

# **Our Deficit, Your Problem: Fiscal Sustainability and Exchange Rates<sup>\*</sup>**

C. Christopher Hyland<sup>†</sup>      Tobias Kawalec<sup>‡</sup>

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## **Abstract**

We develop and estimate an open-economy present-value framework for the government budget constraint that embeds discount factors, exchange-rate expectations, and time-varying foreign-exchange risk premia. Using newly constructed market-value data for U.K. and U.S. public debt covering 1975-2024, we document that unexpected changes in the debt ratio are split equally between revisions to expected future surpluses and discount-rate news; the latter reflects movements in global real yields, revisions to expected real exchange rates, and UIP-premium shocks. Surplus innovations recovered from market prices is shown to materially affect the bilateral real exchange rate. We then present a tractable two-country model in which fiscal shocks in a financial hegemon propagate internationally through exchange-rate adjustments that feed back into real interest rates; the model rationalises the empirical shares and predicts “fiscal contagion” across sovereign balance sheets. A continuous-time general equilibrium framework further shows how exchange rate movements can be induced by changes to relative surpluses and debt issuance and attaches 2.5 p.p. of the total inflationary pressure in the U.K. since 2021 to fiscal spillovers from expansionary U.S. fiscal policy.

**Keywords:** Debt Sustainability, International Macroeconomics, Fiscal Deficits, Exchange Rate Determination.

**JEL Classification:** E63, F41, E62.

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<sup>†</sup>University of Oxford, Saïd Business School, Exeter College, and Oxford-Man Institute. Email: christopher.hyland@sbs.ox.ac.uk.

<sup>‡</sup>University of Oxford, Department of Economics and Nuffield College. Email: tobias.kawalec@economics.ox.ac.uk.

# 1 Introduction

Fiscal deficits and debt sustainability have returned to the forefront of macroeconomic policy debates. Beyond the well-known link between fiscal sustainability and inflation risk, recent developments also highlight the risks that deficits pose to exchange rates. In April 2025, the U.S. dollar depreciated while Treasury yields rose — an unusual combination consistent with a lack of safe-haven inflows into U.S. government debt, hitherto regarded as a “safe asset”. This episode is part of a broader pattern: in the post-Bretton Woods era, large government deficits have repeatedly coincided with abrupt currency movements and puzzling revaluations of foreign public debt. Existing empirical work, which is often geared toward business-cycle frequencies, focuses on book-value debt and is silent on the distinction between expected and realised deficits. Because of this limitation, it struggles to explain why these international spillovers occur or how they can be reconciled with the intertemporal government budget constraint.

This paper revisits deficits and exchange rates from the perspective of an international financial investor, showing that cross-border adjustments in exchange rates and discount factors are required for global sovereign debt markets to clear. We leverage this insight first in a tractable model and then in a rich quantitative model of ‘fiscal contagion’. Households engage in cross-border trade of goods and financial products, with the ‘Home’ bond featuring a convenience yield. Using these models, we show that deficit shocks in the Home country directly impact exchange rates, thereby also affecting the fiscal position of the Foreign sovereign by altering effective discount rates. In particular, Home deficit shocks can *deteriorate* the fiscal position of Foreign, causing u-shaped movements in bilateral exchange rates as well as fiscally-driven inflation in Foreign.

Empirically, we start from a present-value identity that embeds the exchange rate, nominal discount rates, and time-varying foreign-exchange (FX) risk premia directly in the government budget constraint, building on present-value logic advanced by [Hall and Sargent \(2011\)](#), [Cochrane \(2019\)](#), and [Jiang et al. \(2024b\)](#). Using newly-constructed market-value data for U.K. (and U.S.) sovereign liabilities spanning 1975-2024, we quantify how much of local debt dynamics is driven by primary-surplus news, by global real-rate shocks, and by exchange-rate or risk-premium re-pricing. Our results establish that almost 30% of the financial aspects driving the year-by-year revaluation of the market value of government debt in the United Kingdom, a representative G10 open economy, can be attributed to movements in the real exchange rate. While the domestic fiscal-surplus process remains the largest determinant of the value of U.K. government debt, accounting for real-exchange-rate-induced movements helps reconcile episodes that appear contradictory when considering only surpluses and interest-rate movements in isolation.

To rationalise the observed empirics, we develop a two-country open-economy model in which fiscal shocks in a financial hegemon, identified through the existence of a convenience yield on its

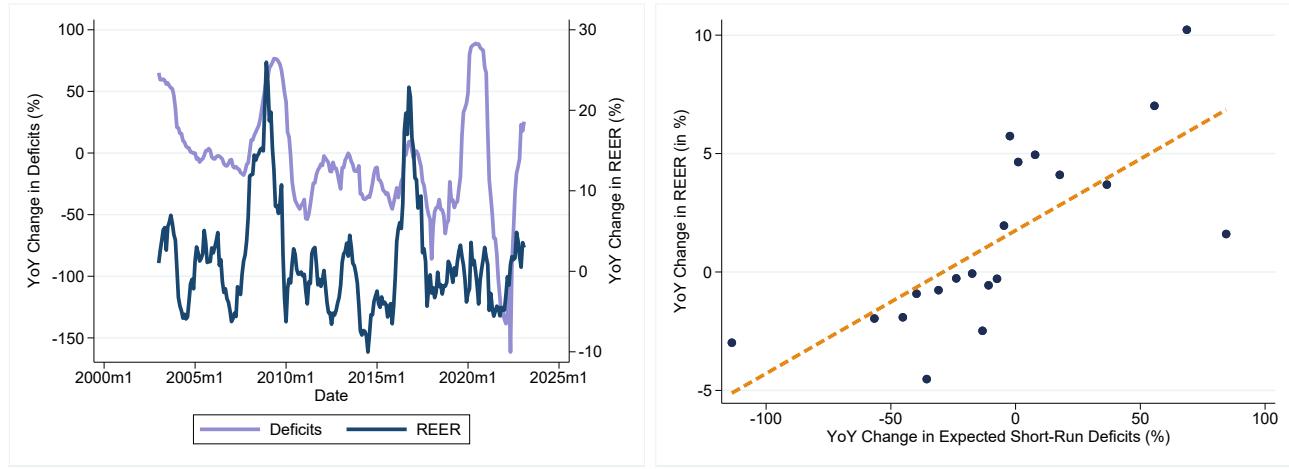
sovereign debt, propagate internationally through the uncovered-interest-parity condition. Assuming a financial hegemon, we show that the threat of fiscal inflation in that country can transmit fiscal pressure to other economies by increasing the cost of servicing debt across countries. In the model, we identify a simple mechanism by which inflationary pressures at the hegemon country can spill over to other economies - a mechanism of 'international fiscal contagion', leading to fiscally-driven inflation spillovers. A deterioration of the Home country's expected surpluses tightens the Foreign intertemporal budget constraint, even when its own projected surpluses are unchanged, because currency-denominated discount factors adjust rather than current-account flows. Intuitively, fair valuation of terminal debt streams requires that a domestic devaluation of the real value of debt be matched by a comparable decline in the value of foreign debt. Thus, weaker Home surpluses necessitate either a depreciation of the Home currency or a rise in foreign prices. This mechanism operates through the interest rate charged on foreign government debt in equilibrium, with the nominal exchange rate driving much of the adjustment. Finally, we present a continuous-time general-equilibrium model in which the market-clearing exchange rate between two economies is again heavily influenced by changes in relative surpluses. The model rationalizes the previous mechanism in a simple manner, as we are able to reduce the model to seven core equations despite the rich goods and asset markets.

Mechanisms linking (a) deficit changes to exchange rate movements and (b) deficit changes in one (Hegemon) country to price level changes in *another* country are gaining traction (e.g., [Alberola et al. \(2021\)](#), [Ding and Jiang \(2024\)](#), [Mac Mullen \(2025\)](#)). Recent empirical evidence supports a close nexus between cross-country deficits and exchange rates, but it assigns only a limited role to government-debt valuation in equilibrium. While this may be plausibly secondary in the short run, no-arbitrage in the long run provides a useful guide to the exchange-rate movements required to sustain a fair market value of government debt over time. Put differently, the literature often overlooks the consistency between short-run exchange-rate fluctuations and their long-run implications—best observed in a relatively low-frequency object such as the aggregate market value of government debt. Moreover, as laid out by [Hazell and Hobler \(2024\)](#) and [Kawalec \(2025\)](#), expected deficits appear to matter more for financial variables than realised deficits.

Our contribution addresses these gaps. We explicitly focus on exchange rate determination from the perspective of the government debt valuation equation, recovering the link between fiscal deficits, exchange-rate movements, and the observed market value of government debt. Our main empirical exercise provides a detailed narrative of how fiscal deficit changes and exchange rate movements interact in jointly determining the equilibrium value of government debt. The long-run perspective spanning the last 50 years of macroeconomic history in the U.K. allows us to rationalize seemingly inconsistent episodes of debt valuation movements through corresponding exchange rate adjustments. This analysis is consistent with mechanisms in which changes in expected (rather

than realised) deficits drive fiscal equilibrium. The accompanying theoretical frameworks further show how expected deficits in one country affect both domestic and foreign inflation by inducing exchange-rate and interest-rate movements that jointly determine the real value of government debt in equilibrium.

