Stock prices and monetary policy: An analysis of a Bayesian DSGE model

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Stock prices and monetary policy: Analysis of a Bayesian DSGE model*

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Abstract

This study evaluates the reaction of stock prices to monetary policy in Japan during the 1980s. We employ Bayesian estimation of the dynamic stochastic general equilibrium model, revealing the presence of the wealth channel from increased stock prices in Japan. We argue that the Bank of Japan (BOJ) may have implemented its monetary policy by targeting stock price stability, inflation and the output gap. Our results indicate that, while the BOJ may have reacted to stock prices, a monetary contraction could not prevent deviations from their fundamental values.

JEL Codes: E52; E58;

Keywords : Monetary policy; Bayesian estimation; DSGE model; Stock prices; Wealth effect

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1 Introduction

This study uses Bayesian estimation of the dynamic stochastic general equilibrium (DSGE) model to evaluate how stock prices reacted to monetary policy in Japan during the 1980s. Some studies have argued that stock prices generally fall in response to monetary tightening shocks, which seems to be the conventional wisdom of monetary tightening on stock prices (Bernanke and Kuttner, 2005; Rigobon and Sack, 2004). In contrast, other studies have found that stock prices increased in response to monetary tightening during the stock market boom in the United States (US)(Galí and Gambetti, 2015; Jansen and Zervou, 2017). Therefore, this study poses two questions. Does monetary tightening lead to stock price declines during a stock price boom? If so, does the central bank gain additional benefits from stabilising stock price fluctuations in addition to standard policy objectives such as inflation and the output gap? While some theoretical research has examined this issue (Bonchi and Nisticò, 2024; Nistico, 2016; Galí, 2021; Airaudo et al., 2013), we employ empirical evaluation. While these research and policy questions are important, the answers vary across economies.

We address these research questions by examining the Bank of Japan's (BOJ) monetary policy actions during Japan's 1980s stock market boom. During this time, no consensus was reached concerning whether monetary contraction caused a significant decline in stock prices in a low-inflation environment (Okina et al., 2001). In particular, researchers disagreed on whether the BOJ should have reacted more aggressively to asset price fluctuations in the latter half of the 1980s (Jinushi et al., 2000; Okina et al., 2001). Focusing on the BOJ's monetary policy in the 1980s yields significant policy implications for the recent low and stable inflation environment affecting central banks in advanced economies.

As noted, evaluating Japan's 1980s stock price boom has raised debate regarding whether the BOJ should have raised its policy rates in response, which can be separated into two perspectives: the view of the Federal Reserve System (FED) and that of the Bank of International Settlement (BIS). Some economists determined that the BOJ would have faced challenges raising the policy rate in response to a sudden stock price boom because the inflation rate remained stable, which is considered to be the FED view (Kohn, 2006). In contrast, other economists have asserted that the BOJ's failure to increase the interest rate to prevent the extraordinary boom in stock prices caused the ensuing secular stagnation. This group has argued that although inflation was stable, the BOJ could have prevented the stock price boom if the central bank had responded correctly, which is the BIS view (Cecchetti et al., 2002).

This study uses a Bayesian estimation of the DSGE model to assess the performance of the BOJ's monetary policy from the 1980s to 1990s.[1] The DSGE model quantifies stock price movement by demand and supply sides. A stock's wealth effect represents the demand side, implying that increased stock prices raise private sector consumption spending (Castelnuovo and Nistico, 2010). In contrast, the supply side of stock prices implies that an increase in stock prices decreases real marginal costs, reducing inflation (Carlstrom and Fuerst, 2007).

While we acknowledge the importance of both channels in the Japanese economy, this study examines whether the demand channel substantially affected movements in stock prices. Therefore, this study challenges the identification of a deep parameter that captures the stock price demand channel. We also consider whether a wealth effect model can identify the BOJ's intention to stabilise stock prices. Specifically, this study assesses whether the BOJ responded to stock prices and standard policy goals such as inflation and output stabilisation. We incorporate the role of stock price stabilisation into the standard Taylor rule and identify the coefficient for stock price stabilisation.

To do so, we employ the DSGE model developed by Castelnuovo and Nistico (2010), who incorporated the Blanchard–Yaari type perpetual youth model into the standard new Keynesian (NK) model to consider the wealth channel of stock prices, demonstrating that the FED may have responded systematically to fluctuations in stock prices. Using this theoretical framework, we evaluate the BOJ's monetary policy stances during the 1980s, which enables us to consider stock price demand and supply channels in a single DSGE model. As noted previously, while Bayesian estimation can directly identify the demand side of the wealth channel, the model can also theoretically consider the supply side; therefore, Castelnuovo and Nistico (2010)'s model is suitable for our purpose.

Our results confirm the presence of the wealth channel resulting from increased stock prices in Japan; therefore, the BOJ's monetary policy decisions at the time may have given weight to stock price stabilisation in addition to more traditional policy goals such as inflation and the output gap. Our results also indicate that while the BOJ might have reacted to stock prices deviating from their fundamental values, a contractionary monetary policy shock would have

[1] See also Kaihatsu and Kurozumi (2014), Hirakata et al. (2016), Hirose (2008), Iiboshi et al. (2006), Muto et al. (2016) and Sugo and Ueda (2008) for Bayesian estimation of the DSGE using Japanese time-series data.

been unable to prevent a stock price boom. This assertion may be supported by considering that stock price measurement error may be significant; therefore, we argue that the BOJ's monetary policy stance may have been intended to stabilise stock price fluctuations and minimise macroeconomic volatility.

We also consider several monetary policy rules to explore the optimal policy reaction to stock price misalignment to achieve the lowest welfare loss among all policy regimes. Notably, the estimated Taylor rule performance in response to stock price misalignment may produce an outcome that is inferior to the standard Taylor rule. Moreover, while the standard Taylor rule appears to capture the actual policy rate, periods are shown when the estimated rule indicates a different interest rate path relative to a change in the actual policy rate. Our estimation results reveal a significant measurement error in capturing booms and busts in stock prices, indicating considerable uncertainty in the effects of monetary policy on the real economy. Therefore, we infer that if the BOJ had been able to implement optimal monetary policy at the time, the measurement error would have been minimised. Consequently, the size of the measurement error should significantly influence the deviation between the interest rate path under the estimated rule and that under an optimal policy.

Our study is closely related to Castelnuovo and Nistico (2010), and although we use the same framework, our study differs in the following aspects. First, the authors used US data to consider the role of stock price stabilisation using the Blanchard–Yaari NK (BYNK). In contrast, we employ Japanese data. Second, unlike the traditional perspective of the stock price channel of monetary policy, our model demonstrates that stock prices persistently rise in response to monetary tightening. This result contradicts Castelnuovo and Nistico (2010) and is consistent with the empirical result of Galí and Gambetti (2015). Third, we find that the degree of nominal wage stickiness and habit formation are critical for generating a positive stock price response to monetary tightening.

Our study is also related to Bernanke and Gertler (2000) and Jinushi et al. (2000). Both studies argued that the BOJ could not raise the policy rate sufficiently, which caused the boom and subsequent crash in stock prices in the late 1980s; however, their evaluations are derived from simulation results using the estimated Taylor rule. Furthermore, while Okina et al. (2001) examined whether the BOJ should have responded to the drastic increase in stock prices, their investigation did not use a structural macroeconomic model. Moreover, Miyao

(2002) found that BOJ monetary policy was characterised by active policy stances in the late 1980s; however, this finding was based on estimation results derived from a structural vector autoregressive (VAR) model. In contrast, this study addresses the challenge of evaluating to stock price reactions using monetary policy rules in a Bayesian DSGE model. In other words, this study complements previous research using a Bayesian DSGE model. To the best of our knowledge, this is the first study to use an estimated DSGE model to evaluate whether the BOJ directly reacted to stock price fluctuations.

Finally, our study is related to Hirose (2008), who estimated a medium-scale DSGE model with a sunspot shock and a financial accelerator effect. The author demonstrated that the BOJ's estimated reaction function was close to the performance of an optimal monetary policy rule that minimises the central bank's loss function. The simulation result indicated that BOJ monetary policy could have minimised macroeconomic volatility during the period. Hirose (2008) did not explore how the BOJ reacted to stock prices in the latter part of the 1980s. In contrast, this study identifies the BOJ's response to stock price fluctuations during the period by incorporating stock price stabilisation into the Taylor rule. Our results reveal that BOJ responses may have considered stock price fluctuations in the late 1980s. Unlike Hirose (2008), this possibility is characterised by the positive coefficient of stock price stabilisation in our estimated BOJ reaction function.

The remainder of this paper is structured as follows. Section 2 details the facts concerning the Japanese economy from the 1980s to the 1990s, demonstrating how stock price changes affected the Japanese economy. We then review the related literature and address our study's contributions. Section 3 describes the DSGE model and the Bayesian estimation methods, and Section 4 presents the baseline results. Section 5 uses the estimation results obtained in the previous section to examine whether the BOJ should have responded to the stock price gap, and Section 6 briefly concludes. Appendix A provides log-linearized equations, and Appendix B describes the data sources used in the Bayesian estimation.

2 Stock prices and monetary policy

2.1 A brief review of the Japanese economy in the 1980s

This section briefly explains the Japanese economy in the 1980s, when a boom and a bust occurred. Figure 1 plots time-series data depicting the Japanese economy in the 1980s and 1990s. Following the 1985 Plaza Accord, the Japanese economy faced deflation risk from sharp exchange rate appreciation. The Japanese yen (JPY) appreciated sharply against the US dollar in response to the Plaza Accord, falling from approximately 250 JPY in 1985 to around 120 JPY in the subsequent year. Figure 1 shows that the inflation rate was near zero, following the sharp appreciation of the nominal exchange rate after the Plaza Accord, and the actual gross domestic product (GDP) gap was negative from 1986 to 1987.

[Insert Figure 1 around here]

In response to this risk, the BOJ aggressively cut official discount and call rates as its monetary policy stance in the 1980s. The left lower panel of Figure 1 shows that the official discount rate dropped sharply from 6.5 % in 1985 to 2.5% in 1987, and this monetary easing continued until April 1989. The left upper panel of Figure 1 shows that while the actual GDP gap was negative in response to the Plaza Accord, monetary easing improved the gap. Several studies have indicated that the continuation of monetary easing from 1987 to 1989 induced the asset price boom, while the sharp increase in the official discount rate led to the subsequent collapse (Jinushi et al., 2000; Miyao, 2002; Okina et al., 2001). The BOJ sharply increased the policy rate in April 1989, and the official discount rate reached 6.25% in 1990. As Miyao (2002) noted, the BOJ's monetary policy stance was active in that the BOJ's monetary policy eased from 1986 to 1987 and contracted from 1989 to 1990.

We calculate the detrended stock price index, defined as the deviation of actual stock prices from detrended ones as a proxy for stock prices' deviation from fundamental values. The lower right panel of Figure 1 shows that detrended stock prices significantly increased with monetary easing during these periods. Bernanke and Gertler (2000) and Jinushi et al. (2000) argued that the BOJ could have prevented the asset price bubble by raising its policy rate following the stock price increase.

The BOJ did not aggressively raise the official discount rate in response to asset price movements for several reasons (Okina et al., 2001), one of which is related to the changing inflation rate in the late 1980s. The FED view posits that if the inflation rate remains stable, the central bank will have difficulty raising the policy rate even if asset price movement fluctuates are attributable to non-fundamental components (Bernanke and Gertler, 2000). Therefore, the FED view supports the policy in which the central bank is incentivised to implement monetary tightening only if an asset price boom leads to inflation risk, which did not occur in this period. Consequently, as Okina et al. (2001) explained, the BOJ may have lost the opportunity to increase the official discount rate.

We intend to determine whether the central bank contemplated responding to an increase in stock prices even if low inflation was maintained.

2.2 Stock prices and monetary policy: Literature review

This section briefly reviews the literature related to our study, clarifying how it relates to previous research on the role of asset price stabilisation.[2] We first review empirical studies concerning how stock prices respond to a contractionary monetary policy shock. Conventionally, a monetary tightening shock decreases stock prices, which has been supported by several studies observing that stock prices responded negatively to a monetary tightening shock in the US economy (Alessi and Kerssenfischer, 2019; Bernanke and Kuttner, 2005; Paul, 2020; Rigobon and Sack, 2004). In contrast, Galí and Gambetti (2015) found that monetary tightening produced a positive stock price response during the stock price boom in the US.[3] We use Castelnuovo and Nistico (2010)'s model with Japanese data, and our results align with Galí and Gambetti (2015) and Jansen and Zervou (2017). In contrast, the results of Castelnuovo and Nistico (2010) mirror previous studies, indicating that monetary tightening decreases stock prices in the US economy.

Several studies have also investigated whether the central bank should have considered how asset prices affect the real economy. As noted, whether central banks should react to asset price fluctuations has been the subject of debate. For example, Bernanke and Gertler (2000) asserted that the central bank should not stabilise asset prices unless they affect future inflation expectations. Conversely, Cecchetti et al. (2002) argued that asset price bubbles bursting could cause severe economic stagnation; therefore, the central bank should respond to asset prices

[2] See Shibamoto et al. (2020) for a detailed discussion regarding BOJ's monetary policy in the 1980s.

[3] See also Jansen and Zervou (2017).

as a precautionary objective. Furthermore, Chadha et al. (2004) and Haugh (2008) contended that the central bank might consider how stock price misalignment that causes stock prices to deviate from their fundamental values can impact the real economy.

To the best of our knowledge, the debate regarding the theoretical aspects of the NK model has not reached consensus. Several studies supported Bernanke and Gertler (2000), arguing that asset price reactions in the policy rule are redundant when the central bank aggressively raises the policy rate in response to inflation (Carlstrom and Fuerst, 2007; Gilchrist and Leahy, 2002; Faia and Monacelli, 2007; Iacoviello, 2005). Additionally, Galí (2014) questioned whether the central bank should follow the "leaning against the wind" response to stock price fluctuations amidst growing stock price bubbles. Conversely, some previous studies have asserted that the central bank could benefit from asset price stabilisation (Airaudo, 2013; Gambacorta and Signoretti, 2014; Kannan et al., 2012; Pfajfar and Santoro, 2014).[4] For example, Airaudo et al. (2013) showed that a mild response in a monetary policy rule to asset prices could achieve a unique rational expectations equilibrium and rule out non-fundamental volatility. Moreover, Kannan et al. (2012) found that when a model includes household heterogeneity, the central bank can obtain gains through an augmented monetary policy rule that integrates stock price stabilisation and a macro-prudential tool such as a credit growth rate.

