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Bank of Japan's Exit Policy in 2024-2025

Kohei Hasui and Yuki Teranishi

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Do Monetary Policy and Cost-push Shock Matter? Bank of Japan's Exit Policy in 2024-2025*

Kohei Hasui† Yuki Teranishi‡

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Abstract

This paper examines how the Bank of Japan (BOJ)'s "Inflation-Overshooting Commitment" and cost-push shocks contributed to its exit from a liquidity trap during 2024–2025. To this end, we use a New Keynesian model incorporating shocks to demand and inflation, along with simple monetary policy rules. Our simulations show that such rules, especially those that maintain a zero interest rate even amid high inflation after 2021, can significantly elevate inflation. Under a price-level targeting rule, inflation exceeds 2 percent, while the average inflation targeting rule stabilizes inflation close to 2 percent over an extended period. These findings indicate that both policy commitment and cost-push shocks played a quantitative role in raising inflation and widening the output gap, ultimately facilitating the BOJ's exit policy.

JEL Classification: E31; E52; E58; E61
Keywords: monetary policy; commitment; liquidity trap

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†Aichi University. E-mail: khasui@vega.aichi-u.ac.jp

‡Keio University. E-mail: yukitera@fbc.keio.ac.jp

1 Introduction

In September 2016, the Bank of Japan (BOJ) announced its "Inflation-Overshooting Commitment" as part of the policy framework known as "Quantitative and Qualitative Monetary Easing with Yield Curve Control."[1] Under this commitment, the BOJ promised to continue monetary easing by maintaining its the zero interest rate policy until the year-on-year CPI inflation rate stably exceeded the 2 percent target. Despite the disruptions caused by the COVID-19 pandemic, the BOJ confirmed in March 2024 that inflation had sufficiently overshot the 2 percent target and therefore ended the zero interest rate policy.

Our motivation in this paper is to investigate whether the BOJ's inflation-overshooting commitment actually worked to raise inflation rates to over 2 percent and thereby end the zero interest rate policy, or whether other elements, such as cost-push shocks, created the conditions that allowed the BOJ to escape a liquidity trap.

To reveal this, we adopt the conventional New Keynesian model with inflation persistence, which has been widely used in monetary policy analyses particularly because it captures the relationship between inflation and monetary policy, as in Woodford (2003) and Christiano et al. (2005). To describe the BOJ's monetary policy, we assume a set of conventional simple monetary policy rules. Identifying the BOJ's actual policy rule is typically difficult; in this case, however, the BOJ offers guidance on the nature of its policy commitment. Ueda (2023) explains that the BOJ maintains the stance that it will continue expanding the monetary base until the year-on-year rate of increase in the observed CPI (all items less fresh food) exceeds 2 percent and remains stably above the target. This stance implies a prolonged zero and low interest rate policy. One way to represent such a history-dependent policy through a simple rule is to include lagged variables. For example, Bank of Japan (2021) examines the inflation-overshooting com-

[1] See Bank of Japan (2016) for details. Kawamoto et al. (2025) explains that the BOJ's "Quantitative and Qualitative Monetary Easing with Yield Curve Control"consists of two elements, "Yield Curve Control (YCC)"and "Inflation-Overshooting Commitment." Our paper focuses on "Inflation-Overshooting Commitment."

mitment using the BOJ's macroeconomic model and similarly assumes a simple monetary policy rule that includes lagged inflation rates.

In our paper, we assume a variety of monetary policy rules, such as the Taylor-type rule, the price-level targeting rule, and the average inflation targeting rule, which differ in their degrees of commitment. We apply our model to the BOJ's exit policy from the zero interest rate policy following the pandemic. Here, we assume shocks to demand and inflation because the Japanese economy experienced a steep decline in output and deflationary pressures in 2020 due to the pandemic. After 2021, cost-push shocks, such as commodity price surges and yen depreciation, contributed to rising inflation, as noted by Ikeda et al. (2022). To analyze the Japanese economy after 2020, it is therefore necessary to incorporate these shocks into the model. Through a variety of simulations, we quantitatively evaluate whether a prolonged zero interest rate policy achieves inflation overshooting and whether cost-push shocks contribute to the BOJ's exit from the zero interest rate policy.

The simulation results show that the Taylor-type rule does not cause inflation overshooting, even though the zero interest rate policy continues for a sufficiently prolonged period, consistent with the BOJ's policy stance. In this case, cost-push shocks, rather than monetary policy, contribute to high inflation and provide the BOJ with an opportunity to terminate the zero interest rate policy under the inflation-overshooting commitment. Under the price-level targeting rule, inflation rates exceed 2 percent and the zero interest rate policy continues even after such high inflation. The monetary policy commitment thus helps generate sustained inflation and facilitates the BOJ's exit from the zero interest rate policy. In any case, we conclude that the BOJ successfully implemented its exit policy under an inflation-overshooting commitment, having sustained the zero interest rate policy long enough, even amid high inflation. These results remain robust across a variety of parameters and models. Analysis using the average inflation targeting rule shows that the reality lies between the Taylor-type rule and the price-level targeting rule, with both the monetary policy commitment and the cost-push shocks contributing to exiting a liquidity trap.

The literature on monetary policy is extensive, and our paper relates to three strands of prior research. First, our paper relates to analyses of monetary policy research based on a New Keynesian model. The theory of monetary policy has been developed since the 1990s based on the New Keynesian model, as represented by Clarida et al. (1999) and Woodford (2003). Christiano et al. (2005) and Smets and Wouters (2007) extend the New Keynesian model to a medium-sized dynamic stochastic general equilibrium model for monetary policy analysis. They estimate the hybrid Phillips curve and show that a simple monetary policy rule welll describe the U.S. economy.

Second, our paper relates to the literature on monetary policy in a liquidity trap. Eggertsson and Woodford (2003b,a) and Jung et al. (2001, 2005) show that a key feature of optimal monetary policy in a liquidity trap is history dependence: a central bank needs to maintain a zero interest rate even after the natural rate turns positive and inflation exceeds a level above the target. Nakata and Schmidt (2019) assume that the objective function for a discretionary central bank includes an interest-rate smoothing term. This modification encourages keeping the policy rate low for a longer duration in a liquidity trap, implying a history-dependent monetary policy. Budianto et al. (2023) show that monetary policy aimed at stabilizing the average inflation rate effectively captures a history-dependent monetary policy in a liquidity trap.

Third, our paper relates to quantitative analyses of monetary policy in a liquidity trap. Several studies evaluate the BOJ's monetary policy in a liquidity trap. Kawamoto et al. (2025) analyze the BOJ's inflation-overshooting commitment as an implementation of a "makeup strategy" using an estimated model of the Japanese economy. They assume Taylor-type rules and show that a prolonged zero interest rate policy with inflation overshooting can function as a makeup strategy for achieving the inflation target at an earlier stage. In contrast, Ikeda et al. (2022) analyze inflation dynamics before and after the pandemic. They argue that cost-push pressures, including commodity price increases and yen depreciation, temporarily raise inflation in the post-pandemic period. They further argue that these effects are not persistent. Their analysis suggests that cost-push shocks can induce high inflation at the time when the BOJ terminates the zero interest rate policy in 2024. Our paper is closely related to Kawamoto et al. (2025) and Ikeda et al. (2022). All three papers evaluate the effectiveness of the BOJ's inflation-overshooting commitment. A key difference is that we apply the analysis to the actual exit from the zero interest rate policy in 2024, following the pandemic.

Lastly, our paper is also related to Hasui and Teranishi (2025). A clear difference between the two papers is that they assume optimal monetary policy rather than a simple monetary policy rule. They show that the BOJ's monetary policy shares several similarities with optimal monetary policy in a liquidity trap. Optimal monetary policy indicates the path of each variable, but it is difficult to clearly show how the BOJ reacts in actual policy conduct. In contrast, our paper uses simple and implementable monetary policy rules to clarify how the central bank responds to inflation, the output gap, and lagged variables. Moreover, although optimal monetary policy is one candidate to explain the BOJ's monetary policy, our paper presents alternative rules that replicate the key features of the BOJ's monetary policy.

The remainder of the paper is organized as follows. In Section 2, we explain a brief history of the BOJ's monetary policy. Section 3 presents the model incorporating inflation persistence. In Section 4, we calibrate the model. Section 5 presents simulation results under the Taylor-type rule and the price-level targeting rule. Section 6 quantifies the roles of monetary policy commitment and cost-push shocks in exiting a liquidity trap. Section 7 presents sensitivity analyses across a variety of parameters and models. Section 8 concludes the paper.

2 Brief History of BOJ's Monetary Policy: Commitment Policy

The BOJ has long implemented monetary policies to respond to the conditions of low inflation and low growth that have persisted in the Japanese economy since the mid-1990s. In 1999, the BOJ first introduced the zero interest rate policy, which BOJ Governor Masaru Hayami committed to continuing until deflationary concerns were dispelled. By this commitment, the BOJ intended to create high expected inflation and a low real interest rate to stimulate the Japanese economy.

The BOJ introduced several additional commitments after 1999. For example, in March 2001, the BOJ introduced "Quantitative Monetary Easing" and committed to targeting the BOJ's current account balance until CPI inflation stabilized at or above 0 percent. Moreover, in April 2013, the BOJ introduced "Quantitative and Qualitative Monetary Easing" and promised to achieve the price stability target of 2 percent at the earliest possible time, with a time horizon of about two years. For this, the BOJ adopted monetary base control and promised to double the monetary base and the amounts outstanding of Japanese government bonds as well as exchange-traded funds in two years.[2]

To strengthen its commitment policy, in September 2016 the BOJ introduced the inflation-overshooting framework under which it continued monetary easing by maintaining the zero interest rate policy until the year-on-year CPI inflation stably exceeded the 2 percent target. This represented a more explicit commitment to stronger monetary easing than before, as the BOJ clarified that exceeding a 2 percent inflation rate served as its criterion for exiting the zero interest rate policy.

During the pandemic in 2020, the Japanese economy temporarily experienced significant negative shocks related to the output gap and inflation. After the pandemic, the economy showed quick recovery and high inflation partially driven by cost-push pressures, such as commodity price hikes and yen depreciation. Given this historical background, the BOJ finally faced a situation in which inflation has stably exceeded 2 percent since 2022. This high inflation reflected steady economic activity. Bank of Japan (2022, "The Bank's View") emphasizes the role of a cost-push shocks and argues that the year-on-year rate of change in the consumer price index is likely to remain positive due to high energy prices in January 2022. At the same time, the BOJ predicts that CPI inflation will remain around 1, although the positive contribution of the rise in energy prices is expected to wane. Therefore, at that time, the BOJ judged that monetary easing was

[2] Please see details in Bank of Japan (2013).

not enough to return the inflation rate to the 2 percent target, even though the year-on-year rate of change in the CPI was 2.7 percent in 2022. On the other hand, in January 2025, Bank of Japan (2025) emphasizes steady economic activity and concludes that CPI inflation is expected to increase, since the output gap will improve and medium- to long-term inflation expectations will rise, while the effects of import price increases are expected to wane.

After confirming inflation-overshooting and steady economic activity, the BOJ terminated the zero interest rate policy and increased the policy rate to between 0 and 0.1 percent in March 2024. The BOJ then raised the policy rate to 0.5 percent in January 2025 and further increased the policy rate to 0.75 percent in December 2025. As of January 2026, it is in the process of further increasing the policy rate. Terminating the zero interest rate policy under inflation stably above 2 percent is an ideal scenario for the inflation-overshooting commitment policy.

3 The Model

We use a New Keynesian model following Woodford (2003) and Eggertsson and Woodford (2006) and omit detailed explanations of the model. The macroeconomic structure is expressed by the two equations:

$$x_t = \mathrm{E}_t x_{t+1} - \chi \left(i_t - \mathrm{E}_t \pi_{t+1} - r_t^n \right), \tag{1}$$

$$\pi_t - \gamma \pi_{t-1} = \kappa x_t + \beta \left(\mathrm{E}_t \pi_{t+1} - \gamma \pi_t \right) + \mu_t, \tag{2}$$

where x_t, i_t and π_t denote the output gap, the nominal interest rate (or policy rate), and the rate of inflation in period t, respectively. χ is the intertemporal elasticity of substitution of expenditure, β is a discount factor, γ $(0 \leq \gamma \leq 1)$ is the degree of inflation persistence, and

$$\kappa = \frac{(1-\alpha)(1-\beta\alpha)}{\alpha} \frac{\omega + \chi^{-1}}{1 + \omega\theta},$$

where ω is the elasticity of a firm's real marginal cost and θ is an elasticity of substitution across goods. It should be noted that the slope of the Phillips curve κ depends on price stickiness α. E_t is the expectations operator conditional on information available at time t. r_t^n is the natural rate of interest and acts as the shock. μ_t is the cost-push shock.

Equation (1) is the forward-looking IS curve, as shown in Clarida et al. (1999) and Woodford (2003). The IS curve states that the current output gap is determined by the expected value of the output gap and the deviation of the current real interest rate, defined as $i_t - \mathrm{E}_t\pi_{t+1}$, from the natural interest rate.

Equation (2) is the hybrid Phillips curve. When $\gamma = 0$, the hybrid Phillips curve transforms into a purely forward-looking Phillips curve, where current inflation depends on expected inflation and the current output gap. When $0 < \gamma \leq 1$, the Phillips curve is both forward-looking and backward-looking, and the current inflation rate depends on the lagged inflation rate, as well as expected inflation and the current output gap. When γ is closer to 1, the coefficient on the lagged inflation rate is closer to 0.5. Following the indexation rule in Woodford (2003), some firms that can not reoptimize their own goods prices adjust current prices based on the past inflation rate.

