Fiscal Funding, Treasury Convenience and the Real Exchange Rate

Marco Graziano[a,*] Maria Pia Lombardo[b] Maxime Phillot[c,†]

July 18, 2026

Abstract

How the U.S. government finances its spending—with taxes or with debt—determines how fiscal shocks move the real exchange rate. In a New-Keynesian model with complete markets and U.S. Treasuries providing liquidity services, government debt carries a convenience yield that falls as its supply grows. A debt-financed spending shock expands the supply of Treasuries and compresses the convenience yield. Because bonds and consumption are complements, the lower convenience yield raises consumption, and international risk sharing then induces a depreciation of the real exchange rate, in line with the empirical evidence. A tax-financed shock instead delivers the standard appreciation. The funding mix at the time of the shock is thus a sufficient statistic for the sign of the exchange-rate response. In a quantitative two-country model, the monetary-fiscal regime shapes the mechanism: the real exchange rate depreciates on impact under both monetary and fiscal dominance, but the convenience yield falls under the first and rises under the second. State-dependent local projections on U.S. data confirm the joint pattern predicted by monetary dominance. Liquidity services of government debt thus reshape the international transmission of fiscal policy.

JEL Classification: E63, F31, F41

Keywords: exchange rates, convenience yields, monetary-fiscal interactions, fiscal shocks, safe assets.

[a]University of Basel, Faculty of Business and Economics. Peter Merian-Weg 6, 4002 Basel, Switzerland. marco.graziano@unibas.ch

[b]University of Lausanne, Department of Economics. Quartier UNIL-Chamberonne, Internef Building, 1015 Lausanne, Switzerland. mariapia.lombardo@unil.ch

[c]Swiss National Bank. Börsenstrasse 15, 8022 Zurich, Switzerland. maxime.phillot@snb.ch

[*]Corresponding author.

[†]The views, opinions, findings, and conclusions or recommendations expressed in this paper are strictly those of the authors. They do not necessarily reflect the views of the Swiss National Bank (SNB). The SNB takes no responsibility for any errors or omissions in, or for the correctness of, the information contained in this paper.

1 Introduction

Governments across advanced economies have run large and volatile deficits over the past two decades, from the response to the Great Financial Crisis to the unprecedented fiscal stimulus of the Covid-19 pandemic. How such expansions transmit across borders is a central question for open-economy macroeconomics, and the real exchange rate is a key margin of adjustment. Yet theory and evidence disagree on how it responds.

A large class of DSGE models with flexible (Backus et al., 1994; Engel, 2002) or sticky (Corsetti and Pesenti, 2001) prices predicts that an expansionary fiscal shock causes a real appreciation. As government spending increases, forward-looking households expect higher future taxation, which lowers their permanent income. They consume less, and the real exchange rate appreciates through the international risk-sharing condition implied by market completeness. Contrary to these predictions, a vast empirical literature finds that fiscal shocks induce an *increase* in consumption and a *depreciation* of the real exchange rate (Kim and Roubini, 2008; Monacelli and Perotti, 2010; Ravn et al., 2012).

This paper establishes the role of the convenience yield of U.S. Treasuries and its interaction with the funding composition of government spending in reconciling this discrepancy.

Under Ricardian equivalence, the contemporaneous funding source of new expenditure is irrelevant, provided the government ultimately covers expenditure through future taxation. However, the empirical literature on fiscal multipliers shows that the source of immediate funding matters (Ilzetzki et al., 2010; Chodorow-Reich, 2019; Ramey, 2019). Likewise, several theoretical mechanisms can break Ricardian equivalence, including finitely-lived agents (Blanchard, 1985) and household heterogeneity (Galí et al., 2007; Brinca et al., 2016).

We focus on the convenience yield of U.S. Treasuries as a mechanism that can break Ricardian equivalence. U.S. Treasuries trade at a premium relative to similarly safe domestic securities (Krishnamurthy and Vissing-Jorgensen, 2012) and foreign government bonds (Du et al.,

2018) due to their liquidity, dollar denomination, and role as the premier global safe asset. These non-pecuniary benefits are robustly negatively correlated with the nominal and real amount of debt outstanding (Jiang et al., 2024). The literature commonly models this feature as a term in households' utility function that is increasing and concave in real debt holdings (Krishnamurthy and Vissing-Jorgensen, 2012; Jiang et al., 2021, 2023).[1] In this framework, an increase in government debt supply resulting from a debt-funded fiscal expansion lowers the marginal utility of real debt holdings and the convenience yield. As a result, consumption increases *ceteris paribus* through intratemporal substitution. Under complete markets, the real exchange rate then depreciates in accordance with the empirical evidence.

This link is visible in the data: periods of dollar depreciation tend to coincide with a compression of the convenience yield (Figure 1), mirroring the tight correlation between convenience yields and the real dollar exchange rate (Valchev, 2020; Engel and Wu, 2023).

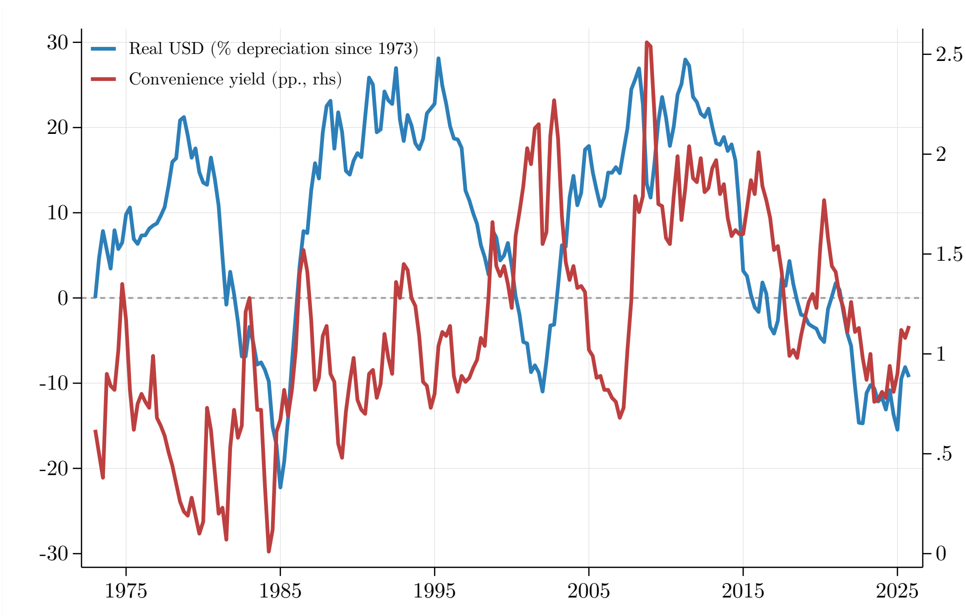


Figure 1: Correlation between real exchange rate depreciation and convenience yield

Notes: Correlation between the cumulative real depreciation of the U.S. dollar narrow index and the convenience yield, proxied by the spread between the Moody's Aaa corporate bond yield and the ten-year Treasury constant maturity rate. Both series are monthly averages. Sample: 1973Q1–2025Q4.

[1] A related mechanism arises in Bacchetta et al. (2026), where agents alternate between saving and investment states and limited pledgeability creates a demand for liquid government liabilities.

We start by embedding this mechanism in a simple New-Keynesian open-economy model with complete markets and a fiscal rule allowing the government to choose the mix of taxation or debt that contemporaneously finances new expenditure. We posit that the central bank keeps the real interest rate fixed, so that the feedback of monetary policy to consumption through intertemporal substitution is shut down, and there is no possibility of government debt revaluation through surprise inflation.

Thanks to this assumption, we derive an analytical solution of the model in terms of consumption and real government debt. For a sufficiently high fraction of debt funding, an expansionary fiscal shock leads to an increase in consumption and a real depreciation. On the contrary, a tax-funded shock implies a drop in consumption and an appreciation as in the standard New-Keynesian open-economy model. Therefore, the degree of debt financing is a sufficient statistic for the sign of the real exchange rate response.

We then move to a quantitative model to understand the effects of the convenience yield in a richer environment. We micro-found the convenience yield by explicitly modeling the liquidity benefits of U.S. Treasuries as facilitating transactions (Bansal and Coleman, 1996), introducing a further channel through the stochastic discount factor of households. We also assume the central bank follows an inertial Taylor rule, restoring the response of consumption to monetary policy. Consequently, the model also relaxes the assumption of debt repayment solely through future taxation, allowing us to analyze the intertemporal funding source of government spending in "monetary dominance" and "fiscal dominance" equilibria, following the nomenclature in Leeper (1991).

Under fiscal dominance, a debt-funded fiscal shock results in higher inflation on impact as the central bank accommodates the fiscal expansion by raising the nominal rate only weakly. As a consequence, the real interest rate falls and consumption rises through an intertemporal substitution effect. This mechanism, first examined by Jiang (2022), can deliver a real depreciation with complete markets. However, in this regime the convenience yield actually *increases* with nominal outstanding debt. This co-movement arises because the central bank inflates away the real value of government debt to satisfy its budget constraint.

Under monetary dominance, the central bank reacts to the inflationary pressure of a debt-funded fiscal shock by raising the nominal interest rate enough for the real rate to rise as well, according to the Taylor principle. As a result, the relative marginal utility of domestic consumption rises and the real exchange rate appreciates *ceteris paribus* due to the Backus-Smith condition. However, the convenience yield effect dominates as long as nominal rates do not react too strongly to inflation or taxes to debt, leading to an increase in consumption and a real depreciation. The convenience yield drops in response to the debt-funded shock, as the amount of real debt outstanding rises in tandem with its nominal counterpart.

Therefore, the quantitative model predicts the correlation between the convenience yield and the real exchange rate should be positive under fiscal dominance, and negative under monetary dominance. This pattern is borne out in the data, as Figure 1 shows: the convenience yield and real exchange rate move in opposite directions in periods of recognized monetary dominance such as the Great Moderation (Bianchi and Ilut, 2017), while they move in tandem in times of likely fiscal dominance such as the late 1970s and the post-Great Financial Crisis years (Bianchi et al., 2023).

Notably, a tax-financed fiscal shock predicts an appreciation of the real exchange rate under both fiscal and monetary dominance, underscoring the crucial role of the contemporaneous financing source regardless of the monetary-fiscal regime.

We also provide empirical evidence on the importance of the funding composition for the response of the real exchange rate to fiscal shocks. We introduce a new methodology to identify states of debt- or tax-financing of government spending via the dynamics of budget deficits. In a debt-financing state, a fiscal expansion leads to an exchange rate depreciation accompanied by a fall of the convenience yield of U.S. Treasuries, while in the tax-financed one the real exchange rate appreciates and the convenience yield rises. Such results are consistent with the predictions of both the analytical model and the quantitative model under monetary dominance.

Related literature

This paper sits in the literature on the exchange rate appreciation puzzle. A set of studies reconciles the puzzle via alternative specifications of households' utility function, including non-separability of consumption and leisure (Monacelli and Perotti, 2010) and deep habits (Ravn et al., 2012), while others depart from the assumption of unproductive government spending (Di Giorgio et al., 2018) or introduce government spending in the utility function (Bouakez and Rebei, 2007). An alternative explanation relies on spending reversals (Corsetti et al., 2012): in a Ricardian setting, a real depreciation can follow a fiscal expansion if households expect future spending cuts. Another strand relaxes the complete-markets assumption to break the link between consumption and the real exchange rate (Kollmann, 2010; Bouakez and Eyquem, 2015).

Our key contribution lies in proposing a mechanism based on the unique role of U.S. Treasuries as a global safe asset, helping explain why the empirical evidence of real depreciation following fiscal shocks is particularly robust for the United States, but weaker for the European Union (Beetsma et al., 2008; Benetrix and Lane, 2013) and emerging markets (Miyamoto et al., 2019).

The closest paper is Jiang (2022), which reconciles the exchange rate appreciation puzzle via the fiscal theory of the price level. Our results extend this analysis by drawing implications for the joint response of the real exchange rate and the convenience yield to fiscal shock under monetary and fiscal dominance.

In studying fiscal funding, we connect to the literature on state-dependent fiscal multipliers. While much of this literature examines how multipliers vary with the business cycle or monetary-policy regime (Auerbach and Gorodnichenko, 2012; Ramey and Zubairy, 2018), we focus on the source of fiscal financing. Mountford and Uhlig (2009) finds that debt-financed spending raises output and consumption modestly. Priftis and Zimic (2021) and Broner et al. (2022) distinguish between debt holders, showing that foreign purchases raise fiscal multipliers by mitigating crowding-out. Ghomi et al. (2025) show that short-term debt financing yields larger multipliers. We contribute by developing a novel empirical methodology to identify debt- and tax-funded fiscal shocks and demonstrating their different effects on real and financial variables.

Another related literature studies the macroeconomic implications of the convenience yield of U.S. Treasuries, especially for nominal exchange rates. Valchev (2020) develops a model with bond preferences and slow tax adjustment that generates exchange rate oscillations and short-run Uncovered Interest Parity (UIP) failures with long-run reversals. Jiang et al. (2024) shows how demand for the non-pecuniary benefits of Treasuries accounts for exchange rate volatility, disconnect, and UIP deviations. More broadly, Jiang et al. (2021) links dollar exchange rate dynamics to movements in the convenience yield. We contribute by showing that convenience yields also help explain real exchange rate dynamics.

An emerging literature studies the implications of convenience yields for fiscal policy. Bonam (2020) shows that convenience yields relax fiscal constraints and enhance countercyclical policy effectiveness. Rannenberg (2021) shows that fiscal expansions can raise consumption when government bonds enter utility through a mechanism closely related to ours. Ghomi et al. (2025) explain larger multipliers under short-term debt through the safety and liquidity services of government debt. We extend this line of work to an open-economy setting and analyze the role of tax versus debt financing.

Roadmap

The rest of the paper is structured as follows. Section 2 contains the analytical model. Section 3 contains the quantitative model. Section 4 provides empirical evidence. Section 5 concludes.

2 Analytical model

In this section, we present a stylized model to deliver analytical results and clearly illustrate the core mechanism. The framework builds on the standard New-Keynesian small open-economy model with complete markets. The global economy consists of a small open economy — referred to as the home country — and a large foreign country representing the rest of the world. Each country is populated by a continuum of identical, infinitely-lived households, and features a continuum of monopolistically competitive firms producing differentiated final goods.

Following Krishnamurthy and Vissing-Jorgensen (2012), we adopt a bonds-in-the-utility-function approach to capture the non-pecuniary convenience benefits investors derive from holding home-issued nominal bonds. Moreover, both countries exhibit a symmetric preference for bonds issued by the home country, following Jiang et al. (2021). This assumption reflects the unique global role of U.S. Treasuries as safe assets, which command a premium over other sovereign bonds with similar risk and return profiles (Du et al., 2018; Jiang et al., 2021; Jiang, 2023).

In our model, the small open economy represents the United States. While this is a strong and stylized assumption, it serves as a useful benchmark for understanding the role of the convenience yield in addressing the exchange rate appreciation puzzle. We relax this assumption by building a quantitative two-country model in Section 3.

In what follows, we use an asterisk to denote variables associated with the rest of the world. Throughout the paper, variables without time subscripts denote steady-state values. Further details on the analytical model are provided in Appendix A.

2.1 The household

The representative household in the home country maximizes expected lifetime utility

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} + \chi \frac{(\frac{B_{Ht}^n}{P_t})^{1-\psi}}{1-\psi} \right), \tag{1}$$

subject to the budget constraint

$$P_t C_t + \mathbb{E}_t \Lambda_{t,t+1} D_{t+1} + B_{Ht}^n + \mathcal{E}_t B_{Ft} = D_t + W_t N_t - P_t T_t + B_{Ht-1}^n (1+i_{t-1}) + \mathcal{E}_t B_{Ft-1}^n (1+i_{t-1}^*) \tag{2}$$

and to the appropriate no-Ponzi-game conditions. In the utility function 1, parameters $\beta \in (0,1)$ and φ are, respectively, the subjective discount factor and the inverse of Frisch elasticity of labor supply. The utility provided by home-issued government bonds depends on real holdings, $B_{Ht} \equiv \frac{B_{Ht}^n}{P_t}$, the preference weight χ, and the curvature parameter, ψ. The assumption $\psi > 0$ ensures decreasing marginal utility from real government bond holdings. As a consequence, the equilibrium convenience yield is decreasing in the real amount of bond holdings, in accordance with empirical evidence. C_t is a composite consumption index and N_t denotes hours of labor supplied to the firms. In Equation 2, B_{Ht}^n and B_{Ft}^n are the household's nominal holdings of, respectively, domestic and foreign government bonds; D_{t+1} is the nominal payoff in period $t+1$ of the portfolio of Arrow securities held at the end of period t (including shares in firms); $\Lambda_{t,t+1}$ is the stochastic discount factor for one-period-ahead nominal payoffs relevant to the domestic household; $\mathcal{E}_t$ is the nominal exchange rate, defined as the price of a unit of foreign currency in terms of the domestic currency; W_t is the nominal hourly wage; i_t and i_t^* are the nominal interest rates paid on, respectively, domestic and foreign government bonds. The presence of Arrow securities makes foreign government bonds redundant, but we keep them as a separate asset to derive the UIP condition and the convenience yield. They can be equally considered as an Arrow security that pays one unit of foreign currency with certainty.

We log-linearize the model around a zero-inflation steady state, denoting log-deviations from steady-state in lowercase. Denote by q_t the real exchange rate, defined as the ratio of foreign to domestic prices, c_t^* foreign level of consumption, and $\omega_t \equiv w_t - p_t$ the domestic real wage. Then, the household's log-linearized optimality conditions are

$$\sigma c_t + \varphi n_t = \omega_t, \tag{3}$$

$$\sigma \mathbb{E}_t \Delta c_{t+1} + \mathbb{E}_t \pi_{t+1} - i_t = \frac{1-\beta(1+i)}{\beta(1+i)}(\sigma c_t - \psi b_{ht}), \tag{4}$$

$$\sigma \mathbb{E}_t \Delta c_{t+1} + \mathbb{E}_t \pi_{t+1} - i_t^* - \mathbb{E}_t \Delta e_{t+1} = 0, \tag{5}$$

along with the respective transversality conditions. Equation 3 represents the standard labor supply curve, which balances consumption and hours worked.

Equations 4 and 5 are the optimality conditions with respect to the real holdings of domestic and foreign government bonds, respectively. From 4, we observe that the convenience yield on domestic bonds — defined as the right-hand side of the equation — equals the marginal rate of substitution between real domestic government bond holdings and consumption, and it is a decreasing function of the real bond holdings. Consequently, consumption and bonds are complements in the convenience yield margin: an increase in bond holdings requires consumption to rise *ceteris paribus* for Equation 4 to hold.

By combining Equations 4 and 5, we derive the UIP condition for the domestic economy:

$$i_t^* + \mathbb{E}_t \Delta e_{t+1} - i_t = \frac{1-\beta(1+i)}{\beta(1+i)}(\sigma c_t - \psi b_{ht}). \tag{6}$$

The convenience yield is defined as the right-hand side of Equation 6: a wedge in the UIP condition implying that the difference between the domestic interest rate, i_t, and the foreign interest rate, i_t^*, is not fully compensated by movements in the nominal exchange rate. The modified UIP condition also implies that in the steady state the domestic interest rate is lower than both the foreign interest rate and the domestic household's rate of time preference,

$1/\beta$.

By combining domestic and foreign optimality conditions, we can derive the standard Backus-Smith international risk-sharing condition in complete markets:

$$q_t = \sigma(c_t - c_t^*). \tag{7}$$

Therefore, in the analytical model the real exchange rate is proportional to the relative marginal utility of domestic and foreign consumption. As foreign consumption is fixed due to the small-open-economy assumption, the dynamics of domestic consumption fully determine those of the real exchange rate.

By examining the equilibrium conditions above, we can already identify how the core mechanism of our model addresses the exchange rate appreciation puzzle in partial equilibrium. Specifically, holding c_t^*, i_t^*, i_t and $\mathbb{E}_t\pi_{t+1}$ constant, a debt-financed government spending shock raises the supply of government bonds, in turn reducing the convenience yield. A lower convenience yield then leads to higher current consumption (and lower consumption growth), as reflected in Euler equation 4. In turn, the rise in current consumption results in a depreciation of the real exchange rate *ceteris paribus*, as indicated by the Backus-Smith condition 7; and in an expected appreciation of the nominal exchange rate, as shown by the modified UIP condition 6.

The key mechanism is the complementarity between consumption and bond holdings, and the wedge in intertemporal consumption smoothing—both arising from introducing government bonds in the utility function, as in Rannenberg (2021). The first reflects the dependence of Equation 4 on the marginal rate of substitution between consumption and bonds: a debt-funded fiscal expansion lowers the marginal utility of government debt, inducing higher consumption. The second arises because the convenience yield makes the marginal utility of current consumption less than proportional to that of future consumption, as seen by isolating c_t in Equation 4, thereby dampening intertemporal substitution. Hereafter we refer to these two channels jointly as the "intratemporal substitution channel", as they both ultimately arise from the substitution margin between consumption and government bonds. If sufficiently strong, these channels offset the negative wealth effect of government spending, which in standard complete-market models reduces consumption via the Ricardian effect of current or expected future tax increases.

2.2 The firms

We adopt an entirely standard approach in the New-Keynesian literature by positing that monopolistically competitive firms produce differentiated goods and set prices à la Calvo (1983), so that each period a fraction θ of firms cannot change their prices.

The solution of the firms' optimization problem results in a Phillips curve expressed in terms of domestic CPI inflation. Its log-linearized expression is

$$\pi_t = \beta\,\mathbb{E}_t\pi_{t+1} + \eta\big(\Delta q_t - \beta\,\mathbb{E}_t\Delta q_{t+1}\big) + \kappa\left[(w_t - p_t) + \eta\,q_t + \frac{\alpha_p}{1-\alpha_p}y_t\right], \tag{8}$$

where $\alpha_p \in (0,1)$ denotes the output elasticity with respect to labor, $\epsilon_p > 1$ the elasticity of substitution across differentiated goods, and defining composite parameters $\eta \equiv \frac{\epsilon_b}{1-2\epsilon_b}$, and $\kappa \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}\,\frac{1-\alpha_p}{1-\alpha_p+\epsilon_p\alpha_p}$.

2.3 Fiscal policy

Given that households derive utility from holding U.S. government bonds, Ricardian Equivalence does not hold. Therefore, the composition of government financing through taxes or deficits affects real variables, including consumption, by altering the equilibrium level of domestic government debt. We therefore specify fiscal policy to isolate the role of funding composition through variation in policy parameters.

The government budget constraint is

$$B_t^n + P_t T_t = (1 + i_{t-1}) B_{t-1}^n + P_t G_t, \tag{9}$$

where B_t^n denotes the nominal value of government bonds and G_t the real level of government expenditure. We also denote with $B_t \equiv \frac{B_t^n}{P_t}$ the real amount of domestic government bonds, analogously with B_{Ht}.

Similarly to Galí et al. (2007), we assume a fiscal policy rule of the form

$$t_t = \phi_b b_{t-1} + \phi_g g_t, \tag{10}$$

where parameters ϕ_b and ϕ_g describe the fiscal policy stance. ϕ_g is of primary interest in our model, as it determines the funding source of government spending. The extreme cases are $\phi_g = 0$, corresponding to full debt financing; and $\phi_g = 1$, corresponding to full tax financing. The model also allows for a range of partially debt-funded spending with $\phi_b \in (0, 1)$.

Importantly, the notion of funding embedded in ϕ_g is purely *contemporaneous*, while the parameter ϕ_b regulates the degree to which debt shocks are funded by future taxation. In the simplified version of the model, we restrict our attention to equilibria in which the fiscal authority eventually repays all debt by means of a high enough ϕ_b. These equilibria correspond to the notion of monetary dominance in the monetary-fiscal interaction literature (Leeper, 1991). In Section 3, we extend our analysis to cases of fiscal dominance in which the central bank stabilizes debt by accommodating deficits through higher inflation.

Finally, government purchases are assumed to evolve exogenously according to a first order autoregressive process

$$g_t = \rho_g g_{t-1} + \varepsilon_t, \tag{11}$$

where $\rho_g \in (0, 1)$ and ε_t is a serially uncorrelated disturbance with zero mean.

2.4 Monetary policy

To obtain analytical results, we assume that the monetary authority adjusts the nominal interest rate one-for-one with expected inflation.

This implies that the real interest rate remains constant in every period, i.e.

$$i_t - \mathbb{E}_t \pi_{t+1} = \sum_{s=0}^{\infty} (i_{t+s} - \mathbb{E}_t \pi_{t+1+s}) = 0 \quad \forall t.$$

As a consequence, the effect of monetary policy on consumption through intertemporal substitution is shut down, allowing us to isolate the convenience yield mechanism. Importantly, a fixed real rate also prevents debt revaluation through unexpected jumps in inflation. Combined with debt repayment through future taxation ensured by a high enough ϕ_b, this feature rules out solutions of the appreciation puzzle through a lower real interest rate as in models that adopt the fiscal theory of the price level (Jiang, 2022).

2.5 Equilibrium dynamics

The model is closed by market-clearing conditions for domestic goods and domestic government bonds, reported in Appendix A.1. To solve the model, we log-linearize its equilibrium conditions around a symmetric, zero-inflation steady state.[2] We assume that all foreign variables remain at their steady state values ($c_t^* = 0$, $i_t^* = 0$, $\pi_t^* = 0$, $g_t^* = 0$), with the sole exception of real domestic government bond holdings by foreign countries, normalized by domestic prices (b_{ht}^*). Since foreign households also derive utility from holding domestic government bonds, we can solve for b_{ht}^* and express the equilibrium conditions solely in terms of total domestic government debt, i.e. b_t. Further details on foreign households are provided in Appendix A.2.

Under a constant real interest rate, the model simplifies to a system of two equations with

[2] Appendix A.3 characterizes the steady state in further detail.

two endogenous dynamic variables, c_t and b_{t-1}, and one exogenous state variable, g_t.