Several studies have provided theoretical justifications to examine explicit monetary policy concerns regarding financial stability. For example, Nistico (2016) derived the optimal monetary policy using the BYNK model, demonstrating that the central bank's policy objectives include the term for financial stability stemming from cross-sectional consumption dispersion. Additionally, Bonchi and Nisticò (2024) found that the financial stability term, which resembles that of Nistico (2016), also characterises the central bank's loss function in a BYNK model with rational asset bubbles. Furthermore, although Galí (2021) did not explicitly derive the central bank's loss function using a BYNK model with rational asset bubbles, the study explored the role of a simple monetary policy rule that reacts to stock price bubbles.

In summary, no consensus has been reached concerning how contractionary monetary policy shocks affect stock prices during stock price booms or whether central banks should react aggressively to stock price changes. This study does not answer whether the central bank

[4] Di Giorgio and Nisticò (2007), Ida (2011) and Ida (2013) considered the role of asset price stabilisation in an open economy.

should react to stock prices aggressively; instead, we evaluate the BOJ's monetary policy stance in the 1980s, focusing on stock price stabilisation in the monetary policy rule. As stock price fluctuations in advanced countries generally occur with low interest rates and inflation, this study documents essential policy implications, expanding the debate on how the central bank should consider the role of stock price stabilisation.

3 Model description

This study concentrates on the stock price wealth channel to evaluate the BOJ's monetary policy stance. We adopt the framework of Castelnuovo and Nistico (2010), which introduces the discrete-time perpetual youth model developed by Blanchard (1985) and Yaari (1965) into the standard NK model. This section briefly describes the perpetual youth NK model framework. Detailed model derivations are available in Castelnuovo and Nistico (2010). Readers who are familiar with this model are welcomed to proceed to Section 4.

3.1 Model summary

The economy includes an indefinite number of cohorts subject to the constraint of a constant probability (ξ) of being replaced at the beginning of the next period. Following Castelnuovo and Nistico (2010), the interaction between "newcomers" who owning zero financial assets and "old traders" who accumulate wealth causing a wedge. This wedge separates the stochastic discount factor pricing all securities and the average marginal rate of substitution in consumption that is equalised in a representative agent (RA) model. In this case, optimal individual consumption smoothing in an RA model does not carry over in aggregate terms because agents in the financial markets change over time and their wealth and consumption levels may vary. This difference generates the stock price wealth effect through a dynamic IS equation, which is captured by parameter ξ. The case for $\xi = 0$ corresponds to the RA model.

Each household obtains utility from consumption and disutility from labour supply. Specifically, each household has Cobb–Douglas preferences over consumption and labour supply, and habit formation captures household consumption.

Furthermore, households specialise in supplying different types of labour, while each cohort spans all labour types. An infinitely lived monopoly labour union determines the nominal wage for each labour type, and each union faces Calvo's (1983) nominal wage rigidity. A fraction of $1-\theta_w$ can change nominal wages in its union. The remaining fraction (θ_w) cannot optimally choose their wages and follows the indexation rule associated with past price inflation, productivity growth and steady-state inflation.

As in a standard NK model, we introduce nominal price rigidity assuming staggered price contracts. The production sector includes retailers and intermediate goods firms. Retailers use intermediate goods to produce final goods in a perfectly competitive market. Following Calvo (1983), firms that sell wholesale goods stagger their nominal prices; therefore, a fraction $(1-\theta_p)$ of all firms optimally adjust their prices. In contrast, the remaining fraction (θ_p) of firms that do not optimally change prices follows the indexation rule associated with past and steady-state inflation.

Finally, we consider a stochastic trend in productivity to estimate the DSGE model, which enables us to estimate the model without implementing data pre-filtering.

3.2 Model description

3.2.1 Households

The representative household obtains utility from consuming final goods and leisure spending; therefore, the household's preference is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\xi)^t e^{z_t^b} \left[\log\left(C_t(j,k) - hC_{t-1}\right) + \chi \log\left(1 - l_t(k)\right)\right], \tag{1}$$

where β is the subjective discount factor, ξ denotes the turnover rate, z_t^b represents a shock to preference, $C_t(j,k)$ is individual consumption and C_t denotes aggregate consumption. h is a parameter of habit persistence, χ is the weight of leisure, and $l_t(k)$ represents hours worked.

The household's budget constraint is given by

$$C_t(j,k) + E_t f_{t,t+1} \frac{P_{t+1}B_{t+1}}{P_t} + \int_0^1 Q_t(i) Z_{t+1}(j,k,i)di = W_t(k)l_t(k) - T_t + \frac{1}{1-\xi}\Omega_t(j,k), \tag{2}$$

where $f_{t,t+1}$ is the stochastic discount factor. P_t represents the price level, B_t denotes the household's nominal bond holdings and $Q_t(i)$ is the real stock price. $Z_t(j,k,i)$ is the equity share issued by intermediate good firms, $W_t(k)$ is the real wage and T_t is a lump sum transfer. Finally, $\Omega_t(j,k)$ is financial wealth, which we define as follows:

$$\Omega_t(j,k) \equiv B_t(j,k) + \int_0^1 \left(Q_t(i) + D_t(i)\right) Z_t(j,k,i)di, \tag{3}$$

where $D_t(i)$ represents the dividend. The no-arbitrage condition is given by

$$E_t f_{t,t+1} = \frac{1}{R_t^n}, \tag{4}$$

where R_t^n is the gross nominal interest rate.

The first-order conditions are summarised as follows:

$$P_t Q_t = E_t f_{t,t+1} P_{t+1} \left(Q_{t+1}(i) + D_{t+1}(i) \right), \tag{5}$$

$$E_t f_{t,t+1} = \beta E_t \frac{P_t \tilde{C}_t(j,k)}{P_{t+1} \tilde{C}_{t+1}(j,k)} e^{z_{t+1}^b - z_t^b}, \tag{6}$$

where $\tilde{C}_t(j,k) \equiv C_t(j,k) - hC_{t-1}$. Equations (5) and (6) respectively denote the stock price dynamics and the consumption Euler equation.

3.2.2 Retailers

Retailers produce final goods (Y_t) using intermediate goods ($Y_t(i)$) to maximise profit in the perfectly competitive market. Retailers' profit is given by $P_t Y_t - \int_0^1 P_t(i) Y_t(i) di$. Here, Y_t is retailers' production function, given by $Y_t = \left[\int_0^1 Y_t(i)^{1/(1+\mu_t^p)} di \right]^{(1+\mu_t^p)}$ and μ_t^p is the time-varying price markup. $P_t(i)$ is the price for intermediate goods produced by firm i. The first-order condition for retailers is obtained as follows:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-(1+\mu_t^p)/\mu_t^p} Y_t, \tag{7}$$

which denotes the demand for intermediate goods. Given the perfect competitive market, the price level is given as follows:

$$P_t = \left(\int_0^1 P_t(i)^{-1/\mu_t^p} di \right)^{-\mu_t^p}. \tag{8}$$

3.2.3 Intermediate good firms

Intermediate goods firm i uses labour service $l_t(i)$ to produce output $Y_t(i)$. The production function of intermediate goods firms is as follows:

$$Y_t(i) = A_t l_t(i)^{1-\alpha}, \tag{9}$$

where $\alpha \in (0,1)$, $Y_t(i)$ is an intermediate good, and A_t is a neutral technology level, which is obtained as follows:

$$\ln A_t = \ln \gamma + \ln A_{t-1} + z_t^{\gamma},$$

where γ is the technology growth rate, and z_t^{γ} is the stochastic term of technology.

Given the demand for intermediate goods (7), intermediate goods firms set prices to maximise their discount future profit in the monopolistically competitive market, which follows Calvo (1983). Specifically, while a fraction $(1-\theta_p)$ of all firms re-optimises their price, and the remaining fraction (θ_p) that does not optimally set prices follows the indexation rule associated with past inflation and the steady-state inflation rate. Regarding firms that re-optimise prices, the first-order condition for P_t^o is given by

$$E_t \sum_{s=0}^{\infty} \theta_p^s f_{t,t+1} \frac{P_{t+s} Y_{t+s|t}}{\mu_{t+s}^p} \left[\frac{P_t^o}{P_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}} \right)^{\iota_p} \pi^{s(1-\iota_p)} - (1+\mu_{t+s}^p) mc_{t+s|t} \right] = 0, \tag{10}$$

where P_t^o is the re-optimised price, and ι_p is the degree of price indexation. $mc_{t+s|t}$ is the economy-wide marginal cost, which is expressed as follows:

$$mc_{t+s|t} = mc_{t+s} \left\{ \frac{P_t^o}{P_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}} \right)^{\iota_p} \pi^{s(1-\iota_p)} \right\}^{-\alpha/(1-\alpha)(1+\mu_t^p)/\mu_t^p}. \tag{11}$$

Here, mc_t is the average marginal cost, which is given by

$$mc_t = \frac{W_t}{(1-\alpha)A_t} \left(\frac{Y_t}{A_t} \right)^{\alpha/(1-\alpha)}. \tag{12}$$

Given the manner of staggered price, we transform the price level (8) as follows:

$$P_t = \left\{ \theta_p (P_{t-1} \pi_{t-1}^{\iota_p} \pi^{1-\iota_p})^{-1/\mu_t^p} + (1-\theta_p)(P_t^o)^{-1/\mu_t^p} \right\}^{-\mu_t^p}. \tag{13}$$

3.2.4 Labour unions

Labour unions negotiate with intermediate goods firms to set nominal wages that maximise the discount future income in the monopolistically competitive market based on the demand for labour service $l_t(k) = (W_t(k)/W_t)^{-(1+\mu_t^w)/\mu_t^w} l_t$. Here, $l_t = \left[\int_0^1 l_t(k)^{1/(1+\mu_t^w)} dk \right]^{(1+\mu_t^w)}$, which denotes aggregate labour hours, and $W_t = \left[\int_0^1 W_t(k)^{-1/\mu_t^w} dk \right]^{-\mu_t^w}$ is the aggregate real wage. μ_t^w is the time-varying wage markup. Firms are not always free to change wages, and their wage setting follows Calvo (1983). While a fraction $(1-\theta_w)$ re-optimises their wages, the remaining fraction (θ_w) does not optimally change wages following the indexation rule related to past inflation and productivity growth. For labour unions that re-optimise wages, the first-order condition for W_t^o is given by

$$E_t \sum_{s=0}^{\infty} \theta_w^s f_{t,t+s} \frac{l_{t+s|t}}{\mu_{t+s}^w} \left[P_t W_t^o \left(\frac{P_{t+s-1}}{P_{t-1}} \frac{A_{t+s-1}}{A_{t-1}} \right)^{\iota_w} (\pi\gamma)^{s(1-\iota_w)} - (1+\mu_{t+s}^w) P_{t+s} MRS_{t+s|t} \right] = 0, \tag{14}$$

where W_t^o denotes the optimised real wage, ι_w is the degree of wage indexation and $MRS_{t+s|t}$ is the average marginal substitution rate between consumption and labour hours. The relationship between the average and economy-wide marginal rate of substitution (MRS_t) is determined as follows:

$$MRS_{t+s|t} = MRS_{t+s} \frac{1-l_{t+s}}{1-l_{t+s}\left\{ \frac{P_t W_t^o}{P_{t+s} W_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}} \frac{A_{t+s-1}}{A_{t-1}} \right)^{\iota_w} (\pi\gamma)^{s(1-\iota_w)} \right\}^{-(1+\mu_{t+s}^w)/\mu_{t+s}^w}}, \tag{15}$$

where MRS_{t+s} is defined as follows:

$$MRS_{t+s} \equiv \chi \frac{\tilde{C}_{t+s}}{1-l_{t+s}}.$$

Given a staggered wage setting, we transform the aggregate wage index as follows:

$$P_t W_t = \left[\theta_w \left\{ P_{t-1} W_{t-1} \left(\pi_{t-1} \gamma e^{z_{t-1}^{\gamma}} \right)^{\iota_w} (\pi\gamma)^{1-\iota_w} \right\}^{-1/\mu_t^w} + (1-\theta_w)(P_t W_t^o)^{-1/\mu_t^w} \right]^{-\mu_t^w}. \tag{16}$$

3.2.5 Market clearing condition

The market clearing condition for final goods is given as follows:[5]

$$Y_t = C_t + g e^{z_t^g} A_t, \tag{17}$$

where g denotes the steady-state demand factors other than household consumption, and z_t^g denotes a shock to the exogenous demand.

3.3 Log-linearized model

We next describe the log-linearized equations of our model,[6] which includes the production technology trend; therefore, we must rewrite the model to the detrended equilibrium conditions.

[5]Unlike Castelnuovo and Nistico (2010), we assume that the public sector does not consume the fraction of total output and its consumption is stochastically determined.

[6]See Appendix A for the list of log-linearized equations.

Lowercase variables denote detrended macro-variables. We introduce the detrended macro-variables as follows: $y_t = Y_t/A_t$, $c_t = C_t/A_t$, $d_t = D_t/A_t$, $w_t = W_t/A_t$, $q_t = Q_t/A_t$, $\omega_t = \Omega_t/A$ and $mrs_t = MRS_t/A_t$.

Following Castelnuovo and Nistico (2010), variables with a hat denote the log deviation from the detrended steady state, and those with an asterisk denote the counterparts under frictionless equilibrium. Following Castelnuovo and Nistico (2010), frictionless equilibrium indicates flexible prices and wages in addition to the non-stochastic markup on prices and wages and no financial shocks. Appendix A defines variables under frictionless equilibrium.

