Monetary Policy with Partial Fiscal Backing*

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Abstract

The surge of inflation and government debt in recent years has renewed interest in the interaction between monetary and fiscal policy. Using a New Keynesian framework, this paper examines the welfare implications of partially unfunded government debt, defined as debt not fully backed by future budget surpluses. We find that such debt can improve social welfare, particularly in the presence of demand and technology shocks. Under a Taylor rule, the optimal share of shock absorption through unfunded debt is about one-third, and this share increases when nominal interest rates are constrained by the zero lower bound (ZLB). However, as monetary policy becomes more effective, for example, when a first-difference rule is used, the welfare benefits of unfunded debt diminish and may even become negative. Unfunded debt remains a useful tool for addressing price markup shocks, but may be undesirable in the case of wage markup shocks. These findings underscore the importance of flexible and coordinated policy frameworks in environments with high government debt and monetary constraints.

Keywords: Automatic stabilizers; fiscal-monetary policy interaction; partially unfunded government debt; welfare analysis.

JEL codes: E31; E52; E63.

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1 Introduction

The surge in inflation observed in many advanced economies in recent years has renewed interest in the interplay between monetary and fiscal policy. This episode of high inflation stands in contrast to the preceding decade, when many central banks grappled with persistently low inflation and the constraints imposed by the zero lower bound (ZLB) on nominal interest rates. At the same time, fiscal authorities faced increasing pressure to support economic stabilization, often resulting in elevated levels of government debt.

A central question in this context is how the degree of fiscal backing affects macroeconomic outcomes and social welfare. Here, fiscal backing refers to the share of government debt that is fully backed by future budget surpluses. The Fiscal Theory of the Price Level (FTPL) provides a key framework for analyzing these issues, offering insight into the joint determination of prices and government debt. However, the welfare implications of partially unfunded debt remain less well understood, particularly under different shock scenarios and policy regimes.

In this paper, we address these issues using a New Keynesian model with wage rigidities. The model is calibrated to standard macroeconomic parameters and incorporates demand, technology, price markup, and wage markup shocks. Monetary policy may be constrained by the ZLB. We systematically evaluate welfare outcomes under different monetary and fiscal policy rules, varying the share of government debt that is not backed by future budget surpluses. The automatic stabilizer in the fiscal rule, specifically its response to the output gap, is calibrated to maximize welfare in the fiscal-led regime. This ensures that fiscal policy provides effective stabilization in regimes where monetary policy is required to accommodate unfunded government debt.

Our analysis reveals that permitting a portion of government debt to remain unfunded can substantially improve social welfare, when the economy faces demand and technology shocks. This welfare gain is most pronounced under a conventional Taylor-type rule, where monetary policy is less effective at the ZLB, increasing the importance of fiscal support. We find that the optimal share of shock absorption through unfunded debt is about one-third. When the ZLB binds and monetary policy is less effective, the welfare-improving share of unfunded debt increases. This result highlights the importance of fiscal support in such environments. Conversely, as monetary policy becomes more effective, for example, with a first-difference rule, the benefits of unfunded debt diminish and may even become negative.

Furthermore, our results show that unfunded debt remains a useful tool for monetary policy to accommodate price markup shocks, helping to achieve broader stabilization objectives even when other policy instruments are constrained. This is because, in the face of price markup shocks, which tend to push inflation and output in opposite directions, unfunded debt gives policymakers the flexibility to support real activity without an excessive contractionary response to inflation. In contrast, for wage markup shocks, where inflation and output tend

to move together, the "look through" logic is less relevant, as tolerating higher inflation does not yield the same stabilization benefits. These findings provide new normative insights into the design of fiscal-monetary frameworks, especially in settings where fiscal constraints and economic shocks interact.

Related literature. This paper contributes to the literature on the interaction between monetary and fiscal policy, building on the FTPL as developed by Leeper (1991), Sims (1994), Woodford (2001), and Cochrane (2001). These foundational works demonstrate how the coordination of monetary and fiscal regimes shapes equilibrium outcomes and anchors the price level. More recent contributions, including Leeper and Leith (2016) and Cochrane (2023), provide comprehensive overviews and further theoretical development.

Moreover, our modeling approach builds on Galí (2015), who presents a comprehensive introduction to the New Keynesian framework and its applications to monetary policy analysis. We also draw on Billi and Galí (2020) and Billi (2020), who examine the implications of wage flexibility and the ZLB for monetary policy effectiveness.

Our work is closely related to recent advances by Cochrane (2022), Bianchi, Faccini, and Melosi (2023), and Smets and Wouters (2024) in the FTPL literature. Cochrane (2022) explores fiscal and monetary policy shocks in a fiscal-led regime, where fiscal authorities may not always fully fund government debt with future budget surpluses. Bianchi, Faccini, and Melosi (2023) develop a fiscal theory of persistent inflation, highlighting the macroeconomic effects of both funded and unfunded fiscal transfer shocks. Smets and Wouters (2024) provide empirical evidence on how partial fiscal backing affects the transmission of various shocks, including non-fiscal shocks, to output and inflation.

Building on these theoretical and empirical foundations, our paper offers a normative analysis of the optimal degree to which central banks should accommodate unfunded government debt. We systematically quantify the welfare effects of partially unfunded debt across different shock scenarios and policy regimes, with particular attention to the ZLB and the presence of demand, technology, and markup shocks. Unlike previous studies, our framework determines the optimal share of shock absorption through unfunded debt, providing a systematic basis for policy evaluation and yielding new insights for designing macroeconomic stabilization frameworks in environments with fiscal constraints.

Paper outline. The remainder of the paper is organized as follows. Section 2 describes the baseline model and its calibration, including demand and technology shocks and the standard Taylor-type rule. Section 3 presents the main findings. Section 4 analyzes the effects of adopting a first-difference interest rate rule. Section 5 examines the role of price and wage markup shocks. Section 6 concludes with a summary of key results and policy implications. The appendices provide robustness checks for alternative policy rules and present the equilibrium conditions for the optimal commitment policy.

2 Baseline Model and Calibration

We employ a New Keynesian model with price and wage rigidities to analyze the welfare effects of partial fiscal backing. The private sector is subject to demand and technology shocks. Government bonds are modeled as perpetuities with declining coupons, while the fiscal authority's budget constraint allows for a variable share of debt that is not backed by future budget surpluses. Policy regimes are formalized through distinct monetary and fiscal rules. The model is calibrated to standard values to ensure comparability with the literature and the robustness of the welfare analysis.

2.1 Private Sector

The private sector is modeled as a closed economy with staggered price and wage setting à la Calvo, subject to demand and technology shocks. This follows the standard New Keynesian framework. As in Galí (2015, chapter 6), all equations are log-linearized around an efficient steady state with zero price and wage inflation.

The supply side of the model is described by the price and wage Phillips curves, together with the dynamics of the real wage gap:

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} + \varkappa_p \widetilde{y}_t + \lambda_p \widetilde{\omega}_t \tag{1}$$

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \varkappa_w \widetilde{y}_t - \lambda_w \widetilde{\omega}_t \tag{2}$$

$$\widetilde{\omega}_t \equiv \widetilde{\omega}_{t-1} + \pi_t^w - \pi_t^p - \Delta\hat{\omega}_t^n \tag{3}$$

where π_t^p and π_t^w denote price and wage inflation, respectively, while $\widetilde{y}_t$ and $\widetilde{\omega}_t$ represent the output and real wage gaps. These gaps are defined as deviations from their respective natural levels in the absence of nominal rigidities: $\widetilde{y}_t \equiv \hat{y}_t - \hat{y}_t^n$ and $\widetilde{\omega}_t \equiv \hat{\omega}_t - \hat{\omega}_t^n$. The natural output and wage reflect shifts in technology, with $\hat{y}_t^n \equiv \psi_{ya} a_t$ and $\hat{\omega}_t^n \equiv \psi_{\omega a} a_t$.[1]

On the demand side, the model features a dynamic IS equation:

$$\widetilde{y}_t = E_t\{\widetilde{y}_{t+1}\} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\{\pi_{t+1}^p\} - \hat{r}_t^n\right) \tag{4}$$

where $\hat{\imath}_t \equiv i_t - \rho$ is the nominal interest rate deviation from steady state, and $\rho \equiv 1/\beta - 1 > 0$ is the discount rate. The natural rate of interest, $\hat{r}_t^n$, is a function of both demand and technology shocks: $\hat{r}_t^n \equiv (1-\rho_z) z_t - \sigma\,(1-\rho_a)\,\psi_{ya} a_t$. The demand and technology shocks, z_t and a_t, follow independent $AR(1)$ processes, reflecting persistent fluctuations.

[1] In addition, the slope coefficients in the Phillips curves are given by $\varkappa_p \equiv \lambda_p\left(\frac{\alpha}{1-\alpha}\right)$ and $\varkappa_w \equiv \lambda_w\left(\sigma + \frac{\varphi}{1-\alpha}\right)$, where $\lambda_p \equiv \frac{(1-\theta_p)(1-\beta\theta_p)(1-\alpha)}{\theta_p(1-\alpha+\alpha\epsilon_p)}$ and $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$. The coefficients for the natural output and wage are $\psi_{ya} \equiv \frac{1+\varphi}{\sigma(1-\alpha)+\varphi+\alpha}$ and $\psi_{\omega a} \equiv \frac{\sigma+\varphi}{\sigma(1-\alpha)+\varphi+\alpha}$, respectively.

The model parameters include the Calvo indexes for price and wage rigidity (θ_p and θ_w), elasticities of substitution (ϵ_p and ϵ_w), risk aversion (σ), labor disutility (φ), discount factor (β), and decreasing returns to labor (α). These parameters are calibrated to standard values in Section 2.6 to ensure comparability with the literature (Billi and Galí, 2020; Billi, 2020).