Finally, we give a nonnegativity constraint on the nominal interest rate:

$$i_t \geq 0. \tag{3}$$

To close the model, we need a monetary policy rule.

4 Calibration for Japanese Economy

Table 1 shows the parameter values. We use parameter values estimated in previous studies of the Japanese economy. Sugo and Ueda (2008) estimate a DSGE model for the Japanese economy and show that $\alpha = 0.875$, $\omega = 2.149$, and $\theta = 6$.[3] Then, we calculate $\kappa = 0.0048$, and $\lambda_x = 0.0008$. Iiboshi et al. (2022) estimate a Japanese DSGE model and show $\chi = 0.646$.

For inflation persistence, Kawamoto et al. (2025) use a coefficient of 0.85 on the lagged inflation rate to evaluate the BOJ's inflation-overshooting commitment policy in the

[3] Mukoyama et al. (2021) also estimate high price stickiness as $\alpha = 0.82$.

BOJ's small-scale projection model. Moreover, to evaluate quantitative and qualitative monetary easing policy, Kawamoto et al. (2023) use the BOJ's macroeconomic model, in which a coefficient on the lagged inflation rate in the Phillips curve is estimated at 0.69. These papers show substantial inflation persistence in Japan.[4] Thus, we use $\gamma = 1$.[5]

As shown in Woodford (2004), the model does not change when we set $\gamma = 1$, even for a non-zero inflation target $\bar{\pi}$. For a non-zero inflation target, the inflation rate in the model is described as $\pi_t - \bar{\pi}$. However, in the hybrid Phillips curve of Equation (2), $\pi_t - \pi_{t-1}$ is equivalent to $\pi_t - \bar{\pi} - (\pi_{t-1} - \bar{\pi})$. In the forward-looking IS curve of Equation (1), the non-zero inflation target appears to shift up the steady-state level of the nominal interest rate: $i_t - (\mathrm{E}_t \pi_{t+1} - \bar{\pi}) - (r_t^n + \bar{\pi})$.

For the simulations, we need to set the anchored inflation expectation in the steady state and the natural rate of interest. Osada and Nakazawa (2024) show that the principal component-based composite index of inflation expectations for different forecast horizons is about 1.5 percent at the end of 2023. Moreover, Bank of Japan (2024) shows that the break-even inflation rate is about 1.5 percent in April 2024. Thus, we set the anchored inflation expectation, which serves as the steady-state and target inflation rate, at 1.5 percent. Regarding the natural interest rate in the steady-state, Bank of Japan (2024) shows several estimates due to difficulties in calculating an exact natural interest rate. The latest estimates of the natural interest rates are distributed around -0.5 in 2023.

In our model, the long-run nominal interest rate is given by the sum of an anchored inflation expectation and the natural rate of interest. Therefore, the nominal interest rate in the steady-state is set at 1 percent annually, and a discount factor, i.e., the inverse of the nominal interest rate, is given by $\beta = 0.9975$.

In simulations, we interpret the second quarter of 2020 as the starting point, since we observe the largest negative shocks for the output gap and the inflation rate due to the pandemic. The output gap is -6.3 percent and the inflation rate is -2.8 percent annually

[4] Sugo and Ueda (2008) also estimates γ as high as 0.862.

[5] These papers imply that $\gamma = 1$ is still conservative in describing inflation persistence since $\gamma = 1$ corresponds to about 0.5 for a coefficient on the lagged inflation rate, as shown in Equation (2).

in the second quarter of 2020.[6] Regarding shocks for the simulation, we apply a one-time negative natural rate shock and a one-time negative cost-push shock without shock persistence, following Eggertsson and Woodford (2003b), to match the model results to the data for the inflation rate and the output gap in the second quarter of 2020, as shown in Figure 1, for example.[7] Moreover, we provide a positive cost-push shock to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation. As discussed in Ikeda et al. (2022), inflation rates rise quickly during this period, and these high inflation rates can be driven by cost-push pressures, such as commodity price hikes and yen depreciation. In implementation, we describe this by assuming a positive cost-push shock in 2021Q4. The simulations are based on perfect foresight, and we use Dynare to run them.[8]

5 Analyses with Conventional Monetary Policy Rules

We first assume conventional monetary policy rules: the Taylor rule with an interest rate lag and the price-level targeting rule. We examine a variety of monetary policy rules in the following sections.

[6] We use the Real Gross Domestic Product (Expenditure), Quarterly, Seasonally Adjusted Annual Rate for the output gap. We create a trend series of one-year moving averages and calculate the gap from the trend series to real GDP. For inflation rates, we use the Consumer Price Index for all items, less fresh food, seasonally adjusted for inflation rates. We calculate the annual inflation rate from the growth rate from a previous period. For the BOJ's policy rate, we use the call rate, uncollateralized overnight, average, annually.

[7] In simulations, we use the inflation rate data from the first quarter of 2020 as an inflation lag in the model in period 0. Before shocks occur, other variables are set to zero.

[8] We extend the code by Johannes Pfeifer for optimal monetary policy in a liquidity trap, available at JohannesPfeifer/DSGE_mod/blob/master/Gali_2015/Gali_2015_chapter_5_commitment_ZLB.mod. Our code is available upon request.

5.1 Taylor-type Rule

We assume the Taylor-type rule with an interest rate lag as follows:

$$i_t = \max\left[0, (1-\rho_i)\left\{i^* + \phi_\pi(\pi_t - \bar{\pi})\right\} + \rho_i i_{t-1}\right], \tag{4}$$

where ϕ_π and ρ_i are positive parameters. This rule includes history dependence by gradually changing the interest rate. We set $\phi_\pi = 5$, $\rho_i = 0.842$.[9]

Figure 1 shows inflation rates, the output gap, and policy rates under the Taylor rule with an interest rate lag from the second quarter of 2020 to the fourth quarter of 2025, as well as the corresponding Japanese data.[10] It indicates that the Taylor-type rule exhibits strong history dependence, with a coefficient $\rho_i = 0.842$ on the interest rate lag.

We observe that the Taylor-type rule can not replicate inflation overshooting, even though the zero interest rate policy continues throughout the simulation. The Taylor-type rule, however, raises inflation gradually toward the end of the simulation and achieves approximately the 2 percent target.[11]

As discussed in Ikeda et al. (2022), cost-push pressures temporarily raise the inflation rate after the pandemic. This suggests that inflation overshooting is caused by these cost-push shocks, and the BOJ's role is to patiently continue the zero interest rate policy under high inflation rates. If there were no cost-push shocks, the BOJ would not be able to achieve inflation overshooting. Thus, the inflation overshooting promised by the BOJ is due to the presence of cost-push shock and not to the BOJ's monetary policy.

This analysis indicates that the BOJ follows the conventional Taylor-type rule but excludes responses to cost-push shocks. This is the implementation of the inflation-overshooting commitment. Figure 2 shows a case where we apply cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model

[9] For example, Fujiwara et al. (2013) assume $\phi_\pi = 5$, and Sugo and Ueda (2008) set $\rho_i = 0.842$.

[10] We assume a -8.65 percent natural rate shock and a -0.86 percent cost-push shock at time zero on a quarterly basis.

[11] Hasui and Teranishi (2025) show a similar result using the Taylor-type rule without a policy rate lag. We show this case in the Appendix.

simulation.[12] The results show that the zero interest rate policy ends very early and the output gap declines sharply, which is inconsistent with the data.

To evaluate the simulation results, we use the root mean squared error (RMSE). The details of RMSE are in Appendix A. The results for our figures are shown in Table 2. In Figure 1, RMSE_π is 2.35 which is sufficiently large when compared to other cases, as shown in the following sections. The total RMSE L is relatively small at 3.44 due to good matches with the output gap and the policy interest rate. In Figure 2, the total RMSE L is very large due to poor consistency with all the data.

We also show averages of variables for 2020Q2–2024Q4 in simulations and data in Table 3. The average inflation rate is -0.1 percent in the simulation under the Taylor-type rule, whereas it is 1.72 percent in the data. The Taylor-type rule can not achieve high inflation.

5.2 Price-level Targeting Rule

We assume the Price-level targeting rule as follows:

$$i_t = \max\left[0, i^* + \phi_p p_t + \phi_x x_t\right], \tag{5}$$

where p_t is the price level, and we define $\pi_t - \bar{\pi} = p_t - p_{t-1}$. We set ϕ_p and ϕ_x as positive parameters. This price level is evaluated from an inflation deviation from the steady state" to "The first difference of the price level reflects the deviation of inflation from a non-zero inflation target $\bar{\pi}$. However, there remains an important feature of price level targeting, which maintains the zero-interest rate policy until the initial price level is recovered. This creates strong history dependence in a liquidity trap. We set $\phi_p = 1.5$ and $\phi_x = 0.5$.

We often discuss whether the Taylor rule is a guideline for monetary policy. The price-level targeting rule is an alternative candidate to describe monetary policy, as Eggertsson

[12] We assume -4.14 percent of the natural rate shock and -0.98 percent of the cost-push shock at time zero, along with an additional cost-push shock of 0.42 percent at time 6 (2021Q4) on a quarterly basis.

and Woodford (2003b) show that the price-level targeting rule can be a proxy for optimal monetary policy with history dependence in a liquidity trap.

Figure 3 shows inflation rates, the output gap, and policy rates under the price-level targeting rule.[13] We observe that inflation rates rise to more than 2 percent, and the zero interest rate policy continues even after inflation rates sufficiently exceed 2 percent. This is consistent with the BOJ's inflation-overshooting commitment, which allows inflation rates to stably exceed the 2 percent target. The model simulation closely replicates inflation rates and the output gap.

When we include cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation, as shown in Figure 4, the timing to terminate the zero interest rate policy occurs earlier, and the model's fit to inflation rates, the output gap, and policy rates improves.[14] This suggests that the cost-push shocks, as well as the monetary policy commitment, are quantitatively important factors in exiting from a liquidity trap.

In Figure 3, RMSE_π is 1.41, which is much smaller than that in Figure 1, as shown in Table 2. Thus, consistency with inflation rates improves significantly under the price-level targeting rule. On the other hand, RMSE_x is larger in Figure 3 than in Figure 1, since the zero interest rate persists longer and the output gap increases in Figure 3. In Figure 4, the total RMSE L improves to 3.31, which is better than under the Taylor rule, as consistency with the output gap improves due to a shorter zero interest rate policy.

As shown in Table 3, the average inflation rate is 1.4 percent in the simulation under the price-level targeting rule and 1.72 percent in the data. The average inflation rate increases slightly to 1.53 percent with a cost-push shock. The price-level targeting rule achieves high inflation rates to replicate the data.

[13] We assume -15.45 percent of the natural rate shock and -0.99 percent of the cost-push shock at time zero on a quarterly basis.

[14] We assume a -14.33 percent natural rate shock and a -1.03 percent cost-push shock at time zero, as well as an additional cost-push shock of 0.15 percent at time 6 on a quarterly basis.

6 Evaluating Roles of Commitment and Shock

We assume a more flexible monetary policy rule to ensure that the model accurately describes the data. In particular, we search for the best pairing of commitment degree and shock size. This allows us to quantitatively evaluate the roles of monetary policy commitment and cost-push shocks while improving the consistency of the output gap and the nominal interest rate with the data.

We assume the following average inflation targeting rule:

$$
\begin{aligned}
i_t &= \max[0, i^* + \phi_{\hat{\pi}}\hat{\pi}_t + \phi_x x_t], \\
\hat{\pi}_t &= (\pi_t - \bar{\pi}) + (1 - \omega_\pi)\hat{\pi}_{t-1}.
\end{aligned}
\tag{6}
$$

Equation (6) nests three cases: when $\omega_\pi = 1$, it corresponds to the Taylor rule; when $0 < \omega_\pi < 1$, it corresponds to the average inflation targeting rule; and when $\omega_\pi = 0$, it corresponds to the price-level targeting rule. As ω_π decreases, the power of commitment increases.

To show the decomposition of the roles of monetary policy commitment and cost-push shocks, we also search for the optimal size of a cost-push shock at time 6, as in previous simulations where we introduce the cost-push shock at time 6 to match the average inflation rate for 2021Q1–2022Q4 between the data and the model simulation. We also match the initial sizes of cost-push and natural rate shocks to the data under other search processes. Thus, we search over $\vartheta = [\,\omega_\pi, \mu_0, \mu_6, r_0^n\,]^\top$.

The consistency with the data is evaluated using the RMSE. The sample period is 2020Q2–2024Q4. The parameter search is conducted as follows:

$$
\min_{\vartheta} L(\vartheta) = w_\pi \mathrm{RMSE}_\pi(\vartheta) + w_x \mathrm{RMSE}_x(\vartheta) + w_i \mathrm{RMSE}_i(\vartheta) \tag{7}
$$

$$
\mathrm{RMSE}_z(\vartheta) = \sqrt{\frac{1}{T}\sum_{t=0}^{T}\left[z_t(\vartheta) - z_t^{\mathrm{data}}\right]^2}, \quad \text{for } z = \pi, x, i,
$$

where $\pi_t(\vartheta)$, $x_t(\vartheta)$, and $i_t(\vartheta)$ denote the model's outputs for inflation, the output gap, and the nominal interest rate, respectively. π_t^{data}, x_t^{data}, and i_t^{data} denote the corresponding data for inflation, the output gap, and the nominal interest rate, respectively. The model time index $t = 0, ..., T$ corresponds to 2020Q2-2024Q4. The weights w_π, w_x, and w_i are set to unity, i.e., $w_\pi = w_x = w_i = 1$. For parameters that are not estimated, all values are set to those reported in Table 1, except for $\phi_{\hat{\pi}}$ and ϕ_x. For $\phi_{\hat{\pi}}$ and ϕ_x, we set $\phi_{\hat{\pi}} = 2.07$ and $\phi_x = 0.137$ following Iiboshi et al. (2022).

