The Quantity Channel of Quantitative Easing [†]

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Abstract

This paper shows that fiscal backing is a new channel for quantitative easing (QE) to affect the macroeconomy. Using standard New Keynesian models, we show that if central bank holdings of government debt are not fully backed by current or future taxation, output and inflation increase through a wealth effect. The strength of this effect depends on whether the central bank accommodates the inflation generated by QE. When it does, government debt is partially financed through increases in the price level and debt revaluation, significantly reducing households' real tax obligations. We validate the empirical relevance of this quantity channel using high-frequency identification of QE shocks and daily US fiscal data.

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1 Introduction

"The problem with QE is it works in practice but it doesn't work in theory."
-Ben Bernanke

Following the global financial crisis and the coronavirus pandemic, central banks deployed quantitative easing (QE) programs of unprecedented scale. Over the course of 2020 alone, the Federal Reserve's asset holdings rose by over $3 trillion. Yet the channels through which these interventions affect the macroeconomy and the size of their effects remain unsettled. The theoretical transmission channels central to the literature—portfolio-balance and signaling channels—imply effects in macroeconomic models that are modest relative to the scale of interventions.

This paper proposes a new transmission channel of QE where asset purchases can change not only the fiscal backing of government debt in addition to its maturity outstanding. When central bank holdings of government debt increase, the share of outstanding government debt held by the public falls. If the fiscal authority collects less current or future taxation as a consequence, then QE reduces the present value of households' tax liabilities. In economies where Ricardian equivalence fails, this change in the magnitude or timing of expected taxation raises households' wealth and therefore output and inflation. Because this mechanism depends on the quantity of debt purchased, we refer to it as the quantity channel.

We first illustrate the quantity channel in a framework where the central bank offsets the macroeconomic effects of its own QE program by raising short-term interest rates and the fiscal authority adjusts deficits to ensure solvency. In our two-agent New Keynesian model, Ricardian equivalence is broken through a fraction of households that always consume their income. Consequently, a fall in taxes results in an increase in consumption, which then pushes up aggregate demand, and thus output and inflation. Because the central bank is bound by the Taylor principle, it raises the policy rate to counteract the effects of QE, curtailing the expansionary effect of the policy.

To relax the assumption of the central bank responding to their own QE shocks, we solve a version of the model with funded and unfunded shocks as in Bianchi, Faccini, and Melosi (2023) and Jacobson, Leeper, and Preston (2019). In this setting, the central bank responds aggressively to funded shocks, but accommodates inflation arising from unfunded QE shocks. We document the latter assumption empirically and argue that is natural in the context of QE programs, which are explicitly designed to provide monetary accommodation—as shown by Bhattarai and Neely (2022)—and are often accompanied by forward guidance that short-term interest rates will remain low. In this setting, the fiscal authority only provides partial fiscal backing for the portion of government debt held by the central bank. Because QE reduces the real tax obligations of households without the expectation that future taxes will rise to offset it, output and inflation rise through a wealth effect. Monetary policy accommodates the inflation generated by QE and, as a result, government debt is financed partially through increases in the price level and debt revaluation.

We then turn to US data to test the modeling assumptions necessary for the quantity

channel. We first show that budget deficits are positively associated with the Federal Reserve's government debt holdings. We then provide causal evidence. Following Swanson (2021), we construct a series of exogenous shocks to asset purchases using high-frequency identification of interest rate movements in narrow windows around monetary policy announcements. After extracting a factor corresponding to the effects of QE programs on longer-term yields, we measure the response of daily US tax revenues and government debt issuance to a QE shock. We find that an accommodative shock leads to persistently lower levels of tax revenue and persistently higher levels of government debt—the key assumptions necessary for the quantity channel. We conclude that central bank asset purchases in the US operate, at least in part, via fiscal actions.

Additional empirical evidence supports the interpretation that QE affects the fiscal backing of government debt. The federal funds rate is essentially unchanged following a QE shock, consistent with the idea that the central bank does not offset the inflationary effects of its own QE through short-term interest rate policy. Furthermore, the ratio of the market to par value of privately-held Treasury debt also declines within two years after an accommodative QE shock—the opposite-signed response from the conventional signaling and portfolio-balance channels, which predict that bonds should appreciate as longer-term yields fall. The evidence therefore points to a fiscal effect on yields that counteracts the direct asset-pricing effects emphasized in standard accounts of QE transmission.

While unfunded fiscal shocks and partial fiscal-backing are increasingly examined in the macroeconomics and finance literatures,[1] our paper departs from the standard assumption that fiscal policy does not respond to QE. While we do not take a stance on why taxation and debt supply may respond to QE, Arden, Hauptmeier, and Kamps (2025) show that optimal fiscal policy when interest rates are constrained by an effective lower bound calls for a larger fiscal expansion than would otherwise be the case. Such an expansion may be facilitated by a central bank commitment to keep short-term interest rates low, which reduces expected debt service costs, and by a preannounced path of central bank holdings, which reduces the rollover risk associated with the debt purchased. Moreover, by removing duration risk from private portfolios, central bank purchases reduce the effects of long-term issuance on longer-term yields (Vayanos and Vila, 2021). Asset purchases may also generate expectations of price support in bad future states of the world (Haddad et al., 2023). Larger deficits may therefore be financed at lower term premiums and with less risk of disrupting debt markets. In most markets, supply is assumed to increase when prices rise. Taken together, these factors suggest that allowing fiscal policy to respond to QE could be a better approximation of fiscal actions.

We view this paper's findings as leading to three policy implications. First, because QE affects fiscal backing, it could have more expansionary macroeconomic effects than previously assumed. However, interventions may be more challenging to appropriately calibrate given that the central bank does not control the fiscal stance. Furthermore, the inflationary effects of deficit responses to QE may be difficult for a central bank

[1] Jiang et al. (2024) and Gomez Cram et al. (2024) find that Treasury securities are not fully funded by fiscal surpluses. Gomez Cram et al. (2025) show that term premiums on longer-term government debt may arise as compensation for the inflationary effects of unfunded shocks.

to reverse without breaking a prior commitment to keep policy rates low (Orphanides, 2023). Second, our work provides an additional reason for why monetary policymakers may wish to limit the size of a central bank's balance sheet beyond the usual considerations of market functioning, remittances, or operating frameworks. Central bank holdings of government debt weaken the link between current deficits and future taxation, making inflation or debt revaluation more likely to absorb part of the fiscal burden—a blurring of lines between fiscal and monetary policy that monetary policymakers may wish to avoid. Finally, the effects of QE may be difficult to infer from yield curve movements alone. Over both short event windows or longer horizons, a small observed response of longer-term yields to QE could reflect a genuinely weak financial market effect through portfolio balance channels or a large financial market effect offset by an anticipated fiscal response working in the opposite direction. These cases are observationally equivalent in terms of yield movements, but imply very different paths for output, inflation, and public finances.

Related literature

Our paper relates to several strands of the literature on the macroeconomic effects of QE. Since Wallace (1981), a benchmark result in monetary economics is that open market operations are neutral when the assets exchanged by the central bank are sufficiently close substitutes and fiscal policy is unchanged. Much of the subsequent literature on QE obtains non-neutral effects by relaxing the asset substitutability underlying this result. Two channels have received particular attention: signaling about the path of short-term interest rates and portfolio-balance effects on term premiums.[2] Other work emphasizes financial-intermediary frictions as an additional source of transmission (Gertler and Karadi, 2011). Our paper instead departs from the assumption that fiscal policy remains unchanged when the central bank purchases government debt. The quantity channel operates when QE changes the amount of taxation by changing the quantity of debt held by the public. Our mechanism relates to Auerbach and Obstfeld (2005), who show that open-market purchases can raise the price level in a liquidity trap when the associated increase in the monetary base is expected to be permanent.

A growing heterogeneous agent literature studies how asset purchases affect aggregate activity through redistribution and portfolio rebalancing across households (Cui and Sterk, 2021; Sims, Wu, and Zhang, 2022; Cantore and Meichtry, 2024; Seidl and Seyrich, 2023). Our TANK model builds on macroeconomic frameworks in which Ricardian equivalence is broken by households that consume their current income (Galí, López-Salido, and Vallés, 2007; Caramp and Silva, 2023; Debortoli and Gali, 2025; Bhattarai, Lee, and Yang, 2023). When households are non-Ricardian, Rachel and Ravn (2025) show that monetary and fiscal policies cannot be considered independently. Our mechanism differs from the papers above by directly linking fiscal behavior and the prevailing fiscal/monetary regime to the quantity of debt purchased by the central bank.

[2]See, for example, Vissing-Jorgensen and Krishnamurthy (2011); Bauer and Rudebusch (2014); Vayanos and Vila (2021); Swanson (2021), and Tischbirek (2018). Bhattarai and Neely (2022) provide a comprehensive overview.

Accordingly, our model structure relates closely to the fiscal theory and monetary-fiscal interaction literatures (Leeper, 1991; Woodford, 2001). Cochrane (2014) studies inflation determination in an environment with interest-bearing reserves and a large central bank balance sheet, emphasizing the role of fiscal policy in determining the value of government liabilities. Recent work develops environments in which some fiscal shocks are only partially backed by future primary surpluses (Jacobson, Leeper, and Preston, 2019; Bianchi, Faccini, and Melosi, 2023). Our setting applies this logic to QE shocks backed only by debt held by the public. The inflation generated by unfunded QE shocks depends on the extent to which central bank holdings are backed by future taxation. Relatedly, Caramp and Silva (2023) show analytically that the transmission of monetary policy depends on the fiscal response that accompanies it, while Kolasa, Walerych, and Wesolowski (2025) find that the magnitude of fiscal stimulus influences the macroeconomic effects of asset purchase programs. With respect to expectations formation, Andrade, Gautier, Mengus, Moench, and Schmidt (2025) find that beliefs about fiscal backing influence households' inflation expectations.

A final related literature studies central bank solvency and the consolidated government balance sheet. Del Negro and Sims (2015) derive conditions under which a central bank requires fiscal support to maintain control of inflation, while Hall and Reis (2015, 2017); Reis (2017) study central bank financial stability, interest on reserves, and the fiscal consequences of central-bank balance-sheet policies. Li and Merkel (2026) make the case that QE worsens government debt sustainability by decreasing central bank capital. From the stance of policy evaluation, Adrian, Erceg, Kolasa, Lindé, and Zabczyk (2026), Levin, Lu, and Nelson (2022), and d'Avernas, Hubert de Fraisse, Ning, and Vandeweyer (2024) quantify the macroeconomic and fiscal consequences of QE and the interest rate risk associated with a large central bank balance sheet. Our paper also adopts a consolidated view of government liabilities, but focuses on a different margin. Rather than asking how gains, losses, or remittances from the central bank ultimately affect the fiscal authority, we ask how central bank ownership of government debt may change fiscal actions. When the central bank holds and rolls over a portion of outstanding government debt, future primary surpluses need not respond to that debt in the same way as they respond to debt held by the public.

Our paper proceeds as follows: Section 2 presents theory illustrating the quantity channel. Section 3 presents empirical evidence in support of the theoretical predictions. Section 4 concludes.

2 Modeling the Quantity Channel

The economy comprises a fiscal authority, a central bank, two household types, and a standard New Keynesian production sector. For financial assets, curly fonts indicate quantity supplied and non-curly fonts quantity demanded. We illustrate the quantity channel using two models, each of which breaks Ricardian equivalence. We begin by describing the elements common to both models.

Government budget constraint and central bank balance sheet. The government budget constraint is given as:

$$(1 + Q_t^P \mu)\mathcal{B}_{t-1} + P_t G_t = Q_t^P \mathcal{B}_t + P_t T_t + P_t \Lambda_t \tag{1}$$

Where the government issues multi-period debt $\mathcal{B}_t$ at price Q_t^P. As in Woodford (2001), long-term bonds are perpetuities paying an exponentially decaying coupon $\{\mu, \mu^2, ...\}$ for $\mu \in (0, 1]$.[3] Debt is one period if $\mu = 0$ and consol debt if $\mu = 1$. The government collects taxes from households T_t, spends G_t, and receives remittances Λ_t from the central bank. T_t is split between each type of household which will be defined in more detail for each model.

The central bank balance sheet is:

$$Q_t^P B_t^{CB} - Q_t^R \mathcal{M}_t = (1 + Q_t^P \mu) B_{t-1}^{CB} - \mathcal{M}_{t-1} - P_t \Lambda_t \tag{2}$$

Where the central bank buys quantity B_t^{CB} of government debt at price Q_t^P and funds it by issuing reserves $\mathcal{M}_t$ to households at price Q_t^R. To ensure that the central bank's balance sheet is bounded and well-defined, we assume that per-period bond purchases equal the cost of issuing reserves.

$$Q_t^P B_t^{CB} - Q_t^R \mathcal{M}_t = 0$$

Asset markets clear such that (1) households and the central bank buy bonds issued by the fiscal authority and (2) households buy reserves issued by the central bank.

$$\mathcal{B}_t = B_t^P + B_t^{CB} \tag{3}$$
$$\mathcal{M}_t = M_t \tag{4}$$

Production and firms. We use the Woodford (2004) Phillips Curve with Calvo (1983) pricing. In this setting, there are strategic complementarities such that there is firm-specific labor input. A continuum of monopolistically competitive intermediate-goods firms, $i \in [0, 1]$ produces differentiated varieties of goods with a constant elasticity of substitution, $\theta > 1$, between goods. There is a demand schedule for firm i and aggregate demand Y_t:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\theta} Y_t$$

$P_t(i)$ and $P_t \equiv \left[\int_0^1 p_t(i)^{1-\theta} di\right]^{1/(1-\theta)}$ are the price levels of firm i and the aggregate economy, respectively.

Each firm produces output using linear production technology, which is consistent with the estimates of Gagliardone et al. (2025) at the sectoral and aggregate levels.

$$Y_t(i) = N_t(i)$$

[3] Bhattarai et al. (2023) allow the debt maturity μ to be time-varying and match the government liabilities outstanding held by the public.

Consequently, the real marginal cost of firm i is identical to its real wage,

$$w_t(i) = mc_t(i)$$

Nominal prices are subject to standard Calvo frictions. In each period, a fraction $1-\phi$ of firms can reset their price. Log-linearizing the optimal price-setting condition and the aggregate price index around a zero-inflation steady state yields

$$\pi_t = \beta \mathbb{E}_t[\pi_{t+1}] + \Theta\, \widehat{w}_t, \qquad \Theta = \frac{(1-\phi)(1-\beta\phi)}{\phi(1+\theta\varphi)} \tag{5}$$

where φ is the inverse Frisch elasticity of labor supply. Appendix A provides the complete derivation of the optimal reset price and the Phillips curve. Appendix A.1 discusses the assumptions that deliver the same Phillips curve for the TANK and partial FTPL models.

2.1 A Two-Agent New Keynesian Model

The optimzer households (P) save in long-term bonds issued by the fiscal authority ($\mu \in (0,1]$) and one-period reserves issued by the central bank. We assume the other households are hand-to-mouth (HtM) such that they consume their income less taxes each period. Both households have preferences over goods consumption, C_t^j, and disutility of firm-specific labor $N_t^j = \int_0^1 N_t^j(i)di$ for $j = \{P, HtM\}$. The risk aversion and inverse Frisch-elasticity parameters are σ and φ, respectively. The optimizer households hold reserves and long-term bonds, M_t and B_t^P, respectively, with transaction cost, ζ_t, as in Adrian et al. (2026).[4] Each household earns a wage, W_t, and pays lump-sum taxes $\{T_t^P, T_t^{HtM}\}$.

The maximization problem for optimizer households (type P) is:

$$\max_{\{C_t^P, N_t^P, B_t^P, M_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t^P)^{1-\sigma}}{1-\sigma} - \frac{(N_t^P)^{1+\varphi}}{1+\varphi} \right)$$

subject to

$$P_t C_t^P + (1+\zeta_t) Q_t^P B_t^P + Q_t^R M_t = (1+\mu Q_t^P) B_{t-1}^P + M_{t-1} + W_t N_t^P - P_t T_t^P + \chi_t, \tag{6}$$

The bond adjustment costs ζ_t are rebated lump sum back to P households via χ_t and are assumed to satisfy:

$$\frac{1+\zeta_t}{1+\zeta} = \left(\frac{B_t^P}{B^P} \right)^{\xi}, \tag{7}$$

for $\xi > 0$ so that a decrease in holdings of government debt by the public B_t^P—as occurs with QE—reduces the term premium. Consequently, $\zeta = 0$.

[4] Results with preferences over reserves and bonds as in Nagel (2016) are available upon request.

Euler equations for the optimizer households are below. Let $w_t = W_t/P_t$:

$$Q_t^P = \mathbb{E}_t \left[\frac{\beta}{1+\zeta_t} \left(\frac{C_{t+1}^P}{C_t^P} \right)^{-\sigma} \frac{(1+\mu Q_{t+1}^P)}{\pi_{t+1}} \right] \tag{8}$$

$$Q_t^R = \mathbb{E}_t \left[\beta \left(\frac{C_{t+1}^P}{C_t^P} \right)^{-\sigma} \frac{1}{\pi_{t+1}} \right] \tag{9}$$

$$w_t = \left(C_t^P \right)^{\sigma} \left(N_t^P \right)^{\varphi} \tag{10}$$

For hand-to-mouth households (HtM), the optimization problem is:

$$\max_{\{C_t^{HtM}, N_t^{HtM}\}} \frac{(C_t^{HtM})^{1-\sigma}}{1-\sigma} - \frac{(N_t^{HtM})^{1+\varphi}}{1+\varphi}$$

subject to

$$C_t^{HtM} = w_t N_t^{HtM} - T_t^{HtM} \tag{11}$$

Because the problem is static, this yields an intratemporal Euler equation:

$$w_t = \left(C_t^{HtM} \right)^{\sigma} \left(N_t^{HtM} \right)^{\varphi}. \tag{12}$$

As is standard, labor supply can differ across the two types of households. Aggregate consumption and labor supply are thus,

$$C_t = (1-\eta) C_t^P + \eta C_t^{HtM}$$
$$N_t = (1-\eta) N_t^P + \eta N_t^{HtM}$$

Where $\eta \in [0,1]$ is the population weight on the types of households in the economy, such that η is the share of hand-to-mouth households and $1-\eta$ the share of optimizers.

Following Leeper (1991) and Galí et al. (2007), lump-sum net taxes T_t^P and T_t^{HtM} follow rules where the parameters γ^P and γ^{HtM} determine how strongly the government adjusts taxes in response to government debt outstanding. The higher γ^P or γ^{HtM}, the more swiftly taxes are adjusted to pay down debt. Let real debt held by the public be defined as $b_t^P = B_t^P/P_t$. The tax rules are thus,

$$T_t = (1-\eta) T_t^P + \eta T_t^{HtM} \tag{13}$$

$$\frac{T_t^P}{T^P} = \left(\frac{b_{t-1}^P}{b^P} \right)^{\gamma^P} \tag{14}$$

$$\frac{T_t^{HtM}}{T^{HtM}} = \left(\frac{b_{t-1}^P}{b^P} \right)^{\gamma^{HtM}} \tag{15}$$

We posit rules where taxes only need to be adjusted to finance debt held by the public b_t^P and not total debt $b_t = \mathcal{B}_t/P_t$, which includes debt held by the central bank.

Market clearing conditions for bonds and reserves reflect the share of optimizing households in the economy, $(1-\eta)$, that hold these assets:

$$\mathcal{B}_t = (1-\eta) B_t^P + B_t^{CB} \tag{16}$$
$$\mathcal{M}_t = (1-\eta) M_t \tag{17}$$

Aggregating and summing across all budget constraints yields the following aggregate resources constraint:

$$(1-\eta) C_t^P + \eta C_t^{HtM} + G_t = Y_t \tag{18}$$

Taken together, the log-linearized Euler equations, balance sheet conditions, and market clearing yield the system of equations. Let $\hat{i} = -\hat{q}_t^R$ and $m_t = M_t / P_t$.

$$\hat{q}_t^P + \hat{i}_t = \mu\beta \mathbb{E}_t[\hat{q}_{t+1}^P] - \hat{\zeta}_t \tag{19}$$
$$\hat{c}_t^P = \mathbb{E}_t[\hat{c}_{t+1}^P] - \sigma^{-1}\left(\hat{i}_t - \hat{\pi}_{t+1}\right) \tag{20}$$
$$\hat{c}_t^{HtM} = \frac{w N^{HtM}}{C^{HtM}}(\hat{w}_t + \hat{n}_t^{HtM}) - \frac{T^{HtM}}{C^{HtM}}\hat{\tau}_t^{HtM} \tag{21}$$
$$\hat{w}_t = \sigma \hat{c}_t^P + \varphi \hat{n}_t^P \tag{22}$$
$$\hat{w}_t = \sigma \hat{c}_t^{HtM} + \varphi \hat{n}_t^{HtM} \tag{23}$$
$$\hat{\pi}_t = \beta \mathbb{E}_t[\hat{\pi}_{t+1}] + \Theta \hat{w}_t \tag{24}$$
$$\hat{b}_t = (\mu - 1)\hat{q}_t^P + \left(\frac{1}{Q^P} + \mu\right)\left(\hat{b}_{t-1} - \hat{\pi}_t\right) + \frac{g}{Q^P b}\hat{g}_t - \frac{\tau}{Q^P b}\hat{\tau}_t - \frac{\Lambda}{Q^P b}\hat{\Lambda}_t \tag{25}$$
$$\Lambda\hat{\Lambda}_t = \mu b^{CB} Q^P \hat{q}_t^P + (1 + Q^P \mu) b^{CB}(\hat{b}_{t-1}^{CB} - \hat{\pi}_t) - m(\hat{m}_{t-1} - \hat{\pi}_t) \tag{26}$$
$$\hat{b}_t = \omega \hat{b}_t^{CB} + (1-\omega)(1-\eta)\hat{b}_t^P \tag{27}$$
$$\hat{y}_t = (1 - s_g)\hat{c}_t + s_g \hat{g}_t \tag{28}$$
$$\hat{c}_t = \eta \hat{c}_t^{HtM} + (1-\eta)\hat{c}_t^P \tag{29}$$
$$\hat{n}_t = \eta \hat{n}_t^{HtM} + (1-\eta)\hat{n}_t^P \tag{30}$$
$$\hat{y}_t = \hat{n}_t \tag{31}$$

For $s_g = G/Y$ and $\omega = b^{CB}/b$.