Proposition 1. *The system of stochastic dynamic equations characterizing the solution of the model is*

$$\mathbb{E}_t c_{t+1} = \Gamma c_t - \Omega b_t, \tag{12}$$

$$b_t = \Xi_b b_{t-1} + \Xi_g g_t, \tag{13}$$

where

$$\Xi_b \equiv 1 + i - \left(i + \frac{G}{B}\right)\phi_b, \quad \Xi_g \equiv \frac{G}{B} - \left(i + \frac{G}{B}\right)\phi_g,$$

$$\Omega \equiv \frac{1-\beta(1+i)}{\beta(1+i)}\frac{\psi}{\sigma}, \quad \Gamma \equiv 1 + \frac{1-\beta(1+i)}{\beta(1+i)}\left(\psi\frac{B_H^*}{B} + \frac{B_H}{B}\right).$$

Proof. In Appendix A.4.1. □

The state variables of the system are home-issued real government bonds, b_{t-1}, and the real government expenditure shock, g_t. The term G/B represents the steady state government expenditure-to-home government debt ratio, B_H^*/B denotes the steady state ratio of home government debt held by foreign investors to home government debt and B_H/B represents the steady state ratio of home government debt held domestically to home government debt.

We restrict our attention to unique, determinate solutions, which under the fixed real interest rate rule depend only on fiscal policy.

Corollary 1.1. *The dynamic system in Proposition 1 admits a unique stable solution if and only if*

$$|\Gamma| > 1 \quad \textit{and} \quad |\Xi_b| < 1. \tag{14}$$

Proof. In Appendix A.4.2 □

The condition $|\Gamma| > 1$ is always satisfied by construction in our model. If the steady-state interest rate on domestic government bonds is lower than the household's rate of time preference, then $\Gamma > 1$. [3] The presence of a convenience yield on domestic government bonds lowers their interest rate both in the transition dynamics and at the steady state, guaranteeing this relationship holds (details in Appendix A.4.2).

The condition $|\Xi_b| < 1$ ensures bounded government debt dynamics, requiring that taxes adjust strongly enough to debt so as to eventually repay it, but not so strongly as to induce explosive oscillatory dynamics. These stability conditions ensure that all debt is repaid through taxation in the future regardless of the contemporary source of funding.

We restrict our analysis to monotonic dynamics, so henceforth we assume $\Xi_b \in (0, 1)$ unless otherwise specified.

Applying the method of undetermined coefficients, we conjecture that the policy function for consumption, c_t, takes the following form:

$$c_t = \chi_b b_{t-1} + \chi_g g_t. \tag{15}$$

Proposition 2. *The coefficients χ_b and χ_g that satisfy the conjectured policy function are:*

$$\chi_b = \frac{\Omega \Xi_b}{\Gamma - \Xi_b} \tag{16}$$

$$\chi_g = \frac{\Gamma\, \Omega\, \Xi_g}{(\Gamma - \Xi_b)\,(\Gamma - \rho_g)} \tag{17}$$

Proof. In Appendix A.4.3. □

The convenience yield mechanism crucially shapes the behavior of consumption, as demonstrated by the dependence of both χ_b and χ_g on Ω. If consumers do not derive concave utility from holding government bonds, then $\Omega = 0$ and Ricardian equivalence holds, implying that consumption remains unaffected by the amount of debt.

The parameter χ_b illustrates the complementarity between debt and consumption: as long as debt is not repaid so fast that the Ricardian effect of taxation prevails ($\Xi_b > 0$), an increase in debt is matched by an increase in consumption through the intratemporal substitution

[3] This condition also implies $\Omega > 0$.

channel of the convenience yield, mediated by Ω. The strength of the Ricardian wealth effect is also modulated by Γ, the consumption coefficient in the Euler equation. A high Γ dampens the response of consumption to debt.

The parameter χ_g mediates the effect of government spending shocks on consumption, and hence the real exchange rate. Since the denominator is positive under the stability conditions and the assumption of a non-explosive autoregressive process for government spending, the crucial term for the sign of χ_g is Ξ_g. It parametrizes the response of debt to government spending, highlighting the fundamental role that fiscal funding plays in determining the response of the real exchange rate to government spending shocks. If government debt increases in response to spending ($\Xi_g > 0$), consumption rises with government spending, while it falls if debt decreases ($\Xi_g < 0$).

Combining the solutions for χ_b and χ_g with the laws of motion for government spending g_t and debt b_t from Equations 11 and 13, respectively, we can derive an analytical expression for the impulse response function of consumption to a government spending shock.

Proposition 3. *The impulse response function of consumption to a one-time unit government spending shock $\varepsilon_0^g = 1$ (and $\varepsilon_t = 0$ for $t > 0$) is given by:*

$$c_t = \frac{\Omega \Xi_g}{\Gamma - \Xi_b} \left[\frac{\Xi_b \left(\Xi_b^t - \rho_g^t \right)}{\Xi_b - \rho_g} + \frac{\Gamma}{\Gamma - \rho_g} \rho_g^t \right]. \tag{18}$$

Proof. In Appendix A.4.4. □

Given the Backus-Smith condition in Equation 7, the exchange rate appreciation puzzle is resolved only when domestic consumption increases in response to a government spending shock. Therefore, we establish the conditions under which the IRF is positive.

Corollary 3.1. *Under monotonic debt dynamics with $\Xi_b \in (0, 1)$, the impulse response function of consumption satisfies $c_t > 0 \quad \forall\, t \geq 0$ if and only if $\Xi_g > 0$.*

Under non-monotonic debt dynamics with $\Xi_b \in (-1, 0)$, the sequence $\{c_t\}$ may alternate in sign and no sign-definite impulse response obtains without further restrictions.

Proof. In Appendix A.4.5 □

If debt dynamics are monotonic ($\Xi_b > 0$), so is the impulse response function of consumption, and its sign depends on fiscal funding. If debt dynamics are oscillatory ($\Xi_b < 0$), the impulse response of consumption may oscillate as well if fluctuations in debt are large enough.

Concavity in the demand for government bonds introduced by the convenience yield plays a crucial role in mediating the response of consumption through the parameter Ω. With $\psi > 0$ and hence $\Omega > 0$, the marginal utility of holding government bonds decreases as the current supply of government debt increases, prompting households to consume more through complementarity.

Under monotonicity, $\Xi_g > 0$ is a necessary and sufficient condition for a positive response of consumption to an expansionary fiscal shock, given concavity of Treasury preferences (implying $\Omega > 0$) and stability of the dynamic system (implying $\Gamma > \Xi_b$). Therefore, consumption rises in response to an expansionary fiscal shock if and only if debt also rises with government spending. This condition holds as long as the proportion of new spending financed by debt is high enough (low ϕ_g), given the stock of debt and interest rate at the steady state. Since Ξ_b is monotonically strictly decreasing in ϕ_b, there exists a threshold level $\bar{\phi}_g$ below which the IRF of consumption is positive $\forall\ t$. The source of fiscal funding then emerges as a sufficient statistic for the response of consumption, and in turn of the real exchange rate, to government spending shocks. A numerical illustration of the analytical model in Appendix A.5 shows that $\bar{\phi}_g$ sits above 0.9, implying that almost any amount of debt funding is sufficient to generate a real depreciation. This result reflects the highly stylized nature of the framework, which shuts down real interest rate fluctuations and the associated intertemporal consumption-smoothing channel. We relax this and other simplifying assumptions in the quantitative model presented in Section 3.

3 Quantitative model

In this section we extend the analytical model presented in Section 2 by incorporating three features. First, we micro-found the convenience yield of U.S. Treasuries via transaction costs, which enriches the channels through which convenience yields affect the real exchange rate. Second, we adopt a two-country approach allowing for endogenous responses of foreign variables to domestic fiscal shocks. Third, we reintroduce the effect of monetary policy on consumption via an inertial Taylor rule, which additionally allows us to explore monetary-fiscal interactions.

3.1 Convenience yield channels

The key difference with the analytical model lies in the treatment of the convenience yield. We move from the standard bonds-in-the-utility-function framework to a transaction technology approach. Rather than enjoying utility directly from holding Treasuries, households incur a transaction cost to consume, which Treasuries lower due to their liquidity. The transaction cost is represented by the function

$$\Psi\Big(C_t, \tfrac{B_{H,t}}{P_t}\Big) \equiv \gamma\, C_t^{\alpha} \left(\frac{B_{H,t}}{P_t}\right)^{1-\alpha},$$

where $\alpha > 1$ governs how steeply costs increase as liquidity deteriorates and γ is a scale parameter. For $\alpha > 1$, the transaction cost function is increasing and convex in consumption, and decreasing and convex in real Treasury holdings. In this specification, households do not derive utility directly from holding bonds, but rather benefit from their ability to lower transaction costs as liquid assets. The marginal liquidity benefit is diminishing, and so the strength of the convenience yield is governed by the curvature parameter α in this version of the model.

This modeling choice aligns with the empirical features of government bonds: they are more liquid than other assets, often serve as collateral, and can be readily liquidated in times of stress. This micro-founded rationale is widely adopted in the quantitative macro-finance literature (see, for instance, Bansal and Coleman, 1996; Valchev, 2020). Importantly, the convenience yield now enters the household's stochastic discount factor directly, thereby opening up an additional channel through which bond holdings affect consumption, with consequences rippling to the real exchange rate through the international risk-sharing condition, as pointed out in Kekre and Lenel (2024). The full solution of the household's problem is developed in Appendix B.1. As in the analytical model, the foreign household solves a symmetric problem with Treasuries providing liquidity services. Foreign quantities and prices are indexed by an asterisk.

To illustrate the two convenience yield channels, we turn to the log-linearized first-order conditions of the domestic household's problem. The Euler equations for the domestic and the foreign government bonds are

$$\frac{\beta(1+i)-1}{\beta(1+i)}\alpha\big(c_t - b_{ht}\big) = i_t - \sigma\Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t\pi_{t+1} - \Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t b_{ht+1} - \Delta\mathbb{E}_t c_{t+1}), \quad (19)$$

$$0 = i_t^* + \Delta\mathbb{E}_t e_{t+1} - \sigma\,\Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t\pi_{t+1} - \Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t b_{ht+1} - \Delta\mathbb{E}_t c_{t+1}), \quad (20)$$

where $\Theta \equiv \frac{\alpha\gamma(B_H/C)^{1-\alpha}}{1+\alpha\gamma(B_H/C)^{1-\alpha}}$. The term pre-multiplied by α on the left-hand side is isomorphic to the convenience-yield term in Equation 4 in the analytical model. This intratemporal substitution channel is the only one active in the analytical model. The transaction-cost approach introduces an additional term on the right-hand side, pre-multiplied by $(1-\alpha)$ and function of future Treasury holdings and consumption. As Treasuries ease transaction costs for consumption, they enter the marginal utility of consumption and hence the stochastic discount factor. As a consequence, this term appears in both the domestic and foreign government bond Euler equations. We dub this effect the "stochastic discount factor channel". We analyze the model with both channels active in the main text, while we study the separate effect of the intratemporal substitution channel in Appendix B.4.1.

By combining Equations 19 and 20, we obtain an Uncovered Interest Rate Parity condition isomorphic to Equation 6 in the analytical model:

$$i_t^* + \Delta\mathbb{E}_t e_{t+1} - i_t = \frac{\beta(1+i)-1}{\beta(1+i)}\alpha\big(c_t - b_{ht}\big). \tag{21}$$

3.2 International risk sharing

The quantitative model maintains the complete-markets assumption, so the following international risk-sharing condition links the relative marginal utility of consumption with the real exchange rate:

$$q_t = \frac{1}{1-\Theta^*(1-\alpha^*)}\left[\sigma(c_t - c_t^*) + \Theta(1-\alpha)(b_{ht} - c_t)\right] + b_{ht}^* + c_t^*, \tag{22}$$

where $\Theta^* \equiv \frac{\alpha^*\gamma^*(B_H^*/C^*)^{1-\alpha^*}}{1+\alpha^*\gamma^*(B_H^*/C^*)^{1-\alpha^*}}$.

Two important distinctions exist with its counterpart in the analytical model. First, the two-country framework renders foreign consumption endogenous, so relative consumption becomes the crucial driver of real exchange rate dynamics. Second, terms representing the stochastic discount factor channel for both domestic and foreign households enter the international risk-sharing condition, so the convenience yield affects the real exchange rate directly, rather than just indirectly through consumption. As long as the marginal benefit of Treasuries is diminishing ($\alpha > 1$ and $\alpha^* > 1$), an increase in the Treasury holdings of the domestic household, resulting for example from a debt-funded fiscal expansion, raises the marginal utility of consumption all else equal, pushing the domestic currency toward real appreciation. However, the convenience yield term in the marginal utility of consumption also depends on consumption itself, so the net effect of the stochastic discount factor channel on the real exchange rate is ambiguous *a priori*.

3.3 Monetary Policy

The monetary authority follows an inertial CPI-based Taylor Rule, given by

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\phi_\pi \pi_t, \tag{23}$$

where ρ_i governs the persistence of the nominal interest rate, and ϕ_π its reaction to inflation. The foreign monetary authority follows an analogous rule. This formulation is standard in the literature as it can match the observed persistence of nominal rates (Smets and Wouters, 2007; Valchev, 2020; Bodenstein et al., 2023). Appendix B.4.2 considers alternative monetary policy rules.

Compared to the analytical model with a constant real interest rate, fiscal policy can no longer be considered independently of monetary policy. The interaction between the two links real government bond holdings to the consumption path through the government budget constraint, implying different predictions for the relationship between the convenience yield and the real exchange rate depending not only on the contemporaneous source of fiscal funding, but also on whether expenditures are ultimately paid through taxes or inflation. We analyze both types of equilibria in the following sections.

3.4 Equilibrium

The model is closed by analogous first-order conditions and monetary policy rule for the foreign economy, and by New-Keynesian Phillips curves, government budget constraints, fiscal policy rules, and a domestic bond market clearing condition unchanged from the analytical model. The goods market clearing condition is likewise standard, after accounting for the transaction cost. The full set of equilibrium equations for the quantitative model is provided in Appendix B.

3.5 Calibration

We calibrate the model at a quarterly frequency using data from March 1999 to April 2026, taking the U.S. as the domestic economy and an average of G-10 currency issuers as the foreign economy.[4] The start date is constrained by the introduction of the euro, and by the availability of country-level data on foreign holdings of U.S. Treasuries.

We set preference and technology parameters σ, θ, ϵ_h, ϵ_p, α_p and ρ_i to standard values from the macroeconomic literature. We calibrate i and β to match the average interest rate on 10-year government bonds by G-10 currency issuers, and an annualized convenience yield on U.S. Treasury securities of 1 %, the value used in Valchev (2020) and within the range of existing estimates from the spread between U.S. Treasury securities and a host of other traded or synthetic dollar-denominated securities (Krishnamurthy and Vissing-Jorgensen, 2012; Diamond and Van Tassel, 2022; Acharya and Laarits, 2023). We calibrate α, α^*, γ, γ^*, φ, and ϵ_b jointly by imposing $\alpha = \alpha^*$ and solving steady state equations. Finally, we calibrate the persistence of the government spending shock ρ_g and its standard deviation σ_g by estimating an AR(1) model. Appendix B.3 contains more details on the calibration strategy.

3.6 Impulse responses to a government spending shock

In the following analysis, we present the impulse response functions to government expenditure shocks under monetary dominance and fiscal dominance regimes defined as in Leeper (1991), distinguishing between fully tax-funded and fully debt-funded scenarios. The IRFs presented in this section use representative values of policy parameters typical in the literature, while we explore the policy parameter space in Section 3.7. Throughout the rest of the analysis, we keep policy in the foreign economy fixed in a monetary dominance regime

[4] G-10 currency issuers are Australia, Canada, Denmark, the Euro Area, Great Britain, Japan, New Zealand, Norway, Sweden and Switzerland. For the Euro Area, we use size-weighted averages for real quantities, and the yield of 10-year German government bonds.

with $\phi_\pi^* = 1.5$ and $\phi_b^* = 0.5$. We present results for a fiscal dominance regime in the foreign economy in Appendix B.4.3.

3.6.1 Monetary dominance regime

Figure 2 illustrates impulse responses to a one-standard-deviation government spending shock under monetary dominance with parameters $\phi_\pi = 1.5$ and $\phi_b = 0.5$.

In a monetary dominance regime, the central bank has full control over inflation. It raises the nominal rate enough for the real interest rate to also rise with a lag in response to the bout of inflation following a government expenditure shock. Under full tax funding, this mechanism induces domestic households to reduce their consumption more than their foreign counterparts, while the convenience yield barely moves since domestic debt also remains virtually flat. As a result, the real exchange rate appreciates through international risk sharing, as predicted by the canonical New-Keynesian open-economy model. Therefore, if debt is fully tax-funded the appreciation puzzle persists in the full model as well because the convenience yield channels are muted.

The responses are markedly different under full debt funding. The fiscal shock causes an increase in government debt, accompanied by a decrease in the convenience yield. The intratemporal substitution channel leads households to raise their consumption in tandem with their Treasury holdings due to the slackening transaction cost, which also raises the marginal utility of consumption *ceteris paribus* through the stochastic discount factor channel. As a result, domestic consumption rises while foreign consumption falls on impact, albeit by a smaller amount than under tax funding. The two convenience yield mechanisms jointly outweigh the standard intertemporal substitution effect, demonstrating how the interaction between debt funding and Treasury convenience can reconcile the evidence of real depreciation.

The real exchange rate does not necessarily move in tandem with its nominal counterpart:

for example, the sign of the real rate response flips depending on the source of fiscal funding, while the nominal rate depreciates in expectation regardless. This result confirms that the negative correlation between the convenience yield and the real exchange rate is not an artifact of the tight link between nominal and real exchange rates in sticky-price models.

The IRFs under monetary dominance imply a negative correlation of -0.45 between the convenience yield and the real exchange rate for debt-funded shocks, consistent with the negative co-movement in Figure 1 for periods when monetary policy is commonly regarded as active, such as the Great Moderation (Bianchi and Ilut, 2017).

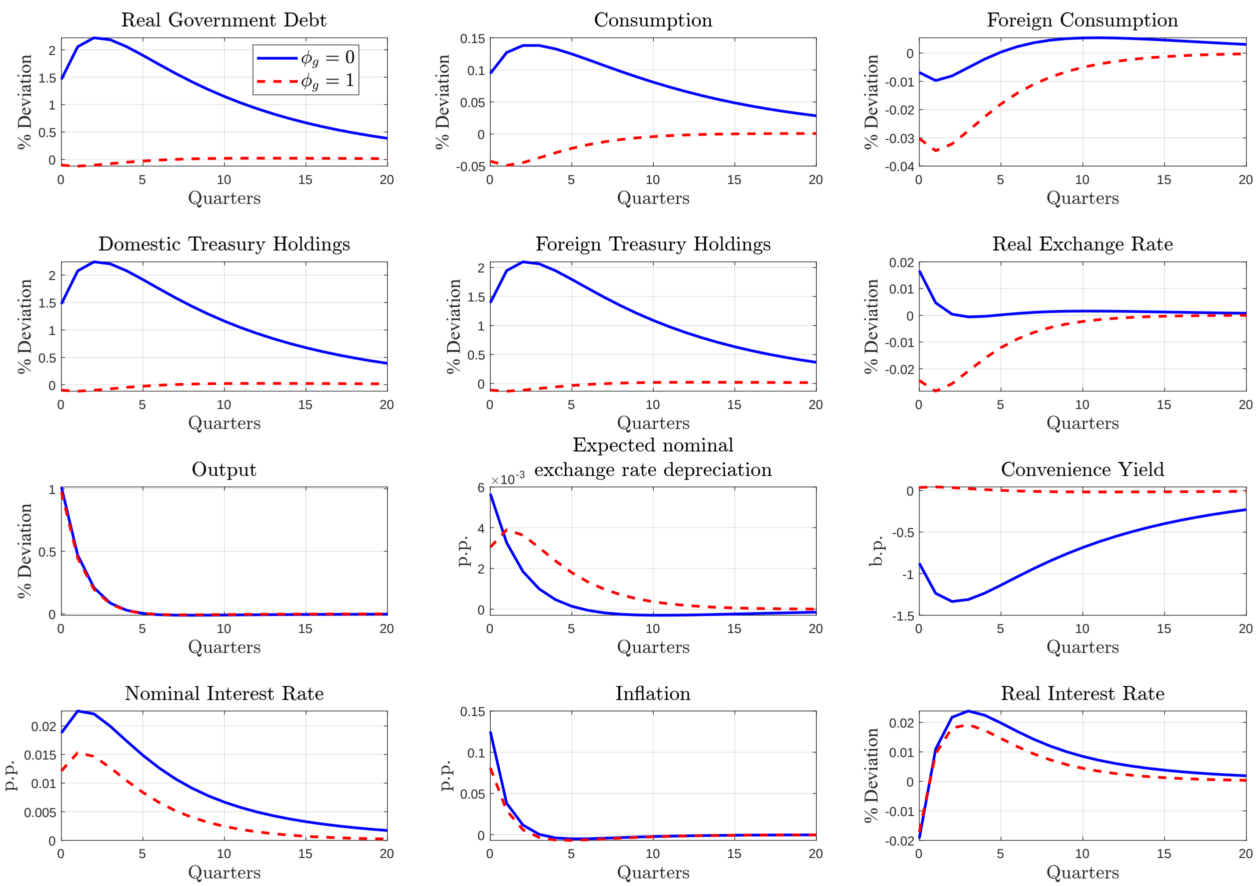


Figure 2: IRF to a 1 SD increase in government expenditure under monetary dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 1.5$, $\phi_b = 0.5$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

3.6.2 Fiscal dominance regime

Figure 3 illustrates impulse responses to a one-standard-deviation government spending shock under fiscal dominance with parameters $\phi_\pi = 0.5$ and $\phi_b = -0.5$.

In a fiscal dominance regime, the monetary authority lacks full control over inflation dynamics and the government budget constraint is satisfied by inflating away debt. Consequently, following a debt-funded government expenditure shock, the central bank reacts weakly to inflation and the real interest rate declines. A lower real interest rate induces households to consume more through the standard intertemporal substitution channel, and thus the real exchange rate depreciates. This mechanism was introduced in Jiang (2022), which demonstrates that under the fiscal theory of the price level—a case of extreme fiscal dominance—the exchange rate appreciation puzzle is resolved. The convenience yield adds a further mechanism that strengthens the increase in consumption under debt funding: provided that the central bank reacts at least partially to inflation, real debt rises as the issuance of new nominal debt offsets the valuation effect from the lower real rate. As a result, domestic households increase their consumption through the intratemporal substitution channel.

However, under fiscal dominance the convenience yield rises following a debt-funded shock, inducing a positive correlation with the real exchange rate of 0.66, consistent with Figure 1 only for the periods typically classified as fiscal dominance, such as the late 1970s (Bianchi and Ilut, 2017) and the post-2008 years (Bianchi et al., 2023).

These results become particularly interesting when compared to Jiang (2022): a full account of the joint dynamics of the real exchange rate and convenience yields in response to fiscal shocks benefits from considering both fiscal and monetary dominance equilibria.

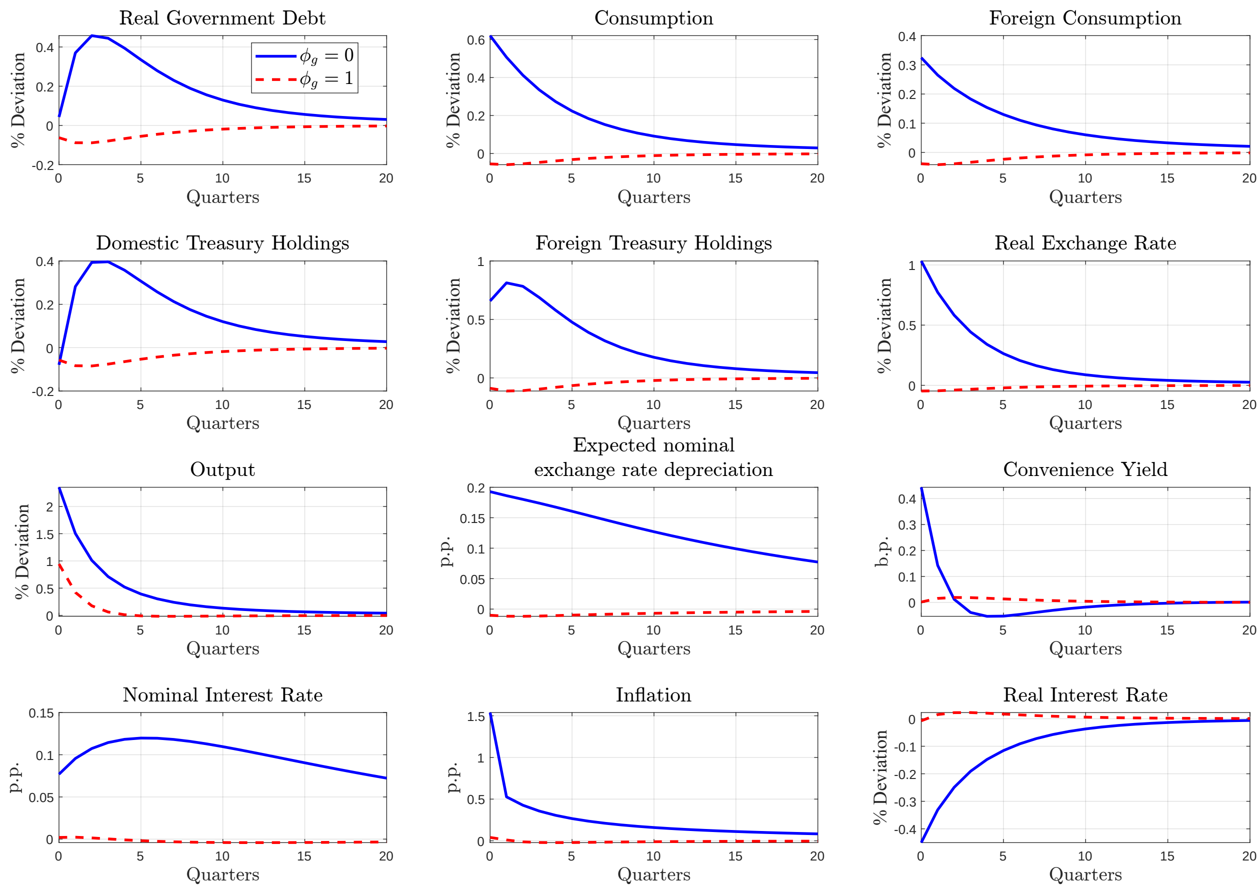


Figure 3: IRF to a 1 SD increase in government expenditure under fiscal dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 0.5$, $\phi_b = -0.5$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

3.7 Real depreciation regions

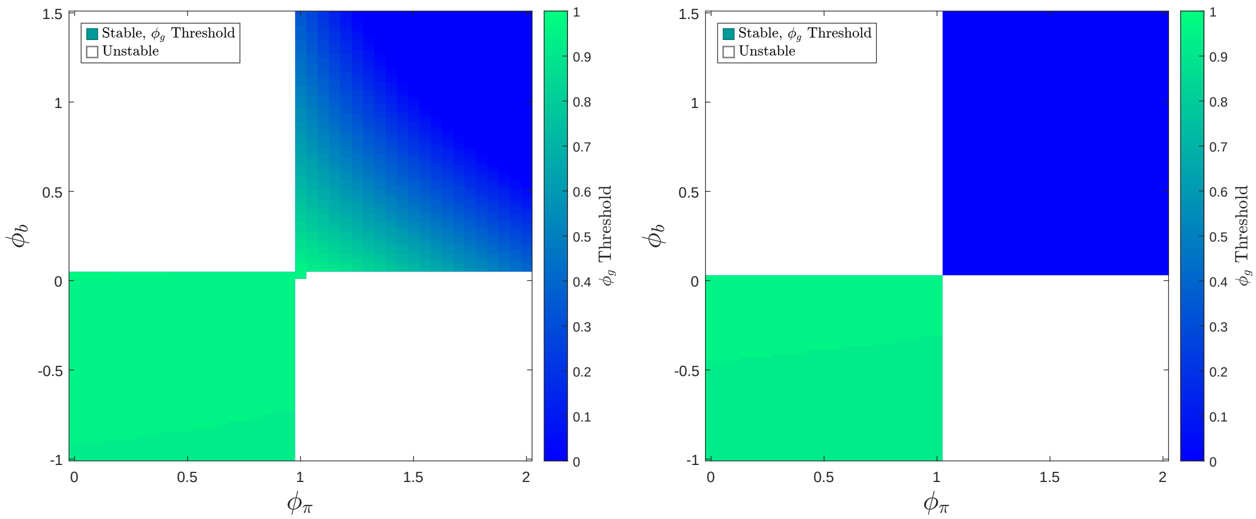
After studying the effects of the convenience yield in the full model under typical values for policy parameters, we inspect the generality of our results by analyzing the response of the real exchange rate to fiscal shocks under different combinations of ϕ_π, ϕ_b and ϕ_g.