To further support the claim that expected deficits plausibly matter for exchange-rate movements, Figure 1 provides evidence in favour of a possible link between deficit expectations and exchange rates. The left panel plots the evolution of monthly changes to the REER (on a year-on-year basis) and of monthly changes to the expectations of fiscal deficits in the subsequent two years (again, changes are depicted on a year-on-year basis) in the United Kingdom. The right panel presents a binscatter of the two quantities against each other over the same sample period. Deficit expectations are cross-sectional averages of forecasts by private-sector institutions (banks and independent research firms) compiled by HM Treasury.



(a) Changes to the REER and expected deficits over time.

(b) Binscatter of  $\Delta$  expected fiscal deficits against  $\Delta$  REER.

Figure 1: Dynamics of expected deficits and the REER in the U.K.

Taken together, Figure 1 suggests a plausible correlation between deficit *expectations* and real exchange rate movements: in particular, as panel (b) shows, higher deficits correlate with depreciations of the domestic currency in the context of an open economy. The figure is purely descriptive: it abstracts from realised deficits and does not identify causality. As panel (a) indicates, domestic deficit expectations are far from the only drivers of realised REER fluctuations, consistent with the broader literature.

## Literature Review

The title of our contribution echoes the book of Rogoff (2025). In this paper, however, our central focus is the role borne by sovereign *deficit* dynamics for exchange rates, where we consider both domestic and foreign deficits in the way they shape exchange rate dynamics of a given country.

We primarily contribute to the literature on sovereign deficits and their ties to inflation and exchange-rate dynamics. The paper is also adjacent to work on fiscally driven price-level determination, which depends on the broader fiscal–monetary policy mix. That literature has been inaugurated by [Sargent and Wallace \(1981\)](#), with the subsequent work of [Leeper \(1991\)](#) and [Woodford \(1995\)](#) laying much of the modern groundwork for the models commonly in use that assign at least a share of inflationary dynamics to fiscal aggregate demand management. Literature reviews and overviews in this field are provided by [Leeper and Leith \(2016\)](#) and [Cochrane \(2023\)](#), among others. Overall support for fiscally-driven inflation has been developed both theoretically ([Bassetto et al., 2024](#); [Bassetto and Cui, 2018](#); [Bianchi et al., 2023](#); [Bigio et al., 2024](#); [Campos et al., 2024](#); [Caramp and Silva, 2023](#); [Corsetti and Maćkowiak, 2024](#); [Kaplan et al., 2024](#); [Miao and Su, 2024](#); [Smets and Wouters, 2024](#)) and through an empirical lens ([Banerjee et al., 2022](#); [Barro and Bianchi, 2024](#); [Chen et al., 2022a](#); [Cochrane, 2022a](#); [Reichlin et al., 2023](#)).

While most of this work is set in closed-economy environments, a small but growing literature brings these insights to international models. Early explorations linking fiscal price level determination and exchange rate dynamics include [Bergin \(2000\)](#), [Dupor \(2000\)](#), [Sims \(1997\)](#), [Sims \(1999\)](#), and [Woodford \(1998\)](#). Initial applications of such ideas include [Benigno and Missale \(2004\)](#) and [Corsetti and Maćkowiak \(2006\)](#), who focus on the ties between public debt and currency stability especially in times of severe currency turmoil.

Alongside the renewed interest in deficit–inflation links, research has revisited the role of deficits in exchange-rate determination. An early contribution of [Schmitt-Grohé and Uribe \(2003\)](#) depicted the role of exchange rate adjustments vis-à-vis inflation in financing fiscal deficits within the context of emerging markets. [Valchev \(2020\)](#) establishes that excess returns on currency holdings can be traced to endogenous movements in bond convenience yields, which in turn depend on prevalent interactions between monetary and fiscal policy. Particularly related to our contribution are the works of [Alberola et al. \(2021\)](#) and [Jiang \(2022\)](#). [Alberola et al. \(2021\)](#) distinguish between Ricardian and non-Ricardian regimes, tying unexpected exchange rate movements (relative to a complete-market frictionless benchmark) to non-Ricardian fiscal regimes in which government debt lacks sufficient fiscal backing. [Jiang \(2022\)](#) in turn makes explicit some of the implications of applying fiscal price level determination to exchange rate dynamics, pointing out concisely that real exchange rate adjustments are linked to government surplus shocks through the cost of issuing government debt, among other factors.

Our theoretical model draws especially on the insights of [Bassetto and Miller \(2025\)](#), placing our modelling framework squarely within the realm of fiscally-led inflation mechanisms. One of our contributions is to add the international dimension to a tractable model of monetary–fiscal interactions, thereby rationalising a clear mechanism through which fiscal inflation in one country translates into fiscal inflation elsewhere via the interest-rate–exchange-rate nexus.

The paper also relates to the large macro-finance literature on nominal and real exchange-rate determination, which we cannot survey fully here. A partial literature review has been provided by Itskhoki (2021), including an overview about the many puzzles related to exchange rate dynamics, which standard complete-market models of exchange rate determination fail to resolve.<sup>1</sup> Of particular noteworthiness are the recent contributions on the exchange rate disconnect (Bacchetta and Van Wincoop, 2004; Chari et al., 2002; Corsetti et al., 2008; Duarte, 2003; Engel and West, 2005; Itskhoki and Mukhin, 2021), as our main argument links the exchange rate back to one specific macroeconomic fundamental; namely, aggregate demand managed by the fiscal authority. In that sense, our paper relates also significantly to recent contributions that push back against the narrative that exchange rates are disconnected from macroeconomic fundamentals. Particularly noteworthy in the light of our analysis are the contributions of Bodenstein et al. (2024), Kekre and Lenel (2024), and Mac Mullen (2025). Bodenstein et al. (2024) link exchange rate dynamics to trade balance shocks, which are reduced-form demand disturbances. Kekre and Lenel (2024) also attribute the majority of cross-country exchange rate variation to demand movements, albeit from the lens of resulting interest rate differentials. Finally, Mac Mullen (2025) shows that these interest rate differentials can be partially attributed to fiscal deficit dynamics, in line with the evidence and models presented in this paper.

By analysing interactions between fiscal hegemons and countries that lack the sovereign-debt privilege conferred by financial dominance, we also speak to this literature. Ellison and Scott (2020) in particular provide a long-run perspective on the valuation of U.K. national debt, which served as a cornerstone for our analysis. Our contribution is the addition of the international dimension, the elongation of their data sample, and an increased focus on inflationary factors. Jiang et al. (2024b) focus extensively on the U.S. experience in recent decades, finding evidence in favour of a persistent mispricing of U.S. sovereign debt. Considering the evidence presented in Chen et al. (2022b), this dominant position of U.S. sovereign debt had been inherited from the United Kingdom in the early 20th century. Ding and Jiang (2024) make explicit a number of interesting channels by which monetary and fiscal policy are intertwined in the presence of a dominant fiscal and financial hegemon.<sup>2</sup> Particularly noteworthy here are the recent contributions of Jiang et al. (2021), who link the valuation of the U.S. Dollar to convenience yields enjoyed by foreign investors holding safe U.S. assets, and Jiang (2021), who argue that the U.S. fiscal cycle links currency risk premia of the Dollar relative to other currencies. Finally, Jiang et al. (2023) and Jiang et al. (2024a) are close to our argument, showing how convenience yields on Dollar-denominated debt enter as a wedge in

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<sup>1</sup>These include the possibility of a disconnect from macroeconomic fundamentals (Meese and Rogoff, 1983), the forward premium puzzle (Fama, 1984), the slightly negative correlation of real exchange rates and relative consumption (Backus and Smith, 1993; Corsetti et al., 2008), the Purchasing Power Parity puzzle (Rogoff, 1996), and the lower volatility of the terms of trade relative to the real exchange rate (Atkeson and Burstein, 2008), among others.

<sup>2</sup>This literature, in turn, can be linked to insights from the literature on dominant currency paradigms, surveyed in Gopinath and Itskhoki (2022).

the Euler equations determining exchange rates.

The remainder of the paper is organised as follows. Section 2 lays out the present-value accounting framework and derives its open-economy linearisation, which we supplement with explicit links between forecasts of deficits and forecasts of exchange rates in section D. Section 3 introduces the two-country model and shows how fiscal shocks propagate internationally through exchange-rate-discount interactions. Section 4 writes down a continuous-time model to show how surpluses affect exchange rates. Section 5 concludes with policy implications for debt management and for the coordination of fiscal and exchange-rate policies.

## 2 Empirical Framework

We first recap the government debt valuation equation typically found in the literature. We then extend the framework to an international open economy setting.

