macroeconomy, the ensuing recovery was achieved quite quickly.

Our second counterfactual simulation supposes that the BOJ implemented *no* policy rate cuts, even though its own policy rule implied in the VARs should have reacted to the economic downturn after the outbreak of the global financial crisis at the end of 2008. Figure 10 shows the actual and simulation values of the macroeconomic variables from December 2007 to December 2012.

Even small policy rate cuts in a low-interest-rate environment contribute significantly to the economic recovery. Figure 10 shows that, apart from policy rate cuts from 0.5 percent to 0.1 percent, the GDP gap would have ranged between minus four percent and minus eight percent even after the recession period, and the CPI inflation would have been persistently negative. Financial conditions would have been more serious than they were: the stock price would have continuously declined. In particular, small changes in the policy rate sufficiently influenced the money market in line with a highly sensitive interest semi-elasticity of money demand in a low-interest-rate-environment as shown in subsection 3.2; the money growth would also have continuously declined, while the actual money growth was stable at around 2%. These results suggest that if the BOJ had hesitated in cutting the interest rate in response to the recession triggered by the global financial crisis, the period of recession and deflation would have lasted longer than it did.[50]

6 Concluding remarks

Monetary authorities and economic researchers have spent a great deal of effort to understand the role of monetary policy in the real world. If we are to assess monetary policy empirically,

[49] On October 31, 2008, a proposed policy rate cut from 0.5 to 0.25 percent was defeated by three votes to five. A vote on an ensuing proposal for a policy rate cut from 0.5 to 0.3 percent was equally split but approved in a final decision by Governor Shirakawa. On December 19, 2008, one of the policy board members dissented from a proposal for a policy rate cut from 0.3 percent to 0.1 percent. He was concerned that if the policy interest rate was reduced to 0.1 percent, the resulting elimination of the spread between the policy rate and interest rate applied to the complementary deposit facility would be likely to degrade the functioning of the market mechanism substantially.

[50] Although this study focuses on the role of *conventional* monetary policy, this exercise does not indicate that unconventional monetary policies, such as the large-scale unconventional asset purchases, *independent from* the target level of the short-term policy rate, are ineffective. The empirical evaluation of unconventional monetary policies following the global financial crisis is left for future research.

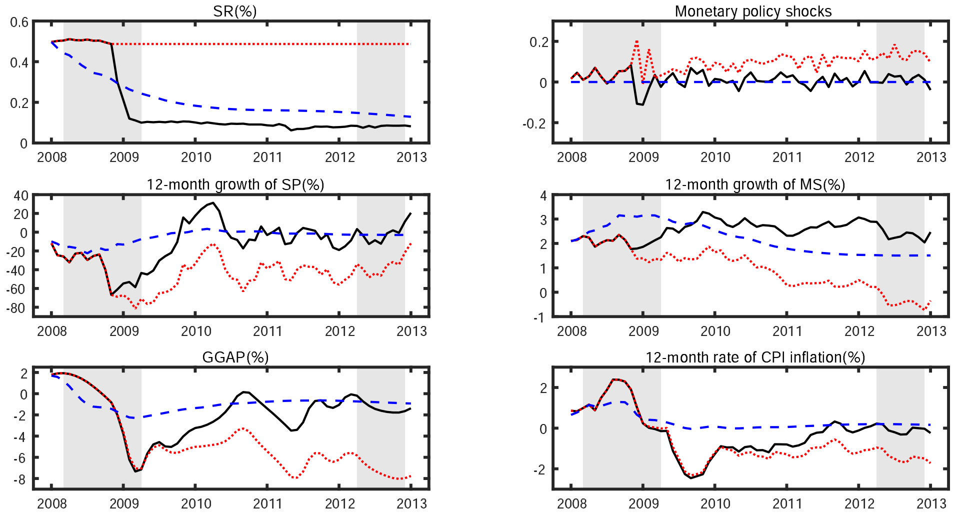

Figure 10: Counterfactual simulation of macroeconomic variables: *No* short-term policy rate cuts after the global financial crisis, starting from November 2008

Notes: Solid lines indicate actual values. Dotted lines indicate simulated values obtained by setting simulated monetary policy shocks that keep the simulated short-term policy rate at the October 2008 level (about 0.5 percent). Dashed lines indicate simulated values in the case without monetary policy shocks over the period of the counterfactual simulation (December 2007 to December 2012). The shaded areas show periods of recession in Japan, as defined by the Cabinet Office. SR: short-term policy rate, SP: stock price, MS: money stock, GGAP: GDP gap, CPI: core consumer price index.

we have three tasks to pursue: describing and summarizing the available macroeconomic data, quantifying what we know or do not know about the true structure of the economy, and exploring the advice for policymakers in implementing monetary policy. Even when we have sufficient data of interest for our purposes, we still face a great challenge in specifying an empirical model that appropriately captures the important features of the macroeconomy and monetary policy. The research methods applied in the literature to overcome the difficulties in empirically assessing monetary policy have steadily progressed. This study describes the historical background leading up to the development of empirical research on monetary policy by reviewing several early empirical studies of Japan's monetary policy that affected the actual policies. We have also assessed the effect of Japan's monetary policy, applying the standard empirical methodology from the present-day literature to discuss the importance of the major role of monetary policy in developed countries (i.e., macroeconomic stability).