Table 4 shows the estimates of ϑ. The table indicates that equation (6) with $\omega_\pi = 0.23$ is much closer to the price-level targeting rule than to the Taylor-type rule. The estimate of μ_6 is 0.08 percent quarterly, suggesting that only a small positive cost-push shock is required, since we set $\mu_6 = 0.42$ for the Taylor-type rule in Figure 2 and $\mu_6 = 0.15$ for the price-level targeting rule in Figure 4.

Figure 5 presents the simulation results under the estimated ϑ. The figure shows that there is no overshooting of inflation beyond 2 percent, but the zero interest rate policy continues even after inflation rates remain stably close to 2 percent for an extended period. The match to inflation rates improves significantly when compared to the Taylor rule case in Figures 1 and 2. Moreover, the consistency of the output gap with the data also improves. The nominal interest rate departs from the zero lower bound earlier than in the data. As shown in Table 2, a total RMSE L is 2.82, and this is one of the best values across our simulations.

The simulation results imply that both commitment and the cost-push shock are quantitatively important factors in increasing inflation and the output gap.

7 Sensitivity Analysis

7.1 Discounted Euler Equation

As shown in Del Negro et al. (2023), the impact of forward guidance is too powerful in New Keynesian models. Some previous studies address this issue, known as the forward guidance puzzle, in models that discount the responses to the output gap to inflation expectations and real interest rates in the IS curve, as shown in McKay et al. (2017), Nakata et al. (2019), and Gabaix (2020).

Following McKay et al. (2017), we assume a discounted IS curve as follows:

$$x_t = \delta \mathrm{E}_t x_{t+1} - \zeta \chi \left(i_t - \mathrm{E}_t \pi_{t+1} - r_t^n \right). \tag{8}$$

The discounted Euler equation differs from the IS curve since discounting parameters δ and ζ are multiplied by the expected output gap and the real interest rate, respectively. We set $\delta = 0.97$ and $\zeta = 0.75$ following McKay et al. (2017) and $\delta = 0.856$ following Hirose et al. (2024). Other parameters are given in Table 1.

Figures 6a-c show the simulation results under the Taylor-type rule.[15] Compared with the results in Figure 1, both inflation rates and the output gap decrease. The zero interest rate policy lasts longer than in Figure 1, since the effect of forward guidance is weakened.

Figures 6d–f show the case under the Taylor-type rule when we include cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[16] The simulation result is very poor at explaining the output gap data.

Figures 7a-c show the simulation results under the price-level targeting rule.[17] Compared to the results in Figure 3, the overshooting of the output gap in period 0 is well mitigated in Figure 7b. In addition, since the effect of forward guidance is weakened, the zero interest rate policy lasts longer than in Figure 3, and the overshooting of inflation occurs in later periods.

[15] We assume a -9.81 percent natural rate shock and a -0.82 percent cost-push shock at time zero, on a quarterly basis, for the case of $\delta = 0.97$ and $\zeta = 0.75$. We can not converge the simulation for the case of $\delta = 0.856$ and $\zeta = 0.75$.

[16] We assume a -8.76 percent the natural rate shock and a -0.99 percent the cost-push shock at time zero, and an additional cost-push shock of 0.38 percent at time 6 on a quarterly basis for the case of $\delta = 0.97$ and $\zeta = 0.75$. We assume a -11.63 percent natural rate shock and a -1.00 percent cost-push shock at time zero, and an additional cost-push shock of 0.33 percent at time 6 on a quarterly basis for the case of $\delta = 0.856$ and $\zeta = 0.75$.

[17] We assume a -11.75 percent natural rate shock and a -0.88 percent cost-push shock at time zero on a quarterly basis for the case of $\delta = 0.97$ and $\zeta = 0.75$. We assume a -16.70 percent natural rate shock and a -0.95 percent cost-push shock at time zero on a quarterly basis for the case of $\delta = 0.856$ and $\zeta = 0.75$.

Figures 7d–f show the case under the price-level targeting rule when we include cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[18] Compared to Figure 4, Figure 7e shows that the response of the output gap improves sufficiently.

As shown in Table 2, RMSE_x and the total RMSE L in Figure 7 are smaller than those in Figures 3 and 4. Table 3 shows that the average of the output gap improves to 1.91 (0.71) from 2.49 (1.25) in the data 0.21 without (with) the cost-push shock for $\delta = 0.97$ and $\zeta = 0.75$. For $\delta = 0.856$ and $\zeta = 0.75$, the average of the output gap sufficiently improves to 0.82 (0.37) without (with) the cost-push shock.

7.2 Two Percent Inflation Rate in the Steady-state

We change the inflation rate and the natural interest rate in the steady-state. Following the BOJ's official inflation target rate, we set the inflation rate in the steady-state, i.e., the target rate of inflation $\bar{\pi}$, at 2 percent, though this value is not supported by the data, as shown in Osada and Nakazawa (2024) and Bank of Japan (2024). At the same time, we set the natural interest rate in the steady-state at -1 percent, which is the lowest estimate reported, as shown in Bank of Japan (2024). Then, the steady-state nominal interest rate does not change and is given by 1 percent.

Figure 8 shows the case of the Taylor-type rule.[19] We observe a similar result to that shown in Figure 1. The Taylor-type rule can not generate inflation overshooting even though the zero interest rate policy lasts longer. The Taylor-type rule, however, raises inflation toward the end of the simulation and achieves the 2 percent target, which gives the BOJ an opportunity to terminate the zero interest rate policy after a high inflation.

[18] We assume -13.61 percent of the natural rate shock and -1.00 percent of the cost-push shock at time zero, and an additional cost-push shock of 0.20 percent at time 6 on a quarterly basis for the case of $\delta = 0.97$ and $\zeta = 0.75$. We assume -16.27 percent of the natural rate shock and -1.02 percent of the cost-push shock at time zero, and an additional cost-push shock of 0.18 percent at time 6 on a quarterly basis for the case of $\delta = 0.856$ and $\zeta = 0.75$.

[19] We assume a -7.50 percent natural rate shock and a -0.85 percent cost-push shock at time zero on a quarterly basis.

Figure 9 shows the case of the price-level targeting policy.[20] We observe that inflation exceed 2 percent, and the zero interest remains stably above 2 percent, as shown in Figure 3.

In an alternative calibration, the natural interest rate in the steady-state is set at -0.5 percent, the baseline calibration in Table 1. The steady-state of the nominal interest rate is then set to 1.5 percent, and the inflation target remains at 2 percent. Figure 10 shows the case of the Taylor-type rule. Compared to the results in Figure 8, inflation approaches 2 percent earlier but does not result in significant overshooting, and the zero interest rate policy ends earlier. Figure 11 shows the case of the price-level targeting policy.[21] Compared to the results in Figure 9, the zero interest rate policy ends earlier but continues even after inflation remains stably above 2 percent.

These results suggest that even when the inflation target is set at 2 percent, the findings presented in Sections 5.1 and 5.2 remain unchanged.

7.3 Augmented Taylor-type Rule

The analysis of the price-level targeting rule demonstrated that a rule with strong history dependence can generate inflation overshooting and earlier termination of the zero interest rate policy with a small cost-push shock.

In this section, we conduct a simulation under the augmented Taylor-type rule with strong history dependence, as proposed by Reifschneider and Williams (2000), as follows:

$$\begin{aligned} i_t &= \max\left[0, \tilde{\imath}_t - \phi_z z_t\right], \\ \tilde{\imath}_t &= (1-\rho_i)\left\{i^* + \phi_\pi(\pi_t - \bar{\pi}) + \phi_x x_t\right\} + \rho_i \tilde{\imath}_{t-1}, \\ z_t &= z_{t-1} + (i_t - \tilde{\imath}_t), \end{aligned} \tag{9}$$

where $\tilde{\imath}_t$ denotes the nominal shadow rate and z_t denotes the cumulative past deviation of the nominal interest rate from the nominal shadow rate. The monetary policy rule, which

[20] We assume a -15.6 percent natural rate shock and a -1.01 percent cost-push shock at time zero on a quarterly basis.

[21] We assume a -17.57 percent natural rate shock and a -1.03 percent cost-push shock at time zero on a quarterly basis.

is proposed by Reifschneider and Williams (2000), is used to compare its performance with the optimal commitment policy as in Nakov (2008).[22] We set ϕ_z to 0.5 following Nakov (2008) and set ϕ_x to 0, with other parameters as given in Table 1.

Figures 12a–c show inflation rates, the output gap, and policy rates under the augmented Taylor rule from the second quarter of 2020 to the fourth quarter of 2025, as well as these Japanese data.[23] Unlike the previous simulation results based on the Taylor-type rule, we observe that inflation exceeds 2 percent, and the zero interest rate policy persists even after inflation remains stably above 2 percent. Interestingly, this result is highly similar to the simulation results of the price-level targeting rule in Figure 3.

Figures 12d–f show the result when we include cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation. This result is also highly similar to the simulation results of the price-level targeting rule in Figure 4: The zero interest rate policy is terminated earlier, and the model's fit to inflation, the output gap, and policy rates improves.[24]

As Nakov (2008) mentions, the augmented Taylor-type rule has influenced US monetary policy from 2003 to 2005. Figure 12 suggests that a monetary policy rule that incorporates cumulative past information on the interest rate can be important in explaining Japan's macroeconomic behavior in the post-pandemic period. Together with the result in Section 5.2, we can conclude that a monetary policy with a prolonged zero interest rate policy replicates inflation overshooting and escapes a liquidity trap. This implies that the BOJ can achieve these outcomes by implementing a prolonged zero interest rate policy.

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[22] Nakata and Tanaka (2016) use Reifschneider and Williams (2000)'s monetary policy rule to analyze the effects of forward guidance.

[23] We assume a −14.85 percent natural rate shock and a −0.98 percent cost-push shock at time zero on a quarterly basis.

[24] We assume a −13.50 percent natural rate shock and a −1.03 percent cost-push shock at time zero, and an additional cost-push shock of 0.18 percent at time 6 on a quarterly basis.

7.4 Low Elasticity of Demand to the Real Interest Rate

In this section, we assume a low intertemporal elasticity of substitution of expenditure, i.e., a low elasticity of the output gap to the real interest rate. Weak demand is one reason for the prolonged low growth in Japan. Following the estimate by Cashin and Unayama (2016), we set $\chi = 0.21$ for the simulation.[25]

Figures 13a–c show the simulation results under the Taylor-type rule.[26] We observe a similar result to that shown in Figure 1. The Taylor-type rule can not replicate inflation overshooting even though the zero interest rate policy continues long enough. Figures 13d–f show the case in which we apply cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[27] The result contradicts the data, as shown in Figure 2. The zero interest rate policy ends at a very early stage, and the output gap decreases significantly.

Figures 14a–c show the results under the price-level targeting rule.[28] As in Figure 3, we observe that inflation exceeds 2 percent, and the zero interest rate policy continues for a prolonged period. The model's fit to inflation, the output gap, and the nominal interest rate improves compared to Figure 3. Figures 14d–f show the case under the price-level targeting rule in which we include cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[29] We observe that the zero interest rate policy is terminated earlier compared to the case with no cost-push shock.

As shown in Table 2, the total RMES L is the lowest at 2.26 among the simulations

[25] For parameters other than χ, we use the values shown in Table 1.

[26] We assume a -28.30 percent natural rate shock and a -0.82 percent cost-push shock at time zero on a quarterly basis.

[27] We assume a -23.50 percent natural rate shock and a -0.96 percent cost-push shock at time zero, along with an additional cost-push shock of 0.38 percent at time 6 on a quarterly basis.

[28] We assume a -28.3 percent natural rate shock and a -0.82 percent cost-push shock at time zero, on a quarterly basis.

[29] We assume a -34.11 percent natural rate shock and a -0.99 percent cost-push shock at time zero, and an additional cost-push shock of 0.20 percent at time 6 on a quarterly basis.

in Figures 14d–f, indicating that the model describes the data well. Table 3 shows that the average output gap (inflation) in Figures 14d–f is 0.13 (1.5) relative to the data value of 0.21 (1.72).

7.5 Inflation Persistence

In this section, we analyze how the simulation results change with different degrees of inflation persistence, such as γ set to 0 (purely forward-looking), 0.358 (Hirose, 2020), 0.631 (Hirose and Kurozumi, 2012), and 0.862 (Sugo and Ueda, 2008).[30] For these simulations, we replace π_t with $\pi_t - \bar{\pi}$ in the Phillips curve (2), where $\bar{\pi}$ is an exogenously given anchored inflation rate and $\pi_t = \bar{\pi}$ in the steady-state.

Figures 15a–c show the results under the Taylor-type rule.[31] We observe that the rise in the inflation rate occurs later, and that the zero interest rate policy lasts longer as γ becomes larger. This indicates that higher inflation persistence leads to a longer period of deflation, requiring a longer zero interest rate policy under the Taylor-type rule. However, in all cases of γ, there is no overshooting of inflation above 2 percent, and the zero interest rate policy ends earlier in the simulations than in the data.