2.2 Government Budget with Long-Term Debt

The fiscal authority issues long-term, risk-free bonds. Following Woodford (2001), these bonds are modeled as perpetuities with coupon payments that decline at a rate $\eta \in [0, 1]$ each period. The government's budget constraint and the arbitrage condition are log-linearized around a steady state with no trend growth and zero inflation, which provides a tractable description of fiscal dynamics.[2]

The fiscal side of the model is, thus, described by the flow budget constraint and the arbitrage condition for government debt:

$$\hat{b}_t = \beta^{-1}\hat{b}_{t-1} + b\beta^{-1}\left(\eta\beta\hat{Q}_t - \hat{Q}_{t-1} - \pi_t^p\right) - \hat{\tau}_t \tag{5}$$

$$\hat{\imath}_t = \eta\beta E_t\left\{\hat{Q}_{t+1}\right\} - \hat{Q}_t \tag{6}$$

where $\hat{b}_t \equiv (B_t - B)/Y$ and $\hat{\tau}_t \equiv (T_t - T)/Y$ are the real market value of government debt and non-distortionary taxes, measured as deviations from steady state and normalized by output. In this framework, $\hat{\tau}_t$ is interpreted as the government's primary surplus, as government spending is omitted from the analysis. $b \equiv B/Y$ is the long-run debt target as a share of output. $\hat{Q}_t \equiv (Q_t - Q)/Q$ is the percent deviation of the bond price, where $Q \equiv \beta/(1 - \eta\beta)$. The average duration of the bond, $1/(1 - \eta\beta)$, increases as η rises, reflecting the long-term nature of government debt in this setting. The debt target and bond duration are calibrated to recent data, as described in Section 2.6.

2.3 Fiscal-Led Shadow Economy

Next, we extend the model to allow government debt to be only partially backed by future budget surpluses. Such situations arise when fiscal authorities cannot credibly commit to fully repaying debt through future tax increases or spending cuts, thereby requiring monetary policy to accommodate part of the fiscal burden. Following Smets and Wouters (2024), we consider an environment where only a fraction of government debt is backed by future budget surpluses, while the remainder is unfunded and accommodated by monetary policy.

[2]Government debt issuance is determined by the rollover of outstanding debt, the real interest cost of servicing the debt, and the primary surplus. The government's primary surplus is the excess of government revenues over expenditures, excluding interest payments on public debt. The arbitrage condition ensures that the return on government bonds aligns with the interest rate and bond pricing.

In our model, we introduce a "shadow economy" block that tracks the evolution of unfunded government debt. The shadow economy represents the fiscal-led regime, while the observed economy represents the monetary-led regime. Formally, we replicate equations (1)–(6), adding a superscript "F" to all variables to distinguish the fiscal-led regime. We also introduce a parameter $\gamma \in [0, 1]$ that multiplies each shock (z_t and a_t) in the fiscal-led regime, thereby determining the proportion of each shock absorbed by unfunded debt.[3] When $\gamma = 0$, the regime is monetary-led (full fiscal backing); when $\gamma = 1$, it is fiscal-led (no fiscal backing). Intermediate values of γ correspond to partial fiscal backing, allowing for a flexible mix of fiscal and monetary responses to shocks.

The model thus consists of equations (1)–(6) for the monetary-led observed economy, alongside their counterparts with superscript "F" and shocks multiplied by γ in the fiscal-led shadow economy. In the analysis that follows, we systematically vary γ to investigate the welfare-optimal degree of shock absorption via unfunded debt. We next specify the policy rules that govern the behavior of both the shadow and observed economies.

2.4 Policy Rules under the ZLB

We now present the policy rules that distinguish the shadow and observed economies within our framework. In particular, we highlight how the fiscal rule incorporates an automatic stabilizer, designed to enhance the economy's response to shocks in regimes where monetary policy must accommodate unfunded government debt.

In the fiscal-led shadow economy, we assume a policy configuration where the nominal interest rate is permanently pegged at steady state, representing a passive monetary policy stance. Fiscal policy is active, meaning the primary surplus is set independently of deviations of government debt from its target (Leeper, 1991). In this regime, government debt is unfunded, and inflation serves as the main mechanism for returning debt to its target level, rather than adjustments in taxes or spending. The following policy rules formalize these assumptions:[4]

$$\hat{\imath}_t^F = 0 \tag{7}$$

$$\hat{\tau}_t^F = \psi_\tau \hat{\tau}_{t-1}^F + (1 - \psi_\tau)\, \psi_y \widetilde{y}_t^F \tag{8}$$

[3] For example, in the fiscal-led shadow economy block of the model, the counterpart of the dynamic IS equation (4) is given by $\widetilde{y}_t^F = E_t\{\widetilde{y}_{t+1}^F\} - \frac{1}{\sigma}\left(\hat{\imath}_t^F - E_t\{\pi_{t+1}^{pF}\} - \gamma \hat{r}_t^n\right)$, where all variables have superscript "F" and the parameter γ multiplies the natural rate of interest $\hat{r}_t^n$.

[4] This standard description of policy rules in a fiscal-led economy does not restrict our analysis. Specifically, Appendix A extends the model to allow monetary policy to lean against fiscal inflation ($\hat{\imath}_t^F$ responds to π_t^{pF}), which reduces the desirability of unfunded debt, relative to our baseline analysis. Appendix B instead considers fiscal policy that leans against unfunded debt ($\hat{\tau}_t^F$ responds to $\hat{b}_{t-1}^F$); however, because of an automatic stabilizer in the fiscal rule, the desirability of unfunded debt remains the same as in the baseline model.

where ψ_τ controls how gradually the primary surplus adjusts over time. The parameter ψ_y measures the strength of the automatic stabilizer in the fiscal rule by determining how strongly the primary surplus responds to the output gap. The value of this parameter is calibrated to maximize welfare in the fiscal-led regime, as discussed in Section 2.6, ensuring that fiscal policy provides effective stabilization in regimes where monetary policy is required to accommodate unfunded government debt.

In the monetary-led observed economy, the policy configuration is characterized by active monetary policy and passive fiscal policy. Monetary policy follows the standard Taylor-type rule, by responding to inflation and the output gap, while fiscal policy adjusts the primary surplus to stabilize government debt. This regime reflects a setting where monetary policy faces a zero lower bound (ZLB) on nominal interest rates, and fiscal actions are subordinated to maintaining debt sustainability. The corresponding policy rules are:

$$\hat{\imath}_t = \max\left[-\rho, \hat{\imath}_t^*\right] \tag{9}$$

$$\hat{\imath}_t^* = \phi_i \hat{\imath}_{t-1}^* + (1-\phi_i)\left[\phi_p^M\left(\pi_t^p - \pi_t^{pF}\right) + \phi_y^M\left(\widetilde{y}_t - \widetilde{y}_t^F\right)\right] \tag{10}$$

$$\hat{\tau}_t = \psi_\tau \hat{\tau}_{t-1} + (1-\psi_\tau)\left[\psi_b^M\left(\hat{b}_{t-1} - \hat{b}_{t-1}^F\right) + \psi_y \widetilde{y}_t\right] \tag{11}$$

where ϕ_i is the smoothing coefficient for the unconstrained nominal interest rate. The parameters ϕ_p^M and ϕ_y^M govern how monetary policy responds to the portion of inflation and output gap associated with funded government debt. In particular, π_t^{pF} and $\widetilde{y}_t^F$ are time-varying targets reflecting the inflation and output gap arising from the unfunded part of government debt, as determined in the fiscal-led shadow economy. Similarly, ψ_b^M governs the responsiveness of fiscal policy to changes in the funded portion of government debt.[5]

Some considerations regarding our model framework are as follows. First, fiscal and monetary policy shocks are not included in the policy rules, as their implications for the welfare-optimal value of γ are straightforward. Since the model assumes non-distortionary taxes, fiscal shocks can be fully absorbed by funded government debt, implying $\gamma = 0$. For monetary shocks, if government debt is unfunded, the permanent interest rate peg specified in equation (7) ensures that monetary shocks are absent, so $\gamma = 1$. Second, another implication of the peg in equation (7) is that the optimal value of γ is unaffected by the duration of government debt.[6] However, the appendices provide robustness checks for alternative policy rules.

[5] In this setting, a "passive" fiscal policy requires $\psi_b^M > \rho$. Specifically, the government budget constraint and fiscal rule, equations (5) and (11), imply that the dynamics of funded debt, $\hat{b}_t$, depend on $\left(\beta^{-1} - \psi_b^M\right)\hat{b}_{t-1}$. Stable dynamics of funded debt require $\beta^{-1} - \psi_b^M < 1$, or equivalently, $\psi_b^M > \beta^{-1} - 1 \equiv \rho$.

[6] Specifically, in the fiscal-led regime under the peg, the government budget constraint and arbitrage condition, equations (5) and (6), pin down the bond price to steady state, $\hat{Q}_t^F = \hat{\imath}_t^F = 0$ for all t. Thus, $\hat{b}_t^F$ is independent of η, which implies that the duration of government debt does not affect the outcomes of our baseline model.

Remark 1 ***Continue the write-up of the text from here.***

2.5 Welfare Loss Criterion

A key objective of our analysis is to assess the implications of partial fiscal backing for monetary policy from a social welfare perspective. Following the approach in Galí (2015), we adopt as our welfare metric the second-order approximation of the welfare loss incurred by the representative household, resulting from fluctuations around an efficient steady state with zero inflation. This welfare loss is expressed as a fraction of steady-state consumption. The welfare loss function can be written as:

$$\mathbb{L} = \frac{1}{2}\left[\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right) var\left(\widetilde{y}_t\right) + \frac{\epsilon_p}{\lambda_p} var\left(\pi_t^p\right) + \frac{\epsilon_w(1-\alpha)}{\lambda_w} var\left(\pi_t^w\right)\right] \tag{12}$$

where the welfare loss consists of three distinct components, respectively associated with the volatilities of the output gap, price inflation, and wage inflation.