The log-linearized equations can be summarised as follows:

$$\begin{aligned}\tilde{y}_t &= \frac{1-h/\gamma}{1-h/\gamma+\psi}\left(E_t\tilde{y}_{t+1} - \frac{h}{\gamma}\tilde{y}_t\right) + \frac{(1-h/\gamma)(1-g/y)\psi}{1-h/\gamma+\psi}\tilde{s}_t \\ &\quad + \frac{h}{\gamma}\tilde{y}_{t-1} - \frac{(1-h/\gamma)^2(1-g/y)}{1-h/\gamma+\psi}\left(\hat{R}^n_t - E_t\hat{\pi}_{t+1} - \hat{R}^*_t\right), \qquad (18)\end{aligned}$$

$$\begin{aligned}\tilde{s}_t &= \tilde{\beta}E_t\tilde{s}_{t+1} + \frac{\mu^p(1-\tilde{\beta})}{\alpha+\mu^p}E_t\tilde{y}_{t+1} - \frac{(1-\tilde{\beta})(1-\alpha)}{\alpha+\mu^p}E_t\tilde{w}_{t+1} \\ &\quad - \left(\hat{R}^n_t - E_t\hat{\pi}_{t+1} - \hat{R}^*_t\right) + z^{\nu}_t, \qquad (19)\end{aligned}$$

$$\hat{\pi}_t = \tilde{\beta}\left(E_t\hat{\pi}_{t+1} - \iota_p\hat{\pi}_t\right) + \iota_p\hat{\pi}_{t-1} + \lambda_p\tilde{w}_t + \frac{\alpha\lambda_p}{1-\alpha}\tilde{y}_t + z^p_t, \qquad (20)$$

$$\begin{aligned}\hat{w}_t &= \tilde{\beta}\left(E_t\hat{w}_{t+1} - \hat{w}_t + E_t\hat{\pi}_{t+1} - \iota_w\hat{\pi}_t + E_t z^{\gamma}_{t+1} - \iota_w z^{\gamma}_t\right) + \hat{w}_{t-1} \\ &\quad - \hat{\pi}_t + \iota_w\hat{\pi}_{t-1} - z^{\gamma}_t + \iota_w z^{\gamma}_{t-1} + \lambda_w\left(\frac{1}{(1-h/\gamma)(1-g/y)} + \frac{\varphi}{1-\alpha}\right)\tilde{y}_t \\ &\quad - \frac{\lambda_w h/\gamma}{(1-h/\gamma)(1-g/y)}\tilde{y}_{t-1} - \lambda_w\tilde{w}_t + z^w_t. \qquad (21)\end{aligned}$$

where $\hat{\pi}_t$ denotes the inflation rate, $\hat{y}_t$ represents output, and $\hat{R}^n_t$ is the nominal interest rate. $\hat{w}_t$ is the real wage rate, and $\hat{R}^*_t$ is the natural interest rate, which we define as the real interest rate under frictionless equilibrium. This section focuses on equations expressed by a gap term that implies the log deviation of the level value from the counterpart under frictionless equilibrium. The output gap is expressed by $\tilde{y}_t = \hat{y}_t - \hat{y}^*_t$. Similarly, we define the real wage gap as $\tilde{w}_t = \hat{w}_t - \hat{w}^*_t$ and the stock price gap as $\tilde{s}_t = \hat{q}_t - \hat{q}^*_t$. We next discuss the list of structural shocks introduced in the paper.

Equation (18) is the dynamic IS curve, which indicates that stock price wealth effects are present as long as $\xi > 0$. Unlike a RANK model, this implies that the demand channel of stock prices positively affects the output gap. Equation (19) represents stock price dynamics. The second and third terms on the right-hand side are related to the dividend, which reacts positively to the output gap and negatively to the real marginal cost. Following Carlstrom and Fuerst (2007), the negative relationship between the dividend and the real marginal cost indicates stock prices' supply-side channels. Equation (20) is the NK Phillips curve for price, and equation (21) is the NK Phillips curve for wage. As described below, z_t^j (for $j \in \{\gamma, p, w, g, b, \nu, r\}$) denotes structural shocks that follow the autoregressive (AR)(1) process. The deep parameters in the above structural equations are defined as follows:

$$\tilde{\beta} = \frac{\beta(1-h/\gamma)}{1-h/\gamma+\psi}, \ \lambda_p = \frac{\mu^p(1-\theta_p)(1-\theta_p\tilde{\beta})(1-\alpha)}{\theta_p(\mu_p+\alpha)},$$
$$\lambda_w = \frac{\mu^w(1-\theta_w)(1-\theta_w\tilde{\beta})}{\theta_w(\mu_w+\varphi(1+\mu_w))}, \ \psi = \xi\frac{1-\beta(1-\xi)}{1-\xi}\frac{\omega}{c}.$$

where g/y is the ratio of exogenous demand relative to output and α is the degree of diminishing return to scale in the production function. Finally, ω/c denotes the ratio of the aggregate wealth to aggregate consumption in the steady state.

We employ the standard monetary policy rule proposed by Taylor (1993) to consider whether each central bank should react to the stock price gap. Specifically, we specify the following log-linearized monetary policy rule:

$$\hat{R}_t^n = \phi_r \hat{R}_{t-1}^n + (1-\phi_r)\left(\phi_\pi \hat{\pi}_t + \phi_y \tilde{y}_t + \phi_s \tilde{s}_t\right) + z_t^r, \tag{22}$$

where ϕ_π is the coefficient of the inflation rate, ϕ_y is the coefficient of the output gap and ϕ_s denotes the coefficient of the stabilisation weight on the stock price gap.

We consider technology, price markup, wage markup, demand, preference, financial and monetary policy structural shocks, which are given as follows:

$$z_t^\gamma = \rho_\gamma z_{t-1}^\gamma + \varepsilon_t^\gamma,$$
$$z_t^p = \rho_p z_{t-1}^p + \varepsilon_t^p,$$
$$z_t^w = \rho_w z_{t-1}^w + \varepsilon_t^w,$$
$$z_t^g = \rho_g z_{t-1}^g + \varepsilon_t^g,$$
$$z_t^b = \rho_b z_{t-1}^b + \varepsilon_t^b,$$
$$z_t^\nu = \rho_\nu z_{t-1}^\nu + \varepsilon_t^\nu,$$
$$z_t^r = \rho_r z_{t-1}^r + \varepsilon_t^r,$$

where ε_t^j follows $N(0, \sigma_j^2)$ for all $j \in \{\gamma, p, w, g, b, \nu, r\}$. Section 4 defines the stock price growth rate measurement error.

4 Baseline results

This section presents our baseline results. Subsection 4.1 presents our estimation strategy, Subsection 4.2 provides the structural model's posterior estimates and Subsection 4.3 explores whether the BOJ reacted to the stock market. Subsections 4.4 and 4.5 examine the variance, historical decomposition and the estimated model's dynamic properties using the impulse response function. Subsection 4.6 presents sensitivity experiments regarding the degree of nominal wage stickiness and habit formation.

4.1 Bayesian estimation

We use Bayesian methods to estimate our DSGE model with the wealth channel of asset prices.[7] We evaluate the likelihood function by applying the Kalman filter to the system of log-linearized equilibrium and observation equations. We obtain 1,000,000 draws from the posterior distribution of parameters, which we estimate using Metropolis–Hastings (MH) algorithms, which enables us to approximate the moments. We set the scale parameter in the MH algorithms so that the acceptance ratio is maintained at around 25%, discarding the draws from the first half and using the remaining draws for our analysis.

We identify the key structural parameters using seven quarterly Japanese time-series data. Y_t is real per capita GDP and C_t is real per capita consumption. We divide per capita series by the population over 15 years old. SP_t is the quarterly growth rate of the real Nikkei stock average (NIKKEI 225). W_t is the real wage, l_t is hours worked, DEF_t is the GDP deflator and R_t^n is the call rate. Appendix B presents a detailed data description. Finally, we use the sample period from 1981:Q1 to 1998:Q4 to avoid problems of nonnegativity constraints on nominal interest rates.[8]

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[7] Our estimation is conducted using Dynare (Adjemian et al., 2011).

[8] We concentrate on the role of stock price stabilisation in this period. If we allow for the zero lower bounds on the nominal interest rate, the sample period can be extended to use the shadow rate of the nominal interest rate. This extension is beyond the scope of the study; therefore, we plan to examine this issue in future work.

The observation equations are constructed as follows:

$$\begin{bmatrix} 100\Delta\ln Y_t \\ 100\Delta\ln C_t \\ 100\Delta\ln SP_t \\ 100\Delta\ln W_t \\ 100\Delta\ln l_t \\ 100\Delta\ln DEF_t \\ R_t^n \end{bmatrix} = \begin{bmatrix} \overline{\gamma} \\ \overline{\gamma} \\ \overline{\gamma} \\ \overline{\gamma} \\ 0 \\ \overline{\pi} \\ \overline{R}^n \end{bmatrix} + \begin{bmatrix} z_t^{\gamma} + \hat{y}_t - \hat{y}_{t-1} \\ z_t^{\gamma} + \hat{c}_t - \hat{c}_{t-1} \\ z_t^{\gamma} + \hat{q}_t - \hat{q}_{t-1} \\ z_t^{\gamma} + \hat{w}_t - \hat{w}_{t-1} \\ 1/(1-\alpha)\left(\hat{y}_t - \hat{y}_{t-1}\right) \\ \hat{\pi}_t \\ \hat{R}_t^n \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ me_t \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

where $\overline{\gamma} = 100\ln\gamma$, $\overline{\pi} = 100\ln\pi$ and $\overline{R}^n = 100\ln R^n$.[9] me_t is the measurement error for the stock price growth rate, which is given by

$$me_t = \rho_{mq} me_{t-1} + \varepsilon_t^{mq},\ \varepsilon_t^{mq} \sim \text{i.i.d.}N(0, \sigma_{mq}^2),$$

where $\rho_{mq} \in [0, 1)$ represents the autoregressive coefficient, and σ_{mq}^2 is the white noise. The measurement error follows the AR(1) process used by Matsumae et al. (2011).[10]

Following previous research, we assume that some parameters in the model are fixed. For example, we set the capital share ($\alpha = 0.37$), the discount factor ($\beta = 0.995$) and price and wage markup, $\mu^p = \mu^w = 0.2$ following Sugo and Ueda (2008). The steady-state exogenous demand factors to output ratio, $g/y = 0.3$, follow the sample mean.

We follow previous studies to set the prior distributions of estimated parameters below. Table 1 presents the priors of each parameter. The priors of the turnover rate (ξ), leisure weight in the household's utility (χ) and monetary policy response to the stock price gap (ϕ_s) follow Castelnuovo and Nistico (2010). Specifically, χ and ϕ_s follow the gamma distribution with a mean of 1.4 and a standard deviation of 1.0 and the normal distribution with a mean of zero and a standard deviation of 0.025, respectively. Regarding ξ, we set a uniform distribution with mean 0.5 and a standard deviation of $1/\sqrt{12}$, which implies that the uniform distribution of ξ is specified by the closed interval $[0, 1]$. We follow Sugo and Ueda (2008) for the priors of the

[9] We use the growth rate of hours worked in the observation equation to maintain the specification of Castelnuovo and Nistico (2010)'s model.

[10] As Castelnuovo and Nistico (2010) argued, measurement errors are also introduced for stock prices; however, they are white noise. In contrast, the measurement error in our model is the AR(1) process because the contamination from the errors would continue to carry over from the previous period.

structural parameters $\{h, \theta_p, \theta_w, \iota_p, \iota_w\}$. Previous studies on the Japanese economy that have used a Bayesian DSGE model have argued that the monetary policy rule parameters follow the distributions used by Iiboshi et al. (2006) and Kaihatsu and Kurozumi (2014), excluding ϕ_s.

[Insert Table 1 around here]

Regarding the priors of our seven structural shocks, the persistence of each shock $\rho_x,\ x \in \{\gamma, p, w, g, b, \nu, r\}$ are a beta distribution with a mean of 0.5 and a standard deviation of 0.2. The standard deviation of shocks $\sigma_x,\ x \in \{\gamma, p, w, g, b, \nu, r\}$ are the inverse gamma with a mean of 0.5 and a standard deviation of infinity. Finally, previous studies that have used DSGE models for the Japanese economy have not incorporated non-fundamental financial shock z_t^{ν}. In contrast, we assume that the prior distribution of the financial shock is the same as other shocks, which enables us to ensure the same conditions.

4.2 Posterior estimates

Table 1 summarises the values of the estimated parameter and the 90% posterior interval.[11] We focus on the turnover rate (ξ), which is characterised by the stock price wealth effect through household's demand side, which enables us to confirm stock prices' significance in the model. The posterior mean ($\xi = 0.047$) and its 90% interval are $[0.027, 0.066]$, confirming the presence of wealth effects. Therefore, we identify the effect of the stock prices on real activities through variations in household's consumption. Castelnuovo and Nistico (2010) estimated ξ to be about 0.13 for the US economy. Our results indicates that the Japanese economy's wealth effects are smaller than in the US economy.

The posterior mean of most structural parameters is similar to that obtained using the DSGE model for Japan; however, some differ from previous studies. For example, wage stickiness ($\theta_w = 0.286$) is lower than Hirose and Kurozumi (2012) and Kaihatsu and Kurozumi (2014), with respective estimated values of 0.522 and 0.503. Our estimated value of price indexation (ι_p) is 0.045, which is much smaller than that in Hirose and Kurozumi (2012) and Kaihatsu and Kurozumi (2014), with respective estimated values of 0.631 and 0.408. Specifically, Hirose and Kurozumi (2012) and Kaihatsu and Kurozumi (2014) introduced the Consumer Price Index into the observation equation; however, our analysis uses the GDP deflator

[11] We confirmed that the estimated parameters in our model are accurately identified. Additional results for this identification problem are available upon request.

as price data. Hirakata et al. (2016) used the GDP deflator, and we confirm that the resulting estimated value of the price indexation is similar to our results.[12]

The leisure weight in the utility ($\chi = 0.03$) is relatively low compared with Castelnuovo and Nistico (2010), who analysed the US economy using the estimated DSGE model with $\chi = 1.4456$. The difference may be attributed to including the period before *Jitan*, when the hours worked in a week were reduced due to 1987 amendments to the Labour Standards Act in Japan. Therefore, the leisure weight might be underestimated by including periods of long working hours.