Tax rules are given as before:

$$\tau\hat{\tau}_t = \eta \tau^{HtM}\hat{\tau}_t^{HtM} + (1-\eta)\tau^P \hat{\tau}_t^P \tag{32}$$
$$\hat{\tau}_t^P = \gamma^P \hat{b}_{t-1}^P \tag{33}$$
$$\hat{\tau}_t^{HtM} = \gamma^{HtM}\hat{b}_{t-1}^P \tag{34}$$

The model is closed by the interest rate rule:

$$\hat{i}_t = \phi_\pi \hat{\pi}_t \tag{35}$$

And the bond adjustment cost log-linearized to,

$$\hat{\zeta}_t = \xi \hat{b}_t^P$$

The only exogenous shock in the model is the QE shock to central bank asset holdings, $\hat{b}_t^{CB}$, which evolves according to the rule below. Government spending is set at its steady-state value, $\hat{g}_t = g$.

$$\hat{b}_t^{CB} = \gamma^{\Lambda} \hat{b}_{t-1}^{CB} + \epsilon_t$$

$$\epsilon_t = \rho_{\Lambda} \epsilon_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma_{\Lambda}^2)$$

Table 1 shows the parameterization of the model. Parameters are as standard as possible with sources listed for where they are found in the literature. Steady-state taxation is set such that per-capita consumption is equal across households.

Parameter	Value	Description	Source
Households			
β	0.99	Discount factor	Standard
σ	2.0	Risk aversion / IES	Standard
φ	1.0	Inverse Frisch Elasticity	Rupert and Šustek (2019)
ξ	0.02	Long-term debt adj. cost	Adrian et al. (2026)
η	0.23	Share of HtM Households	Bhattarai et al. (2023)
τ^{HtM}	0.02	Tax revenue, household HtM	Equal consumption
τ^{P}	0.6875	Tax revenue, household P	Equal consumption
Production and Price Setting			
θ	10	Elasticity of sub. between goods	Woodford (2004)
ϕ	0.66	Share of firms who hold prices	Standard
Monetary Policy			
ϕ_{π}	1.5	Taylor rule	Bianchi et al. (2023)
Fiscal Policy			
γ^{P}	10	Tax response to debt, P	
γ^{HtM}	2	Tax response to debt, HtM	
μ	0.9596	Debt maturity, 5 years	Standard
$b/(4Y)$	0.5	Debt-to-GDP ratio, quarterly	Bhattarai et al. (2023)
g/Y	0.11	Gov't spending-to-GDP	Leeper et al. (2017)
Central Bank			
ω	0.2	Central bank share of debt	
ρ_{Λ}	0.8	Persistence of QE shock	
σ_{Λ}^2	0.01Y	1% of output	

Table 1: TANK Model Parameters

Proposition 1. *A QE shock is expansionary such that output and inflation, $\hat{y}_t$, and $\hat{\pi}_t$, respectively, rise on impact, as shown in figure 1.*

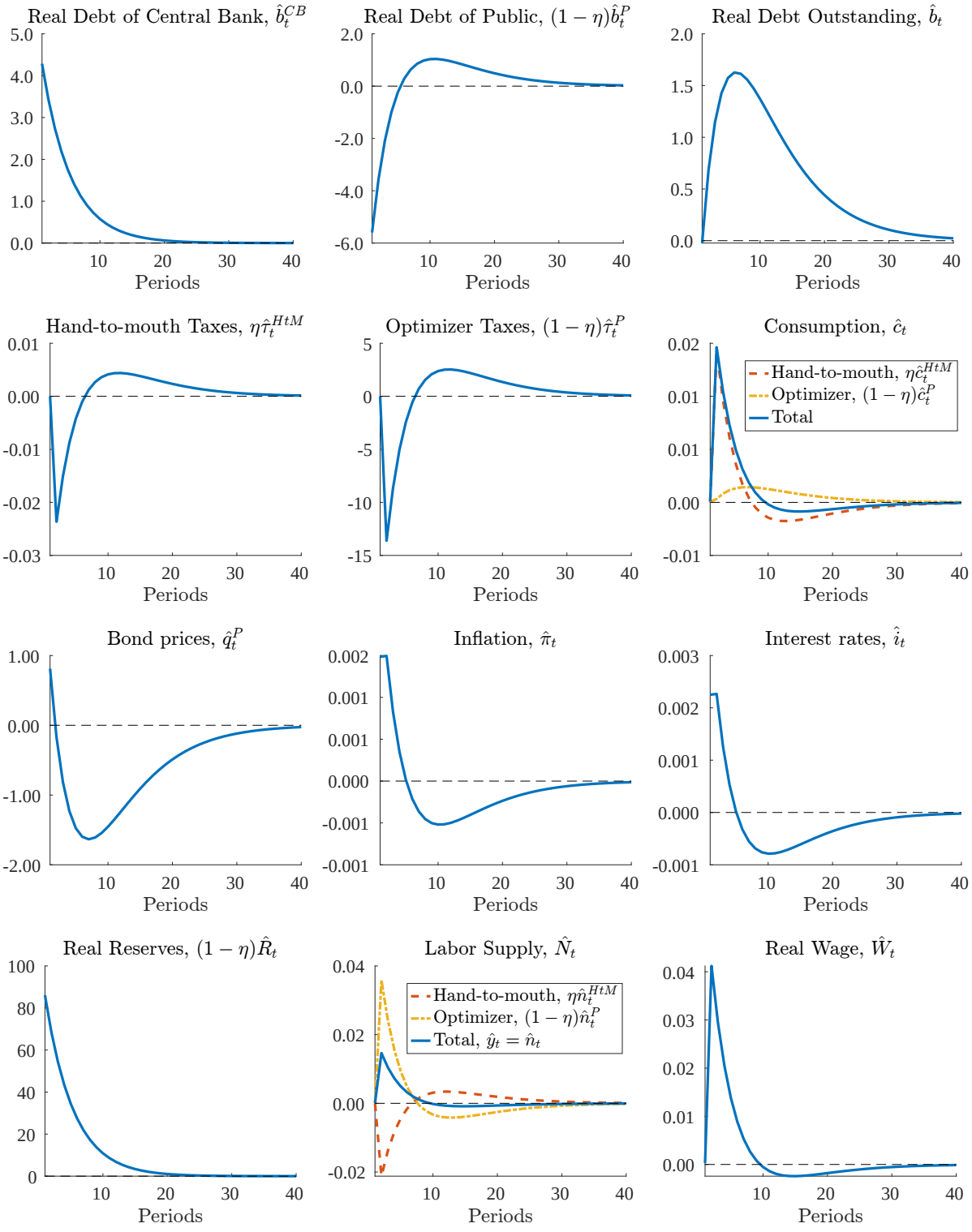


Figure 1: Impulse Response of TANK Model to a QE shock, $\hat{b}_t^{CB}$, equal to 1% of GDP, Percent.

The first row of figure 1 shows that the QE shock, $\hat{b}_t^{CB}$, results in a drop in debt held by the public, $(1-\eta)\hat{b}_t^P$, and little change in total debt outstanding, $\hat{b}_t$. These dynamics can be accounted for by equations (27) and (25), the market clearing condition for debt and the government budget constraint, respectively. The increase in central bank assets, $\hat{b}_t^{CB}$, pushes up the right side of equation (27), but the left side is mostly pinned down by equation (25) because steady-state remittances, Λ, are small and most other terms are pre-determined by time t. Consequently, the quantity of debt held by the public, $(1-\eta)\hat{b}_t^P$, must fall to clear the debt market.

The second row of figure 1 shows how the QE shock decreases taxes on households, which, in turn, pushes up aggregate demand. Taxes fall for both households, $\hat{\tau}_t^{HtM}$ and $\hat{\tau}_t^P$, in response to the QE shock because the tax rules are both based on lagged debt held by the public, $\hat{b}_{t-1}^P$, as shown in equations (34) and (33). Even if the parameters governing the responsiveness of taxes to debt, γ^{HtM} and γ^P, were equal, the magnitudes of the impulse responses would still differ for two reasons. First, the impulse responses are scaled by the aggregation weights $\eta = 0.23$ and $(1-\eta) = 0.77$. Second, steady-taxes, τ^P and τ^{HtM}, differ because they are set so that steady-state consumption is equal across both types of agents as is standard in the literature (Galí et al., 2007). As taxes decrease for hand-to-mouth households, their consumption, $\hat{c}_t^{HtM}$, mechanically rises because they cannot smooth consumption. Their increase in consumption raises aggregate demand, which then pushes up output, $\hat{y}_t$. Because aggregate demand increases, optimizer households increase consumption, $\hat{c}_t^P$, as well, but to a much smaller extent than the hand-to-mouth households. This is because their consumption is attributable to a wealth effect from the increase in long-term bond prices, $\hat{q}_t^P$, shown in the first panel of row 3. As long-term bond prices rise, these households become wealthier and increase consumption.

The third row of figure 1 shows that the QE shock pushes up inflation and interest rates in addition to bond prices. Inflation, $\hat{\pi}_t$, rises because of the increase in aggregate demand—the prices of goods rise so that the quantity of consumption goods demanded equals that supplied. Interest rates $\hat{i}_t$ rise by more than one-for-one in response to the increase in inflation because the central bank follows the Taylor Principle, $\phi_\pi > 1$. The assumption that the central bank responds to inflationary shocks it generates will be relaxed in the following section. The price of long-term bonds $\hat{q}_t^P$ rises rather than falls because of the adjustment cost detailed in equation (7). Otherwise, a drop in debt held by the public—as occurs with central bank asset purchases—would reduce the term premium, which is opposite of what is observed in practice.

2.1.1 TANK Model Properties

Proposition 2. *The macroeconomic effects of QE are increasing in the share of hand-to-mouth households, η, such that higher inequality results in larger macroeconomic effects.*

Figure 2 shows that a QE shock is relatively more expansionary when the share of hand-to-mouth households, η, is higher. As the share of hand-to-mouth households increases from $\eta = 0.23$ in the baseline (solid blue lines) to 0.30 (yellow dashed lines), output, inflation, and total consumption increase by more in response to the same-sized

shock to central bank assets. This is because hand-to-mouth households have a larger marginal propensity to consume than optimizers so that when there are more of them output rises by more, which, in turn, pushes up consumption of optimizing households via a wealth effect. See figure B.1 in Appendix B.1 for all impulse responses.

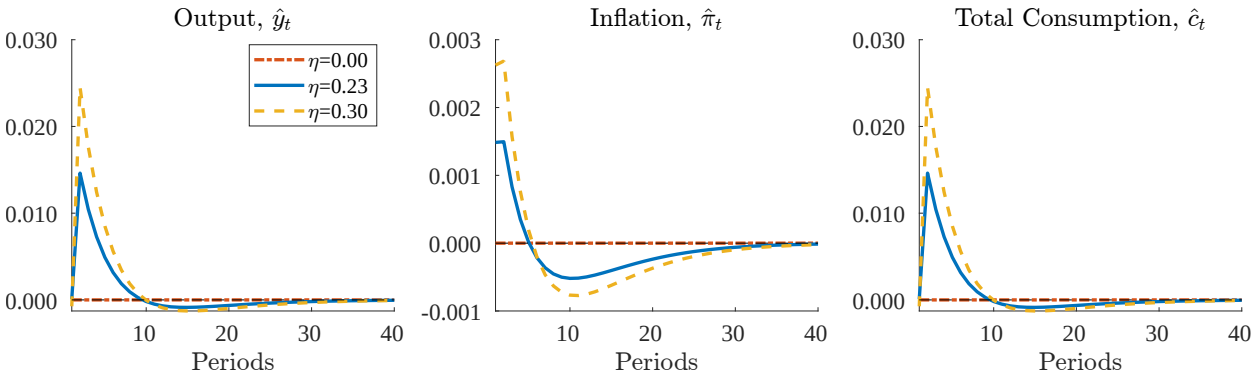


Figure 2: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent. The baseline is the solid blue line with $\eta = 0.23$. See figure B.1 in Appendix B.1 for all impulse responses.

Corollary 2.1. *If all households are optimizers such that $\eta = 0$, Ricardian equivalence holds and there are no macroeconomic effects of QE.*

The dashed red lines in figure 2 show that QE has no effect on the macroeconomy when $\eta = 0$. This is because all households are optimizers who know that a decrease in taxes in the present will be financed by future taxation and do not adjust consumption. Consequently, there is no change in aggregate demand, which results in output and inflation also remaining unchanged.

Proposition 3. *The macroeconomic effects of QE are increasing in the portion of debt outstanding held by the central bank, ω.*

Figure 3 shows that a higher share of total debt held by the central bank in the steady state, ω, leads to larger macroeconomic effects of QE. The top panel of figure 3 shows that a larger ω results in more debt purchased by the central bank, a larger initial decline in debt held by the public, and a bigger increase in debt outstanding. This larger decrease in debt held by the public results in a relatively larger tax cut to households. Hand-to-mouth households respond by consuming more, which pushes up output and inflation.

Proposition 4. *If taxes collected on hand-to-mouth households are more responsive to the level of debt held by the public, the larger the macroeconomic effects of QE. The opposite is true for taxes collected on optimizer households.*

The top two rows of figure 4 show that a QE-induced tax decrease to hand-to-mouth households is larger when taxes are more responsive to lagged debt held by the public, via

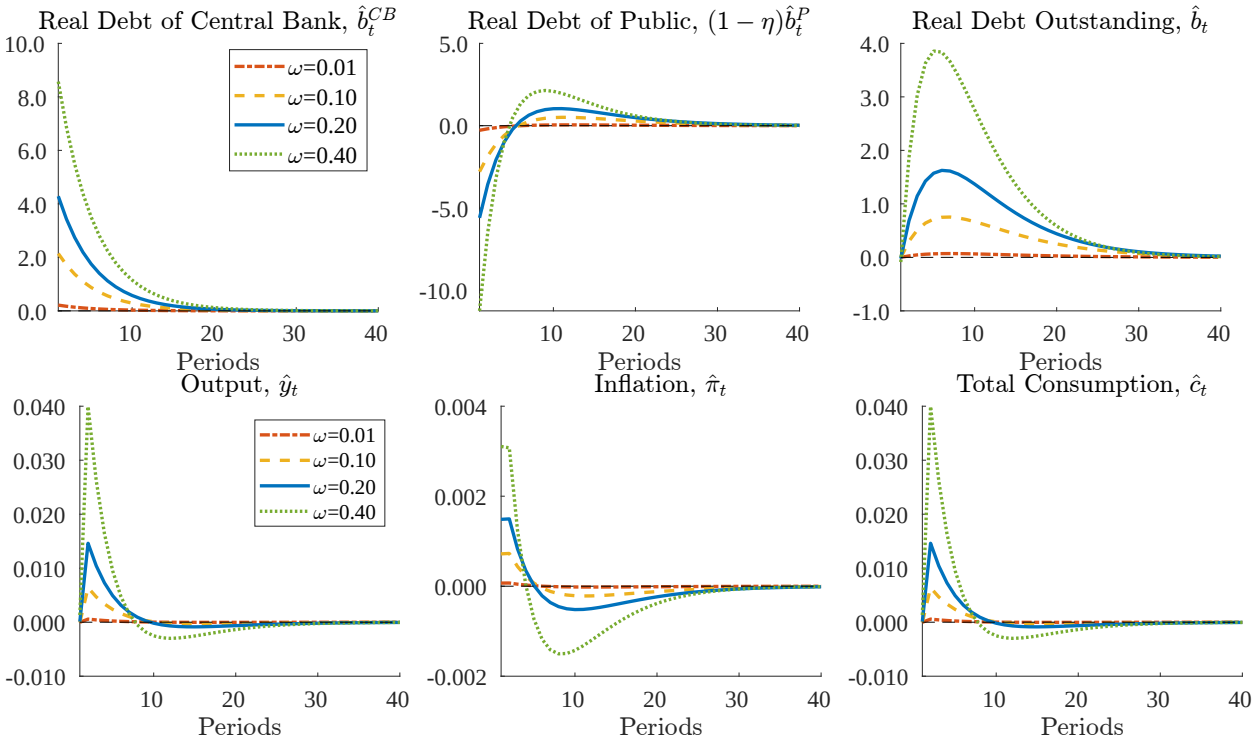


Figure 3: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent. The baseline is the solid blue line with $\omega = 0.2$. See figure B.2 in Appendix B.1 for all IRFs.

a larger value of γ^{HtM}. These panels show that the responsiveness parameter γ^{HtM} has little effect on optimizer taxes or real debt held by the public, such that the simulations shown are similar. However, this parameter affects hand-to-mouth consumption, which then affects output and inflation. As γ^{HtM} rises, the effects of an asset purchase shock on output and inflation increase in size as well. The red dashed line corresponding to $\gamma^{HtM} = 0$ shows that the QE shock has no macroeconomic effects when there are no taxes collected on hand-to-mouth households. This is because $\hat{c}^{HtM} = \hat{y}_t$ and there is no channel for the consumption of these households to adjust in response to QE. As discussed in corollary 2.1, optimizers are Ricardian and therefore unaffected by a decrease in taxes today because they know that future taxes will rise in the future. In fact, Appendix B.2 discusses the values of tax responsiveness parameters that allow for a determinate equilibrium.

The bottom two rows of figure 4 show the opposite of the top two rows. That is, consumption of hand-to-mouth households, and hence output and inflation, are all larger when the taxes collected on optimizer households are *less* responsive to lagged debt via a smaller value of γ^{P}. This is because debt held by the public decreases by relatively more, which leads to a larger tax cut on hand-to-mouth households, and hence higher consumption.

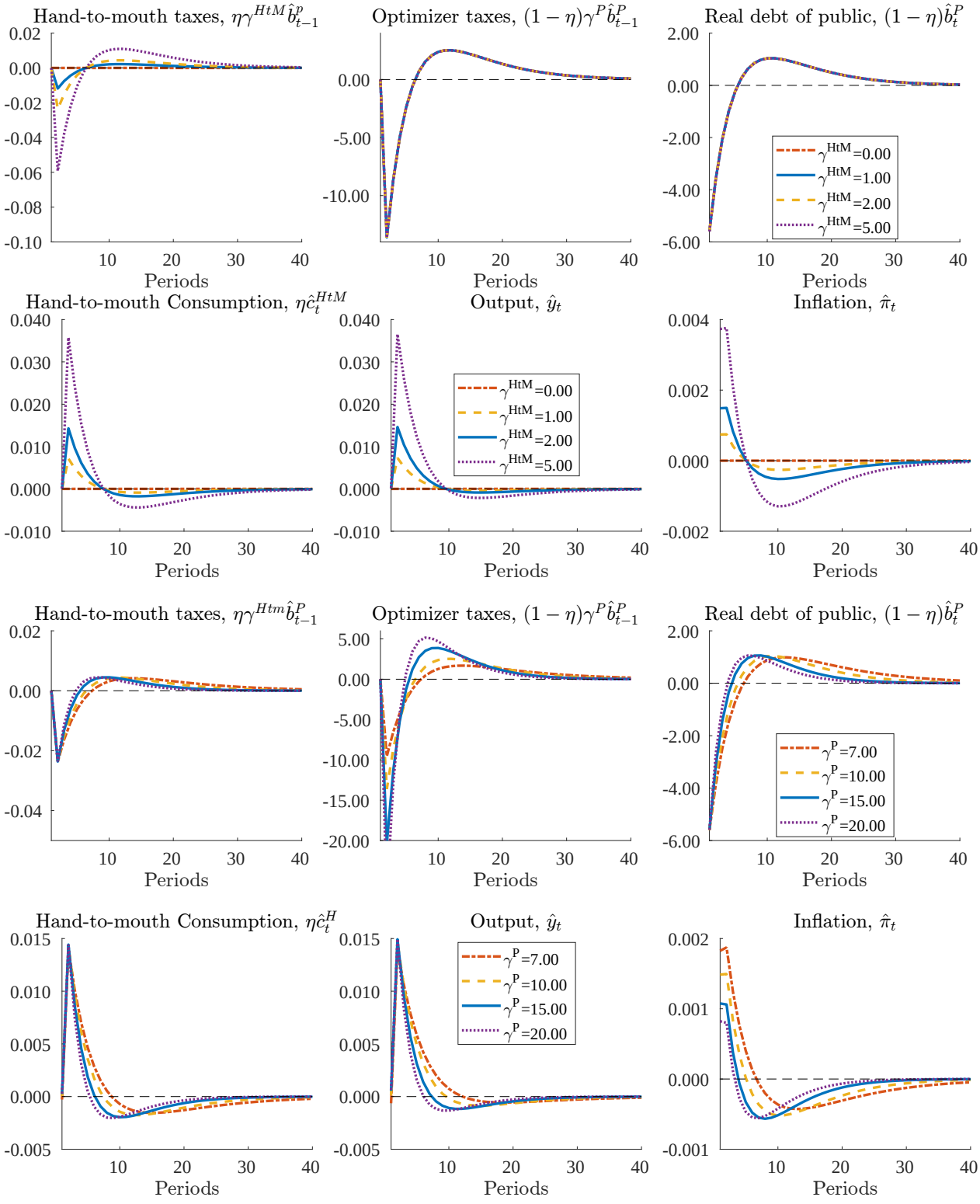


Figure 4: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}^{CB}_{t}$, Percent. See figures B.3 and B.4 in Appendix B.1 for all IRFs.

2.1.2 TANK Model Robustness

Additional results can be found in Appendix B.1. Figure B.5 shows that the responsiveness of monetary policy to inflation, ϕ_π, affects the impulse response of inflation, but has little effect on output and consumption. Figure B.6 shows that changing steady-state debt outstanding b does little to the effects of a QE shock on the macroeconomy. Same for the duration of debt, μ, shown in figure B.7 and steady-state government spending, g, shown in figure B.8. Figure B.9 shows that the persistence of the asset purchase shock, ρ_Λ, affects the size and duration of the macroeconomic response. Figure B.10 shows that an asset purchase shock propagates through the economy differently than tax cut shocks even though the asset purchase shock transmits to the real economy via tax rules. Figure B.11 shows that there are no macroeconomic effects of a QE shock if the tax rules in equations (33) and (34) are based on total debt instead of debt held by the public. Appendix B.2 explores the determinacy properties of the policy parameters.