The welfare outcomes obtained by the above policy rules (varying γ between zero and unity) are compared to the welfare achieved by the optimal policy under commitment (which is independent of γ). The equilibrium conditions of the optimal commitment policy are shown in Appendix C.

2.6 Baseline Calibration

See Table 1. The calibration of the economy and of the Taylor rule are standard. The fiscal rule is calibrated to maximize social welfare when debt is unfunded, $\gamma = 1$. The bond coupon decay rate $\eta = 0.955$ is chosen so the average duration of the bond is 5 years, but the welfare outcomes are independent of η.

- The standard deviations of the shocks σ_z and σ_a are chosen so that conditional on each shock the ZLB binds 20 percent of the time if $\gamma = 0$ (funded debt), see Figure 1.
- Regarding the automatic stabilizer in the fiscal rule, i.e. the fiscal responsiveness to the output gap, set $\psi_y = 1$ so to maximize welfare if $\gamma = 1$ (unfunded debt), see Figure 2.
- Set $b = 4$ which corresponds to a debt target equal to 100% of annual GDP and it maximizes welfare if $\gamma = 1$, see Figure 3.

3 Welfare Effects of Partially Unfunded Debt

- Figures 4 to 5 show the response of the economy with and without ZLB to shocks $-z_t$ and $+a_t$, i.e. shocks that cause a recession and that reduce the nominal interest rate

when debt is funded. With funded debt ($\gamma = 0$) *inflation falls* the most, while unfunded debt ($\gamma = 1$) results in *overshooting of inflation*, regardless of the ZLB. But partially unfunded debt ($\gamma = 0.5$) *stabilizes inflation* which implies that it is welfare improving.

- Figures 6 and 7 show partially unfunded debt can improve social welfare, with and without ZLB. In Figure 6, conditional on each shock z_t and a_t, the optimal γ is around 0.3 without ZLB and increases to 0.4 with ZLB. The ZLB calls for relatively more unfunded debt, so more inflation pressure to stabilize the economy in downturns. In Figure 7, with funded debt ($\gamma = 0$) all three components of the welfare loss are larger when facing the ZLB; hence the ZLB implies more room for fiscal policy to help stabilize both inflation and the output gap.

4 First-Difference Monetary Policy Rule

Replace the above Taylor rule (10) with a first-difference rule

$$\Delta \hat{\imath}_t^* = \phi_p^M \left(\pi_t^p - \pi_t^{pF} \right) + \phi_y^M \left(\Delta \hat{y}_t - \Delta \hat{y}_t^F \right) \tag{13}$$

where ϕ_p^M and ϕ_y^M are kept at their baseline values.

- Figures 8 shows the first-difference rule (13) can so improve welfare to make unfunded debt undesirable, with and without ZLB.

5 Effects of Price and Wage Markup Shocks

Introduce price markup shock u_t and wage markup shock v_t. The persistence of these shocks is again 0.8, but their standard deviations are set to $\sigma_u = \sigma_v = 0.06\%$ which is small enough to avoid the ZLB in the model outcomes. Hence (1) and (2) become

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} + \varkappa_p \widetilde{y}_t + \lambda_p \widetilde{\omega}_t + u_t \tag{14}$$

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \varkappa_w \widetilde{y}_t - \lambda_w \widetilde{\omega}_t + v_t \tag{15}$$

- Figures 9 shows unfunded debt can be welfare improving as a means for monetary policy to look through price markup shocks. In the left panel, facing price markup shocks the welfare loss is larger under the first-difference rule (13) relative to the Taylor rule (10). Intuitively, price markup shocks push price inflation and the output gap in opposite

directions, and so the strong reaction of rule (13) reduces price inflation volatility but at the cost of increased output gap volatility. Welfare will also depend on how rule (13) affects wage inflation, as shown next.

- Figures 10 shows the response to shocks $-u_t$ and $-v_t$. Note, wage inflation tends to rise after $-u_t$ but tends to fall after $-v_t$. Facing either shock, the first-difference rule (13) raises the output gap and so puts upward pressure on wage inflation. Rule (13) thus can make wage inflation more volatile facing price markup shocks but less volatile facing wage markup shocks.

6 Conclusion

TBA

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Parameter	Description	Value
β	Discount factor	0.995
σ	Curvature of consumption utility	1
φ	Curvature of labor disutility	5
α	Index of decreasing returns to labor	0.25
ϵ_p	Elasticity of substitution of goods	9
ϵ_w	Elasticity of substitution of labour	4.5
θ_p	Calvo index of price rigidities	0.75
θ_w	Calvo index of wage rigidities	0.75
ϕ_i	Smoothing coefficient in Taylor rule	0.85
ϕ_p^M	Monetary response to price inflation	1.5
ϕ_y^M	Monetary response to output gap	0.125
ψ_τ	Smoothing coefficient in fiscal rule	0.85
ψ_b^M	Fiscal response to debt	0.1
ψ_y	Fiscal response to output gap	1
γ	Share unfunded debt (baseline fully funded)	0
b	Debt-to-GDP target (100% annual GDP)	4
η	Bond coupon decay rate (duration 5 years)	0.955
$\rho_{z,a}$	Persistence of shocks	0.8
σ_z	Std. deviation of demand shock (%)	9.7
σ_a	Std. deviation of technology shock (%)	7.4

Table 1: Baseline calibration of model parameters. All values are quarterly rates.

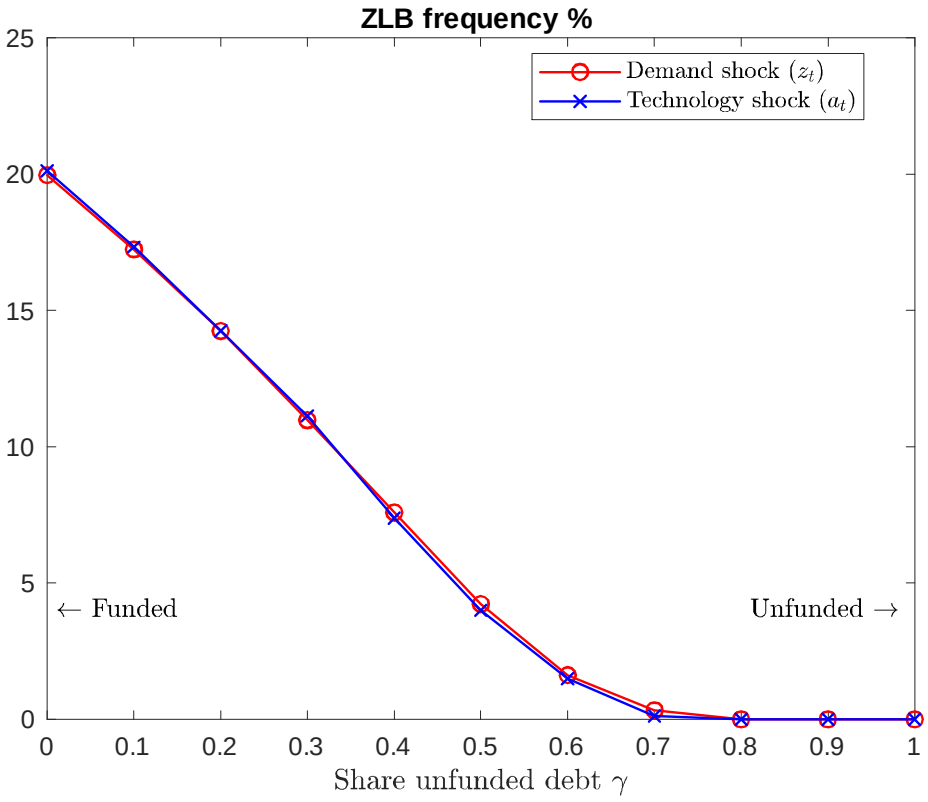


Figure 1: Partially unfunded debt can reduce the incidence of ZLB episodes.