Figure 4 plots the maximum fraction of tax funding $\bar{\phi}_g$ that results in an on-impact real exchange rate depreciation in response to a government spending shock, against a grid of $\phi_\pi \in [0, 2]$ by $\phi_b \in [-1, 1.5]$. The regions in white admit no stable equilibrium, while the colored regions represent stable equilibria. The lower-left quadrant represents fiscal dominance, characterized by low values of ϕ_b and ϕ_π, where fiscal policy is active and monetary policy is passive. Conversely, the upper-right quadrant corresponds to monetary dominance, where both ϕ_b and ϕ_π are high, leading to an active monetary policy alongside a passive fiscal policy.

In addition to analyzing the interactions between ϕ_π and ϕ_b, we let the tax-funding share ϕ_g vary within the interval $[0, 1]$. This allows us to identify the maximum fraction of tax funding $\bar{\phi}_g$ consistent with resolving the exchange rate appreciation puzzle. As $\bar{\phi}_g$ increases, a smaller share of government expenditure must be financed through debt issuance for the convenience yield channel to dominate and the real exchange rate to depreciate on impact. For $\bar{\phi}_g = 0$, the exchange rate appreciates on impact regardless of the fiscal funding configuration.

The left-hand side figure shows that the real exchange rate depreciates on impact under a wide range of policy parameters, with the threshold collapsing to 0 only in the upper-right half of the quadrant. At the baseline parameter values of $\phi_\pi = 1.5$ and $\phi_b = 0.5$, a fraction of debt funding of about 50% suffices to engender a real depreciation. The ϕ_g threshold is decreasing along a northeasterly gradient. For a given ϕ_b, as the central bank reacts more strongly to inflation the domestic household lowers consumption relatively more due to the higher real interest rate, pushing the real exchange rate toward appreciation and hence raising the portion of debt funding necessary for the convenience yield channels to prevail. Likewise, for a given ϕ_π a stronger response of taxation to debt makes the latter less persistent, dampening convenience yield dynamics and hence raising the debt-funding threshold.

The right-hand side figure presents the same exercise in a version of the model without convenience yield ($\gamma = \gamma^* = \alpha = \alpha^* = 0$). The upper-right quadrant clearly shows that without the convenience yield the model cannot reconcile a real depreciation, consistent with the exchange rate appreciation puzzle literature. The lower-left quadrant shows that the convenience yield affects the fiscal dominance equilibrium too by lowering the debt-funding threshold in the lower half of the quadrant through the intratemporal substitution channel.



With Convenience Yield

No Convenience Yield

Figure 4: On-impact depreciation regions

Notes: Threshold values of tax funding fraction $\bar{\phi}_g \in [0, 1]$ (green to blue gradient) below which the real exchange rate depreciates on-impact in response to a one-standard-deviation government spending shock. The threshold values are plotted against a grid of domestic policy parameters $\phi_\pi \in [0, 2]$ by $\phi_b \in [-1, 1.5]$. Foreign policy parameters are kept fixed at $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and all other parameters are kept fixed at their baseline values over the whole grid. White areas denote combinations of policy parameters for which the model does not admit a unique, stable solution. Left panel: model with convenience yield. Right panel: model without convenience yield ($\gamma = \gamma^* = \alpha = \alpha^* = 0$).

4 Empirical evidence

In this section, we investigate whether the financing composition of government spending, determined by ϕ_g in the model, matters empirically for the reaction of the real exchange rate and convenience yield to government spending shocks. We focus on the source of *contemporaneous* funding for government expenditures, remaining agnostic on whether the intertemporal budget constraint of the government ultimately adjusts through future tax increases, corresponding to a monetary-led regime, or through surprise inflation, corresponding to a fiscal-led regime.

Distinguishing between monetary and fiscal dominance in the data is notoriously challenging (Leeper and Walker, 2012), but our approach allows us to test the predictions of the two regimes by comparing the joint reaction of the real exchange rate and the convenience yield of U.S. Treasuries in response to government spending shocks that differ in their implied financing conditions.

4.1 Methodology

The empirical approach consists of a local projection on government spending shocks interacted with a continuous state variable that defines a spectrum of debt-tax financing combinations. The empirical analysis uses quarterly U.S. data over the post-Bretton Woods era of flexible exchange rates. The sample is restricted to periods for which the Ramey (2016) military news instrument is available (1973Q2–2015Q4). Appendix C.1 describes the data in detail.

4.1.1 Fiscal state variable

Rather than classifying episodes into discrete debt- and tax-financed regimes, we characterize fiscal financing conditions through a continuous, predetermined state variable. Let $D_t \equiv g_t - t_t$ denote the purchases-based primary fiscal gap, where g_t and t_t are, respectively, real federal purchases and receipts expressed as shares of potential output. Because g_t captures federal purchases excluding transfers and debt service and t_t measures total federal receipts, D_t is negative throughout the sample, reflecting the long-run average U.S. fiscal deficit stance. We identify the dynamics of the fiscal funding state through the *trend evolution* of D_t, which we extract via the Hodrick–Prescott filter with the standard quarterly smoothing parameter $\lambda = 1600$. The fiscal state variable is then defined as the lagged first difference of this trend, centered at its sample mean, which we denote x_t^c. Low values of x_t^c correspond to periods in which the trend fiscal gap is stable or narrowing, i.e., an environment more consistent with spending being backed by current or near-future taxation. High values correspond to periods in which the trend gap is widening, i.e., an environment more consistent with debt financing.

The lag preserves predetermination: x_t^c is known at the time the spending shock occurs and is therefore orthogonal to contemporaneous shocks. Appendix C.2 provides narrative evidence that the fiscal state variable maps well to historical episodes.

4.1.2 Estimating equation

For each outcome variable y_t and horizon $h = 0, 1, \ldots, H$, we estimate a state-dependent reduced-form local projection (Jordà, 2005; Ramey and Zubairy, 2018):

$$y_{t+h} - y_{t-1} = \alpha^h + \gamma_0^h z_t + \gamma_1^h \left(z_t \cdot x_t^c\right) + \Gamma^h W_{t-1} + \varepsilon_t^h, \tag{24}$$

where $z_t = \text{news}_t / Y^*_{t-1}$ is the Ramey (2016) military spending news shock normalized by lagged nominal potential GDP, x_t^c is the fiscal state defined earlier, and W_{t-1} collects one lag of the first differences of all outcome variables and two additional controls.[5]

The long-difference dependent variable implies that coefficients are interpretable as cumulative responses from $t-1$ to $t+h$. Rather than interpreting (γ_0^h, γ_1^h) directly, we summarize state dependence through marginal effects evaluated at selected percentiles of the state:

$$\text{IRF}^h(q) = \gamma_0^h + q\,\gamma_1^h, \quad q \in \{p_{10},\, p_{50},\, p_{90}\}, \tag{25}$$

where p_{10}, p_{50}, and p_{90} denote the 10th, 50th, and 90th percentiles of x_t^c. These correspond to environments of stable or narrowing fiscal gap, median financing conditions, and widening fiscal gap — broadly consistent with, respectively, the consolidation episodes of the 1990s, a typical quarter, and the debt-expanding episodes of the 1980s and 2000s. Inference is based on HAC-robust standard errors (Newey and West, 1987) with Newey–West bandwidth $h+1$,

[5]The outcome variables entering W_{t-1} are government purchases, the fiscal deficit, consumption, the real interest rate, the real dollar index, and the convenience yield spread, all expressed in the units described in Section C.1. The two additional controls are the Baa minus ten-year Treasury spread, which proxies for the aggregate risk premium, and the ten-year minus one-year Treasury spread, which proxies for the term premium. All variables enter as lagged first differences to preserve predetermination.

and marginal effects are computed by the delta method.

The reduced-form specification has several advantages. First, the estimating equation is standard OLS conditional on z_t and $z_t \cdot x_t^c$, so inference is straightforward and does not depend on first-stage strength. Second, since x_t^c is predetermined, the interaction $z_t \cdot x_t^c$ inherits the exogeneity of the instrument, so Equation (24) identifies the causal effect of the news shock on outcomes at different points in the fiscal state distribution. Third, the marginal effect representation at percentiles avoids the arbitrary threshold problem that besets binary regime approaches, since the choice of cutoff is not theoretically motivated.[6]

The identification assumption underlying Equation (24) is that the military news shock z_t is orthogonal to the error term conditional on x_t^c and the controls W_{t-1}. The shock series is constructed by Ramey (2016) by extracting public expectations of newly-announced military spending from newspaper articles and historical accounts, and should be understood as a news shock in the sense of the government spending anticipation literature (Mertens and Ravn, 2010; Leeper et al., 2013). Because x_t^c is the lagged first difference of the HP trend of the fiscal gap, it is known at the time z_t occurs and is therefore orthogonal to the shock.

4.2 Results

Figure 5 reports the main empirical results as on-impact marginal effects ($h = 0$) evaluated at the 10th, 50th, and 90th percentiles of x_t^c. Each panel displays, for a given outcome variable, the estimated response to a military news shock across the three fiscal environments, with 68% HAC confidence intervals.[7] The three evaluation points span the empirical distribution of the fiscal state from tax-backed environments (where the trend fiscal gap was stable or narrowing) to debt-financed environments (where it was widening), with the median state

[6] As a robustness check, we also estimate an IV local projection that uses z_t and $z_t \cdot x_t^c$ to instrument the endogenous regressors Δg_t and $\Delta g_t \cdot x_t^c$; the results from that specification are reported in Appendix C.3.2.

[7] The raw empirical shock is 1 pp of potential output. In the quantitative model, since the steady-state government spending share is 0.197 (see Table A.1), this corresponds to a deviation of 5.1% of steady-state G. Because $\sigma_{\varepsilon_g} = 7.15\%$, we rescale the empirical shock by a factor of $7.15/5.1 \approx 1.4$ to match the size of the theoretical impulse. The rescaled shock thus corresponds to 1.4 pp of potential output.

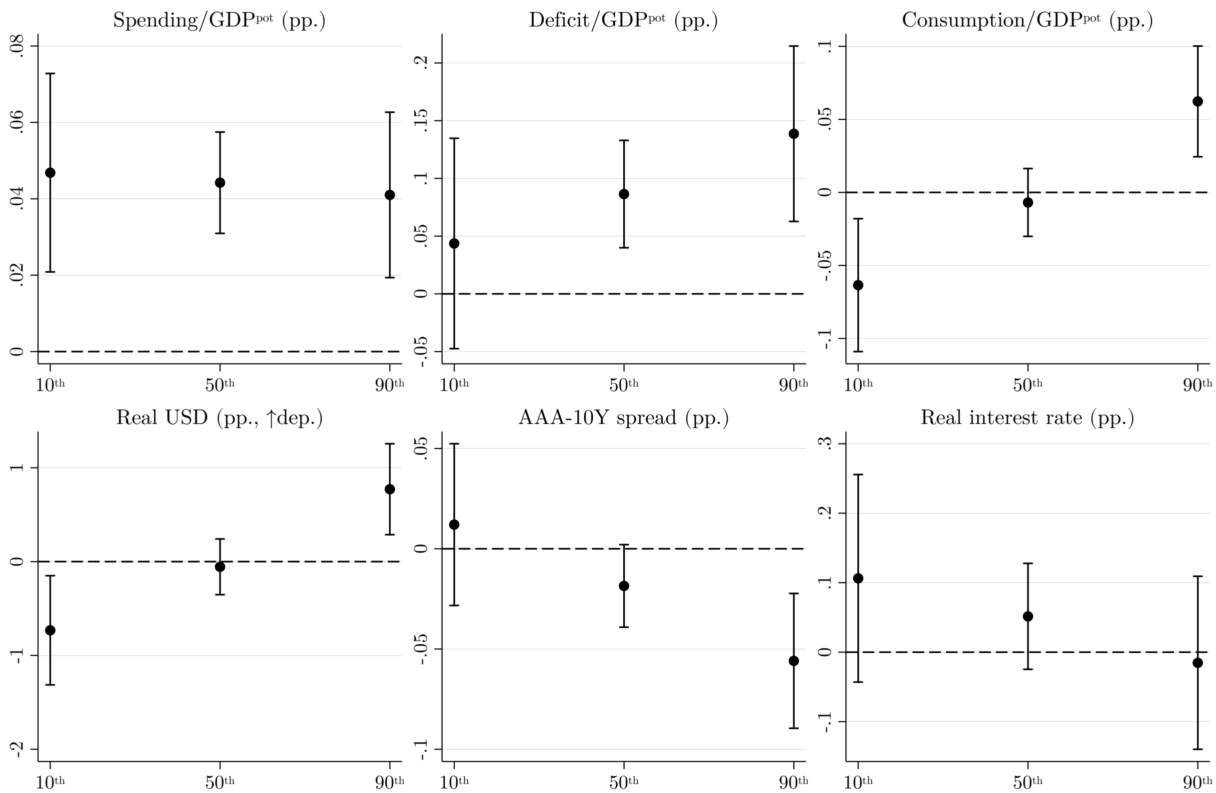


Figure 5: On-impact responses to military news shocks by fiscal state

Notes: On-impact marginal effects ($h = 0$) from Equation (24), evaluated at the 10th, 50th, and 90th percentiles of x_t^c. The outcome variables are, from left to right and top to bottom: government purchases, fiscal deficit, consumption, real interest rate, real dollar index (positive values denote depreciation), and convenience yield. All fiscal and real variables are expressed as shares of potential GDP. Vertical bars are 68% HAC confidence intervals based on Newey and West (1987) standard errors with bandwidth $h + 1 = 1$. The three evaluation points span the empirical distribution of x_t^c from tax-backed fiscal environments where the trend fiscal gap was stable or narrowing (p10), through median financing conditions (p50), to debt-financed environments where the trend fiscal gap was widening (p90).

as an intermediate benchmark. Here we report on-impact responses for consistency with the model-implied depreciation regions examined in Section 3.7, while full dynamic impulse responses up to $H = 20$ quarters are reported in Appendix C.3.1.[8]

Government spending rises by approximately 0.05 percentage points of potential GDP on

[8]The dynamic responses confirm that the on-impact results are not transitory: the sign patterns documented below persist for several years following the initial shock. One feature worth noting is the convenience yield response under debt-financed conditions: it declines on impact, rises modestly for several quarters, and then falls persistently into negative territory. The transitory increase in the intermediate quarters may reflect a flight-to-safety dynamic: military news shocks are associated with heightened geopolitical uncertainty, which can temporarily raise the demand for safe assets and affect the spread between corporate and Treasury yields independently of supply conditions. As the associated Treasury issuance materializes and accumulates over subsequent quarters, the supply-side effect dominates and the convenience yield declines persistently in the direction predicted by the model. This non-monotonic dynamic does not contradict the model's central prediction, which concerns the medium-run behavior of the convenience yield.

impact across all fiscal states, confirming that the military spending news shock generates a positive spending impulse regardless of the financing environment. The purchases-based primary fiscal gap widens by approximately 0.05 percentage points in tax-backed environments (a response that is not statistically significant) and by approximately 0.15 percentage points in debt-financed environments, consistent with spending shocks being accompanied by less contemporaneous fiscal offset when the trend gap is already widening.

The response of consumption displays substantial state dependence. At low values of the state, the on-impact response is negative, at approximately -0.05 percentage points of potential GDP, consistent with the standard Ricardian wealth effect operating when spending is perceived as tax-backed. At high values, the consumption response becomes positive, at approximately 0.05 percentage points, consistent with the convenience yield mechanism: a debt-financed expansion reduces the marginal utility of government bond holdings and raises consumption. Both responses are statistically significant at the 68% confidence level.

The financial variables move in a direction consistent with this interpretation. As the fiscal state shifts from low to high values, the real-rate proxy declines, the convenience yield falls, and the real exchange rate depreciates more strongly. In the high-state environment, the dollar depreciates by approximately 0.7 percentage points on impact and the depreciation persists; in the low-state environment, it appreciates by roughly 0.7 percentage points, i.e., a total state-dependent swing of nearly one percentage point from a single quarter's shock. The convenience yield falls by approximately 0.05 percentage points in debt-financed environments, a statistically significant response, and rises by approximately 0.02 percentage points in tax-backed environments, a response that is not statistically significant. The magnitude of the empirical impulse responses generally lies between those generated by the quantitative model under monetary and fiscal dominance.

Importantly, the joint behavior of the real exchange rate and the convenience yield allows us to discriminate between two competing explanations for the high-state depreciation. A real depreciation accompanied by a *falling* convenience yield is consistent with the core mechanism of our model under monetary dominance: higher debt supply reduces the convenience yield on Treasuries and raises consumption. By contrast, a real depreciation accompanied by a *rising* convenience yield would be consistent with the fiscal theory channel of Jiang (2022), in which debt is stabilized through surprise inflation that erodes its real value. The empirical evidence favors the former: the convenience yield falls at high state values, suggesting that a monetary dominance equilibrium is overall a better fit for the data in our sample. This joint sign pattern — depreciation and falling convenience yield in high-state environments, appreciation and rising convenience yield in low-state environments — constitutes the central empirical finding of the paper.

5 Conclusion

This paper establishes two implications of the convenience yield of U.S. Treasuries for the reaction of the real exchange rate to fiscal shocks.

First, if households value the liquidity of government bonds, real debt holdings become a key equilibrium variable, affecting consumption through both an intratemporal substitution margin and the stochastic discount factor. As a consequence, the *contemporaneous* composition of funding for government spending assumes a crucial role for real exchange rate dynamics under complete markets. In a simple New-Keynesian open-economy model with a fixed real interest rate, this mechanism suffices to deliver a real depreciation following fiscal expansions, provided they are financed at least in part by debt.

Second, in a model with a variable real interest rate, monetary-fiscal interactions take center stage by determining the *intertemporal* source of fiscal funding. Under fiscal dominance, a debt-funded fiscal expansion depreciates the real exchange rate, but it also causes the convenience yield to rise. Instead, a monetary-led regime predicts a drop in the convenience yield and a real depreciation following debt-funded fiscal shocks, provided that the central bank reacts relatively weakly to inflation. Intriguingly, the direction of the empirical co-movement between the convenience yield and the exchange rate under periods typically regarded as displaying monetary or fiscal dominance matches the predictions of the model.

Empirical evidence supports the predictions of the quantitative model under monetary dominance: in the U.S., a debt-funded fiscal shock leads to a real depreciation and a lower convenience yield, while a tax-funded one results in an appreciation and a higher convenience yield.

In an environment of large and volatile government spending, these results underscore the importance of fiscal financing and monetary-fiscal interactions, as debt- and tax-funded shocks have starkly different implications not only for the domestic economy and the liquidity of its government debt, but also beyond national borders through exchange rates. More broadly, these findings suggest that accounting for the liquidity services of government debt is essential for understanding the international transmission of fiscal policy.

References

Acharya, V. V. and T. Laarits (2023). When do Treasuries Earn the Convenience Yield? – A Hedging Perspective. SSRN Working Paper.

Auerbach, A. J. and Y. Gorodnichenko (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy 4*(2), 1–27.

Bacchetta, P., K. Benhima, Y. Kalantzis, and M. Phillot (2026). The international transmission of asset market shocks in liquidity traps. *Journal of International Economics*, 104235.

Backus, D. K., P. J. Kehoe, and F. E. Kydland (1994). Dynamics of the Trade Balance and the Terms of Trade: The J-Curve? *American Economic Review 84*(1), 84–103.

Bansal, R. and W. J. Coleman (1996). A Monetary Explanation of the Equity Premium, Term Premium, and Risk-Free Rate Puzzles. *Journal of Political Economy 104*(6), 1135–1171.

Beetsma, R., M. Giuliodori, and F. Klaassen (2008). The Effects of Public Spending Shocks on Trade Balances and Budget Deficits in the European Union. *Journal of the European Economic Association 6*(2-3), 414–423.

Benetrix, A. S. and P. R. Lane (2013). Fiscal Shocks and the Real Exchange Rate. *International Journal of Central Banking 9*(3), 32.

Bianchi, F., R. Faccini, and L. Melosi (2023). A Fiscal Theory of Persistent Inflation. *The Quarterly Journal of Economics 138*(4), 2127–2179.

Bianchi, F. and C. Ilut (2017, October). Monetary/fiscal policy mix and agent's beliefs. *Review of Economic Dynamics 26*(None), 113–139.

Blanchard, O. J. (1985). Debt, Deficits, and Finite Horizons. *Journal of Political Economy 93*(2), 223–247.

Bodenstein, M., P. C. Borda, N. Gornemann, I. Presno, A. Prestipino, A. Queralto, and A. Raffo (2023). Global Flight to Safety, Business Cycles, and the Dollar. Technical Report 1381, Board of Governors of the Federal Reserve System.

Bonam, D. (2020). A Convenient Truth: The Convenience Yield, Low Interest Rates and Implications for Fiscal Policy. SSRN Working Paper.

Bouakez, H. and A. Eyquem (2015). Government spending, monetary policy, and the real exchange rate. *Journal of International Money and Finance 56*, 178–201.

Bouakez, H. and N. Rebei (2007). Why does private consumption rise after a government spending shock? *Canadian Journal of Economics/Revue canadienne d'économique 40*(3), 954–979.

Brinca, P., H. Holter, P. Krusell, and L. Malafry (2016). Fiscal multipliers in the 21st century. *Journal of Monetary Economics 77*(C), 53–69.

Broner, F., D. Clancy, A. Erce, and A. Martin (2022). Fiscal multipliers and foreign holdings of public debt. *The Review of Economic Studies 89*(3), 1155–1204.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics 12*(3), 383–398.

Chodorow-Reich, G. (2019). Geographic cross-sectional fiscal multipliers: What have we learned? *American Economic Journal: Economic Policy 11*(2), 1–34.

Corsetti, G., A. Meier, and G. J. Müller (2012). Fiscal Stimulus with Spending Reversals. *Review of Economics and Statistics 94*(4), 878–895.

Corsetti, G. and P. Pesenti (2001). Welfare and Macroeconomic Interdependence. *The Quarterly Journal of Economics 116*(2), 421–445.

Di Giorgio, G., S. Nisticò, and G. Traficante (2018). Government spending and the exchange rate. *International Review of Economics & Finance 54*, 55–73.

Diamond, W. and P. Van Tassel (2022). Risk-free rates and convenience yields around the world. Staff Reports 1032, Federal Reserve Bank of New York.

Du, W., J. Im, and J. Schreger (2018). The U.S. Treasury Premium. *Journal of International Economics 112*, 167–181.

Du, W., A. Tepper, and A. Verdelhan (2018). Deviations from Covered Interest Rate Parity. *The Journal of Finance 73*(3), 915–957.

Engel, C. (2002). Expenditure switching and exchange rate policy. *NBER Macroeconomics Annual 17*, 231–300.

Engel, C. and S. P. Y. Wu (2023). Liquidity and Exchange Rates: An Empirical Investigation. *The Review of Economic Studies 90*(5), 2395–2438.

Galí, J., J. D. López-Salido, and J. Vallés (2007). Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association 5*(1), 227–270.

Ghomi, M., J. Mankart, R. Oikonomou, and R. Priftis (2025). Debt maturity and government spending multipliers. Working Papers 2532, Banco de España.

Ilzetzki, E., E. Mendoza, and C. Vegh (2010). How big (small?) are fiscal multipliers? Cep discussion papers, Centre for Economic Performance, LSE.

Jiang, Z. (2022). Fiscal Cyclicality and Currency Risk Premia. *The Review of Financial Studies 35*(3), 1527–1552.

Jiang, Z. (2023). Exorbitant Privilege: A Safe-Asset View. SSRN Working Paper.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2021). Foreign Safe Asset Demand and the Dollar Exchange Rate. *The Journal of Finance 76*(3), 1049–1089.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2023). Dollar safety and the global financial cycle. *The Review of Economic Studies 91*(5), 2878–2915.

Jiang, Z., A. Krishnamurthy, H. Lustig, and J. Sun (2024). Convenience Yields and Exchange Rate Puzzles. Technical Report w32092, National Bureau of Economic Research, Cambridge, MA.

Jiang, Z., R. Richmond, and T. Zhang (2024). Convenience Lost. Working paper.

Jordà, O. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review 95*(1), 161–182.

Kekre, R. and M. Lenel (2024). The flight to safety and international risk sharing. *American Economic Review 114*(6), 1650–91.

Kim, S. and N. Roubini (2008). Twin deficit or twin divergence? Fiscal policy, current account, and real exchange rate in the U.S. *Journal of International Economics 74*(2), 362–383.

Kollmann, R. (2010). Government Purchases and the Real Exchange Rate. *Open Economies Review 21*(1), 49–64.