When evaluating the framework, we make use of the data used in Cochrane (2019) for U.S. variables, updating the macroeconomic aggregates using the data of Müller et al. (2025). For the bulk of the U.K. data analysis, we use data from Ellison and Scott (2020) on the market value of government debt, which we update using the Gilt database of Cairns and Wilkie (2023). The macroeconomic aggregates are again majorly sourced in Müller et al. (2025), with additional real exchange rate data being supplemented from the Bank of International Settlements and its Real Effective Exchange Rate Index (REER).

We define the nominal end-of-period market value of debt  $V_t$  as

$$V_t \equiv M_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)}, \quad (1)$$

where  $M_t$  is non-interest bearing money,  $B_t^{(t+j)}$  is the *face-value* of a zero-coupon nominal debt outstanding at the *end* of period  $t$  and due at the *beginning* of period  $t+j$ ,  $Q_t^{(t+j)}$  is the time  $t$  market price of that bond where  $Q_t^{(t)} = 1$ . We can divide by nominal GDP and take logs of both sides

$$\nu_t \equiv \log \left( \frac{V_t}{P_t Y_t} \right), \quad (2)$$

where  $P_t$  is the price level and  $Y_t$  is real GDP. We divide by the price level to turn the market value of debt into a real variable and by GDP  $Y_t$  to turn the object into a stationary variable and hence more stable to work with in the time series.

We define the *nominal return on the portfolio of government debt*. This is defined as the change in the value of debt held between periods, expressed in price changes between the end of period  $t$  and the beginning of period  $t+1$ . The nominal return on the portfolio of government

debt (holding period returns) is

$$R_{t+1}^n \equiv \frac{M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)}}{M_t + \sum_{j=1}^{\infty} Q_t^{(t+j)} B_t^{(t+j)}} \quad (3)$$

The denominator is the end-of-period  $t$  payout value of all government liabilities. The numerator is the market value of the debt now that each bond is one period closer to maturity. Following [Hall and Sargent \(2011\)](#) and [Cochrane \(2019\)](#), we stress the importance of using the market value of debt as opposed to the commonly reported book value of debt. Using the market value of debt ensures that discount-rate variation is priced in. Bond prices embed time-varying real yields and risk premia. Ignoring these would mechanically attribute all swings in debt-to-GDP to prospective surpluses or growth, biasing any present-value decomposition. Following commonly reported measures of the book value of government debt omits capital gains within the debt portfolio, leading to the period-by-period government budget identity not holding without ad-hoc valuation adjustments. We can take logs to get the *log nominal return* on the portfolio of government debt

$$r_{t+1}^n \equiv \log(R_{t+1}^n). \quad (4)$$

The nonlinear government flow identity is given by

$$M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)} = P_{t+1} s p_{t+1} + M_{t+1} + \sum_{j=1}^{\infty} Q_{t+1}^{(t+1+j)} B_{t+1}^{(t+1+j)}. \quad (5)$$

Here,  $s p_{t+1}$  is the *real primary surplus* (i.e. does *not* include interest payments). At the beginning of period  $t+1$ , money  $M_t$  and bonds  $B_t^{(t+1+j)}$  are outstanding. Following [Campbell and Shiller \(1988\)](#); [Cochrane \(2019\)](#), we provide a definition of the linearised government flow identity, with the derivation being available in Appendix [B.4](#).

**Proposition 1** (Linearised Government Debt Flow Identity, [Cochrane \(2019\)](#), [Cochrane \(2022b\)](#) eq. (A.1)). *The linearised government debt flow identity is*

$$\rho v_{t+1} = v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} - s_{t+1}, \quad (6)$$

where  $v_t$  is the log of ratio of the market value of debt to GDP at the end of period  $t$ ,  $r_{t+1}^n$  is the log nominal return on the portfolio of government bonds,  $\pi_t$  is inflation,  $g_{t+1}$  is the log of GDP growth, and  $s_{t+1}$  is the scaled real primary surplus to GDP ratio.

Equation (6) is an *accounting* identity; that is, it holds in every model. We re-arrange the govern-

ment flow identity to solve for surpluses<sup>3</sup>

$$s_{t+1} = v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} - \rho v_{t+1}.$$

In Figure 10 in the appendix, we plot the ratio of the *implied* primary surpluses to the contemporaneous market value of U.K. public debt from 1830 to 2021. Because the surplus series is expressed in “per-unit-of-debt” terms, a value of -0.2, means the government ran a primary deficit equal to 20% of the previous year’s market value of debt. A description of key periods of history through this approach is provided in the corresponding appendix B.5.

We now extend equation (6) into an open economy setting.<sup>4</sup> Suppose we have two economies, home (H) and foreign F. Define the nominal exchange  $\mathcal{E}_t$  as the number of home currencies per unit of foreign currency (i.e. an increase in  $\mathcal{E}_t$  is a depreciation). Following equation (6), we can define each country’s linearised government debt equation as

$$\rho_H v_{t+1}^H = v_t^H + r_{t+1}^{n,H} - \pi_{t+1}^H - g_{t+1}^H - s_{t+1}^H, \quad (7)$$

$$\rho_F v_{t+1}^F = v_t^F + r_{t+1}^{n,F} - \pi_{t+1}^F - g_{t+1}^F - s_{t+1}^F, \quad (8)$$

where  $v_t^X \equiv \log\left(\frac{V_t^X}{P_t^X Y_t^X}\right)$ ,  $r_{t+1}^{n,X}$ ,  $\pi_{t+1}^X$ ,  $g_{t+1}^X$ ,  $s_{t+1}^X$ ,  $\rho_X$  are the analogous objects as defined above for country  $X \in \{H, F\}$ . Here we define the log of the exchange rate  $e_t \equiv \log \mathcal{E}_t$  and therefore  $\Delta e_{t+1} = e_{t+1} - e_t > 0$  is a depreciation of the home currency.

The uncovered-interest-parity (UIP) condition with a risk premium shock  $\varphi_t$  is

$$r_{t+1}^{n,H} - r_{t+1}^{n,F} = \Delta e_{t+1} + \varphi_{t+1}, \quad (9)$$

where  $\mathbb{E}_t[\varphi_{t+1}] = 0$ . We can substitute the UIP condition in equation (9) into the home country’s flow identity to get

$$\rho_H v_{t+1}^H = v_t^H + \left( r_{t+1}^{n,F} + \Delta e_{t+1} + \varphi_{t+1} \right) - \pi_{t+1}^H - g_{t+1}^H - s_{t+1}^H. \quad (10)$$

Equation (10) shows that *foreign* discount-rate news  $r_{t+1}^{n,F}$ , exchange-rate movements  $\Delta e_{t+1}$ , and the UIP premium  $\varphi_{t+1}$  now do the same fiscal work of absorbing the home country’s surplus shocks as inflation and home discount-rate news did in the single-country model. For further intuition,

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<sup>3</sup>A few comments on why we back out implied surpluses rather than use government account tables. First, it is helpful to ensure exact accounting for surpluses. The constructed surplus by definition satisfies equation (6). Present-value decompositions later in the paper therefore close exactly, with no statistical discrepancy term. The economic meaning of this approach ensures mark-to-market changes in the debt stock represent genuine gains or losses for the fiscal authority and hence the taxpayer. For example, as documented by Hall and Sargent (2011), the NIPA primary surplus in the U.S. omits these valuation effects and so understates fiscal effort when bond prices fall (higher real returns) and overstates it when prices rise. Second, we therefore place us squarely within our intuition of expected deficits (as the inverse of surpluses) being relevant, and our decomposition allows us to back out such expected surpluses/deficits identically.

<sup>4</sup>We give a full microfounded model yielding the exact same relationship in appendix B.

suppose that the home country is the U.K. and foreign country is the U.S. Suppose there is a U.S. primary deficit shock. That is, suppose  $s_{t+1}^F$  falls unexpectedly ( $-s_{t+1}^F \uparrow$ ). By equation (8), this can be offset by a corresponding increase in foreign discount rates. If this were to happen, the transmission of increased discount rates would be akin to a decrease in fiscal surpluses for the home country due to the higher cost of serving debt.

Equation (10) must still hold, so one (or a combination) of the following channels might adjust conditional on the overall value of government debt and surpluses of the home country remaining untouched:

1. *Fiscal inflation*:  $\pi_{t+1}^H \uparrow$  directly erodes value of debt.
2. *Growth*: GDP growth  $g_{t+1}^H \uparrow$  raises taxes and pays down deficits. This is analogous to deficits being self-financing as explored in the HANK literature (Angeletos et al., 2024).
3. *Dollar depreciates*:  $\Delta e_{t+1}$  moves as investors find U.S. assets less desirable.
4. *UIP-premium shock*:  $\varphi_{t+1} < 0$  as investors accept lower Dollar excess return.

Therefore, any variable that moves to offset the U.S. deficit enters the U.K. constraint via  $r_{t+1}^{n,F}$  or  $\Delta e_{t+1}$  and forces a counteracting adjustment in U.K. inflation, growth, or future surpluses.