2.2 Partial Fiscal Theory of the Price Level Model

The model is a case where $\eta = 0$ such that there are only optimizer households (superscript P as before). There is also a shadow economy (superscript S) that replicates the main economy exactly except for the policy rules, which, in their log-linearized form, are the following:

$$\hat{\tau}_t^P = \gamma^P(\hat{b}_{t-1}^P - \hat{b}_{t-1}^{P,S}) + \gamma^S \hat{b}_{t-1}^{P,S} \tag{36}$$

$$\hat{i}_t = \phi_\pi^P(\hat{\pi}_t - \hat{\pi}_t^S) + \phi_\pi^S \hat{\pi}_t^S \tag{37}$$

$$\hat{\tau}_t^S = \gamma^S(\hat{b}_{t-1}^{P,S}) \tag{38}$$

$$\hat{i}_t^S = \phi_\pi^S \hat{\pi}_t^S \tag{39}$$

The log-linearized equations for this model are in Appendix C. There are two QE shocks: one in the main economy and the other in the shadow economy, b_t^{CB} and $b_t^{CB,S}$, respectively. The QE shock in the main economy is Ricardian and is equivalent to regime M in the parlance of Leeper (1991) because the Taylor Principle holds such that the nominal interest rate responds more than one-for-one to inflation and fiscal policy passively ensures its backing. ϕ_π^P is set at its value in the TANK model, while γ^P is set at the lowest possible value for a determinate solution. Figure C.2 in Appendix C.1 shows that this parameter has no effect on the magnitudes of IRFs.

$$\begin{aligned} 1 &< \phi_\pi^P = 1.5 \\ Q^P b(1-\beta)/\tau &< \gamma^P = 1.587 \end{aligned}$$

By contrast, the QE shock is expansionary in the shadow economy because monetary policy accommodates inflation and fiscal policy actively determines the price level, which is equivalent to regime F in Leeper (1991).

$$\begin{aligned} 1 &> \phi_\pi^S = 0 \\ Q^P b(1-\beta)/\tau &> \gamma^S = 0.5 \end{aligned}$$

With the coefficient on inflation in the shadow economy set at $\phi_\pi^S = 0$, the Taylor rule of the main economy in equation (37) becomes,

$$\hat{i}_t = \phi_\pi^P(\hat{\pi}_t - \hat{\pi}_t^S)$$

Because the inflation response to the QE shocks originates from the unfunded shock in the shadow economy, by setting this coefficient to zero, it relaxes the assumption in the TANK model that the central bank is responding to its own inflationary shocks.

Figure 5 below shows that the QE shock, $\hat{b}_t^{CB}$, in the main economy is fully funded, while it is unfunded in the shadow economy, $b_t^{CB,S}$. In the case of the former, there are no effects of QE on the macroeconomy, as shown by the solid blue lines. This is because agents know that the decrease in taxes in response to the QE shock will eventually have to be offset by higher taxes and aggregate demand remains unchanged. Consequently, consumption, output and inflation do not rise.

By contrast, the QE shock from the shadow economy, $\hat{b}_t^{CB,S}$, is unfunded, as shown by the dashed red lines. This results in macroeconomic responses that are non-Ricardian, like those shown for the TANK model in the previous section. Because the QE-induced tax decline is not expected to be offset by higher future taxes, agents feel wealthier and increase their demand for goods. This in turn leads them to work more and production to expand. Prices rise to offset this increased demand for goods, but interest rates do not offset this increase. In fact, interest rates do not respond at all, which is consistent with what is observed in practice. That is, the federal funds rate was near zero when all QE programs were undertaken by the Fed.

2.2.1 Partial FTPL Model Robustness

Additional results can be found in Appendix C.1. Figure C.1 shows that the size of the macroeconomic response is increasing in the share of debt held by the central bank, ω. Figure C.2 shows that the sensitivity of taxes to debt of the main economy, γ^P, has no effect on the size of the macroeconomic response. By contrast, the macroeconomic response is increasing in γ^S, the tax sensitivity to debt in the shadow economy, as shown in figure C.3. Figure C.4 shows that the macroeconomic response is decreasing in the responsiveness of monetary policy to unfunded inflation, ϕ_π^S. Figure C.5 shows that the macroeconomic response is increasing in steady-state debt outstanding b. Same for the duration of debt, μ, shown in figure C.6 and steady-state government spending, g, shown in figure C.7. Figure C.8 shows that the persistence of the QE shock, ρ_Λ, affects the size and duration of the macroeconomic response. Figure C.9 shows that the QE shock propagates through the economy similarly, which is the opposite of that in the TANK model. Figure C.10 shows that there is an opposite macroeconomic effect to an increase in asset purchases if the tax rules in equations (36) and (38) are based on total debt instead of debt held by the public.

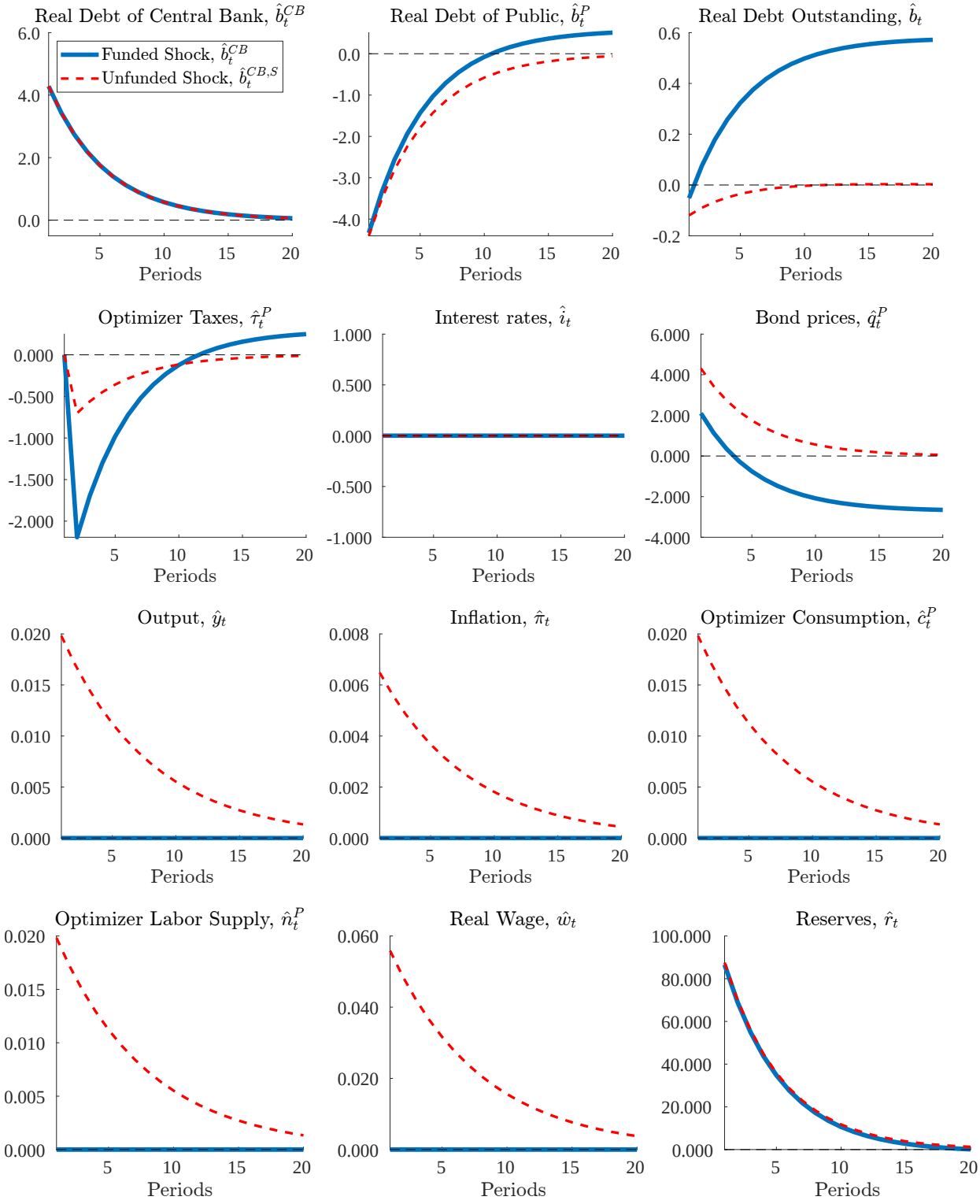


Figure 5: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized QE shock to funded and unfunded central bank asset holdings, $\hat{b}_t^{CB}$ and $\hat{b}_t^{CB,S}$, respectively, Percent.

3 Empirical Evidence

In order for the quantity channel to be applicable, a key assumption must be satisfied: the share of debt issuance financed by taxation must fall in response to QE. This section provides empirical evidence in support of this behavior. We present correlational evidence and then use standard methods from the literature to measure causal impulse responses to exogenous asset purchase shocks in the next section. We find that deficits rise, taxation falls, and debt issuance increases in response to asset purchase shocks. Furthermore, in support of the partial fiscal theory model, we find that the federal funds rate does not empirically respond to anticipated balance sheet actions. In addition, over a longer horizon, the market value of Treasury debt falls.

3.1 Stylized Facts

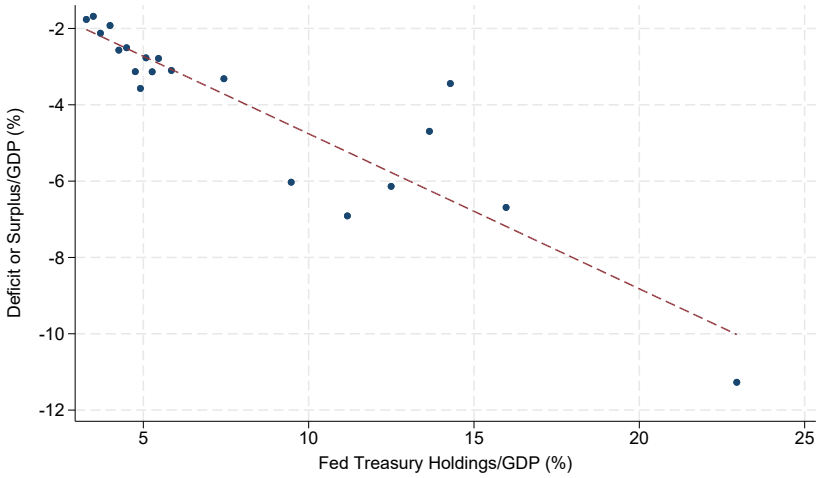


Figure 6: Scatter Plot of Surplus/Deficit and Federal Reserve Treasury Holdings

Notes: Figure presents a binned scatter plot of the US Federal Deficit or Surplus against Federal Reserve Treasury holdings, both as fractions of nominal GDP. Variables are in terms of four quarter moving averages and residualized with respect to the four quarter moving average of the unemployment rate. Sample: 1980:Q1-2025:Q4.

Figure 6 presents a binned scatter plot of Federal surpluses/deficits against Federal Reserve Treasury holdings, both scaled by nominal GDP and residualized against the unemployment rate. Higher levels of Treasury holdings are strongly associated with larger fiscal deficits, consistent with the fiscal behavior the quantity channel requires.

Table 2 shows that this association is a robust feature of the data. We present OLS estimates of

$$y_t = \alpha + \beta X_t + \epsilon_t, \tag{40}$$

where y_t is the annualized dollar fiscal deficit or surplus as a ratio of nominal GDP,$X_t$is a column of covariates of interest, and β is a row of coefficients. Standard errors are

Newey-West with a four lag bandwidth to accommodate the MA(4) structure induced by the four-quarter moving averages.

Across specifications, a 10 percentage point increase in Fed holdings is associated with a 2 to 4 percentage point increase in the annualized deficit-to-GDP ratio. The first row shows that the ratio of the Federal Reserve's securities holdings is strongly correlated with the magnitude of fiscal deficits. Columns (2) and (3) condition on macroeconomic conditions by including the unemployment rate and real GDP growth; notably, the coefficient on Fed holdings is largely unchanged by the inclusion of these cyclical controls, suggesting the association is not driven solely by contemporaneous business-cycle variation. Column (4) controls for the Chicago Fed National Financial Conditions Index. Column (5) restricts the sample to the post-GFC period (2009:Q1 onward) and finds a coefficient of similar magnitude. Columns (6) and (7) show that the association persists when SOMA agency MBS holdings are added to Treasury holdings in the independent variable, though the coefficient attenuates somewhat, consistent with agency MBS purchases having a weaker direct link to Treasury issuance than outright Treasury purchases.

3.2 Causal Evidence

3.2.1 Construction of an Asset Purchase Shock

Following the methodology of Swanson (2021) and Swanson (2024), we decompose interest rate responses to US monetary policy announcements into three factors: a federal funds rate, a forward guidance, and a large-scale asset purchase component. Our first step is to extend the sample of Gurkaynak, Sack, and Swanson (2005) through December 2024 and measure the high frequency responses of the first and third federal funds futures contracts, the second, third, and fourth Eurodollar futures contracts, and the on-the-run 10- and 30-year Treasury yields to monetary policy announcements. As is standard in the literature, we use thirty minute windows to measure the response of interest rates to monetary policy announcements. We normalize all interest rate responses to unit variance and extract the first and second principal components of the interest rate movements. We then rotate these factors into a target rate and forward guidance component. The forward guidance component is identified such that changes in this factor have no effect on the current federal funds rate.

Following Swanson and Jayawickrema (2023), LSAP shocks are defined to be zero through 2008. From 2009 onwards, the LSAP factor is defined as the the movement of the average of the 10- and 30- year Treasury yields that is orthogonal to the target and forward guidance factors. As a last step in the shock construction, we orthogonalize the LSAP factor to its own two lags in order to account for the "Fed Response to News" channel documented by Swanson (2024) . We normalize the factor so that a 1 unit increase has a negative 10 basis point effect on 10-year Treasury yields at the daily level.

Because market participants do not systematically receive any other information over narrow windows around monetary policy announcements, changes in interest rates over that time reflect the surprise component of monetary policy. The LSAP factor, which loads on longer-term yields and is orthogonal to the pre-2009 monetary policy toolkit,

Table 2: Annualized Surplus/Deficit and Fed Securities Holdings

Dependent Variable:	Annualized Federal Surplus/Deficit over GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fed Holdings/GDP	-0.31***	-0.40***	-0.40***	-0.39***	-0.47***	-0.23***	-0.41**
	(0.10)	(0.08)	(0.08)	(0.07)	(0.16)	(0.05)	(0.16)
Unemployment Rate		-1.21***	-1.18***	-1.21***	-1.09***	-1.22***	-1.33***
		(0.20)	(0.20)	(0.20)	(0.31)	(0.20)	(0.40)
GDP Growth			0.98*	1.13**	1.09	1.11*	1.54
			(0.58)	(0.57)	(1.14)	(0.67)	(1.32)
Financial Conditions				0.29	-2.44**	0.36	-2.59*
				(0.43)	(1.20)	(0.43)	(1.31)
Constant	-1.51*	6.56***	5.70***	5.80***	5.16	5.24***	8.31
	(0.84)	(1.49)	(1.45)	(1.52)	(3.39)	(1.49)	(5.02)
Full Sample	✓	✓	✓	✓	Post-GFC	✓	Post-GFC
MBS Included	×	×	×	×	✓	×	✓
Observations	181	181	181	181	68	181	68
R-squared	0.25	0.62	0.64	0.65	0.53	0.63	0.51

Notes: Newey-west standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Samples: 1980:Q4-2025:Q4 for full sample and 2009:Q1-2025:Q4 for "Post-GFC". "MBS Included" indicates that the independent variable, "Fed Holdings/GDP," includes SOMA agency securities holdings in addition to SOMA Treasury securities. All variables are in terms of four-quarter moving averages. "Financial Conditions" is the Chicago Fed National Financial Conditions Index.

measures exogenous changes to expectations of balance sheet policy.

3.3 Empirical Specification

We use daily data from the US Treasury on tax revenues and Treasury debt issuance to measure the fiscal response to asset purchase shocks.[5] We employ local projections at each daily horizon h (Jordà, 2005). For debt outstanding, a stock variable, we estimate:

$$y_{t+h} = \alpha_h + \theta_h s_t + \sum_{j=1}^{60} \rho_{h,j}\, y_{t-j} + \delta_{h,m} + \varepsilon_{t+h}, \quad h = 0, \ldots, H; \tag{41}$$

where y_{t+h} is 100 times the log of a 22-day backward moving average of debt outstanding at horizon h, and the coefficients $\rho_{h,j}$ capture the effects of past realizations of the dependent variable. We include monthly indicators $\delta_{h,m}$ for the months of the coronavirus pandemic from March through August 2020. The coefficients of interest, θ_h, measure the percentage change in the moving average of debt outstanding at horizon h following an asset purchase shock s_t.

Because tax revenues are a flow rather than a stock variable, we specify a local projection to obtain the cumulative impulse response:

$$y^c_{t,t+h} = \alpha_h + \theta_h s_t + \sum_{j=1}^{60} \rho_{h,j}\, x_{t-j} + \delta_{h,d} + \delta_{h,m} + \varepsilon_{t+h}, \quad h = 0, \ldots, H; \tag{42}$$

where $y^c_{t,t+h} = 100 \times \log\left(\sum_{\ell=0}^{h} \text{tax}_{t+\ell}\right)$ is 100 times the log of cumulative daily tax revenues from day t to day $t+h$ in terms of a 60-day backwards moving average. The lagged controls x_{t-j} are the logs of a 60-day backward moving average of tax revenues, corresponding approximately to the number of business days in a quarter and thus capturing that important tax inflow dates occur on a quarterly basis. We include fixed effects $\delta_{h,d}$ for each calendar day of the year to account for significant predictable daily variation in tax receipts and include monthly indicators $\delta_{h,m}$ for the months of the coronavirus pandemic from March through August 2020. The local projection specifications measure cumulative percentage changes in total taxes collected and total debt outstanding, respectively, following an asset purchase shock.

Identification: The asset purchase shocks s_t are assumed to satisfy the exclusion restriction such that

$$\mathrm{E}[s_t \epsilon_{t+h}] = 0, \quad h = 0, 1, \ldots, H, \tag{43}$$

as the interest rate movements underlying the LSAP shocks are unexpected by market participants and are orthogonal to information up to five minutes before each monetary policy announcement. In addition, the daily frequency of the dependent variables makes it unlikely that omitted variables bias the impulse responses. Regarding the statistical

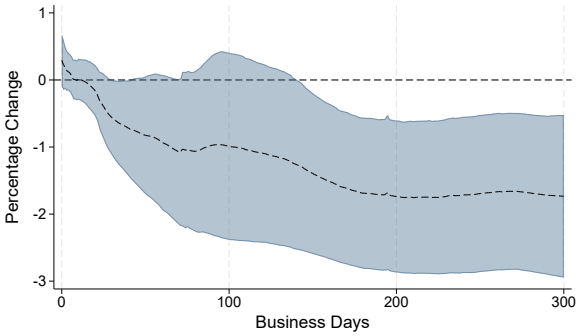
[5] Daily debt outstanding is obtained from the Treasury's "Debt to the Penny" release. Total daily tax collection is from Haver Analytics and available under the series name TDA@DAILY.

relevance of the LSAP shocks, we replicate the financial market analysis of Swanson (2021) in the appendix and confirm that an accommodative asset purchase shock leads to a statistically significant reduction in the 10-year Treasury yield at the daily frequency.

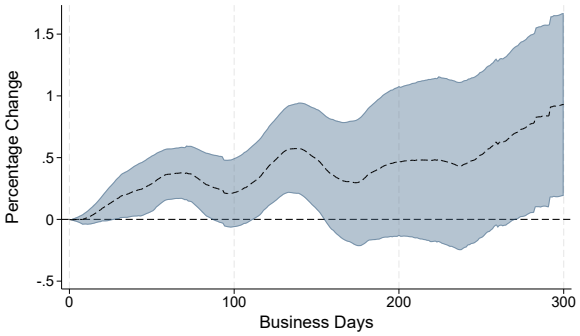
3.4 Results

Figure 7: Fiscal Impulse Responses to an Accommodative Asset Purchase Shock

(a) Cumulative Tax Revenue



(b) Treasury Debt Outstanding



Notes: Panel (a) plots the response of the log of cumulative tax revenues to an accommodative QE shock. Panel (b) plots the response of the log of Treasury debt outstanding to an accommodative QE shock. Sample periods: January 1, 2008—May 22, 2024. 90% confidence intervals constructed with heteroskedasticity-robust standard errors.

3.4.1 Taxation and Debt Issuance

Figures 7a and 7b present the responses of tax revenues and debt issuance, respectively. The empirical responses align closely with the theoretical impulse responses in Section 2.[6]

Because the asset purchase shock is measured from yield changes around monetary policy announcements, it does not contain information about the expected size of purchases. However, we can gauge the extent of this response using evidence from the fiscal literature for the effects of Treasury supply on yields. Using elasticities for the effects of Treasury supply (Bhatt, Diercks, Eyal, and Skaperdas, 2026; Wiegand, 2025), a 10 basis point reduction in the 10-year Treasury yield from our normalized 1 unit accommodative QE shock corresponds to an effective reduction in Treasuries outstanding in the range of 2-3 percentage points of debt to nominal GDP. The impulse response in Figure 7b therefore suggests a sizeable fiscal response: for each 2-3 percentage point effective reduction in the public's Treasury holdings as a share of GDP from central bank actions in terms

[6]Impulse responses at the monthly frequency, available in the appendix, yield less statistically precise but qualitatively similar impulse responses.

of market pricing, the Treasury increases debt supply by about 1 percentage point at a 300 day horizon.