Krishnamurthy, A. and A. Vissing-Jorgensen (2012). The Aggregate Demand for Treasury Debt. *Journal of Political Economy 120*(2), 233–267.

Leeper, E., T. Walker, and S.-C. Yang (2013). Fiscal foresight and information flows. *Econometrica 81*(3), 1115–1145.

Leeper, E. M. (1991). Equilibria under 'active' and 'passive' monetary and fiscal policies. *Journal of Monetary Economics 27*(1), 129–147.

Leeper, E. M. and T. B. Walker (2012). Perceptions and Misperceptions of Fiscal Inflation. In *Fiscal Policy after the Financial Crisis*, NBER Chapters, pp. 255–299. National Bureau of Economic Research, Inc.

Mertens, K. and M. Ravn (2010). Measuring the impact of fiscal policy in the face of anticipation: A structural var approach. *Economic Journal 120*(544), 393–413.

Miyamoto, W., T. L. Nguyen, and V. Sheremirov (2019). The effects of government spending on real exchange rates: Evidence from military spending panel data. *Journal of International Economics 116*, 144–157.

Monacelli, T. and R. Perotti (2010). Fiscal Policy, the Real Exchange Rate and Traded Goods. *The Economic Journal 120*(544), 437–461.

Mountford, A. and H. Uhlig (2009). What are the effects of fiscal policy shocks? *Journal of Applied Econometrics 24*(6), 960–992.

Newey, W. K. and K. D. West (1987). A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica 55*(3), 703–708.

Priftis, R. and S. Zimic (2021). Sources of borrowing and fiscal multipliers. *The Economic Journal 131*(633), 498–519.

Ramey, V. A. (2016). Defense news shocks, 1889 - 2015: Estimates based on news sources. Technical report, University of California, San Diego and National Bureau of Economic Research.

Ramey, V. A. (2019). Ten years after the financial crisis: What have we learned from the renaissance in fiscal research? *Journal of Economic Perspectives 33*(2), 89–114.

Ramey, V. A. and S. Zubairy (2018). Government spending multipliers in good times and in bad: evidence from us historical data. *Journal of Political Economy 126*(2), 850–901.

Rannenberg, A. (2021). State-dependent fiscal multipliers with preferences over safe assets. *Journal of Monetary Economics 117*(C), 1023–1040.

Ravn, M. O., S. Schmitt-Grohé, and M. Uribe (2012). Consumption, government spending, and the real exchange rate. *Journal of Monetary Economics 59*(3), 215–234.

Smets, F. and R. Wouters (2007). Shocks and frictions in us business cycles: A bayesian dsge approach. *American Economic Review 97*(3), 586–606.

Valchev, R. (2020). Bond Convenience Yields and Exchange Rate Dynamics. *American Economic Journal: Macroeconomics 12*(2), 124–166.

Online Appendix

Fiscal Funding, Treasury Convenience and the Real Exchange Rate

Marco Graziano

Maria Pia Lombardo

Maxime Phillot

A Analytical model

In this appendix, we provide a more detailed exposition of the analytical model introduced in Section 2, clarifying key aspects where additional information is necessary for a full understanding of the model.

A.1 Market clearing

The goods market clearing condition for domestic output is

$$Y_t = \left(\frac{P_{Ht}}{P_t}\right)^{-\epsilon_h} \left\{(1-\epsilon_b)C_t + \epsilon_b Q_t^{\epsilon_h} C_t^* + (1-\epsilon_b)\frac{G_t}{P_t} + \epsilon_b Q_t^{\epsilon_h} \frac{G_t^*}{P_t^*}\right\}. \tag{A.1}$$

The market-clearing condition for domestic government bonds is

$$B_T^n = B_{H,t}^n + B_{H,t}^{n*}, \tag{A.2}$$

where $B_{H,t}^{n*}$ are the foreign household's nominal holdings of domestic government bonds. We also denote with $B_t^* \equiv \frac{B_{Ht}^{n*}}{P_t}$ the real amount of domestic government bonds normalized to the domestic price level, analogously with B_{Ht} and B_t.

A.2 The foreign household

The representative household in the rest of the world maximizes its expected lifetime utility

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{*1-\sigma}}{1-\sigma} - \frac{N_t^{*1+\varphi}}{1+\varphi} + \chi^* \frac{\left(\frac{B_{Ht}^{n*}}{P_t^*}\right)^{1-\psi}}{1-\psi} \right), \tag{A.3}$$

subject to the budget constraint

$$\begin{aligned} & P_t^* C_t^* + \mathbb{E}_t \Lambda_{t,t+1}^* \mathcal{E}_t^{-1} D_{t+1}^* + \mathcal{E}_t^{-1} B_{Ht}^{n*} + B_{Ft}^{n*} \\ = & \mathcal{E}_t^{-1} D_t^* + W_t^* N_t^* - P_t^* T_t^* + \mathcal{E}_t^{-1} B_{Ht-1}^{n*}(1+i_{t-1}) + B_{Ft-1}^{n*}(1+i_{t-1}^*) \end{aligned} \tag{A.4}$$

and to the appropriate no-Ponzi-game conditions. In Equation A.4, B_{Ht}^{n*} and B_{Ft}^{n*} are the foreign household's nominal holdings of, respectively, home-issued and foreign-issued government bonds.

The foreign household's optimality conditions for real government bond holdings $B_{Ht} \equiv \frac{B_{Ht}^{n*}}{P_t}$ and $B_{Ft}^* \equiv \frac{B_{Ft}^{n*}}{P_t^*}$, log-linearized around a zero-inflation steady state, are given by

$$\sigma \mathbb{E}_t \Delta c_{t+1}^* + \mathbb{E}_t \pi_{t+1}^* + \mathbb{E}_t \Delta e_{t+1} - i_t = \frac{1-\beta(1+i)}{\beta(1+i)} (\sigma c_t^* - \psi b_{ht}^* + \psi q_t), \tag{A.5}$$

$$\sigma \mathbb{E}_t \Delta c_{t+1}^* + \mathbb{E}_t \pi_{t+1}^* - i_t^* = 0. \tag{A.6}$$

Equations A.5 and A.6 are the optimality conditions with respect to home-issued and foreign-issued government bonds, respectively.

By combining Equations A.5 and A.6, we derive the Uncovered Interest Parity condition for the rest of the world:

$$i_t^* + \mathbb{E}_t \Delta e_{t+1} - i_t = \frac{1-\beta(1+i)}{\beta(1+i)} (\sigma c_t^* - \psi b_{ht}^* + \psi q_t). \tag{A.7}$$

A.3 Steady state

According to the Backus-Smith condition (Equation 7), in steady state, we have:

$$C = \nu C^* Q^{\frac{1}{\sigma}}, \tag{A.8}$$

where ν is a constant equal to one when both countries share the same preferences and economic environment. However, in our setup, the home country and the rest of the world are asymmetric, as both economies exhibit a preference for home-issued bonds. To address this technical challenge, we calibrate the steady-state ratio of consumption to output in the home country, i.e. C/Y.

Moreover, we assume that all nominal prices are normalized to one in the steady state:

$$P_H = P_F = P = 1 \implies Q = 1. \tag{A.9}$$

Given the elasticity of substitution across varieties, the steady-state markup for firms is given by

$$\frac{P}{W} = \frac{\epsilon_p}{(\epsilon_p - 1)} \frac{Y^{\frac{\alpha_p}{1-\alpha_p}}}{(1-\alpha_P)}. \tag{A.10}$$

Furthermore, following the standard New-Keynesian framework, we impose

$$Y = N^{1-\alpha_p}, \tag{A.11}$$

$$C^{\sigma} N^{\varphi} = \frac{W}{P}. \tag{A.12}$$

Now we can express steady-state output as

$$Y = \left(\frac{\frac{\epsilon_p - 1}{\epsilon_p}(1-\alpha_p)}{(\frac{C}{Y})^{\sigma}} \right)^{\frac{1}{\sigma + \frac{\varphi+\alpha_p}{1-\alpha_p}}}. \tag{A.13}$$

By evaluating Equations 4 and 5 at the steady state, we derive an expression for the steady-state convenience yield:

$$1 = \beta(1 + i^*) \tag{A.14}$$

$$1 = \beta(1+i) + \chi B^{-\psi} C^{\sigma} \tag{A.15}$$

$$\implies i^* - i = \frac{\chi}{\beta} B^{-\psi} C^{\sigma}. \tag{A.16}$$

A.4 Proofs

A.4.1 Proposition 1

Proof. We derive the reduced-form dynamic system by expressing the model solely in terms of aggregate domestic government debt b_t and consumption c_t.

We begin with the log-linearized market-clearing condition for domestic government bonds in real terms (derived from Equation A.2), which implies

$$b_t = \frac{b_H}{b} b_{ht} + \frac{b_H^*}{b} b_{ht}^*. \tag{A.17}$$

Next, combining the modified UIP condition for the home country (Equation 6) with its foreign counterpart (Equation A.7), we obtain

$$\sigma c_t - \psi b_{ht} = \sigma c_t^* + \psi b_{ht}^* - \psi q_t.$$

Letting $c_t^* = 0$ without loss of generality thanks to the small open economy assumption and solving for b_{ht}^*:

$$b_{ht}^* = b_{ht} + \sigma \frac{\psi - 1}{\psi} c_t.$$

Substituting for b_{ht}^* in Equation A.17 and solving for $b_{h,t}$ yields

$$b_{ht} = b_t + \frac{b_H^*}{b} \sigma \frac{1-\psi}{\psi} c_t.$$

Substituting this expression into the Euler equation for domestic bonds (Equation 4), and using the constant real interest rate condition implied by monetary policy rule $i_t = \mathbb{E}_t \pi_{t+1}$, yields an expression of the form

$$\mathbb{E}_t c_{t+1} = \Gamma c_t - \Omega b_t,$$

where the composite parameters Ω and Γ are defined in the proposition. This establishes Equation 12.

Finally, expressing the government budget constraint (Equation 9) in real terms, log-linearizing it around a zero-inflation steady state, and substituting in the monetary policy rule yields

$$b_t + \frac{iB + G}{B} t_t = (1 + i) b_{t-1} + \frac{G}{B} g_t. \tag{A.18}$$

Combining Equation A.18 with the fiscal rule (Equation 10) we obtain a law of motion for government debt of the form

$$b_t = \Xi_b b_{t-1} + \Xi_g g_t,$$

with coefficients Ξ_b and Ξ_g defined in the proposition. □

A.4.2 Corollary 1.1

Proof. We derive the Blanchard–Kahn conditions by expressing the system in first-order linear rational expectations form.

We begin by defining the vector of endogenous variables

$$x_t \equiv \begin{pmatrix} b_t \\ c_t \end{pmatrix}.$$

We shift the law of motion of government debt (Equation 13) forward one period to obtain

$$b_{t+1} = \Xi_b b_t + \Xi_g g_{t+1}.$$

Taking expectations conditional on time t yields

$$\mathbb{E}_t b_{t+1} = \Xi_b b_t + \Xi_g \mathbb{E}_t g_{t+1}. \tag{A.19}$$

Combining Equations A.19 and 12, we obtain a system of the form

$$\mathbb{E}_t x_{t+1} = A x_t + D \mathbb{E}_t g_{t+1},$$

where

$$A \equiv \begin{pmatrix} \Xi_b & 0 \\ -\Omega & \Gamma \end{pmatrix} \qquad D \equiv \begin{pmatrix} \Xi_g \\ 0 \end{pmatrix}.$$

Since g_t is exogenous, it does not affect the determinacy properties of the system. These are governed entirely by the eigenvalues of the matrix A.

Because A is lower triangular, its eigenvalues are given by

$$\mu_1 = \Xi_b, \quad \mu_2 = \Gamma.$$

The variable b_t is predetermined, while c_t is forward-looking. The Blanchard–Kahn conditions therefore require that the number of eigenvalues outside the unit circle equals the number of forward-looking variables.

Since there is one forward-looking variable (c_t), a unique bounded equilibrium exists if and only if exactly one eigenvalue lies outside the unit circle. This requires

$$|\Xi_b| < 1 \quad \text{and} \quad |\Gamma| > 1.$$

The condition $|\Gamma| > 1$ requires

$$\left|1 + \frac{1-\beta(1+i)}{\beta(1+i)}\left(\psi\frac{B_H^*}{B} + \frac{B_H}{B}\right)\right| > 1.$$

Since the term in brackets is always positive for $\psi > 0$, the condition is equivalent to

$$\frac{1-\beta(1+i)}{\beta(1+i)} > 0 \iff 1+i < \frac{1}{\beta}.$$

That is, the steady-state interest rate on domestic government bonds must be lower than the household's rate of time preference. This condition always holds, as shown in Equation A.15. Therefore, $\Gamma > 1$ always holds, and as a result the stability condition $|\Gamma| > 1$ is always satisfied by construction. □

A.4.3 Proposition 2

Proof. We conjecture that the policy function for consumption takes the form

$$c_t = \chi_b b_{t-1} + \chi_g g_t.$$

Taking expectations at time t yields

$$\mathbb{E}_t c_{t+1} = \chi_b b_t + \chi_g \mathbb{E}_t g_{t+1}.$$

Using the law of motion for government spending, $\mathbb{E}_t g_{t+1} = \rho_g g_t$, and the law of motion of debt from Equation 13, we obtain

$$\mathbb{E}_t c_{t+1} = \chi_b(\Xi_b b_{t-1} + \Xi_g g_t) + \chi_g \rho_g g_t.$$

Substituting the conjectured policy function and the law of motion of debt into the Euler equation 12 gives

$$\mathbb{E}_t c_{t+1} = -\Omega(\Xi_b b_{t-1} + \Xi_g g_t) + \Gamma(\chi_b b_{t-1} + \chi_g g_t).$$

Equating coefficients on b_{t-1} and g_t from both expressions for $\mathbb{E}_t c_{t+1}$ gives the system:

$$\begin{aligned} \chi_b \Xi_b &= -\Omega \Xi_b + \Gamma \chi_b, \\ \chi_b \Xi_g + \chi_g \rho_g &= -\Omega \Xi_g + \Gamma \chi_g. \end{aligned}$$

Rearranging the first equation yields

$$\chi_b(\Xi_b - \Gamma) = -\Omega \Xi_b,$$

which implies

$$\chi_b = \frac{\Omega \Xi_b}{\Gamma - \Xi_b}.$$

Substituting this expression into the second equation gives

$$\frac{\Omega \Xi_b}{\Gamma - \Xi_b} \Xi_g + \chi_g \rho_g = -\Omega \Xi_g + \Gamma \chi_g.$$

Solving for χ_g yields

$$\chi_g = \frac{\Gamma \, \Omega \, \Xi_g}{(\Gamma - \Xi_b)(\Gamma - \rho_g)}.$$

□

A.4.4 Proposition 3

Proof. Following a one-time unit shock at $t = 0$, i.e. $\varepsilon_0^g = 1$ and $\varepsilon_t = 0$ for $t > 0$, according to the law of motion for government spending the path of g_t is given by

$$g_t = \rho_g^t.$$

Next, consider the law of motion for government debt (Equation 13). Iterating backward yields

$$b_t = \sum_{j=0}^{t} \Xi_b^{t-j} \Xi_g g_j = \Xi_g \sum_{j=0}^{t} \Xi_b^{t-j} \rho_g^j,$$

which can be written in closed form as

$$b_t = \Xi_g \frac{\Xi_b^{t+1} - \rho_g^{t+1}}{\Xi_b - \rho_g}.$$

Hence,

$$b_{t-1} = \Xi_g \frac{\Xi_b^t - \rho_g^t}{\Xi_b - \rho_g}.$$

Substituting into the policy function for consumption (Equation 15), we obtain

$$c_t = \frac{\Omega\Xi_b}{\Gamma - \Xi_b} \cdot \Xi_g \frac{\Xi_b^t - \rho_g^t}{\Xi_b - \rho_g} + \frac{\Gamma\Omega\Xi_g}{(\Gamma - \Xi_b)(\Gamma - \rho_g)}\rho_g^t.$$

Rearranging terms, the impulse response can be written as

$$c_t = \frac{\Omega\Xi_g}{\Gamma - \Xi_b}\left[\frac{\Xi_b\left(\Xi_b^t - \rho_g^t\right)}{\Xi_b - \rho_g} + \frac{\Gamma}{\Gamma - \rho_g}\rho_g^t\right].$$

□

A.4.5 Corollary 3.1

Proof. Consider the sign of the consumption IRF from Proposition 3, letting

$$D_t \equiv \frac{\Xi_b\left(\Xi_b^t - \rho_g^t\right)}{\Xi_b - \rho_g}.$$

Regardless of monotonicity assumptions, $\Gamma > 1$ so

$$\frac{\Gamma}{\Gamma - \rho_g}\rho_g^t > 0.$$

Under monotonic dynamics, $\Xi_b \in (0, 1)$. Therefore, $\Gamma - \Xi_b > 0$ and $D_t > 0$ as

$$\text{sign}(\Xi_b^t - \rho_g^t) = \text{sign}(\Xi_b - \rho_g).$$

Therefore, noting that $\Omega > 0$,

$$\text{sign}(c_t) = \text{sign}(\Xi_g).$$

Under non-monotonic dynamics with $\Xi_b < 0$, the term Ξ_b^{t+1} alternates in sign, while $\rho_g^{t+1} > 0$.

Hence, the sign of c_t can change for different t if the oscillations in Ξ_b^{t+1} are large enough for D_t to change sign over time. $\square$

A.5 Numerical illustration

We illustrate the impulse response functions of a calibrated version of the simple analytical model built in Section A to build intuition on the core mechanism and analyze the sensitivity of the responses of consumption and the real exchange rate to structural parameters.

A.5.1 Calibration

We calibrate i and β to match the average interest rate on 10-year government bonds by G-10 currency issuers, and the convenience yield on U.S. Treasury securities. We start by setting β to 0.994 to match the observed average annualized interest rate of 2% for G-10 currency issuers.[9] Then, we set i to obtain a steady-state annualized convenience yield of U.S. Treasury of 1 %.

The Calvo price-setting probability is set to $\theta = 0.75$, following Galí (2015). The risk aversion parameter σ is set to 3, the inverse Frisch elasticity of labor supply is set to $\varphi = 1.5$ and the labor elasticity to $\alpha_p = 1/3$. Trade openness is captured by $\epsilon_b = 0.2$, while the elasticity of substitution between domestic and foreign goods is set to $\epsilon_h = 1.5$. The elasticity of substitution across varieties within a country is set to $\epsilon_p = 6$. These parameter values are all in line with the macroeconomic literature.

Government debt to GDP (B/Y), government spending to GDP (G/Y) and consumption to GDP (C/Y) are set to the corresponding averages for the United States from March 1999 to April 2026. Foreign holdings of government debt to GDP (B_H^*/Y) are set to the average

[9] The steady-state convenience yield is a function of both χ and ψ, but χ drops out of the log-linearized dynamic equations. Therefore, we can pick an arbitrary level of χ to make any value of $\psi > 0$ consistent with the steady-state calibration of the convenience yield. Given a particular choice of ψ, the utility weight of government bonds χ is determined at the steady state as $\chi = [1 - \beta(1+i)] \frac{B^\psi}{C^\sigma}$.

of G-10 holdings of U.S. Treasuries from March 1999 to April 2026.

To calibrate the autocorrelation coefficient of the government spending process, we estimate an AR(1) model of de-trended log U.S. government spending.

In our analysis, we explore the interactions between the parameters ψ, ϕ_b and ϕ_g, by testing various combinations. Specifically, we examine three values for the curvature parameter $\psi \in \{0.5, 1.0, 1.5\}$.

For the debt dynamics parameter ϕ_b, we restrict our attention to the values admitting monotonic debt dynamics, corresponding to $\phi_b \in [0.044, 3.19]$ given other calibrated parameters. The government expenditure response parameter, ϕ_g, is allowed to vary continuously within the interval $\phi_g \in [0, 1]$.

Table A.1 summarizes our parameter calibration.

A.5.2 Impulse responses to a government spending shock

In this section, we examine the impulse response functions following both fully tax-funded ($\phi_g = 1$) and fully debt-funded ($\phi_g = 0$) government expenditure shocks, as well as intermediate values of ϕ_g. Additionally, we analyze the sensitivity of the impulse responses to variations in the fiscal policy parameter ϕ_b, which determines the speed of debt repayment through taxation.

Tax-funded government expenditure shock

In Figure A.1, we present the impulse response functions of real government debt, consumption, the real exchange rate and the convenience yield following a 0.25% tax-funded government expenditure shock, with $\phi_g = 1$. The upper row shows the case of $\phi_b = 0.044$, while the lower row shows the case of $\phi_b = 3.19$. These two cases represent the lower and upper bound on the fiscal policy parameter imposed by the Blanchard-Kahn conditions. Within each row, different lines correspond to different values of ψ, modulating the curvature

Table A.1: Analytical Model – Parameter Calibration and Values

Parameter	**Description**	**Value**
External parameters		
σ	Risk aversion parameter	3
φ	Inverse Frisch elasticity of labor supply	1.5
ϵ_b	Trade openness	0.2
θ	Calvo probability of not changing prices	0.75
α_p	Output elasticity with respect to labor	1/3
ϵ_h	Elasticity of substitution between domestic and foreign goods	1.5
ϵ_p	Elasticity of substitution across varieties	6
Calibrated parameters		
β	Discount factor	0.994
ρ_g	Persistence of government expenditure shocks	0.49
Calibration targets		
i^*	Quarterly average real interest rate on 10-year G-10 currency government bonds	0.0056
$i^* - i$	Quarterly convenience yield on U.S. Treasuries	0.0025
B/Y	Steady-state government debt to GDP ratio	0.89
B_H^*/Y	Steady-state foreign holdings of Treasuries to domestic GDP ratio	0.15
C/Y	Steady-state consumption to GDP ratio	0.67
G/Y	Steady-state government expenditure to GDP ratio	0.20
Variable parameters		
ψ	Convenience yield curvature parameter	$\{0.5, 1.0, 1.5\}$
ϕ_b	Fiscal rule reaction to taxation	$[0.044, 3.19]$
ϕ_g	Fiscal rule tax-funded spending fraction	$[0, 1]$

of Treasury preferences.

Overall, impulse response functions are much more persistent with $\phi_b = 0.044$, while they revert quickly back to the steady state with $\phi_b = 3.19$. The more strongly taxes respond to debt through a higher ϕ_b, the faster debt returns to steady state, and so do consumption and the real exchange rate through the convenience yield mechanism.

In either case, a tax-funded shock lowers the real amount of government debt, as existing debt is gradually repaid through the fiscal policy while no new debt is issued to finance spending. Due to concavity of Treasury utility, the convenience yield rises as debt decreases. As a result of lower consumption, the exchange rate appreciates through the Backus-Smith condition (Equation 7). Therefore, tax-funded fiscal shocks cannot result in a real exchange rate depreciation. Overall, the responses of all variables are very small because the standard effect of monetary policy on consumption through the real interest rate is inactive in the analytical model, and the debt dynamics governing the intratemporal substitution channel of the convenience yield are muted due to full tax financing.

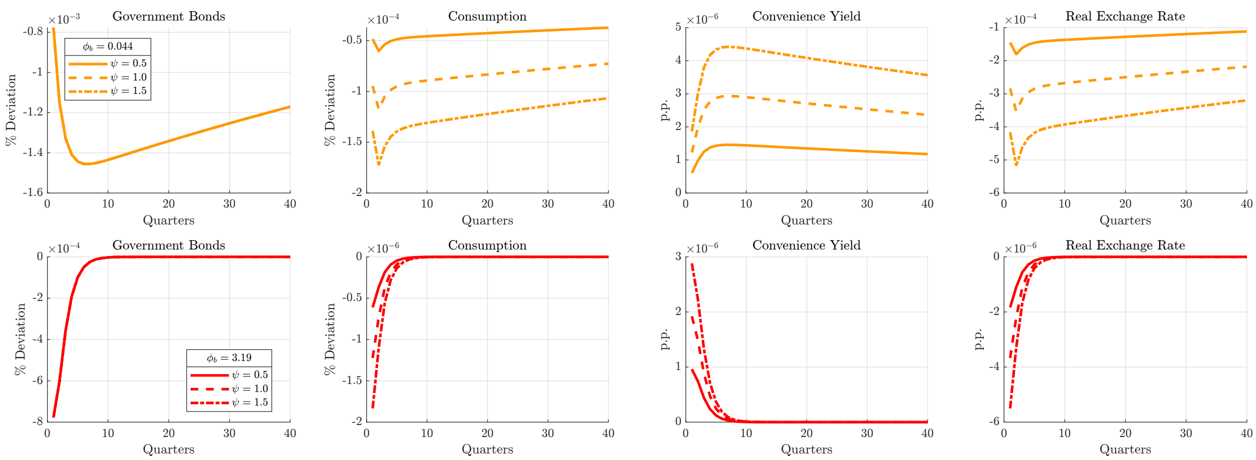


Figure A.1: IRFs following 0.25% tax-funded government expenditure shock, $\phi_g = 1$

Notes: Impulse response functions of domestic government bonds, domestic consumption, the convenience yield on domestic government bonds, and the real exchange rate to a 0.25% government spending shock in the analytical model with full tax funding ($\phi_g = 1$). The top row displays impulse responses with $\phi_b = 0.044$ (orange), the bottom row displays impulse responses with $\phi_b = 3.19$ (red). Both rows display impulse response functions for $\psi = 0.5$ (solid), $\psi = 1.0$ (dashed), and $\psi = 1.5$ (dashed-dotted). All other parameters are kept fixed to the baseline calibration reported in Table A.1.

Debt-funded government expenditure shock

In Figure A.2, we present the same impulse response functions following a debt-funded government expenditure shock, with $\phi_g = 0$. Since the shock is entirely financed through an increase in the real value of government debt, the convenience yield drops and households raise their consumption due to the intratemporal complementarity between consumption and debt. This effect is more pronounced as the curvature of the utility from bonds, ψ, increases. The increase in domestic consumption then leads to a depreciation of the real exchange rate through the Backus-Smith condition. Furthermore, the increase in consumption is weaker as the fiscal parameter governing real debt dynamics, ϕ_b, increases. A larger ϕ_b implies a more rigid policy, where the fiscal authority curtails the increase in debt quickly through higher taxes. As a result, consumption does not rise as much due to both the Ricardian effect of higher taxation, and the weaker complementarity effect with debt holdings.