## 2.1 Backward and Forward Decompositions

### 2.1.1 Backward Decomposition

Equipped with the decomposition of the value of government debt, we take stock of the historical arithmetics of the public balance sheet. The backward-looking decomposition asks the accounting question: *given the debt ratio we observe today, how much of it can be traced to realised primary surpluses and deficits, how much to the cumulative effect of inflation and growth, and how much to the repricing of that debt through interest-rate and exchange-rate movements?* Equation (10) allows us to examine the historical drivers of the U.K's debt.

Starting from the linearised flow constraint in equation (10) for the *home country* (the U.K.)<sup>5</sup>

$$v_{t+1}^H = v_t^H + [r_{t+1}^{n,F} + \Delta e_{t+1} + \varphi_{t+1}] - \pi_{t+1}^H - g_{t+1}^H - s_{t+1}^H, \quad (11)$$

we iterate equation (11) from an origin date 0 to arrive at

$$v_t^H = v_0^H + \sum_{j=1}^t [r_j^{n,F} + \Delta e_j + \varphi_j] - \sum_{j=1}^t \pi_j^H - \sum_{j=1}^t g_j^H - \sum_{j=1}^t s_j^H. \quad (12)$$

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<sup>5</sup> $\rho_H \approx 0.97$  is the Campbell–Shiller discount factor at annual frequency. Because  $\rho_H \approx 1$ , we suppress it to keep notation light.

This is an accounting identity where the value of debt today is the sum of the initial value of debt, the accumulation of FX-risk-premium less inflation, growth, and surpluses. We note that this decomposition measures, and does not test, the present value relation as discussed in [Cochrane \(2019\)](#). We do the backward decomposition of debt in Figure 2 and summarise the components in Table 1. Figure 2 applies equation (12) as a backward accounting exercise. Each coloured path starts at zero in the base year (1975) and then *cumulates* one term of the identity forward through time. The blue line ( $v$ ) is the realised market-value debt ratio; the orange line ( $-s$ ) shows what that ratio would have been had *only* primary surpluses and deficits changed. The distance between the blue and orange series is therefore the *total valuation effect*, which we disaggregate into foreign discount-rate news ( $r^{n,F}$ ), domestic inflation ( $-\pi$ ), real growth ( $-g$ ), movements in the real exchange rate (REER) and uncovered-interest-parity premia (UIP).

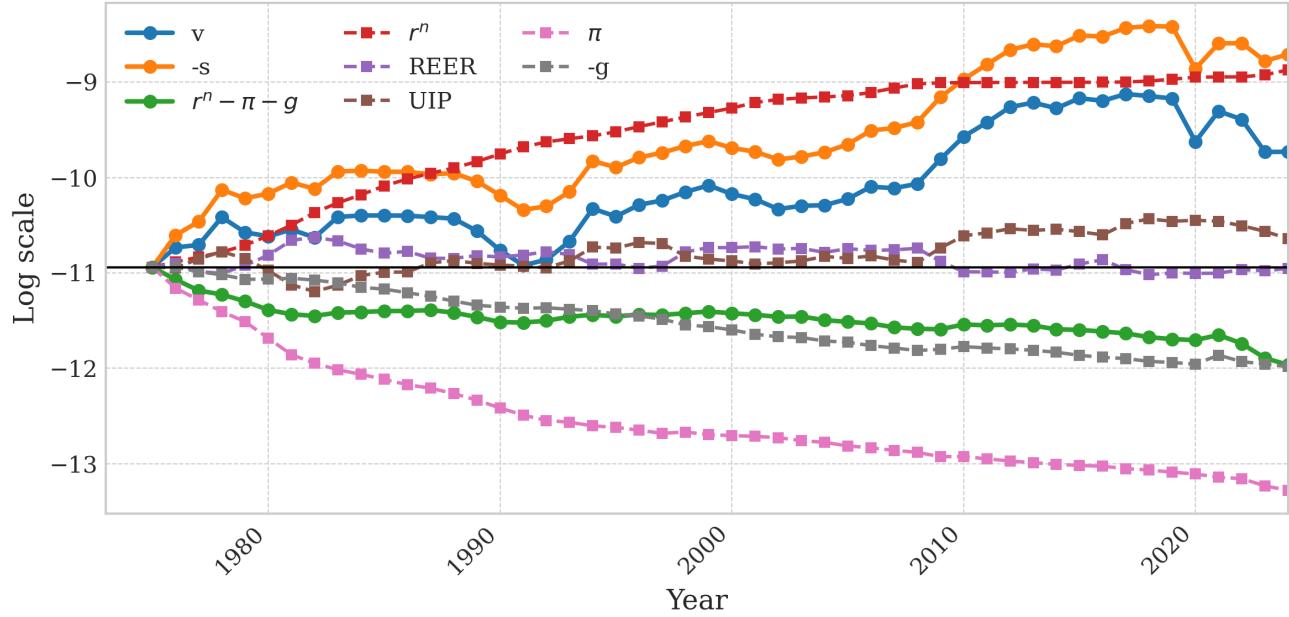


Figure 2: U.K. backward decomposition of government debt with exchange rates.

Primary surpluses explain only about one half of the cumulative change in U.K. debt since 1975; the remainder is valuation, split almost evenly between the global discount factor ( $r^n - \pi - g$ ) and exchange-rate channels (REER and UIP). Second, every regime break identified by [Bordo et al. \(2022\)](#) shows up as a kink in one of the valuation curves, confirming that shifts in discount factors, not just fiscal flows, drive debt dynamics. Finally, the open-economy channels matter quantitatively: a permanent 10 % Sterling depreciation raises the domestic currency value of future Dollar coupons by the same 10 %, while a 200 bp UIP shock lowers today's discount factor enough to add roughly 10% of GDP to the market value of outstanding debt—all without any change in cash surpluses.<sup>6</sup>

<sup>6</sup>A detailed description of key macroeconomic episodes in the U.K. is provided in appendix B.5.1.

Line	Path (Start in 1975)	Interpretation
$v$	$v_0^H + \sum_{j \leq t} (r_j^{n,F} + \Delta e_j + \varphi_j - \pi_j^H - g_j^H - s_j^H)$	Actual (market-value) debt/GDP ratio.
$-s$	$v_0^H - \sum_{j \leq t} s_j^H$	Counterfactual path if <i>only</i> realised primary surpluses/deficits moved.
$r^n - \pi - g$	$v_0^H + \sum_{j \leq t} (r_j^{n,F} - \pi_j^H - g_j^H)$	Debt path driven by discount-rate, inflation, and growth.
$r^n$	$v_0^H + \sum_{j \leq t} r_j^{n,F}$	Cumulated foreign nominal return.
$-\pi$	$v_0^H - \sum_{j \leq t} \pi_j^H$	Inflation erosion of real debt.
$-g$	$v_0^H - \sum_{j \leq t} g_j^H$	Contribution of real growth.
$REER$	$v_0^H + \sum_{j \leq t} \Delta e_j$	Cumulated Sterling depreciation.
$UIP$	$v_0^H + \sum_{j \leq t} \varphi_j$	Cumulated FX risk-premium shocks.

Table 1: Mapping of Figure 2 series to the components of the backward decomposition in equation (12).

### 2.1.2 Forward Decomposition

The forward-looking present-value identity is an even more natural starting point: under a government debt valuation equation, the entire stream of expected future primary surpluses discounted at the rates investors require matters for today's value of debt. By writing the flow constraints in present-value form, we place the exchange rate, real discount rates, and the UIP-premium on the same footing as surpluses and growth: each enters as a discounted sum that must balance the market value of debt. This forward-looking perspective makes two things transparent. First, because the identity holds period-by-period in expectation, any news about future surpluses, inflation, discount rates, or exchange-rate movements is reflected immediately in debt valuations and currency prices. Second, following the finance literature, we are able to decompose movements in the value of debt into distinct channels of fiscal, monetary, real, and exchange rates. In short, the present-value identity turns a sequence of forward flows into one equilibrium condition we can take to the data and decompose visually into economically meaningful pieces.

We translate the government's intertemporal budget constraint into a form that can be empirically estimated with a finite-order vector autoregression (VAR), again following [Cochrane \(2019, 2022b\)](#). Let  $x_t$  be the state variable consistent of the variables of interest. The state variable consists of (i) the foreign nominal return that discounts both countries' bonds; (ii) real consumption growth, inflation, the primary surplus, and the market value of debt for the home country; (iii) real-exchange-rate changes  $\Delta e_t$  and the ex-ante UIP premium  $\varphi_t$  that jointly affect Dollar pricing;

and (iv) short and long U.S. Treasury yields, which improve forecasts of future nominal returns and inflation. All series are annual logs or log-ratios. With the state variable, we can estimate a first-order annual VAR

$$x_{t+1} = Ax_t + \varepsilon_{t+1}, \quad \varepsilon_{t+1} \sim \mathcal{N}(0, \Sigma),$$

on post-war U.K. data. Because all eigenvalues of  $A$  lie strictly inside the unit circle, the VAR implies finite long-run multipliers. Conditional expectations of any element of  $x_{t+j}$ , and therefore the discounted present value sum, can therefore be written in closed form:

$$E_t[x_{t+j}] = A^j x_t \implies \sum_{j=1}^{\infty} E_t[x_{t+j}] = (I - A)^{-1} A x_t.$$

Define selection vectors  $a_s$ ,  $a_g$ , and  $a_r$  that pick out, respectively, the surplus, growth, and *nominal-return minus inflation* rows of  $x_t$ . Let  $a_s, a_g, a_r, a_\pi, a_{\Delta e}, a_\varphi$  be row-selection vectors that return, respectively,  $(s_t^H, g_t^H, r_t^{n,F}, \pi_t^H, \Delta e_t, \varphi_t)$  from  $x_t$ . The infinite-horizon *expected* present-value contributions that enter the linearised budget identity are

$$PV_t^{(k)} := a'_k (I - A)^{-1} A x_t, \quad k \in \{s, g, r, \pi, \Delta e, \varphi\},$$

and  $PV_t^{(d)} \equiv PV_t^{(r)} - PV_t^{(\pi)}$ .

