History-Dependent Monetary Policy and Wage Rigidity at the Zero Lower Bound*

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Abstract

This paper shows that the macroeconomic effects of downward nominal wage rigidity (DNWR) at the zero lower bound depend (ZLB) critically on monetary-policy history dependence. In a New Keynesian model with occasionally binding ZLB and DNWR constraints, wage rigidity operates through two opposing forces. By limiting the decline in marginal cost and inflation while the ZLB binds, DNWR lowers the real interest rate and stabilises demand. Under history-dependent policy, however, the smaller inflation or price-level shortfall also reduces the future accommodation that agents expect, weakening the expectations channel that supports demand at the ZLB. We show analytically that this second force reverses the output effect of DNWR once policy is sufficiently history-dependent. In the quantitative model, the reversal occurs at interior degrees of history dependence and is robust to alternative calibrations. Under current inflation targeting DNWR mitigates the recession, whereas under sufficiently history-dependent average inflation targeting and price-level targeting it amplifies the contraction. The same mechanism operates under Ramsey-optimal policy, where DNWR weakens the low-for-long accommodation that supports expected inflation and current demand.

Keywords: Wage rigidity, Zero lower bound, Monetary policy

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1 Introduction

The zero lower bound (ZLB) fundamentally changes the transmission of macroeconomic disturbances. When the nominal interest rate is unconstrained, monetary policy can respond to a contraction in aggregate demand by lowering the policy rate. At the ZLB, this adjustment is no longer available, so movements in expected inflation become especially important for the real interest rate and current demand. This observation raises a broader question about downward nominal wage rigidity (DNWR). DNWR is conventionally viewed as a distortion because it prevents nominal wages from adjusting downward and shifts labour-market adjustment towards employment. At the ZLB, however, the same rigidity can also limit the decline in real marginal cost and inflation. Whether this stabilising effect survives, however, depends on how monetary policy responds to inflation shortfalls over time.

To examine this interaction, we consider a New Keynesian model with a ZLB constraint on the nominal interest rate and occasionally binding DNWR following Schmitt-Grohé and Uribe (2016). The monetary policy rule nests regimes that differ in how they treat past inflation shortfalls. Under current inflation targeting, past shortfalls are bygones and policy responds only to current inflation. Under average inflation targeting, past inflation enters the policy state variable, so a current shortfall affects expectations about future policy accommodation.[1] Price-level targeting arises as the limiting case of average inflation targeting and provides the strongest form of history dependence among the regimes considered: a decline in the price level below its target path calls for policy to remain accommodative until the shortfall is reversed. We show that this distinction is central to the effects of DNWR at the ZLB.

DNWR interacts differently with these regimes because it affects the economy through two opposing channels. The first operates through the inflation path when the ZLB persists for multiple periods. By preventing nominal wages and real marginal cost from falling sharply, DNWR keeps inflation higher while the nominal interest rate remains constrained. This raises near-term expected inflation, lowers the real interest rate, and supports aggregate demand. The second operates through

[1] Such history-dependent frameworks are often referred to as make-up policies (Bernanke, 2019) and embody the history dependence emphasised by Eggertsson and Woodford (2003). Their effectiveness depends on expectations about future policy (Bodenstein et al., 2022).

the future policy response to past inflation shortfalls. Under history-dependent policy, a larger inflation or price-level shortfall generates stronger expectations of future accommodation. By reducing that shortfall, DNWR weakens the expected future accommodation that would otherwise support demand at the ZLB.

The balance between these two channels determines the effect of DNWR on output. Under current inflation targeting, past inflation misses are bygones, so DNWR operates primarily through the inflation path and mitigates the output contraction. As monetary policy becomes more history-dependent, however, the second channel becomes increasingly important because the smaller inflation shortfall created by DNWR reduces the future accommodation that agents expect. Once history dependence is sufficiently strong, this effect dominates, so DNWR amplifies rather than mitigates the contraction. The mechanism is strongest under price-level targeting, where the accumulated price-level shortfall must eventually be reversed, generating the strongest expectations of future accommodation among the rule-based regimes.

We first isolate the role of monetary-policy history dependence analytically in a two-period version of the model. Because the ZLB lasts for only one period in this benchmark, the first channel is absent: DNWR has no effect on current output under current inflation targeting but amplifies the contraction once policy becomes history-dependent. We then turn to the infinite-horizon economy, where persistent shocks keep the ZLB and DNWR binding for multiple periods, allowing both channels to operate. Quantitatively, DNWR mitigates the contraction under current inflation targeting, but its output effect declines as monetary policy becomes more history-dependent. Both the impact and cumulative effects eventually change sign at interior degrees of history dependence, so DNWR amplifies the contraction under sufficiently history-dependent policies, including our baseline average inflation targeting and price-level targeting.

We also study optimal monetary policy. The Ramsey allocation features a low-for-long path of the nominal interest rate following the initial downturn. This prolonged accommodation raises expected inflation and lowers the real interest rate at the ZLB. DNWR reduces the initial inflation shortfall associated with this low-for-long accommodation and thereby weakens its effect on expectations. Expected inflation therefore rises by less, the real interest rate falls by less, and output declines more than in the equilibrium in which DNWR does not bind. Among the considered rule-based regimes, price-level targeting most closely approximates the optimal policy path.

The central contribution of the paper is to identify a new interaction between labour-market rigidity and monetary-policy history dependence. DNWR affects not only current wages, real marginal cost, and inflation, but also the intertemporal transmission of monetary policy by changing the size of the inflation or price-level shortfall that policy is expected to offset. The aggregate effect of wage rigidity therefore cannot be inferred from its impact on current inflation alone. Instead, it depends on whether that shortfall is treated as a bygone or generates expectations of future policy accommodation.

Related Literature This paper contributes to three strands of literature. The first studies how DNWR shapes macroeconomic fluctuations. Benigno and Ricci (2011) and Schmitt-Grohé and Uribe (2016) provide key theoretical foundations: DNWR generates a nonlinear long-run Phillips curve and can give rise to involuntary unemployment and substantial aggregate dynamics when nominal wage adjustment is constrained. Jo (2025) provides micro-level support for this specification, showing that DNWR is the wage-setting scheme most consistent with the shape and cyclicality of the nominal wage change distribution. Subsequent work examines the implications of DNWR for policy design and macroeconomic transmission. Mineyama (2022) and Aktug (2025) study how worker heterogeneity shapes the optimal inflation rate under DNWR. Born et al. (2024) and Jo and Zubairy (2025) instead examine how DNWR affects the transmission of government spending, respectively in a small open economy with fixed exchange rates and across recessions differing in their inflation dynamics and underlying sources. Ji and Xiao (2026) extend this question to the ZLB and find that the sign reverses: because DNWR dampens the inflation response to a fiscal expansion, it lowers rather than raises the government spending multiplier when the nominal interest rate is constrained, which is the fiscal counterpart of the mechanism we identify for monetary policy. Most closely related to our work, Amano and Gnocchi (2023) show that DNWR can reduce the severity of ZLB episodes by limiting deflation. Our contribution is to show that this result is not a structural property of DNWR, but depends on the monetary policy regime. The same rigidity that mitigates the output contraction under current inflation targeting can amplify it once policy responds to past inflation shortfalls.

Second, this paper contributes to the literature on monetary policy at the ZLB and history dependence. A central lesson from this literature is that expectations about future policy are crucial when the current nominal interest rate is constrained. Eggertsson and Woodford (2003) show that history-dependent policy can mitigate the distortions created by the ZLB by shaping expectations about future interest rates and inflation. Jung et al. (2005) characterise optimal policy at the ZLB as involving policy inertia, in which the nominal interest rate remains low even after the shock has begun to dissipate. More recently, Nakata et al. (2019) analyse how the strength of forward guidance shapes optimal policy at the lower bound, Budianto et al. (2023) propose the average-inflation-targeting rule we adopt, and Bonciani and Oh (2026) show that unemployment risk amplifies liquidity-trap recessions and strengthens the role of low-for-long policy. Bernanke (2019) evaluates temporary price-level targeting as a make-up policy for the ZLB, and Bodenstein et al. (2022) show that its stabilisation benefits depend on private agents learning and trusting the new policy rule. Price-level targeting provides a simple rule-based form of history dependence because past inflation shortfalls must be offset by future inflation. Our contribution is to show that labour-market rigidities interact with this history dependence: by limiting the current fall in inflation and the price level, DNWR can reduce the expectations of future inflation on which history-dependent policy relies for stabilisation at the ZLB.

Third, this paper is related to the literature on the paradox of flexibility and other New Keynesian policy paradoxes at the ZLB. Eggertsson and Krugman (2012) show that greater price flexibility can be destabilising in a liquidity trap because it amplifies deflation, raises the real interest rate, and depresses aggregate demand. Kiley (2016) shows that the standard New Keynesian model can generate several policy paradoxes at the ZLB, including the result that greater price flexibility may exacerbate output declines. Bhattarai et al. (2018) revisit the stabilising role of price flexibility and show that its effects depend on the shocks hitting the economy and on the systematic response of monetary policy. Eggertsson and Garga (2019) study related paradoxes in models with alternative nominal rigidities. Bonciani and Oh (2023a) show that monetary policy inertia can eliminate the paradox of flexibility by altering expectations about future policy, while Bonciani and Oh (2023b) show that quantitative easing can resolve several New Keynesian policy paradoxes at the effective lower bound. Our paper extends this logic from price flexibility to wage flexibility. Greater nominal wage flexibility can be destabilising under current inflation targeting, but under history-dependent policy it instead raises expected inflation and lowers the real interest rate, strengthening the stabilising force of the regime. The direction of the effect therefore depends on whether flexibility mainly amplifies current deflationary pressure or instead increases the future accommodation that history-dependent policy delivers.

The remainder of this paper is organised as follows. Section 2 presents the model. Section 3 develops analytical results in a two-period version of the model. Section 4 presents the calibration and solution method and reports impulse responses in the infinite-horizon model under current inflation targeting, average inflation targeting, and price-level targeting. Section 5 studies optimal monetary policy and compares the Ramsey allocation with the rule-based regimes. Section 6 concludes.

2 Model

We consider a New Keynesian economy with a ZLB on the short-term nominal interest rate and DNWR. The model combines a standard monopolistically competitive production structure with Calvo (1983)-style staggered price setting and a constraint on downward wage adjustment following Schmitt-Grohé and Uribe (2016). We use the model to study how DNWR interacts with the ZLB, and how this interaction affects the transmission of demand shocks under alternative monetary policy regimes. All equilibrium conditions of the model are summarised in Appendix A.

2.1 Households

The representative household chooses consumption, labour supply, and nominal bond holdings in order to maximise expected lifetime utility:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{{C_t}^{1-\sigma} - 1}{1-\sigma} - \chi \frac{{N_t}^{1+\varphi}}{1+\varphi} \right), \tag{1}$$

where C_t denotes consumption, N_t denotes hours worked, $\beta \in (0, 1)$ is the subjective discount factor, σ is the inverse of the intertemporal elasticity of substitution, φ is the inverse Frisch elasticity of labour supply, and χ governs the disutility of labour.

The household faces the nominal budget constraint:

$$P_t C_t + \frac{B_t}{Z_t} = W_t N_t + R^s_{t-1} B_{t-1} + D_t, \tag{2}$$

where P_t is the aggregate price level, W_t is the nominal wage, B_t denotes nominal bond holdings, R^s_{t-1} is the gross nominal return on bonds purchased in the previous period, and D_t represents profits rebated from firms. The variable Z_t is an exogenous demand disturbance that affects the intertemporal price of bonds and therefore shifts households' desired saving and consumption decisions.