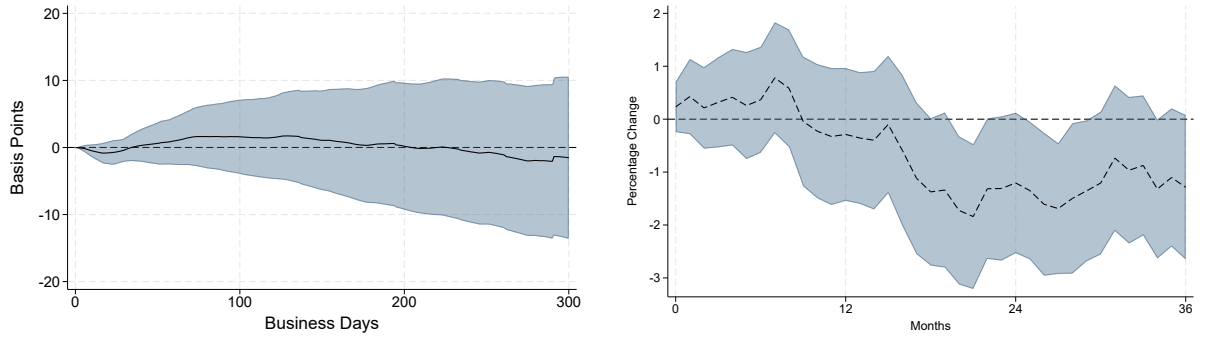
3.4.2 Evidence for the partial FTPL Model

To motivate our partial fiscal theory model, we test that the federal funds rate does not increase in response to the Federal Reserve's QE. We present estimates from specification (42) using the 22 day moving average of the federal funds rate as the dependent variable of interest and include monthly pandemic indicators. Figure 8a confirms the federal funds rate response is statistically insignificant from zero and remains within its 25 basis point target range. The empirical evidence confirms the model assumptions necessary for the quantity channel under the partial FTPL model, as the key assumption that the federal funds rate does not respond to QE is satisfied.

Figure 8: Impulse Responses to an Accommodative Asset Purchase Shock

(a) Effective Federal Funds Rate

(b) Market/Par Value of Privately-Held Treasury Securities



Notes: Panel (a) plots the daily response of a 22-day moving average of the effective federal funds rate to an accommodative QE shock. Includes 22 lags of the dependent variable. Sample period: January 1, 2008—May 22, 2024. Panel (b) plots the monthly response to an accommodative QE shock of the ratio of the market value of privately held Treasury debt to its par value . Includes 12 lags of the dependent variable, the unemployment rate, the change in the Chicago National Financial Conditions Index, and monthly indicators for March-August 2020. Sample: January, 2008—May, 2024. 90% confidence intervals constructed with heteroskedasticity-robust standard errors.

In order to examine the market value of Treasury debt, we obtain publicly-available estimates from the Federal Reserve Bank of Dallas. Because these data are monthly, we present impulse responses at the monthly frequency using 12 lags of the dependent variable with the QE shocks summed within each month. Figure 8b shows that an expected balance sheet expansion initially increases the ratio of the real market value of privately-held Treasuries to its par value. However, the response is negative within two years, consistent with a partial FTPL equilibrium that erodes the value of government debt.

4 Conclusion

This paper presents a new channel of QE where the fiscal backing of debt can matter for the size of macroeconomic effects. We use standard New Keynesian models that break Ricardian equivalence to analyze the effects of QE when the fiscal authority only adjusts budget surpluses for debt held by the public. As a result, households' tax obligations are reduced and QE expands economic activity and inflation. Empirical evidence using exogenous QE shocks and daily US fiscal data indicates a sizeable fiscal response to QE, with subsequent debt revaluation through increases in the price level.

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Appendix

A Firms and Phillips Curve

The derivation of the New Keynesian Phillips Curve in equation (5) follows from Woodford (2004). There is a continuum of monopolistically competitive intermediate-good firms. The representative final-good producer aggregates the differentiated varieties $Y_t(i)$, indexed by $i \in [0,1]$, according to

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} \, \mathrm{d}i\right]^{\frac{\theta}{\theta-1}}, \tag{44}$$

where $\theta > 1$ denotes the elasticity of substitution across intermediate goods.

Taking prices as given, the final-good firm selects its demand for each variety to solve

$$\max_{\{Y_t(i)\}_{i\in[0,1]}} \left\{P_t Y_t - \int_0^1 P_t(i) Y_t(i) \, \mathrm{d}i\right\}, \tag{45}$$

subject to equation (44). Cost minimization implies the demand schedule

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\theta} Y_t, \tag{46}$$

where the aggregate price index is

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta} \, \mathrm{d}i\right]^{\frac{1}{1-\theta}}. \tag{47}$$

Each intermediate-good firm produces its differentiated variety using labor as its only input with constant returns to scale.

$$Y_t(i) = N_t(i) \tag{48}$$

Because labor supply is firm-specific and technology is linear, the real marginal cost of firm i equals its real wage, which is pinned down by the optimizer households' intratemporal Euler equation

$$mc_t(i) = w_t(i) = (C_t^P)^\sigma (N_t(i)^P)^\varphi$$

Combining with equations (48) and (46)

$$mc_t(i) = (C_t^P)^\sigma Y_t^\varphi \left(\frac{P_t(i)}{P_t}\right)^{\varphi\theta}$$

Letting the economy-wide average real marginal cost, mc_t, be evaluated at the aggregate price level $P_t(i) = P_t$, yields $mc_t \equiv (C_t^P) Y_t^\varphi$ and the firm-level marginal cost can be written as

$$mc_t(i) = mc_t \left(\frac{P_t(i)}{P_t}\right)^{-\theta\varphi} \tag{49}$$

Intermediate-good producers face Calvo price rigidity. In any period, a firm is allowed to reset its price with probability $1-\phi$, while its existing price remains unchanged with probability ϕ. Let P_t^* denote the price selected by a firm that receives a reset opportunity in period t. Conditional on resetting, the firm solves

$$\max_{P_t^*} \mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \left(\frac{\lambda_{t+k}}{\lambda_t}\right) \left[P_t^* Y_{t+k}(i) - \text{Nominal Cost}_{t+k}(Y_{t+k}(i))\right], \tag{50}$$

subject to the demand for its variety,

$$Y_{t+k}(i) = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\theta} Y_{t+k}. \tag{51}$$

Here, $Y_{t+k}(i)$ is the output produced in period $t+k$ by firm i whose price was most recently reset in period t. The stochastic discount factor used to value nominal profits is

$$\beta^k \frac{\lambda_{t+k}}{\lambda_t} \equiv \beta^k \frac{U_{c^P,t+k}}{U_{c^P,t}} \frac{P_t}{P_{t+k}}. \tag{52}$$

The relevant stochastic discount factor is that of the optimizing household who accrues profits, denoted by superscript P. The first-order condition for the optimal reset price, p_t^*, where the derivative of the nominal cost equals marginal cost, is given below. Both sides are divided by λ_t

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \lambda_{t+k} Y_{t+k} \left(\frac{P_t^*}{P_{t+k}}\right)^{-\theta} \left[\frac{P_t^*}{P_{t+k}} - \frac{\theta}{\theta-1} mc_{t+k|t}\right] = 0. \tag{53}$$

The real marginal cost of a firm charging reset price P_t^* can be defined from equation (49),

$$mc_{t+k|t} \equiv mc_{t+k} \left(\frac{P_t^*}{P_{t+k}}\right)^{-\theta\varphi} \tag{54}$$

is the real marginal cost in period $t+k$ of a firm whose price was last adjusted in period t. Moving $(P_t^*/P_{t+k})^{-\theta}$ inside the parentheses yields,

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \lambda_{t+k} Y_{t+k} \left[\left(\frac{P_t^*}{P_{t+k}}\right)^{1-\theta} - \frac{\theta}{\theta-1} mc_{t+k} \left(\frac{P_t^*}{P_{t+k}}\right)^{-\theta(1+\varphi)}\right] = 0 \tag{55}$$

Log-linearization. Following the standard approach, we characterize the economy's dynamics in a neighborhood of a zero-inflation steady state. For any variable X_t, its log deviation from its steady state is defined as $x_t \equiv \log\left(\frac{X_t}{X}\right)$, where X denotes the value of X_t in the zero-inflation steady state. We derive the resulting equilibrium conditions under the case of equal steady-state consumption across optimizing and hand-to-mouth households, $C^P = C^H$. Let $p^*/p = 1$ and $mc = (\theta-1)/\theta$.

$$\log \frac{P_t^*}{P_{t+k}} = \log\left(\frac{P_t^*}{P_t}\frac{P_{t+1}}{P_t}, ..., \frac{P_{t+k-1}}{P_{t+k}}\right) = \log\left(\frac{P_t^*}{P_t}\pi_{t+1}^{-1}, ..., \pi_{t+k}^{-1}\right)$$

Letting $\hat{P}_t^* = \log(P_t^*/P_t)$ and re-writing,

$$\log \frac{P_t^*}{P_{t+k}} = \hat{P}_t^* - \sum_{j=1}^{k} \hat{\pi}_{t+j} \tag{56}$$

The term in the brackets in equation (55) is equal to zero, so the pre-multiplied expressions do not need to be linearized. Consequently, only the term in brackets needs to be linearized. Using (56) above, this yields

$$(1+\theta\varphi)\left(\hat{P}_t^* - \sum_{j=1}^{k} \hat{\pi}_{t+j}\right) = \widehat{mc}_{t+k} \tag{57}$$

Inserting back into (55) and writing $\lambda_{t+k} Y_{t+k}$ in the steady state,

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \lambda Y \left[(1+\theta\varphi)\left(\hat{P}_t^* - \sum_{j=1}^{k} \hat{\pi}_{t+j}\right) - \widehat{mc}_{t+k}\right] = 0$$

Now dividing by $\lambda Y(1+\theta\varphi)$,

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \left[\left(\hat{P}_t^* - \sum_{j=1}^{k} \hat{\pi}_{t+j}\right) - \frac{1}{1+\varphi\theta}\widehat{mc}_{t+k}\right] = 0$$

Re-arranging and using the fact that P_t^* is known at time t:

$$\frac{P_t^*}{1-\phi\beta} = \mathbb{E}_t \sum_{k=0}^{\infty} (\phi\beta)^k \left[\sum_{j=1}^{k} \hat{\pi}_{t+j} + \frac{1}{1+\varphi\theta}\widehat{mc}_{t+k}\right] \tag{58}$$

Re-writing and noting that $\sum_j^k \hat{\pi}_{t+j} = 0$ at $k = 0$,

$$\frac{P_t^*}{1-\phi\beta} = \frac{1}{1+\varphi\theta}\widehat{mc}_t + \mathbb{E}_t \sum_{k=1}^{\infty} (\phi\beta)^k \left[\sum_{j=1}^{k} \hat{\pi}_{t+j} + \frac{1}{1+\varphi\theta}\widehat{mc}_{t+k}\right] \tag{59}$$

Redefining some terms and letting $m = k - 1$

$$\sum_{j=1}^{k} \hat{\pi}_{t+j} = \hat{\pi}_{t+1} + \sum_{j=2}^{k} \hat{\pi}_{t+j}^{k} = \hat{\pi}_{t+1} + \sum_{\ell=1}^{m} \hat{\pi}_{t+\ell+1}$$

And

$$\widehat{mc}_{t+k} = \widehat{mc}_{t+m+1}$$

This allows equation (59) to be re-written with m indexes instead of k indexes, noting that the term in the summation is exactly equal to equation (58) taken at time t expectations,

$$\frac{P_t^*}{1-\phi\beta} = \frac{1}{1+\varphi\theta}\widehat{mc}_t + \frac{\phi\beta}{1-\phi\beta}\mathbb{E}_t[\hat{\pi}_{t+1}] + \phi\beta \underbrace{\mathbb{E}_t \sum_{m=0}^{\infty} (\phi\beta)^m \left[\sum_{\ell=1}^{m} \hat{\pi}_{t+\ell+1} + \frac{1}{1+\varphi\theta}\widehat{mc}_{t+m+1}\right]}_{\frac{\mathbb{E}_t[\hat{P}_{t+1}^*]}{1-\phi\beta}} \tag{60}$$

This yields,

$$\hat{P}_t^* = \frac{1-\phi\beta}{1+\theta\varphi}\widehat{mc}_t + \phi\beta\mathbb{E}_t[\hat{\pi}_{t+1}] + \phi\beta\mathbb{E}_t[\hat{P}_{t+1}^*] \tag{61}$$

The expression for $\hat{P}_t^*$ in terms of $\hat{\pi}_t$ follows from the Calvo price index:

$$P_t^{1-\theta} = (1-\phi)P_t^*(1-\theta) + \phi P_{t-1}^{1-\theta}$$

Taking dividing both sides by $(1-\theta)\log(P_t)$ ang log-linearizing:

$$0 = (1-\phi)\underbrace{\log\left(\frac{P_t^*}{P_t}\right)}_{\hat{p}_t^*} + \phi\underbrace{\log\left(\frac{P_{t-1}}{P_t}\right)}_{-\hat{\pi}_t}$$

$$\hat{P}_t^* = \frac{\phi}{1-\phi}\hat{\pi}_t. \tag{62}$$

Using the expression in (62), equation (61) can be written as:

$$\begin{aligned}\frac{\phi}{1-\phi}\hat{\pi}_t &= \frac{1-\phi\beta}{1+\theta\varphi}\widehat{mc}_t + \phi\beta\mathbb{E}_t[\hat{\pi}_{t+1}] + \frac{\phi\beta\phi}{1-\phi}\hat{\pi}_{t+1} \\ \hat{\pi}_t &= \underbrace{\frac{(1-\phi)(1-\phi\beta)}{\phi(1+\theta\varphi)}}_{\Theta}\widehat{mc}_t + \beta\mathbb{E}_t[\hat{\pi}_{t+1}]\end{aligned}$$

$1/(1+\theta\varphi)$ is the strategic complementarity generated by firm-specific segmented labor markets.

And since $\hat{w}_t = \hat{mc}_t$, this yields (5) in the main text,

$$\hat{\pi}_t = \Theta\widehat{mc}_t + \beta\mathbb{E}_t[\hat{\pi}_{t+1}]$$

A.1 TANK and Partial FTPL Phillips Curve

This section derives the Phillips curve for the TANK model, which is equivalent to that of the partial FTPL model.

From equations (22) and (23),

$$\hat{w}_t = \sigma\hat{c}_t^P + \varphi\hat{n}_t^P = \sigma\hat{c}_t^{HtM} + \varphi\hat{n}_t^{HtM}$$

Because labor supply, $\hat{n}_t = \eta\hat{n}_t^{HtM} + (1-\eta)\hat{n}_t^P$, can vary across the types of agents, we can express the real wage in terms of the aggregate labor supply.

$$\hat{w}_t = \sigma\hat{c}_t + \varphi\hat{n}_t \tag{63}$$

Using aggregate consumption and labor supply from equations (29) and (30), respectively, we can derive the above expression

$$\begin{aligned}\sigma\hat{c}_t + \varphi\hat{n}_t &= \sigma\left((1-\eta)\hat{c}_t^P + \eta\hat{c}_t^{HtM}\right) + \varphi\left((1-\eta)\hat{n}_t^P + \eta\hat{n}_t^{HtM}\right) \\ &= (1-\eta)\left(\sigma\hat{c}_t^P + \varphi\hat{n}_t^P\right) + \eta\left(\sigma\hat{c}_t^{HtM} + \varphi\hat{n}_t^{HtM}\right) \\ &= (1-\eta)\hat{w}_t + \eta\hat{w}_t = \hat{w}_t\end{aligned}$$

Now using the fact that technology is linear, $\hat{y}_t = \hat{n}_t$, and the aggregate resource constraint in equation (28), $\hat{y}_t = (1 - s_g)\hat{c}_t + s_g\hat{g}_t$, where $s_g = G/Y$

$$\begin{aligned}\widehat{mc}_t = \hat{w}_t =& \sigma\hat{c}_t + \varphi\hat{n}_t \\ =& \sigma\left(\frac{\hat{y}_t - s_g\hat{g}_t}{1 - s_g}\right) + \varphi\hat{y}t \\ =& \left(\frac{\sigma}{1 - s_g} + \varphi\right)\hat{y}_t - \left(\frac{\sigma s_g}{1 - s_g}\right)\hat{g}_t\end{aligned}$$

The Phillips Curve in equation (5) can be written as,

$$\hat{\pi}_t = \beta\mathbb{E}_t[\hat{\pi}_{t+1}] + \kappa_y\hat{y}_t - \kappa_g\hat{g}_t \tag{64}$$

Where $\kappa_y \equiv \Theta\left(\frac{\sigma}{1 - s_g} + \varphi\right)$ and $\kappa_g \equiv \Theta\left(\frac{\sigma s_g}{1 - s_g}\right)$

The derivation of the Phillips curve in terms of aggregate resources follows trivially from the fact that $\eta = 0$. Therefore by construction,

$$\hat{w}_t = \sigma\hat{c}_t + \varphi\hat{n}_t$$

And it is straightforward to obtain equation (64).