Figure 3 plots the *forward* decomposition implied by the open-economy identity in equation (26). In Table 2, we describe the mapping between the formulas and Figure 3. The blue line is the realised market value of debt, while every other series is the *expectation* on the right-hand side of equation (26), taken with the information available at date  $t$ .<sup>7</sup>

Curve	Algebraic object	Economic meaning
$v$	$v_t^H$	Market value of debt/consumption ratio.
$s$	$PV_t^{(s)}$	Present value of future primary surpluses.
$-(r^n - \pi)$	$-PV_t^{(d)}$	Present value of future <i>real</i> discount rates.
$r^n$	$PV_t^{(r)}$	Present value of future nominal returns.
$-\pi$	$-PV_t^{(\pi)}$	Present value of future U.K. inflation.
REER	$PV_t^{(\Delta e)}$	Present value of future real-exchange-rate changes.
UIP	$PV_t^{(\varphi)}$	Present value of future UIP-premium shocks.
$g$	$PV_t^{(g)}$	Present value of future real growth.

Table 2: Mapping of figure 3 series to the analytic components in eq. (25). By construction,  $v_t^H = PV_t^{(s)} + PV_t^{(g)} - PV_t^{(d)}$ .

From the perspective of this forward decomposition, real surpluses and changes to the price level are the material contributors to the equilibrium valuation of government debt. Real exchange

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<sup>7</sup>Appendix B.5.2 presents a description of the emergent historical episodes.

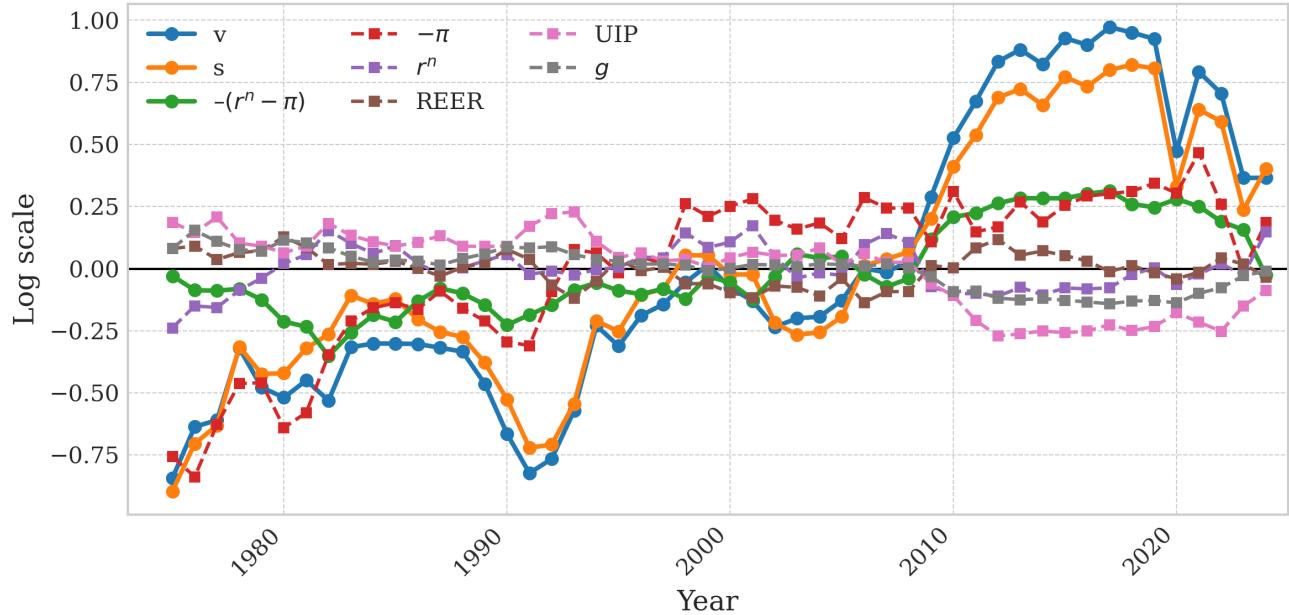


Figure 3: U.K. forward decomposition of government debt with exchange rates.

rate movements and UIP deviations, depicted with the brown and pink lines, respectively, help to reconcile the relative under-valuation of U.K. debt vis-à-vis the surplus process until the early 2000s, as well as the over-valuation of U.K. debt implied by our VAR framework since then.

Complementing this picture, appendix B.5 also provides a historical variance decomposition of the equilibrium value of U.K. sovereign debt, highlighting that while surplus news dominate in contributing to variance in the value of government debt, UIP and inflation channels nonetheless matter economically significantly for the valuation of government debt.

## 2.2 Linking exchange rate movements to deficit shocks

The previous exercise has shown how UIP deviations and cross-border interest rate spillovers matter significantly for the equilibrium valuation of government debt. We now leverage the inverse of the recovered surplus processes (*deficits*) for the U.K. and the U.S. to determine how much they each contribute to medium-run movements in U.K. real exchange rates. We view this exercise as informative about the plausible contributors of secular determinants of U.K. exchange rates, showing how much of the observed variance in U.K. exchange rates can be plausibly attributed to movements in domestic or foreign deficits, where foreign deficits matter through foreign interest rates and associated exchange-rate and UIP-deviation channels, as explained above.

Table 3 summarizes the results of this exercise, linking the deficit innovations implied by the forward decomposition of the VAR in section 2.1 to observed year-on-year movements in U.K. real exchange rates. We weight the U.S. deficit innovations by the relative U.S./U.K. GDP to reflect

the relative size of both countries, but not weighting the deficit does not impact the qualitative results of the exercise.

Strikingly, deficit expectation revisions relate to the observed movements in U.K. exchange rates significantly and in the direction implied by the government debt valuation equation: a deficit innovation in the U.K. relates to an *depreciation* of the U.K. real exchange rate, with a 1% deficit-to-GDP innovation being related to a 37 basis point relative *depreciation*. Dynamics of U.S. deficits matter an order of magnitude less, as expected and prescribed by our framework. In numbers, a 1% deficit-to-GDP innovation in the U.S. relates to a 1.8 basis point relative *appreciation* of U.K. exchange rates. The second column confirms that the *differential* between U.K. and U.S. surpluses relates most materially to annual exchange rate movements. The third column, providing an interaction effect with local recessions, reveals that in such recessionary periods it is plausible for deficit innovations to matter through unconventional channels that are otherwise not captured.<sup>8</sup>

Dependent variable: $\Delta$ U.K. REER			
	(1)	(2)	(3)
$\Delta \mathbb{E}(\text{Deficit})_t^{U.K.}$	0.370*** (0.077)	0.352*** (0.075)	0.358*** (0.107)
$\Delta \mathbb{E}(\text{Deficit})_t^{U.K.} \times \mathbf{1}_{g_Y < 0}$			-2.370*** (0.615)
$\Delta \mathbb{E}(\text{Deficit})_t^{U.S.}$	-0.018*** (0.005)		-0.010** (0.004)
$\Delta \mathbb{E}(\text{Deficit})_t^{U.S.} \times \mathbf{1}_{g_Y < 0}$			0.210*** (0.061)
$\Delta \mathbb{E}(\text{Deficit})_t^{U.K.-U.S.}$		0.016*** (0.006)	
Constant	-0.006 (0.010)	-0.022 (0.014)	-0.001 (0.009)
Observations	25	25	25
Adjusted R <sup>2</sup>	0.469	0.320	0.523

Note: HAC-robust standard errors. \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Table 3: Long-run correlates of U.K. exchange rates

The observed links between deficits and the exchange rate are fairly robust over time. We can see this by running the following local projection on our exogenous deficit measure:

$$\Delta e_{t+h} = \alpha_h + \beta_h^{U.K.} \text{Def}_t^{U.K.} + \beta_h^{U.S.} \text{Def}_t^{U.S.} + \gamma_h e_{t-1} + u_{h,t}, \quad h = 0, 1, \dots, H,$$

<sup>8</sup>In appendix C we provide additional results based on the [Engel and West \(2005\)](#) reverse-regression approach, showing that exchange rates are able to predict materialized deficits in the U.K. The link between exchange rates and deficits follows an 'overshooting' pattern.

where  $\Delta e_{t+h}$  is the change in the log real exchange rate index, and the left-hand side independent variables are the U.K. and U.S. deficit measures, respectively. Figure 4 plots the results of our local projection measure, showing that the movements in the exchange rate in response to the expected deficit innovations are relatively persistent across time.