The demand shock follows the autoregressive process:

$$\log Z_t = \rho_Z \log Z_{t-1} + \sigma_Z \varepsilon_{Z,t}, \tag{3}$$

where ρ_Z measures the persistence of the shock and $\varepsilon_{Z,t}$ is an i.i.d. innovation. A contractionary demand shock increases households' desire to save, reduces current consumption demand, and puts downward pressure on output, inflation, and the nominal interest rate.

Following Schmitt-Grohé and Uribe (2016), nominal wages are subject to downward rigidity. In particular, the nominal wage cannot fall below a fraction γ of its previous-period level:

$$W_t \geq \gamma W_{t-1}. \tag{4}$$

When γ is close to one, nominal wages are highly rigid downward. This constraint prevents wages from adjusting sufficiently in response to adverse demand shocks. As a result, the labour market may fail to clear through wage adjustment alone.

The labour-market equilibrium is characterised by the complementary slackness condition:

$$W_t \geq \gamma W_{t-1}, \quad N^s_t \geq N_t, \quad \left(N^s_t - N_t\right)\left(W_t - \gamma W_{t-1}\right) = 0, \tag{5}$$

where N_t^s denotes the household's notional labour supply. If the wage constraint is not binding, then $W_t > \gamma W_{t-1}$ and employment equals notional labour supply, $N_t = N_t^s$. If the constraint binds, then $W_t = \gamma W_{t-1}$ and employment may fall short of notional labour supply, $N_t < N_t^s$. In this case, DNWR generates involuntary unemployment.

2.2 Firms

The final good is produced by a competitive final-good firm using a continuum of differentiated intermediate goods. The final-good technology is given by:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{6}$$

where $\epsilon > 1$ is the elasticity of substitution across intermediate goods. Cost minimisation by the final-good firm implies the demand function for intermediate variety i:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t. \tag{7}$$

The associated aggregate price index is

$$P_t = \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}. \tag{8}$$

Intermediate-good firms operate under a linear production technology:

$$Y_t(i) = N_t(i), \tag{9}$$

so that labour is the only input in production. Since production is linear in labour, real marginal cost is directly related to the real wage.

Intermediate-good firms are monopolistically competitive and set prices subject to Calvo-style staggered price setting, as in Calvo (1983). In each period, a firm can reset its price with probability $1-\theta$, while with probability θ it must keep its price unchanged. A price-setting firm chooses its reset price to maximise the expected present discounted value of real profits:

$$\max_{P_t^\star(i)} \mathbb{E}_t \sum_{j=0}^{\infty} \theta^j \Lambda_{t,t+j} \left((1+\tau) \frac{P_t^\star(i)}{P_{t+j}} - \frac{MC_{t+j}}{P_{t+j}} \right) Y_{t+j}(i) \tag{10}$$

subject to the demand function (7). Here, $\tau = \frac{1}{\epsilon - 1}$ denotes a revenue subsidy that offsets the steady-state monopolistic distortion, $\Lambda_{t,t+j}$ is the stochastic discount factor, and MC_t denotes nominal marginal cost.

2.3 Monetary Authority

The monetary authority sets the short-term nominal interest rate subject to the ZLB. We consider a policy rule that nests current inflation targeting, average inflation targeting, and price-level targeting as special or limiting cases. Following Budianto et al. (2023), let average inflation be defined by

$$\Pi_t^{avg} = \Pi_t^{\omega} \Pi_{t-1}^{avg\,1-\omega}, \tag{11}$$

where $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ denotes gross inflation and $\omega \in (0, 1]$ determines the degree of history dependence. The monetary policy rule is

$$R_t^s = \max\left\{1,\ R^s \Pi_t^{avg\,\frac{\phi}{\omega}}\right\}, \tag{12}$$

where R^s denotes the steady-state gross nominal interest rate and ϕ measures the strength of the policy response. We assume a zero-inflation steady state, so that $\Pi = 1$, and normalise the steady-state price level to one, $P = 1$. The max operator captures the ZLB: the nominal interest rate cannot fall below one.

First, when $\omega = 1$, the rule collapses to current inflation targeting. In this case, $\Pi_t^{avg} = \Pi_t$, and the policy rule becomes

$$R_t^s = \max\left\{1,\ R^s \Pi_t^{\phi}\right\}. \tag{13}$$

Thus, under current inflation targeting, the monetary authority responds only to current inflation. Past deviations of inflation from target are bygones and do not generate any direct commitment to offset them in the future.

Second, when $0 < \omega < 1$, the rule corresponds to average inflation targeting. Current inflation affects the average-inflation state variable, but past inflation also matters through Π_{t-1}^{avg}. A lower value of ω increases the weight placed on past inflation and therefore strengthens history dependence. Under this regime, an inflation shortfall today lowers average inflation and creates expectations of a future policy response. As a result, average inflation targeting lies between current inflation targeting and price-level targeting.

Finally, price-level targeting arises as the limiting case $\omega \to 0$. In the limit, the policy rule becomes

$$R_t^s = \max\left\{1,\ R^s P_t^{\phi}\right\}. \tag{14}$$

This is price-level targeting.[2] Unlike current inflation targeting, price-level targeting is fully history-dependent: past deviations of inflation from target are not bygones. If inflation falls below target today, the central bank is expected to generate higher future inflation in order to return the price level to its target path. This expectation channel is especially powerful at the ZLB because higher expected inflation lowers the real interest rate and stimulates current demand.

2.4 Market Clearing

Aggregate output satisfies:

$$\Delta_t Y_t = N_t. \tag{15}$$

where $N_t = \int N_t(i)\, di$ and $\Delta_t = \int \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} di$ is relative price dispersion. The goods-market-clearing condition is

$$Y_t = C_t. \tag{16}$$

The final good is used for household consumption.

[2]See Appendix B for a derivation of the price-level-targeting policy rule.

3 Analytical Insights

To establish insights into the interaction between the ZLB and DNWR, we work with a log-linearised version of the model. The equilibrium dynamics are summarised by four key equations: the dynamic IS equation, the New Keynesian Phillips curve (NKPC), the real marginal cost equation depending on whether the DNWR constraint binds, and the monetary policy rule. Lowercase variables and variables with hats denote log deviations from their respective steady-state values.

The dynamic IS equation and NKPC are given by:

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}\left(r_t^s - \mathbb{E}_t \pi_{t+1} + z_t\right), \tag{17}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}\widehat{mc}_t. \tag{18}$$

The dynamics of real marginal cost depend on the state of the labour market. When DNWR does not bind, the labour market clears, and real marginal cost is given by:

$$\widehat{mc}_t = (\sigma + \varphi)\, y_t. \tag{19}$$

In this case, marginal cost is increasing in output because higher output requires higher labour input and a higher real wage. By contrast, when DNWR binds, nominal wages cannot fall sufficiently to clear the labour market. Real marginal cost is then determined by the wage floor:

$$\widehat{mc}_t = \log\gamma + \widehat{\omega}_{t-1} - \pi_t. \tag{20}$$

This expression captures the central mechanism of the model. If nominal wages are prevented from falling, then adjustment occurs through employment rather than wages. In this case, real marginal cost is no longer increasing in current output. Instead, it is pinned down by the inherited real wage and current inflation (equivalently, by the inherited nominal wage and current price level). Lastly, the log-linearised monetary policy rule is given by

$$r_t^s = \max\left\{-\frac{R^s - 1}{R^s}, \frac{\phi}{\omega}\pi_t^{avg}\right\}, \tag{21}$$

where $\pi_t^{avg} = \omega\pi_t + (1-\omega)\,\pi_{t-1}^{avg}$.

3.1 AD–AS Representation

We first characterise the model's mechanism analytically, adopting the two-period structure used in Eggertsson and Garga (2019) and Bonciani and Oh (2023a, 2023b, 2025). We impose a one-period ZLB episode: the demand shock is present only in period 0, while in period 1 the shock disappears and the ZLB is slack. This structure allows us to isolate the role of history dependence, because DNWR can affect period-0 demand only through its effect on expectations of future policy, rather than also through the within-episode force that operates when the ZLB persists for multiple periods. Section 4 confirms this mechanism quantitatively in an infinite-horizon setting, where both forces are present. The detailed derivations of the AD–AS curves are provided in Appendix C.

The economy is hit by a sufficiently large contractionary demand shock in period 0 ($z_0 > 0$), while the shock disappears in period 1 ($z_1 = 0$). We assume perfect foresight, so that $\mathbb{E}_t x_{t+1} = x_{t+1}$ for all variables. The economy is initially at the deterministic steady state, so that $\widehat{\omega}_{-1} = 0$. In period 0, the ZLB binds ($r_0^s = -\frac{R^s-1}{R^s}$) and, in the economy with DNWR, the DNWR constraint also binds ($\widehat{mc}_0 = \log\gamma - \pi_0$). In period 1, the shock disappears, the ZLB no longer binds, and the DNWR constraint is assumed not to bind ($-\frac{R^s-1}{R^s} < r_1^s \leq 0$, $\widehat{mc}_1 = (\sigma+\varphi)\,y_1$).

Under these assumptions, the period-0 IS equation, the AD curve, gives

$$AD_0^{ZLB}: \quad y_0 = \frac{1}{\sigma}\left(\frac{R^s-1}{R^s} - z_0\right) - \frac{\phi\,(1-\omega)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\,(\sigma+\varphi)\right)}{\sigma\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\,(\sigma+\varphi)\,\phi\right)}\pi_0. \tag{22}$$

We first consider the case in which DNWR binds in period 0. The period-0 NKPC, the AS curve, gives

$$AS_0^{w/\,DNWR}: \quad \pi_0 = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\,(\sigma+\varphi)\,\phi\right)}{\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\,(\sigma+\varphi)\,\phi\right) + \beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\,(\sigma+\varphi)\,\phi\,(1-\omega)}\log\gamma. \tag{23}$$

The NKPC is horizontal under DNWR because current marginal cost is pinned down by the wage floor rather than by current output. Therefore, the period-0 equilibrium with binding DNWR is

$$y_0^* = \frac{1}{\sigma}\left(\frac{R^s-1}{R^s} - z_0\right) - \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\phi\left(1-\omega\right)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)}{\sigma\left(\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)\right)}\log\gamma, \tag{24}$$

and

$$\pi_0^* = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)}{\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)}\log\gamma. \tag{25}$$

For comparison, we consider a counterfactual economy without DNWR, subject to the same contractionary demand shock. Wages can adjust freely downward, and the period-0 NKPC is therefore

$$AS_0^{w/o\,DNWR}: \quad \pi_0 = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)}{1+\beta\frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\phi(1-\omega)}{\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\phi}}y_0. \tag{26}$$

Without DNWR, the AS curve is upward-sloping because current marginal cost responds to current output through the standard marginal-cost channel. Combining this AS curve (26) with the AD curve (22) gives the period-0 equilibrium in the economy without DNWR

$$y_0^{\#} = \frac{\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)\right)}{\sigma^2+\sigma\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1+\left(1+\beta\right)\left(1-\omega\right)\right)+\left(\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)^2\phi\left(1-\omega\right)}\left(\frac{R^s-1}{R^s}-z_0\right), \tag{27}$$

and

$$\pi_0^{\#} = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)}{\sigma^2+\sigma\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1+\left(1+\beta\right)\left(1-\omega\right)\right)+\left(\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)^2\phi\left(1-\omega\right)}\left(\frac{R^s-1}{R^s}-z_0\right). \tag{28}$$

The equilibrium with binding DNWR characterised above applies when the contractionary demand shock is sufficiently large for both the ZLB and the DNWR constraint to bind. In particular, the shock must satisfy

$$z_0 > \underbrace{\frac{R^s - 1}{R^s}}_{\text{ZLB}} \underbrace{- \frac{\left(\sigma^2 + \sigma \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi) \phi (1 + (1+\beta)(1-\omega)) + \left(\frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi)\right)^2 \phi (1-\omega)\right)}{(\sigma + \varphi) \left(\left(1 + \frac{(1-\theta)(1-\theta\beta)}{\theta}\right) \left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi) \phi\right) + \beta \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi) \phi (1-\omega)\right)} \log \gamma}_{\text{DNWR}}. \tag{29}$$

The first term is the shock size required for the ZLB to bind: the contractionary demand shock must be large enough to push the desired nominal interest rate below its lower bound. The second term captures the additional requirement for DNWR to bind. Specifically, it ensures that the counterfactual equilibrium without the wage floor would imply nominal wage growth below γ, so that the DNWR constraint becomes effective.