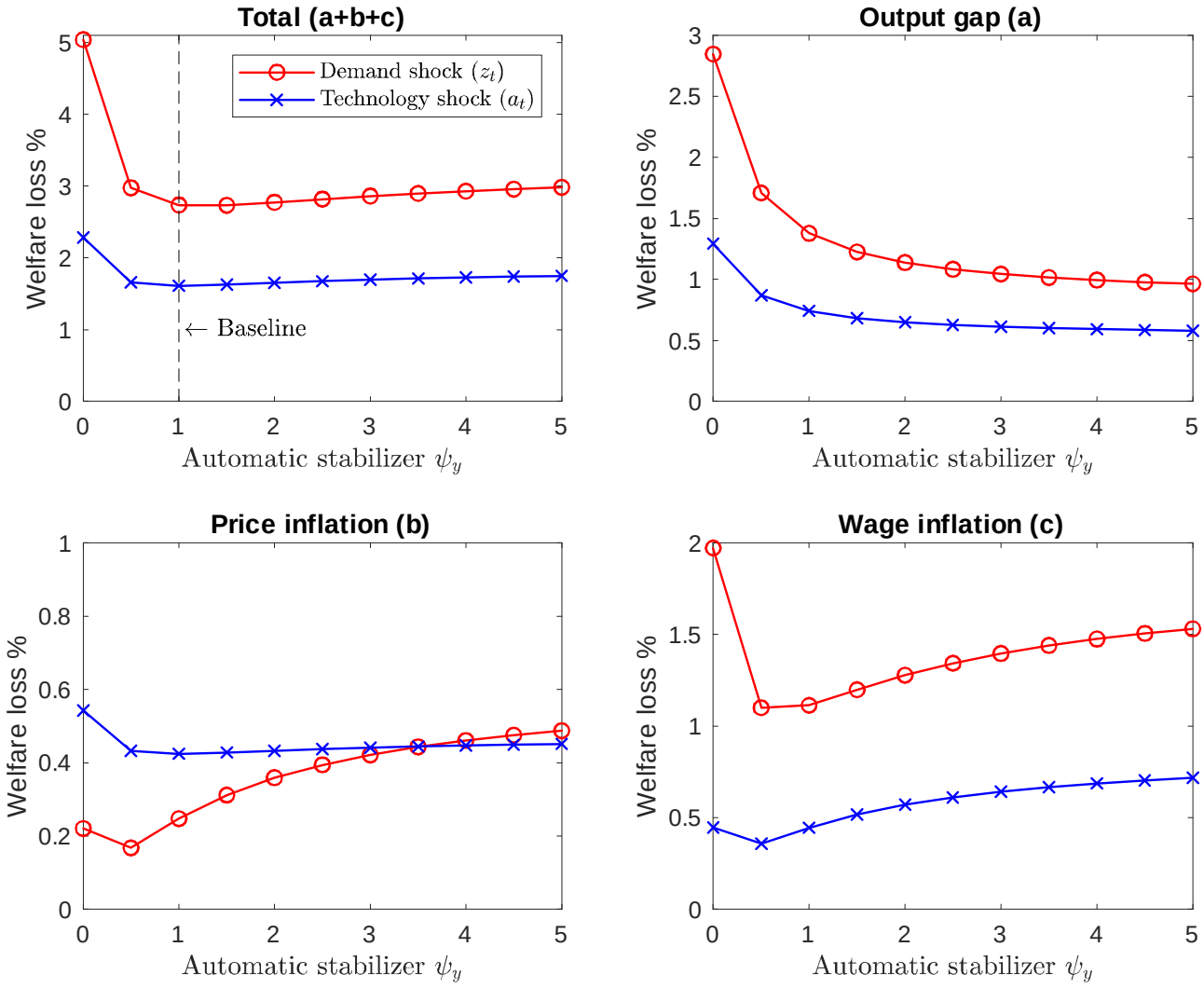


Figure 2: With unfunded debt ($\gamma = 1$), the optimal automatic stabilizer ψ_y in the fiscal rule is near 1.

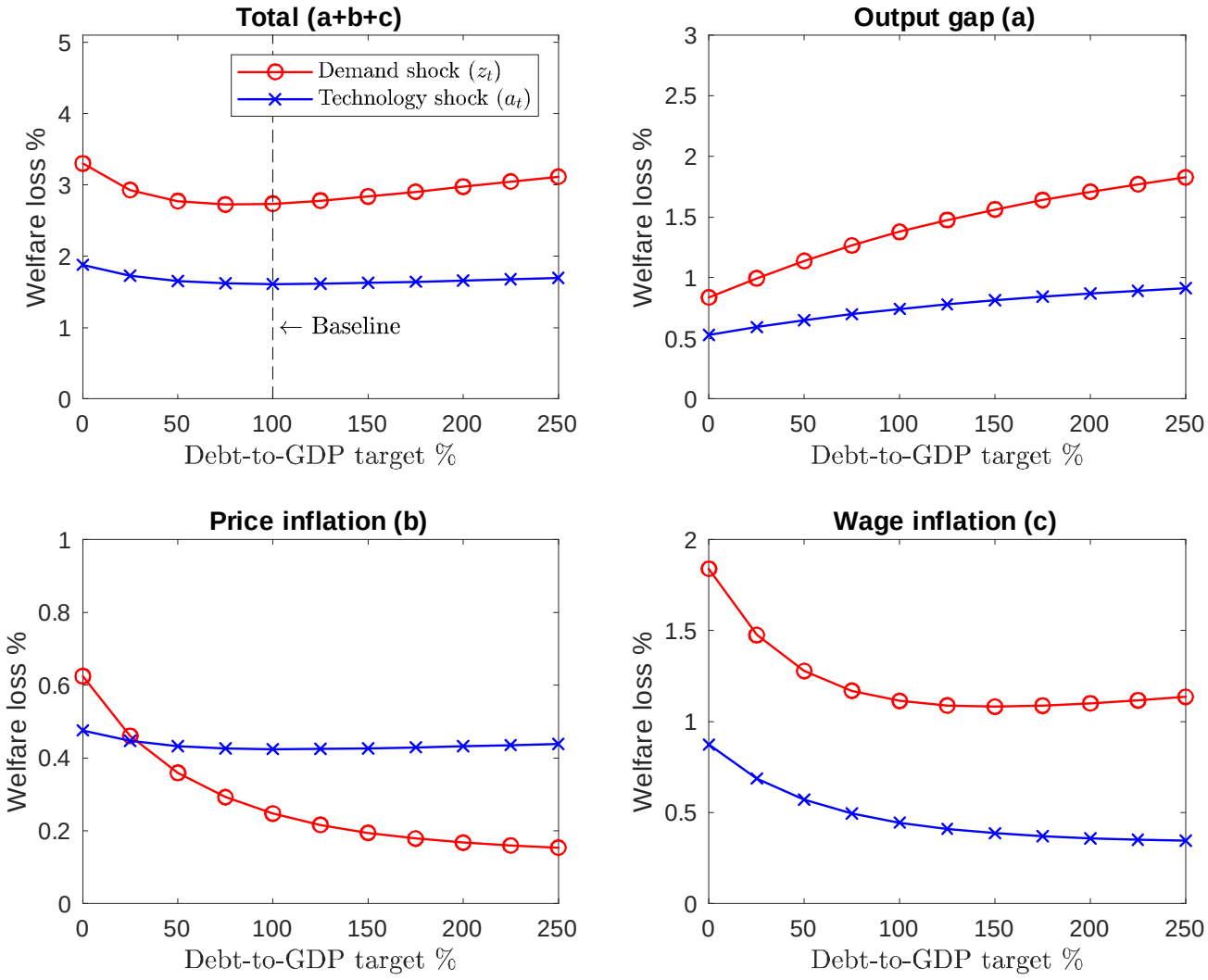


Figure 3: With unfunded debt ($\gamma = 1$), the optimal annual debt-to-GDP target $b/4$ is near 100%.

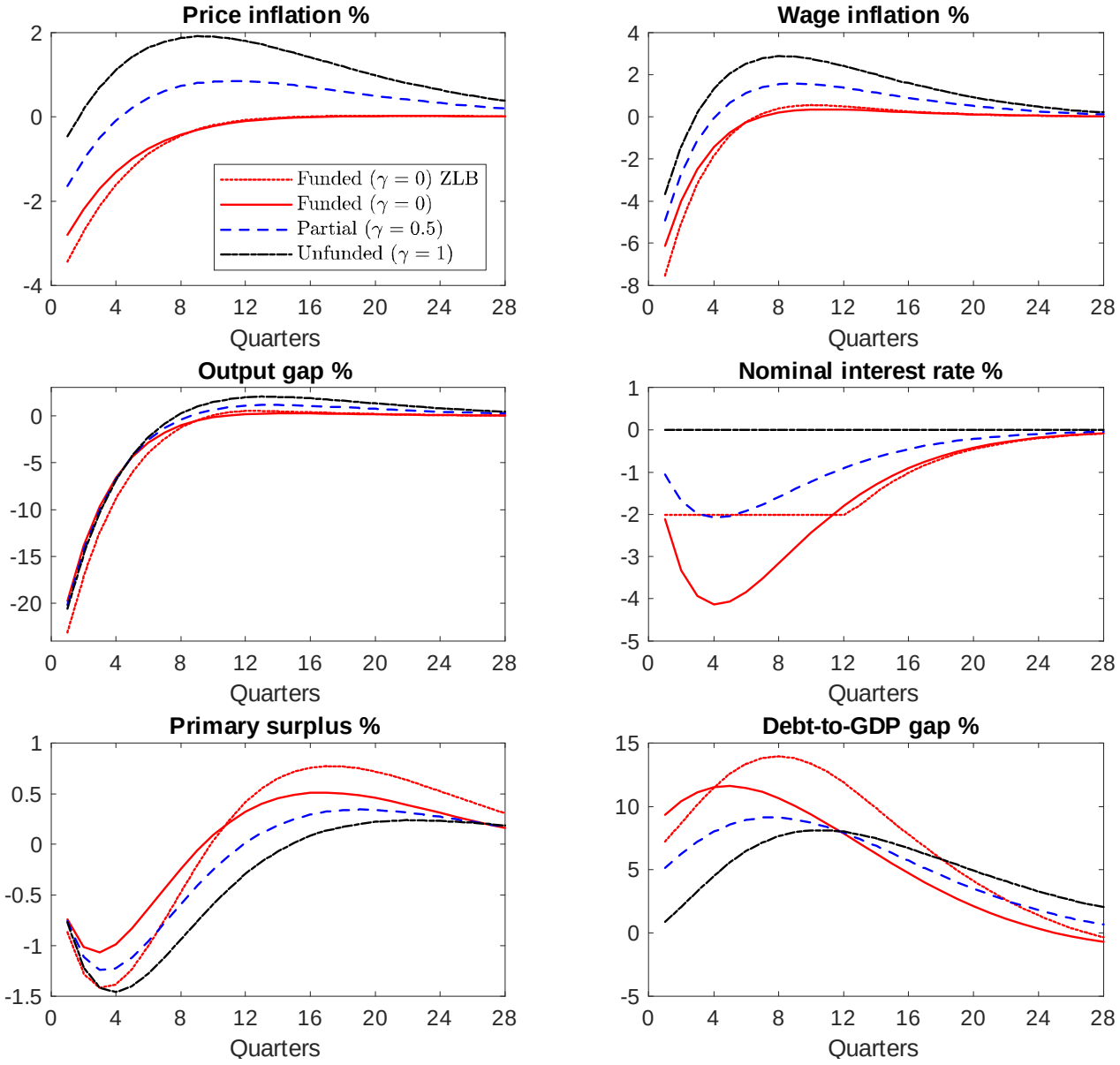


Figure 4: Partially unfunded debt can stabilize inflation facing demand shocks, with and without ZLB. Response to $-3sd$ demand shock. Annual deviation from steady state.