Figures 15d–f show the case in which we give cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[32] We observe that, as γ becomes larger, it takes longer for inflation to exceed 2 percent, even in the presence of a positive cost-push shock. Therefore, the zero interest rate policy lasts longer as γ increases. However, similar to the result in Figure 2, the zero interest rate policy ends much earlier in the simulation than in the data, indicating that the simulation result contradicts the data.

[30]For parameters other than γ, we use the values shown in Table 1.

[31]We assume −10.99, −11.11, −10.92, and −10.20 percent natural rate shocks and −1.06, −0.97, −0.91, and −0.87 percent cost-push shocks at time zero on a quarterly basis for the cases of $\gamma = 0$, 0.358, 0.631, and 0.862, respectively.

[32]We assume −5.05, −6.92, −7.18, and −5.85 percent natural rate shocks, −1.30, −1.10, −1.01, and −0.97 percent cost-push shocks at time zero, and 0.42, 0.27, 0.24, and 0.31 percent of the additional cost-push shocks at time 6 on a quarterly basis for the cases of $\gamma = 0$, 0.358, 0.631, and 0.862, respectively.

Figures 16a–c show the results under the price-level targeting rule.[33] We observe overshooting of inflation above 2 percent for all values of γ. When γ is lower, inflation overshooting occurs earlier. As γ increases, greater inflation overshooting occurs later. The zero interest rate policy lasts longer as γ increases, but for all values of γ, the simulation results for the nominal interest rate closely resemble the data.

Figures 16d–f show the case in which we apply cost-push shocks to match the average inflation rate for 2021Q1-2022Q4 between the data and the model simulation.[34] We observe that the simulation results for $\gamma = 0.862$ are consistent with the data, even when including a positive cost-push shock.[35] While $\gamma = 0.358$, the zero interest rate policy ends earlier than in the data, and the simulation results for the output gap and inflation are more consistent with the data compared to the Taylor-type rule results shown in Figures 12d–f.

8 Concluding Remarks

We use the New Keynesian model and simple monetary policy rules to evaluate whether an inflation-overshooting commitment can raise inflation above 2 percent to end the zero interest rate policy, or whether cost-push shocks lead to high inflation rates in the BOJ's exit policy from a liquidity trap in 2024-2025.

Our analyses reveal a monetary policy commitment effect that achieves high inflation and a high output gap. The monetary policy commitment, in addition to cost-push shocks, contributes to the exit from a liquidity trap. We also show that the BOJ does not respond to positive cost-push shocks when implementing the exit from the zero

[33] We assume −15.62, −15.62, −15.55, and −15.44 percent natural rate shocks and −1.20, −1.11, −1.04, and −1.00 percent cost-push shocks at time zero on a quarterly basis for the cases of $\gamma = 0$, 0.358, 0.631, and 0.862, respectively.

[34] We assume −13.88 and −15.14 percent natural rate shocks, −1.14 and −1.01 percent cost-push shocks at time zero, and 0.13 and 0.04 percent of the additional cost-push shocks at time 6 on a quarterly basis for the cases of 0.358 and 0.862, respectively.

[35] Due to the simulation's technical constraints, we present only the cases of $\gamma = 0.358$ and $\gamma = 0.862$.

interest rate policy. The BOJ mainteined the zero interest rate policy under high inflation until March 2024. These two successful actions changed our inflationary expectations and actual inflation. This is the BOJ's implementation of an inflation-overshooting commitment.

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Table 1: Calibration for Japan

Parameters	Values	Explanation
β	0.9975	Discount Factor
χ	0.646	Intertemporal Elasticity of Substitution of Expenditure
ω	2.149	Elasticity of Firm's Real Marginal Cost
θ	6	Elasticity of Substitution across Goods
κ	0.0048	Elasticity of Inflation to Output Gap
α	0.875	Price Stickiness
γ	1	Degree of Inflation Persistence
ϕ_π	5	Coefficient of Inflation in Taylor Rule
ρ_i	0.842	Coefficient of Interest rate Lag in Taylor Rule
ϕ_x	0.5	Coefficient of the Output Gap in Price-level Rule
ϕ_p	1.5	Coefficient of Price in Price-level Rule
i^*	1	Steady-state Nominal Interest Rate (Annual)

Table 2: Comparison of RMSE

Figure: policy rule	L	RMSE_π	RMSE_x	RMSE_i
Fig. 1: TR	3.44	2.35	1.05	0.04
Fig. 2: TR $*$	7.39	1.74	3.15	2.50
Fig. 3: PLTR	4.15	1.41	2.66	0.07
Fig. 4: PLTR $*$	3.31	1.48	1.68	0.15
Fig. 5: AITR $*$	2.81	1.73	0.80	0.28
Fig. 6: Dis. IS TR, $\delta = 0.97$, $\zeta = 0.75$	4.08	2.82	1.19	0.07
Dis. IS TR, $\delta = 0.97$, $\zeta = 0.75$ $*$	6.62	1.70	2.36	2.57
Dis. IS TR, $\delta = 0.856$, $\zeta = 0.75$ $*$	5.89	1.66	1.59	2.64
Fig. 7: Dis. IS PLTR, $\delta = 0.97$, $\zeta = 0.75$	3.51	1.50	1.94	0.07
Dis. IS PLTR, $\delta = 0.97$, $\zeta = 0.75$ $*$	2.67	1.49	1.04	0.14
Dis. IS PLTR, $\delta = 0.856$, $\zeta = 0.75$	3.23	1.84	1.32	0.07
Dis. IS PLTR, $\delta = 0.856$, $\zeta = 0.75$ $*$	2.53	1.48	0.78	0.26
Fig. 8: TR, $\bar{\pi} = 2$	3.49	2.24	1.19	0.07
Fig. 9: PLTR, $\bar{\pi} = 2$	4.41	1.41	2.92	0.07
Fig. 10: TR, $\bar{\pi} = 2$, $r^* = -0.5$	3.36	1.89	1.28	0.19
Fig. 11: PLTR, $\bar{\pi} = 2$, $r^* = -0.5$	4.82	1.41	3.34	0.06
Fig. 12: ATR	4.00	1.45	2.47	0.07
ATR $*$	3.16	1.53	1.37	0.26
Fig. 13: TR, $\chi = 0.21$	3.54	2.62	0.85	0.07
TR, $\chi = 0.21$ $*$	5.99	1.69	1.69	2.61
Fig. 14: PLTR $\chi = 0.21$	2.56	1.51	0.98	0.07
PLTR $\chi = 0.21$ $*$	2.26	1.50	0.67	0.10
Fig. 15: TR, $\gamma = 0$	3.46	1.91	0.76	0.79
TR, $\gamma = 0.358$	3.22	1.82	0.69	0.71
TR, $\gamma = 0.631$	2.97	1.74	0.63	0.60
TR, $\gamma = 0.862$	2.87	1.83	0.72	0.32
TR, $\gamma = 0$ $*$	7.69	2.31	2.83	2.56
TR, $\gamma = 0.358$ $*$	6.31	2.11	2.17	2.02
TR, $\gamma = 0.631$ $*$	5.79	1.95	1.99	1.86
TR, $\gamma = 0.862$ $*$	6.36	1.81	2.44	2.12
Fig. 16: PLTR, $\gamma = 0$	3.57	1.98	1.50	0.09
PLTR, $\gamma = 0.358$	3.57	1.89	1.61	0.07
PLTR, $\gamma = 0.631$	3.57	1.74	1.79	0.05
PLTR, $\gamma = 0.862$	3.71	1.48	2.15	0.07
PLTR, $\gamma = 0.358$ $*$	3.36	2.04	0.85	0.47
PLTR, $\gamma = 0.862$ $*$	3.49	1.53	1.91	0.05

Note: $L = \sum_z \text{RSME}_z$ for $z = \pi, x, i$. TR, PLTR, AITR, and ATR denotes Taylor-type rule, price-level targeting rule, average inflation targeting rule, and augmented Taylor rule, respectively. $\bar{\pi}$ and r^* denote anchored inflation rate and natural rate at the steady-state, respectively. Asterisk "$*$" denotes the case with positive cost-push shocks.

Table 3: Comparison of Average

Figure: policy rule	Average for 2020Q2–2024Q4 π	x	i
Data	1.72	0.21	0.00
Fig. 1: TR	−0.10	0.63	0.02
Fig. 2: TR $*$	1.22	−2.53	2.03
Fig. 3: PLTR	1.40	2.49	0.00
Fig. 4: PLTR $*$	1.53	1.25	0.08
Fig. 5: AITR $*$	0.81	0.54	0.16
Fig. 6: Dis. IS TR, $\delta = 0.97$, $\zeta = 0.75$	−0.62	0.03	0.00
Dis. IS TR, $\delta = 0.97$, $\zeta = 0.75$ $*$	1.26	−1.87	2.11
Dis. IS TR, $\delta = 0.856$, $\zeta = 0.75$ $*$	1.30	−1.19	2.17
Fig. 7: Dis. IS PLTR, $\delta = 0.97$, $\zeta = 0.75$	1.22	1.91	0.00
Dis. IS PLTR, $\delta = 0.97$, $\zeta = 0.75$ $*$	1.53	0.71	0.07
Dis. IS PLTR, $\delta = 0.856$, $\zeta = 0.75$	0.73	0.82	0.00
Dis. IS PLTR, $\delta = 0.856$, $\zeta = 0.75$ $*$	1.53	0.37	0.12
Fig. 8: TR, $\bar{\pi} = 2$	0.06	0.53	0.00
Fig. 9: PLTR, $\bar{\pi} = 2$	1.87	2.75	0.00
Fig. 10: TR, $\bar{\pi} = 2$, $r^* = -0.5$	0.49	1.17	0.12
Fig. 11: PLTR, $\bar{\pi} = 2$, $r^* = -0.5$	1.94	3.00	0.00
Fig. 12: ATR	1.26	2.33	0.00
ATR $*$	1.45	0.79	0.10
Fig. 13: TR, $\chi = 0.21$	−0.40	0.03	0.00
TR, $\chi = 0.21$ $*$	1.26	−1.20	2.14
Fig. 14: PLTR $\chi = 0.21$	1.18	0.88	0.00
PLTR $\chi = 0.21$ $*$	1.50	0.13	0.04
Fig. 15: TR, $\gamma = 0$	1.29	−0.16	0.75
TR, $\gamma = 0.358$	1.19	−0.06	0.62
TR, $\gamma = 0.631$	1.00	0.09	0.47
TR, $\gamma = 0.862$	0.57	0.39	0.21
TR, $\gamma = 0$ $*$	1.61	−1.98	2.26
TR, $\gamma = 0.358$ $*$	1.46	−1.48	1.74
TR, $\gamma = 0.631$ $*$	1.33	−1.38	1.56
TR, $\gamma = 0.862$ $*$	1.24	−1.84	1.74
Fig. 16: PLTR, $\gamma = 0$	1.50	1.36	0.07
PLTR, $\gamma = 0.358$	1.50	1.45	0.05
PLTR, $\gamma = 0.631$	1.50	1.59	0.03
PLTR, $\gamma = 0.862$	1.49	1.93	0.00
PLTR, $\gamma = 0.358$ $*$	1.50	0.46	0.34
PLTR, $\gamma = 0.862$ $*$	1.50	1.63	0.01

Note: TR, PLTR, AITR, and ATR denotes Taylor-type rule, price-level targeting rule, average inflation targeting rule, and augmented Taylor rule, respectively. $\bar{\pi}$ and r^* denote anchored inflation rate and natural rate at the steady-state, respectively. Asterisk "$*$" denotes the case with positive cost-push shocks.