3.2 The Role of History Dependence

We now compare the implications of DNWR under current inflation targeting and average inflation targeting, maintaining the binding condition in (29). The key difference between the two regimes is whether current inflation affects expectations about future policy. When $\omega = 1$, the policy rule collapses to current inflation targeting. When $0 < \omega < 1$, the policy rule is average inflation targeting and history-dependent. The limiting case $\omega \to 0$ corresponds to price-level targeting.

Under the binding condition (29), the wage path implied by the counterfactual equilibrium without DNWR would fall below the wage floor. When DNWR binds, real marginal cost cannot fall as much as in that counterfactual equilibrium, and inflation is consequently less negative:

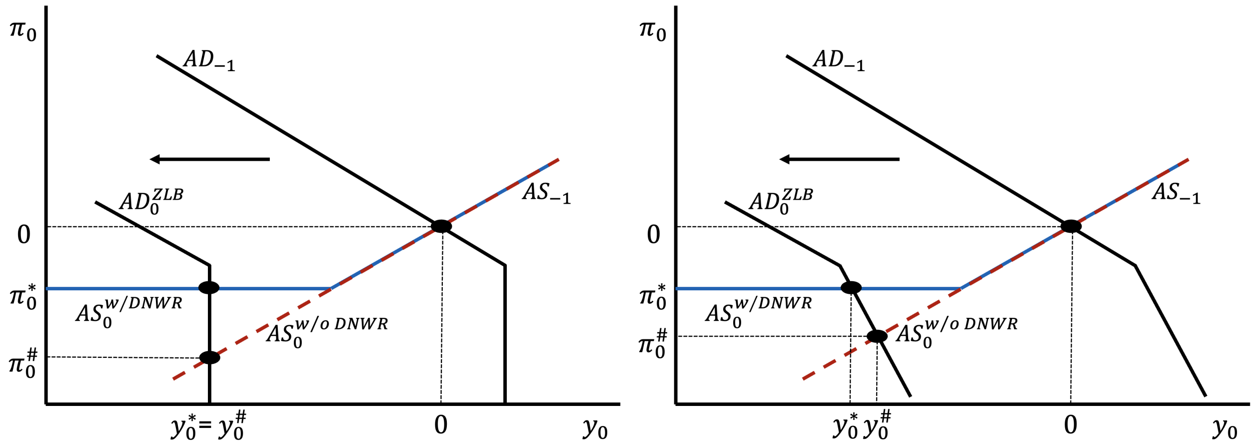
$$\pi_0^* > \pi_0^\#. \tag{30}$$

Using the period-0 IS equation (22), we then obtain

$$y_0^\# - y_0^* = \frac{\phi (1-\omega) \left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi)\right)}{\sigma \left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi) \phi\right)} \left(\pi_0^* - \pi_0^\#\right). \tag{31}$$

The coefficient multiplying $\pi_0^* - \pi_0^\#$ is non-negative and is proportional to $1 - \omega$. Hence, the effect

Figure 1: AD–AS Representation under Different Monetary Policy Regimes



(a) Current Inflation Targeting (b) Average Inflation Targeting

Notes: The figure illustrates the period-0 equilibrium following a contractionary demand shock at the ZLB. The left panel shows current inflation targeting, while the right panel shows average inflation targeting. For expositional simplicity, the right panel abstracts from the quantitative effects of the degree of history dependence, $1-\omega$, on the positions of the AD and AS schedules, and focuses on the key qualitative implication: history dependence makes the ZLB segment of AD downward-sloping. Price-level targeting is nested as the limiting case of average inflation targeting when $\omega \to 0$.

of DNWR on output depends directly on the degree of history dependence in the policy rule.

Figure 1 provides a graphical representation of the comparison between current inflation targeting and average inflation targeting. The figure illustrates the period-0 equilibrium following a contractionary demand shock at the ZLB. The left panel shows current inflation targeting, while the right panel shows average inflation targeting.

First, under current inflation targeting, $\omega = 1$, the coefficient above is zero, and therefore

$$y_0^* = y_0^{\#}. \tag{32}$$

In this case, DNWR affects inflation but not current output in the two-period benchmark. The reason is that expected inflation is zero once the demand shock disappears. As shown in Figure 1a, the period-0 AD curve is therefore vertical at the ZLB: current output is pinned down by the adverse demand shock and by the ZLB on the nominal interest rate. DNWR makes inflation less negative by preventing real marginal cost from falling too sharply, but this inflation effect does not feed back into current demand through expectations.

On the other hand, average inflation targeting, $0 < \omega < 1$, introduces history dependence. The coefficient in the output comparison becomes strictly positive. Since $\pi_0^* > \pi_0^\#$, it follows that

$$y_0^* < y_0^\#. \tag{33}$$

The mechanism differs from that under current inflation targeting. As seen in Figure 1b, average inflation targeting makes the ZLB segment of AD downward-sloping because current inflation affects expected inflation through the history-dependent policy rule. A lower current inflation rate therefore implies stronger expected inflation, as the central bank is expected to offset the current shortfall. Higher expected inflation lowers the real interest rate even at the ZLB and supports current demand. However, DNWR weakens this mechanism. By limiting the fall in current inflation, DNWR also limits the future inflation that agents expect under the history-dependent policy rule. As a result, the real interest rate falls by less, and current output is lower than in the non-binding counterfactual.

The limiting case $\omega \to 0$ corresponds to price-level targeting. In this case, the policy rule responds to the accumulated inflation shortfall, or equivalently to the price-level gap. Because policy responds to the full accumulated shortfall rather than a partial one, the link between the current price level and expected inflation is strongest under this regime: a decline in the current price level implies stronger expected inflation, as the central bank is expected to raise future inflation until the price level returns to its target path. DNWR still raises current inflation relative to the non-binding counterfactual, but by reducing the price-level shortfall it dampens the rise in expected inflation that would otherwise follow. Hence, under price-level targeting, DNWR reduces the stabilising force generated by history dependence.

These results show that the effect of DNWR at the ZLB depends on the monetary policy regime. Under current inflation targeting, DNWR mainly limits deflationary pressure and leaves current output unchanged in the two-period benchmark. Under average inflation targeting and in the price-level-targeting limit, DNWR also affects expectations. By making current inflation less negative, it dampens the rise in expected inflation that history-dependent policy would otherwise generate to stimulate current demand. Thus, the aggregate consequences of nominal wage rigidity cannot be assessed independently of the monetary framework that governs expectations.

4 Numerical Results

This section presents the quantitative results from the infinite-horizon model. We first discuss the calibration and solution method. We then analyse impulse responses to contractionary demand shocks under current inflation targeting, average inflation targeting, and price-level targeting. The purpose of the exercise is to examine how the interaction between the ZLB and DNWR shapes the transmission of demand shocks in a dynamic environment, and how monetary-policy history dependence changes this interaction.

4.1 Calibration and Solution

The model is calibrated to a quarterly frequency. Table 1 summarises the baseline parameter values. The discount factor is set to $\beta = 0.995$, which implies an annualised steady-state real interest rate of approximately 2 percent. We set $\sigma = 1$ and $\varphi = 1$, corresponding to log utility in consumption and a unit inverse Frisch elasticity of labour supply. The labour disutility parameter χ is chosen to normalise steady-state employment to $N = 1$.

The parameter governing DNWR is set to $\gamma = 0.99$, in line with Schmitt-Grohé and Uribe (2016) and Jo and Oh (2026). This implies that nominal wages can fall by at most one percent per quarter. The elasticity of substitution across differentiated goods is set to $\epsilon = 11$, implying a steady-state gross markup of approximately 10 percent. We set the quarterly probability of not adjusting prices to $\theta = 0.75$, implying an average price duration of four quarters. The Taylor-rule coefficient on inflation is set to $\phi = 1.8$.

Finally, the demand shock follows an AR(1) process with persistence $\rho_Z = 0.7$, implying a half-life of approximately two quarters, and innovation standard deviation $\sigma_Z = 0.03$. Consistent with quantitative ZLB studies that calibrate severe-recession scenarios to generate output contractions of approximately 10% (Bonciani & Oh, 2025; Eggertsson & Garga, 2019; Nakata et al., 2019), a one-standard-deviation contractionary demand-shock innovation generates, under current inflation targeting with $\omega = 1$ in the model with both the ZLB and DNWR, an impact output contraction of

Table 1: Calibrated Parameters

Parameter	Description	Value	Target/Source
β	Discount factor	0.995	Annual 2% interest rate
σ	Inverse intertemporal elasticity of substitution	1	Log utility
φ	Inverse labour supply elasticity	1	Standard
χ	Labour disutility parameter	1	$N = 1$
γ	Nominal wage floor parameter	0.99	Schmitt-Grohé and Uribe (2016)
ϵ	Elasticity of substitution between goods	11	10% price markup
θ	Probability of keeping prices unchanged	0.75	4Q price stickiness
ϕ	Inflation-response coefficient	1.8	Standard
ρ_Z	Persistence of demand shock	0.7	6Q ZLB duration
σ_Z	Volatility of demand shock	0.03	10% impact output decline

approximately 10% and a ZLB episode lasting 6 quarters. Section 4.4 assesses the sensitivity of the results to alternative values of these parameters.

We solve the model using the piecewise linear perturbation method proposed by Guerrieri and Iacoviello (2015) in the Dynare software package (Adjemian et al., 2026). This method is well suited for the present environment because the equilibrium conditions include occasionally binding constraints.

4.2 Impulse Response Functions

We now examine the dynamic effects of a contractionary demand shock. In each experiment, the economy is hit by a contractionary demand shock large enough to push the nominal interest rate to the ZLB and, in the economy with DNWR, to make the wage floor bind as well. We compare an economy without DNWR (labelled "ZLB Only") with an economy in which both the ZLB and DNWR constraints are present (labelled "ZLB+DNWR"). This comparison allows us to isolate how DNWR changes the propagation of demand shocks at the ZLB, and how this effect depends on the monetary policy regime.

4.2.1 Current Inflation Targeting

We first consider current inflation targeting, $\omega = 1$. Figure 2 reports the impulse responses. The solid line shows the economy with the ZLB only, while the dashed line shows the economy in which both the ZLB and DNWR are present.