We next examine the parameters of the financial shock that directly affects stock prices, which is relatively persistent but does not fluctuate much: $\rho_\nu = 0.958$ and $\sigma_\nu = 0.580$. This relative stability occurs because the measurement error for the stock prices absorbs its volatility in the observation equation. The estimated financial shock's standard deviation would be a relatively low value; however, the standard deviation of the measurement error for the stock prices is extremely high: $\sigma_{mq} = 7.059$.

4.3 On the BOJ's policy response to stock prices

Table 1 indicates that a positive value of ξ significantly accounts for the wealth effect of stock prices in Japan. We next examine whether this wealth effect justifies the BOJ's stock price stabilisation. Table 1 reports the estimated value of stock price stabilisation (ϕ_s). The estimated value of ϕ_s is 0.3204, potentially indicating that the BOJ responded to stock price movements. Furthermore, the estimated value indicates that the BOJ responded to fluctuations in stock prices significantly because the credible interval ([0.0418, 0.6162]) does not contain zero. Therefore, while the BOJ reacted to increased stock prices in the 1980s, this result indicates significant uncertainty in terms of stabilising stock prices.

We next investigate whether the BOJ could have reacted more aggressively to the sharp stock price increase in the late 1980s. We conduct counterfactual estimations as if the BOJ responded strongly to asset prices during the period. Table 2 presents the related estimation results of the coefficients for a monetary policy rule and log-likelihood. This table demonstrates that the BOJ's reaction to stock prices is stronger than the baseline case ($\phi_s = 0.3204$).

[12] Hirakata et al. (2016) selected a sample period from 1981:Q1 to 2013:Q4; the sample period in our analysis is from 1981:Q1 to 1998:Q4.

Comparing our baseline model with those that include $\phi_s = 0.5$ shows that a more aggressive response to stock prices can improve the model's performance. When $\phi_s = 0.75$, this strong response to stock prices cannot outperform the model with $\phi_s = 0.5$; however, it can outpace the baseline model. Moreover, the log-likelihood is larger under the model with $\phi_s = 0.25$ than under a benchmark model. Finally, the result excluding stock price stabilisation ($\phi_s = 0$) produces the worst log-likelihood outcomes in Table 2; therefore, compared with the model with $\phi_s = 0$, including stock price stabilisation in the Taylor rule has some merit for model evaluation. These results imply that the BOJ might confront greater uncertainty resulting from the effect of stock price fluctuations on the Japanese economy. Since this is an important policy issue, we further examine this point in the next section.

[Insert Table 2 around here]

4.4 Variance and historical decomposition

This subsection evaluates the contribution of shocks to business cycle fluctuations in the Japanese economy, examining the variance and historical decomposition of several key variables. Table 3 presents the variance decomposition of the key macro-variables at quarterly forecast horizons of $T = 8$ and $T = 32$. The results reveal that the monetary policy shock accounts for short- and medium-term variation in the nominal interest rate. Financial shock also generates interest rate fluctuations, and the contribution particularly increases in the medium term. This occurs because financial shock may result in non-fundamental stock price disturbances, implying that the central bank may manipulate the interest rate to prevent stock price fluctuations from the financial shock. These findings confirm that monetary policy responds to stock prices, as demonstrated previously.

[Insert Table 3 around here]

As noted, the financial shock affects the non-fundamental component of the stock prices, which is confirmed by the stock price gap variance decomposition. Furthermore, fluctuations in the stock price gap can also be caused by exogenous demand shocks. Our analysis does not incorporate real investment as the observation data and endogenous variable; therefore, our results overestimate the effects of the exogenous demand shock on the economy's demand side. Structural shocks do not explain much of the stock price growth variance decomposition because of the measurement error introduced to the observation equation. The neutral technology shock primarily generates fluctuations in output growth, which aligns with Hirose and Kurozumi (2012) and Kaihatsu and Kurozumi (2014).

Figure 2 illustrates the historical decomposition of the nominal interest rate, revealing that the monetary policy shock has strong fluctuations over time. The historical decomposition demonstrates the significant effect of financial shock on the policy rate in which monetary policy shock exerted downward pressure on the policy rate in the late 1980s. This result may be interpreted as a scenario in which the BOJ sought to combat a sharp increase in stock prices but could not substantially raise the nominal interest rate due to adverse shocks such as financial frictions from 1987 to 1990. In contrast, Figure 2 indicates that the negative contributions of financial shocks can also explain precautionary monetary easing from 1992 to 1993. This implies that the BOJ's precautionary monetary easing policy rate reacted to the recession associated with the collapse of the asset price boom, resulting in aggressive reduction in its policy rate. To obtain further insight into this issue, we examine whether the interest rate path suggested by the estimated Taylor rule is consistent with a change in the actual policy rate in Section 5.

[Insert Figure 2 around here]

4.5 Dynamic properties of the estimated model

This subsection investigates the estimated model's quantitative properties. Figures 3–6 summarise the impulse responses of the nominal interest rate, stock price gap, inflation, stock price growth and output growth to monetary policy, preference, financial conditions and neutral technology shocks. "Baseline" represents the model variable's impulse responses to shocks under the estimated parameters of the benchmark model, which we first focus on.

Figure 3 illustrates the impulse response to a monetary policy shock in our DSGE model. The contractionary monetary policy shock increases the nominal interest rate while decreasing the inflation rate and output growth. Although monetary contraction initially reduces the stock price gap and growth, causing subsequent increases in these variables. The impulse responses demonstrate that this shock generates a trade-off between stabilising the inflation rate and the stock price gap. These results indicate that as long as a monetary policy rule contains the stabilisation term that responds to the stock price gap, the central bank must sacrifice price stability to prevent stock price fluctuations. The results reveal that inflation and the stock price gap are characterised by persistent responses (compared with other shocks). These results contrast with those obtained by Castelnuovo and Nistico (2010), who found that an increase in the policy rate negatively affects stock prices. Conversely, our impulse response analyses indicate that an increase in the nominal interest rate causes a subsequent rise in stock prices. Figure 1 shows that stock prices substantially increased even when the BOJ raised the nominal interest rate from 1989 to 1990, and a reduction in the policy rate could not prevent the subsequent stock price decline in the 1990s.

[Insert Figure 3 around here]

As in Castelnuovo and Nistico (2010), in an NK model with the wealth channel of stock prices, the output gap directly increases with a stock price increase in the dynamic IS curve. Our findings indicate that a substantial rise in the policy rate could not prevent a stock price boom associated with the wealth channel. Theoretically, increasing the policy rate in this model decreases the real marginal cost and output, a decrease in real marginal cost increases dividends and a decrease in output leads to a proportional decrease in dividends. Therefore, monetary tightening increases stock prices when a real marginal cost decrease exceeds an output decrease. This result implies that the above mechanism might work in Japan.

Figure 4 reveals that the preference shock causes stock price fluctuations. With the exception of stock price growth, a positive preference shock increases macro-variables; however, the impulse responses remain unaffected by an increased value in the stock price stabilisation weight (ϕ_s). Figure 5 illustrates the financial shock, which induces non-fundamental disturbances for the stock prices. This shock increases stock prices, inflation and the output gap through stock price wealth effects. The central bank raises its nominal interest rate in response to both shocks; however, the policy reaction is more persistent in the financial shock than other shocks, with a more persistent effect on the interest rate than any other structural shock. Figure 6 demonstrates that the positive, neutral technology shock intensifies output growth and stock prices by increasing dividends. A positive productivity shock increases output and dividends; hence, a rise in stock prices induced by these variables creates a positive output gap through a stock price wealth effect in a dynamic IS curve. The productivity shock also decreases inflation in our model.

[Insert Figure 4 around here]

[Insert Figure 5 around here]

[Insert Figure 6 around here]

Figures 3–6 also reveal whether monetary policy stabilises the real economy in reaction to stock prices. These figures summarise the impulse responses under the different ϕ_s values. Baseline ($\phi_s = 0.3204$), $\phi_s = 0.25$ and $\phi_s = 0.5$. As ϕ_s increases, demonstrating that monetary policy reacts more strongly to stock market conditions.[13] These impulse responses show that as the central bank responds to stock price gap fluctuations, the nominal interest rate tends to react more strongly and is more persistent. In contrast, the stock price growth rate and output exhibit no significant changes relative to the baseline model. These results indicate that even if monetary policy reacts strongly to stock price gap fluctuations, the central bank will struggle to stabilise the stock price and output volatility sufficiently.

4.6 Effect of changing several key parameters

Finally, we investigate whether changes in several key parameters affect the main results from the previous section. First, we examine whether a change in wage stickiness affects stock prices' response to a monetary tightening shock, which hinges on whether nominal wages are sticky.[14] Figure 7 (i) illustrates stock price response to monetary tightening under several calibrated values of wage stickiness (θ_w). The stock price response in our model represents an intermediate case between flexible and sticky nominal wage cases. The results reveal that if nominal wages become increasingly flexible, stock prices will react positively; however, contractionary policy shocks will negatively affect stock prices if nominal wages become increasingly sticky.

[Insert Figure 7 around here]

Second, we assess whether the degree of habit persistence affects the stock price response to monetary tightening. Figure 7 (ii) plots the stock price response under several habit persistence values (h), revealing a positive stock price response to monetary tightening unless the h

[13] In this simulation, we only change the value of ϕ_s in the baseline model; however, we do not consider model re-estimation under a different ϕ_s values.

[14] Carlstrom and Fuerst (2007) indicated that nominal wage stickiness affects the determinacy condition under a monetary policy rule with stock price stabilisation.

parameter is predominately large. Conversely, a relatively more significant value of h appears to be inconsistent with previous studies.

Our wage stickiness estimation is $\theta_w = 0.286$, and this value might be lower than the calibrated value in the standard NK model with nominal price and wage rigidities. Furthermore, even in the BYNK model, the θ_w and h parameters in our estimation result are lower than those reported by Castelnuovo and Nistico (2010), who demonstrated that stock prices reacted negatively to monetary tightening in the US economy with the presence of wage stickiness. Therefore, monetary tightening does not cause an adverse stock price reaction unless wage stickiness and habit persistence are considerably higher.

5 Discussion: Policy re-evaluation

We next examine the role of stock price stabilisation in the 1980s based on the simulation results obtained in the previous section. As Bernanke and Gertler (2000), Jinushi et al. (2000) and Okina et al. (2001) demonstrated, the delay and shortage of monetary tightening policies from 1985 to 1987 may have created the stock price bubble. Furthermore, sharp increases in the official discount rate in subsequent periods resulted in the bubble bursting in 1990. The problem is whether the BOJ could have prevented the stock price boom in the late 1980s if it had aggressively increased the policy rate in response to stock prices.

As noted, Bernanke and Gertler (2000) used the estimation result of the BOJ's reaction function suggested by the Taylor rule, arguing that the BOJ should have aggressively reacted to the stock price boom in the late 1980s.[15] Using a VAR model, Miyao (2002) found that the BOJ's monetary policy was characterised by an active policy stance in the late 1980s, asserting that the BOJ's monetary policy was eased from 1986 to 1987 and tightened from 1989 to 1990. These results indicate the significance of the BOJ's active policy stance in these periods. Hirose (2008) estimated the financial accelerator effects using a DSGE model with a sunspot shock, arguing that the estimated monetary policy rule indicates that the BOJ could minimise welfare loss during the 1980s by following the optimal rule. The study concluded that the monetary policy could reduce Japan's macroeconomic fluctuations; therefore, the endogenous volatility

[15] Bernanke and Gertler (2000) also indicated that an increased policy rate should be justified if the BOJ combats the inflationary risk induced by the stock price boom. They subsequently claimed that the central bank should not react to asset price fluctuations if they are not connected to inflationary risk.

during the period was associated with exogenous shocks induced by "bad luck" rather than "bad policy".

Our model demonstrates that the BOJ might not have prevented a stock price boom even if it increased the weight on stock price stabilisation in its reaction function. Figure 3 reveals that a reaction function with a larger weight on stock prices results in a persistent decline in the inflation rate while simultaneously creating an increased response to the stock price gap. This result might imply that even if the BOJ implemented powerful monetary tightening in 1987, they would not prevent a drastic increase in stock prices from their fundamental values during that period.

To gain further insight into this issue, we explore why the positive weight on stock prices did not prevent a stock price boom. The monetary tightening policy may positively respond to the stock price gap in our model. A contractionary monetary policy facilitates a decrease in output and inflation, which reduces the real marginal cost. In our model, stock price dynamics proportionally change with the dividend, which is positively related to output and negatively related to the real marginal cost.[16] Monetary contraction decreases the real marginal cost, increasing the dividend. As noted, when the effect of a decline in the real marginal cost dominates that of decreased output, stock prices may rise in response to monetary tightening. Figure 8 presents the historical decomposition of the dividend, revealing that it increased regardless of contractionary monetary policy from 1989 to 1990. Therefore, fluctuations in financial shocks contributed significantly to rising dividends in this period. This empirical finding is consistent with the model prediction in Section 4 and aligns with Okina et al. (2001).

[Insert Figure 8 around here]

Our results indicate that a stock price boom may have occurred that the financial shock did not adequately capture. Stock prices should be determined based on fundamental value; namely, the discounted present value of dividends. Therefore, if the stock market is perfectly efficient, the impact of economic shocks would be immediately reflected by changes in current stock prices. In this case, almost no measurement error should arise in stock prices. Conversely, we demonstrated significant measurement errors in stock prices that structural shocks could

[16] We rewrite the log-linearized dividends as follows: $\hat{d}_t = \hat{y}_t - \frac{1-\alpha}{\alpha+\mu^p}(\hat{w}_t + \alpha\hat{l}_t)$. The dividend is the remaining income net of the cost of production.

not explain. Accordingly, when that significant measurement error in stock prices was strongly connected to a stock price boom, the BOJ may have managed monetary policy inadequately in the 1980s. We interpret this measurement error as extreme uncertainty that conventional structural shocks such as productivity and demand shocks cannot explain. Thus, even if the BOJ had raised its policy rate in response to these shocks, it may have been unable to prevent the stock price boom.