Table 4: Estimated values for ω_π, μ_0, μ_6, and r_0^n

Parameters	ω_π	μ_0	μ_6	r_0^n
Estimated values	0.23	−0.74	0.08	−11.21

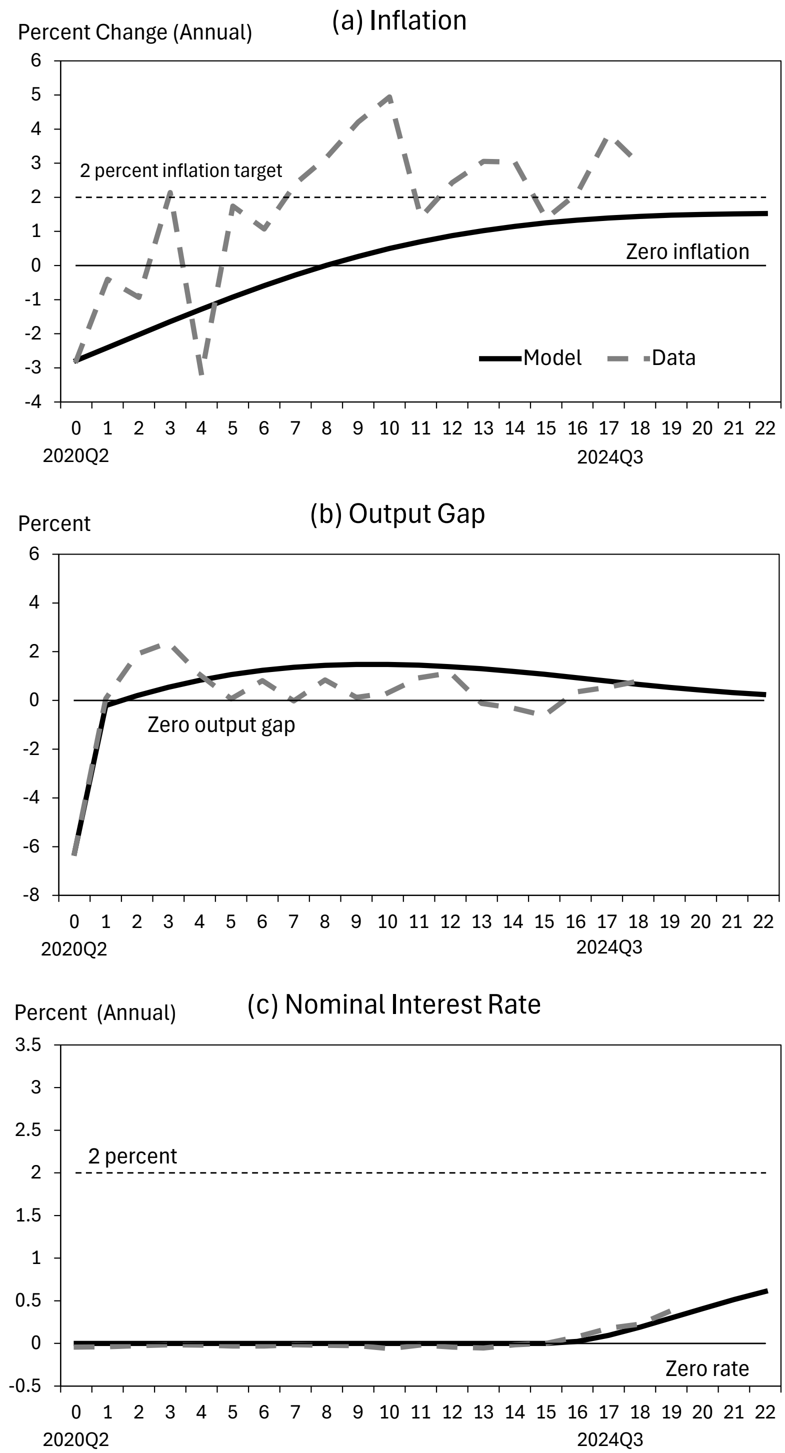

Figure 1: Taylor-type Rule

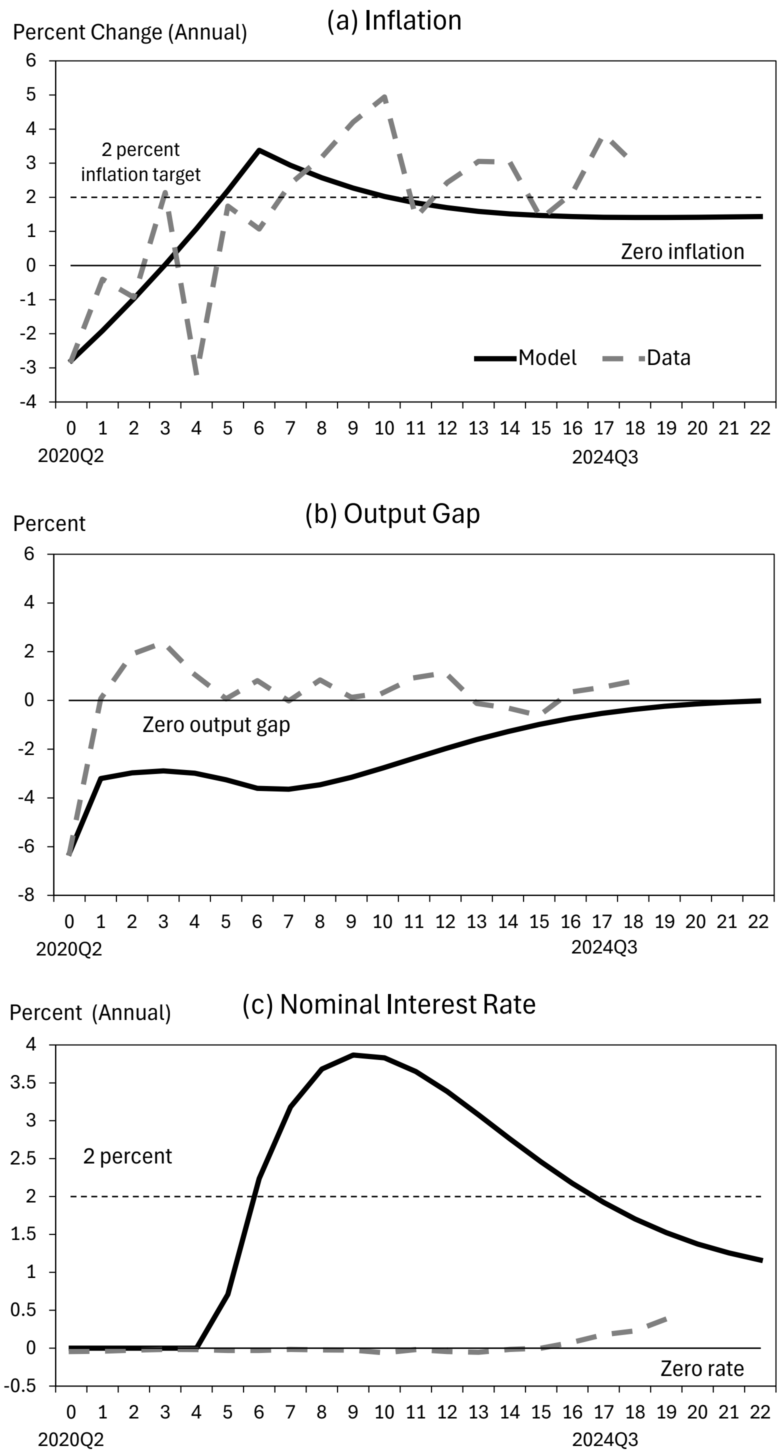

Figure 2: Taylor-type Rule with Cost-push Shock

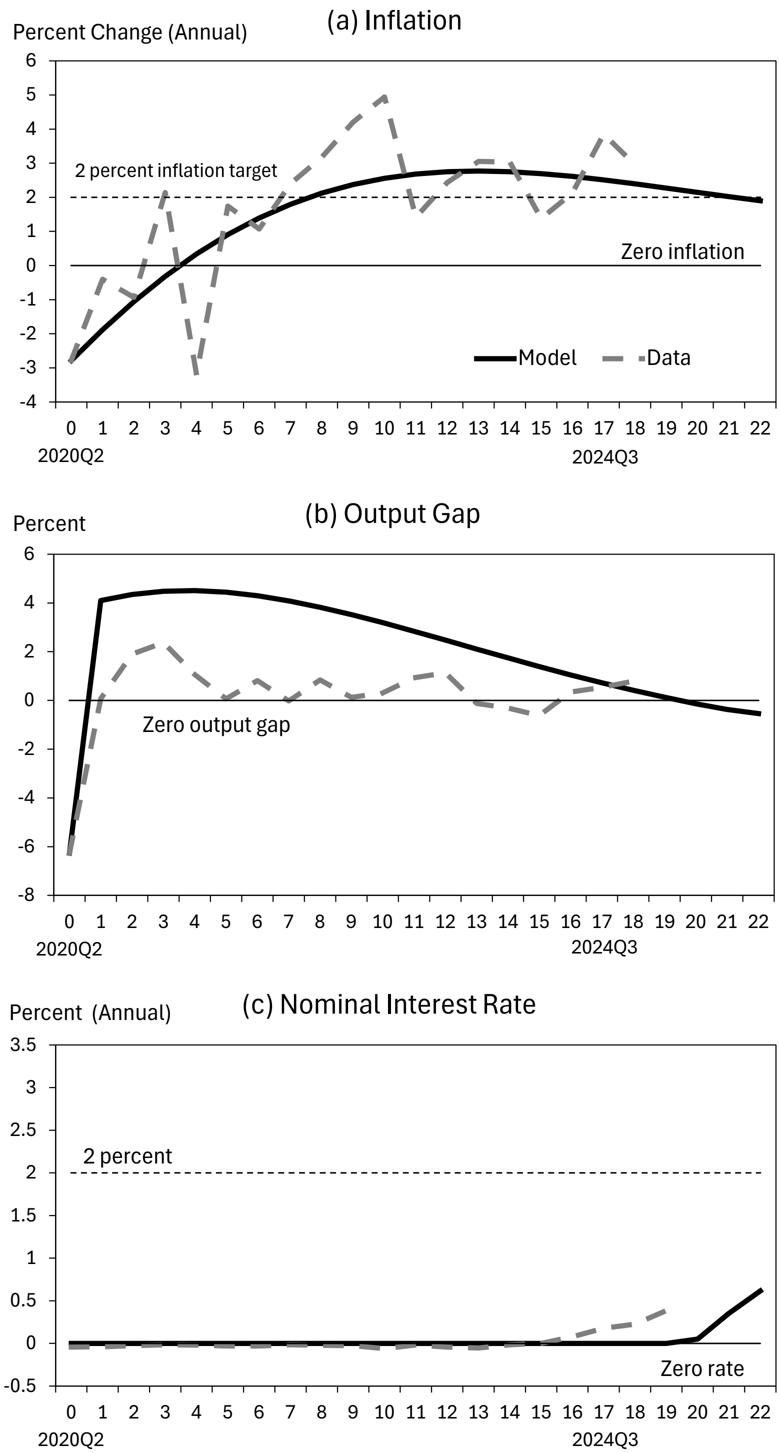

Figure 3: Price-level Targeting Rule

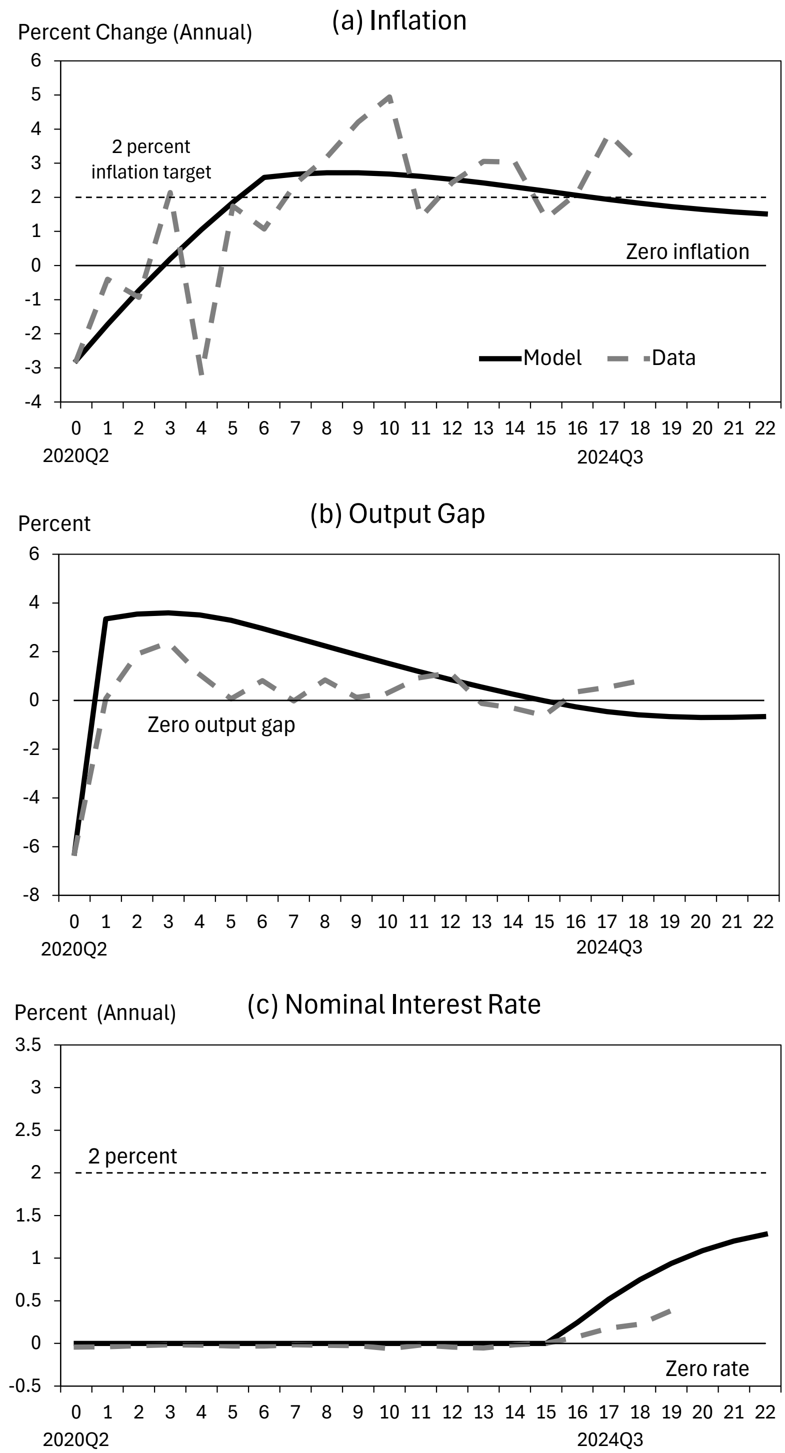

Figure 4: Price-level Targeting Rule with Cost-push Shock

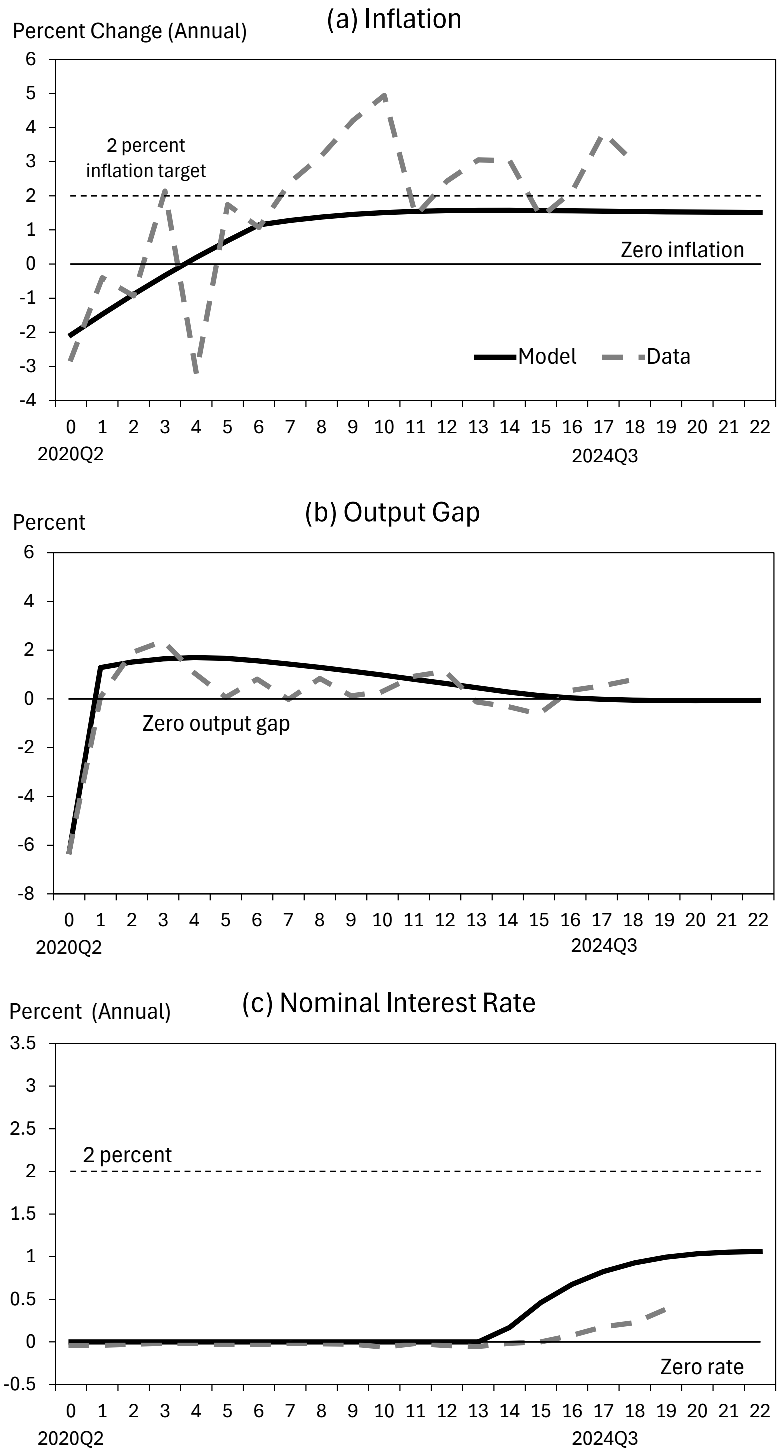

Figure 5: Average Inflation Targeting Rule when $\omega_\pi = 0.23$ and $\mu_6 = 0.08$.