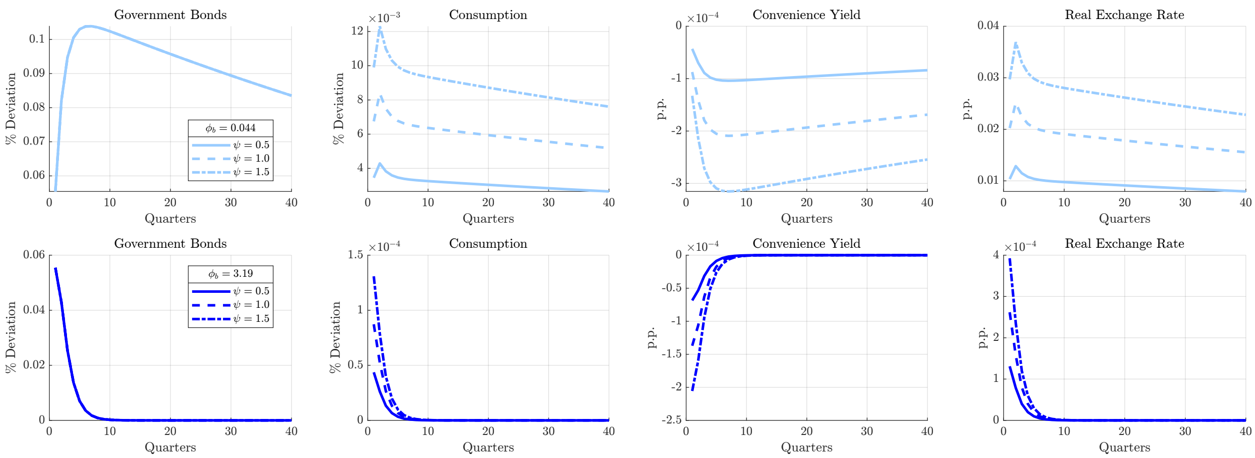


Figure A.2: IRFs following 0.25% debt-funded government expenditure shock, $\phi_g = 0$

Notes: Impulse response functions of domestic government bonds, domestic consumption, the convenience yield on domestic government bonds, and the real exchange rate to a 0.25% government spending shock in the analytical model with full debt funding ($\phi_g = 0$). The top row displays impulse responses with $\phi_b = 0.044$ (light blue), the bottom row displays impulse responses with $\phi_b = 3.19$ (dark blue). Both rows display impulse response functions for $\psi = 0.5$ (solid), $\psi = 1.0$ (dashed), and $\psi = 1.5$ (dashed-dotted). All other parameters are kept fixed to the baseline calibration reported in Table A.1.

A.5.3 Sensitivity to variations in the fiscal policy parameter ϕ_g

Figure A.3 displays impulse response functions for values of ϕ_g around the threshold that flips the sign of responses for consumption and hence the real exchange rate. Lower values of ϕ_g imply that the government expenditure shock is largely debt-financed, generating a positive equilibrium relationship between debt and government spending. As a result, consumption rises and the real exchange rate depreciates following an expansionary fiscal shock. Notably, the threshold below which consumption increases is very high, at $\phi_g = 0.956$. Hence, even

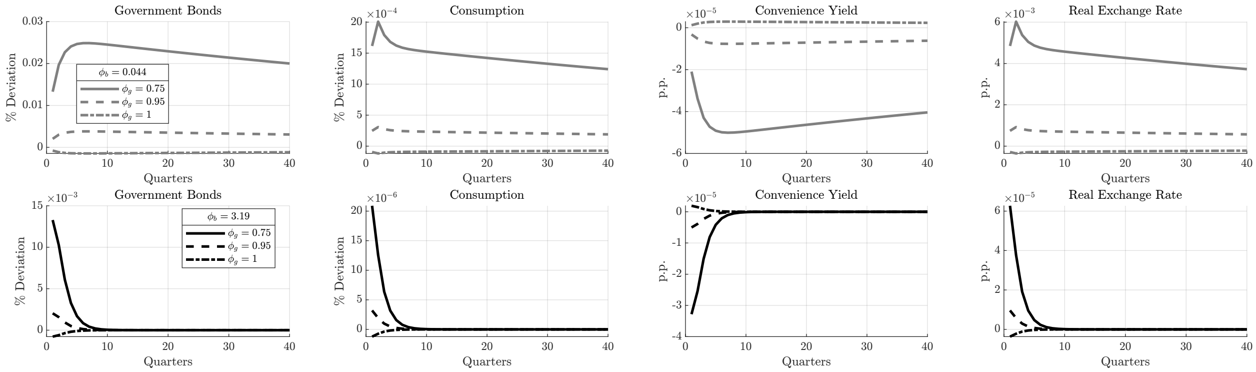


Figure A.3: Sensitivity of IRFs to ϕ_g

Notes: Impulse response functions of domestic government bonds, domestic consumption, the convenience yield on domestic government bonds, and the real exchange rate to a 0.25% government spending shock in the analytical model. The top row displays impulse responses with $\phi_b = 0.044$ (gray), the bottom row displays impulse responses with $\phi_b = 3.19$ (black). Both rows display impulse response functions for $\phi_g = 0.75$ (solid), $\phi_g = 0.95$ (dashed), and $\phi_g = 1$ (dashed-dotted). All other parameters are kept fixed to the baseline calibration reported in Table A.1 and $\psi = 1$ in all plots.

minimal debt financing leads to higher consumption and a real exchange rate depreciation in the analytical model.

B Quantitative model

In this section, we provide a more detailed exposition of the quantitative model presented in Section 3, including the full set of equilibrium equations. The remaining elements of the analytical model are unchanged and continue to apply within the context of the quantitative model.

B.1 Domestic household problem

The representative U.S. household maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right],$$

choosing $\{C_t,\ B_{H,t}/P_t,\ \varepsilon_t B_{F,t}/P_t,\ N_t,\ D_{t+1}/P_t\}$ subject to the flow budget constraint

$$\begin{aligned} P_t C_t + \mathbb{E}_t[Q_{t,t+1} D_{t+1}] + B_{H,t} + \varepsilon_t B_{F,t} + P_t\, \Psi\Big(C_t, \tfrac{B_{H,t}}{P_t}\Big) \\ = D_t + W_t N_t - T_t + B_{H,t-1}\,(1+i_{t-1}) + \varepsilon_t\,(1+i^*_{t-1})\, B_{F,t-1}. \end{aligned}$$

Letting

$$\Psi_{B_{H,t}/P_t} \;=\; (1-\alpha)\,\gamma\bigg(\frac{C_t}{B_{H,t}/P_t}\bigg)^{\alpha}, \qquad \Psi_{C_t} \;=\; \alpha\,\gamma\bigg(\frac{B_{H,t}/P_t}{C_t}\bigg)^{1-\alpha}$$

the derivatives of the transaction cost function Ψ with respect to $B_{H,t}/P_t$ and C_t, the first-order conditions of the problem are

$$\begin{aligned}
[D_{t+1}/P_t]: &\qquad -\lambda_t\,\mathbb{E}_t Q_{t,t+1}\,P_t + \beta\,\mathbb{E}_t\lambda_{t+1} \;=\; 0,\\
[\varepsilon_t B_{F,t}/P_t]: &\qquad -\lambda_t\,P_t + \beta\,\mathbb{E}_t\lambda_{t+1}\,(1+i^*_t)\,\frac{\varepsilon_{t+1}}{\varepsilon_t}\,P_t \;=\; 0,\\
[B_{H,t}/P_t]: &\qquad -\lambda_t\,P_t + \beta\,\mathbb{E}_t\lambda_{t+1}\,(1+i_t)\,P_t - \lambda_t\,P_t\,\Psi_{B_{H,t}/P_t} \;=\; 0,\\
[C_t]: &\qquad C_t^{-\sigma} - \lambda_t\,P_t\,(1+\Psi_{C_t}) \;=\; 0 \;\;\Longrightarrow\;\; \lambda_t = \frac{C_t^{-\sigma}}{P_t\,(1+\Psi_{C_t})},\\
[N_t]: &\qquad -N_t^{\varphi} + \lambda_t\,W_t \;=\; 0 \;\;\Longrightarrow\;\; \lambda_t = \frac{N_t^{\varphi}}{W_t}.
\end{aligned}$$

Combining the first-order conditions yields the following intratemporal and intertemporal optimality conditions:

$$\frac{W_t}{P_t\,(1+\Psi_{C_t})} = N_t^{\varphi}\, C_t^{\sigma}, \tag{B.1}$$

$$1 = \beta\, \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t}\, Q_{t,t+1}^{-1}, \tag{B.2}$$

$$1 = \beta\, \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t}\, (1+i_t^*)\, \frac{\varepsilon_{t+1}}{\varepsilon_t}, \tag{B.3}$$

$$1 = \beta\, \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t}\, (1+i_t) \;-\; \Psi_{B_{H,t}/P_t}. \tag{B.4}$$

Substituting the marginal utility expression $\lambda_t = C_t^{-\sigma}/[P_t(1+\Psi_{C_t})]$ into (B.2):

$$1 \;=\; \beta\, \mathbb{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+1}}\, \frac{1+\Psi_{C_t}}{1+\Psi_{C_{t+1}}}\, Q_{t,t+1}^{-1}. \tag{B.5}$$

Therefore, the convenience yield affects the stochastic discount factor directly through the derivatives of the transaction cost function to current and future consumption.

Log-linearization

Log-linearizing the domestic and foreign bond Euler equations around the symmetric, zero-inflation steady state yields

$$0 = \beta(1+r)\Big\{r_t - \sigma\, \Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t \pi_{t+1} - \Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t bh_{t+1} - \Delta\mathbb{E}_t c_{t+1})\Big\}, \tag{B.6}$$

$$0 = \beta(1+i^*)\Big\{i_t^* + \Delta\mathbb{E}_t e_{t+1} - \sigma\, \Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t \pi_{t+1} - \Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t bh_{t+1} - \Delta\mathbb{E}_t c_{t+1})\Big\}. \tag{B.7}$$

For the home-currency bond Euler equation with convenience yield, the steady state implies

$$1 + \Psi(BH/P) \;=\; 1 + i, \tag{B.8}$$

and so the log-linearized Euler equation can be written as

$$\big[\beta(1+i)-1\big]\big(\alpha c_t-\alpha\, bh_t\big) = \beta(1+i)\Big\{i_t-\sigma\Delta\mathbb{E}_t c_{t+1}-\mathbb{E}_t\pi_{t+1}-\Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t bh_{t+1}-\Delta\mathbb{E}_t c_{t+1})\Big\}.$$

Finally, log-linearizing the labor supply around the steady state yields

$$\omega_t \;=\; \sigma c_t + \varphi n_t + \Theta\,(1-\alpha)\,(bh_t - c_t).$$

B.2 Equilibrium equations

An equilibrium in the quantitative model consists of a sequence of endogenous variables $\{c_t, c_t^*, b_{ht}, b_{ht}^*, n_t, n_t^*, \pi_t, \pi_t^*, \omega_t, \omega_t^*, y_t, y_t^*, \Delta e_t, q_t, i_t, i_t^*, b_t, b_t^*, t_t, t_t^*, g_t\}_{t=0}^{\infty}$, with $\omega_t^* \equiv w_t^* - p_t^*$ the foreign real wage, and shocks $\{\epsilon_t\}_{t=0}^{\infty}$ such that the households' and firms' optimality conditions and associated transversality conditions hold in the domestic and foreign economy, that the domestic and foreign government budget constraint are satisfied, that the domestic and foreign goods market and the domestic bond market clear, and that the stability conditions of the dynamic system are satisfied, given the monetary and fiscal policy rules for the domestic and foreign economy.

For notational convenience, define composite parameters

$$\eta \equiv \frac{\epsilon_b}{1-2\epsilon_b}, \qquad \kappa \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}\,\frac{1-\alpha_p}{1-\alpha_p+\epsilon_p\alpha_p},$$
$$\Phi \equiv 1+\gamma(BH/C)^{1-\alpha}, \qquad \Phi^* \equiv 1+\gamma^*(BH^*/C^*)^{1-\alpha^*}.$$

Then, the set of log-linearized equations defining an equilibrium is

$$0 = i_t^* + \Delta\mathbb{E}_t e_{t+1} - \sigma\,\Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t\pi_{t+1} - \Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t b_{ht+1} - \Delta\mathbb{E}_t c_{t+1}), \tag{B.9}$$

$$\frac{\beta(1+i)-1}{\beta(1+i)}\alpha\big(c_t-b_{ht}\big)=i_t-\sigma\Delta\mathbb{E}_t c_{t+1}-\mathbb{E}_t\pi_{t+1}-\Theta\,(1-\alpha)\,(\Delta\mathbb{E}_t b_{ht+1}-\Delta\mathbb{E}_t c_{t+1}), \tag{B.10}$$

$$\omega_t \;=\; \sigma c_t+\varphi n_t+\Theta\,(1-\alpha)\,(b_{ht}-c_t), \tag{B.11}$$

$$\begin{aligned}\frac{\beta(1+i)-1}{\beta(1+i)}\alpha^*\big(c_t^*-b_{ht}^*+q_t\big)=i_t-\sigma\,\Delta\mathbb{E}_t c_{t+1}^*-\mathbb{E}_t\pi_{t+1}^*-\Delta\mathbb{E}_t e_{t+1}\\ -\Theta^*(1-\alpha^*)\big(\Delta\mathbb{E}_t b_{ht+1}^*-\Delta\mathbb{E}_t c_{t+1}^*-\Delta\mathbb{E}_t q_{t+1}\big),\end{aligned} \tag{B.12}$$

$$0=i_t^*-\sigma\Delta\mathbb{E}_t c_{t+1}^*-\mathbb{E}_t\pi_{t+1}^*-\Theta^*(1-\alpha^*)(\Delta\mathbb{E}_t b_{ht+1}^*-\Delta\mathbb{E}_t c_{t+1}^*-\Delta\mathbb{E}_t q_{t+1}), \tag{B.13}$$

$$\omega_t^* \;=\; \sigma c_t^*+\varphi n_t^*+\Theta^*(1-\alpha^*)(b_{ht}^*-c_t^*-q_t), \tag{B.14}$$

$$q_t=\sigma(c_t-c_t^*)+\Theta(1-\alpha)(b_{ht}-c_t)-\Theta^*(1-\alpha^*)(b_{ht}^*-q_t-c_t^*), \tag{B.15}$$

$$\Delta e_t=\Delta q_t+\pi_t-\pi_t^*, \tag{B.16}$$

$$\pi_t=\beta\,\mathbb{E}_t\pi_{t+1}+\eta\big(\Delta q_t-\beta\,\mathbb{E}_t\Delta q_{t+1}\big)+\kappa\left[(w_t-p_t)+\eta\,q_t+\frac{\alpha_p}{1-\alpha_p}y_t\right], \tag{B.17}$$

$$\pi_t^* = \beta\,\mathbb{E}_t\pi_{t+1}^* - \eta\big(\Delta q_t - \beta\,\mathbb{E}_t\Delta q_{t+1}\big) + \kappa\left[(w_t^* - p_t^*) - \eta\, q_t + \frac{\alpha_p}{1-\alpha_p} y_t^*\right], \tag{B.18}$$

$$y_t = (1-\alpha_p)n_t, \tag{B.19}$$

$$y_t^* = (1-\alpha_p)n_t^*, \tag{B.20}$$

$$\begin{aligned} y_t = {} & (1-\epsilon_b)\,\frac{C}{Y}\,\Phi\Big[\epsilon_H\eta\, q_t + c_t + \Theta(1-\alpha)(bh_t - c_t)\Big] \\ & + \epsilon_b\,\frac{C^*}{Y}\,\Phi^*\Big[\epsilon_H(\eta+1)\, q_t + c_t^* + \Theta^*(1-\alpha^*)(bh_t^* - q_t - c_t^*)\Big] \\ & + (1-\epsilon_b)\,\frac{G}{Y}\big[\epsilon_H\eta\, q_t + g_t\big] + \epsilon_b\,\frac{G^*}{Y}\big[\epsilon_H(\eta+1)\, q_t + g_t^*\big], \end{aligned} \tag{B.21}$$

$$\begin{aligned} y_t^*\,\frac{Y^*}{Y} = {} & (1-\epsilon_b)\,\frac{C^*}{Y}\,\Phi^*\Big[-\epsilon_H\eta\, q_t + c_t^* + \Theta^*(1-\alpha^*)(bh_t^* - q_t - c_t^*)\Big] \\ & + \epsilon_b\,\frac{C}{Y}\,\Phi\Big[-\epsilon_H(\eta+1)\, q_t + c_t + \Theta(1-\alpha)(bh_t - c_t)\Big] \\ & + (1-\epsilon_b)\,\frac{G^*}{Y}\big[-\epsilon_H\eta\, q_t + g_t^*\big] + \epsilon_b\,\frac{G}{Y}\big[-\epsilon_H(\eta+1)\, q_t + g_t\big], \end{aligned} \tag{B.22}$$

$$i_t = \rho_i i_{t-1} + (1-\rho_i)\phi_\pi\pi_t, \tag{B.23}$$

$$i_t^* = \rho_i^* i_{t-1}^* + (1-\rho_i^*)\phi_\pi^*\pi_t^*, \tag{B.24}$$

$$\frac{B}{G}\,b_t + \left(\frac{iB}{G} + 1\right)\tau_t = (1+i)\,\frac{B}{G}\big(b_{t-1} + i_{t-1} - \pi_t\big) + g_t, \tag{B.25}$$

$$t_t = \phi_b b_{t-1} + \phi_g g_t, \tag{B.26}$$

$$\frac{B^*}{G^*}\,b_t^* + \left(\frac{i^* B^*}{G^*} + 1\right)\tau_t^* = (1+i^*)\,\frac{B^*}{G^*}\big(b_{t-1}^* + i_{t-1}^* - \pi_t^*\big), \tag{B.27}$$

$$\tau_t^* = \phi_b^*\, b_{t-1}^*, \tag{B.28}$$

$$g_t = \rho_g g_{t-1} + \varepsilon_t. \tag{B.29}$$

B.3 Calibration

This section details the parts of the calibration strategy for the quantitative model that differ from the calibration used for the numerical illustration of the analytical model. Refer to Section A.5.1 for the remaining parameters.

We calibrate α, α^*, γ, γ^*, φ, and ϵ_b jointly by imposing $\alpha = \alpha^*$ and solving the Treasury Euler equation for the domestic household, the combined UIP condition for the domestic and foreign households, the domestic goods market clearing condition, the relative labor demand in the domestic and foreign countries, and the domestic aggregate resource constraint (Equations B.30 to B.34 below), targeting foreign output, domestic consumption, foreign consumption, and domestic net exports, all as a fraction of domestic output.

$$\beta(1+i) = 1 + (1-\alpha)\,\gamma\left(\frac{C}{B_H}\right)^{\alpha}, \tag{B.30}$$

$$(1-\alpha^*)\,\gamma^*\left(\frac{C^*}{B_H^*}\right)^{\alpha^*} = (1-\alpha)\,\gamma\left(\frac{C}{B_H}\right)^{\alpha}, \tag{B.31}$$

$$\left(\frac{Y^*}{Y}\right)^{\frac{\varphi+\alpha_p}{1-\alpha_p}}\left(\frac{C^*/Y}{C/Y}\right)^{\sigma} = \frac{1-\alpha\gamma(B_H/C)^{1-\alpha}}{1-\alpha^*\gamma^*(B_H^*/C^*)^{1-\alpha^*}}, \tag{B.32}$$

$$1 = (1-\epsilon_b)\,\frac{C}{Y}\left(1+\gamma(B_H/C)^{1-\alpha}\right)+\epsilon_b\,\frac{C^*}{Y}\left(1+\gamma^*(B_H^*/C^*)^{1-\alpha^*}\right)+(1-\epsilon_b)\,\frac{G}{Y}+\epsilon_b\,\frac{G^*}{Y}, \tag{B.33}$$

$$\frac{NX}{Y} = 1 - \frac{C}{Y}\left(1+\gamma(B_H/C)^{1-\alpha}\right) - \frac{G}{Y}. \tag{B.34}$$

Specifically, first we set $\alpha = \alpha^*$, then solve for α and γ jointly using Equations B.30 and B.34. Then, we solve for γ^* given α and γ using Equation B.31. Then, we solve for φ using Equation B.32 and for ϵ_b using Equation B.33.

The resulting value of $\alpha = 2.55$ implies curvature in the transaction cost function as it is larger than one, confirming our assumption of diminishing marginal liquidity benefits of Treasury holdings. The scale parameter γ is an order of magnitude larger for domestic consumers than for foreigners, consistent with a more prominent role for Treasury convenience in the U.S. This calibration strategy also solves for two parameters that are usually set externally in the macroeconomic literature: trade openness ϵ_b and the inverse Frisch elasticity of labor supply φ. We obtain $\epsilon_b = 0.28$ and $\varphi = 1.83$, well within the range commonly used in the literature.

Table B.1 summarizes our calibration for parameters that differ from the numerical illustration of the analytical model. Table B.2 lists data sources for the calibration of both the analytical and quantitative model.

B.4 Additional results

B.4.1 Convenience yield channels

In this section, we disentangle the effects of the intratemporal substitution and stochastic discount factor effects of the convenience yield. We shut down the stochastic discount factor

Table B.1: Quantitative Model – Parameter Calibration and Values

Parameter	**Description**	**Value**
External parameters		
ρ_i	Persistence of nominal interest rate	0.9
Calibrated parameters		
ϵ_b	Trade openness	0.28
φ	Inverse Frisch elasticity of labor supply	1.83
γ	Domestic transaction cost scale	0.09
γ^*	Foreign transaction cost scale	0.001
α	Domestic transaction cost curvature	2.55
α^*	Foreign transaction cost curvature	2.55
σ_g	Standard deviation of government expenditure shocks	0.07
Calibration targets		
C^*/Y	Steady-state foreign consumption to domestic GDP ratio	0.28
B^*/Y	Steady-state foreign government debt to domestic GDP ratio	1.41
NX/Y	Steady-state net export to GDP ratio	-0.04

channel by setting $\alpha = \alpha^* = 1$, so that the domestic Euler equation for Treasuries reduces to

$$\frac{\beta(1+i)-1}{\beta(1+i)}\big(c_t - b_{ht}\big) = i_t - \sigma\Delta\mathbb{E}_t c_{t+1} - \mathbb{E}_t\pi_{t+1}, \tag{B.35}$$

and the international risk-sharing condition reverts to

$$q_t = \sigma(c_t - c_t^*), \tag{B.36}$$

purged from direct effects of the convenience yield. As a result, all equations involving convenience yield terms are isomorphic to those of the analytical model, allowing us to compare the two models on an equal footing.

Table B.2: Calibration – Data Sources

Data	**Source**
U.S. GDP	FRED / U.S. Bureau of Economic Analysis
U.S. private consumption	FRED / U.S. Bureau of Economic Analysis
U.S. government expenditure	FRED / U.S. Bureau of Economic Analysis
U.S. net exports	FRED / U.S. Bureau of Economic Analysis
U.S. federal government debt	FRED / U.S. Department of the Treasury
Foreign holdings of U.S. Treasury securities	U.S. Treasury International Capital (TIC) System
G-10 nominal GDP	IMF World Economic Outlook (non-EA) / ECB (Euro Area)
G-10 government expenditure	IMF World Economic Outlook (non-EA) / ECB Government Finance Statistics (Euro Area)
G-10 general government gross debt	IMF World Economic Outlook (non-EA) / ECB (Euro Area)
G-10 private consumption	FRED / ECB
G-10 bilateral exchange rates	LSEG Datastream
G-10 10-year government benchmark yields	LSEG Datastream
U.S. 10-year Treasury yield	FRED / Board of Governors of the Federal Reserve

Since we fix α, we slightly amend our calibration strategy by solving for ϵ_b, φ, γ, and γ^* in the system of steady-state Equations B.32, B.33, and B.34 along with the steady-state market-clearing condition for foreign goods. The calibrated parameters are reported in Table B.3.

Figures B.1 and B.2 report impulse response functions to a government spending shock under monetary and fiscal dominance, respectively, in the $\alpha = 1$ case with only the intratemporal substitution channel of convenience yields active. The impulse responses display similar shapes to the baseline case under both monetary and fiscal dominance, but the size of the responses of consumption and the real exchange rate is smaller by one to two orders of magnitude, while the response of the convenience yield is also muted.

In the monetary dominance equilibrium, both domestic and foreign consumption rise by a very similar amount, with the slightly higher reaction being driven by the intratemporal substitution channel, accompanied by a drop in the convenience yield. As a result, the real exchange rate depreciates slightly, as it only depends on relative consumption in this version of the model. On the contrary, after a tax-funded shock the convenience yield does not move, and so domestic and foreign consumption drop by the same amount, leaving the real exchange rate unchanged. This behavior is markedly different from the baseline case, where the convenience yield affects the real exchange rate even under tax funding through the stochastic discount factor channel.

Under fiscal dominance, consumption still rises by a similar amount after shutting down the stochastic discount factor channel, as its response is driven mainly by the large drop in the real interest rate. However, the response of the real exchange rate is significantly muted, albeit still a depreciation, confirming that the stochastic discount factor channel of the convenience yield is quantitatively meaningful in the fiscal dominance case through its interaction with households' intertemporal and intratemporal consumption decisions.

Figure B.3 plots the on-impact depreciation regions in the model with only the intratemporal substitution channel of convenience yields active. Real depreciation now obtains for almost any combination of ϕ_π and ϕ_b even in the monetary dominance quadrant. Since the real exchange rate does not respond to government spending shocks with full fiscal funding, any level of debt funding, no matter how small, leads to a depreciation through the intratemporal substitution channel. On the other hand, the resulting real depreciation is very small. This tradeoff highlights the ambiguous effect of the stochastic discount factor on the real exchange rate, evident from the international risk-sharing condition.

The ubiquitous real depreciation for almost any level of debt funding observed in the full model without the stochastic discount factor channel echoes the very high $\bar{\phi}_g$ in the analytical model, where the convenience yield likewise acts solely through the intratemporal substitution channel.