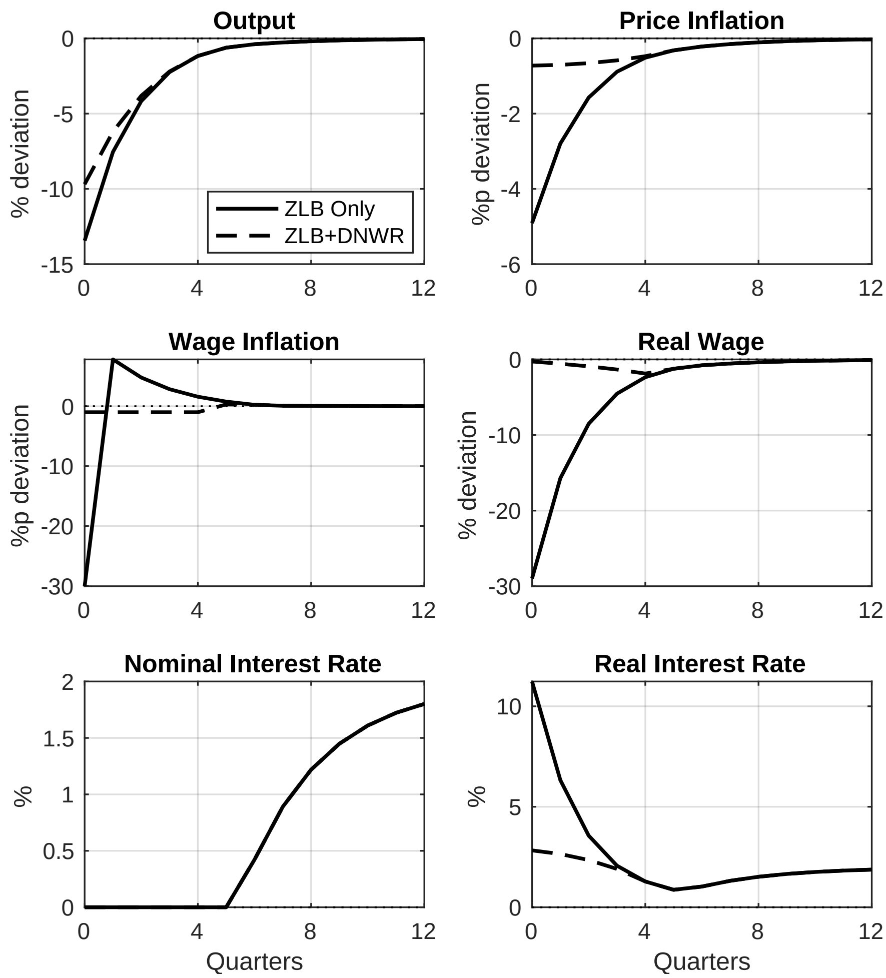
Following the contractionary demand shock, output falls sharply and the nominal interest rate is constrained by the ZLB. In the economy without DNWR, the shock generates a large decline in price inflation and wage inflation. The fall in expected inflation raises the real interest rate, which further depresses aggregate demand. As a result, the output contraction is large and persistent.

The presence of DNWR changes the propagation of the shock. Because nominal wages cannot fall freely, real marginal cost declines by less. This limits the fall in price inflation and prevents the sharp decline in wage inflation observed in the economy without DNWR. By making inflation less negative, DNWR lowers the real interest rate at the ZLB and supports aggregate demand. Consequently, the decline in output is smaller when DNWR is present.

The output effect under current inflation targeting differs from the analytical result in the two-period model. In the analytical benchmark, the demand shock disappears and DNWR ceases to bind in period 1, so DNWR does not affect expected inflation. In the infinite-horizon model, by contrast, the persistent demand shock keeps both constraints active for several periods. DNWR therefore makes expected inflation less negative, lowers the real interest rate, and mitigates the output contraction.

Overall, the impulse responses show that, under current inflation targeting, DNWR mitigates ZLB recessions by limiting deflationary pressure, consistent with the mechanism emphasised by Amano and Gnocchi (2023). This finding is also closely related to the paradox of flexibility studied by Eggertsson and Krugman (2012): when the nominal interest rate is constrained, greater nominal flexibility can be destabilising because it strengthens deflationary pressure, raises the real interest rate, and depresses aggregate demand. In this sense, removing DNWR does not necessarily reduce the output contraction under current inflation targeting; instead, it can make inflation more negative and deepen the contraction.

Figure 2: Impulse Responses to a Contractionary Demand Shock under Current Inflation Targeting



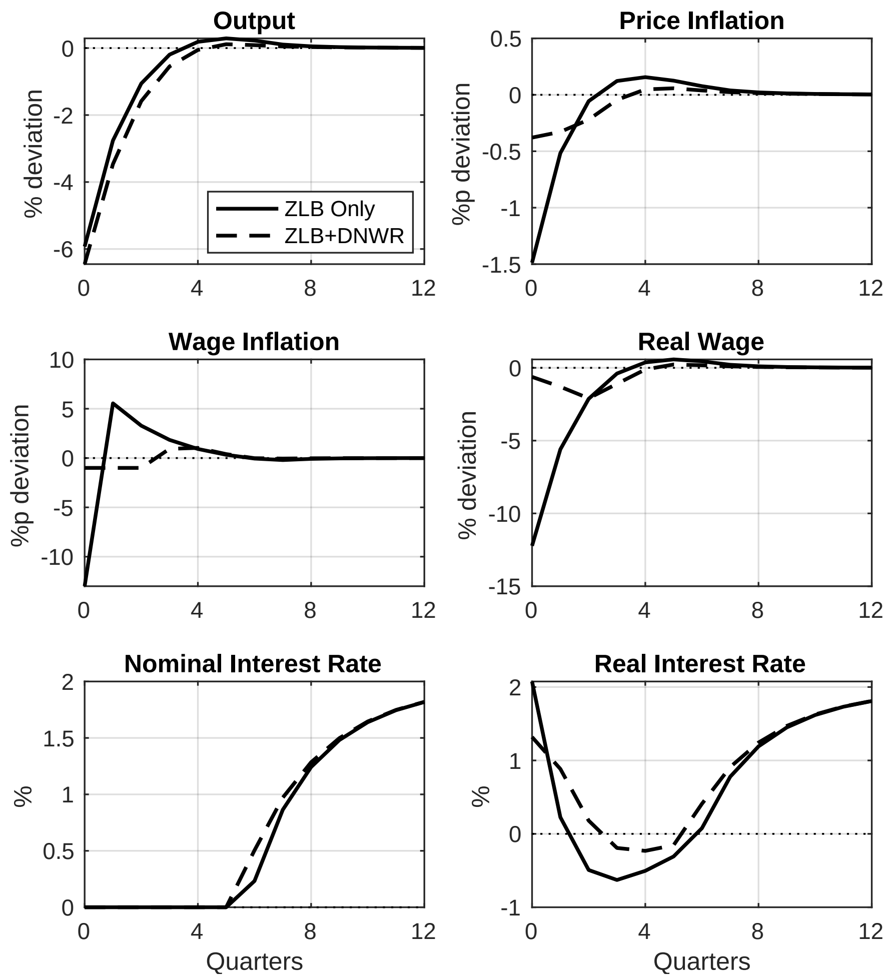
Notes: The figure reports impulse responses to a contractionary demand shock under current inflation targeting with $\omega = 1$. The solid line denotes the economy with the ZLB only, while the dashed line denotes the economy in which both the ZLB and DNWR are present. Output and the real wage are expressed as percentage deviations from their deterministic steady-state values. Price and wage inflation are reported as percentage-point deviations from steady state, while nominal and real interest rates are expressed as annualised percentage rates.

4.2.2 Average Inflation Targeting

We next consider average inflation targeting with $\omega = 0.2$, following Budianto et al. (2023). Figure 3 reports the impulse responses. The solid line shows the economy with the ZLB only, while the dashed line shows the economy in which both the ZLB and DNWR are present.

Average inflation targeting introduces history dependence into the policy rule. A decline in current inflation lowers the average-inflation state, which generates expectations of higher future inflation

Figure 3: Impulse Responses to a Contractionary Demand Shock under Average Inflation Targeting



Notes: The figure reports impulse responses to a contractionary demand shock under average inflation targeting with $\omega = 0.2$. The solid line denotes the economy with the ZLB only, while the dashed line denotes the economy in which both the ZLB and DNWR are present. Output and the real wage are expressed as percentage deviations from their deterministic steady-state values. Price and wage inflation are reported as percentage-point deviations from steady state, while nominal and real interest rates are expressed as annualised percentage rates.

because the central bank is expected to offset the current inflation shortfall. These expectations reduce the real interest rate at the ZLB and support current demand.

This history dependence changes the role of DNWR. In the economy without DNWR, nominal wages and real marginal cost fall sharply after the shock, leading to a large decline in current inflation. Under average inflation targeting, this larger inflation shortfall strengthens expectations of future inflation and provides stimulus through a lower real interest rate. When DNWR is present, the fall in nominal wages and real marginal cost is muted. Inflation therefore falls by less on impact, but the associated inflation shortfall is also smaller. As a result, expected inflation rises by less, the real interest rate falls by less, and current demand receives less support.

Thus, under average inflation targeting, DNWR has a different implication from current inflation targeting. Although DNWR still makes inflation less negative, it weakens the history-dependent rise in expected inflation that would otherwise stabilise output at the ZLB. This is the wage-side counterpart of the reversal documented by Bonciani and Oh (2023a), who show that under history-dependent policy, greater price flexibility becomes stabilising rather than destabilising; here, DNWR runs the same logic in reverse, weakening the expectations that would otherwise support demand and leading output to decline more than in the economy with more flexible nominal wages.

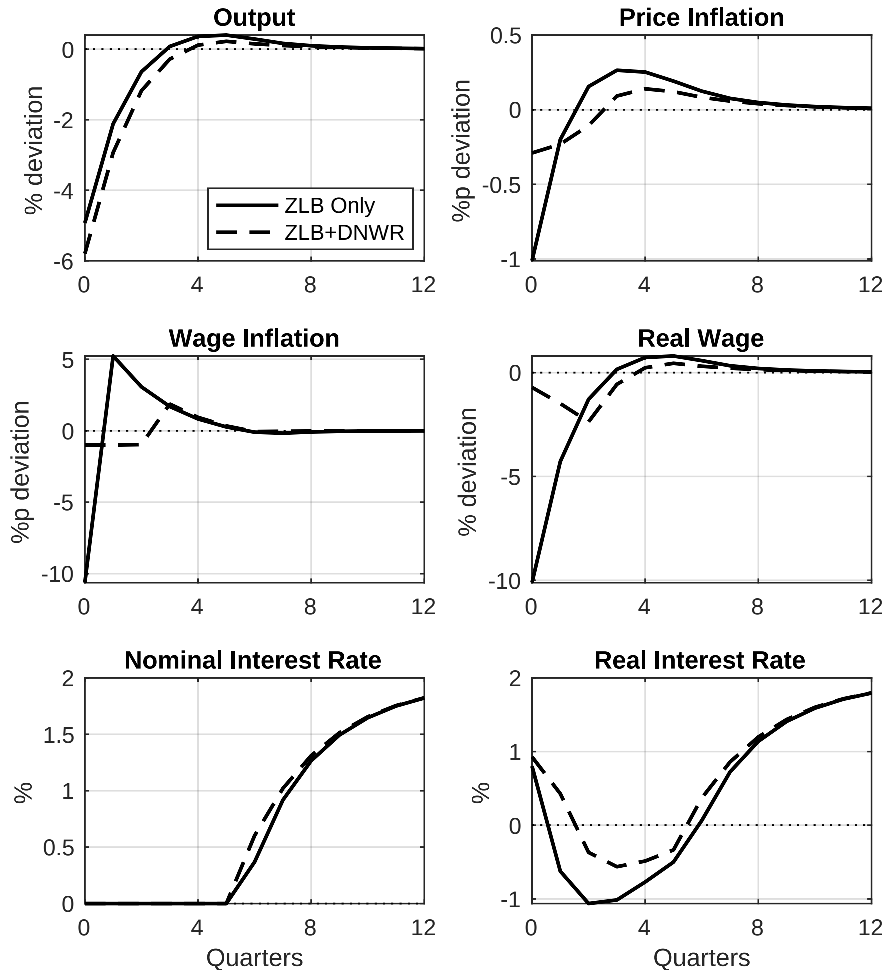
4.2.3 Price-Level Targeting

We finally consider the limiting case $\omega \to 0$, which corresponds to price-level targeting. Figure 4 reports the impulse responses. The solid line shows the economy with the ZLB only, while the dashed line shows the economy in which both the ZLB and DNWR are present.