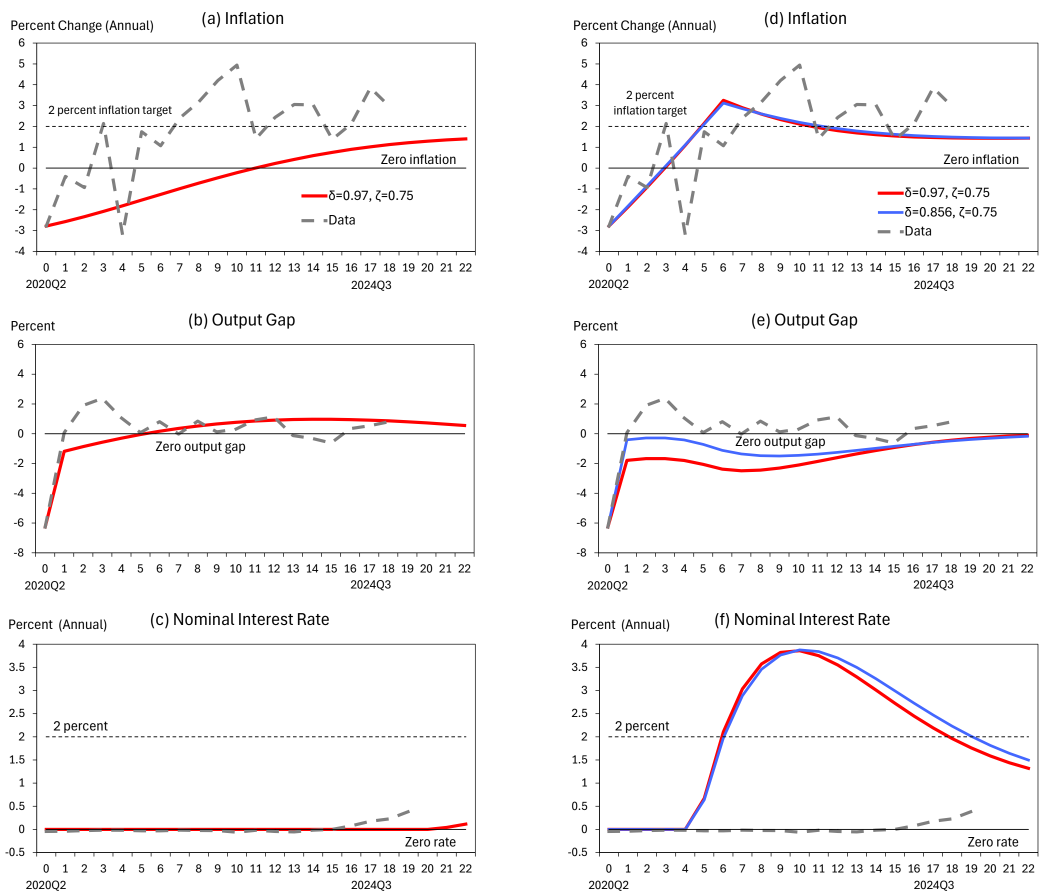

Figure 6: Taylor-type Rule: Discounted Euler Equation

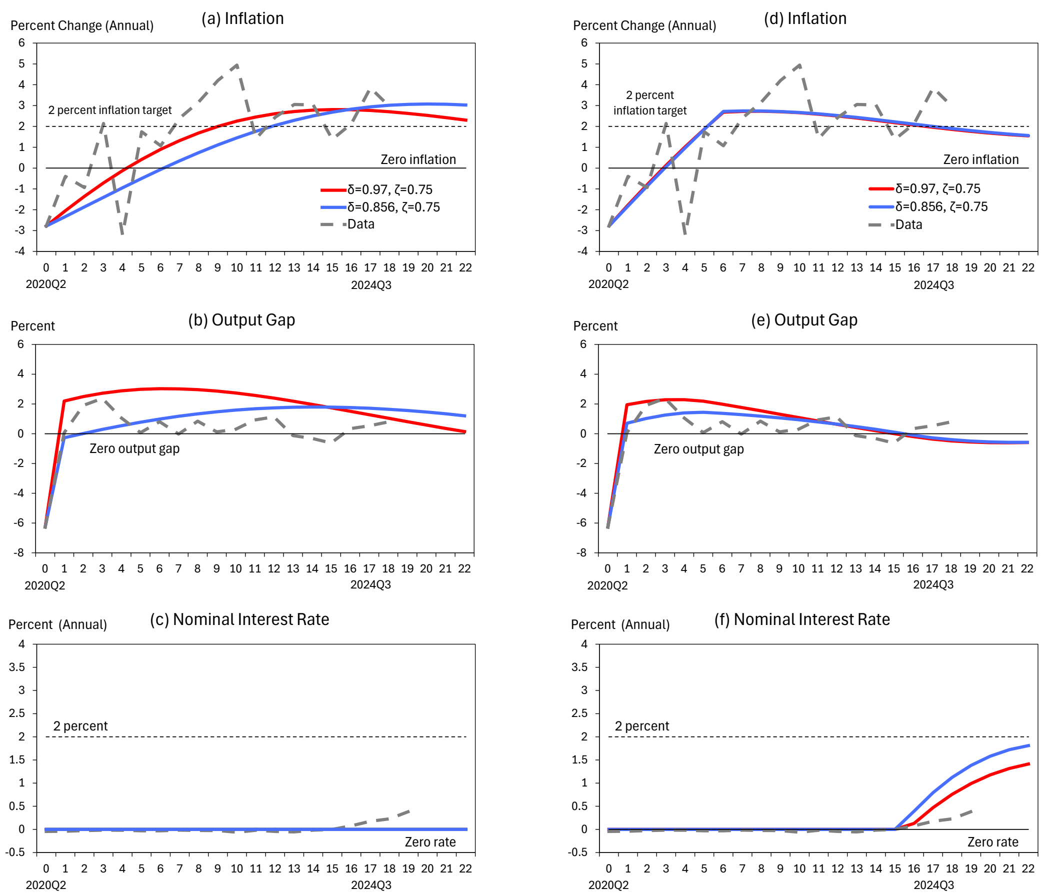

Figure 7: Price-level Targeting Rule: Discounted Euler Equation

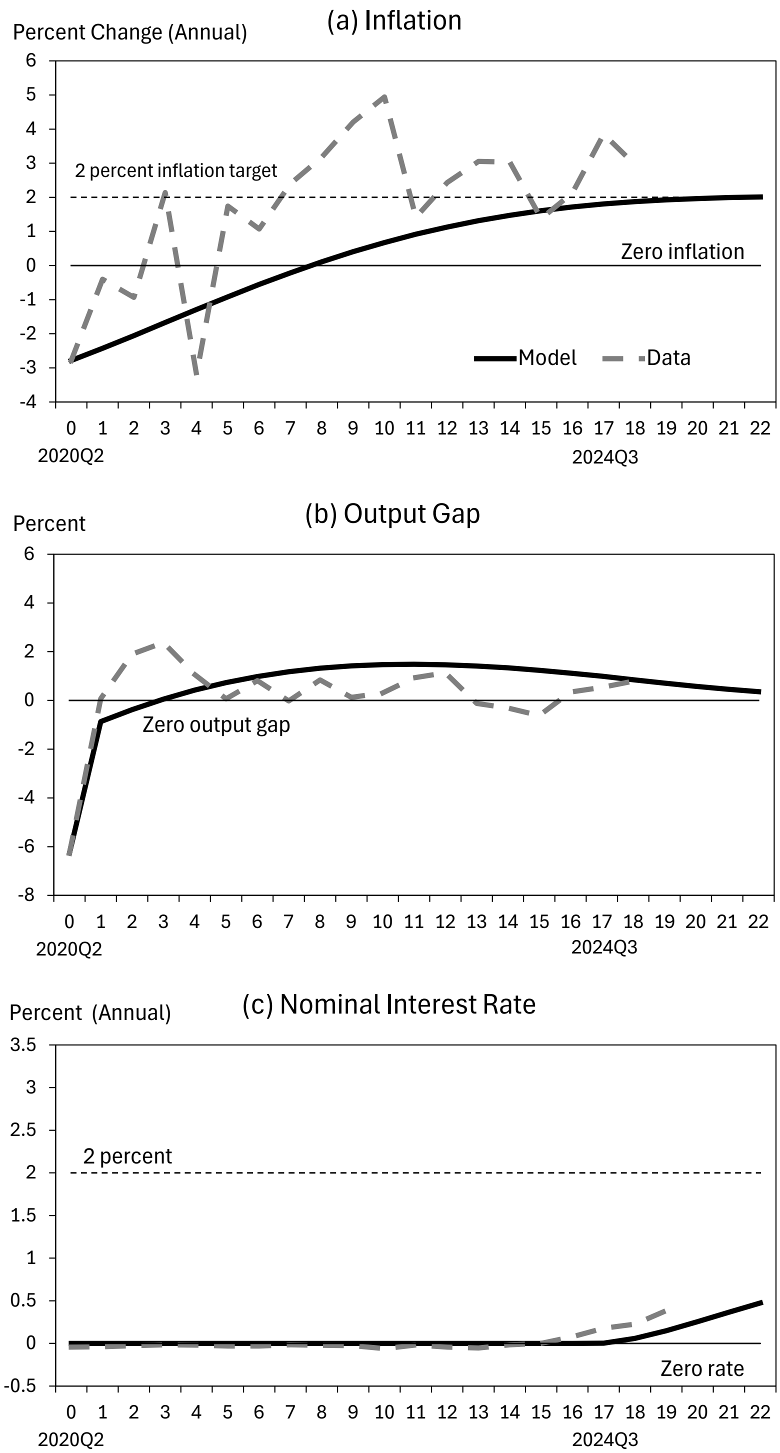

Figure 8: Taylor-type Rule under 2 Percent Target

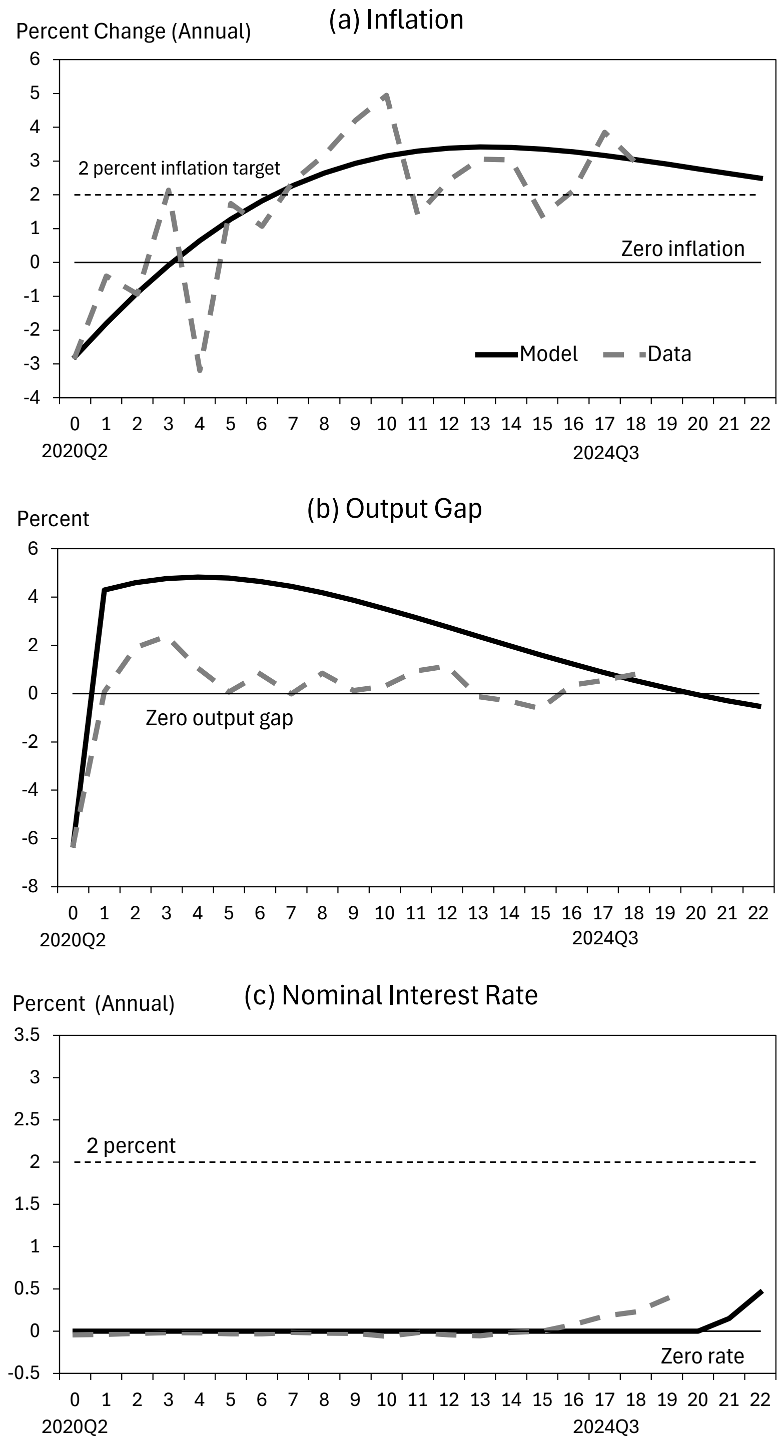