Table B.3: Convenience Yield Channels Variant – Parameter Calibration and Values

Parameter	Description	Value
ϵ_b	Trade openness	0.49
φ	Inverse Frisch elasticity of labor supply	0.1
γ	Domestic transaction cost scale	0.05
γ^*	Foreign transaction cost scale	2.12

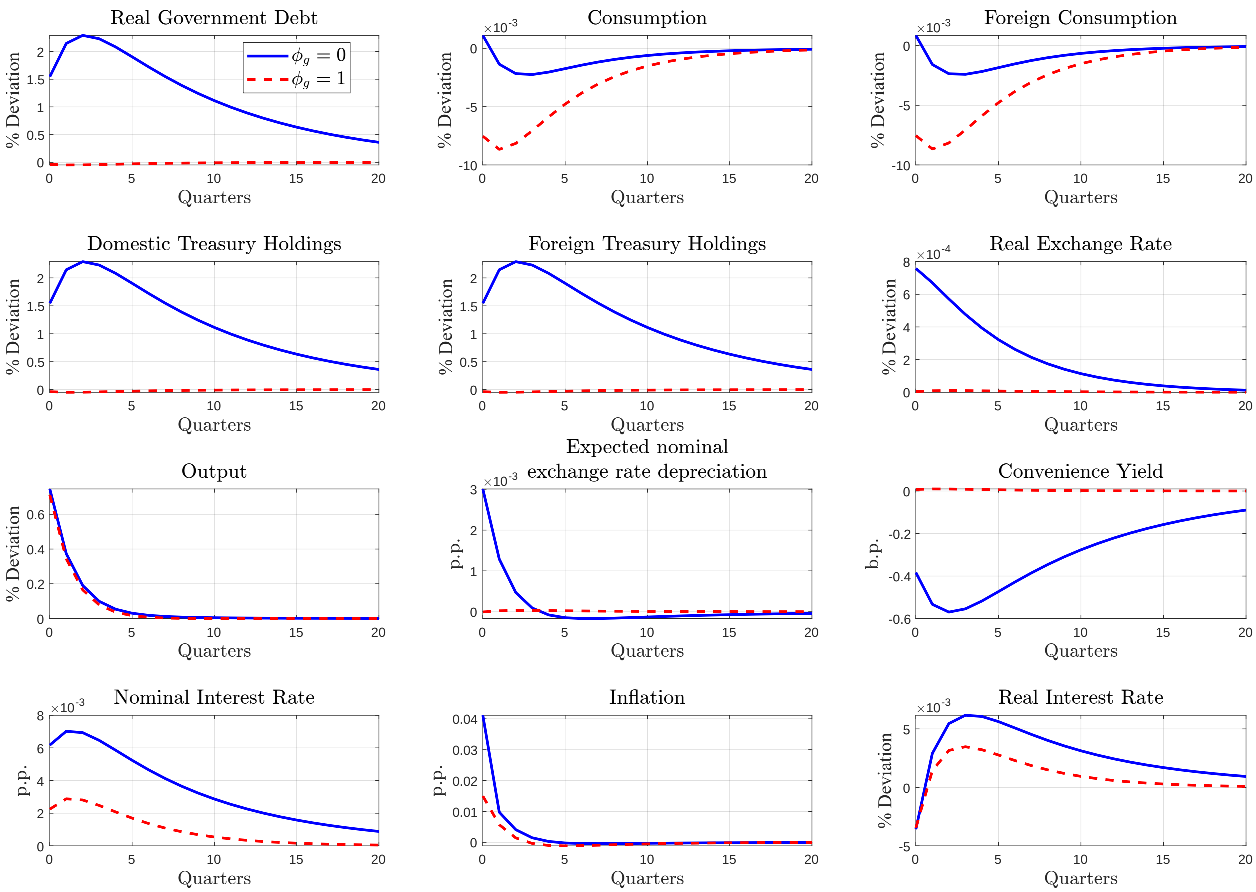


Figure B.1: Convenience yield channels – IRF to a 1 SD increase in government expenditure under monetary dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 1.5$, $\phi_b = 0.5$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$, transaction cost curvature parameters $\alpha = \alpha^* = 1$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

B.4.2 Alternative monetary policy rules

In this section, we investigate the robustness of our results to alternative monetary policy rules common in the literature: a standard inflation Taylor rule, and an inertial Taylor rule

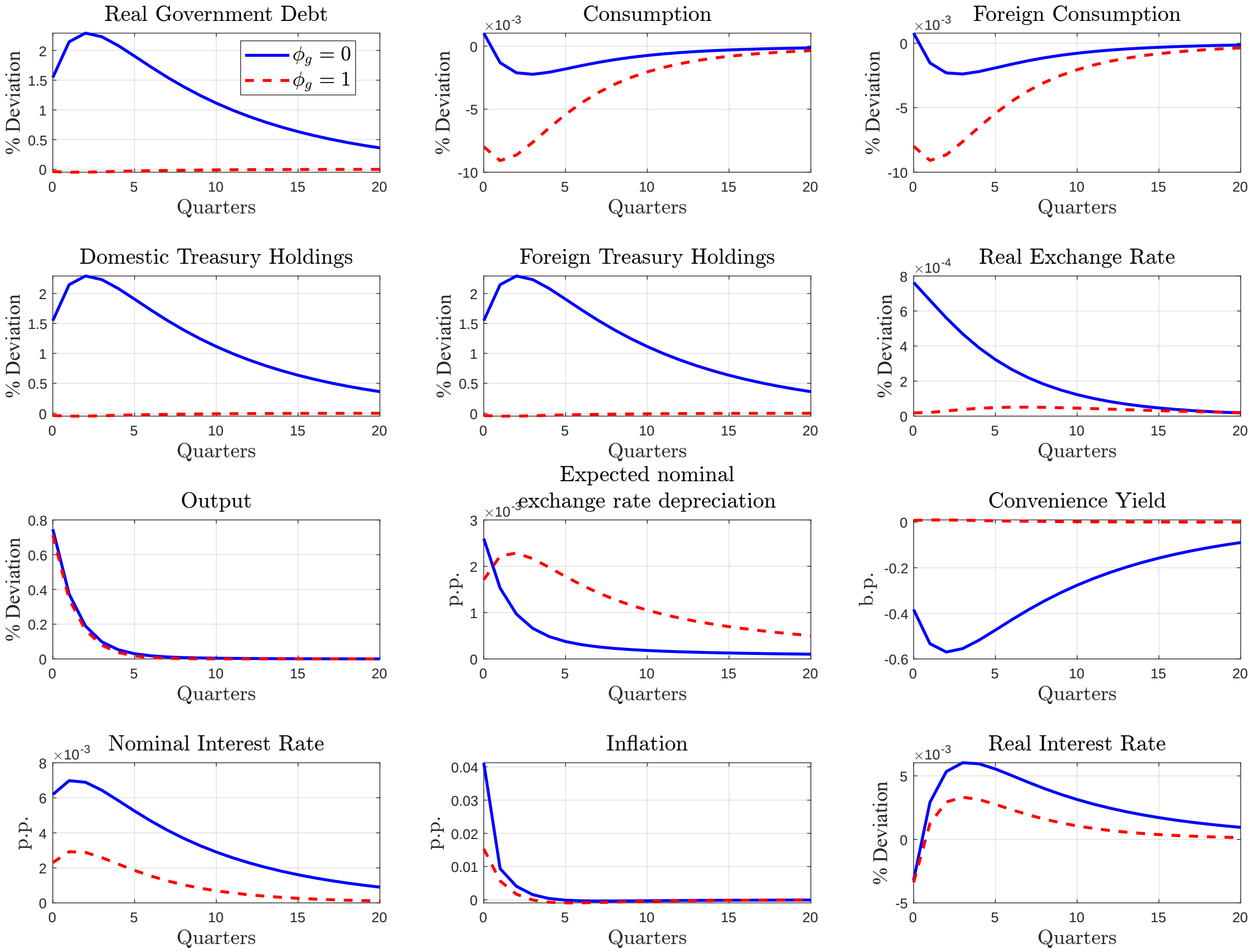


Figure B.2: Convenience yield channels – IRF to a 1 SD increase in government expenditure under fiscal dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 0.5$, $\phi_b = -0.5$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$, transaction cost curvature parameters $\alpha = \alpha^* = 1$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

with an output gap term. Throughout the section, we change only the domestic monetary policy rule, maintaining an inertial Taylor rule for the foreign economy.

Standard Taylor rule

We adopt a standard inflation Taylor rule without an inertial term:

$$i_t = \phi_\pi \pi_t. \tag{B.37}$$

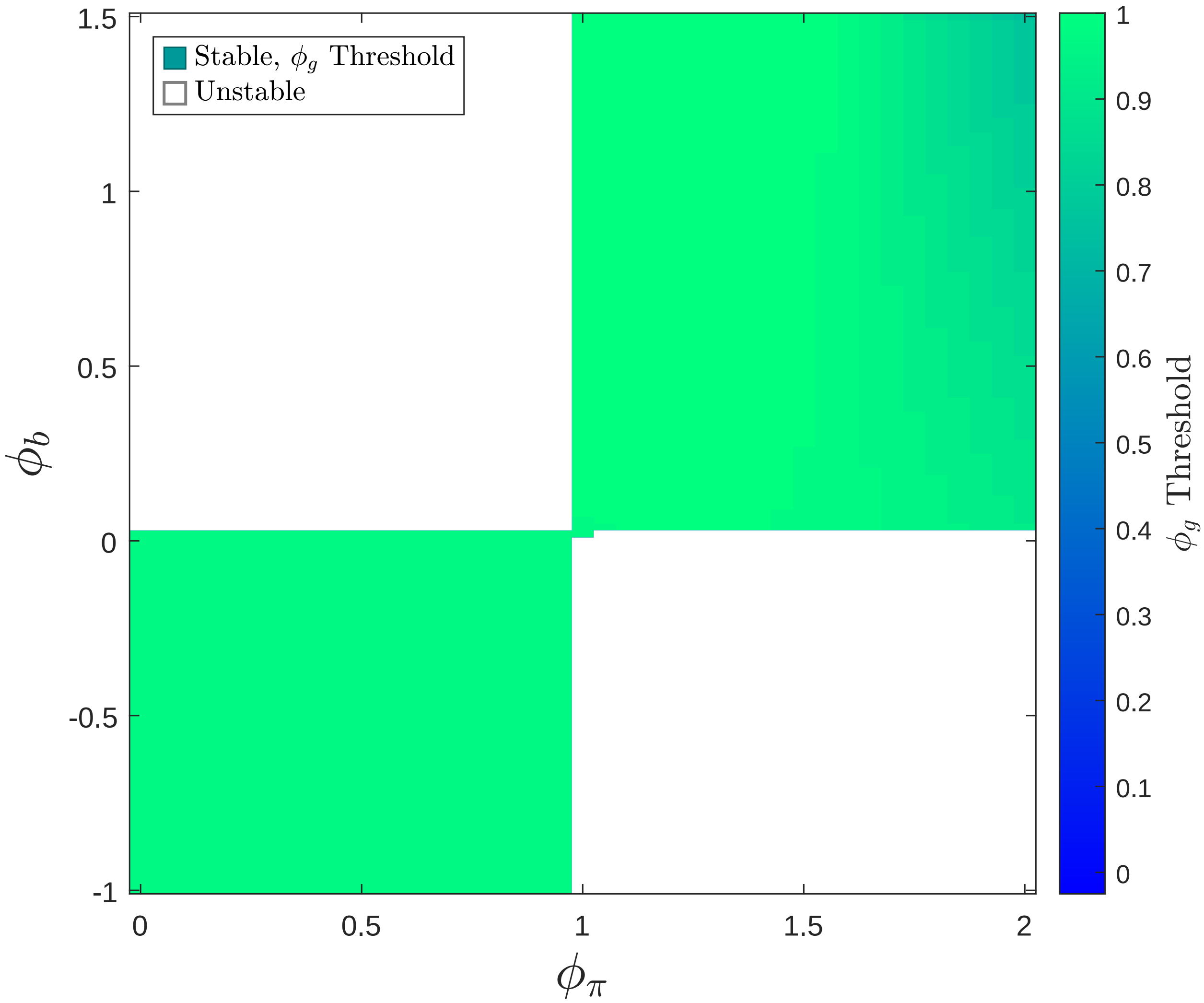


Figure B.3: Convenience yield channels – On-impact depreciation regions

Notes: Threshold values of tax funding fraction $\bar{\phi}_g \in [0, 1]$ (green to blue gradient) below which the real exchange rate depreciates on-impact in response to a one-standard-deviation government spending shock with transaction cost curvature parameters $\alpha = \alpha^* = 1$. The threshold values are plotted against a grid of domestic policy parameters $\phi_\pi \in [0, 2]$ by $\phi_b \in [-1, 1.5]$. Foreign policy parameters are kept fixed at $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and all other parameters are kept fixed at their baseline values over the whole grid. White areas denote combinations of policy parameters for which the model does not admit a unique, stable solution.

Figures B.4 and B.5 report impulse response functions to a government spending shock under monetary and fiscal dominance, respectively, with a standard Taylor rule and a coefficient $\phi_\pi = 1.5$ as in the baseline case.

Under monetary dominance, the removal of the inertial term makes monetary policy more reactive to the bout of inflation resulting from the government spending shock, so the real interest rate rises on impact compared to the inertial Taylor rule case. Therefore, the increase in domestic consumption is muted, and the real exchange rate appreciates on impact under both tax and debt funding. However, as the strong initial response of the real interest rate subsides consumption recovers, and the real exchange rate starts depreciating after two quarters under full debt funding and reverts to steady state monotonically thereafter.

With full tax funding, the steep drop in the real rate after the initial hike, combined with a delayed increase in foreign consumption, also results in a depreciation after a year. This response is attributable mainly to the standard intertemporal substitution mechanism, as evident from the essentially unresponsive dynamics of debt and the convenience yield. However, the convenience yield channels are still quantitatively meaningful in the standard Taylor rule case: the IRF of the exchange rate under debt funding lies everywhere above the IRF under tax funding, resulting in an earlier and stronger depreciation.

Under fiscal dominance, the impulse responses are similar to the inertial Taylor rule case, save for two consequences of more aggressive monetary policy on nominal variables. First, inflation rises by more due to the wealth effect of real rates on households' government bond holdings, as typical in fiscal dominance models. Second, the nominal exchange rate is also more volatile due to the stronger reaction of nominal rates to inflation.

Given the sluggish depreciation observed under the representative policy parameters, we investigate the depreciation regions in the policy parameter space by plotting the sign of one-quarter-ahead response of the real exchange rate to a fiscal shock. The choice of a one-quarter horizon is conservative: as evident from Figure B.4, under the representative parametrization we observe a depreciation only after two quarters, so plotting the response after one quarter understates the depreciation region. Figure B.6 shows that under a standard Taylor rule the real exchange rate depreciates after one quarter, provided that the response of the nominal rate to inflation is not too strong, $\phi_\pi < 1.2$, and that at least 70% of the fiscal shock is funded by debt, ensuring that the convenience yield channels are strong enough.

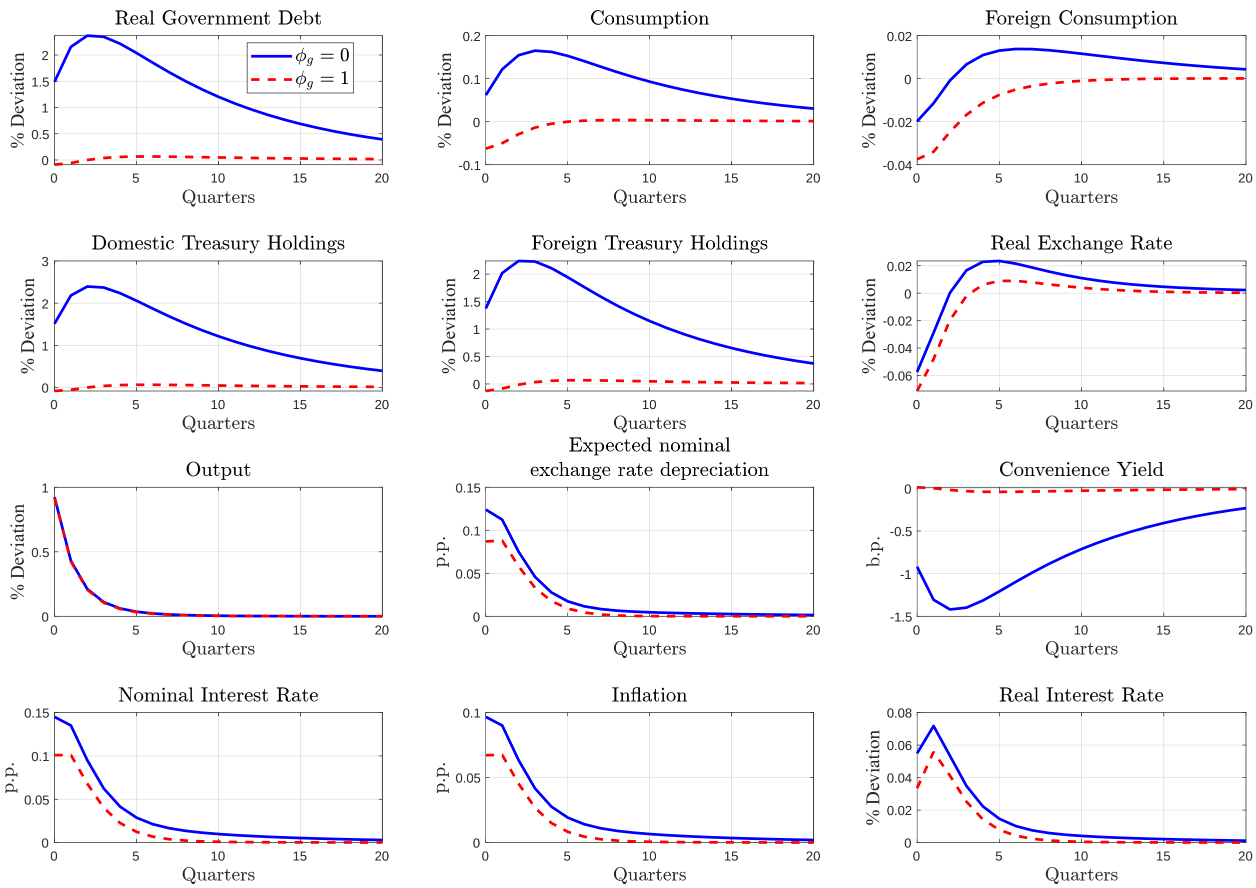


Figure B.4: Standard Taylor rule – IRF to a 1 SD increase in government expenditure under monetary dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under domestic monetary policy rule $i_t = \phi_\pi \pi_t$ and policy parameters $\phi_\pi = 1.5$, $\phi_b = 0.5$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

Output gap Taylor rule

We extend the inertial Taylor rule of the baseline case with a term in the output gap $\tilde{y}_t \equiv y_t - y_t^n$, where y_t^n is output at the flexible price allocation, or natural output, in log deviations from the steady state. The output gap Taylor rule is

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)(\phi_y \tilde{y}_t + \phi_\pi \pi_t). \tag{B.38}$$

We set $\phi_y = 0.125$ following Smets and Wouters (2007), corresponding to an annualized value of 0.5 as suggested in Taylor (1993).

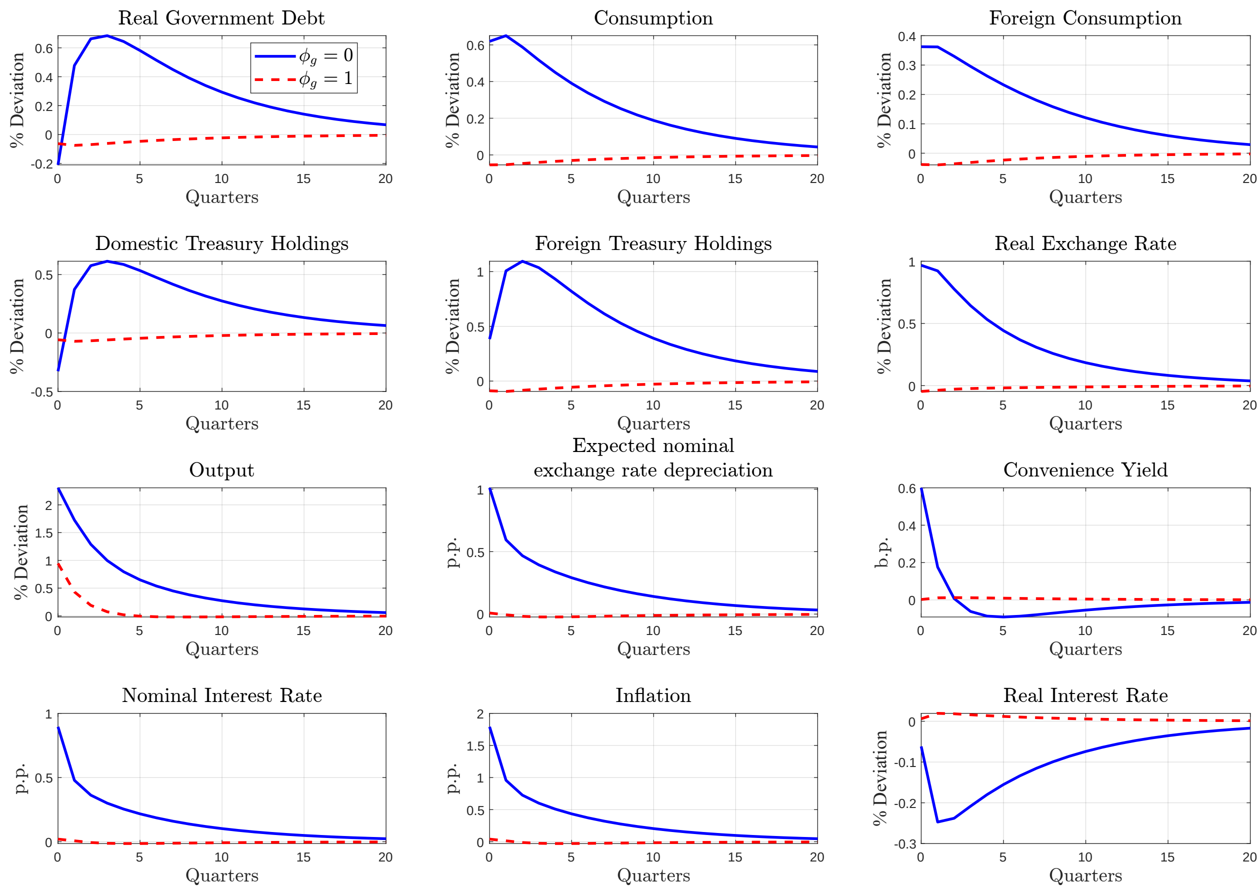


Figure B.5: Standard Taylor rule – IRF to a 1 SD increase in government expenditure under fiscal dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under domestic monetary policy rule $i_t = \phi_\pi \pi_t$ and policy parameters $\phi_\pi = 0.5$, $\phi_b = -0.5$, $\phi^*_\pi = 1.5$, $\phi^*_b = 0.5$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

This monetary policy rule requires determining natural output, which can be expressed as

$$y^n_t = -\frac{1-\alpha_p}{\varphi+\alpha_p}\Big[\sigma c^n_t + \Theta(1-\alpha)(b^n_{ht} - c^n_t) + \eta\, q^n_t\Big]. \tag{B.39}$$

In an economy where Treasury convenience enters the household's stochastic discount factor, natural output depends on the natural values of real government bond holdings b^n_t, consumption c^n_t and the real exchange rate q^n_t. In order to jointly determine these variables, we solve for the flexible-price allocation $\{y^n_t,\, c^n_t,\, b^n_{ht},\, q^n_t,\, y^{*n}_t,\, c^{*n}_t,\, b^{*n}_{ht},\, \omega^n_t,\, \omega^{*n}_t\}$.[10]

[10]Nominal quantities are indeterminate in the flexible-price allocation, but inflation enters the domestic

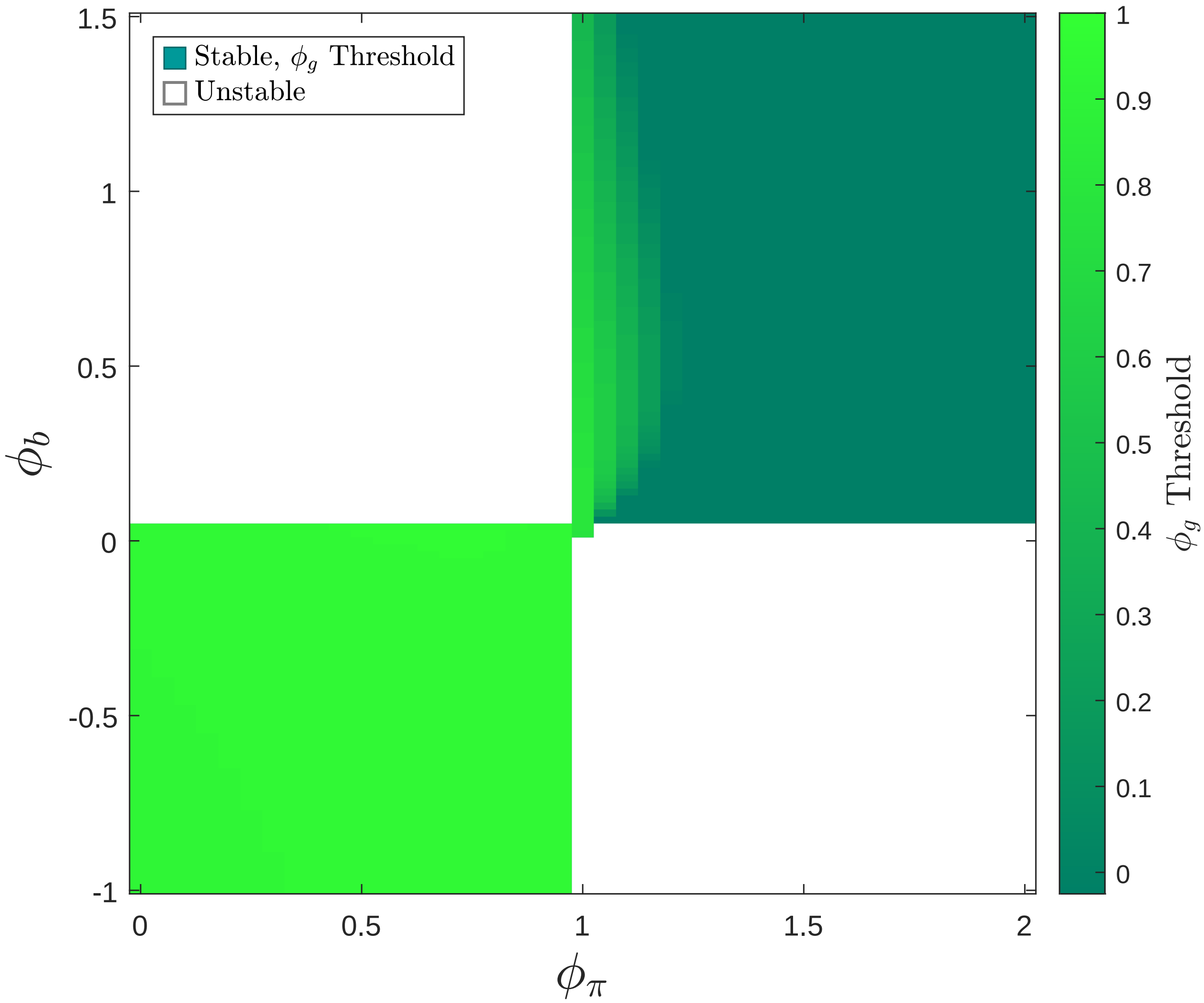


Figure B.6: Standard Taylor rule – One-quarter-ahead depreciation regions

Notes: Threshold values of tax funding fraction $\bar{\phi}_g \in [0, 1]$ (light to dark green gradient) below which the real exchange rate depreciates after one quarter in response to a one-standard-deviation government spending shock with monetary policy rule $i_t = \phi_\pi \pi_t$. The threshold values are plotted against a grid of domestic policy parameters $\phi_\pi \in [0, 2]$ by $\phi_b \in [-1, 1.5]$. Foreign policy parameters are kept fixed at $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and all other parameters are kept fixed at their baseline values over the whole grid. White areas denote combinations of policy parameters for which the model does not admit a unique, stable solution.