B TANK Model

B.1 Additional Results for TANK Model

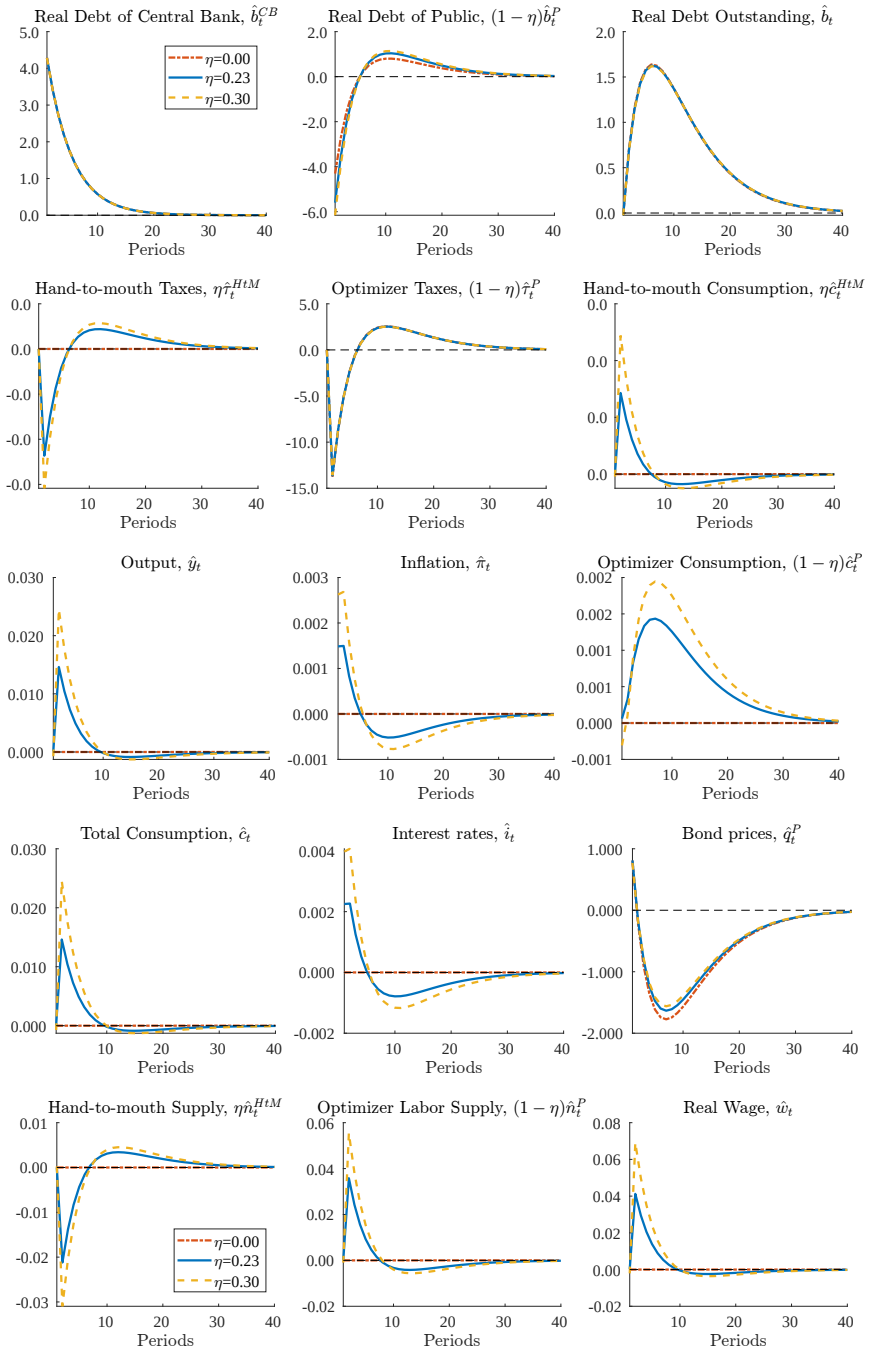


Figure B.1: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

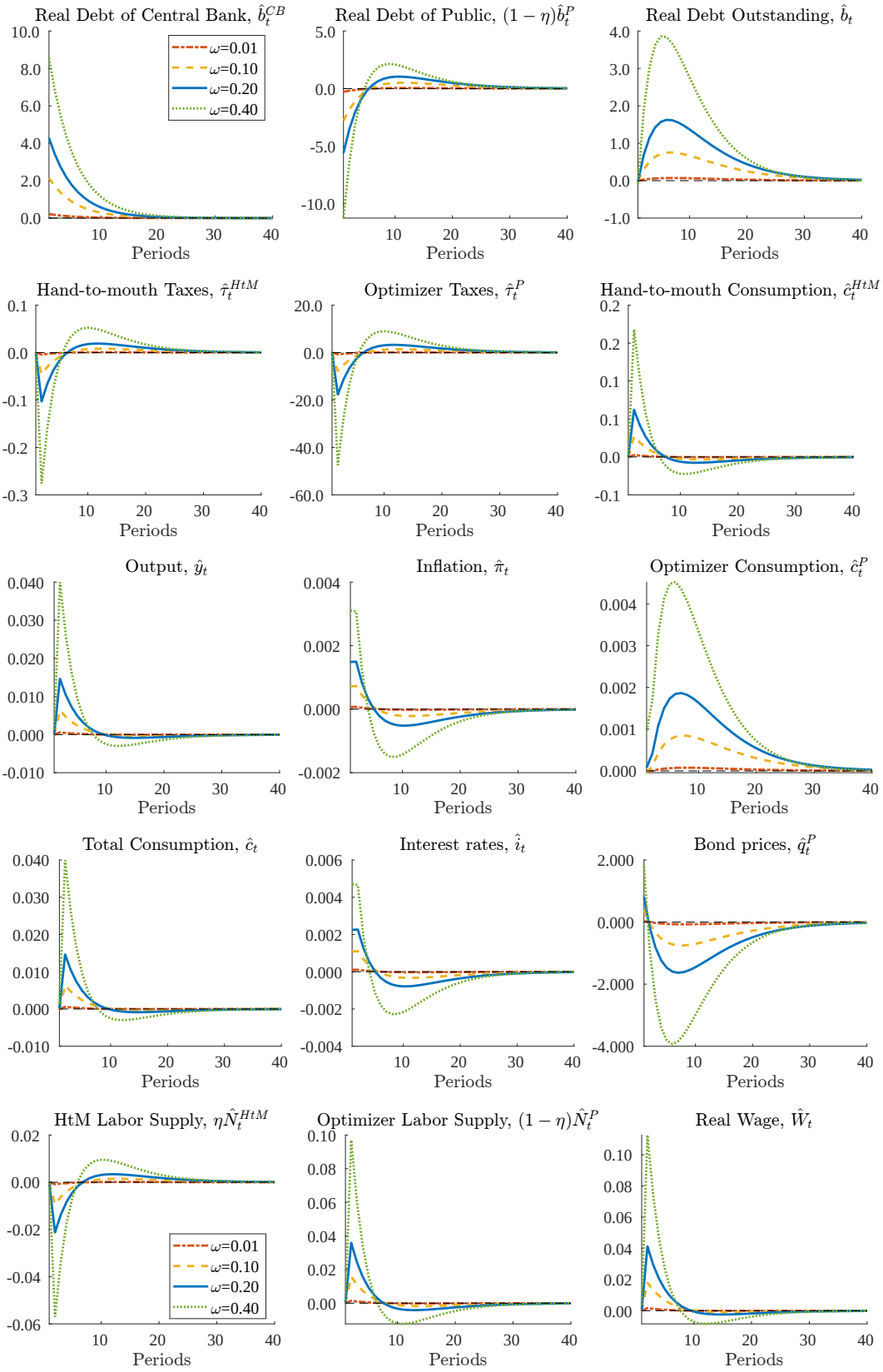


Figure B.2: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

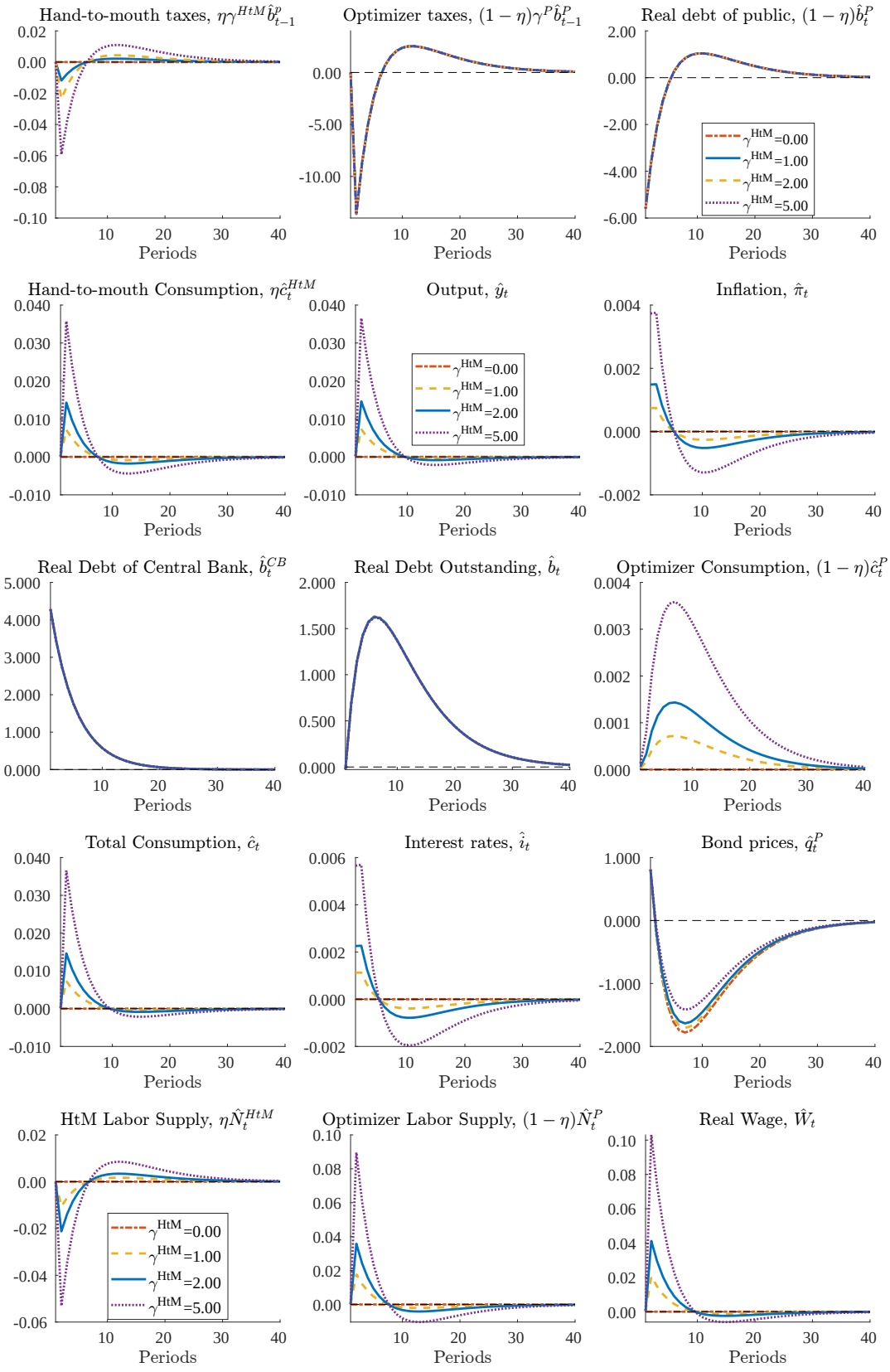


Figure B.3: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}^{CB}_{t}$, Percent.

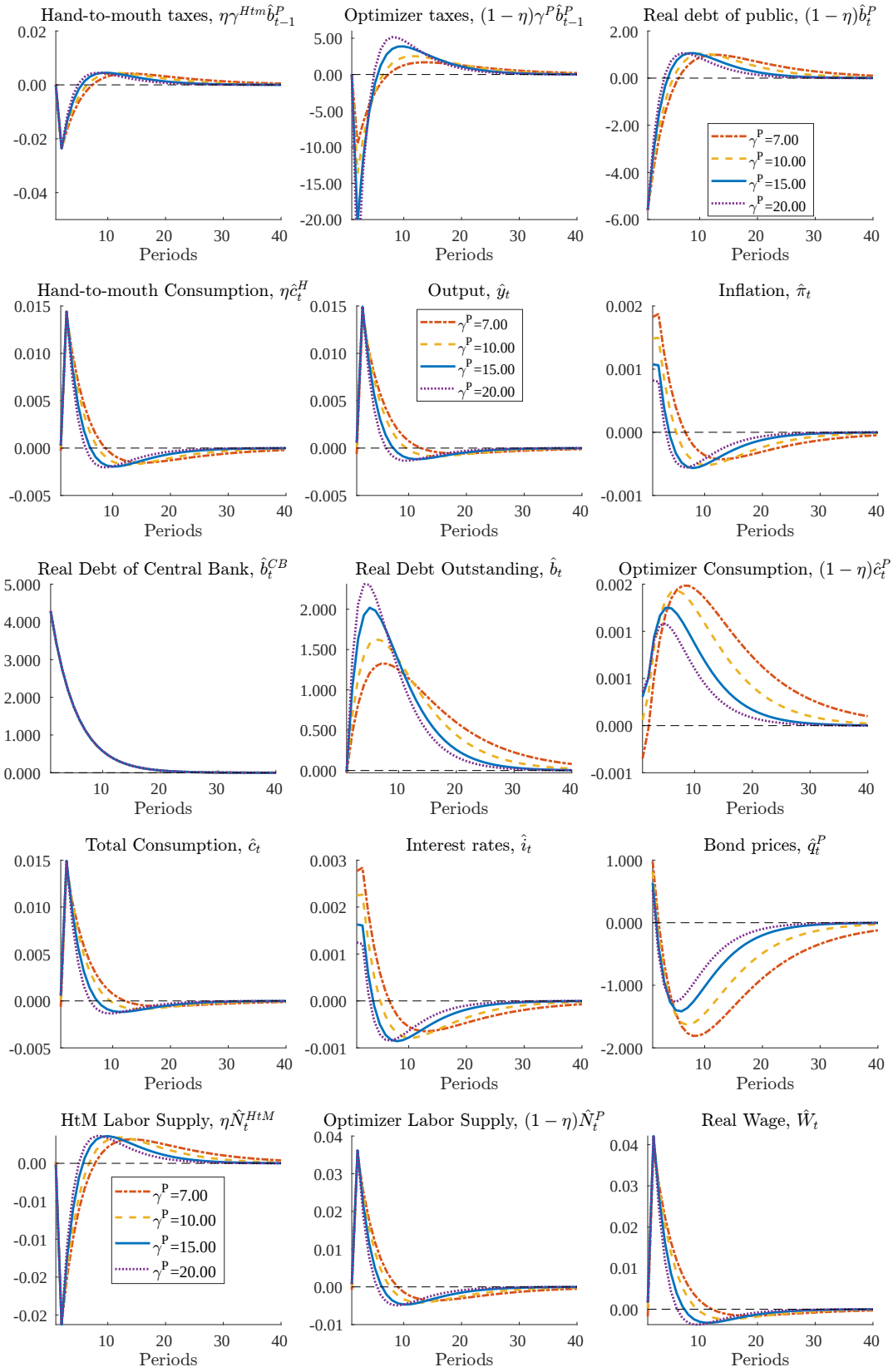


Figure B.4: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}^{CB}_t$, Percent.