Price-level targeting generates a stronger form of history dependence than average inflation targeting. Following the contractionary demand shock, the price level falls below its target path. Under price-level targeting, this creates expectations of future inflation because the central bank is committed to bringing the price level back to target. These expectations lower the real interest rate at the ZLB and support current demand.

In the economy without DNWR, nominal wages and real marginal cost fall sharply on impact, generating a large initial decline in inflation and the price level. However, this larger decline strengthens the rise in expected inflation. The real interest rate falls more, and output recovers more strongly. When DNWR is present, the fall in nominal wages and real marginal cost is muted. As a result, inflation falls by less on impact. This limits the decline in the current price level, but it also dampens the rise in expected inflation that would otherwise follow. The real interest rate therefore falls by less than in the economy without DNWR, and the output contraction is larger. Thus, under price-level targeting, DNWR makes inflation less negative but reduces the expansionary force generated by the

Figure 4: Impulse Responses to a Contractionary Demand Shock under Price-Level Targeting



Notes: The figure reports impulse responses to a contractionary demand shock in the limiting case $\omega \to 0$, which corresponds to price-level targeting. The solid line denotes the economy with the ZLB only, while the dashed line denotes the economy in which both the ZLB and DNWR are present. Output and the real wage are expressed as percentage deviations from their deterministic steady-state values. Price and wage inflation are reported as percentage-point deviations from steady state, while nominal and real interest rates are expressed as annualised percentage rates.

price-level commitment.

Overall, the infinite-horizon results are consistent with the two-period mechanism. DNWR limits the fall in inflation in all regimes, but its output effect depends on the monetary framework. It mitigates the contraction under current inflation targeting, while under average inflation targeting and price-level targeting it dampens the rise in expected inflation that history-dependent policy would otherwise generate, leading to a larger output decline.

4.3 Varying the Degree of History Dependence

The three regimes considered above correspond to three values of ω: current inflation targeting ($\omega = 1$), average inflation targeting ($\omega = 0.2$), and the price-level-targeting limit ($\omega \to 0$). Since ω is continuous, we now compute the effect of DNWR across its full range. This allows us to locate the threshold degree of history dependence at which the effect of DNWR on output changes sign, and confirm that the reversal holds continuously across ω.

For each value of ω we solve the model twice, once with the ZLB alone and once with both the ZLB and DNWR, and record the difference in the output response,

$$\mathcal{D}(\omega) = 100 \times \left(\log\left(\frac{Y_0^{ZLB+DNWR}}{Y} \right) - \log\left(\frac{Y_0^{ZLB}}{Y} \right) \right), \tag{34}$$

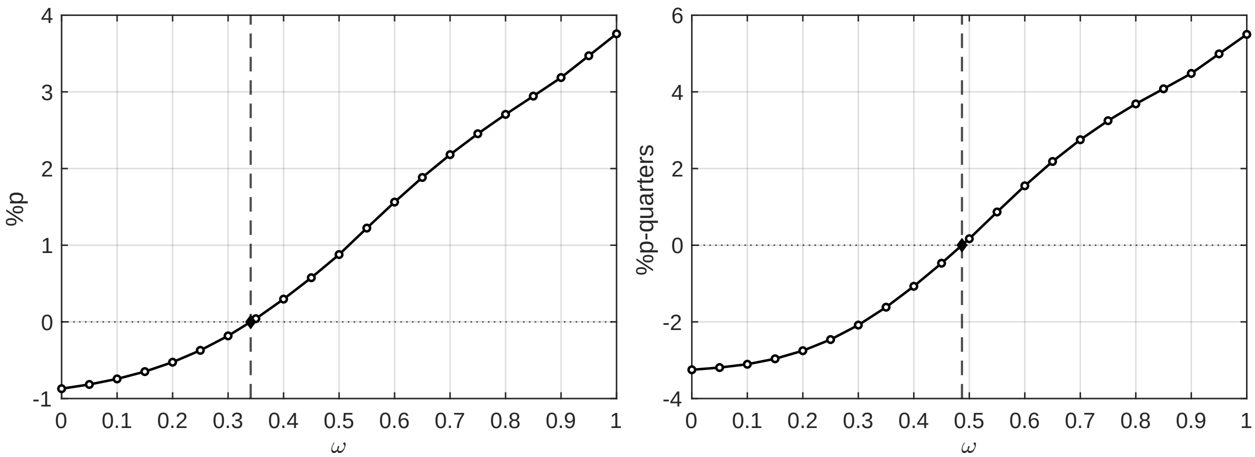
$$\mathcal{D}^{cum}(\omega) = 100 \times \sum_{t=0}^{\infty} \left(\log\left(\frac{Y_t^{ZLB+DNWR}}{Y} \right) - \log\left(\frac{Y_t^{ZLB}}{Y} \right) \right), \tag{35}$$

where Y denotes steady-state output. A positive value indicates that DNWR mitigates the output contraction; a negative value indicates that it amplifies the contraction. Panel (a) of Figure 5 reports this statistic on impact, and Panel (b) reports the cumulative counterpart, summed over an infinite horizon.

The effect of DNWR declines monotonically as history dependence strengthens. Under current inflation targeting, output falls by 13.4 percent on impact when only the ZLB binds and by 9.7 percent when DNWR binds as well, a difference of 3.7 percentage points. The effect falls as ω declines, changes sign at $\omega_I^\star \approx 0.34$, and reaches -0.9 percentage points in the price-level-targeting limit. The cumulative measure behaves in the same way, reaching 5.5 percentage-point quarters under current inflation targeting, changing sign at $\omega_C^\star \approx 0.49$, and falling to -3.2 as $\omega \to 0$. Between the two thresholds the statistics differ in sign: for values of ω between 0.34 and 0.49, DNWR raises output on impact while lowering it cumulatively.

Two features of this result are worth noting. First, the baseline average-inflation-targeting calibration, $\omega = 0.2$, lies below both thresholds, with an impact effect of -0.5 percentage points and a cumulative effect of -2.8. This is why the impulse responses in Section 4 show DNWR deepening

Figure 5: Effect of DNWR on Output across Degrees of History Dependence



(a) Impact Effect (b) Cumulative Effect

Notes: The figure reports the difference in the output response to a contractionary demand shock between the economy with the ZLB and DNWR and the economy with the ZLB only, expressed in percentage points. The impact effect in Panel (a) reports the difference on impact and is measured in percentage points. The cumulative effect in Panel (b) is the undiscounted infinite-horizon sum of the quarterly output-response differences and is measured in percentage-point quarters. Positive values indicate that DNWR mitigates the output contraction, and negative values indicate that it amplifies the contraction. The vertical dashed lines mark the corresponding values of ω at which the impact and cumulative effects change sign. Current inflation targeting corresponds to $\omega = 1$ and price-level targeting to the limit $\omega \to 0$.

the contraction under that regime. Second, the reversal occurs at an interior value of ω rather than at $\omega = 1$, as the two-period benchmark of Section 3 implies.

The difference between the two results reflects what the two-period structure holds fixed. There the shock disappears after period 0 and the ZLB binds for a single period, so DNWR can affect period-0 demand only through expectations of future policy, the force that scales with $1 - \omega$. In the calibrated model the ZLB binds for six quarters at every value of ω considered, and DNWR also supports demand within the episode by limiting deflation while the constraint is in place. This second force operates at any ω and is stabilising. The two offset one another, and $\omega^{\star}$ marks the degree of history dependence at which the first becomes the stronger of the two. The two-period model therefore isolates the mechanism that generates the reversal, while the quantitative model determines how much history dependence is required for it to dominate.

4.4 Thresholds under Alternative Calibrations

The value of ω at which the output effect of DNWR changes sign is an equilibrium object. As the previous subsection showed, it marks the point at which the reduction in the shortfall that history-dependent policy would otherwise make up, which scales with $1-\omega$, overtakes the support that DNWR provides within the episode by limiting deflation, which operates at any ω. The balance between these two forces depends on the parameters of the model, so the location of the reversal may shift with the calibration. To assess this, we recompute the impact and cumulative output effects of DNWR across the range of ω under alternative values of the wage floor parameter, the degree of price stickiness, the inflation-response coefficient, and the persistence and size of the demand shock, and record the value $\omega^\star$ at which each measure changes sign. Table 2 reports the results.

A sign change exists and is interior under every alternative calibration considered, so the reversal documented above is not specific to the baseline parameterisation. The position of the thresholds, however, varies with the calibration, and the direction of this variation is informative about the relative strength of the two forces: a higher threshold indicates that the expectations force overtakes the within-episode force at a weaker degree of history dependence.

Panel A varies the wage floor parameter. A tighter floor lowers both thresholds, from 0.341 to 0.316 on impact and from 0.488 to 0.467 cumulatively at $\gamma = 0.995$, while a looser floor raises them. With a tighter floor, the DNWR constraint binds earlier and for longer after the shock, so more of the deflation is prevented during the quarters in which the nominal interest rate is at its lower bound. This strengthens the within-episode force relative to the expectations force, and a stronger degree of history dependence is accordingly required before the reversal occurs. The movements are small in either direction, so the location of the reversal is not sensitive to the tightness of the wage floor.