Figure 9: Price-level Targeting Rule under 2 Percent Target

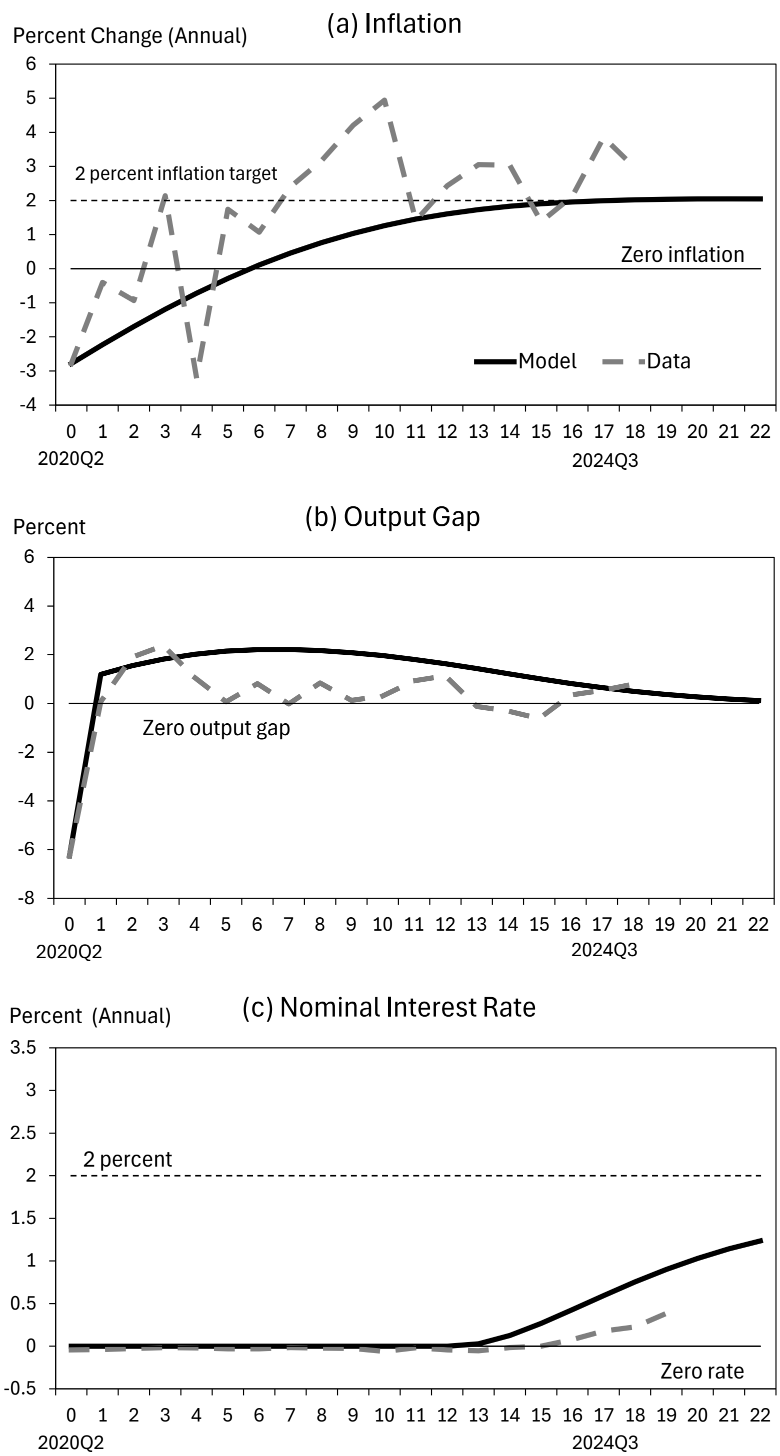

Figure 10: Taylor-type Rule under 2 Percent Target, -0.5 Percent Natural Rate, and 1.5 Percent Nominal Interest Rate

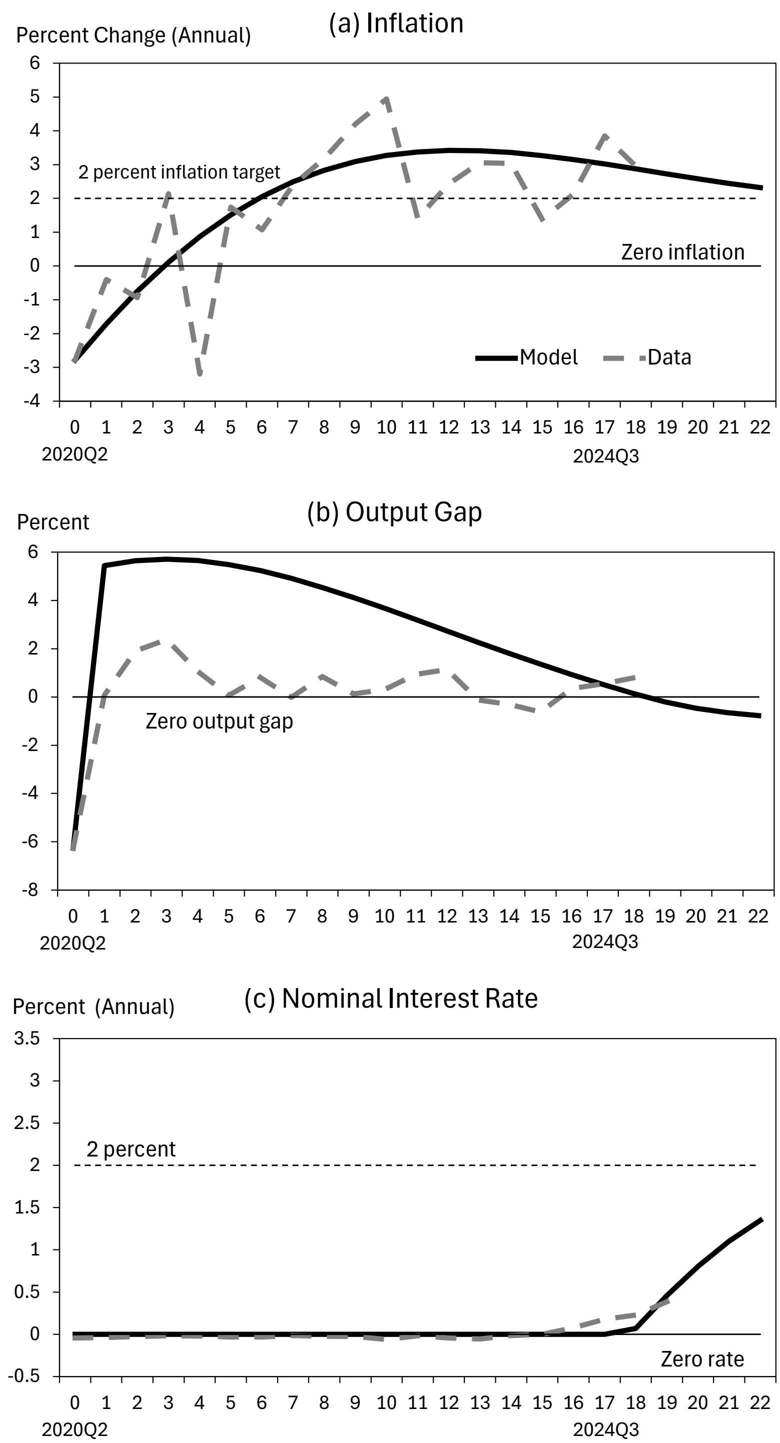

Figure 11: Price-level Targeting Rule under 2 Percent Target, −0.5 Percent Natural Rate, and 1.5 Percent Nominal Interest Rate