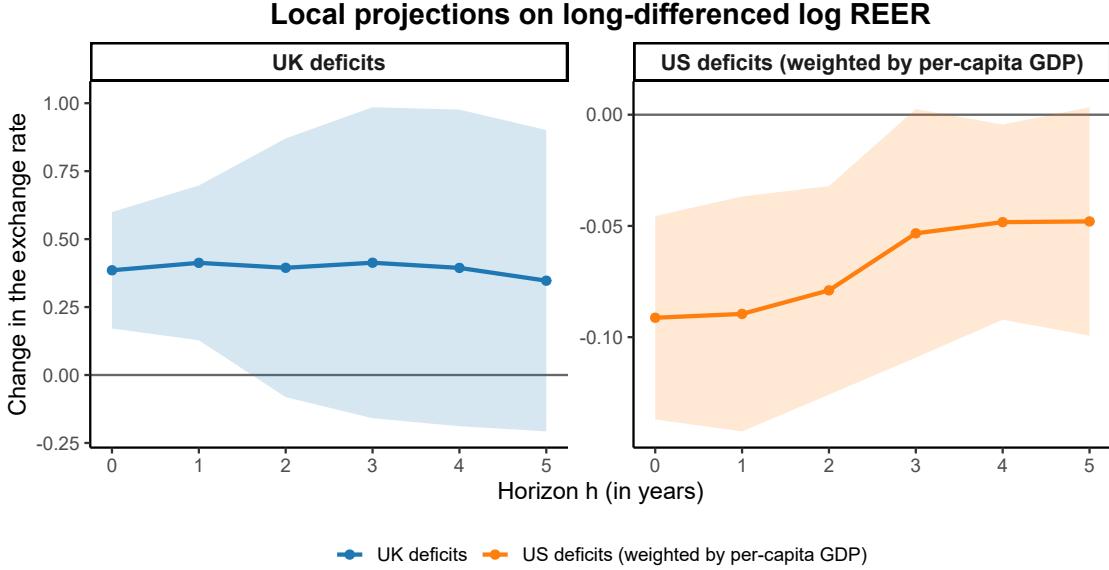


Figure 4: The effect of deficit surprises in the UK and the US on the UK REER.

In sum, our long-run historical analysis focussing on the dynamics underpinning the valuation of government debt underscore that the domestic debt valuation equation is necessarily linked to the UIP condition and fluctuations in the real exchange rate. Additionally, we have shown how measured surplus innovations then contribute to observed movements in real U.K. exchange rates.

The link between expected surplus/deficit dynamics and exchange rates corresponds to the focal novelty of the paper. In this section, we have done so from a longer-run perspective, focussing on the mechanics of the government debt valuation equation. We support the results established herein with a *shorter-run* perspective, utilizing domestic short-run expectations of fiscal deficits to analyse their contribution to observed variation in month-on-month exchange rate revaluations in appendix D.

### 3 A Simple Model of International Fiscal Spillovers

This section presents a minimal model emphasizing a fiscally-led inflation mechanism in a standard international macro context, with plausible relevance of fiscal deficits for nominal exchange rate movements and international spillovers through interest rate adjustments. What we therefore show here is a plausible mechanism how fiscal sustainability concerns in one country can spill over

to the government debt valuation of another country. The interesting messages of the model are kept fully nominal, with no relevance for international goods flows, which we nullify here for expositional simplicity. One particular result will be the possibility to distinguish between *announcements* of spending at Home and their factual implementation, with particular relevance for the announcements through expectations-driven revisions of the Uncovered Interest Rate Parity (UIP) condition.

### 3.1 Environment

The primitives of the model consist of a simplified iteration of the framework of [Bassetto and Miller \(2025\)](#), but with a diminished focus on the information structure. Instead, we add an international dimension facilitating the transmission of fiscal shocks between countries. Denote the Home country by  $H$ , the Foreign country by  $F$ , and let stars (\*) denote variables in the Foreign country, in line with standard notation. Heuristically, we will think of the Home country as an international hegemon determining international spillovers, and of the Foreign country as a small open economy subject to the financial influence of the hegemon, although it has a dis-taste for those spillovers, reflected in the Foreign country not enjoying holdings of Home (Hegemon) bonds. There are two periods:

1. t=1: there exists an initial steady-state inherited from t=0. In period one, the price levels  $P_1, P_1^*$ , as well as the nominal exchange rate  $\mathcal{E}_1$ , are all determined through the respective government budget constraints and cross-border debt holdings inherited from the initial period. There exists an information set about a "government spending shock". This is a shock to Home government spending in period 2,  $G_2$ , whose plausible size is revealed. Additionally, there is a prior about the policy regime in place at Home. Two policy regimes are possible: a 'fiscally-led' regime, in which taxes are a fixed quantity and the spending need will be financed through inflation; and a 'monetary-led' regime in which taxes adjust to ensure that a target price level at Home is achieved. The Foreign fiscal authority levies fixed taxes  $\bar{T}^*$  in all periods, while Foreign interest rates on debt issuance  $i_1^*$  are determined in equilibrium through the UIP condition.
2. t=2: The tax and monetary regimes from Home unfold, yielding the terminal Home price level  $P_2$ . Note that the Foreign price level  $P_2^*$  will already be perfectly revealed in period 1, being a function of equilibrium interest rates on Foreign debt from period 1 to period 2.

## 3.2 Home households

We begin by introducing the households, which are not fully symmetric across the two countries to simplify calculations. Relative to standard macroeconomic models, the sole key difference is that we introduce a reduced-form dis-preference term on behalf of the Foreign households for the bonds issued by Home. This may reflect a home bias in savings vehicles, or a negative perception of Home government bonds through the spillovers possible by their Hegemon status.<sup>9</sup>

*Home* households maximize the utility borne from consumption of the domestic good, adjusted for the disutility from supplying labour:<sup>10</sup>

$$\max U = \max \sum_{t=1}^2 \beta^t \mathbb{E}_t [u(c_t) - L_t],$$

where  $c_t$  is consumption of the representative household,  $L_t$  is labour supplied, and the production function of the household is given by  $y_t = L_t$ . Disutility from labour is kept linear on purpose to simplify determination of the real equilibrium in the presence of fiscal shocks.

Each household takes as given government policy and the price level. Define  $B_{Ht-1}$  as household holdings of Home bonds at the beginning of period  $t$ , having taken them over from period  $t-1$ . The same applies to holdings of Foreign bonds by the Home household, defined as  $B_{Ft-1}$ . Then, the domestic household budget constraint is given by:

$$B_{Ht-1}(1 + \bar{i}) + B_{Ft-1}\mathcal{E}_t(1 + i_{t-1}^*) + P_t L_t = B_{Ht} + B_{Ft}\mathcal{E}_t + P_t(c_t + T_t). \quad (13)$$

Note that no debt is left outstanding in the final period for either household in equilibrium; that is,  $B_{H2} = B_{F2} = B_{H2}^* = B_{F2}^* = 0$ .

## 3.3 Home Fiscal and Monetary Authority

Next, consider the Home government. The government faces an already accrued (inherited) stock of debt  $B_0$ , held by both Home and Foreign households in some proportion. It can raise lump-sum taxes  $T_t$  in each period. We follow [Bassetto and Miller \(2025\)](#) in assuming that  $G_1 = 0$  without loss of generality. In period 1, lump-sum taxes will be set to cover interest payments, such that  $T_t = \frac{B_{t-1} - \frac{B_t}{1+i}}{P_t}$  for  $t = 1$ . In period  $t = 2$ , Home government spending and taxes are uncertain and plausibly disjoint, allowing for altered government debt dynamics.

In line with [Bassetto and Miller \(2025\)](#), two regimes in terms of fiscal policy are possible:

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<sup>9</sup>A similar dis-taste term for the Home household for Foreign bonds can be included, but it would merely obstruct the core message through more involved algebra. Also, we could express the model through a local preference for domestic bonds, but this would not materially change the outcomes at the cost of more involved algebra again.

<sup>10</sup>Note that there is no goods trade in equilibrium, but only trade in financial products at this stage.

- ML (Monetary-led): in this regime,  $T_2 = G_2 + \frac{B_1}{P_2^T}$ , where  $P_2^T$  is an externally supplied targeted price level in period 2. Then, any spending requirement  $G_2$  is fully soaked up by corresponding taxes, while the primary surplus  $\frac{B_1}{P_2^T}$  soaks up the cost of outstanding bond holdings.
- FL (Fiscally-led): in regime FL, taxes do not respond to the spending requirement:  $T_2 = \bar{T}$ , where  $\bar{T}$  is an exogenously supplied known constant.