Panel B varies the degree of price stickiness. The impact threshold rises in both directions, to 0.365 at $\theta = 0.65$ and to 0.400 at $\theta = 0.85$, so it is lowest at the baseline; the cumulative threshold is essentially unchanged under greater flexibility (0.485, against 0.488 at the baseline) and clearly higher under greater stickiness (0.556). The mechanism is particularly transparent in the stickier-price case. When prices respond less to marginal cost, the deflation that the wage floor prevents during

Table 2: Robustness of the Reversal Thresholds

Calibration	Impact $\omega_I^\star$	Cumulative $\omega_C^\star$
Baseline	0.341	0.488
Panel A. Nominal wage floor parameter		
$\gamma = 0.985$	0.366	0.498
$\gamma = 0.995$	0.316	0.467
Panel B. Probability of keeping prices unchanged		
$\theta = 0.65$	0.365	0.485
$\theta = 0.85$	0.400	0.556
Panel C. Inflation-response coefficient		
$\phi = 1.5$	0.334	0.478
$\phi = 2.0$	0.345	0.491
Panel D. Demand shock persistence		
$\rho_Z = 0.6$	0.507	0.639
$\rho_Z = 0.8$	0.209	0.333
Panel E. Demand shock volatility		
$\sigma_Z = 0.02$	0.442	0.567
$\sigma_Z = 0.04$	0.290	0.429

Notes: The table reports the value of the degree of history dependence ω at which the difference in the output response to a contractionary demand shock between the economy with the ZLB and DNWR and the economy with the ZLB only changes sign. A lower value of ω represents stronger monetary-policy history dependence. The impact threshold, $\omega_I^\star$, is based on the difference in the quarter-0 output response. The cumulative threshold, $\omega_C^\star$, is based on the undiscounted infinite-horizon sum of the corresponding quarterly output-response differences. For each measure, DNWR mitigates the output contraction for values of ω above the reported threshold and amplifies it for values below the threshold.

the episode is smaller and the within-episode force is weaker, while the stabilisation delivered by history-dependent policy operates through the expected path of the nominal interest rate after the episode and is not weakened in the same way. Reducing the shortfall therefore forgoes relatively more stabilisation, and the reversal occurs at a weaker degree of history dependence. Greater price flexibility does not reverse this pattern, because it strengthens both forces at once: it deepens the deflation that the wage floor prevents and it enlarges the reduction in the shortfall, and by deepening the contraction it also affects the duration of the episode. The net effect on either measure is ambiguous a priori, and the two thresholds accordingly move by little. The sign change remains interior at both values of θ, and the baseline requires the strongest history dependence of the three for the impact effect to change sign.

Panel C varies the inflation-response coefficient. The thresholds are close to invariant, moving from 0.334 to 0.345 on impact and from 0.478 to 0.491 cumulatively as ϕ rises from 1.5 to 2.0. The coefficient does not affect the policy rate while the ZLB binds, and after the exit it scales the response to the remaining average-inflation shortfall in both economies, so its differential effect is limited. The slight increase in the thresholds with ϕ is consistent with a stronger post-exit response raising the accommodation forgone when DNWR reduces the shortfall.

Panels D and E vary the persistence and the size of the demand shock and produce the largest movements in the thresholds. Lower persistence raises the impact threshold to 0.507 and a smaller innovation raises it to 0.442, while higher persistence and a larger innovation lower it to 0.209 and 0.290, respectively, with the cumulative threshold moving in parallel. Both parameters govern the depth and duration of the ZLB episode. When the episode is short, there are few quarters in which limiting deflation lowers the real interest rate, and the economy approaches the two-period benchmark of Section 3, in which the within-episode force is absent and any degree of history dependence overturns the mitigation. As the episode lengthens, DNWR limits deflation over more quarters while the nominal interest rate is constrained, and progressively stronger history dependence is required for the expectations force to dominate.

Two features of the table are worth noting. First, the cumulative threshold exceeds the impact threshold under every calibration. The accommodation forgone under history-dependent policy lowers output mainly in the later part of the episode and during the recovery, so the cumulative measure changes sign at a weaker degree of history dependence than the impact measure. Second, the thresholds respond most to the parameters of the shock process and least to the policy coefficient: the location of the reversal is governed primarily by the duration of the ZLB episode rather than by the parameters of the policy rule or the nominal rigidities.

The quantitative analysis of this section yields three conclusions. DNWR limits the fall in inflation under every regime considered; its effect on output changes sign at an interior degree of history dependence; and the location of this threshold is governed primarily by the duration of the ZLB episode, remaining interior under every calibration examined.

5 Optimal Monetary Policy

We now examine macroeconomic dynamics under optimal monetary policy. The Ramsey planner chooses the path of the nominal interest rate to maximise household welfare subject to the private-sector equilibrium conditions, the ZLB constraint, and, when present, the DNWR constraint. Following Schmitt-Grohé and Uribe (2005), we assume that the Ramsey planner honours commitments inherited from the distant past, formally from $t = -\infty$, when choosing optimal policy. Consequently, the implementability constraints faced by the planner at dates $t \geq 0$ are treated in the same way as those applying before the initial date. This corresponds to optimal policy from the timeless perspective (Woodford, 2003). Details of the Ramsey problem are provided in Appendix D.

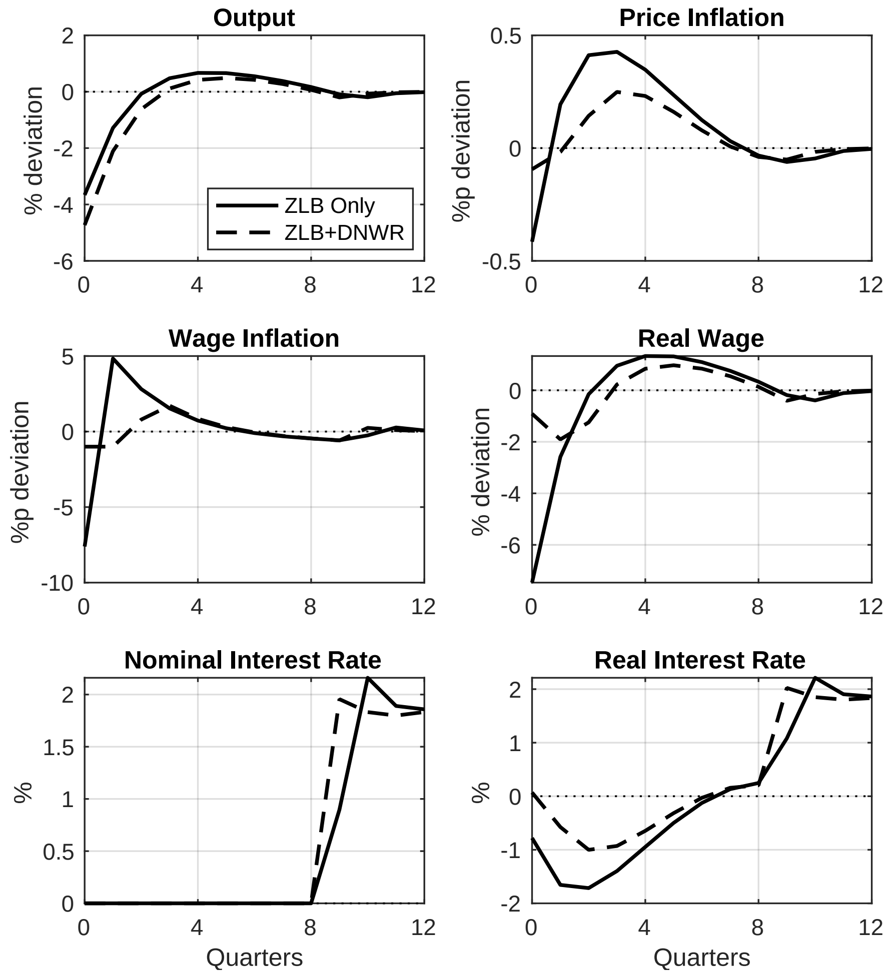
Figure 6 reports the impulse responses to a contractionary demand shock. The solid line shows the economy with the ZLB only, while the dashed line shows the economy in which both the ZLB and DNWR are present.

In the economy without DNWR, the contractionary demand shock pushes the nominal interest rate to the ZLB and generates a sharp decline in output, price inflation, wage inflation, and the real wage. Under optimal monetary policy, the planner keeps the nominal interest rate low for an extended period. This low-for-long policy shapes expectations about the future path of inflation and reduces the real interest rate at the ZLB. As a result, the initial contraction is followed by inflation overshooting and a gradual recovery in output.

The presence of DNWR changes this adjustment. Since nominal wages cannot fall freely, the decline in wage inflation and real marginal cost is muted. This limits the initial fall in price inflation. In the Ramsey allocation, DNWR is also associated with less subsequent monetary accommodation. Expected inflation therefore rises by less, the real interest rate falls by less, and output declines more than in the economy without DNWR.

Although DNWR dampens the deflationary response of inflation and wage inflation, it also dampens the rise in expected inflation through which optimal policy stimulates demand at the ZLB. By limiting the initial inflation shortfall, DNWR reduces the extent of the low-for-long stimulus required under optimal policy: the real interest rate provides less support to current demand, and output declines

Figure 6: Impulse Responses to a Contractionary Demand Shock under Optimal Monetary Policy



Notes: The figure reports impulse responses to a contractionary demand shock under optimal monetary policy. The solid line denotes the economy with the ZLB only, while the dashed line denotes the economy in which both the ZLB and DNWR are present. Output and the real wage are expressed as percentage deviations from their deterministic steady-state values. Price and wage inflation are reported as percentage-point deviations from steady state, while nominal and real interest rates are expressed as annualised percentage rates.

more than in the economy with more flexible nominal wages.

These impulse responses clarify the link between optimal monetary policy and price-level targeting. The central feature of the Ramsey allocation is that the planner keeps the nominal interest rate low for long after the initial downturn. This prolonged accommodation raises expected inflation and lowers the real interest rate at the ZLB. Price-level targeting provides a rule-based counterpart to this qualitative low-for-long behaviour because a price-level shortfall requires future policy to remain accommodative until the price level returns to its target path. In this sense, price-level targeting represents the strongest form of history dependence available within a rule-based framework.

Overall, the Ramsey exercise shows that the regime dependence of DNWR is not an artefact of the particular rules considered. DNWR limits the fall in nominal wages, real marginal cost, and inflation under any policy; what differs across regimes is the value of the deflation it prevents. Under current inflation targeting, past shortfalls carry no policy consequences, and limiting deflation stabilises demand directly. Under optimal policy, commitment to future accommodation generates history dependence. By reducing the initial inflation shortfall, DNWR weakens the associated expectations channel: it makes inflation less negative but causes output to fall by more than in the economy with more flexible nominal wages. The effect of wage rigidity at the ZLB is thus determined jointly by the rigidity and by how policy treats the shortfalls it prevents.

6 Conclusion

This paper studies how DNWR interacts with the ZLB on the nominal interest rate. We develop a New Keynesian model in which both frictions are occasionally binding. The analysis examines the transmission of contractionary demand shocks under current inflation targeting, average inflation targeting, and price-level targeting, and compares these rule-based regimes with optimal monetary policy.

The main result is that the macroeconomic effect of DNWR at the ZLB depends crucially on the monetary policy framework. Under current inflation targeting, DNWR limits deflationary pressure by preventing real marginal cost from falling too sharply. Since the nominal interest rate is constrained by the ZLB, this reduction in deflation lowers the real interest rate and supports aggregate demand. As a result, DNWR mitigates the output contraction following a contractionary demand shock.

This effect changes once monetary policy becomes history-dependent. Under average inflation targeting, a fall in current inflation lowers the average-inflation state and generates expectations of higher future inflation. This rise in expected inflation lowers the real interest rate at the ZLB and supports current demand. When DNWR binds, however, the current fall in inflation is smaller. Although this makes inflation less negative, it also reduces the future inflation that agents expect from the make-up policy. The real interest rate therefore falls by less, and output declines more than in the economy without DNWR.

The mechanism is strongest under price-level targeting, which arises as the limiting case of average inflation targeting. Under price-level targeting, a shortfall in the price level requires future policy to remain accommodative until the price level returns to its target path. This makes the resulting rise in expected inflation particularly powerful at the ZLB. By limiting the initial decline in inflation and the price level, DNWR dampens this rise. Hence, under price-level targeting, DNWR makes inflation less negative but causes output to fall more than in the economy with more flexible nominal wages.