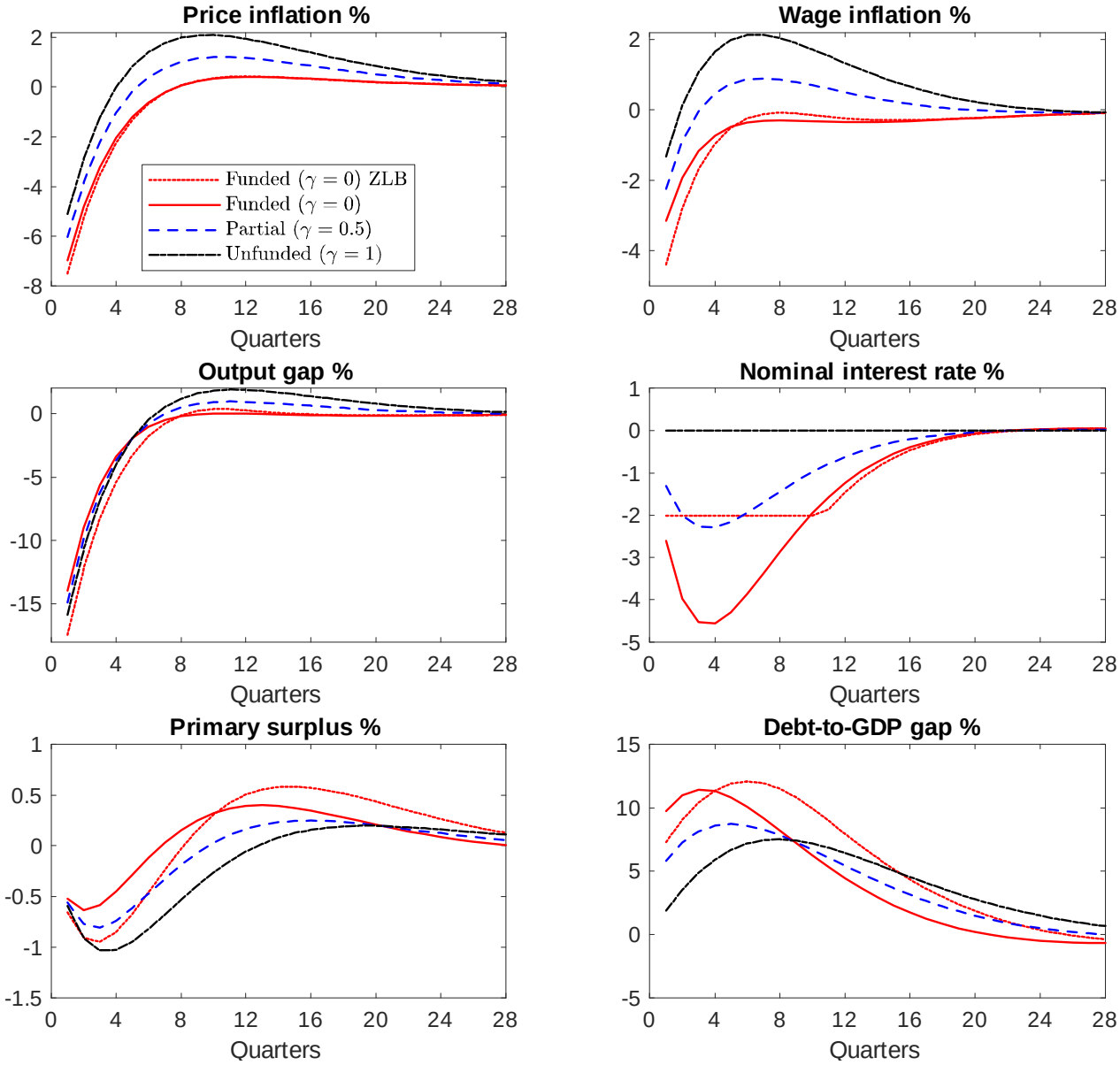


Figure 5: Partially unfunded debt can stabilize inflation facing technology shocks, with and without ZLB. Response to $+3sd$ technology shock. Annual deviation from steady state.

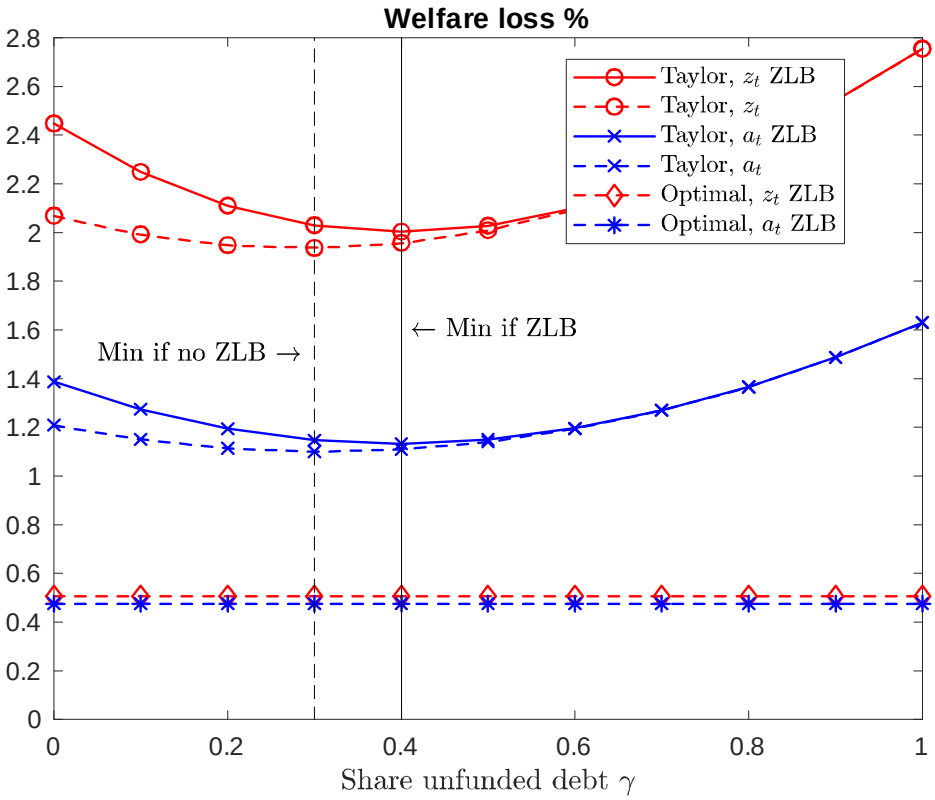


Figure 6: Partially unfunded debt can improve social welfare, with and without ZLB.

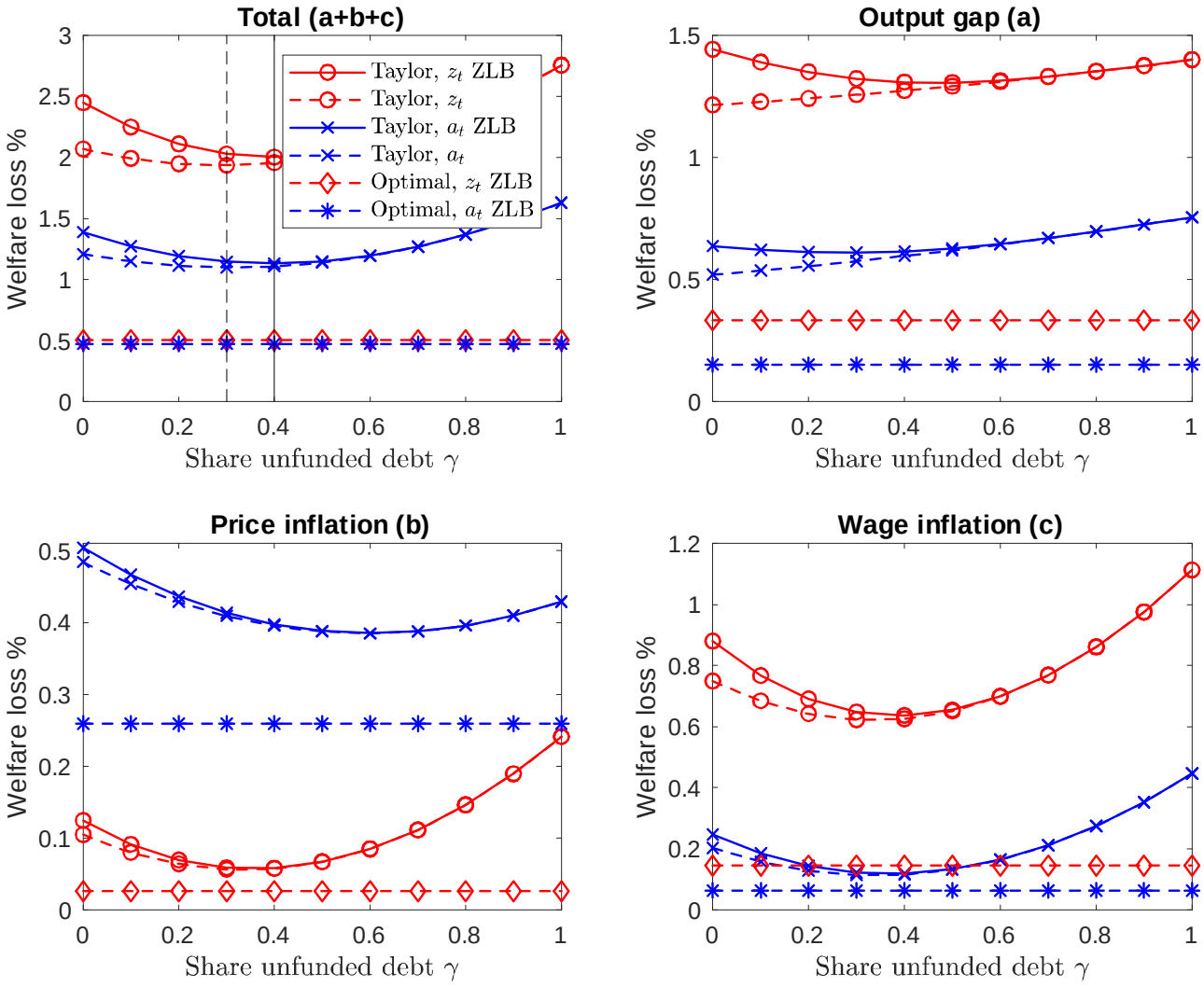


Figure 7: Partially unfunded debt and welfare components, with and without ZLB.