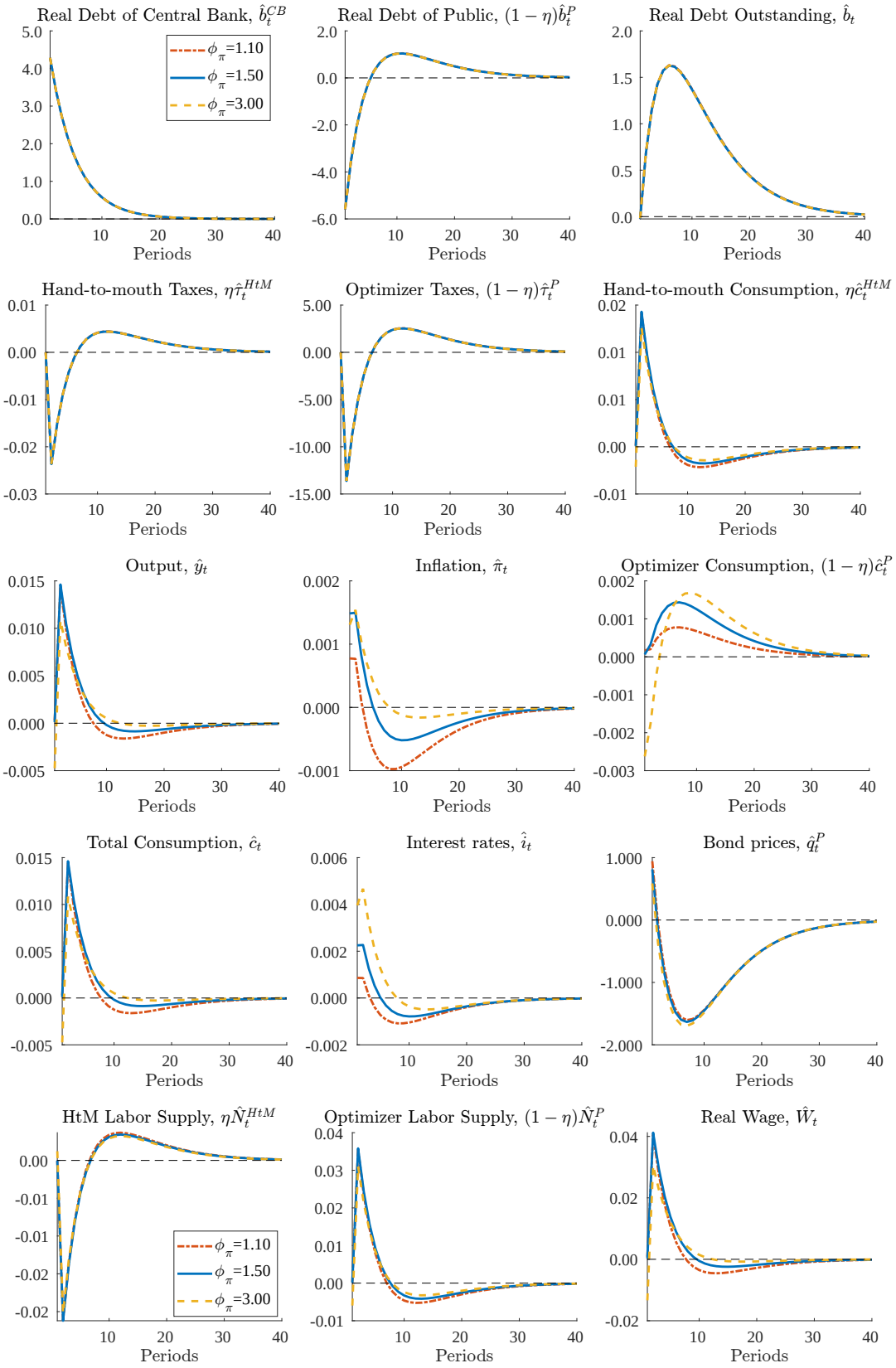


Figure B.5: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

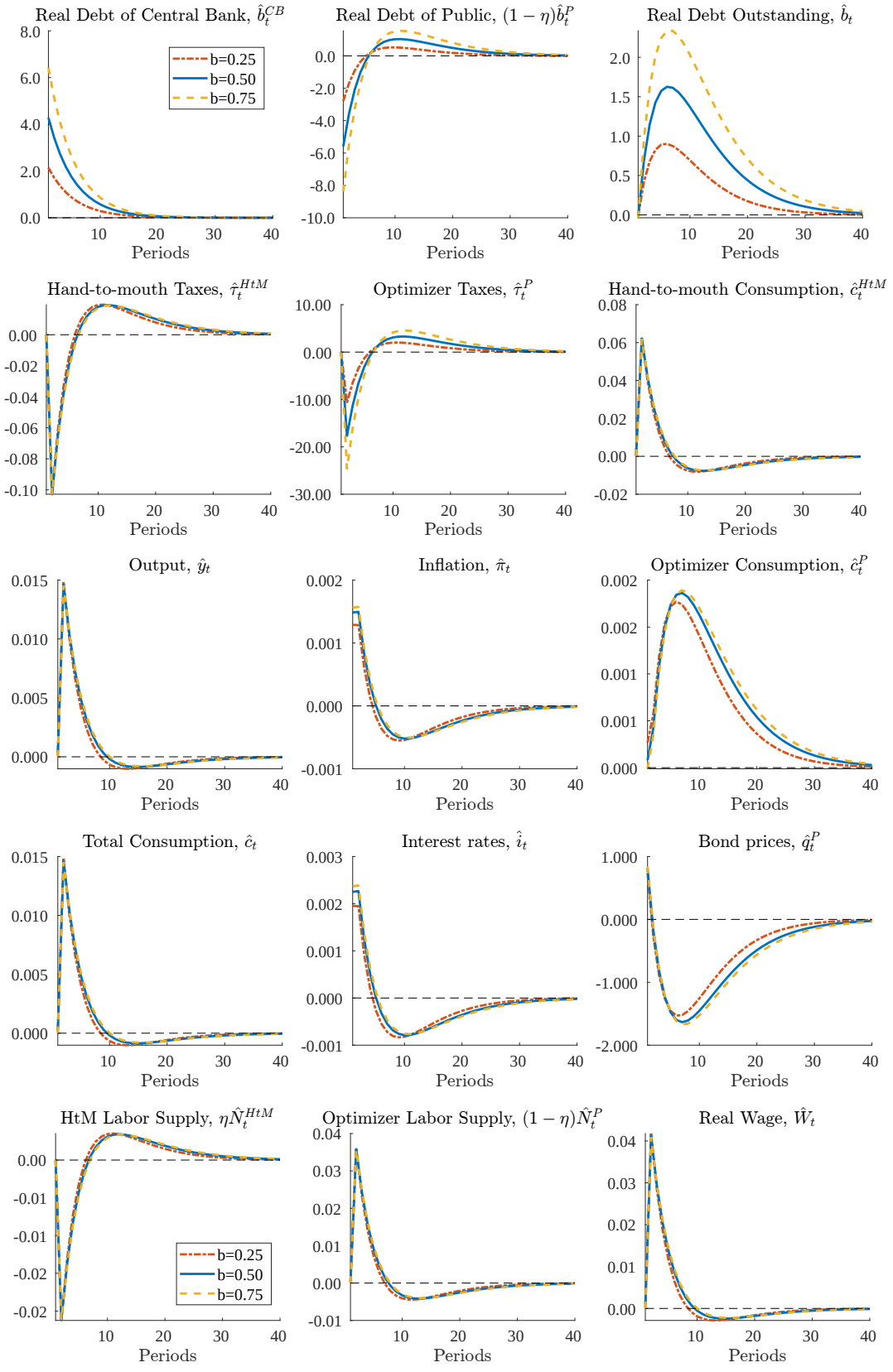


Figure B.6: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

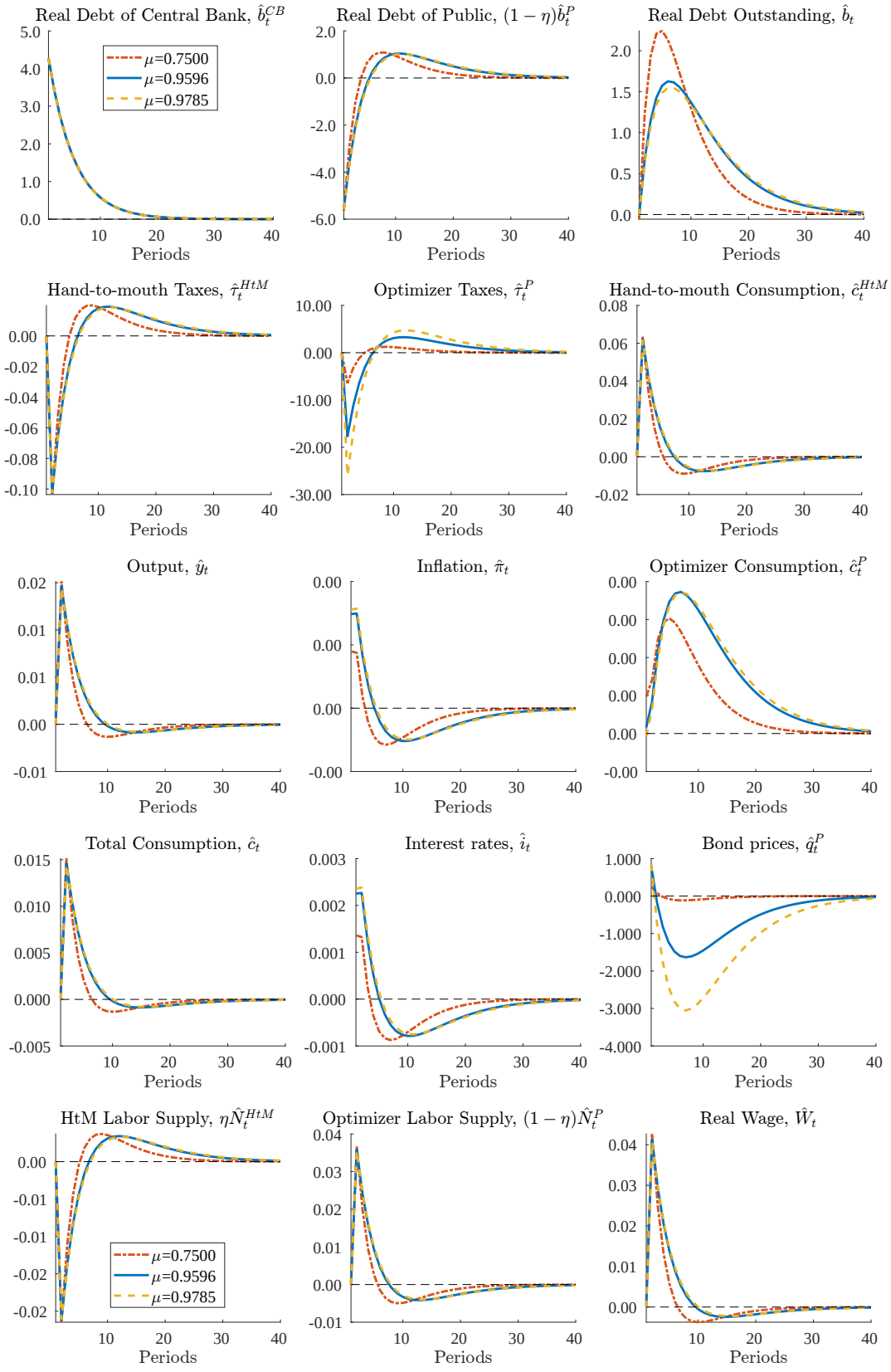


Figure B.7: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

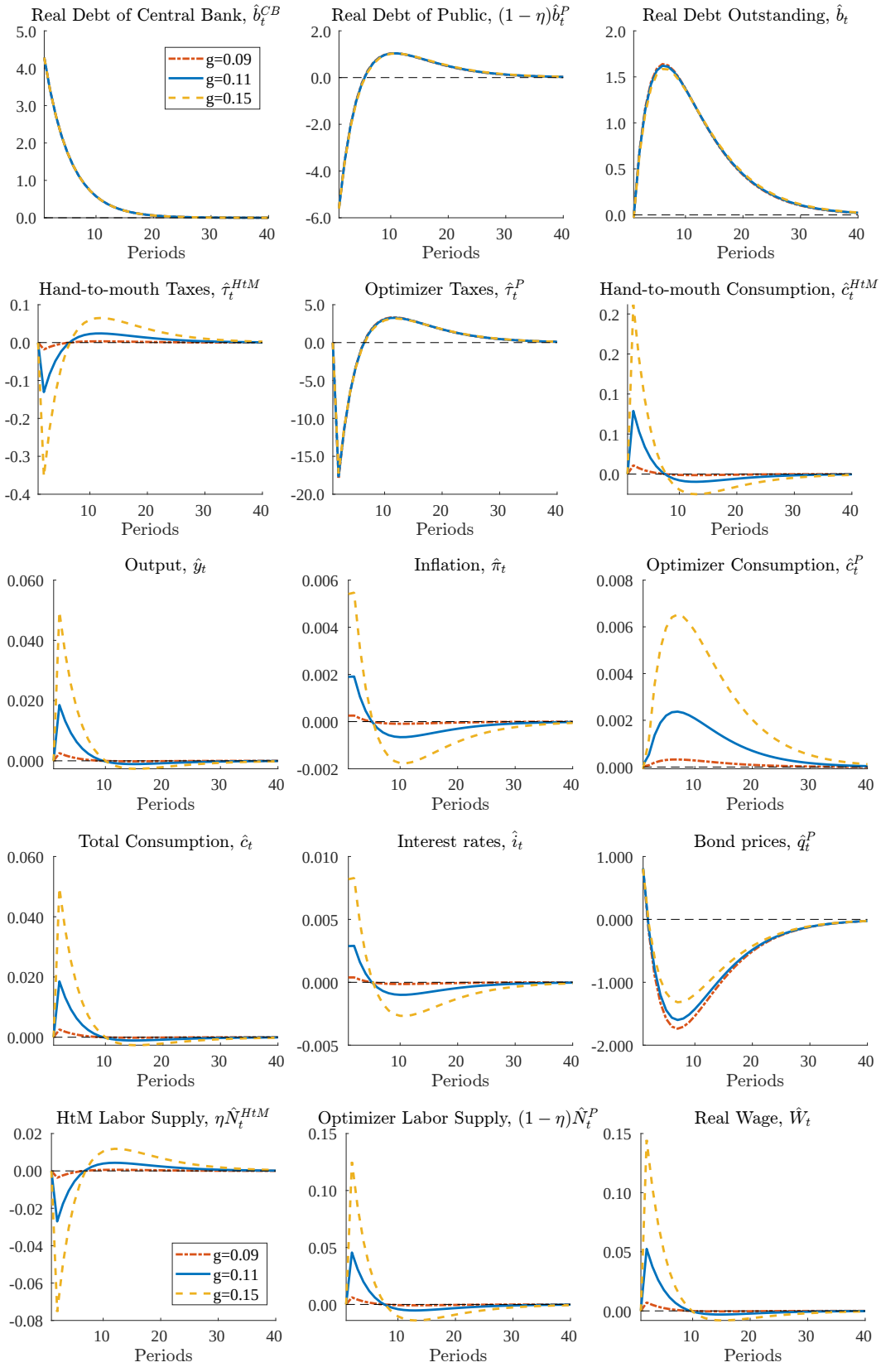


Figure B.8: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

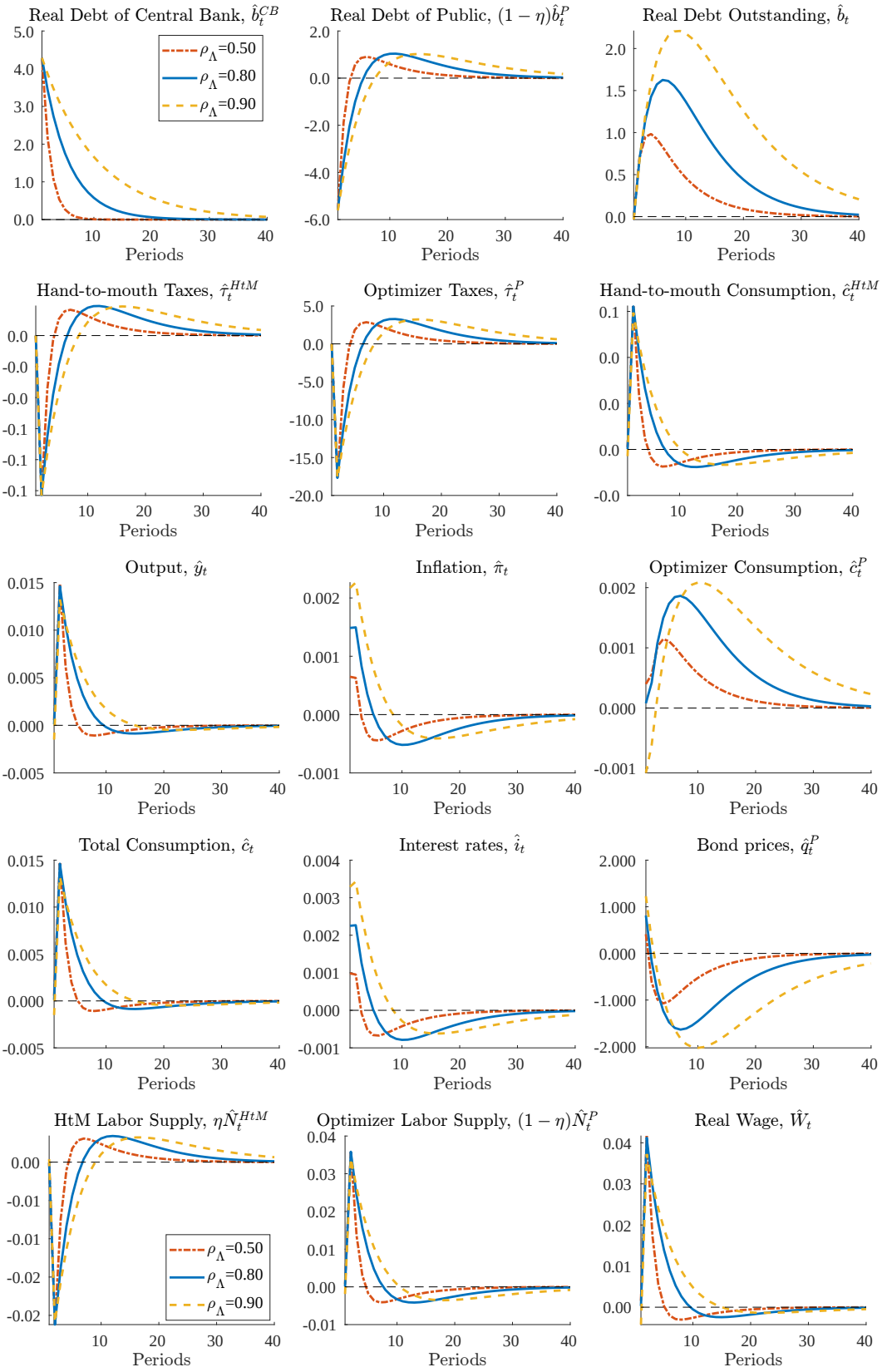


Figure B.9: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

Figure B.10 compares the impulse responses of an asset purchase shock to those of tax-cut shocks to the tax rules in equations (33) and (34) and shows that they are quite different. These shocks, ϵ_t^P and ϵ_t^{HtM}, have the same persistence as the asset purchase shock, but with variances, σ_P^2 and σ_{Htm}^2, that are set so that the impulse response of taxes to a tax shock is close to the impulse response of taxes to the asset purchase shocks studied.

$$\begin{aligned}\hat{\tau}_t^P &= \gamma^P(\hat{b}_{t-1} - \omega\hat{b}_{t-1}^{CB}) + \epsilon_t^P, \quad \epsilon_t^P = \rho\epsilon_{t-1}^P + \varepsilon_t^P, \quad \varepsilon \sim (0, \sigma_P^2) \\ \hat{\tau}_t^{HtM} &= \gamma^{HtM}(\hat{b}_{t-1} - \omega\hat{b}_{t-1}^{CB}) + \epsilon_t^{HtM}, \quad \epsilon_t^{HtM} = \rho\epsilon_{t-1}^{HtM} + \varepsilon_t^{HtM}, \quad \varepsilon \sim (0, \sigma_{HtM}^2)\end{aligned}$$

Even though the path of taxes is similar under a tax shock and a QE shock, the evolution of the economy is quite different. In response to the tax-cut shock to hand-to-mouth households (solid thick purple lines), inflation is higher than under the asset purchase shock (solid thin blue lines) and optimizer consumption actually decreases. This is because bond prices drop and there is little adjustment in real debt held by the public. In response to the tax shock to optimizer households (dashed red lines), debt held by the public rises, which leads to a tax increase on hand-to-mouth households and a decrease in their consumption. However, total consumption still rises which leads to an increase in output, but a decrease in inflation.

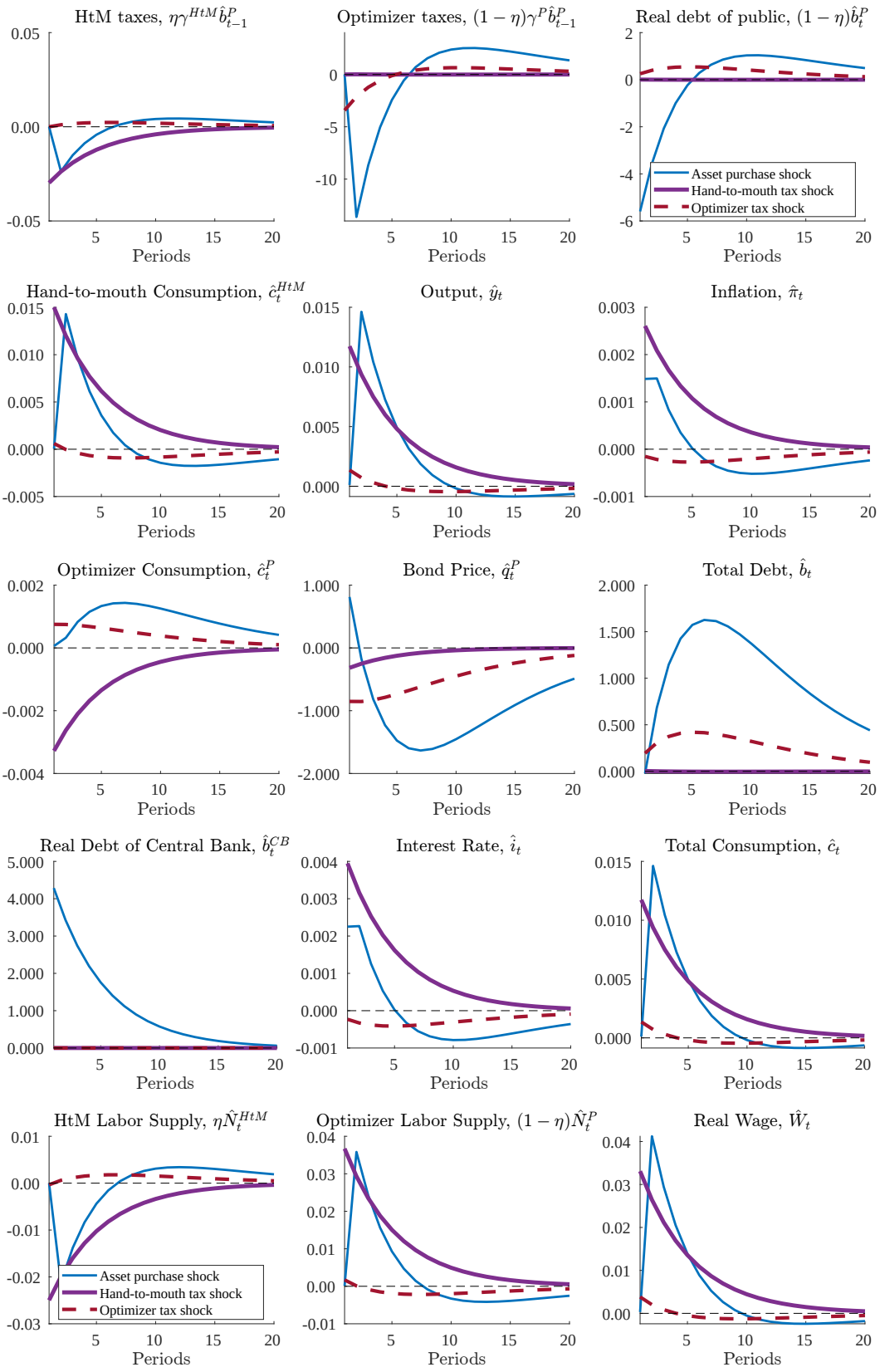


Figure B.10: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}^{CB}_t$, Percent.

Figure B.11 shows that there are no macroeconomic effects of central bank asset purchases when taxes are instead collected based on the total amount of debt outstanding, $\hat{b}_t$, instead of debt held by the public $\hat{b}_t^P$. This is because real debt outstanding, $\hat{b}_t$, does not respond to the QE in the initial period. While real debt of the central bank, $\hat{b}_t^{CB}$, rises and real debt of the public, $(1-\eta)\hat{b}_t^P$ falls, total debt remains relatively flat which alters neither hand-to-mouth consumption nor inflation and output.

in equations (33) and (34),

$$\begin{aligned}\hat{\tau}_t^P &= \gamma^P \hat{b}_{t-1} \\ \hat{\tau}_t^{HtM} &= \gamma^{HtM} \hat{b}_{t-1}\end{aligned}$$

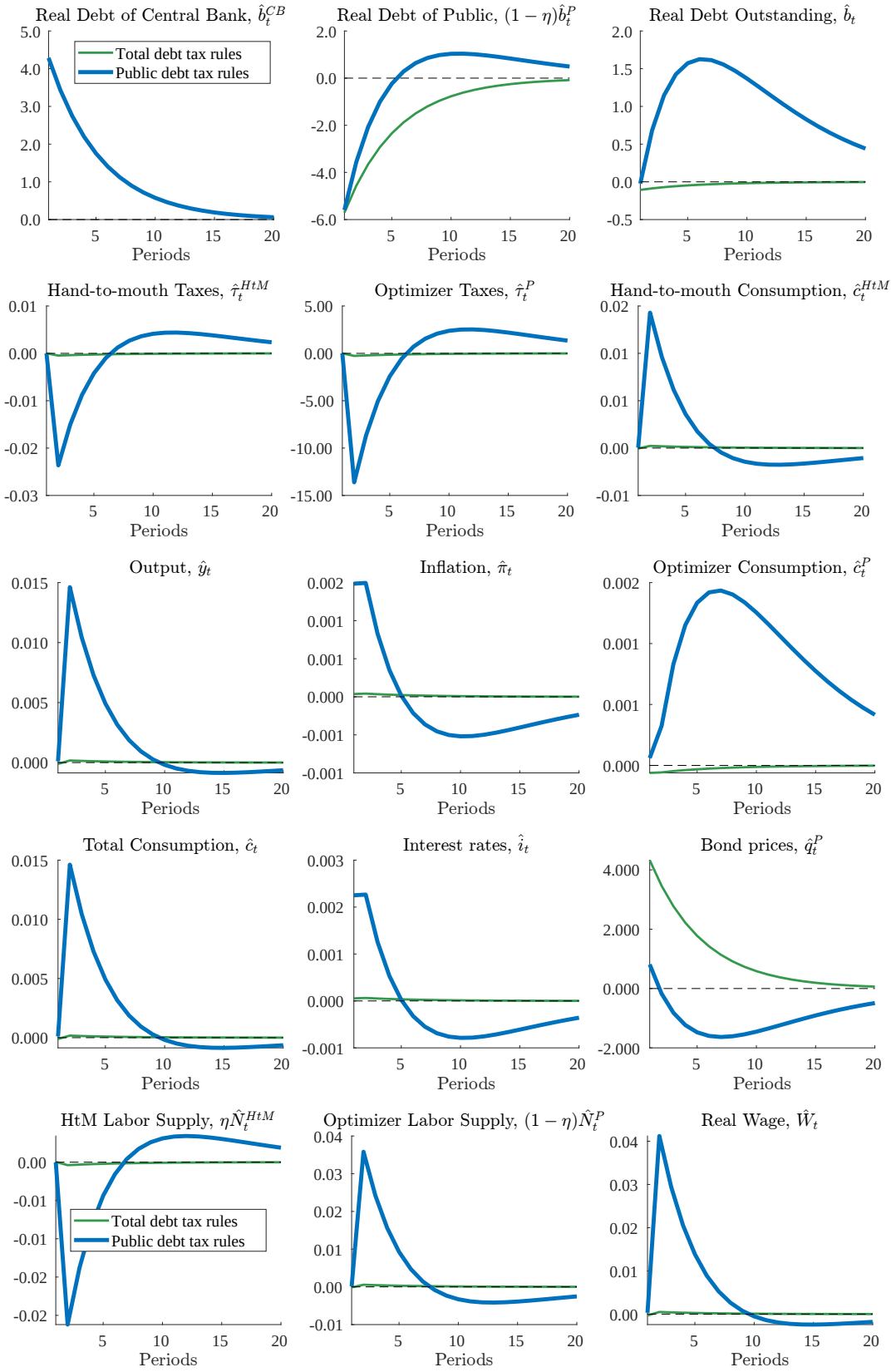


Figure B.11: Impulse Response of TANK Model to a QE shock equal to 1% of GDP, $\hat{b}_t^{CB}$, Percent.

B.2 Determinacy of the TANK Model

This section lays out some numerical explorations of the determinacy regions of the policy parameter space $\{\phi_\pi, \gamma^{HtM}, \gamma^P\}$.

Assuming $\phi_\pi > 1$ such that the Taylor Principle holds, there is some parameter space for $\{\gamma^{HtM}, \gamma^P\}$ where there is a determinate equilibrium as in Leeper (1991) that depends on the aggregate tax rule $\hat{\tau}_t$ in equation (32) and how it enters the government budget constraint in equation (25).

First, re-arranging the aggregate tax rule in equation (32)

$$\begin{aligned}\tau\hat{\tau}_t =& \eta\tau^{HtM}\hat{\tau}_t^{HtM} + (1-\eta)\tau^P\hat{\tau}_t^P \\ =& \eta\tau^{HtM}\gamma^{HtM}\hat{b}_{t-1}^P + (1-\eta)\gamma^P\tau^P\hat{b}_{t-1}^P \\ =& \left(\eta\tau^{HtM}\gamma^{HtM} + (1-\eta)\tau^P\gamma^P\right)\hat{b}_{t-1}^P\end{aligned}$$

And substituting into the government budget constraint in equation (25),

$$\hat{b}_t = (\mu-1)\hat{q}_t^P + \left(\frac{1}{Q^P} + \mu\right)\left(\hat{b}_{t-1} - \hat{\pi}_t\right) + \frac{g}{Q^P b}\hat{g}_t - \underbrace{\frac{\left(\eta\tau^{HtM}\gamma^{HtM} + (1-\eta)\tau^P\gamma^P\right)}{Q^P b}}_{\gamma}\hat{b}_{t-1}^P - \frac{\Lambda}{Q^P b}\hat{\Lambda}_t$$

It follows then that $\gamma > 1 - \beta + \iota$.

Where ι is a small term dependent on the maturity of debt μ and the long-term bond adjustment cost ξ In the calibration in the main text, $\iota \approx 0.01705$.

C Partial FTPL Model

The full equations of the partial FTPL model are as follows. Let $\hat{i} = -\hat{q}_t^R$ and $m_t = M_t/P_t$.

$$
\begin{aligned}
\hat{q}_t^P + \hat{i}_t =& \mu\beta\mathbb{E}_t[\hat{q}_{t+1}^P] - \hat{\zeta}_t \\
\hat{c}_t^P =& \mathbb{E}_t[\hat{c}_{t+1}^P] - \sigma^{-1}\left(\hat{i}_t - \hat{\pi}_{t+1}\right) \\
\hat{w}_t =& \sigma\hat{c}_t^P + \varphi\hat{n}_t^P \\
\hat{\pi}_t =& \beta\mathbb{E}_t[\hat{\pi}_{t+1}] + \Theta\hat{w}_t \\
\hat{b}_t =& (\mu-1)\hat{q}_t^P + \left(\frac{1}{Q^P} + \mu\right)\left(\hat{b}_{t-1} - \hat{\pi}_t\right) + \frac{g}{Q^P b}\hat{g}_t - \frac{\tau}{Q^P b}\hat{\tau}_t - \frac{\Lambda}{Q^P b}\hat{\Lambda}_t \\
\Lambda\hat{\Lambda}_t =& \mu b^{CB}Q^P\hat{q}_t^P + (1+Q^P\mu)b^{CB}(\hat{b}_{t-1}^{CB} - \hat{\pi}_t) - m(\hat{m}_{t-1} - \hat{\pi}_t) \\
\hat{b}_t =& \omega\hat{b}_t^{CB} + (1-\omega)(1-\eta)\hat{b}_t^P \\
\hat{y}_t =& (1-s_g)\hat{c}_t + s_g\hat{g}_t \\
\hat{y}_t =& \hat{n}_t \\
\hat{\tau}_t =& \gamma^P(\hat{b}_{t-1}^P - \hat{b}_{t-1}^{P,S}) + \gamma^s\hat{b}_{t-1}^{P,S} \\
\hat{i}_t =& \phi_\pi^P(\hat{\pi}_t - \hat{\pi}_t^S) + \phi_\pi^S\hat{\pi}_t^S \\
\hat{\zeta}_t =& \xi\hat{b}_t^P \\
\hat{b}_t^{CB} =& \gamma^\Lambda\hat{b}_{t-1}^{CB} + \epsilon_t \\
\epsilon_t =& \rho_\Lambda\epsilon_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma_\Lambda^2)
\end{aligned}
$$

For $s_g = G/Y$. Government spending is set at its steady-state value, $\hat{g}_t = g$.