We also compare these rule-based regimes with optimal monetary policy. The Ramsey allocation features a low-for-long path of the nominal interest rate after the initial downturn, which raises expected inflation and lowers the real interest rate at the ZLB. Price-level targeting provides a rule-based counterpart to this behaviour, as it embodies the strongest degree of history dependence among the regimes considered. DNWR, however, reduces the initial inflation shortfall that would otherwise call for stronger future accommodation. Expected inflation therefore rises by less, the real interest rate falls by less, and output declines more than in the economy without DNWR.

This paper therefore highlights a broader lesson for monetary policy at the ZLB. The consequences of wage rigidity for output dynamics cannot be evaluated independently of the monetary policy framework. DNWR affects not only current marginal cost and inflation, but also the inflation or price-level shortfalls that agents expect policy to make up in the future. Under current inflation targeting, this mainly dampens deflationary pressure and reduces the output contraction relative to an economy with more flexible nominal wages. Under history-dependent regimes, the same force can weaken the future accommodation that supports demand at the ZLB, leading to a larger output decline. Understanding this interaction is essential for assessing how demand shocks propagate in economies where both the ZLB and DNWR are relevant.

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Appendices

A Equilibrium Conditions

This section summarises the equilibrium conditions of the model. The private sector is characterised by household optimality conditions, firms' pricing decisions, production, wage inflation dynamics, and the aggregate resource constraint. DNWR imposes a lower bound on nominal wage inflation, while the monetary authority follows an average-inflation-targeting rule subject to the ZLB. The exogenous demand disturbance follows an autoregressive process.

$$\lambda_t = {C_t}^{-\sigma}, \tag{A.1}$$

$$\chi {N_t^s}^{\varphi} = \lambda_t w_t, \tag{A.2}$$

$$\lambda_t = \beta \mathbb{E}_t \lambda_{t+1} \frac{R_t^s Z_t}{\Pi_{t+1}}, \tag{A.3}$$

$$mc_t = w_t, \tag{A.4}$$

$$p_t^\star = \frac{\epsilon}{(\epsilon - 1)(1+\tau)} \frac{x_{1,t}}{x_{2,t}} \tag{A.5}$$

$$x_{1,t} = \lambda_t Y_t mc_t + \theta \beta \mathbb{E}_t {\Pi_{t+1}}^{\epsilon} x_{t+1}^1 \tag{A.6}$$

$$x_{2,t} = \lambda_t Y_t + \theta \beta \mathbb{E}_t {\Pi_{t+1}}^{\epsilon - 1} x_{t+1}^2 \tag{A.7}$$

$$1 = (1-\theta) {p_t^\star}^{1-\epsilon} + \theta {\Pi_t}^{\epsilon-1} \tag{A.8}$$

$$\Delta_t Y_t = N_t, \tag{A.9}$$

$$\Delta_t = (1-\theta) {p_t^\star}^{-\epsilon} + \theta {\Pi_t}^{\epsilon} \Delta_{t-1} \tag{A.10}$$

$$\Pi_{w,t} = \frac{w_t}{w_{t-1}} \Pi_t, \tag{A.11}$$

$$\Pi_{w,t} \geq \gamma, \quad N_t^s \geq N_t, \quad \left(N_t^s - N_t\right)\left(\Pi_{w,t} - \gamma\right) = 0, \tag{A.12}$$

$$R_t^s = \max\left\{1, R^s {\Pi_t^{avg}}^{\frac{\phi}{\omega}}\right\}, \tag{A.13}$$

$$\Pi_t^{avg} = \Pi_t{}^{\omega} \Pi_{t-1}^{avg\,1-\omega}, \tag{A.14}$$

$$Y_t = C_t, \tag{A.15}$$

$$\log Z_t = \rho_Z \log Z_{t-1} + \sigma_Z \varepsilon_{Z,t}. \tag{A.16}$$

B The Price-Level-Targeting Policy Rule

This section derives Equation (14), showing that the general policy rule converges to price-level targeting as $\omega \to 0$.

Recall the law of motion for average inflation,

$$\Pi_t^{avg} = \Pi_t^{\omega} {\Pi_{t-1}^{avg}}^{1-\omega}, \tag{B.1}$$

and the policy rule,

$$R_t^s = \max\left\{1,\ R^s {\Pi_t^{avg}}^{\frac{\phi}{\omega}}\right\}. \tag{B.2}$$

Define the auxiliary variable

$$Q_t \equiv {\Pi_t^{avg}}^{\frac{1}{\omega}}, \tag{B.3}$$

so that $\Pi_{t-1}^{avg} = Q_{t-1}^{\omega}$. Substituting into Equation (B.1) and raising both sides to the power $1/\omega$ gives

$$Q_t = \left(\Pi_t^{\omega} {Q_{t-1}}^{\omega(1-\omega)}\right)^{\frac{1}{\omega}} = \Pi_t\, {Q_{t-1}}^{1-\omega}, \tag{B.4}$$

which holds exactly for any $\omega \in (0, 1]$; no approximation has yet been made.

The policy rule (B.2) also rewrites exactly in terms of Q_t. Since

$$ {\Pi_t^{avg}}^{\frac{\phi}{\omega}} = Q_t^{\phi}, \tag{B.5}$$

the rule becomes

$$R_t^s = \max\left\{1,\ R^s {Q_t}^{\phi}\right\}, \tag{B.6}$$

for every ω.

We now take the limit $\omega \to 0$. As $\omega \to 0$, ${Q_{t-1}}^{1-\omega} \to Q_{t-1}$, so the law of motion for Q_t converges to

$$Q_t = \Pi_t Q_{t-1}, \tag{B.7}$$

the same first-order recursion that defines the price level itself, $P_t = \Pi_t P_{t-1}$. In the deterministic steady state that prevails before the shock, $\Pi_{-1}^{avg} = 1$, so $Q_{-1} = 1^{\frac{1}{\omega}} = 1$, which coincides with the normalisation $P_{-1} = 1$. Since Q_t and P_t satisfy the identical recursion from the identical initial condition, $Q_t = P_t$ for every subsequent period as $\omega \to 0$.

Substituting $Q_t = P_t$ into Equation (B.6) gives

$$R_t^s = \max\left\{1,\, R^s P_t^{\phi}\right\}, \tag{B.8}$$

which is price-level targeting. Unlike the current-inflation-targeting case $\omega = 1$, in which the rule responds only to Π_t, the rule in this limit responds to the level of prices relative to the pre-shock price level, so that no inflation shortfall is ever bygone.

C AD–AS Curve Derivations

To solve the model analytically, we follow the two-period structure used in Eggertsson and Garga (2019) and Bonciani and Oh (2023a, 2023b, 2025). The economy is hit by a sufficiently large contractionary demand shock in period 0 ($z_0 > 0$), while the shock disappears in period 1 ($z_1 = 0$). We assume perfect foresight, so that $\mathbb{E}_t x_{t+1} = x_{t+1}$ for all variables. The economy is initially at the deterministic steady state, so that $\widehat{w}_{-1} = 0$. In period 0, the ZLB binds ($r_0^s = -\frac{R^s-1}{R^s}$) and, in the economy with DNWR, the DNWR constraint also binds ($\widehat{mc}_0 = \log\gamma - \pi_0$). In period 1, the shock disappears, the ZLB no longer binds, and the DNWR constraint is assumed not to bind ($-\frac{R^s-1}{R^s} < r_1^s \leq 0$, $\widehat{mc}_1 = (\sigma+\varphi)\,y_1$).

Under these assumptions, we first consider the case in which DNWR binds in period 0 ($\widehat{mc}_0 = \log\gamma - \pi_0$). Period 0 is characterised by

$$y_0 = y_1 - \frac{1}{\sigma}\left(-\frac{R^s-1}{R^s} - \pi_1 + z_0\right), \tag{C.1}$$

and

$$\pi_0 = \beta\pi_1 + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\log\gamma - \pi_0). \tag{C.2}$$

The first equation is the IS equation evaluated at the ZLB. Since the nominal interest rate cannot fall below its lower bound, the real interest rate can fall only if expected inflation rises. The second equation is the NKPC under binding DNWR. Because real marginal cost is pinned down by the wage floor, period-0 inflation is determined independently of current output.

In period 1, the demand shock disappears, and neither the ZLB nor DNWR is binding. The monetary authority therefore follows the unconstrained average-inflation rule:

$$y_1 = -\frac{1}{\sigma}\frac{\phi}{\omega}\pi_1^{avg}, \tag{C.3}$$

From the law of motion for average inflation, we have

$$\frac{\pi_1^{avg}}{\omega} = \pi_1 + (1-\omega)\frac{\pi_0^{avg}}{\omega} \tag{C.4}$$

Since the initial average-inflation, π_{-1}^{avg}, is assumed to be zero, period-0 average inflation satisfies

$$\frac{\pi_0^{avg}}{\omega} = \pi_0. \tag{C.5}$$

Hence,

$$\frac{\pi_1^{avg}}{\omega} = \pi_1 + (1-\omega)\,\pi_0. \tag{C.6}$$

Substituting this expression into the period-1 IS equation gives

$$y_1 = -\frac{1}{\sigma}\phi\left(\pi_1 + (1-\omega)\,\pi_0\right), \tag{C.7}$$

and the period-1 NKPC is

$$\pi_1 = \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,y_1. \tag{C.8}$$

Combining these two equations implies

$$y_1 = -\frac{\phi(1-\omega)}{\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi}\pi_0, \tag{C.9}$$

and

$$\pi_1 = -\frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi(1-\omega)}{\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi}\pi_0. \tag{C.10}$$

Substituting the period-1 solution into the period-0 IS equation and NKPC gives

$$y_0 = \frac{1}{\sigma}\left(\frac{R^s-1}{R^s} - z_0\right) - \frac{\phi(1-\omega)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\right)}{\sigma\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi\right)}\pi_0, \tag{C.11}$$

and

$$\pi_0 = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi\right)}{\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi\right) + \beta\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\,\phi(1-\omega)}\log\gamma. \tag{C.12}$$

The NKPC is horizontal under DNWR because current marginal cost is pinned down by the wage floor rather than by current output. Therefore, the period-0 equilibrium with binding DNWR is

$$y_0^* = \frac{1}{\sigma}\left(\frac{R^s-1}{R^s} - z_0\right) - \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\phi\left(1-\omega\right)\left(\sigma + \frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)}{\sigma\left(\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)\right)}\log\gamma, \tag{C.13}$$

and

$$\pi_0^* = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)}{\left(1+\frac{(1-\theta)(1-\theta\beta)}{\theta}\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)}\log\gamma. \tag{C.14}$$

For comparison, consider the case in which DNWR does not bind. The period-0 NKPC is then

$$\pi_0 = \beta\pi_1 + \frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)y_0. \tag{C.15}$$

In this case, inflation is determined by the standard marginal-cost channel rather than by the wage floor. Substituting the expression for π_1

$$\pi_0 = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)}{1+\beta\frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\phi(1-\omega)}{\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}(\sigma+\varphi)\phi}}y_0. \tag{C.16}$$

Combining this NKPC with the period-0 IS equation gives the equilibrium

$$y_0^\# = \frac{\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi+\beta\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1-\omega\right)\right)}{\sigma^2+\sigma\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1+\left(1+\beta\right)\left(1-\omega\right)\right)+\left(\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)^2\phi\left(1-\omega\right)}\left(\frac{R^s-1}{R^s}-z_0\right), \tag{C.17}$$

and

$$\pi_0^\# = \frac{\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\left(\sigma+\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\right)}{\sigma^2+\sigma\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\phi\left(1+\left(1+\beta\right)\left(1-\omega\right)\right)+\left(\frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\sigma+\varphi\right)\right)^2\phi\left(1-\omega\right)}\left(\frac{R^s-1}{R^s}-z_0\right). \tag{C.18}$$

D Optimal Monetary Policy

This section characterises optimal monetary policy in the presence of the ZLB and DNWR. We formulate a Ramsey problem in which the monetary authority chooses allocations and policy instruments to maximise household welfare, subject to the implementability constraints that summarise the private-sector equilibrium conditions. The key complication is that both the ZLB and DNWR are occasionally binding. Hence, the Ramsey allocation must satisfy not only the standard first-order conditions, but also the regime-specific feasibility, multiplier, and complementarity conditions associated with these constraints.