We next evaluate the above point concerning the optimal policies in reaction to stock price misalignments. To do so, we consider four policy regimes encompassing the estimated rule, the optimised rule, the standard Taylor rule and the Ramsey optimal policy. For the welfare criteria, we use the following loss function to capture a trade-off between inflation stabilisation and stock price stabilisation. The loss function with the term for financial stability is based on theoretical justification (Bonchi and Nisticò, 2024; Nisticò, 2012; Pfajfar and Santoro, 2008).[17] We consider the following loss function with stock price stabilisation:

$$L_t^s = \pi_t^2 + \lambda_y \tilde{y}_t^2 + \lambda_s \tilde{s}_t^2, \tag{23}$$

where λ_y and λ_s denote the weight on output gap and stock price gap stabilisation, respectively. We set the respective parameter values for λ_y and λ_s to 0.25 and 0.1.[18]

Table 4 presents the performance of several policy regimes when the loss function contains stock price stabilisation. The Ramsey policy leads to the smallest welfare loss among all policy regimes, and the optimised rule creates preferable outcomes for standard and estimated rules. We use Dynare's *osr* method to obtain the optimised rule.[19] By fixing ϕ_r at 0.9, we obtained the optimal coefficients $\phi_\pi = 0.77$, $\phi_x = 1.57$ and $\phi_s = 0$. Therefore, the optimised rule indicates that while the central bank considers a smaller weight on inflation and a stronger weight on the output gap, it should not respond to stock price fluctuations. Notably, the estimated rule's performance is inferior to that of the standard rule. The results indicate that the BOJ might have confronted a policy trade-off between inflation and stock price stabilisation.

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[17] Nistico (2016) and Bonchi and Nisticò (2024) demonstrated that the loss function includes the financial stability term from the cross-sectional consumption dispersion in the BYNK model; therefore, our criterion considers the stock price stabilisation in the loss function rather than focusing on this type of financial stability.

[18] Our results remain robust to several plausible values for these parameters.

[19] We set the parameter sets for each coefficient in the policy rule as $\phi_\pi \in [0, 5]$, $\phi_y \in [0, 2]$, $\phi_s \in [0, 1.5]$ and $\phi_r \in [0, 1]$. The coefficients are optimally selected to minimise a loss function given the above parameter space.

[Insert Table 4 around here]

Finally, we compare the interest rate path based on estimated and standard Taylor rules with the actual policy rate. Figure 9 shows that standard Taylor and optimised rules capture the actual policy rate; however, the estimated rule indicates an interest rate path that differs from the actual policy rate movement in some periods. For example, the estimated rule requires the central bank to raise the policy rate more aggressively than the actual policy rate from 1989 to 1990. Furthermore, after the stock market bubble burst, the rule dictated aggressively lowering policy rates from 1991 to 1993. These policy prescriptions are consistent with Jinushi et al. (2000).[20] Therefore, we question whether a stock price bubble could have been avoided if the BOJ had reacted strongly to the rising stock prices in the 1980s. Unfortunately, the stock price stabilisation rule's results indicate that the interest rate path implied by the estimated rule might have resulted in significant welfare losses relative to an optimal policy.

[Insert Figure 9 around here]

This study's findings can be summarised as follows. Our estimation results imply that measurement errors capture the boom and bust of stock prices that the structural model cannot explain. Since a more significant measurement error causes volatility in the BOJ's policy rate, it manifests considerable uncertainty about how monetary policy affects the real economy. Okina et al. (2001) indicated that even if the BOJ had known the optimal interest rate path, they would have had difficulty raising policy rates appropriately. Table 4 supports this assertion, demonstrating that the optimal policy can result in the smallest welfare loss of all policy rules. From this, we infer that if the BOJ had implemented an optimal monetary policy, measurement error would have also been minimised. Therefore, if measurement error is minimised under the optimal policy, the deviation between the interest rate path under the estimated rule and that under the optimal policy should be captured by a more substantial measurement error. Our results support this conjecture, indicating that the central bank faces a severe trade-off between inflation and stock price stabilisation if it reacts to fluctuations. This study reveals that the estimation rule that includes stock price stabilisation leads to inferior outcomes from larger welfare losses than the standard rule, despite the advantage of a larger

[20] The policy prescriptions advocated by Jinushi et al. (2000) are based on the Taylor rule with exchange rate fluctuations estimated using the generalised method of moments.

log-likelihood. Accordingly, regarding social welfare, since stock price movements were strongly affected by measurement errors in the Japanese economy during the 1980s, the BOJ could not follow the interest rate path implied by the estimated rule.

6 Concluding remarks

This study examines the role of stock price stabilisation in Japan, employing a DSGE model that includes the wealth channel through stock prices. Our results reveal the presence of a wealth channel through increased stock prices in Japan. Furthermore, we assert the possibility that the BOJ conducted its monetary policy by assigning weight to stock price stabilisation as a policy objective in addition to controlling inflation and the output gap. The results indicate that the BOJ may have reacted to stock prices deviating from fundamental values; however, it could not prevent a stock price boom by implementing monetary contraction.

Furthermore, we explore the optimal policy reaction to stock price misalignment by considering several monetary policy rules. The optimal policy achieves the lowest welfare loss among all policy regimes; however, the estimated Taylor rule's performance in response to stock price misalignment may lead to worse outcomes than the standard Taylor rule. Furthermore, while the standard Taylor rule appears to capture the actual policy rate, there are periods during which the estimated rule indicates a different interest rate path than a change in the actual policy rate. Moreover, our estimation results reveal a significant measurement error in capturing stock price booms and busts, which implies considerable uncertainty in the effects of monetary policy on the real economy. We posit that if the BOJ had implemented optimal monetary policy at the time, the measurement error would have been minimised, concluding that the deviation between the interest rate path under the estimated rule and that under an optimal policy should be mainly explained by the size of the measurement error.

Our results have important policy implications for recent stock price fluctuations, predominantly for advanced countries where stock price fluctuations are likely to occur with low interest rates and inflation. Previous studies have indicated that the stock price boom experienced by the Japanese economy in the 1980s emerged in such an environment. We also argue that the BOJ had difficulty stabilising stock price fluctuations under low inflation. Our study emphasises the importance of considering the role of stock price stabilisation in monetary policy rules during stock price booms in low inflation and low interest rate environments.

Finally, we argue that significant measurement errors in stock prices introduce the possibility of stock price bubbles; however, our model may be insufficient to elucidate the substantial factors that generate stock price bubbles. Moreover, monetary policy shock may have a non-linear effect on stock prices. Unfortunately, estimating a fully non-linear BYNK model is beyond the scope of this study because it is difficult to accurately obtain a non-linear system of equations due to aggregation problems. We will consider and address these issues by revising the model in future work.

A Appendix A: Log-linearized model

A.1 Key equations

$$\hat{y}_t = \frac{c}{y}\hat{c}_t + \frac{g}{y}z_t^g, \tag{A.1}$$

$$\begin{aligned}\hat{c}_t - \frac{h}{\gamma}\left(\hat{c}_{t-1} - z_t^\gamma\right) &= \frac{1-h/\gamma}{1-h/\gamma+\psi}\psi\hat{q}_t - \frac{(1-h/\gamma)^2}{1-h/\gamma+\psi}\left(\hat{R}_t^n - E_t\hat{\pi}_{t+1}\right)\\ &+ \frac{1-h/\gamma}{1-h/\gamma+\psi}\left(E_t\hat{c}_{t+1} - \frac{h}{\gamma}\hat{c}_t + E_t z_{t+1}^\gamma\right)\\ &- (1-h/\gamma)(1+\psi_b)\,E_t\left(z_{t+1}^b - z_t^b\right),\end{aligned} \tag{A.2}$$

$$\hat{q}_t = \tilde{\beta}E_t\hat{q}_{t+1} + (1-\tilde{\beta})E_t\hat{d}_{t+1} - \left(\hat{R}_t^n - E_t\hat{\pi}_{t+1}\right) + E_t z_{t+1}^\gamma + z_t^\nu, \tag{A.3}$$

$$\hat{d}_t = \hat{y}_t - \frac{1-\alpha}{\alpha+\mu^p}\hat{mc}_t, \tag{A.4}$$

$$\hat{l}_t = \frac{1}{1-\alpha}\hat{y}_t, \tag{A.5}$$

$$\hat{mw}_t = \varphi\hat{l}_t + \frac{1}{1-h/\gamma}\hat{c}_t - \frac{h/\gamma}{1-h/\gamma}\left(\hat{c}_{t-1} - z_t^\gamma\right) - \hat{w}_t, \tag{A.6}$$

$$\hat{mc}_t = \hat{w}_t + \frac{\alpha}{1-\alpha}\hat{y}_t. \tag{A.7}$$

A.2 Frictionless equilibrium

$$\hat{y}_t^* = \frac{h/\gamma(1-\alpha)}{1-\alpha+(\alpha+\varphi)(1-h/\gamma)(1-g/y)}\hat{y}_{t-1}^* + \frac{(1-\alpha)(1-g/y)}{1-\alpha+(\alpha+\varphi)(1-h/\gamma)(1-g/y)}\left\{\frac{g/y}{1-g/y}\left(z_t^g - \frac{h}{\gamma}z_{t-1}^g\right) - \frac{h}{\gamma}z_t^\gamma\right\}, \tag{A.8}$$

$$\hat{w}_t^* = \frac{h/\gamma(1-\alpha)}{1-\alpha+(\alpha+\varphi)(1-h/\gamma)(1-g/y)}\hat{w}_{t-1}^* - \frac{\alpha(1-g/y)}{1-\alpha+(\alpha+\varphi)(1-h/\gamma)(1-g/y)}\left\{\frac{g/y}{1-g/y}\left(z_t^g - \frac{h}{\gamma}z_{t-1}^g\right) - \frac{h}{\gamma}z_t^\gamma\right\}, \tag{A.9}$$

$$\begin{aligned}\hat{R}_t^* = &\frac{1}{1-h/\gamma}\left\{\frac{1}{1-g/y}\left(E_t\hat{y}_{t+1}^* - \frac{g}{y}E_t z_{t+1}^g\right) + E_t z_{t+1}^\gamma\right\} \\ &- \frac{h/\gamma}{(1-h/\gamma)(1-g/y)}\left(\hat{y}_t^* - \frac{g}{y}z_t^g\right) \\ &- \frac{1-h/\gamma+\psi}{(1-h/\gamma)^2(1-g/y)}\left(\hat{y}_t^* - \frac{g}{y}z_t^g\right) \\ &+ \frac{(1-h/\gamma+\psi)h/\gamma}{(1-h/\gamma)^2}\left\{\frac{1}{1-g/y}\left(\hat{y}_{t-1}^* - \frac{g}{y}z_{t-1}^g\right) - z_t^\gamma\right\} \\ &- \frac{(1-h/\gamma+\psi)(1+\psi_b)}{1-h/\gamma}\left(E_t z_{t+1}^b - z_t^b\right),\end{aligned} \tag{A.10}$$

$$\hat{q}_t^* = \tilde{\beta}E_t\hat{q}_{t+1}^* + (1-\tilde{\beta})E_t\hat{y}_{t+1}^* - \hat{R}_t^* + E_t z_{t+1}^\gamma. \tag{A.11}$$

A.3 Steady states

$$\begin{aligned}\frac{c}{y} &= 1 - \frac{g}{y}, \\ \frac{\omega}{c} &= \frac{R^n(\mu^p+\alpha)}{(R^n-\gamma\pi)(1+\mu^p)c/y}, \\ \psi &= \frac{\xi\{1-\beta(1-\xi)\}}{1-\xi}\frac{\omega}{c}, \\ \tilde{\beta} &= \frac{\beta(1-h/\gamma)}{1-h/\gamma+\psi}, \\ \varphi &= \frac{1-\alpha}{\chi(1-h/\gamma)(1+\mu^w)(1+\mu^p)c/y}, \\ \psi_b &= \frac{\psi\beta(1-\xi)\rho_b}{(1+\psi-h/\gamma)\{1-\beta(1-\xi)\rho_b\}}, \\ \lambda_p &= \frac{\mu^p(1-\theta_p)(1-\tilde{\beta}\theta_p)(1-\alpha)}{\theta_p(\alpha+\mu^p)}, \\ \lambda_w &= \frac{\mu^w(1-\theta_w\tilde{\beta})(1-\theta_w)}{\theta_w\{\mu^w+\varphi(1+\mu^w)\}}.\end{aligned}$$

B Appendix B: Data sources

This appendix provides a detailed explanation of how to construct a dataset to estimate the DSGE model. The data series we use are as follows:[21]

- Gross Domestic Product (Source: Cabinet Office, "National Account")
- GDP deflator (Source: Cabinet Office, "National Account")
- Call rate (Source: Bank of Japan)
- Nikkei 225 (Source: Federal Reserve Bank of St. Louis)
- Nominal consumption (Source: Cabinet Office, "National Account")
- Nominal wage (Source: Ministry of Health, Labour and Welfare, "Monthly Labour Survey")
- Labour hour (Source: Ministry of Health, Labour and Welfare, "Monthly Labour Survey")
- Population over 15 years old (Source: Statistics Bureau, Ministry of Internal Affairs and Communications, "Labour Force Survey")

References

Adjemian, S., Bastani, H., Juillard, M., Mihoubi, F., Perendia, G., Ratto, M., Villemot, S., 2011. Dynare: Reference manual, version 4. Dynare Working Papers 1 .

Airaudo, M., 2013. Monetary policy and stock price dynamics with limited asset market participation. Journal of Macroeconomics 36, 1–22.

Airaudo, M., Cardani, R., Lansing, K.J., 2013. Monetary policy and asset prices with belief-driven fluctuations. Journal of Economic Dynamics and Control 37, 1453–1478.