Fundamentally, the assumption of introducing tax changes in period 2, but their announcement taking place in period 1, is meant to distinguish the effects of announced deficits from the effects once the deficits actually materialize. It therefore allows us to capture the effects of fiscal spending announcements on exchange rates through their forward-looking nature.

Monetary policy in the Home economy will be captured by a strict nominal interest rate peg as already in use in the Home budget constraint,  $i_t = \bar{i} \forall t$ .

### 3.4 Foreign block

The *Foreign* household is described by a similar problem as the domestic household, but with all variables being starred and the exchange rate adjustment in the budget constraint reflecting that the Foreign household considers the Foreign bonds as domestic, and, crucially, an additional idiosyncratic preference term capturing the dis-utility from holding Home bonds. Formally, the representative Foreign household maximizes:

$$\max U^* = \max \sum_{t=1}^2 \beta^t \mathbb{E}_t \left[ u(c_t^*) - L_t^* - \phi_F \frac{B_{Ht}^*}{P_t^*} \right].$$

The additional term at the end,  $-\phi_F \frac{B_{Ht}^*}{P_t^*}$ , captures the disutility from holding Home bonds.  $\phi_F$  is an exogenous parameter capturing the weight of the disutility term, and  $\frac{B_{Ht}^*}{P_t^*}$  is the real quantity of Home bonds held by Foreign households. We use a linear disutility term for simpler calculations here, but a quadratic disutility term is possible.

This maximization is performed subject to the per-period budget constraint of the Foreign household:

$$B_{Ft-1}^*(1 + i_{t-1}^*) + \frac{B_{Ht-1}^*}{\mathcal{E}_t}(1 + \bar{i}) + P_t^* L_t^* = B_{Ft}^* + \frac{B_{Ht}^*}{\mathcal{E}_t} + P_t^*(c_t^* + T_t^*). \quad (14)$$

Now, we consider the government of Foreign. The Foreign government differs from the Home government in a number of important aspects:

- First, there is no uncertainty with respect to Foreign government spending; that is, we assume  $G_t^* = 0 \forall t$  for simplicity.

- In terms of the policy in use, we postulate that taxes levied in the terminal period by the Foreign government are fixed; that is,  $T_2^* = \bar{T}^*$ . The terminal period price level in the Foreign economy will be determined by the terminal government budget constraint, with the price level adjusting to ensure that the fiscal budget constraint holds.
- Foreign interest rates are allowed to be time-varying:  $i_t^*$  is not constant. It adjusts, however, not based on a policy rule, but instead in a way that allows the UIP, adjusted for the wedge term ensuring a preference for the Foreign bonds, to hold.

**Information structure:** We introduce an explicit information structure that allows us to track the effect of each policy regime in conjecture with government spending on the Home and Foreign price level.

In  $t = 1$ , both Home and Foreign households have a (shared) prior about the policy regime and spending  $G_2$  of Home. To keep it simple, we denote by  $\psi_1$  the prior that the Home government will be in regime  $FL$ , and by  $1 - \psi_1$  the prior that the Home government will be in regime  $ML$ . These priors will be the same in both Home and Foreign. The government spending variable can follow an arbitrary distribution  $\mathcal{G}$ .

**Optimality Conditions:** We provide detailed derivations in appendix A. The domestic household's equilibrium conditions are characterised by:

$$u'(c_t) = 1, \quad t = 1, 2; \quad (15)$$

$$u'(c_t) = \beta(1 + \bar{i}) \mathbb{E}_t \left[ u'(c_{t+1}) \frac{P_t}{P_{t+1}} \right], \quad t = 1; \quad (16)$$

$$u'(c_t) = \beta(1 + i_t^*) \mathbb{E}_t \left[ u'(c_{t+1}) \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right], \quad t = 1. \quad (17)$$

For the foreign household, their equilibrium optimality conditions are characterised by:

$$u'(c_t^*) = 1, \quad t = 1, 2; \quad (18)$$

$$u'(c_t^*) = \beta(1 + \bar{i}) \mathbb{E}_t \left[ u'(c_{t+1}^*) \frac{P_t^*}{P_{t+1}^*} \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} \right] - \phi_F \mathcal{E}_t, \quad t = 1; \quad (19)$$

$$u'(c_t^*) = \beta(1 + i_t^*) \mathbb{E}_t \left[ u'(c_{t+1}^*) \frac{P_t^*}{P_{t+1}^*} \right], \quad t = 1. \quad (20)$$

Note that, in general, no Euler equations apply in period 2 as all bond holdings in that period are set to zero in that period by household optimality.

**Definition 2** (Competitive equilibrium). An allocation  $\{c_t, c_t^*, L_t, L_t^*, B_{Ht}, B_{Ft}, B_{Ht}^*, B_{Ft}^*, B_t, B_t^*\}_{t=1,2}$ ,

nominal prices  $\{P_t, P_t^*, \mathcal{E}_t\}_{t=1,2}$ , fiscal policy  $\{T_t, T_t^*\}_{t=1,2}$ , monetary policy  $\{\bar{i}, i_t^*\}_{t=1,2}$ , and government spending  $\{G_2\}$  are called a competitive equilibrium in this economy, when:

- all time- $t$  variables are  $t$ -measurable;
- given  $\{P_t, \bar{i}, T_t, P_t^*, i_t^*, T_t^*\}$  and  $\{G_2\}$ , the variables  $\{c_t, L_t, B_{Ht}, B_{Ft}\}_{t=1,2}$  solve equations (15), (16), (17), and (13); and the variables  $\{c_t^*, L_t^*, B_{Ht}^*, B_{Ft}^*\}_{t=1,2}$  solve equations (18), (19), (20), and (14), with  $B_{H2} = B_{F2} = B_{H2}^* = B_{F2}^* = 0$ .
- The domestic government satisfies its budget constraint and policy rules:
  - $B_t = B_{t-1}(1 + \bar{i}) + P_t(G_t - T_t)$ ,  $t = 1, 2$ , where  $B_2 = 0$ .
  - $T_2 = G_2 + \frac{B_1(1+\bar{i})}{P_2^*}$  in regime ML;  $T_2 = \bar{T}$  in regime FL. Taxes in periods 1 and 2 adjust to ensure a constant real debt burden
  - Interest rates are pegged to the value  $\bar{i}$ .
- The Foreign government satisfies its budget constraint and policy rules:
  - $B_t^* = B_{t-1}^*(1 + i_{t-1}^*) + P_t^*(G_t^* - T_t^*)$   $t = 1, 2, 3$  and  $B_2^* = 0$ .
  - Taxes in all periods are fixed. In  $t = 1$ , taxes offset the cost of serving maturing debt, while in  $t = 2$ , taxes are simply given by some exogenous level  $\bar{T}^*$ .
  - Interest rates  $i_t^*$  adjust to make sure that household optimality is achieved as the sole free parameter ensuring that the UIP conditions on both households hold.
- Markets clear:
  - $C_t + G_t = L_t$  for  $t = 1, 2$ ,
  - $C_t^* + G_t^* = L_t^*$  for  $t = 1, 2$ ,
  - $B_t = B_{Ht} + B_{Ft}$  for  $t = 1, 2$ ,
  - $B_t^* = B_{Ht}^* + B_{Ft}^*$  for  $t = 1, 2$

In total, we have 17 endogenous variables in 17 conditions.

This model gives rise to the following two UIP conditions:

$$\frac{1}{\mathcal{E}_t} = \beta(1 + \bar{i}) \mathbb{E}_t \left[ \frac{P_t^*}{P_{t+1}^*} \frac{1}{\mathcal{E}_{t+1}} \right] - \phi_F, \quad (21)$$

$$\mathcal{E}_t = \beta(1 + i_t^*) \mathbb{E}_t \left[ \frac{P_t}{P_{t+1}} \mathcal{E}_{t+1} \right]. \quad (22)$$

### 3.5 Solving for equilibrium

We now solve for the equilibrium of this model. We start from the terminal period ( $t = 2$ ) and move backwards in solving the model.

To pin down the terminal exchange rate  $\mathcal{E}_2$  without invoking the UIP (as there are no bonds outstanding in period 3), we start by recognizing that the model set-up requires all cross-border bond holdings to unravel at the terminal period. In an accounting sense, cross-border flows of financial goods in the terminal period must allow the Home country to repatriate the Foreign holdings of Home bonds, and vice versa. Therefore, the terminal exchange rate reflects the price level-adjusted flows that allow cross-country bond holdings to unravel. The logic is that, in equilibrium,

$$P_2(1 + \bar{i})B_{H1}^* = \mathcal{E}_2 P_2^*(1 + i_1^*)B_{F1} \quad \Leftrightarrow \quad \mathcal{E}_2 = \frac{P_2}{P_2^*} \frac{(1 + \bar{i})}{(1 + i_1^*)} \frac{B_{H1}^*}{B_{F1}}, \quad (23)$$

such that the non-domestic bond holdings in period 1 in combination with their respective interest rates are fully informative about the nominal exchange rate in period 2. This assumption allows us to close the outstanding stock of cross-border financial accounts in the terminal period.