Figures B.7 and B.8 report impulse response functions to a government spending shock under monetary and fiscal dominance, respectively, with an output-gap Taylor rule.

The output gap coefficients make the central bank more reactive to a government spending

government's budget constraint. Therefore, we assume $\pi_t^n = 0$ without loss of generality to close the flexible-price block of the model. As a result, the fiscal dominance equilibrium becomes unavailable in the natural allocation, as inflation cannot adjust to satisfy the government's budget constraint. To ensure stability, we define ϕ_b^n the fiscal feedback parameter of the flexible-price block and set $\phi_b^n = 0.5$, so that in the natural allocation the government's budget constraint is satisfied through taxation and debt dynamics are always bounded.

shock, which acts as a demand shock by raising both inflation and the output gap. The responses under fiscal dominance are not materially affected by the addition of the output gap term, much like the case of a standard Taylor rule. On the other hand, in the monetary dominance case the real interest rate rises more than in the baseline, albeit still with a lag due to the inertial term. The response of domestic consumption is slightly muted and that of foreign consumption is more strongly negative compared with the baseline monetary policy rule, both contributing to shifting the IRF of the real exchange rate downwards. The response of the real exchange rate is negative across the whole horizon even for full debt funding, implying that the convenience yield channels cannot reconcile the exchange rate appreciation puzzle in the baseline policy parametrization where the central bank reacts relatively strongly to both inflation and the output gap.

Broadening our perspective to a larger set of policy parameters however reveals a more nuanced picture. Figure B.9 plots the on-impact real depreciation regions, varying ϕ_π and ϕ_b while leaving ϕ_y unchanged. The $\bar{\phi}_g$ threshold lies above zero for a substantial lower-left region of the monetary dominance quadrant, with an overall shape similar to the baseline case: declining in both ϕ_π and ϕ_b. The baseline inflation coefficient $\phi_\pi = 1.5$ admits a depreciation for $\phi_b < 0.2$. Therefore, even with an output gap Taylor rule the convenience yield channels can deliver a real depreciation under monetary dominance, provided that the central bank does not respond too strongly to inflation and that the government does not stabilize debt through taxation too quickly.

B.4.3 Fiscal dominance in the foreign economy

In this section, we study how the impulse responses and depreciation regions change when the foreign economy operates under a fiscal dominance equilibrium with $\phi_\pi^* = 0.5$ and $\phi_b^* = -0.5$.

Figures 3 and B.11 report impulse response functions to a government spending shock under domestic monetary and fiscal dominance, respectively. In both cases, the dynamics of

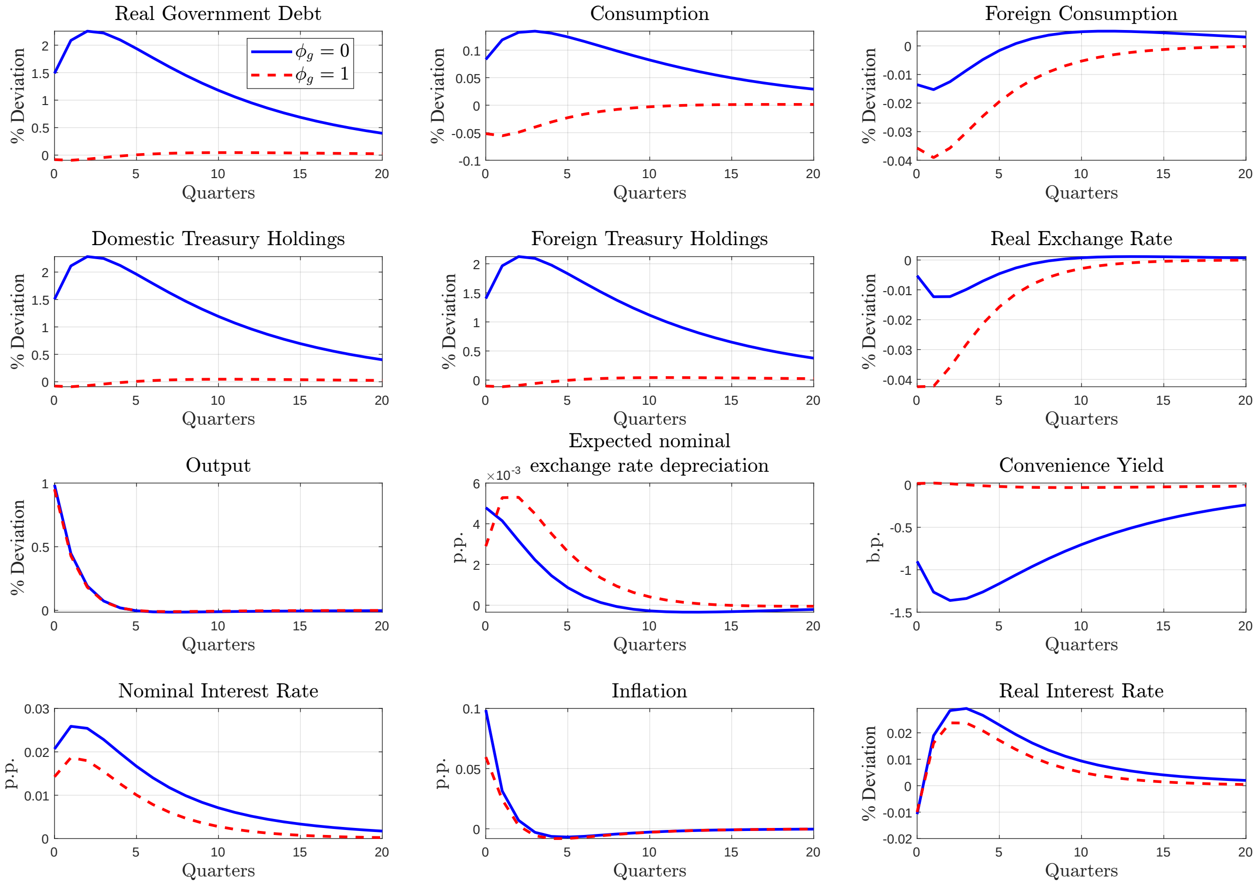


Figure B.7: Output gap Taylor rule – IRF to a 1 SD increase in government expenditure under monetary dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under domestic monetary policy rule $i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_y \tilde{y}_t + \phi_\pi \pi_t)$ and policy parameters $\phi_\pi = 1.5$, $\phi_b = 0.5$, $\phi_y = 0.125$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

domestic variables and of the real exchange rate are virtually unchanged, and so is the response of foreign consumption as the domestic government spending shock transmits abroad mainly through terms of trade. The only material difference is a more muted response of the nominal exchange rate due to lower reactivity of the foreign nominal interest rate under fiscal dominance. Likewise, the on-impact depreciation regions depicted in Figure B.12 match those of the baseline case, with the exception of a slightly higher $\bar{\phi}_g$ in the upper-left region of the domestic monetary dominance quadrant.

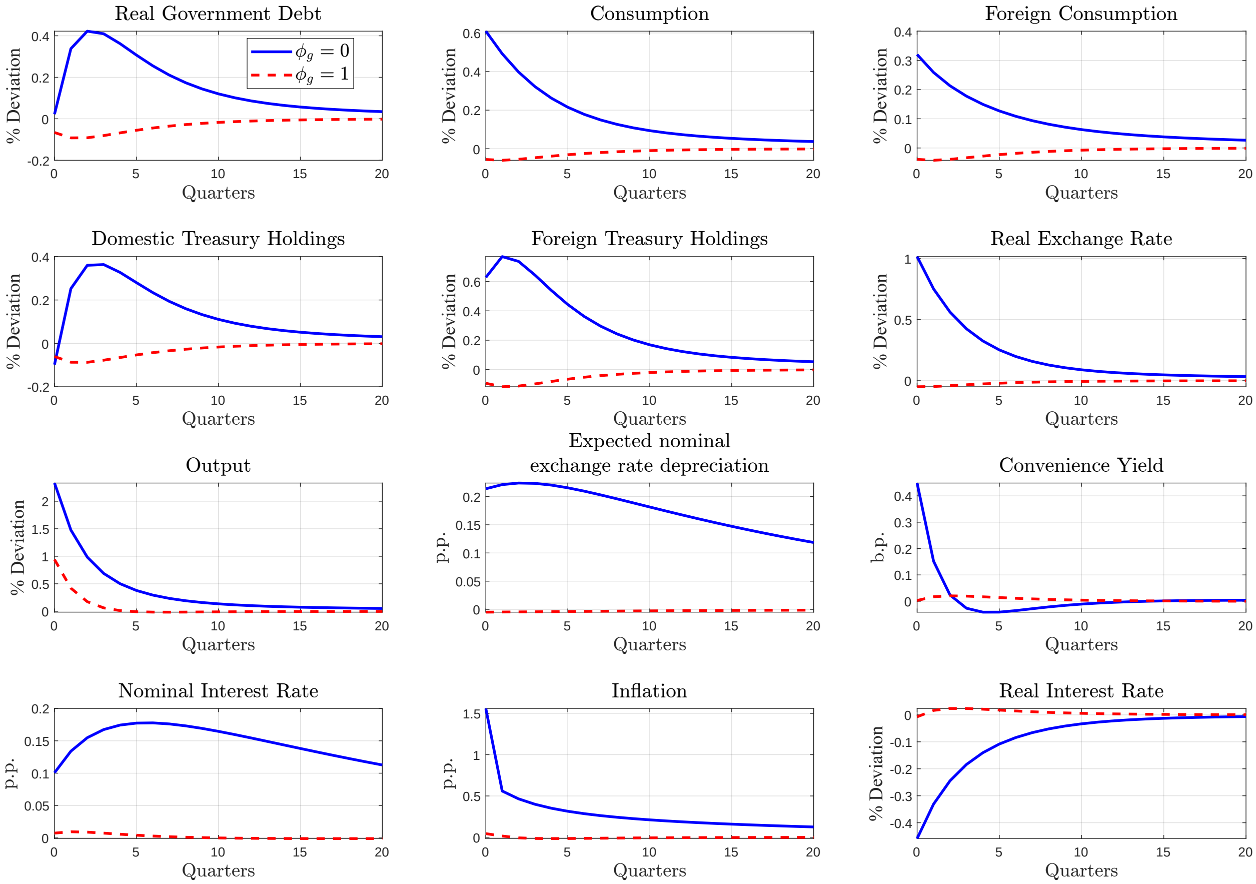


Figure B.8: Output gap Taylor rule – IRF to a 1 SD increase in government expenditure under fiscal dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under domestic monetary policy rule $i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_y \tilde{y}_t + \phi_\pi \pi_t)$ and policy parameters $\phi_\pi = 0.5$, $\phi_b = -0.5$, $\phi_y = 0.125$, $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$, and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

C Empirical evidence

C.1 Data and variables

This section provides a detailed description of the data used in the empirical analysis. Table C.1 lists all data series used in the empirical analysis, together with their FRED mnemonics, units, and sample availability.

All flow variables are obtained from FRED and deflated using the GDP deflator ($2017 = 100$). Fiscal variables are expressed as shares of real potential output, constructed as nominal

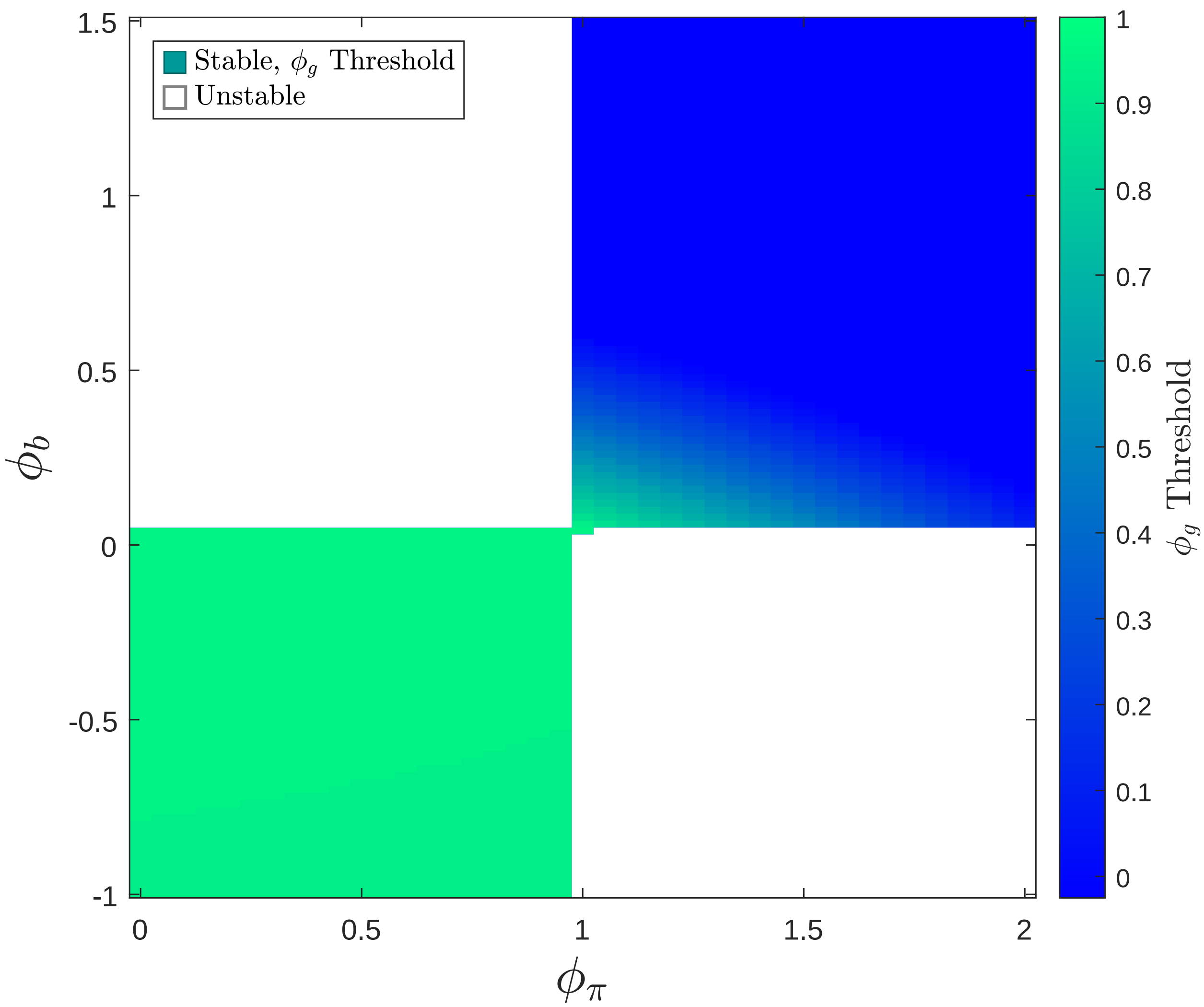


Figure B.9: Output gap Taylor rule – On-impact depreciation regions

Notes: Threshold values of tax funding fraction $\bar{\phi}_g \in [0,1]$ (green to blue gradient) below which the real exchange rate depreciates on-impact in response to a one-standard-deviation government spending shock under domestic monetary policy rule $i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_y \tilde{y}_t + \phi_\pi \pi_t)$ with $\phi_y = 0.125$. The threshold values are plotted against a grid of domestic policy parameters $\phi_\pi \in [0,2]$ by $\phi_b \in [-1, 1.5]$. Foreign policy parameters are kept fixed at $\phi_\pi^* = 1.5$, $\phi_b^* = 0.5$ and all other parameters are kept fixed at their baseline values over the whole grid. White areas denote combinations of policy parameters for which the model does not admit a unique, stable solution.

potential GDP (NGDPPOT) divided by the GDP deflator.

Government purchases g_t are proxied by federal consumption expenditures and gross investment (FGCE), deflated and expressed as a share of potential output. This is the narrow purchases concept standard in the fiscal multiplier literature (Ramey, 2016; Ramey and Zubairy, 2018), which isolates discretionary government activity from transfer payments and debt service. Federal receipts t_t are total federal government receipts (FGRECPT), similarly

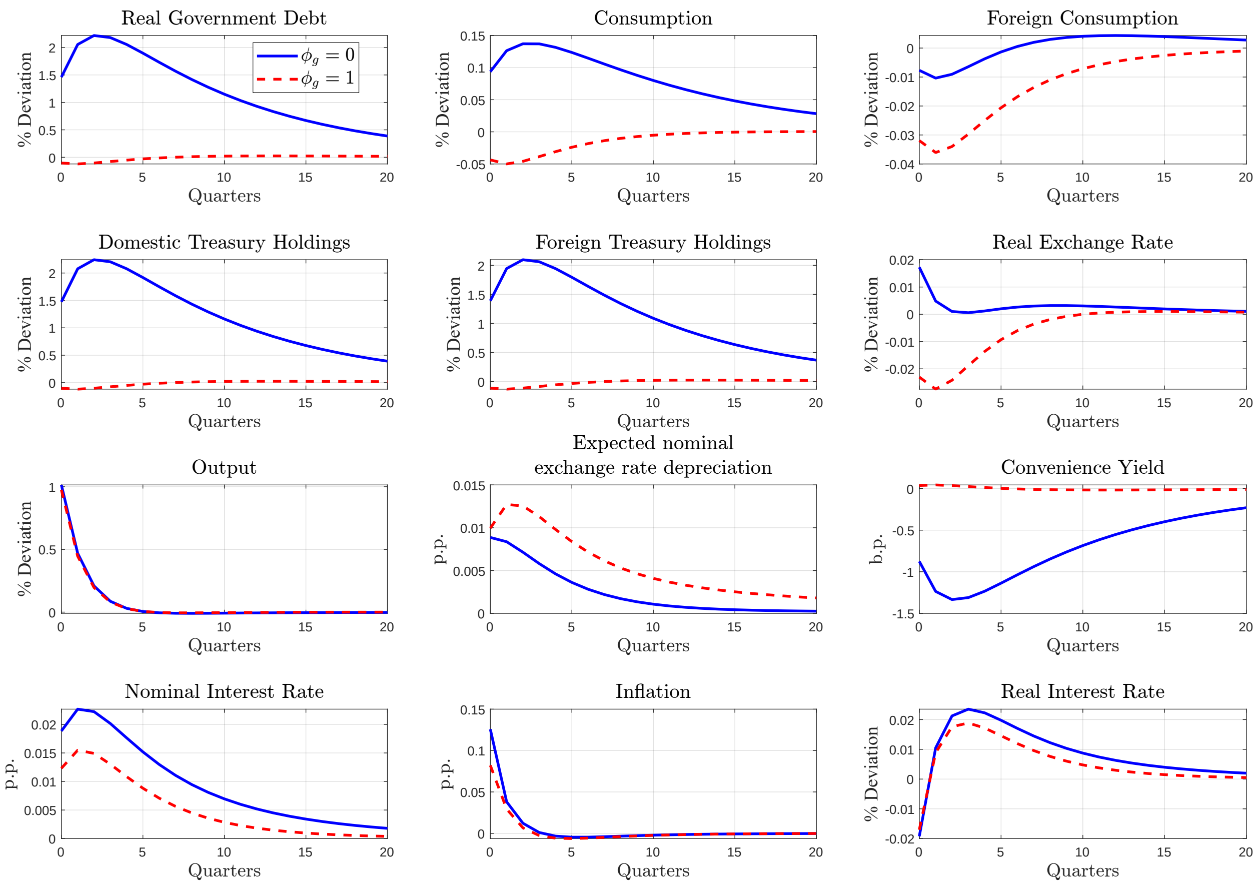


Figure B.10: Foreign fiscal dominance – IRF to a 1 SD increase in government expenditure under monetary dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 1.5$, $\phi_b = 0.5$, $\phi_\pi^* = 0.5$, $\phi_b^* = -0.5$ and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

Table C.1: Empirical analysis – Data sources

Variable	FRED mnemonic	Units	Sample
Federal purchases	FGCE	SAAR \$bn	1947Q1–
Federal receipts	FGRECPT	SAAR \$bn	1947Q1–
PCE nondurables	PCND	SAAR \$bn	1947Q1–
PCE services	PCESV	SAAR \$bn	1947Q1–
Nominal potential GDP	NGDPPOT	\$bn	1949Q1–
GDP deflator	GDPDEF	Index, 2017=100	1947Q1–
1-year Treasury rate	GS1	% per annum	1953Q2–
10-year Treasury rate	GS10	% per annum	1953Q2–
Aaa minus 10-year spread	AAA10YM	pp	1919Q1–
Baa minus 10-year spread	BAA10YM	pp	1919Q1–
Narrow real dollar index	RTWEXAFEGS	Index, 2006=100	2006Q1–
Narrow real dollar index (pre-2006)	TWEXMPA	Index, 1973=100	1973Q1–2014Q1
Military news shock (Ramey, 2016)	N.A.	% potential GDP	1939Q1–2015Q4

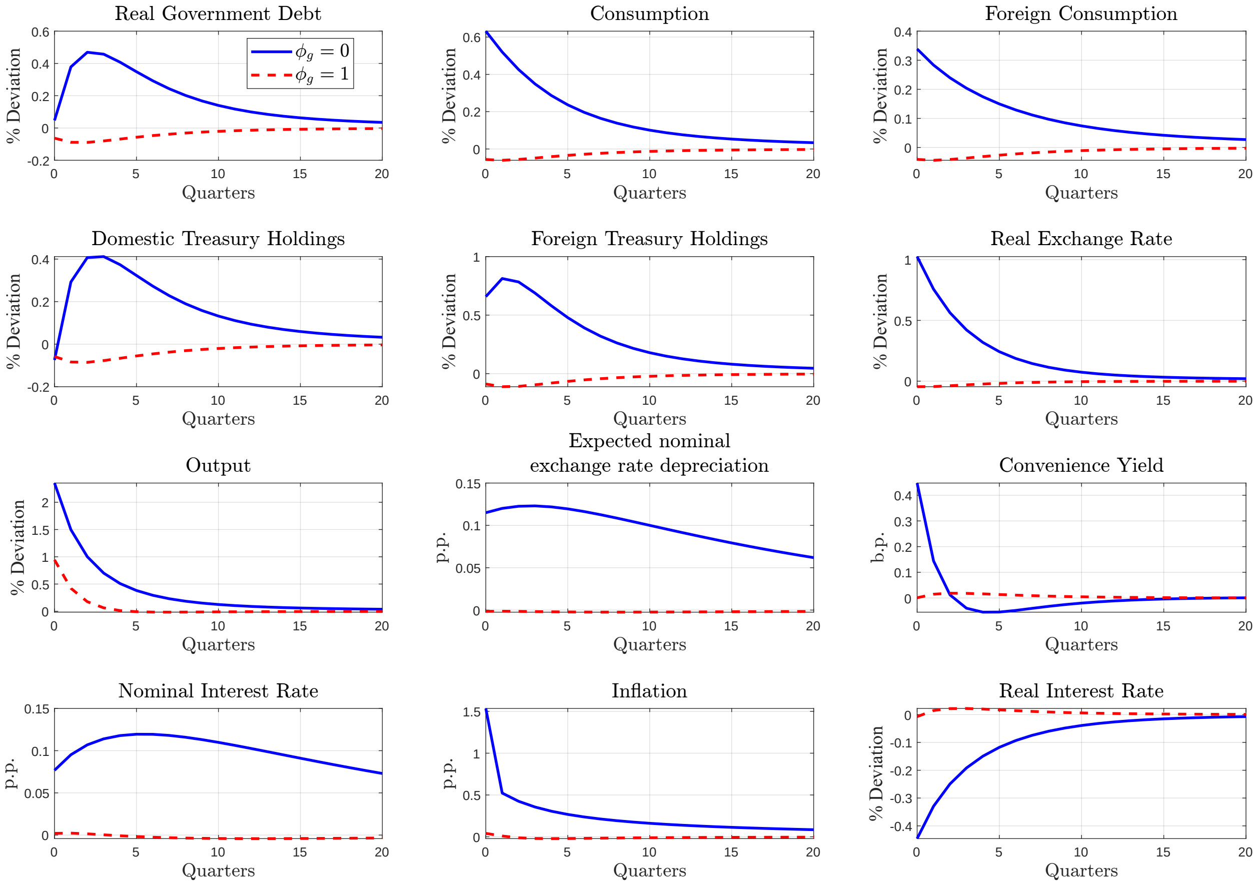


Figure B.11: Foreign fiscal dominance – IRF to a 1 SD increase in government expenditure under fiscal dominance

Notes: Impulse response functions of selected variables to a one-standard-deviation government spending shock, under policy parameters $\phi_\pi = 0.5$, $\phi_b = -0.5$, $\phi_\pi^* = 0.5$, $\phi_b^* = -0.5$ and baseline calibration for other parameters. Blue lines depict IRFs with full debt funding ($\phi_g = 0$). Dashed red lines depict IRFs with full tax funding ($\phi_g = 1$).

deflated and normalized. Consumption c_t is the sum of personal consumption expenditures on nondurable goods and services (PCND and PCESV), deflated and expressed as a share of potential output. The real interest rate r_t is the one-year Treasury constant maturity rate (GS1) minus year-on-year GDP deflator inflation, interpreted as an ex-post real-rate proxy.