The shadow economy replicates the main economy, except with different policy rules. Superscripts S denote the shadow economy.

$$
\begin{aligned}
\hat{q}_t^{P,S} + \hat{i}_t^S =& \mu\beta\mathbb{E}_t[\hat{q}_{t+1}^{P,S}] - \hat{\zeta}_t^S \\
\hat{c}_t^{P,S} =& \mathbb{E}_t[\hat{c}_{t+1}^{P,S}] - \sigma^{-1}\left(\hat{i}_t^S - \hat{\pi}_{t+1}^S\right) \\
\hat{w}_t^S =& \sigma\hat{c}_t^{P,S} + \varphi\hat{n}_t^{P,S} \\
\hat{\pi}_t^S =& \beta\mathbb{E}_t[\hat{\pi}_{t+1}^S] + \Theta\hat{w}_t^S \\
\hat{b}_t^S =& (\mu-1)\hat{q}_t^{P,S} + \left(\frac{1}{Q^{P,S}} + \mu\right)\left(\hat{b}_{t-1}^S - \hat{\pi}_t^S\right) + \frac{g}{Q^P b}\hat{g}_t^S - \frac{\tau}{Q^P b}\hat{\tau}_t^S - \frac{\Lambda}{Q^P b}\hat{\Lambda}_t^S \\
\Lambda\hat{\Lambda}_t^S =& \mu b^{CB} Q^P \hat{q}_t^{P,S} + (1+Q^P\mu)b^{CB}(\hat{b}_{t-1}^{CB,S} - \hat{\pi}_t^S) - m(\hat{m}_{t-1}^S - \hat{\pi}_t^S) \\
\hat{b}_t^S =& \omega\hat{b}_t^{CB,S} + (1-\omega)(1-\eta)\hat{b}_t^{P,S} \\
\hat{y}_t^S =& (1-s_g)\hat{c}_t^S + s_g\hat{g}_t^S \\
\hat{y}_t^S =& \hat{n}_t^S \\
\hat{\tau}_t^S =& \gamma^s\hat{b}_{t-1}^{P,S} \\
\hat{i}_t^S =& \phi_\pi^S\hat{\pi}_t^S \\
\hat{\zeta}_t^S =& \xi\hat{b}_t^{P,S} \\
\hat{b}_t^{CB,S} =& \gamma^\Lambda\hat{b}_{t-1}^{CB,S} + \epsilon_t^S \\
\epsilon_t^S =& \rho_\Lambda\epsilon_{t-1}^S + \varepsilon_t^S, \quad \varepsilon_t^S \sim \mathcal{N}(0, \sigma_{S,\Lambda}^2)
\end{aligned}
$$