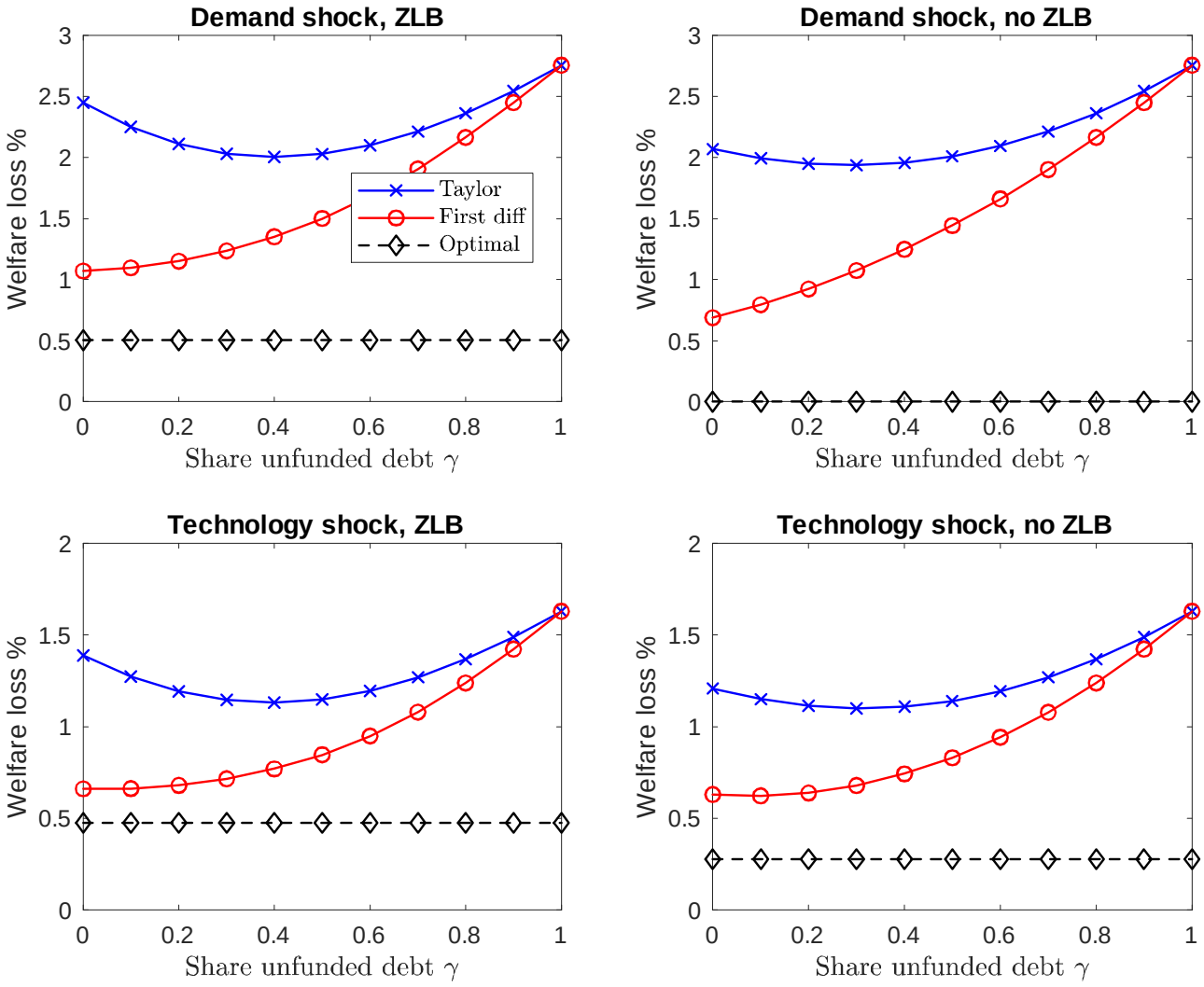


Figure 8: A more effective monetary policy such as a first-difference rule can so improve welfare to make funded debt desirable, with and without ZLB.

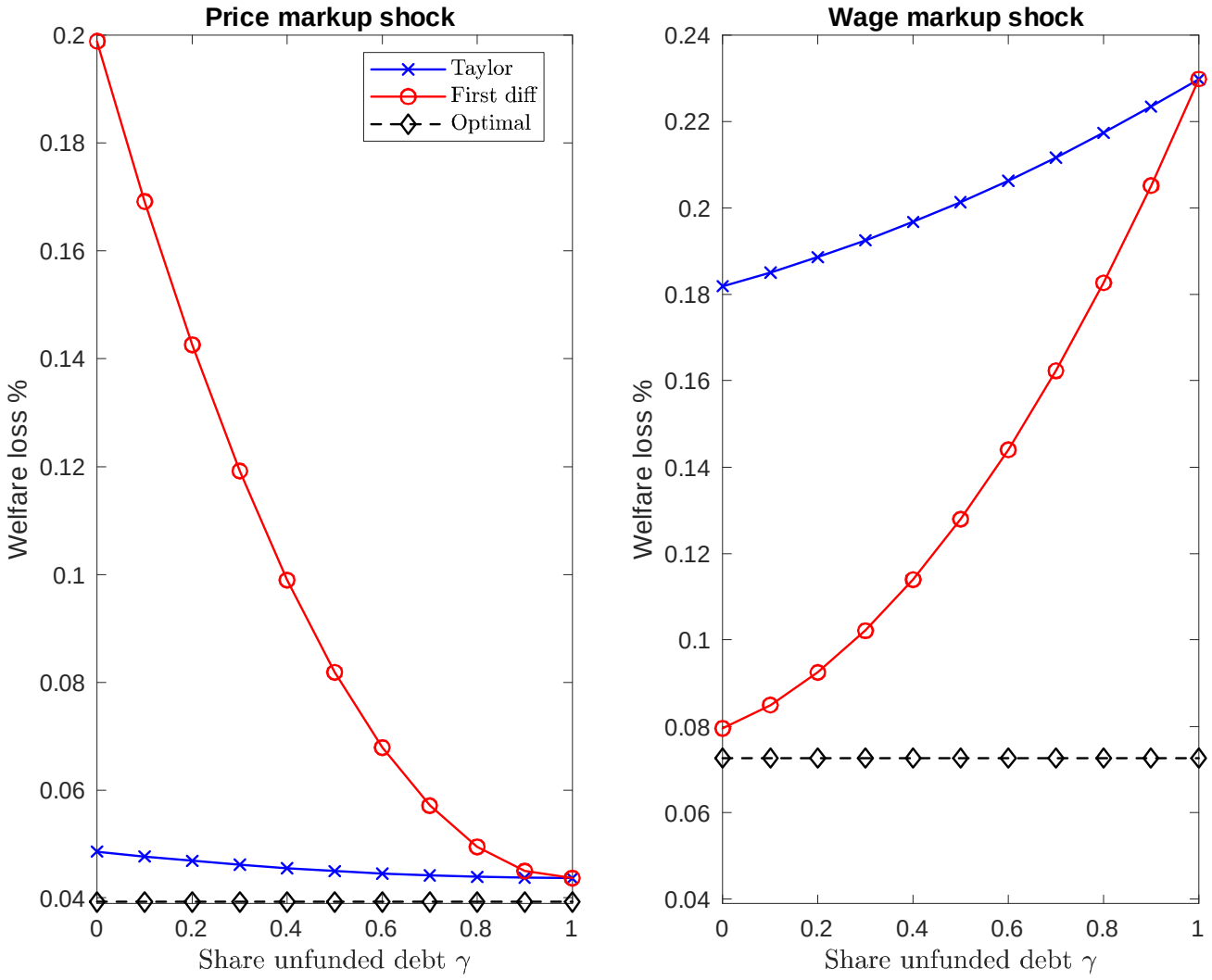


Figure 9: Unfunded debt can be welfare improving as a means for monetary policy to look through price markup shocks. Shock volatility small enough to avoid ZLB.