D.1 Ramsey Planner

The Ramsey planner chooses equilibrium allocations and policy instruments to maximise household welfare, taking as constraints household optimality, firms' pricing conditions, market clearing, and the occasionally binding constraints implied by the ZLB and DNWR. In this formulation, the planner internalises the distortions generated by nominal rigidities and chooses the path of the nominal interest rate subject to implementability.

The planner maximises expected lifetime utility,

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{{C_t}^{1-\sigma} - 1}{1-\sigma} - \chi \frac{{N_t}^{1+\varphi}}{1+\varphi} \right), \tag{D.1}$$

subject to

$$\left[\mu_{1,t}\right]: \quad \lambda_t = {C_t}^{-\sigma}, \tag{D.2}$$

$$\left[\mu_{2,t}\right]: \quad \chi N_t^{s\,\varphi} = \lambda_t w_t, \tag{D.3}$$

$$\left[\mu_{3,t}\right]: \quad \lambda_t = \beta \mathbb{E}_t \lambda_{t+1} \frac{R_t^s Z_t}{\Pi_{t+1}}, \tag{D.4}$$

$$\left[\mu_{4,t}\right]: \quad mc_t = w_t, \tag{D.5}$$

$$\left[\mu_{5,t}\right]: \quad p_t^\star = \frac{\epsilon}{(\epsilon-1)(1+\tau)} \frac{x_{1,t}}{x_{2,t}} \tag{D.6}$$

$$[\mu_{6,t}] : \quad x_{1,t} = \lambda_t Y_t mc_t + \theta\beta\mathbb{E}_t {\Pi_{t+1}}^{\epsilon} x_{1,t+1} \tag{D.7}$$

$$[\mu_{7,t}] : \quad x_{2,t} = \lambda_t Y_t + \theta\beta\mathbb{E}_t {\Pi_{t+1}}^{\epsilon-1} x_{2,t+1} \tag{D.8}$$

$$[\mu_{8,t}] : \quad 1 = (1-\theta)\, {p_t^{\star}}^{1-\epsilon} + \theta {\Pi_t}^{\epsilon-1} \tag{D.9}$$

$$[\mu_{9,t}] : \quad \Delta_t Y_t = N_t, \tag{D.10}$$

$$[\mu_{10,t}] : \Delta_t = (1-\theta)\, {p_t^{\star}}^{-\epsilon} + \theta {\Pi_t}^{\epsilon} \Delta_{t-1} \tag{D.11}$$

$$[\mu_{11,t}] : \quad \Pi_{w,t} = \frac{w_t}{w_{t-1}} \Pi_t, \tag{D.12}$$

$$[\mu_{12,t}] : \quad \Pi_{w,t} \geq \gamma, \tag{D.13}$$

$$[\mu_{13,t}] : \quad N_t^s \geq N_t, \tag{D.14}$$

$$[\mu_{14,t}] : \quad R_t^s \geq 1, \tag{D.15}$$

$$[\mu_{15,t}] : \quad Y_t = C_t. \tag{D.16}$$

We implement the DNWR complementarity condition regime by regime. The multiplier $\mu_{12,t}$ is associated with the wage-floor equality $\Pi_{w,t} = \gamma$ in the binding-DNWR regime and is set to zero otherwise. The multiplier $\mu_{13,t}$ is associated with the labour-market-clearing equality $N_t^s = N_t$ in the non-binding-DNWR regime and is set to zero when DNWR binds. Similarly, $\mu_{14,t}$ is associated with the equality $R_t^s = 1$ when the ZLB binds and is set to zero when the ZLB is slack.

The variables C_t, N_t, N_t^s, λ_t, w_t, mc_t, $p_t^{\star}$, $x_{1,t}$, $x_{2,t}$, Δ_t, R_t^s, $\Pi_{w,t}$, Y_t, and Π_t are jointly determined by the implementability constraints and the prevailing DNWR and ZLB regimes. The multiplier $\mu_{j,t}$ denotes the current-value Ramsey multiplier associated with constraint j.

D.2 First-Order Conditions

Conditional on a given sequence of DNWR and ZLB regimes, the Ramsey first-order conditions are obtained by differentiating the current-value Lagrangian with respect to the endogenous variables chosen by the planner.

They are

$$[C_t]: \quad {C_t}^{-\sigma} - \sigma\mu_{1,t}{C_t}^{-\sigma-1} + \mu_{15,t} = 0, \tag{D.17}$$

$$[N_t]: \quad -\chi {N_t}^{\varphi} + \mu_{9,t} - \mu_{13,t} = 0, \tag{D.18}$$

$$\left[N_t^s\right]: \quad -\chi\varphi\mu_{2,t}N_t^{s\,\varphi-1} + \mu_{13,t} = 0, \tag{D.19}$$

$$[\lambda_t]: \quad -\mu_{1,t} + \mu_{2,t}w_t - \mu_{3,t} + \mu_{3,t-1}\frac{R_{t-1}^s Z_{t-1}}{\Pi_t} + \mu_{6,t}Y_t mc_t + \mu_{7,t}Y_t = 0, \tag{D.20}$$

$$[w_t]: \quad \mu_{2,t}\lambda_t + \mu_{4,t} + \mu_{11,t}\frac{\Pi_t}{w_{t-1}} - \beta\mathbb{E}_t\mu_{11,t+1}\frac{w_{t+1}\Pi_{t+1}}{w_t^2} = 0, \tag{D.21}$$

$$[mc_t]: \quad -\mu_{4,t} + \mu_{6,t}\lambda_t Y_t = 0, \tag{D.22}$$

$$\left[p_t^\star\right]: \quad -\mu_{5,t} + (1-\theta)(1-\epsilon)\,\mu_{8,t}p_t^{\star\,-\epsilon} - \epsilon(1-\theta)\,\mu_{10,t}p_t^{\star\,-\epsilon-1} = 0, \tag{D.23}$$

$$\left[x_{1,t}\right]: \quad \frac{\epsilon}{(\epsilon-1)(1+\tau)}\mu_{5,t}\frac{1}{x_{2,t}} - \mu_{6,t} + \theta\mu_{6,t-1}{\Pi_t}^{\epsilon} = 0, \tag{D.24}$$

$$\left[x_{2,t}\right]: \quad -\frac{\epsilon}{(\epsilon-1)(1+\tau)}\mu_{5,t}\frac{x_{1,t}}{x_{2,t}^2} - \mu_{7,t} + \theta\mu_{7,t-1}{\Pi_t}^{\epsilon-1} = 0, \tag{D.25}$$

$$[\Delta_t]: \quad -\mu_{9,t}Y_t - \mu_{10,t} + \theta\beta\mathbb{E}_t\mu_{10,t+1}\Pi_{t+1}^{\epsilon} = 0, \tag{D.26}$$

$$\left[R_t^s\right]: \quad \beta\mu_{3,t}\mathbb{E}_t\lambda_{t+1}\frac{Z_t}{\Pi_{t+1}} + \mu_{14,t} = 0, \tag{D.27}$$

$$\left[\Pi_{w,t}\right]: \quad -\mu_{11,t} + \mu_{12,t} = 0, \tag{D.28}$$

$$[Y_t]: \quad \mu_{6,t}\lambda_t mc_t + \mu_{7,t}\lambda_t - \mu_{9,t}\Delta_t - \mu_{15,t} = 0, \tag{D.29}$$

$$\begin{aligned}[\Pi_t]: \quad & -\mu_{3,t-1}\lambda_t\frac{R_{t-1}^s Z_{t-1}}{\Pi_t^2} + \theta\epsilon\mu_{6,t-1}{\Pi_t}^{\epsilon-1}x_{1,t} + \theta(\epsilon-1)\,\mu_{7,t-1}\Pi_t^{\epsilon-2}x_{2,t} \\ & +\theta(\epsilon-1)\,\mu_{8,t}{\Pi_t}^{\epsilon-2} + \theta\epsilon\mu_{10,t}{\Pi_t}^{\epsilon-1}\Delta_{t-1} + \mu_{11,t}\frac{w_t}{w_{t-1}} = 0.\end{aligned} \tag{D.30}$$

We assume that the Ramsey policy has been in place prior to the shock and adopt the timeless-perspective initial condition. Accordingly, the inherited multipliers associated with the forward-looking implementability constraints are initialised at their deterministic Ramsey steady-state values, such that $\mu_{3,-1} = \mu_3$, $\mu_{6,-1} = \mu_6$, and $\mu_{7,-1} = \mu_7$.

D.3 Regime Conditions

We solve the occasionally binding Ramsey problem using a regime-switching active-set method. The private-sector DNWR complementarity condition,

$$0 \leq N_t^s - N_t \quad \perp \quad \Pi_{w,t} - \gamma \geq 0, \tag{D.31}$$

is imposed regime by regime.

When DNWR does not bind, the labour market clears:

$$N_t^s = N_t, \qquad \mu_{12,t} = 0. \tag{D.32}$$

The multiplier $\mu_{13,t}$ associated with the labour-market-clearing equality is unrestricted in sign. A candidate allocation for this regime is valid provided that

$$\Pi_{w,t} \geq \gamma, \qquad \mu_{13,t} \in \mathbb{R}. \tag{D.33}$$

When DNWR binds, nominal wage inflation is fixed at its lower bound:

$$\Pi_{w,t} = \gamma, \qquad \mu_{13,t} = 0. \tag{D.34}$$

The multiplier $\mu_{12,t}$ associated with the wage-floor equality is unrestricted in sign. A candidate allocation for this regime is valid provided that

$$N_t^s \geq N_t, \qquad \mu_{12,t} \in \mathbb{R}. \tag{D.35}$$

At the boundary between the two regimes, both equalities may hold:

$$N_t^s = N_t, \qquad \Pi_{w,t} = \gamma. \tag{D.36}$$

At such a kink, the active-set algorithm selects a solution satisfying the equilibrium conditions and the primal feasibility conditions of both regimes.

The ZLB is imposed through the standard complementary-slackness conditions

$$R_t^s - 1 \geq 0, \qquad \mu_{14,t} \geq 0, \qquad \mu_{14,t}\left(R_t^s - 1\right) = 0. \tag{D.37}$$

We implement these conditions regime by regime.

When the ZLB is slack, the unconstrained nominal interest rate lies strictly above its lower bound:

$$R_t^s > 1, \qquad \mu_{14,t} = 0. \tag{D.38}$$

When the ZLB binds, the nominal interest rate is fixed at its lower bound:

$$R_t^s = 1, \qquad \mu_{14,t} \geq 0. \tag{D.39}$$