Alessi, L., Kerssenfischer, M., 2019. The response of asset prices to monetary policy shocks: stronger than thought. Journal of Applied Econometrics 34, 661–672.

[21] For GDP, GDP deflator and nominal consumption time-series data, we use a simple retrospective series up to 1993:Q4 to estimate consistency in the base year.

Bernanke, B., Gertler, M., 2000. Monetary policy and asset price volatility. Technical Report. National bureau of economic research.

Bernanke, B.S., Kuttner, K.N., 2005. What explains the stock market's reaction to federal reserve policy? The Journal of Finance 60, 1221–1257.

Blanchard, O.J., 1985. Debt, deficits, and finite horizons. Journal of Political Economy 93, 223–247.

Bonchi, J., Nisticò, S., 2024. Optimal monetary policy and rational asset bubbles. European Economic Review , 104851.

Calvo, G.A., 1983. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics 12, 383–398.

Carlstrom, C.T., Fuerst, T.S., 2007. Asset prices, nominal rigidities, and monetary policy. Review of Economic Dynamics 10, 256–275.

Castelnuovo, E., Nistico, S., 2010. Stock market conditions and monetary policy in a dsge model for the us. Journal of Economic Dynamics and Control 34, 1700–1731.

Cecchetti, S.G., Genberg, H., Wadhwani, S., 2002. Asset prices in a flexible inflation targeting framework. Technical Report. National Bureau of Economic Research.

Chadha, J.S., Sarno, L., Valente, G., 2004. Monetary policy rules, asset prices, and exchange rates. IMF Staff Papers 51, 529–552.

Di Giorgio, G., Nisticò, S., 2007. Monetary policy and stock prices in an open economy. Journal of Money, Credit and Banking 39, 1947–1985.

Faia, E., Monacelli, T., 2007. Optimal interest rate rules, asset prices, and credit frictions. Journal of Economic Dynamics and Control 31, 3228–3254.

Galí, J., 2014. Monetary policy and rational asset price bubbles. American Economic Review 104, 721–52.

Galí, J., 2021. Monetary policy and bubbles in a new keynesian model with overlapping generations. American Economic Journal: Macroeconomics 13, 121–167.

Galí, J., Gambetti, L., 2015. The effects of monetary policy on stock market bubbles: Some evidence. American Economic Journal: Macroeconomics 7, 233–57.

Gambacorta, L., Signoretti, F.M., 2014. Should monetary policy lean against the wind?: An analysis based on a dsge model with banking. Journal of Economic Dynamics and Control 43, 146–174.

Gilchrist, S., Leahy, J.V., 2002. Monetary policy and asset prices. Journal of monetary Economics 49, 75–97.

Haugh, D.L., 2008. Monetary policy under uncertainty about the nature of asset-price shocks. International Journal of Central Banking 4, 39–83.

Hirakata, N., Sudo, N., Takei, I., Ueda, K., 2016. Japan's financial crises and lost decades. Japan and the World Economy 40, 31–46.

Hirose, Y., 2008. Equilibrium indeterminacy and asset price fluctuation in Japan: A Bayesian investigation. Journal of Money, Credit and Banking 40, 967–999.

Hirose, Y., Kurozumi, T., 2012. Do investment-specific technological changes matter for business fluctuations? Evidence from Japan. Pacific Economic Review 17, 208–230.

Iacoviello, M., 2005. House prices, borrowing constraints, and monetary policy in the business cycle. American Economic Review 95, 739–764.

Ida, D., 2011. Monetary policy and asset prices in an open economy. The North American Journal of Economics and Finance 22, 102–117.

Ida, D., 2013. Tobin's q channel and monetary policy rules under incomplete exchange rate pass-through. Economic Modelling 33, 733–740.

Iiboshi, H., Nishiyama, S.I., Watanabe, T., 2006. An estimated dynamic stochastic general equilibrium model of the Japanese economy: A Bayesian analysis .

Jansen, D.W., Zervou, A., 2017. The time varying effect of monetary policy on stock returns. Economics Letters 160, 54–58.

Jinushi, T., Kuroki, Y., Miyao, R., 2000. Monetary policy in japan since the late 1980s: delayed policy actions and some explanations. Japan's financial crisis and its parallels to US experience , 115–48.

Kaihatsu, S., Kurozumi, T., 2014. Sources of business fluctuations: Financial or technology shocks? Review of Economic Dynamics 17, 224–242.

Kannan, P., Rabanal, P., Scott, A.M., 2012. Monetary and macroprudential policy rules in a model with house price booms. The BE Journal of Macroeconomics 12.

Kohn, D.L., 2006. Monetary policy and asset prices. Monetary Policy , 43.

Matsumae, T., Iiboshi, H., Namba, R., Nishiyama, S., 2011. An application of hybrid mcmc and simulation smoother in estimating a dsge model with measurement errors. J. Japan Statist. Soc. Japanese Issue 41, 83–121.

Miyao, R., 2002. The effects of monetary policy in japan. Journal of Money, Credit and Banking , 376–392.

Muto, I., Sudo, N., Yoneyama, S., et al., 2016. Productivity Slowdown in Japan's Lost Decades: How Much of It Can Be Attributed to Damaged Balance Sheets? Technical Report. Bank of Japan.

Nisticò, S., 2012. Monetary policy and stock-price dynamics in a dsge framework. Journal of Macroeconomics 34, 126–146.

Nistico, S., 2016. Optimal monetary policy and financial stability in a non-ricardian economy. Journal of the European Economic Association 14, 1225–1252.

Okina, K., Shirakawa, M., Shiratsuka, S., 2001. The asset price bubble and monetary policy: Japan's experience in the late 1980s and the lessons. Monetary and Economic Studies (special edition) 19, 395–450.

Paul, P., 2020. The time-varying effect of monetary policy on asset prices. Review of Economics and Statistics 102, 690–704.

Pfajfar, D., Santoro, E., 2008. Credit market distortions, asset prices and monetary policy .

Pfajfar, D., Santoro, E., 2014. Credit market distortions, asset prices and monetary policy. Macroeconomic Dynamics 18, 631–650.

Rigobon, R., Sack, B., 2004. The impact of monetary policy on asset prices. Journal of Monetary Economics 51, 1553–1575.

Shibamoto, M., Takahashi, W., Kamihigashi, T., 2020. Japan's monetary policy: A literature review and an empirical assessment. Research Institute for Economics and Business Administration, Kobe University.

Sugo, T., Ueda, K., 2008. Estimating a dynamic stochastic general equilibrium model for Japan. Journal of the Japanese and International Economies 22, 476–502.

Taylor, J.B., 1993. Discretion versus policy rules in practice, in: Carnegie-Rochester conference series on public policy, Elsevier. pp. 195–214.

Yaari, M.E., 1965. Uncertain lifetime, life insurance, and the theory of the consumer. The Review of Economic Studies 32, 137–150.

Table 1: Priors and posteriors

Parameters		Type	Prior Mean	Prior SD	Posterior Mean	Posterior 90% interval
ξ	Turnover rate	Uniform	0.500	0.289	0.0472	[0.0270, 0.0666]
h	Habit persistence	Beta	0.700	0.150	0.2023	[0.0967, 0.3036]
χ	Leisure weight	Gamma	1.400	1.000	0.0330	[0.0012, 0.0638]
θ_p	Intermediate good price stickiness	Beta	0.375	0.100	0.8771	[0.8470, 0.9146]
θ_w	Wage stickiness	Beta	0.375	0.100	0.2865	[0.1703, 0.3971]
ι_p	Intermediate good price indexation	Beta	0.500	0.250	0.0455	[0.0003, 0.0930]
ι_w	Wage indexation	Beta	0.500	0.250	0.0565	[0.0008, 0.1111]
ϕ_r	Monetary policy rate smoothing	Beta	0.800	0.100	0.9425	[0.9072, 0.9795]
ϕ_π	Monetary policy response to inflation	Gamma	1.700	0.100	1.6508	[1.4885, 1.8152]
ϕ_y	Monetary policy response to output gap	Gamma	0.125	0.050	0.1481	[0.0535, 0.2405]
ϕ_s	Monetary response to stock price gap	Normal	0.000	0.025	0.3204	[0.0418, 0.6162]
$\overline{\gamma}$	Steady-state rate of balanced growth	Gamma	0.480	0.100	0.4721	[0.3465, 0.5950]
$\overline{\pi}$	Steady-state inflation rate	Gamma	0.240	0.100	0.2442	[0.1162, 0.3739]
$\overline{R}^n$	Steady-state interest rate	Gamma	1.090	0.100	1.1078	[0.9457, 1.2655]
ρ_γ	Persistence in z_t^γ	Beta	0.500	0.200	0.0857	[0.0172, 0.1507]
ρ_p	Persistence in z_t^p	Beta	0.500	0.200	0.1200	[0.0243, 0.2059]
ρ_w	Persistence in z_t^w	Beta	0.500	0.200	0.3272	[0.1137, 0.5418]
ρ_g	Persistence in z_t^g	Beta	0.500	0.200	0.9550	[0.9206, 0.9912]
ρ_b	Persistence in z_t^b	Beta	0.500	0.200	0.3345	[0.0448, 0.6307]
ρ_ν	Persistence in z_t^ν	Beta	0.500	0.200	0.9586	[0.9283, 0.9895]
ρ_r	Persistence in z_t^r	Beta	0.500	0.200	0.2592	[0.0758, 0.4374]
ρ_{mq}	Persistence in me_t	Beta	0.500	0.200	0.3656	[0.1982, 0.5264]
σ_γ	Standard deviation of z_t^γ	Inverse gamma	0.500	inf	1.0189	[0.8775, 1.1537]
σ_p	Standard deviation of z_t^p	Inverse gamma	0.500	inf	0.4311	[0.3612, 0.4970]
σ_w	Standard deviation of z_t^w	Inverse gamma	0.500	inf	0.5711	[0.4449, 0.6946]
σ_g	Standard deviation of z_t^g	Inverse gamma	0.500	inf	1.7694	[1.5302, 2.0061]
σ_b	Standard deviation of z_t^b	Inverse gamma	0.500	inf	0.4692	[0.1583, 0.7467]
σ_ν	Standard deviation of z_t^ν	Inverse gamma	0.500	inf	0.5807	[0.3546, 0.8002]
σ_r	Standard deviation of z_t^r	Inverse gamma	0.500	inf	0.1225	[0.1051, 0.1398]
σ_{mq}	Standard deviation of me_t^{mq}	Inverse gamma	0.500	inf	7.0594	[6.0929, 8.0117]

Table 2: Model comparison

	$\phi_s = 0$	$\phi_s = 0.25$	$\phi_s = 0.32^*$	$\phi_s = 0.5$	$\phi_s = 0.75$
ϕ_π	1.6800	1.6477	1.6508	1.6463	1.6522
ϕ_y	0.1409	0.1549	0.1481	0.1439	0.1381
ϕ_r	0.9620	0.9382	0.9425	0.9409	0.9454
Log-marginal likelihood	−654.53	−652.10	−652.97	**−651.06**	−651.19

(Note) Number with asterisks imply an estimated value under a baseline model.

Table 3: Variance decomposition

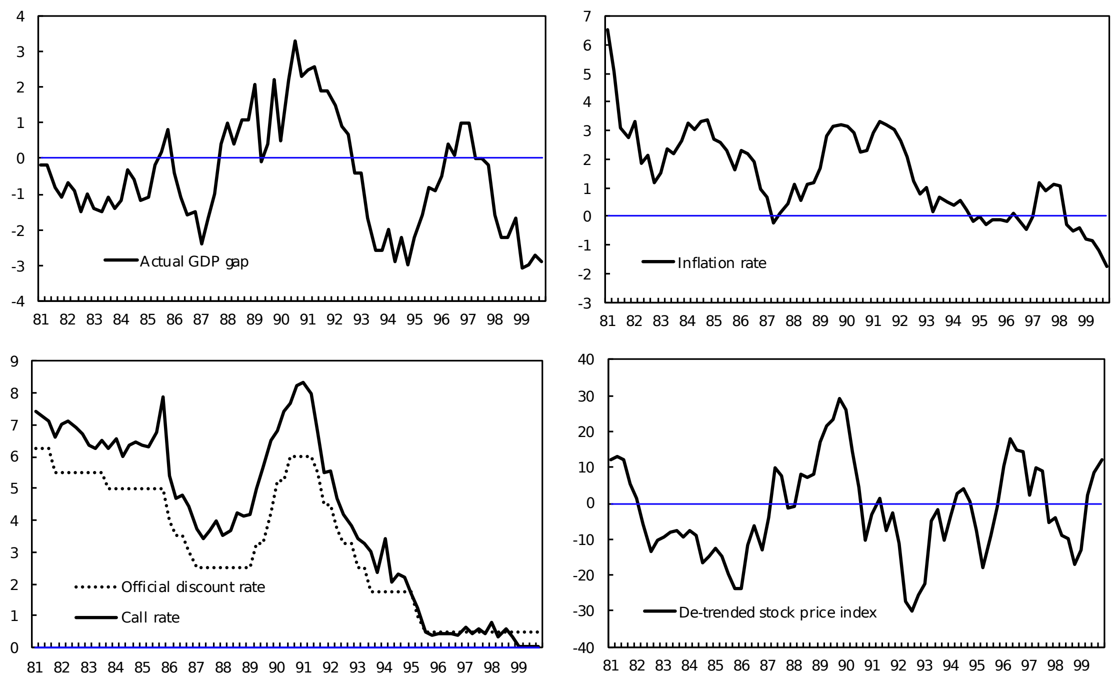
		Stock price gap		Stock price growth		Inflation	
Shock		$T=8$	$T=32$	$T=8$	$T=32$	$T=8$	$T=32$
z_t^γ	Neutral technology shock	15.48	11.23	4.33	4.33	0.56	0.61
z_t^p	Price markup shock	6.51	6.26	0.15	0.15	92.44	85.41
z_t^w	Wage markup shock	17.23	12.49	0.36	0.36	0.42	0.50
z_t^g	Demand shock	7.69	19.79	0.29	0.29	1.68	4.27
z_t^b	Preference shock	3.18	2.16	0.03	0.03	0.04	0.03
z_t^ν	Financial shock	46.16	36.94	1.11	1.12	3.73	6.58
z_t^r	Monetary policy shock	3.74	11.13	0.02	0.02	1.13	2.59
		Output gap		Output growth		Interest rate	
Shock		$T=8$	$T=32$	$T=8$	$T=32$	$T=8$	$T=32$
z_t^γ	Neutral technology shock	8.75	8.65	80.17	80.14	1.46	1.89
z_t^p	Price markup shock	1.21	1.21	0.52	0.52	11.86	9.68
z_t^w	Wage markup shock	11.67	11.52	1.81	1.81	1.80	2.20
z_t^g	Demand shock	19.58	20.14	5.82	5.82	0.33	0.77
z_t^b	Preference shock	7.57	7.46	3.98	3.98	0.18	0.08
z_t^ν	Financial shock	41.11	40.72	6.54	6.56	13.09	30.89
z_t^r	Monetary policy shock	10.10	10.30	1.17	1.17	71.28	54.48