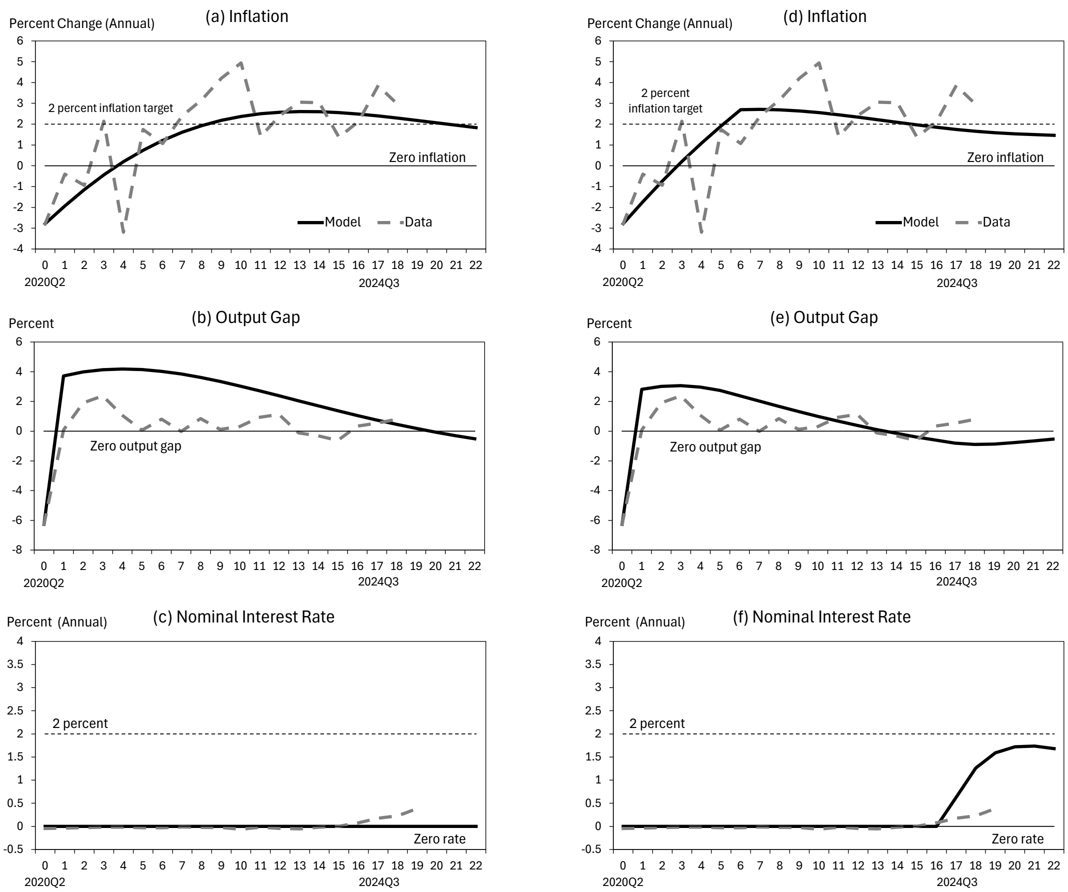

Figure 12: Augmented Taylor Rule

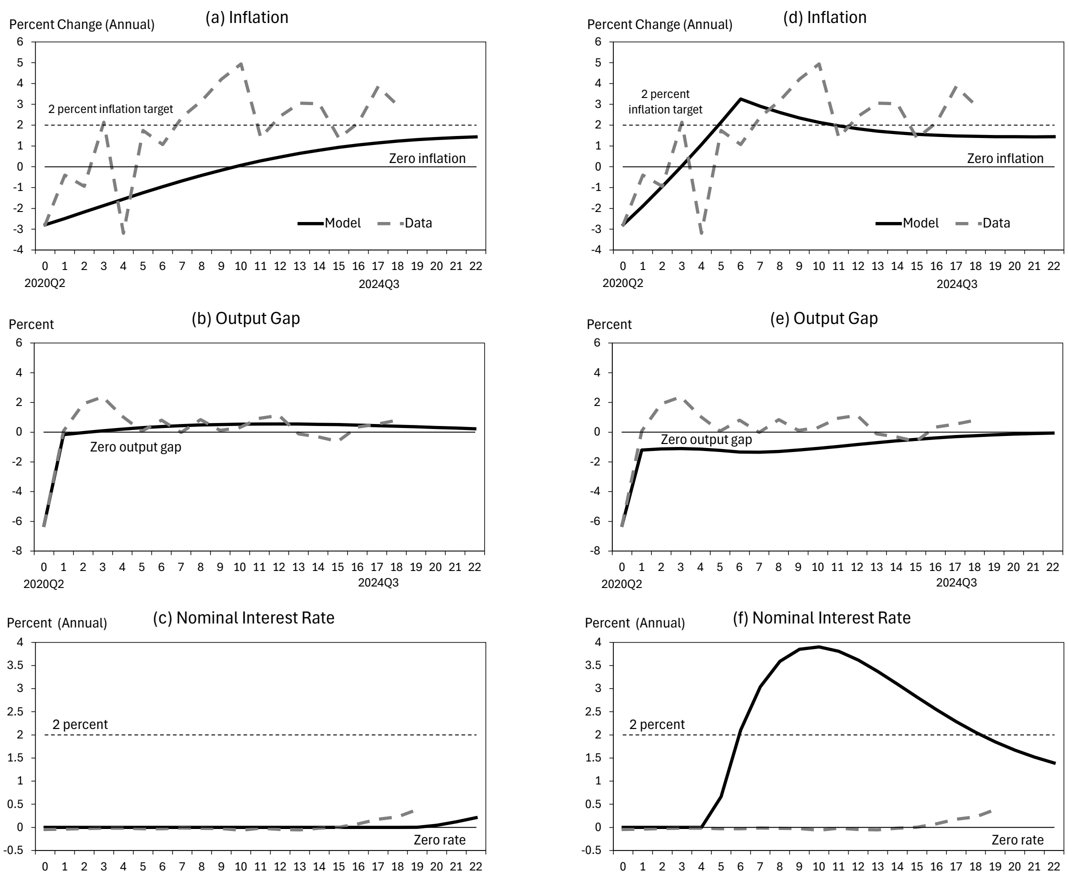

Figure 13: Taylor-type Rule: Low Elasticity of Demand to the Real Interest Rate

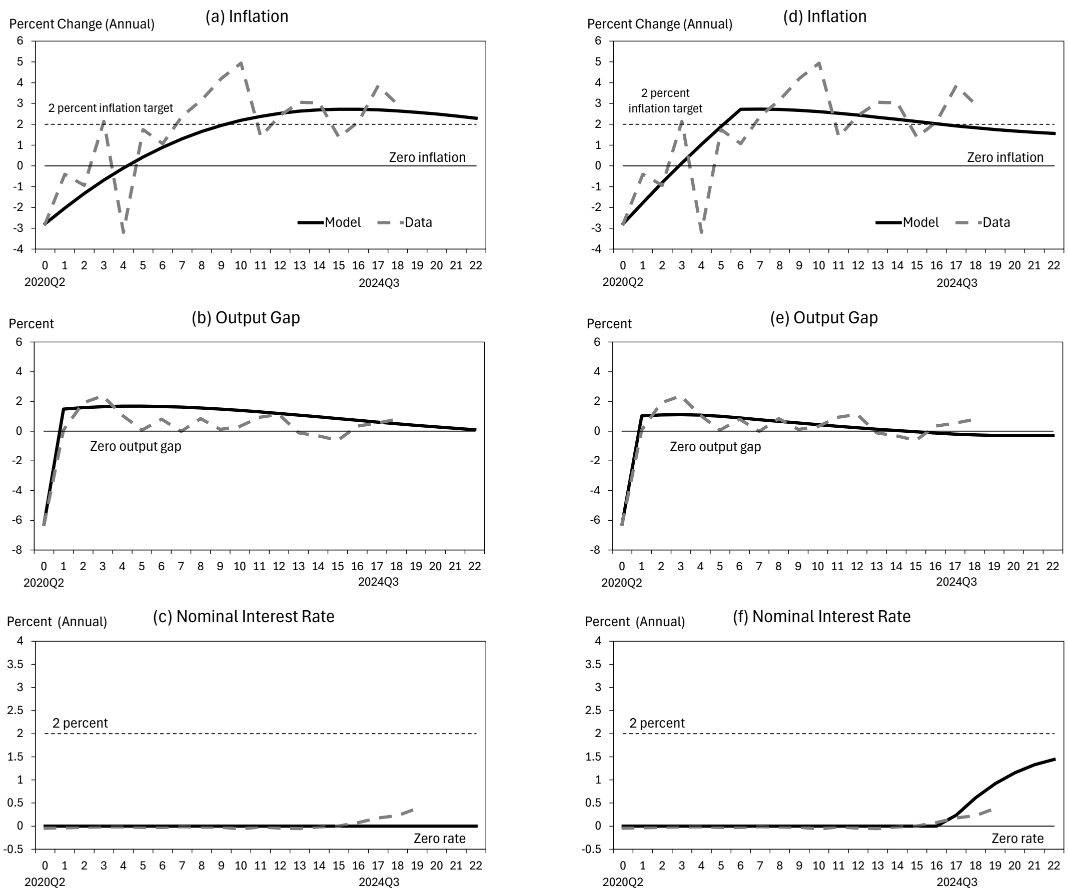

Figure 14: Price-level Targeting Rule: Low Elasticity of Demand to the Real Interest Rate

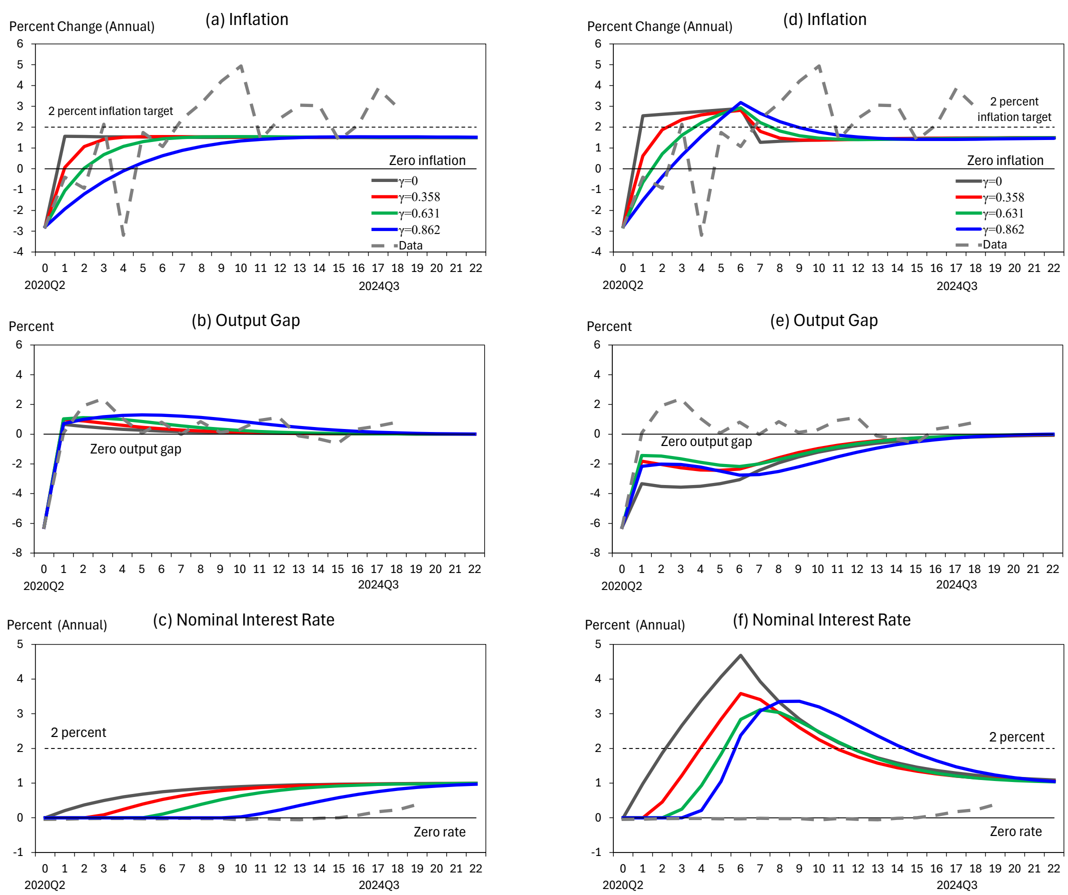

Figure 15: Taylor-type Rule: Inflation Persistence

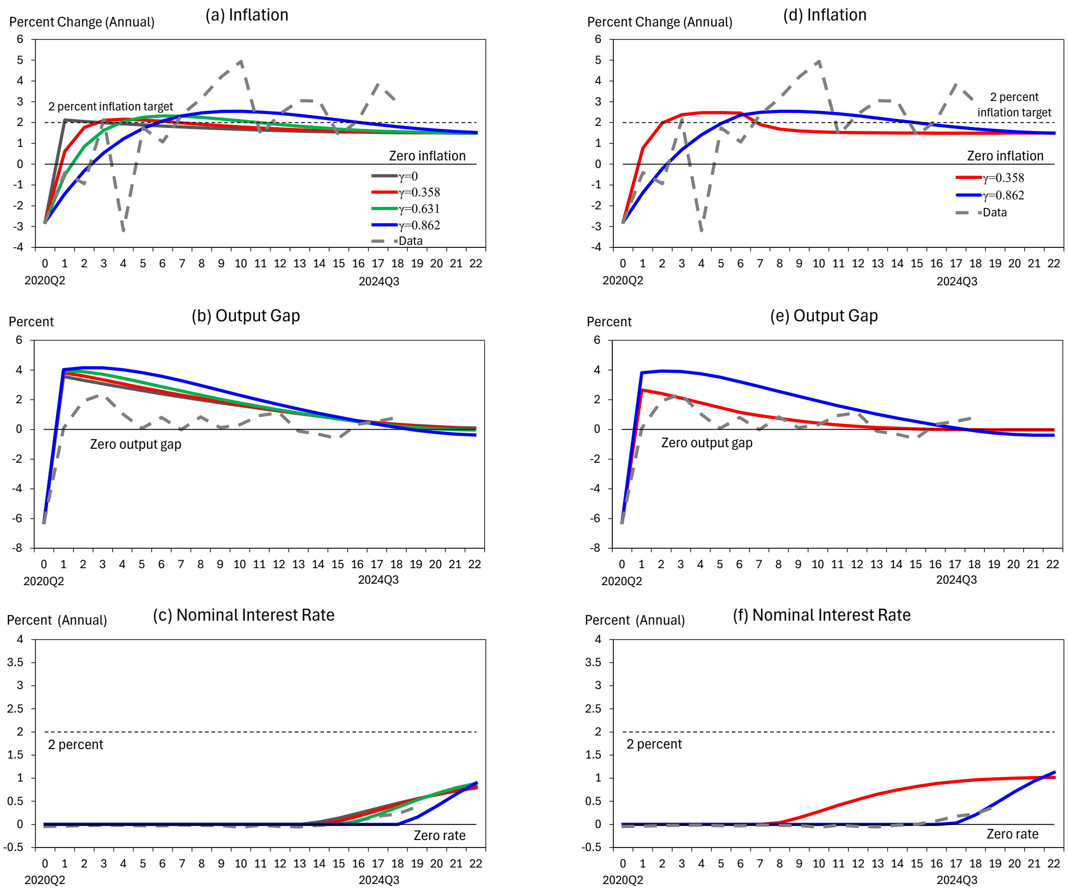

Figure 16: Price-level Targeting Rule: Inflation Persistence

Appendix

A Assessment of the Model's Consistency with Data

We assess the simulation results using the root mean squared error (RMSE) as follows.

$$\text{RMSE}_z = \sqrt{\frac{1}{T}\sum_{t=0}^{T}\left[z_t - z_t^{\text{data}}\right]^2}, \quad \text{for } z = \pi, x, i,$$

where z_t denotes simulation results and z_t^{data} denotes the data. The time index $t = 0, ..., T$ corresponds to 2020Q2–2024Q4. We define L as the sum of RMSE_z.