The convenience yield is the Moody's Aaa corporate bond yield minus the ten-year Treasury constant maturity rate (AAA10YM), averaged within each quarter. This spread narrows when the supply of Treasuries increases, reducing their convenience yield relative to other high-quality fixed income assets, and is the direct empirical counterpart to the convenience yield in the model. The real effective dollar index is constructed by splicing the narrow

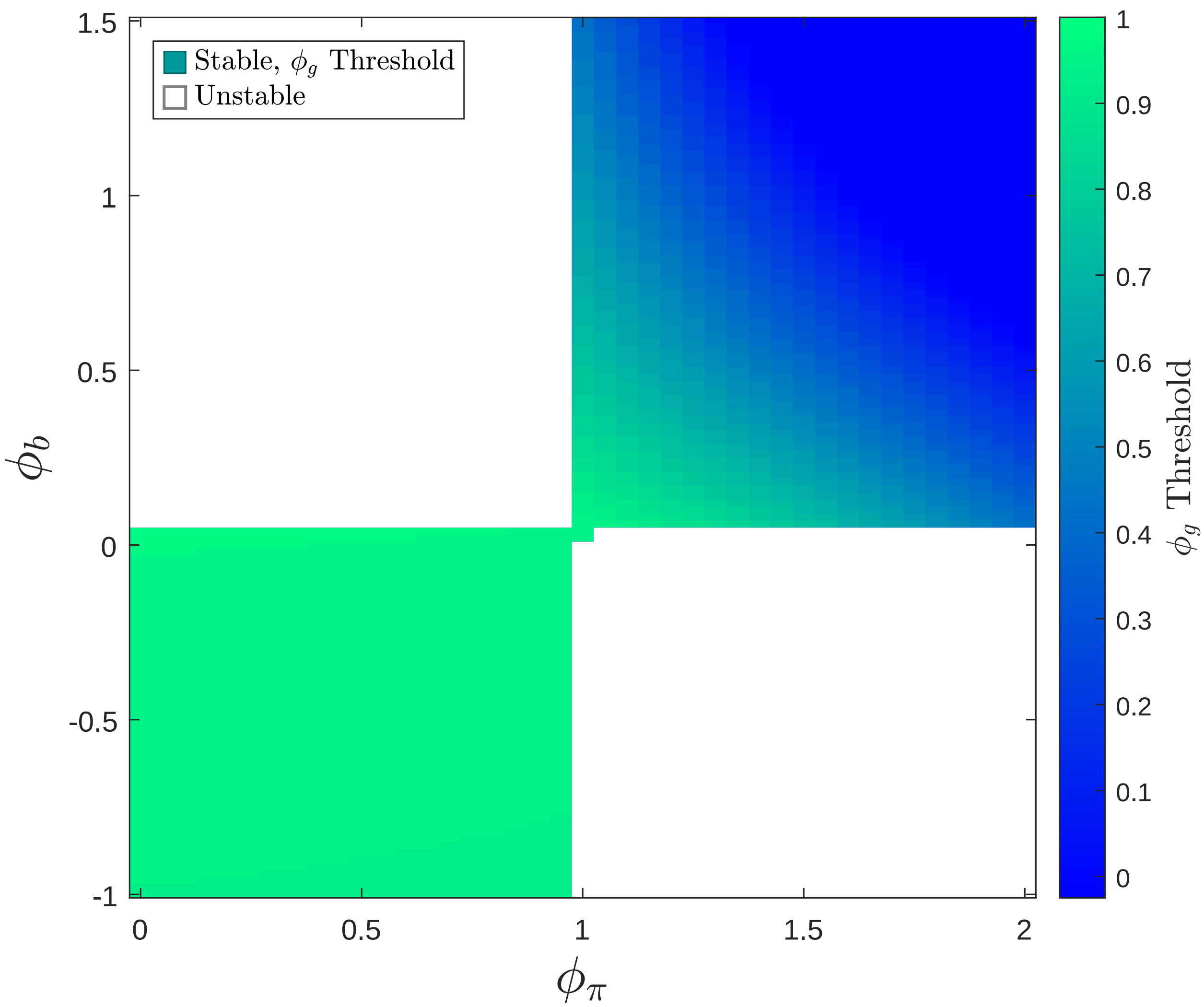


Figure B.12: Foreign fiscal dominance – On-impact depreciation regions

Notes: Threshold values of tax funding fraction $\bar{\phi}_g \in [0, 1]$ (green to blue gradient) below which the real exchange rate depreciates on-impact in response to a one-standard-deviation government spending shock. The threshold values are plotted against a grid of domestic policy parameters $\phi_\pi \in [0, 2]$ by $\phi_b \in [-1, 1.5]$. Foreign policy parameters are kept fixed at $\phi_\pi^* = 0.5$, $\phi_b^* = -0.5$ and all other parameters are kept fixed at their baseline values over the whole grid. White areas denote combinations of policy parameters for which the model does not admit a unique, stable solution.

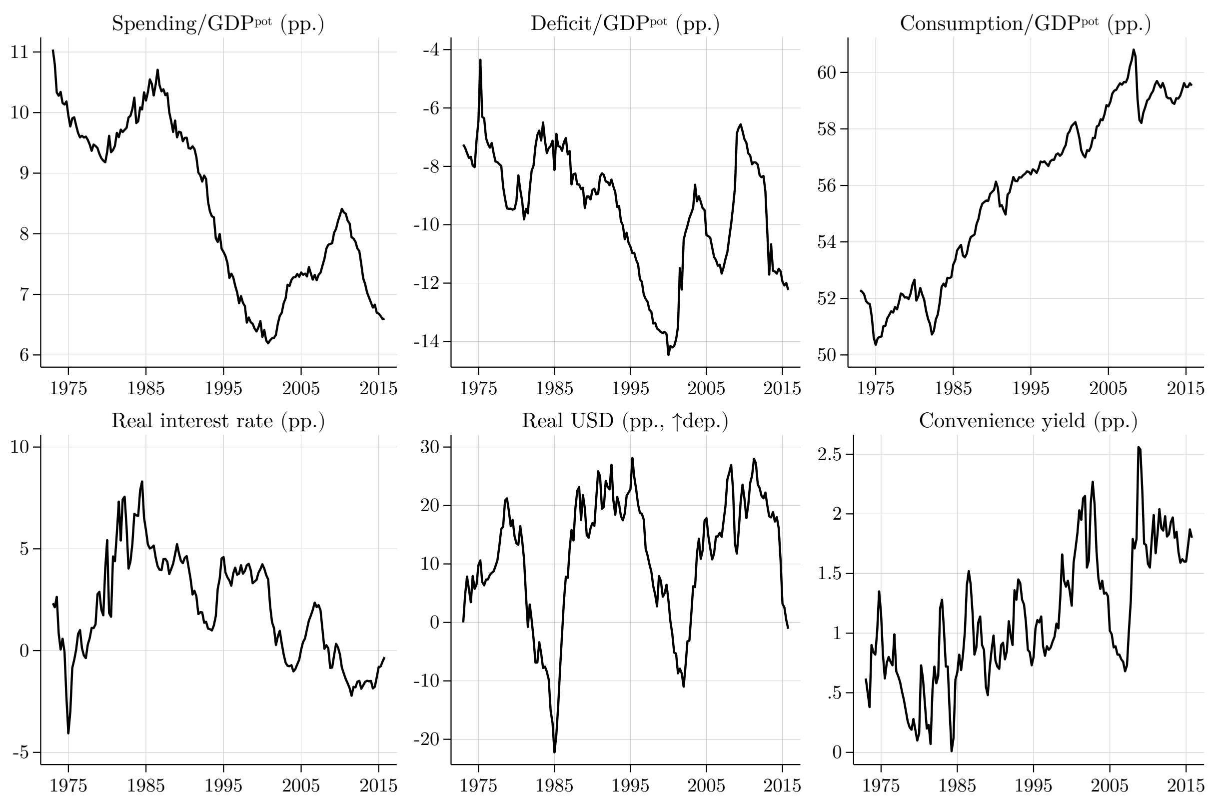
real effective exchange rate index (RTWEXAFEGS, post-2006) with an alternative index (TWEXMPA, pre-2006), scaling the latter to match at the overlap date and taking logs. Positive values correspond to real depreciations.[11] Two additional controls enter the specification: the Baa minus ten-year Treasury spread (BAA10YM) as a risk premium proxy, and the ten-year minus one-year Treasury spread (GS10 − GS1) as a term spread. Government

[11]Results are nearly identical when using the broad real effective exchange rate index (RTWEXBGS spliced with TWEXBPA) in place of the narrow index.

purchases have trended downward as a share of potential output since the early 1980s, while the purchases-based primary fiscal gap has fluctuated between approximately -14 and -4 percentage points. The real interest rate displays the Volcker-era peak in the early 1980s and the prolonged decline thereafter. The real dollar index shows the large Reagan-era appreciation and subsequent depreciation, as well as the post-2001 depreciation cycle. The convenience yield exhibits persistent low-frequency variation broadly negatively correlated with the real dollar index, consistent with Figure 1 of the model section.

Figure C.1 plots these series over the estimation sample.

Figure C.1: Quarterly inputs used in the local-projection analysis



This figure plots the raw quarterly series used as inputs in the local-projection analysis. Government purchases, the purchases-based primary fiscal gap, and consumption are expressed as percentages of potential real GDP. The real-rate proxy is the one-year Treasury rate minus year-on-year GDP deflator inflation, in percentage points. The real effective U.S. dollar index is shown in log units multiplied by -100, so that increases correspond to real depreciations. The convenience yield is the Moody's Aaa corporate bond yield minus the ten-year Treasury constant maturity rate, in percentage points. The sample is restricted to periods for which the military news instrument is available.

C.2 Fiscal state variable details

The time series of $\tilde{D}_t$, plotted in the right panel of Figure C.2, maps cleanly onto well-documented episodes of U.S. fiscal history. Four episodes dominate the sample. First, the Reagan expansion of the early 1980s produces the sharpest widening: the combination of the 1981 Economic Recovery Tax Act and a large military buildup generated the largest peacetime deficit expansion in U.S. history. Second, the Clinton consolidation of the 1990s generates the steepest narrowing: the 1993 deficit reduction act, combined with the peace dividend following the end of the Cold War and a prolonged expansion that inflated the tax base, drove the federal government to a unified surplus by the late 1990s. Third, the Bush-era expansion of the 2000s, comprising two rounds of tax cuts and two military engagements, produced a second sustained widening. Fourth, the post-financial-crisis stimulus of 2008–2009 generates the trough of the series, followed by a gradual narrowing as the sequester and the expiry of stimulus measures reduced the deficit. These turning points align with narrative accounts of shifts in the political economy of fiscal financing rather than with cyclical fluctuations (Romer and Romer, 2010): the Clinton surplus was achieved during the longest peacetime expansion in U.S. history, while the Reagan deficit widened during a recovery, underscoring that x_t^c captures structural fiscal regime shifts orthogonal to the cycle.

Figure C.2 plots the military news instrument alongside the HP-filtered fiscal gap $\tilde{D}_t$. The left panel shows the news shock series: episodes range from Carter's response to the Soviet invasion of Afghanistan to the post-2001 military buildups, with the fall of the Berlin Wall generating a large negative shock. The right panel shows the smooth trend fiscal gap from which x_t^c is constructed, with its four narrative episodes clearly visible. The two panels confirm that the instrument and the state variable capture distinct sources of variation: the news shock identifies the size of the spending impulse, while the fiscal state captures the financing environment in which that impulse occurs.

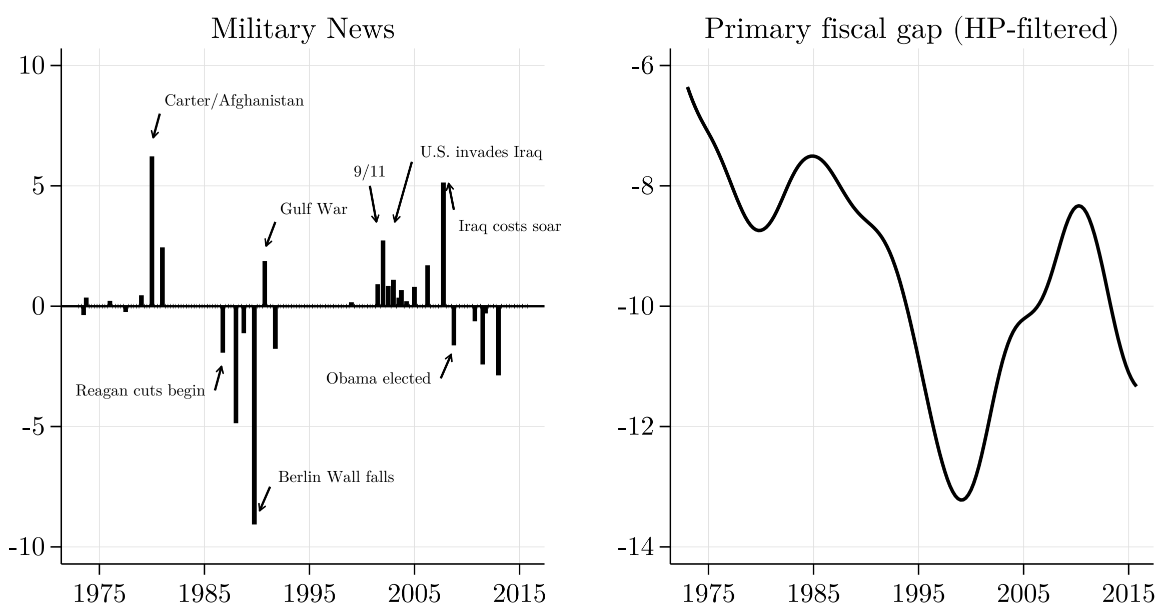


Figure C.2: Military spending news instrument and fiscal state

Notes: Left panel: military spending news shocks from Ramey (2016), expressed as a share of potential output, with selected historical episodes annotated. Right panel: HP-filtered purchases-based primary fiscal gap $\tilde{D}_t = g_t - t_t$, expressed as a share of potential output ($\lambda = 1600$). The series is negative throughout because g_t captures federal purchases only, while t_t measures total federal receipts; the trend evolution rather than the level is economically informative. The sample is restricted to periods for which the military news series is available.

This interpretation connects x_t^c directly to ϕ_g in the model. High values of the state correspond to environments in which households and financial markets would rationally expect a larger share of new spending to be debt-financed — the equivalent of a low ϕ_g — while low values correspond to environments where tax-backing is more credible, mapping to a high ϕ_g.

C.3 Additional results

C.3.1 Dynamic impulse responses: baseline

Figure C.3 reports the full dynamic impulse responses from Equation (24) up to $H = 20$ quarters, comparing the low-state (p_{10}) and high-state (p_{90}) fiscal environments. The sign patterns documented in Figure 5 of the main text persist over the full horizon, confirming that the on-impact results are not transitory.

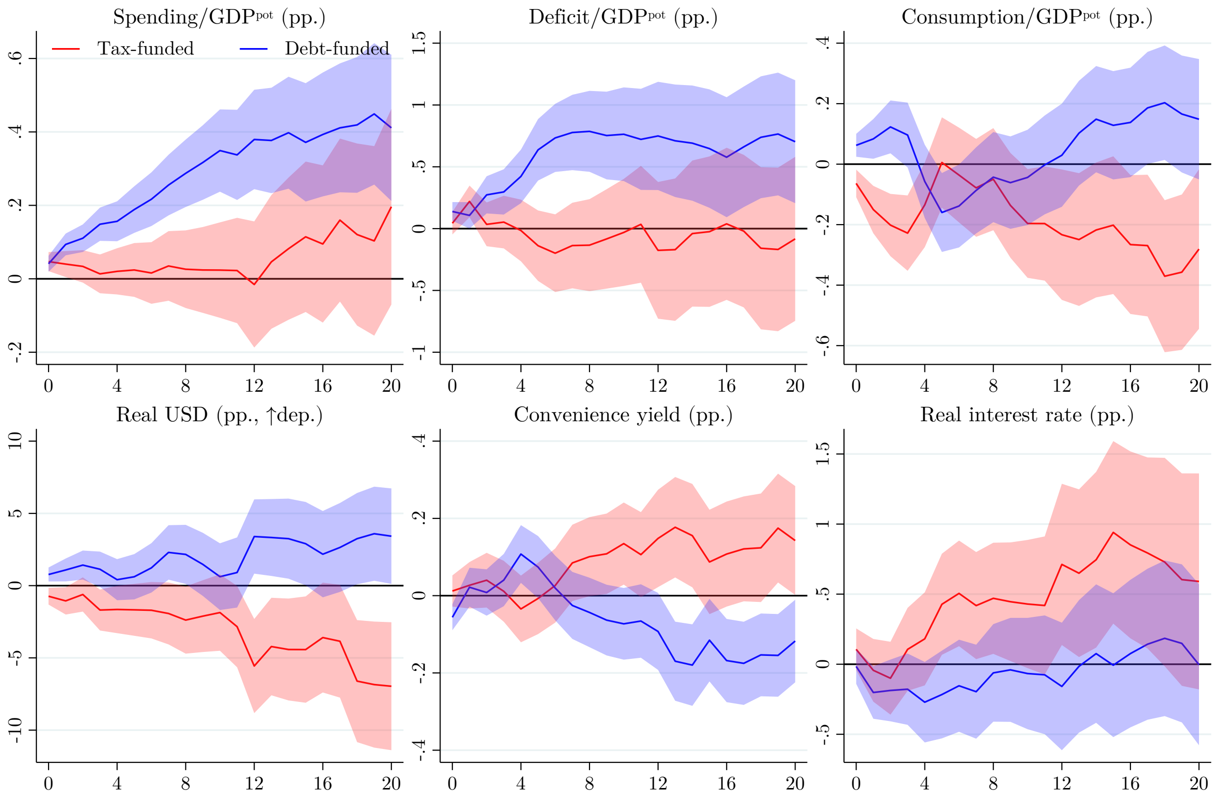


Figure C.3: Dynamic impulse responses to military news shocks by fiscal state

Notes: Cumulative impulse responses from Equation (24), evaluated at the 10th percentile (red, tax-backed environments) and 90th percentile (blue, debt-financed environments) of x_t^c, over horizons $h = 0, \ldots, 20$ quarters. The outcome variables are, from left to right and top to bottom: government purchases, fiscal deficit, consumption, real interest rate, real dollar index (positive values denote depreciation), and convenience yield. Shaded areas are 68% HAC confidence bands based on Newey and West (1987) standard errors with bandwidth $h + 1$.

C.3.2 Robustness: LP-IV specification

As a robustness check, we re-estimate the empirical model replacing the reduced-form specification of Equation (24) with an IV local projection that uses z_t and $z_t \cdot x_t^c$ to instrument the endogenous regressors Δg_t and $\Delta g_t \cdot x_t^c$. Figures C.4 and C.5 report the on-impact marginal effects and the full dynamic responses under this alternative identification. The results are qualitatively identical to the baseline: the joint sign pattern of the real exchange rate and the convenience yield is preserved across all fiscal states and horizons, confirming that the main findings are not an artifact of the reduced-form approach.

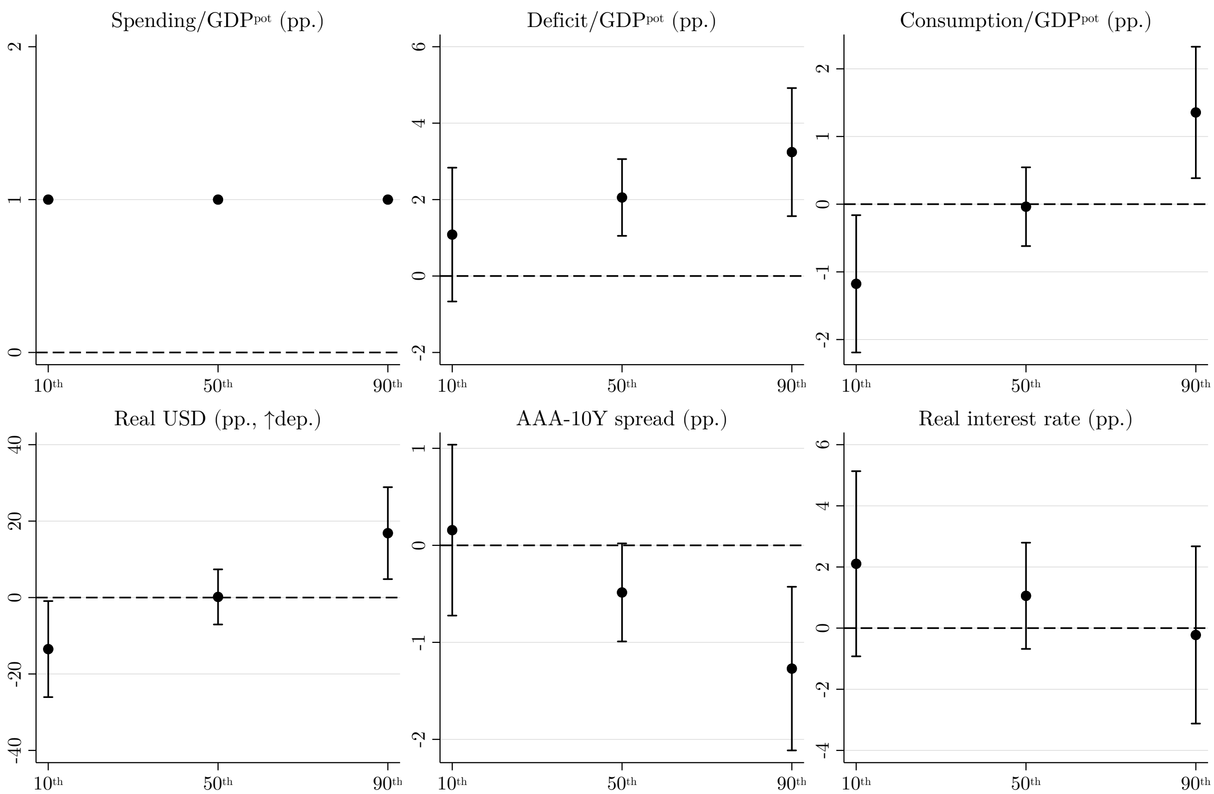


Figure C.4: On-impact responses: LP-IV specification

Notes: On-impact marginal effects ($h = 0$) from the LP-IV specification, in which Δg_t and $\Delta g_t \cdot x_t^c$ are instrumented by z_t and $z_t \cdot x_t^c$. Layout and confidence intervals as in Figure 5.

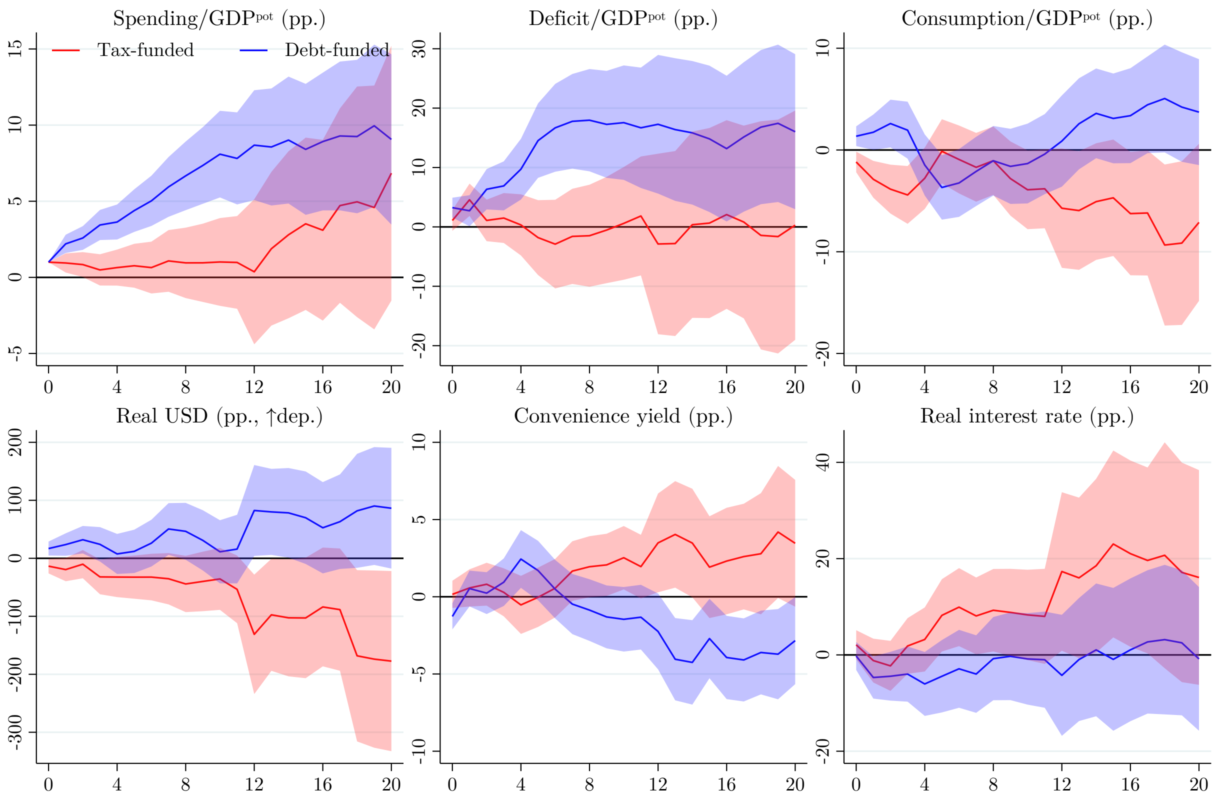


Figure C.5: Dynamic impulse responses: LP-IV specification

Notes: Cumulative impulse responses from the LP-IV specification over horizons $h = 0, \ldots, 20$ quarters. Layout and confidence bands as in Figure C.3.

References

Galí, J. (2015). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications* (Second ed.). Princeton, NJ: Princeton University Press.

Newey, W. K. and K. D. West (1987). A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica 55*(3), 703–708.

Ramey, V. A. (2016). Defense news shocks, 1889 - 2015: Estimates based on news sources. Technical report, University of California, San Diego and National Bureau of Economic Research.

Ramey, V. A. and S. Zubairy (2018). Government spending multipliers in good times and in bad: evidence from us historical data. *Journal of Political Economy 126*(2), 850–901.

Romer, C. D. and D. H. Romer (2010). The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks. *American Economic Review 100*(3), 763–801.

Smets, F. and R. Wouters (2007). Shocks and frictions in us business cycles: A bayesian dsge approach. *American Economic Review 97*(3), 586–606.

Taylor, J. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy 39*(1), 195–214.