Table 4: Welfare loss comparison under several monetary policy rules

Standard deviations and welfare loss				
	std(y_{gap})	std(π)	std(q_{gap})	Welfare loss
(i) Estimated rule	1.1622	0.7638	3.6664	2.2653
(ii) Optimised rule	0.9104	0.7304	2.9367	1.6028
(iii) Standard rule	1.2686	0.7766	3.2758	2.0785
(iv) Ramsey policy	0.8129	0.7408	1.7573	1.0228

Note) The estimated rule (i) represents the estimated Taylor rule with stock price stabilisation. The coefficients under the estimated rule are $\phi_\pi = 1.6508$, $\phi_y = 0.1481$, $\phi_r = 0.9425$ and $\phi_s = 0.3204$. The optimised rule (ii) implies that the coefficients are optimally selected by minimising the loss function. The optimised coefficients are $\phi_\pi = 0.77$, $\phi_x = 1.57$, $\phi_r = 0.9$ and $\phi_s = 0$. The standard rule (iii) means that the monetary policy rule uses the estimated coefficients by excluding stock price stabilisation. This rule's coefficients are $\phi_\pi = 1.68$, $\phi_y = 0.1409$, $\phi_r = 0.9620$ and $\phi_s = 0$. Finally, the Ramsey policy (iv) implies the commitment policy under the loss function.

Figure 1: Time-series data in the Japanese economy from the 1980s to the 1990s



Note) Data sources include the Bank of Japan (call rate and official discount rate, annualised), Cabinet Office National Accounts (GDP gap and GDP deflator) and the Federal Reserve Bank of St. Louis (Nikkei Stock Average, Nikkei 225). Time-series data are presented in percentage.

Figure 2: Historical decomposition of nominal interest rate

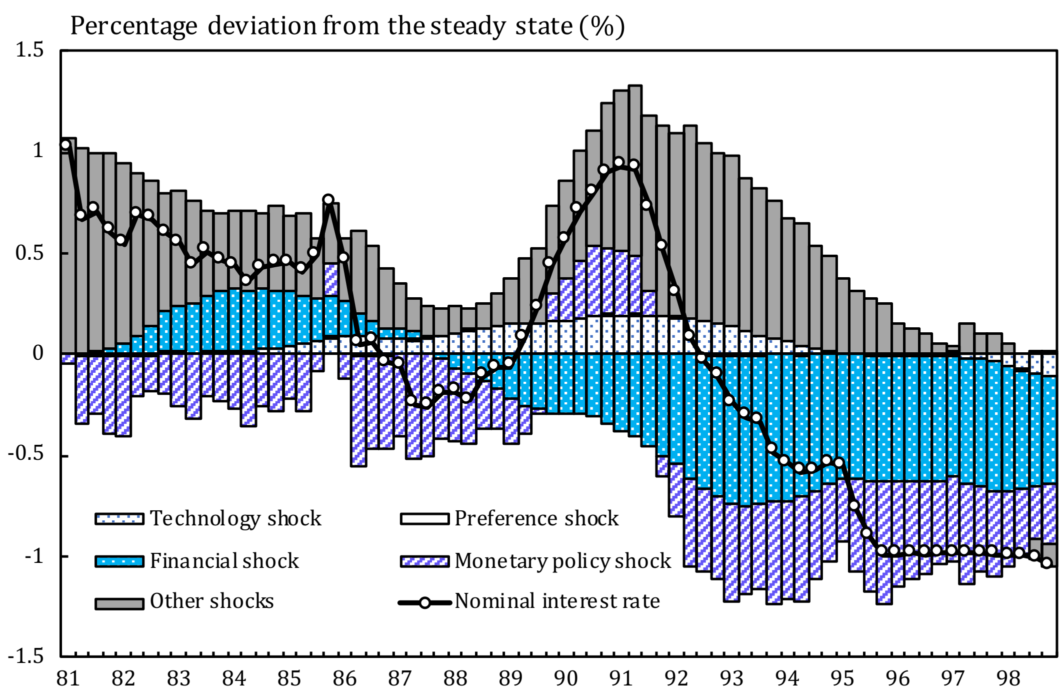
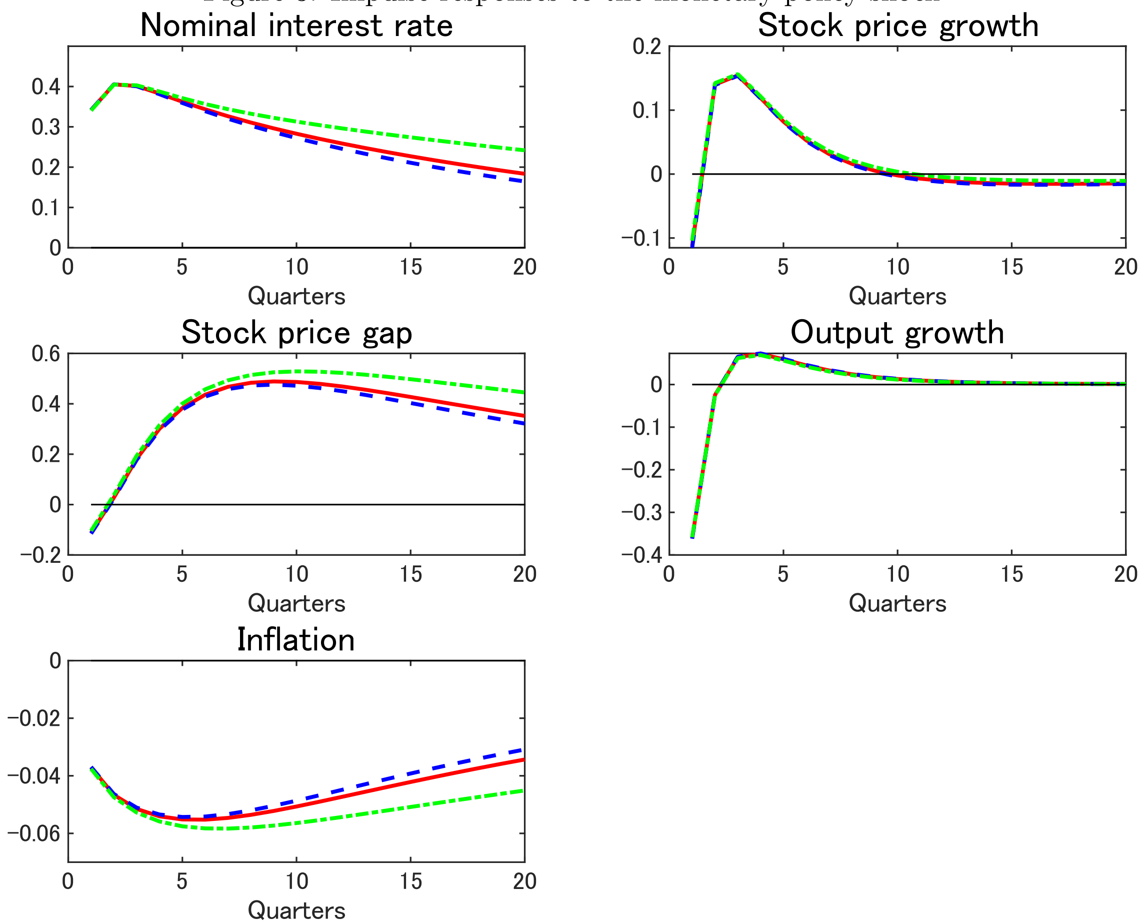
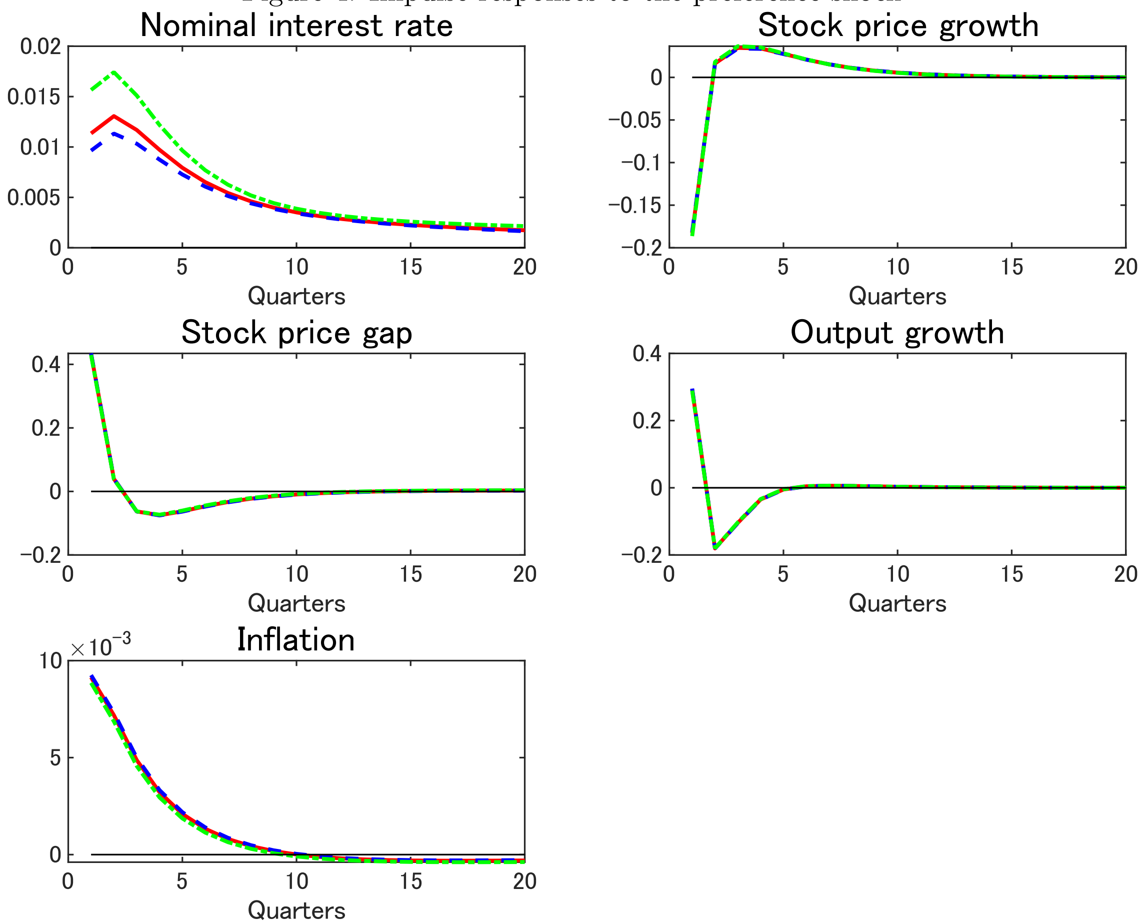


Figure 3: Impulse responses to the monetary policy shock



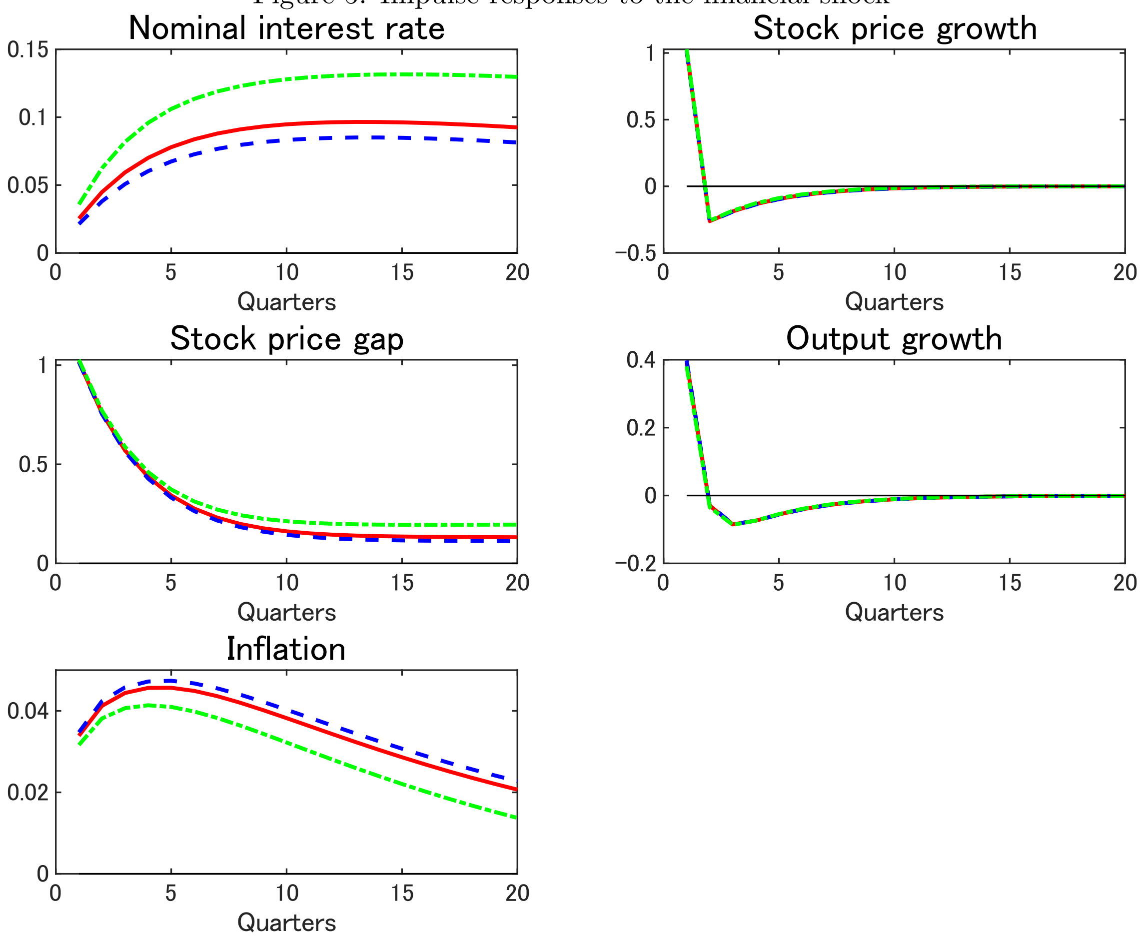
Note) Solid, dashed and dash-dotted lines denote the benchmark, the model with $\phi_s = 0.25$ and the model with $\phi_s = 0.5$, respectively.