Our empirical analyses, using data from the 1980s onwards, attest to the effectiveness of Japan's monetary policy despite Japan's experience with a series of accommodative actions and a protracted weakness in economic performance. Causal inferences on the policy transmission show that a policy-induced change in the short-term interest rate has a statistically significant impact on the financial market and macroeconomy. Our policy evaluations also critically touch upon the crucial role of monetary policy in supporting economic growth. Our counterfactual simulations indicate that (1) the central bank should consistently shift to an immediate and massive stimulus to achieve price stability in the medium and long term in response to the severe decline in real output and falling inflation caused by the extraordinary economic shocks. Moreover, (2) even small policy rate cuts in a low-interest-rate environment make significant contributions to economic recovery.

There are several limitations and restrictions of the empirical analysis of monetary policy in this study, thus leaving room for future research that could extend into several directions. Although we specify a benchmark VAR model similar to existing models in the literature, the model disregards the role of commercial banks in the macroeconomy and monetary policy. Given the history of empirical studies on monetary policy, we observe an undesirable black-boxing of the banking sector. As theoretical studies such as Gertler & Kiyotaki (2011) show, the effects of economic shock and monetary policy can be amplified through their impacts on bank balance sheets because of credit frictions. Further, the Japanese economy seemed to show non-linear interest rate policy effects through the banking sector after the BOJ implemented the NIRP.[51] An important task for future empirical research will be to reveal the dynamic interaction and feedback effects between banking variables and macroeconomic variables.

This study merely estimated the effect of the changes in *current* short-term policy rate. For future research to deepen our understanding of the role of monetary policy, we will have to evaluate monetary policy by changing the *future* path. Today's central banks actively use communication tools such as forward guidance to manage expectations about the future course of monetary policy. While policymakers hope to use forward guidance as a tool for monetary policy, especially under the lower bound on the short-term policy rate, little is known about its effectiveness.

A final important task for future research is to assess the effectiveness of *unconventional* monetary policy. While the actual implementation of the unconventional monetary policy in many advanced countries has stimulated empirical research on policy effects, the effects on

[51] Brunnermeier & Koby (2018) theoretically show the existence of a reversal rate of monetary policy at which a policy rate cut becomes contractionary for bank lending.

the real economy are still disputable.[52] Making causal inferences for an unconventional policy is particularly confounding in this respect.[53] Though beyond the scope of this study, such inferences are worthy of future research.

Conflict of interest

On behalf of all authors, Masahiko Shibamoto states that there is no conflict of interest.

Appendix

Variable Definitions

- ODR: Official discount rate (end of month, %); monthly series retrieved from the Bank of Japan statistics.
- MB: Monetary base; seasonally adjusted series (monthly average, 100 million yen); monthly series retrieved from the Bank of Japan statistics.
- SR: Short-term policy rate; uncollateralized overnight call rate (monthly average, %); monthly series retrieved from the Bank of Japan statistics for the period from July 1985 to March 2019 and calculated backward for the period before June 1985 using the monthly change in the collateralized overnight call rate; retrieved from the Bank of Japan statistics for the period from January 1955 to April 2016.
- MS: M2 money stock; seasonally adjusted series (monthly average, 100 million yen); retrieved from HAVER ANALYTICS.
- Y: Index of industrial production, mining and manufacturing, seasonally adjusted series (2015=100), retrieved from NIKKEI NEEDS FINANCIAL QUEST.
- SP: Stock price; Nikkei Stock Average (Nikkei225) index (end of month, May 16,1949=100); retrieved from HAVER ANALYTICS.
- BCREDIT: Bank credit to the private non-financial sector; quarterly series retrieved from the BIS statistics, Table F2.6 (billion yen).

[52] See Ugai (2007) and Joyce *et al.* (2012) for a survey of the empirical research on unconventional policy effects.
[53] See Nakashima *et al.* (2019) and studies cited therein for more details on the methodology used to identify the effect of unconventional monetary policy.

- PGDP: GDP deflator; National accounts statistics compiled according to 1968 SNA (1990=100) from the 1st quarter of 1955 through the 1st quarter of 2001 and 1993 SNA and 2008 SNA (2011=100) from the 1st quarter of 1980 through the 1st quarter of 2019 (Data prior to 1994 using the 1993 SNA series), fixed-based method (1968 SNA) and chain-linked method (1993 SNA and 2008 SNA), seasonally adjusted quarterly series retrieved from HAVER ANALYTICS.

- RGDP: Real GDP; National accounts statistics compiled according to 1968 SNA (benchmark year=1990) from the 1st quarter of 1955 through the 1st quarter of 2001, and 1993 SNA and 2008 SNA (benchmark year=2011) from the 1st quarter of 1980 through the 1st quarter of 2019 (Data prior to 1994 using the 1993 SNA series), fixed-based method (1968 SNA) and chain-linked method (1993 SNA and 2008 SNA), seasonally adjusted quarterly series retrieved from HAVER ANALYTICS (billion yen).

- GGAP: Real GDP gap; quarterly series retrieved from the Cabinet Office (%); Interpolated (using linear interpolation under the constraint that the average of three monthly observations within a quarter must equal the quarterly series) to obtain monthly observations.

- CPI: Consumer price index for all items less fresh foods (2015=100); consumption-tax-adjusted for the period from April 1989 to March 1990, April 1997 to March 1998, and April 2014 to March 2015; retrieved from the Ministry of Internal Affairs and Communications; Seasonally adjusted series were obtained using the Census X-12.

- LR: Long-term rate; 10-year Japanese government bond yields (end of month, %); retrieved from NIKKEI NEEDS FINANCIAL QUEST.

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