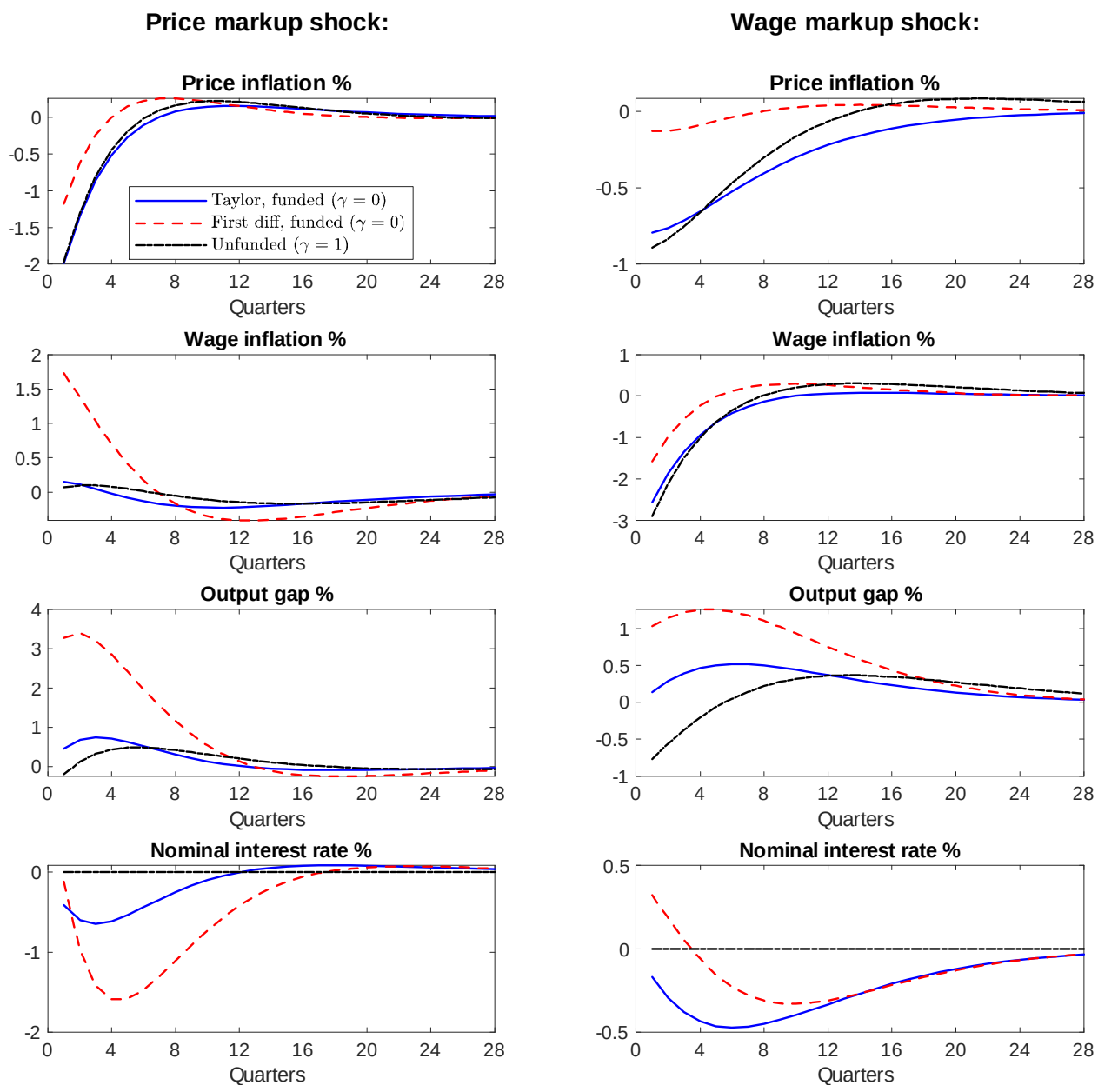


Figure 10: Monetary policy following a first-difference rule can make wage inflation more volatile facing price markup shocks but less volatile facing wage markup shocks. Response to $-3sd$ price or wage markup shock away from ZLB. Annual deviation from steady state.

Appendices

To evaluate the robustness of our main findings, the appendices extend the baseline analysis in several directions. Appendix A analyzes the implications of monetary policy that leans against fiscal inflation. Appendix B explores fiscal policy responses to unfunded debt. Appendix C presents the equilibrium conditions for the optimal commitment policy.

A Monetary Policy Leaning Against Fiscal Inflation

The baseline analysis assumes monetary policy does not respond to fiscal inflation. This appendix relaxes that assumption, allowing monetary policy to react to fiscal inflation.

Specifically, in the fiscal-led shadow economy, the nominal interest rate peg (7) is replaced by a rule that is less accommodative toward inflation:

$$\hat{\imath}_t^F = \phi_i \hat{\imath}_{t-1}^F + (1-\phi_i)\,\phi_p^F \pi_t^{pF} \tag{16}$$

where $\phi_p^F \in [0,1)$ ensures that monetary policy remains "passive." Higher values of ϕ_p^F correspond to monetary policy leaning more strongly against fiscal inflation, reflecting a less accommodative but still passive stance.

In the monetary-led observed economy, the Taylor rule (10) is modified as follows:

$$\hat{\imath}_t^* = \phi_i \hat{\imath}_{t-1}^* + (1-\phi_i)\left[\phi_p^M\left(\pi_t^p - \pi_t^{pF}\right) + \phi_p^F \pi_t^{pF} + \phi_y^M\left(\widetilde{y}_t - \widetilde{y}_t^F\right)\right] \tag{17}$$

Setting $\phi_p^F = 0$ recovers the baseline model. For illustrative purposes, we consider $\phi_p^F = 0.5$ to represent a moderate degree of leaning. Figure A.1 compares the responses of the economy to demand and technology shocks under unfunded debt. It shows results for the case without leaning (red solid lines, $\phi_p^F = 0$) and with leaning (blue dashed lines, $\phi_p^F = 0.5$). The responses show that leaning against fiscal inflation increases the volatility of inflation and the output gap, thereby raising the welfare loss from demand and technology shocks.

Overall, these findings suggest that monetary policy leaning against fiscal inflation can be counterproductive, as it amplifies macroeconomic volatility and reduces the desirability of unfunded debt relative to the baseline model.

B Fiscal Policy Leaning Against Unfunded Debt

In the baseline model, fiscal policy does not react to unfunded debt. Here, we instead permit fiscal policy to respond to deviations of unfunded debt from its long-run target.

Within the fiscal-led shadow economy, the fiscal rule (8) is modified to be less accommodating toward unfunded debt:

$$\hat{\tau}_t^F = \psi_\tau \hat{\tau}_{t-1}^F + (1-\psi_\tau)\left(\psi_b^F \hat{b}_{t-1}^F + \psi_y \widetilde{y}_t^F\right) \tag{18}$$

where $\psi_b^F \in [0, \rho)$ ensures that fiscal policy remains "active." A higher value of ψ_b^F implies that fiscal policy leans more forcefully against unfunded debt, representing a less accommodating but still active approach.

In the monetary-led observed economy, the fiscal rule (11) becomes:

$$\hat{\tau}_t = \psi_\tau \hat{\tau}_{t-1} + (1-\psi_\tau)\left[\psi_b^M\left(\hat{b}_{t-1} - \hat{b}_{t-1}^F\right) + \psi_b^F \hat{b}_{t-1}^F + \psi_y \widetilde{y}_t\right] \tag{19}$$

Imposing $\psi_b^F = 0$ restores the baseline specification. For reference, we set $\psi_b^F = 0.004$, a value just below $\rho \approx 0.005$. Figure A.2 displays the economy's responses to demand and technology shocks under unfunded debt, comparing the case without leaning (red solid lines, $\psi_b^F = 0$) to that with leaning (blue dashed lines, $\psi_b^F = 0.004$). The responses are not visibly different, owing to the presence of an automatic stabilizer in the fiscal rule ($\psi_y = 1$) , which is calibrated to maximize welfare in the fiscal-led regime.

The automatic stabilizer ensures that the primary surplus adjusts strongly to output fluctuations, thereby largely neutralizing the effect of leaning against unfunded debt and supporting macroeconomic stability. For contrast, the figure also shows outcomes for a scenario without the automatic stabilizer (black dash-dotted lines, $\psi_b^F = 0.004$ and $\psi_y = 0$), which leads to noticeably greater volatility of inflation and the output gap, highlighting the stabilizer's crucial role in dampening economic fluctuations.

In summary, the automatic stabilizer in the fiscal rule is strong enough to counteract the effect of leaning against unfunded debt, ensuring that such leaning has a negligible impact on macroeconomic volatility. As a result, the desirability of unfunded debt remains unchanged relative to the baseline model.

C Optimal Commitment Policy with ZLB

This appendix derives the equilibrium conditions that characterize the optimal commitment policy in the presence of a zero lower bound (ZLB) constraint on nominal interest rates. The problem is given by

$$\min \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right)\widetilde{y}_t^2 + \frac{\epsilon_p}{\lambda_p}\left(\pi_t^p\right)^2 + \frac{\epsilon_w(1-\alpha)}{\lambda_w}\left(\pi_t^w\right)^2\right]$$

subject to equations (1)–(4) and $\hat{\imath}_t+\rho \geq 0$. The government budget does not restrict monetary policy, and fiscal policy is assumed to set $\hat{\tau}_t$ so as to fully stabilize debt, $\hat{b}_t = 0$ for all t.

Write the period Lagrangian

$$\begin{aligned}
\mathbb{L}_t = & \frac{1}{2}\left[\left(\sigma+\frac{\varphi+\alpha}{1-\alpha}\right)\widetilde{y}_t^2+\frac{\epsilon_p}{\lambda_p}\left(\pi_t^p\right)^2+\frac{\epsilon_w(1-\alpha)}{\lambda_w}\left(\pi_t^w\right)^2\right] \\
& + m_{1t}\left[\widetilde{y}_t+\frac{1}{\sigma}\left(\hat{\imath}_t-\hat{r}_t^n\right)\right]-\beta^{-1}m_{1t-1}\left(\widetilde{y}_t+\frac{1}{\sigma}\pi_t^p\right) \\
& + m_{2t}\left(\pi_t^p-\varkappa_p\widetilde{y}_t-\lambda_p\widetilde{\omega}_t\right)-m_{2t-1}\pi_t^p \\
& + m_{3t}\left(\pi_t^w-\varkappa_w\widetilde{y}_t+\lambda_w\widetilde{\omega}_t\right)-m_{3t-1}\pi_t^w \\
& + m_{4t}\left(\widetilde{\omega}_t-\widetilde{\omega}_{t-1}-\pi_t^w+\pi_t^p+\Delta\hat{\omega}_t^n\right) \\
& + \beta E_t\mathbb{L}_{t+1}
\end{aligned}$$