C.1 Additional Results for Partial FTPL Model

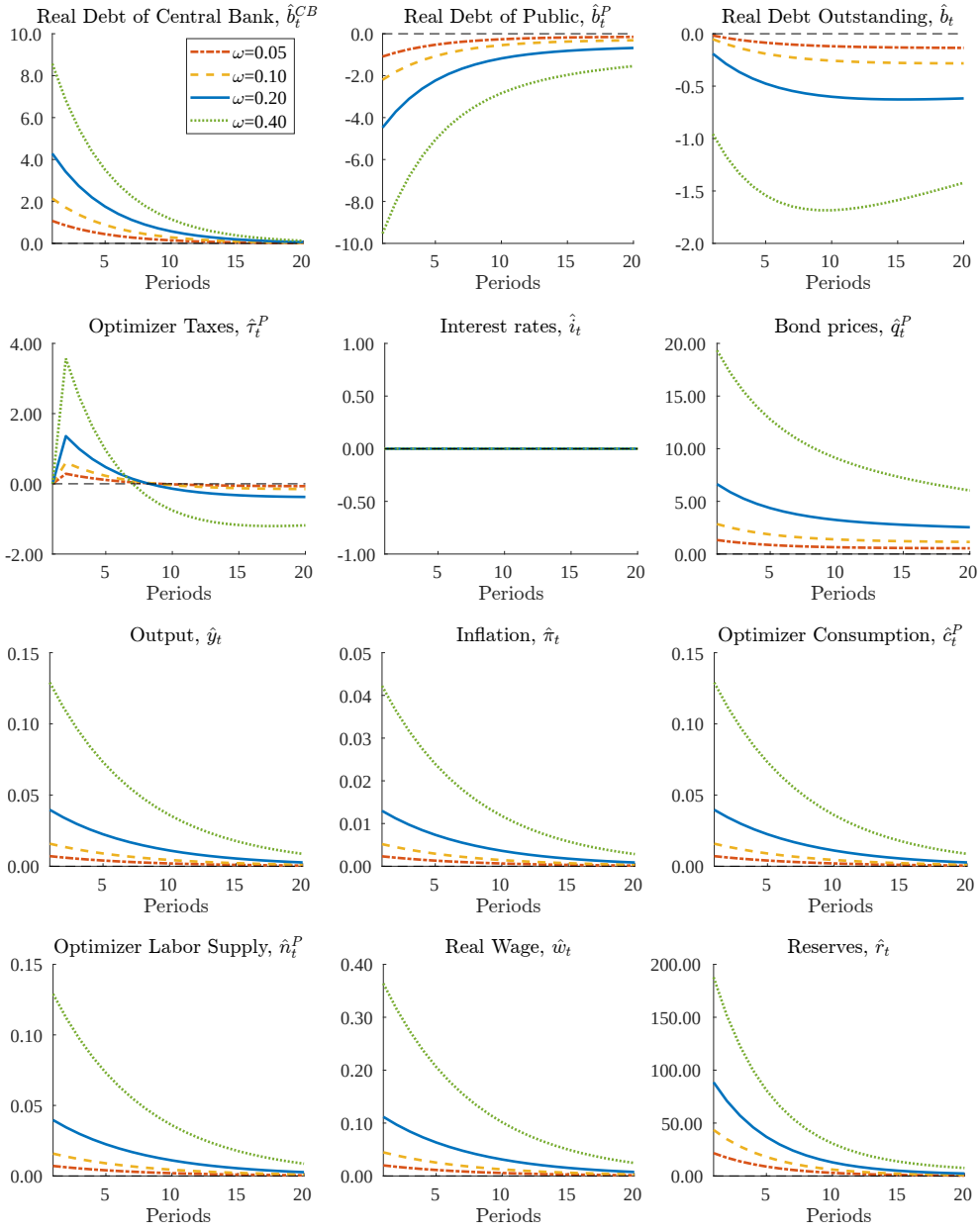


Figure C.1: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

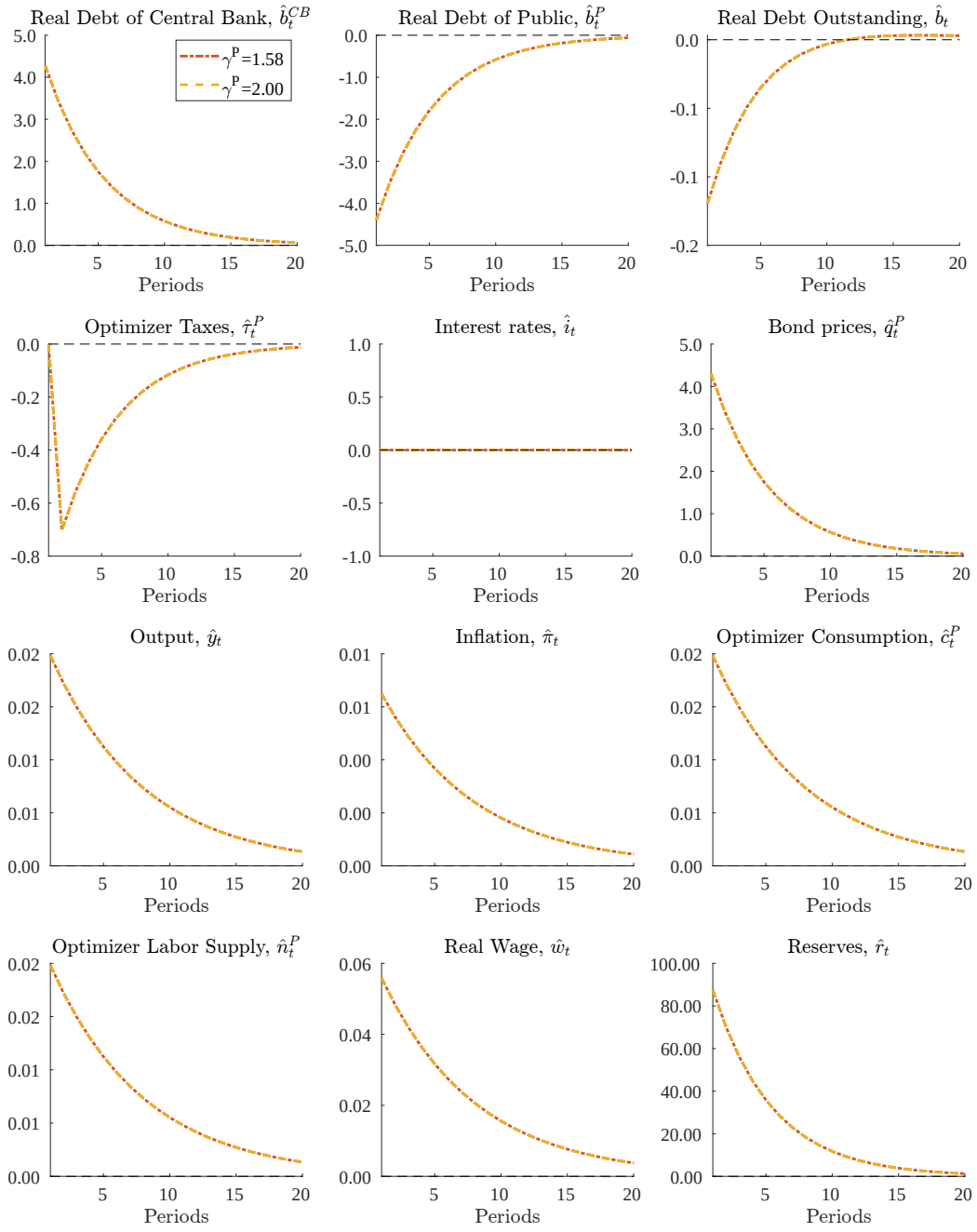


Figure C.2: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

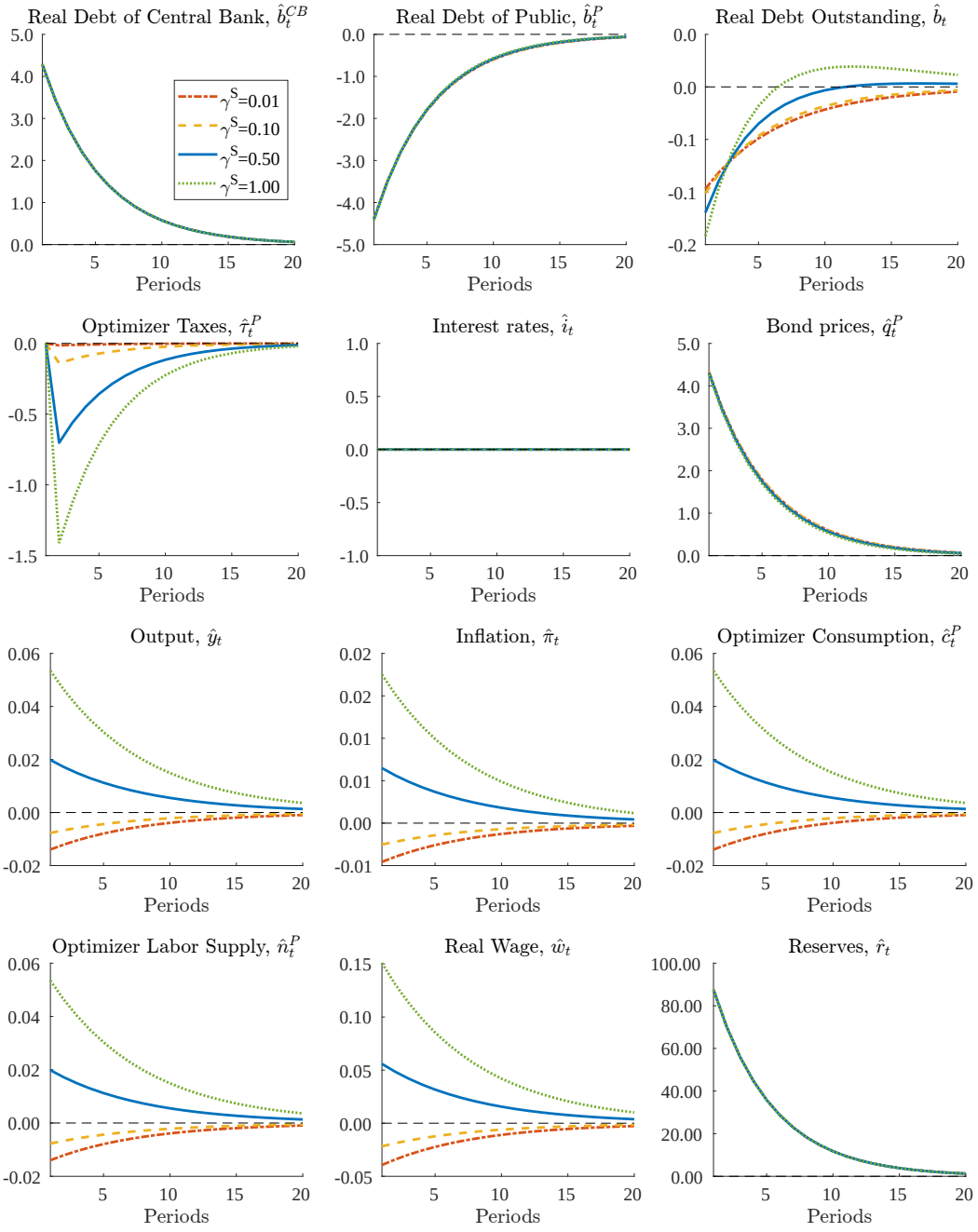


Figure C.3: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

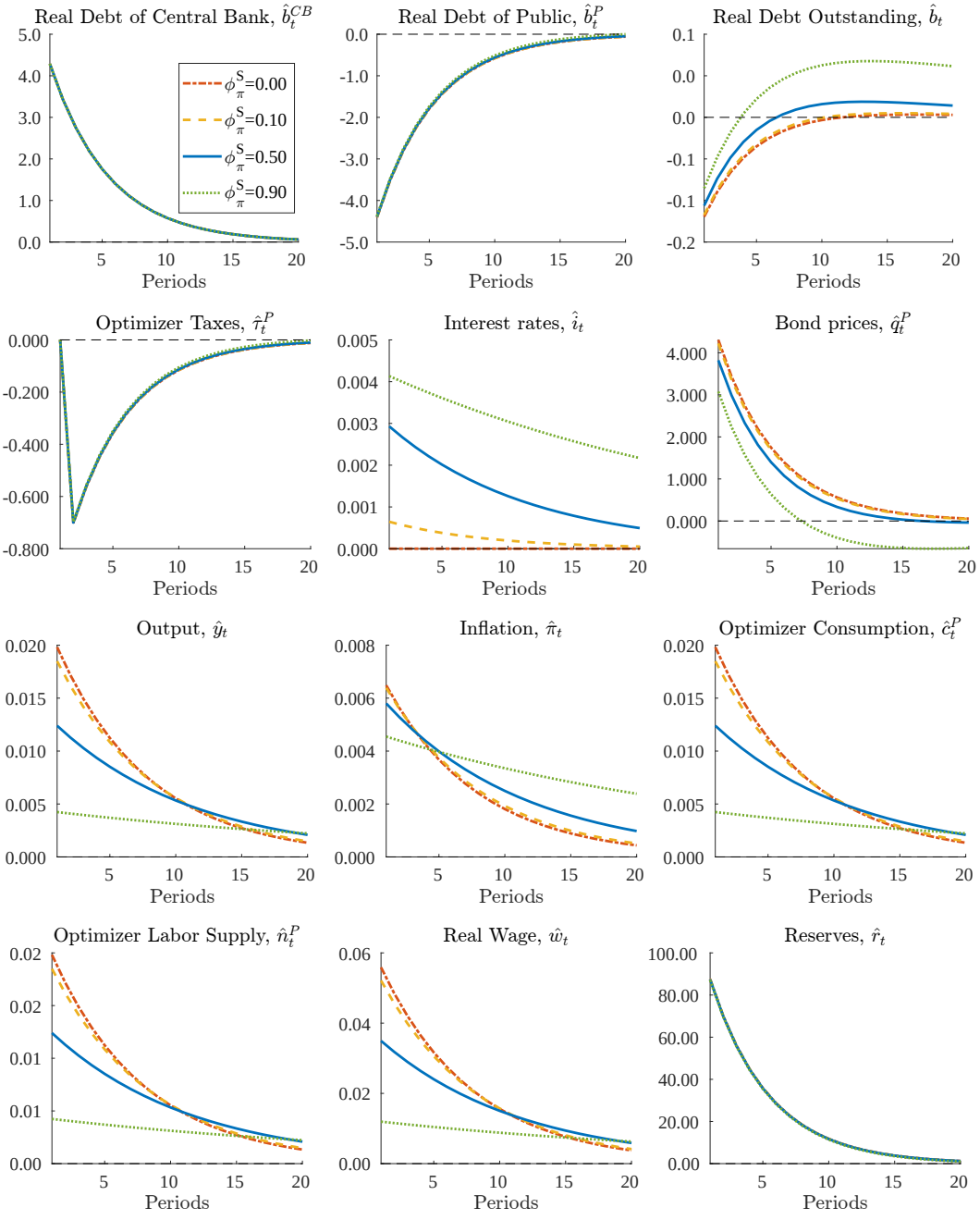


Figure C.4: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

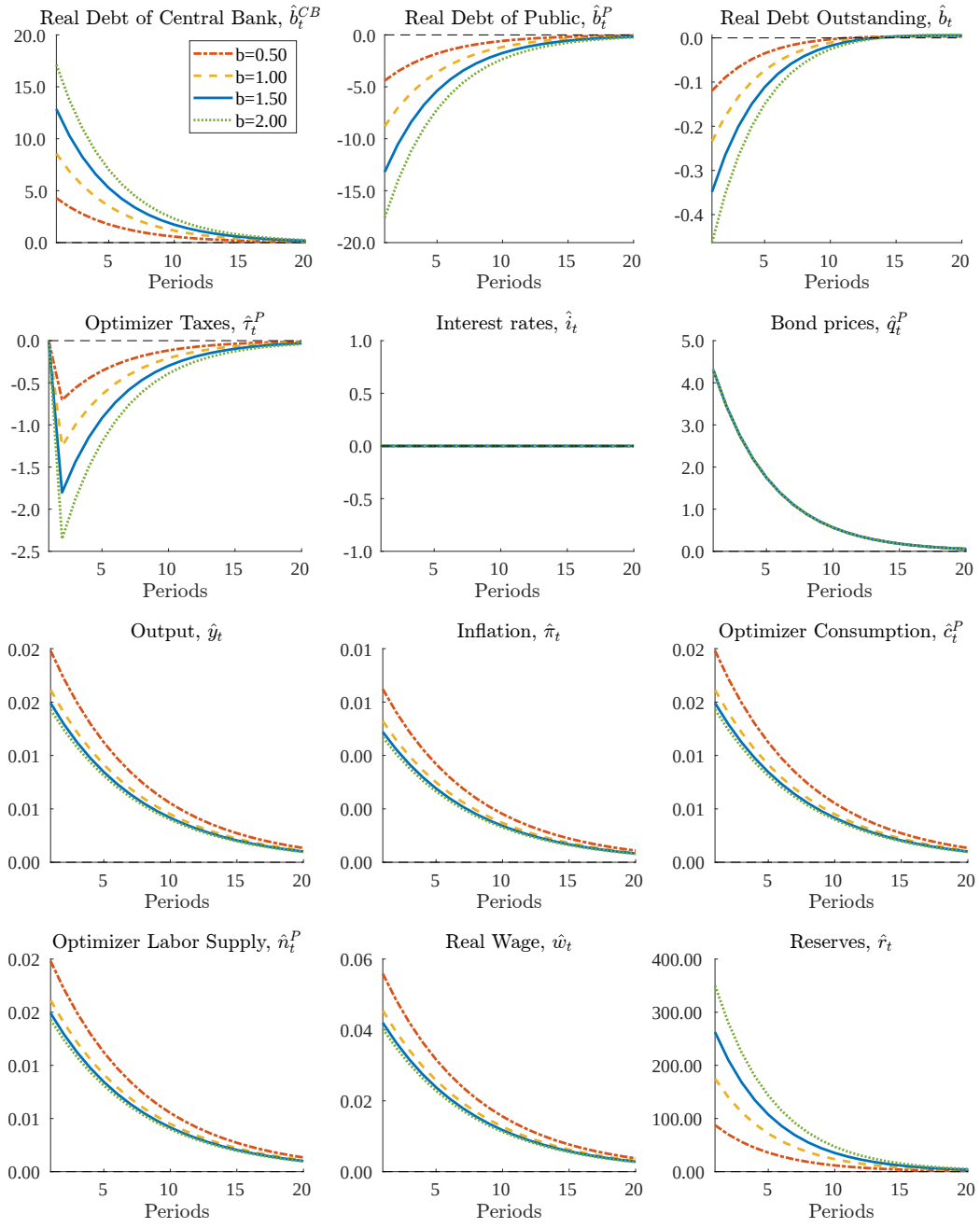


Figure C.5: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

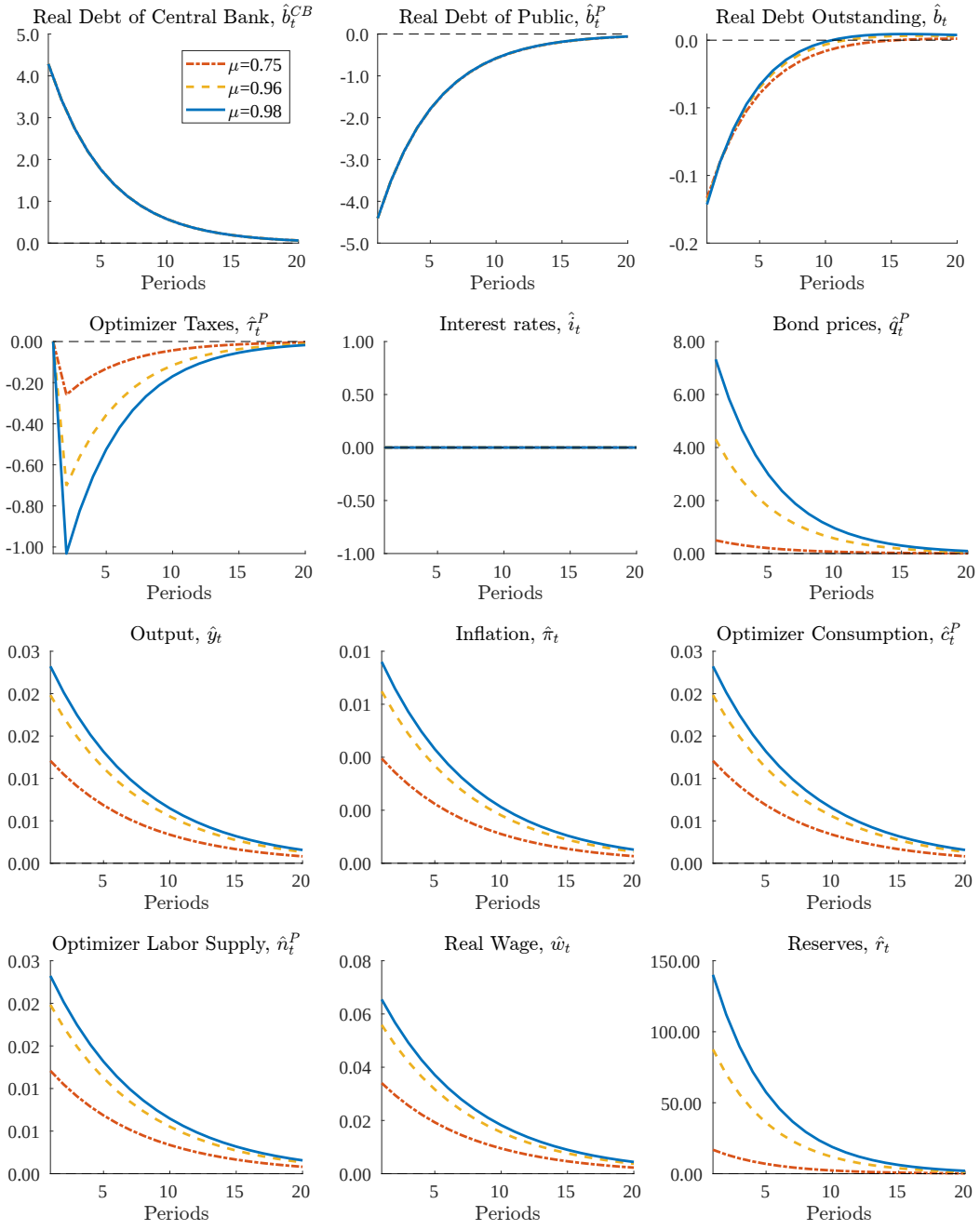


Figure C.6: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

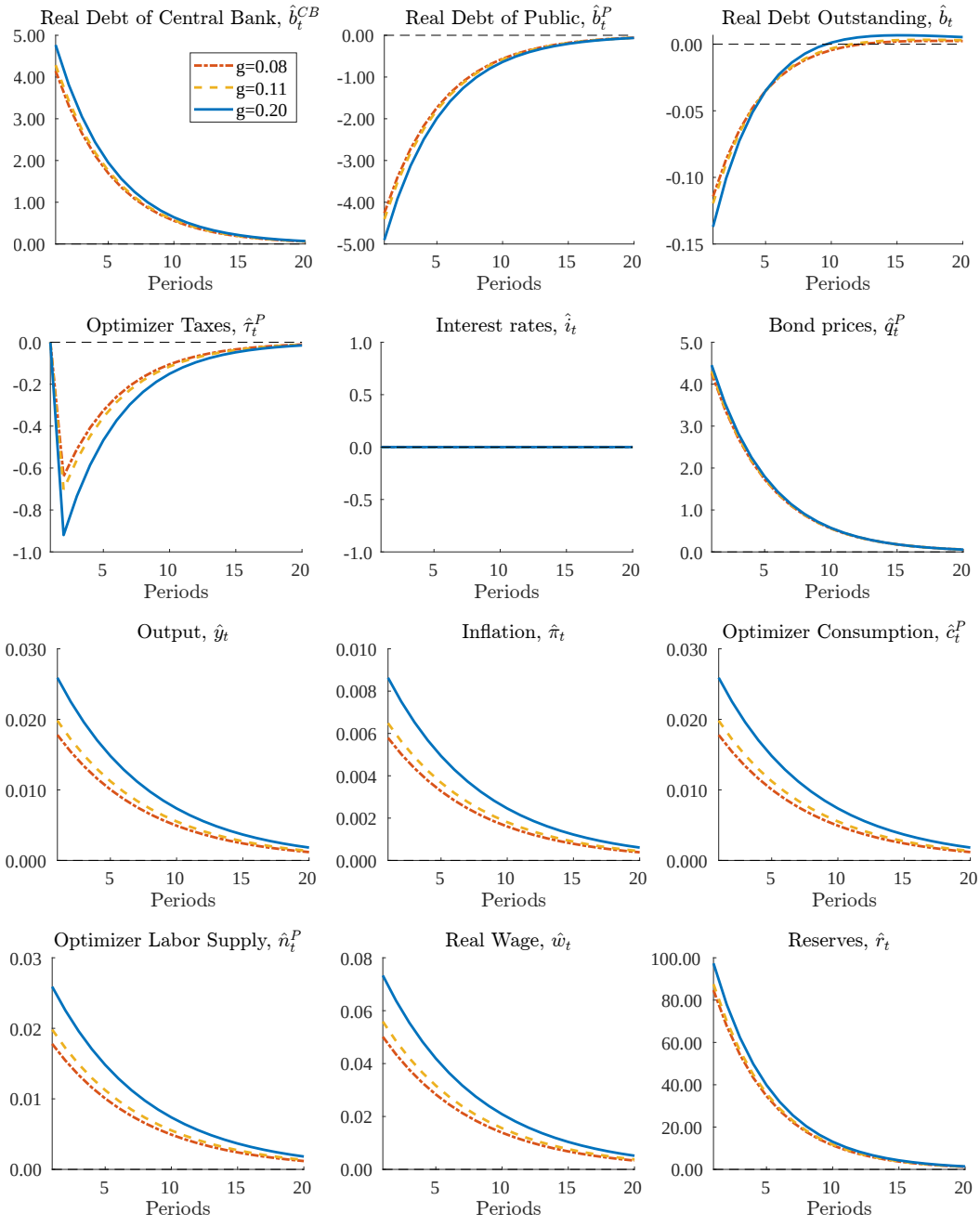


Figure C.7: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

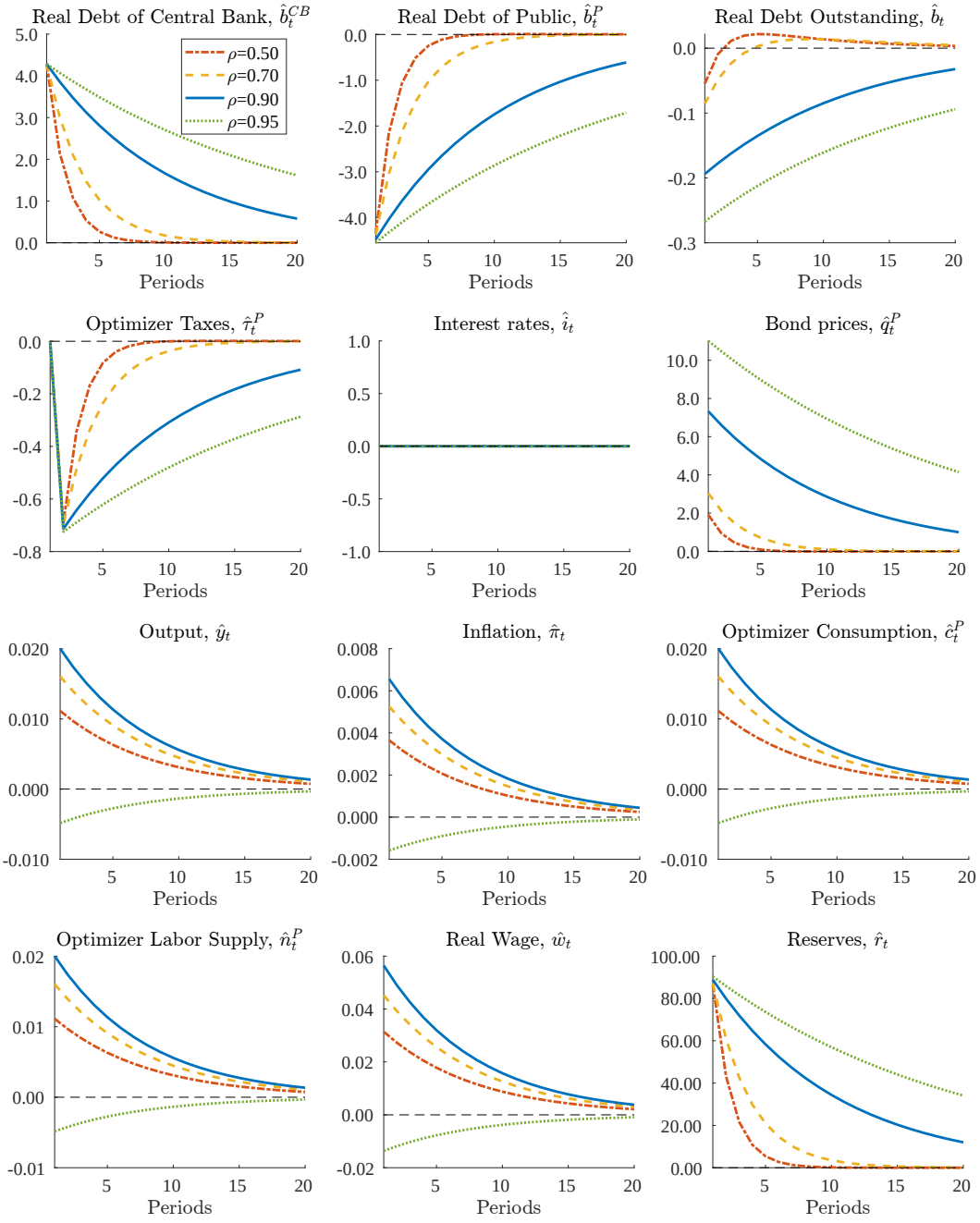


Figure C.8: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

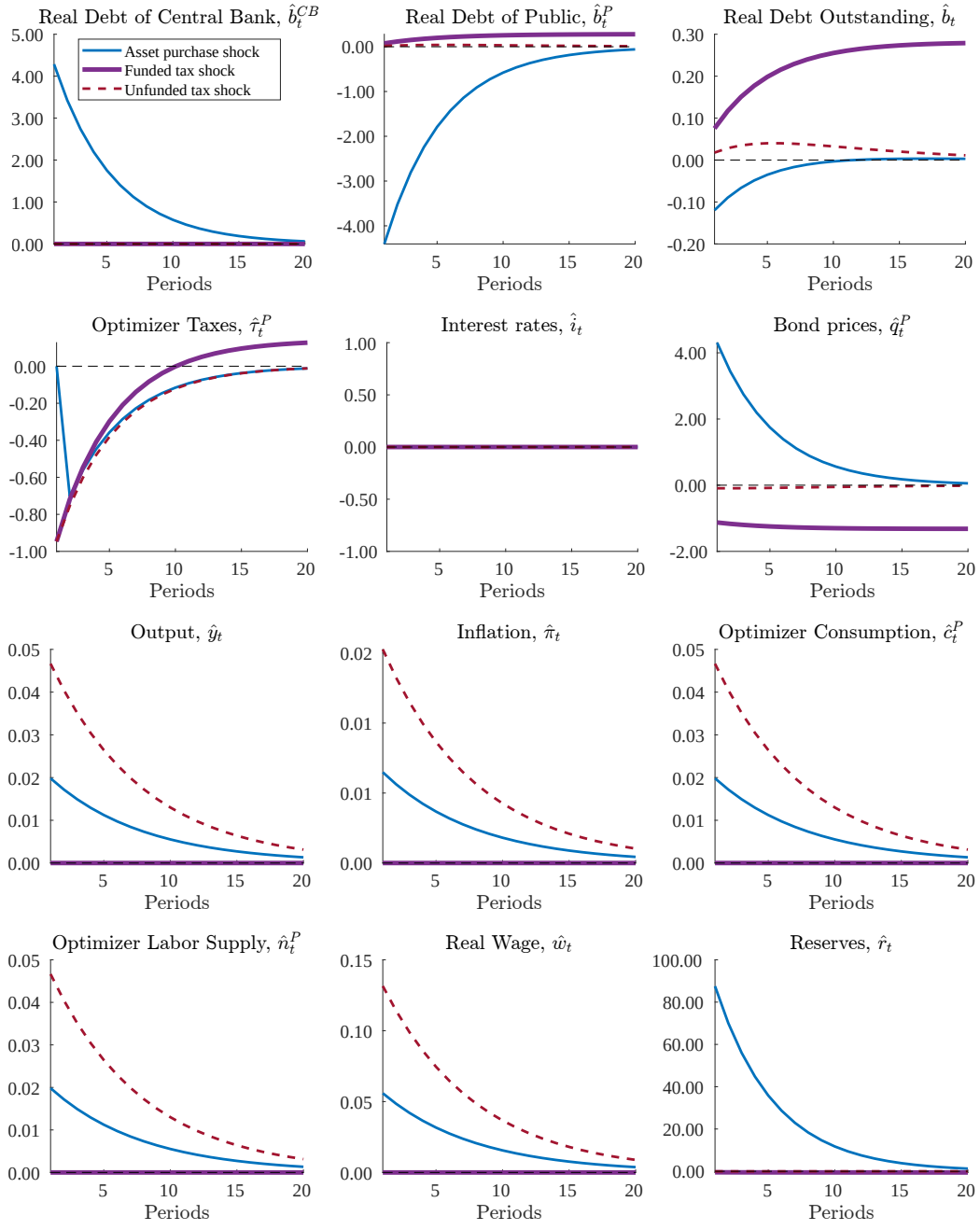


Figure C.9: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

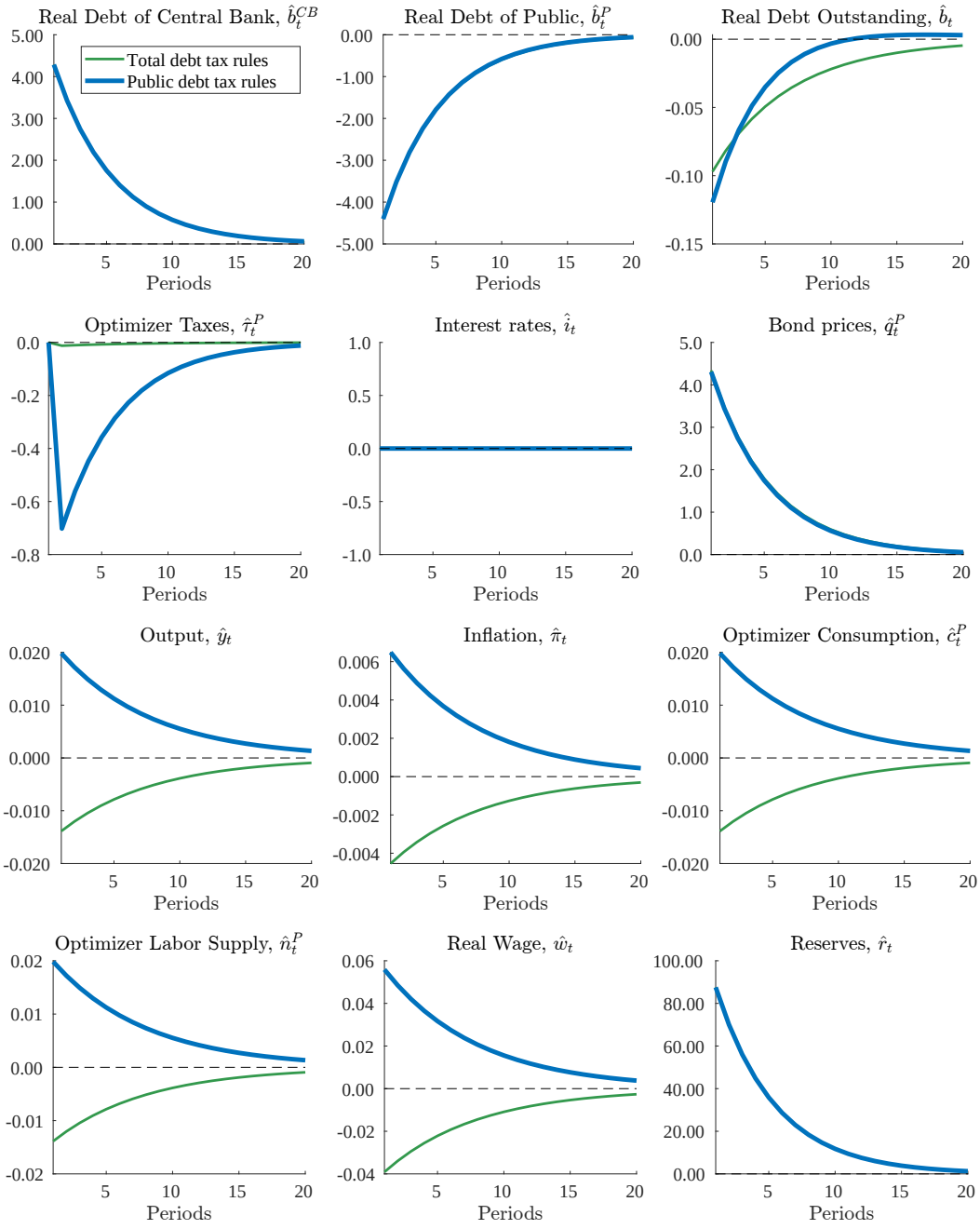
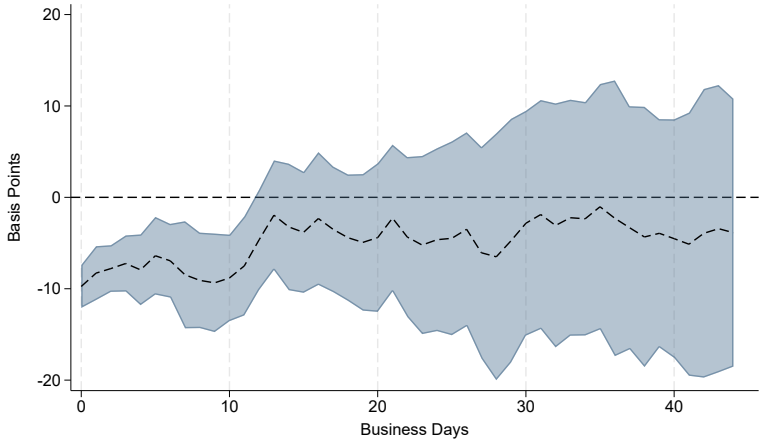


Figure C.10: Impulse Response of Partial Fiscal Theory Model to a 1% of GDP-sized shock to unfunded central bank asset holdings, $\hat{b}_t^{CB,S}$, Percent.

D Additional Empirical Results

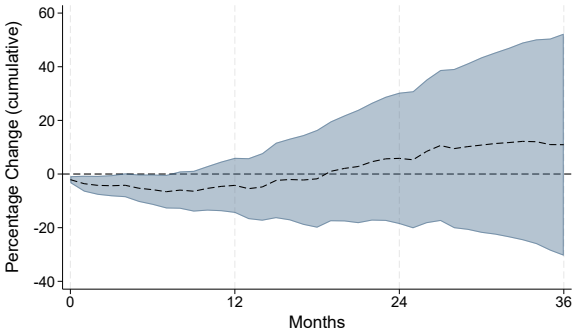
Figure D.1: Impulse Response of the 10-Year Treasury Yield to an Accommodative Asset Purchase Shock



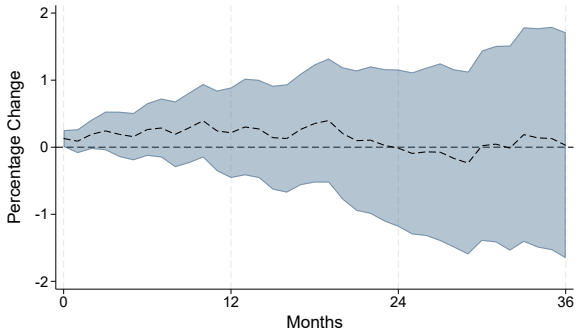
Notes: Figure plots the daily response of the market yield on US Treasury securities at 10-Year constant maturity (DGS10 from FRED). Sample: January 1, 2008- May 22, 2024. Local projection includes 5 lags of the dependent variable. 90% confidence interval constructed with heteroskedasticity-robust standard errors.

Figure D.2: Monthly Impulse Responses to an Accommodative Asset Purchase Shock

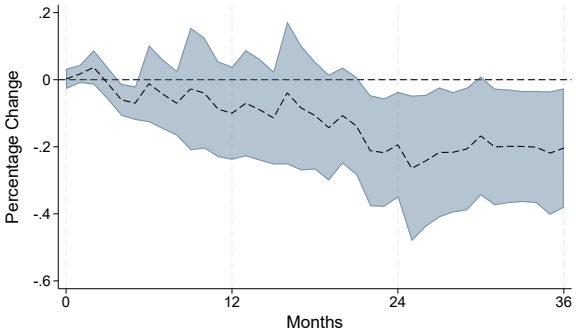
(a) Cumulative Tax Revenue



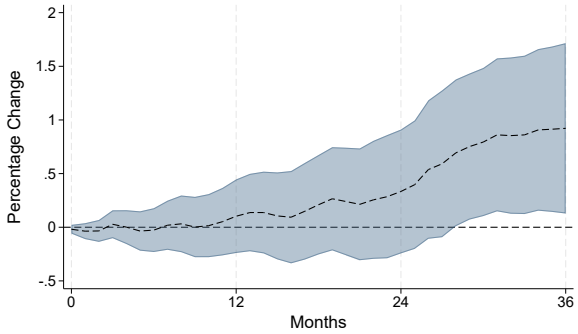
(b) Outstanding Treasury Debt



(c) Unemployment Rate



(d) CPI Inflation



Notes: Panel (a) plots the response of the log of cumulative tax revenue. Panel (b) plots the response of the log of total public debt outstanding. Panel (c) plots the response of the unemployment rate; Panel (d) plots the response of the CPI price level. All IRFs include 12 lags of the dependent variable, 12 lags of the change in the Chicago National Financial Conditions Index, and monthly indicators for March through August 2020. Sample: October 1980–April 2024. The start date of the sample corresponds to the first month for which all variables are available. 90% confidence intervals constructed with heteroskedasticity-robust standard errors.