Figure 4: Impulse responses to the preference shock



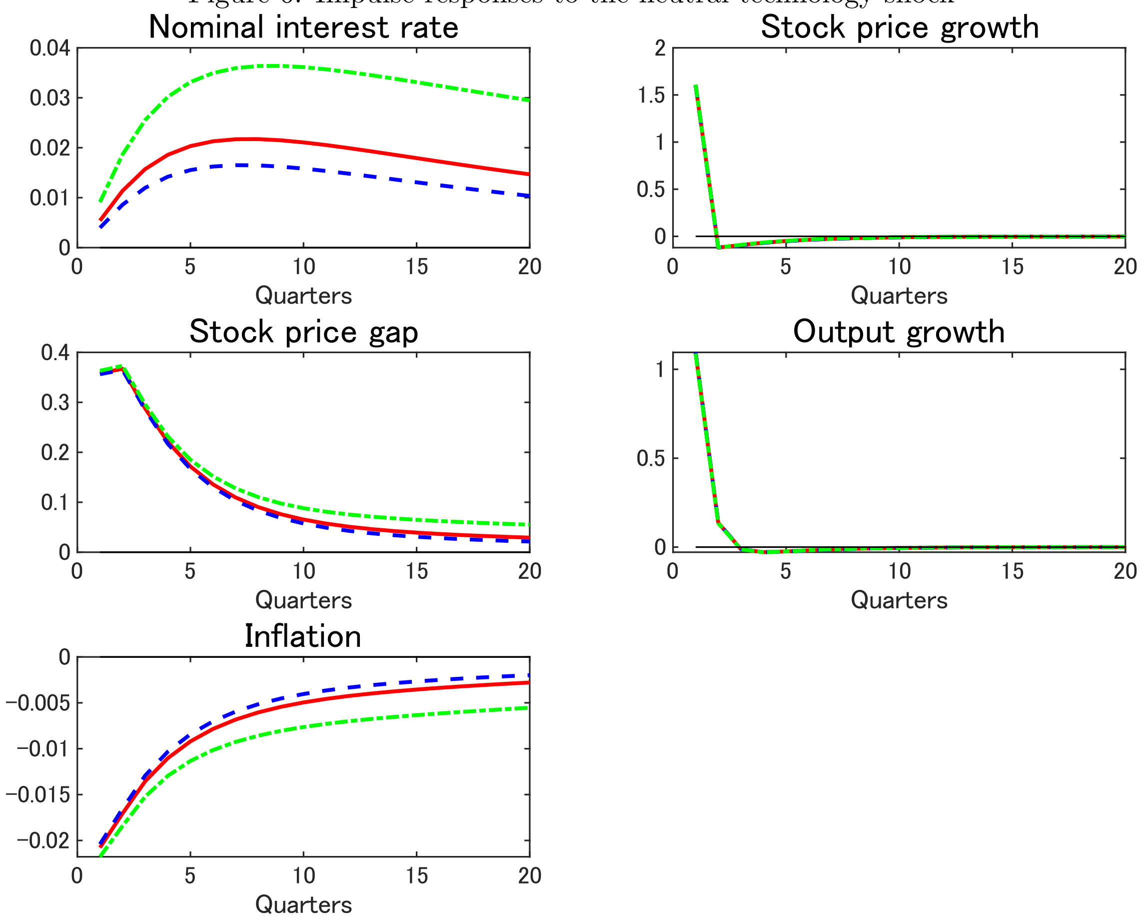
Note) Solid, dashed and dash-dotted lines denote the benchmark, the model with $\phi_s = 0.25$ and the model with $\phi_s = 0.5$, respectively.

Figure 5: Impulse responses to the financial shock



Note) Solid, dashed and dash-dotted lines denote the benchmark, the model with $\phi_s = 0.25$ and the model with $\phi_s = 0.5$, respectively.

Figure 6: Impulse responses to the neutral technology shock



Note) Solid, dashed and dash-dotted lines denote the benchmark, the model with $\phi_s = 0.25$ and the model with $\phi_s = 0.5$, respectively.

Figure 7: Robustness check: effect of monetary policy shock

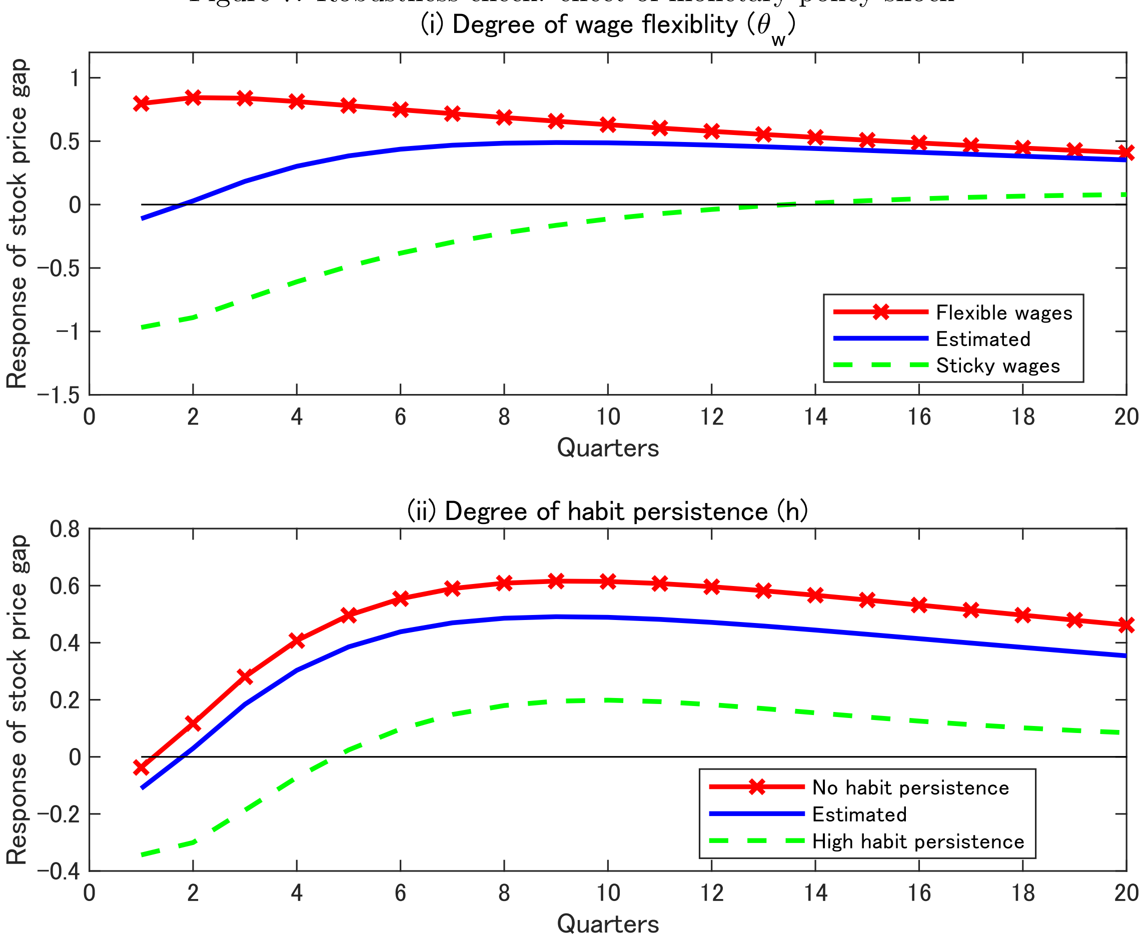


Figure 8: Historical decomposition of dividend

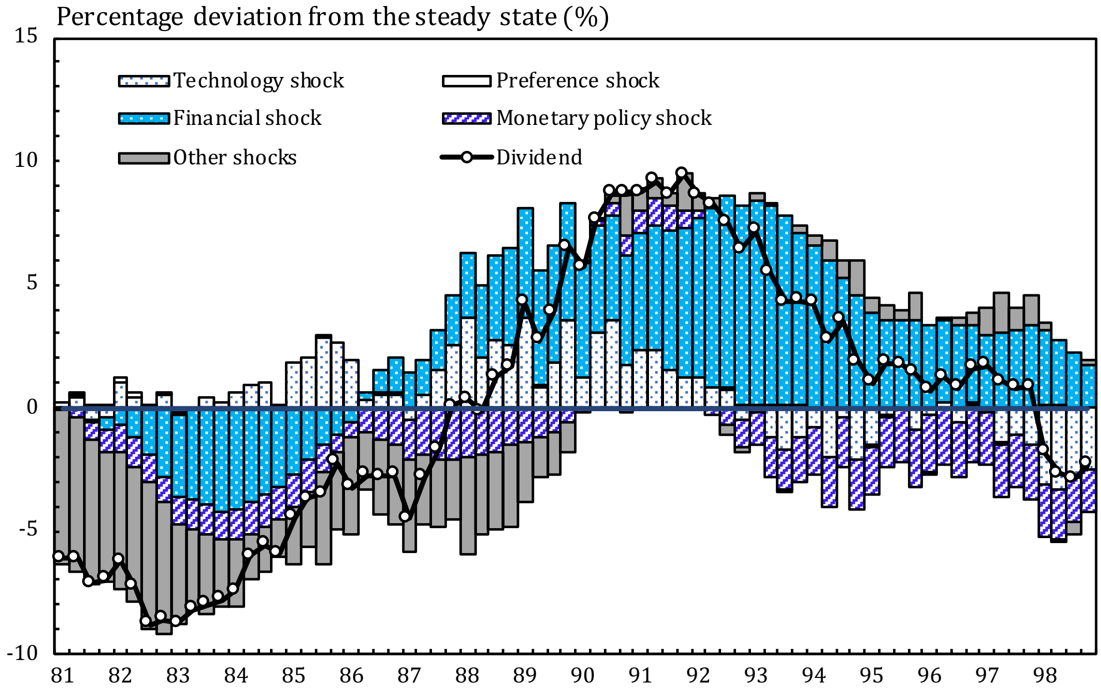
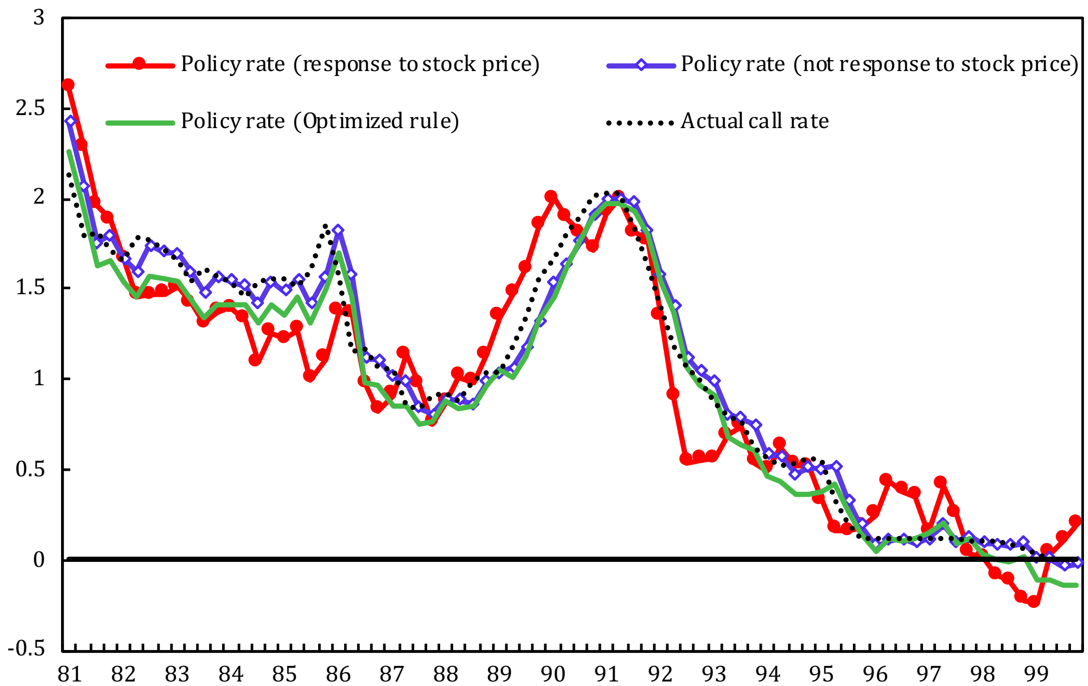


Figure 9: Comparison of several Taylor rules with the actual policy rate



Note) The red line with (o) denotes the policy rate suggested by the estimated Taylor rule. The blue line with (d) indicates the policy rate path suggested by the standard Taylor rule without reacting to stock prices. The green solid line represents the policy rate path the optimised policy rule suggests. See Table 4 for a detailed explanation of these policy specifications. Finally, the dotted line denotes the actual policy (call) rate.