The Kuhn-Tucker conditions are

$$0=\frac{\partial\mathbb{L}_t}{\partial\widetilde{y}_t}=\left(\sigma+\frac{\varphi+\alpha}{1-\alpha}\right)\widetilde{y}_t+m_{1t}-\beta^{-1}m_{1t-1}-\varkappa_p m_{2t}-\varkappa_w m_{3t} \tag{20}$$

$$0=\frac{\partial\mathbb{L}_t}{\partial\pi_t^p}=\frac{\epsilon_p}{\lambda_p}\pi_t^p-\frac{1}{\beta\sigma}m_{1t-1}+m_{2t}-m_{2t-1}+m_{4t} \tag{21}$$

$$0=\frac{\partial\mathbb{L}_t}{\partial\pi_t^w}=\frac{\epsilon_w(1-\alpha)}{\lambda_w}\pi_t^w+m_{3t}-m_{3t-1}-m_{4t} \tag{22}$$

$$0=\frac{\partial\mathbb{L}_t}{\partial\widetilde{\omega}_t}=\frac{\partial\beta E_t\mathbb{L}_{t+1}}{\partial\widetilde{\omega}_t}-\lambda_p m_{2t}+\lambda_w m_{3t}+m_{4t} \tag{23}$$

$$0=\frac{\partial\mathbb{L}_t}{\partial\hat{\imath}_t}\left(\hat{\imath}_t+\rho\right)=\frac{1}{\sigma}m_{1t}\left(\hat{\imath}_t+\rho\right), \quad m_{1t}\geq 0 \text{ and } \hat{\imath}_t+\rho\geq 0 \tag{24}$$

The envelope condition gives

$$\frac{\partial\beta E_t\mathbb{L}_{t+1}}{\partial\widetilde{\omega}_t}=-\beta E_t m_{4t+1}$$

Thus, the equilibrium conditions of the optimal commitment policy under the ZLB are given by equations (1)–(6) and (20)–(24).

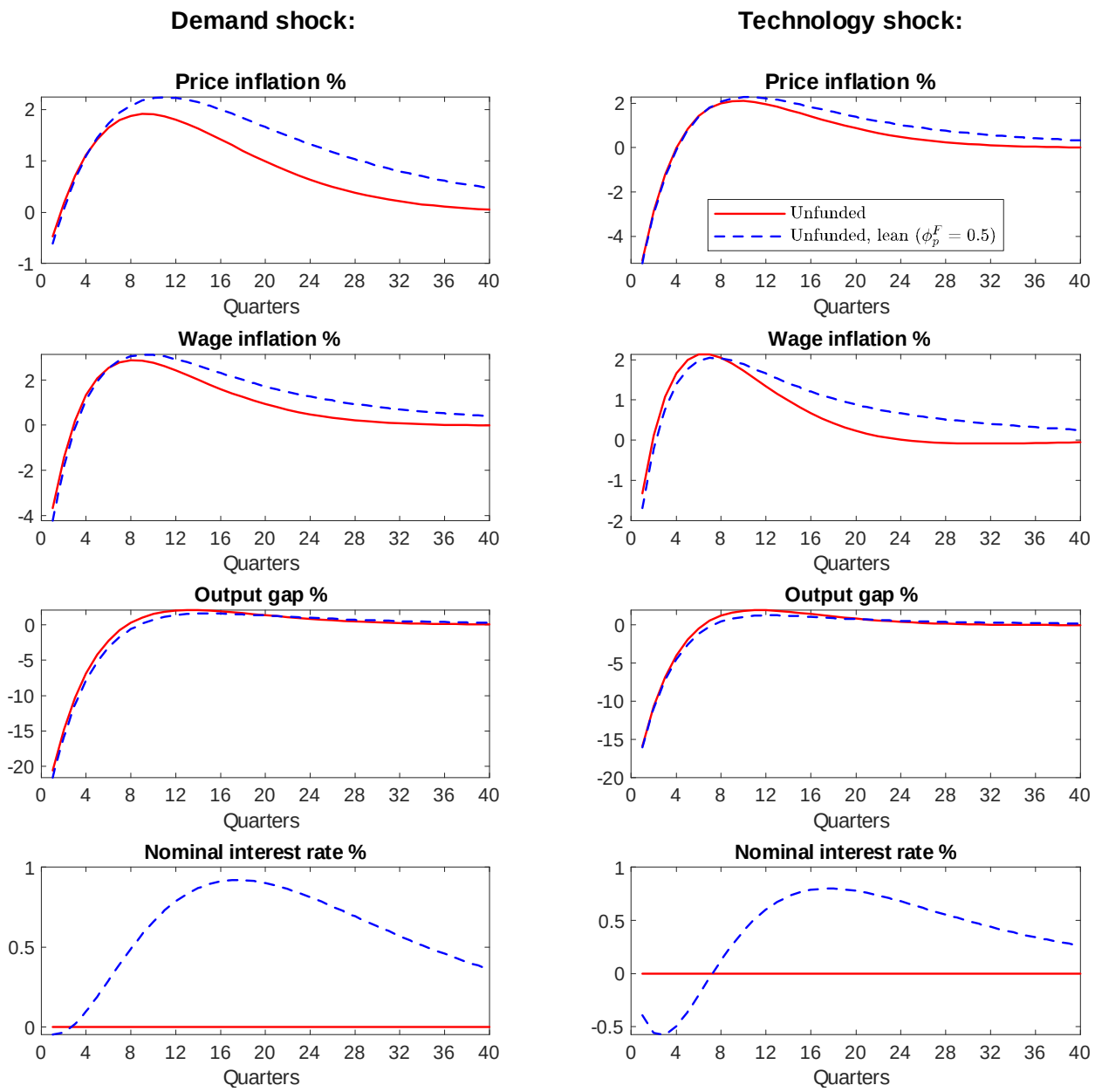


Figure A.1: With unfunded debt ($\gamma = 1$), monetary policy leaning against fiscal inflation can increase the volatility of inflation and the output gap. Response to $-3sd$ demand shock or $+3sd$ technology shock away from ZLB. Annual deviation from steady state.

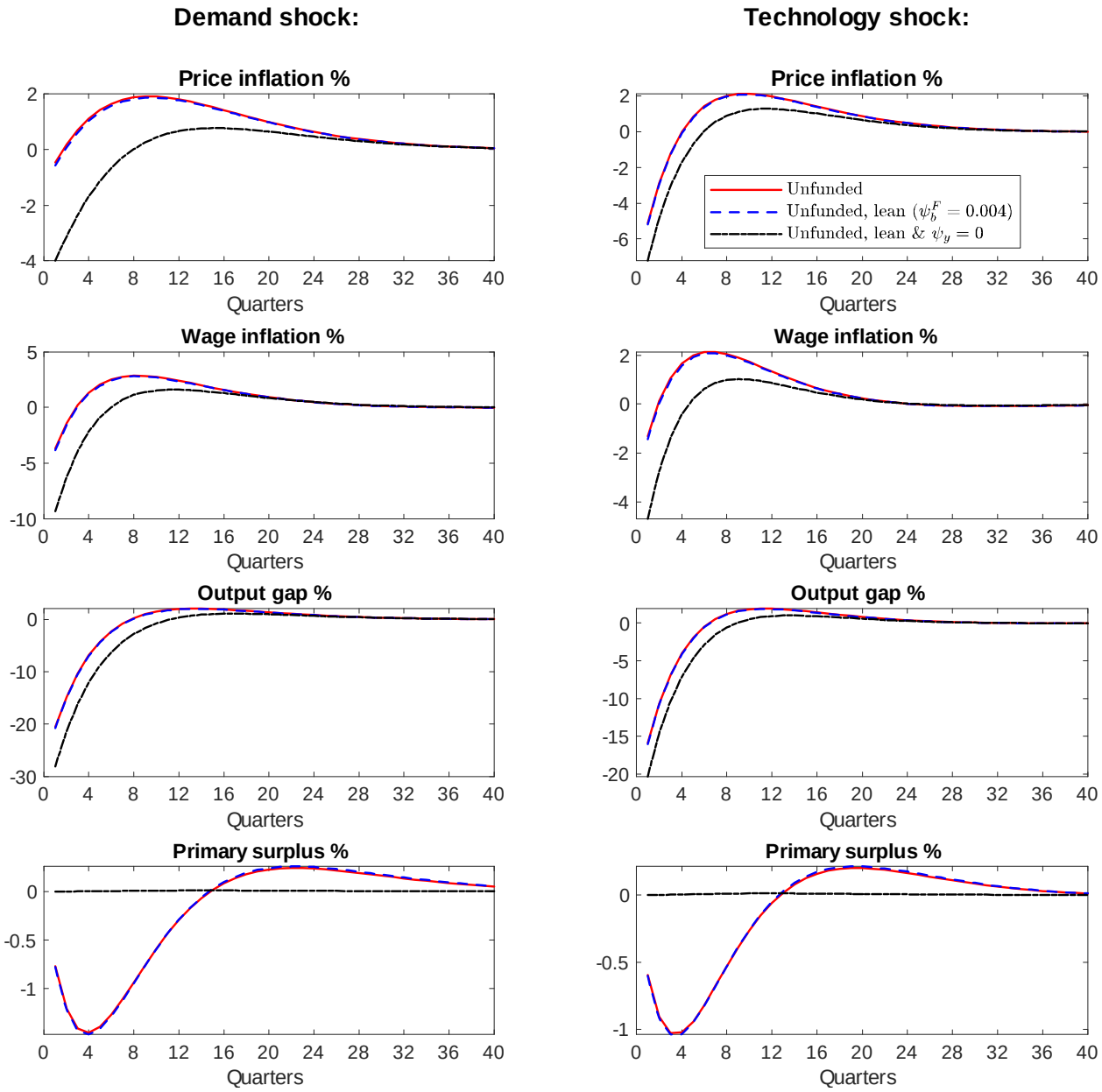


Figure A.2: With unfunded debt ($\gamma = 1$), the automatic fiscal stabilizer ψ_y can make leaning against unfunded debt inconsequential for macroeconomic volatility. Response to $-3sd$ demand shock or $+3sd$ technology shock away from ZLB. Annual deviation from steady state.