In economic terms, this assumption equates the value of Foreign debt held by Home and Home debt by Foreign in the last period. Therefore, it facilitates a *positive* correlation between the value of Home and Foreign debt in the terminal period. Assume a fiscal expansion in Home, reducing the real value of Home debt in the terminal period. By this assumption, the real value of Foreign debt denoted in the Home currency must also decrease, allowing for a simple reduced-form international transmission of fiscal shocks.

This is, in a sense, an assumption about absolute hegemony of Home: since Foreign fiscal policy is assumed to be fixed, a fiscal deterioration at Home must translate to a fiscal deterioration in Foreign by depressing the market value of Foreign debt. To some extent, this rationalizes the distaste for international financial integration in Foreign, manifest in its utility function.

As alluded to previously, terminal bond holdings are zero by household optimality:  $B_2 = B_2^* = B_{H2} = B_{F2} = B_{H2}^* = B_{F2}^* = 0$ . Additionally, for our further analysis, we denote the measure of fiscal spending in the Home country conditional on begin in the fiscally-led regime as  $\mu_1 \equiv \mathbb{E}_1(G_2|FL)$ .

Conditional on the fiscal policy regime in place, we are able to pin down the price level in the terminal period at Home through the specification of the fiscal policy regime in place:

$$P_2 = \begin{cases} P_2^T & \text{if ML,} \\ \frac{B_1(1+\bar{i})}{\bar{T}-G_2} & \text{if FL.} \end{cases} \quad (24)$$

Therefore, the level of taxes levied at Home in the terminal period is given by:

$$T_2 = \begin{cases} \frac{B_1(1+\bar{i})}{P_2^T} + G_2 & \text{if ML,} \\ \bar{T} & \text{if FL.} \end{cases} \quad (25)$$

Since  $G_1 = 0$  and  $u'(c_t) = 1 \forall t$ , we can simplify the Euler equation applying in period 1 in the Home household, which is:

$$u'(c_1) = \beta(1 + \bar{i}) \mathbb{E}_t \left[ u'(c_2) \frac{P_1}{P_2} \right], \quad (26)$$

by recognizing that household optimality prescribes constant consumption across time, such that the Euler equation becomes:

$$\frac{1}{P_1} = \beta(1 + \bar{i}) \left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1 + \bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right]. \quad (27)$$

Alternatively, we can express also the price level explicitly as:

$$P_1 = \frac{1}{\beta(1 + \bar{i})} \frac{1}{\left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1 + \bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right]}, \quad (28)$$

which means that we have now pinned down the domestic price level in both period 1 and period 2. It generally does not depend on the exchange rate and Foreign fiscal or monetary policy. This is because our assumptions implicitly allowed us to characterize the Home policy authorities as the 'dominant' ones, imposing their tax and interest policy on the other country through the exchange rate, with little effect vice versa. We are therefore taking here the stark assumption of an 'absolute hegemon' in terms of the monetary and fiscal policy spillovers.

Now, we focus on the Foreign country as well as the international dimension. Our main guiding point will be the two UIP conditions (21) and (22). Both conditions have to hold. However, since the Home and Foreign price levels are fully informed by the fiscal budget constraint, and the Home interest rate is fixed, equation (21) will be cleared by  $\mathcal{E}_t$  only. Consequently, equation (22) will be cleared by  $i_t^*$ , the Foreign bond interest rate, as it is the only free variable ensuring that the UIP on Foreign bonds held by the domestic household holds.

To aid our discussion, we first solve for the Foreign price level in period 1. By the Foreign Euler condition on Foreign bonds,

$$\frac{1}{P_t^*} = \beta(1 + i_t^*) \mathbb{E}_t \left[ \frac{1}{P_{t+1}^*} \right].$$

We evaluate this at  $t = 1$ . Since

$$P_2^* = \frac{(1 + i_1^*) B_1^*}{\bar{T}^*} \quad (29)$$

by the terminal fiscal budget constraint, we find that

$$\frac{1}{P_1^*} = \beta \frac{\bar{T}^*}{B_1^*(1 + i_0^*)} \quad (30)$$

fully determines the price level. In particular, as  $P_2^*$  is fully known conditional on  $i_1^*$ , we can pin down the price level in Foreign at  $t = 1$  as:

$$P_1^* = \frac{1}{\beta} \frac{B_1^*(1 + i_0^*)}{\bar{T}^*}, \quad (31)$$

where  $i_0^*$  was inherited from the initial steady-state.

What is left is to determine are  $\mathcal{E}_1$ ,  $\mathcal{E}_2$ , and  $i_1^*$ , which will be jointly given by our two UIP conditions and the terminal exchange rate condition. Everything else has already been accounted for.

We solve here for  $(1 + i_1^*)$ , which will be the central object of interest capturing spillovers from expansionary fiscal policy at Home.

**Proposition 3.** *The equilibrium gross interest rate of Foreign in period 1 is given by:*

$$(1 + i_1^*) = \phi_F \frac{(1 + \bar{i})}{\bar{i}} \frac{\bar{T}^*}{B_1^*} \frac{B_{H1}^*}{B_{F1}} \frac{1}{\left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1 + \bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right]}. \quad (32)$$

This solution for the equilibrium interest rate delivers a clear message: if expectations on fiscally-led policy mixes at Home grow in period 1, the equilibrium interest rate on Foreign debt issued in period 1 *increases*. Formally:

**Corollary 4** (Co-movement between Foreign interest rates and Home fiscal policy perceptions). *If the terminal price level at Home is higher under the fiscally-led policy mix ( $P_2|_{FL} > P_2|_{ML}$ ), the co-movement between Foreign interest rates in period 1 and the probability of a fiscally-led policy mix at Home are positive; that is:*

$$\frac{\partial(1 + i_1^*)}{\partial \psi_1} > 0. \quad (33)$$

This result is, at first, counter-intuitive. Even though Foreign households do not enjoy Home debt in any case, fiscal policy that makes Home bonds relatively less attractive is accompanied by an increase in the cost of borrowing in Foreign. A deterioration of Home fiscal conditions correlates with a deterioration in Foreign fiscal conditions, even if Foreign fiscal policy is unchanged. This result is squarely linked to the specification of the terminal exchange rate above, which induced the linkage in fiscal sustainability between Home and Foreign. Thus, an alternative fiscal-monetary

policy specification limiting the factual hegemony of Home in the determination of the exchange rate would alter our results. Our intuitions are therefore related to [Ding and Jiang \(2024\)](#).

At constant taxes and no changes to the aggregate bond issuance in Foreign, this higher cost of borrowing in period 1 directly translates to a higher price level in period 2 (and, thus, also higher inflation from period 1 to period 2).

**Corollary 5.** *The terminal price level in Foreign co-moves positively with the probability of a fiscally-led policy mix at Home:*

$$\frac{\partial P_2^*}{\partial \psi_1} > 0. \quad (34)$$

*Proof.* Follows immediately from equations (33) and (29).  $\square$

A higher probability of a Fiscally-led regime in Home ( $\psi_1 \uparrow$ ) increases the domestic price level generally by equation (28). Additionally, with our specification of international financial markets, this increase in the Home price level must yield an increase in the interest rates charged on Foreign bonds for the UIP to hold. This, in turn yields an *increase* in the *Foreign terminal price level*  $P_2^*$  through the government budget constraint of Foreign, given by  $P_2^* = \frac{(1+i_1^*)B_1^*}{T^*}$ . Therefore, in our simple model, we identify a minimum viable mechanism by which a deterioration in Fiscal conditions at Home spills over to higher inflation from  $t = 1$  to  $t = 2$  in Foreign, manifesting through a deterioration of the fiscal balance of Foreign.

Figure 5 presents these comparative statics graphically. Both the expected price level at Home, here denoted by  $P_2^e$ , as well as the materialized price level in Foreign  $P_2^*$  (which is fully determined in period one through the Foreign government budget constraint) increase in the Foreign interest rate  $i_1^*$ , which in turn increases in the probability of being in the fiscally-led regime. The sensitivity of the Foreign price level to the Home fiscal shock is of a similar order of magnitude in level terms to the Home price level sensitivity, which is a consequence of the fiscal shock being comparatively 'large' from the perspective of Foreign due to their lower bond issuance. Thus, the *relative* change of prices at Foreign is larger than at Home. This resonates the mechanism of [Barro and Bianchi \(2024\)](#), by which a given fiscal deterioration has larger effects on the price level when the stock of sovereign debt is *smaller*, as a relatively larger change in the price level is needed to ensure that the real deterioration of the fiscal balance is sufficiently large.

As for the exchange rate, note that there are two plausibly opposing effects, in line with equation (23): there is a possible direct effect on the terminal exchange rate if the factual policy regime is actually FL through the deterioration of Home fiscal conditions, and an opposing effect from the spillovers on the fiscal budget of Foreign. In our calibration, the latter effect dominates, which is evidenced by the relatively larger deterioration of the real value of debt at Foreign relative to Home. Here, therefore, a higher probability of the fiscally-led regime in Home leads to an *appreciation* of

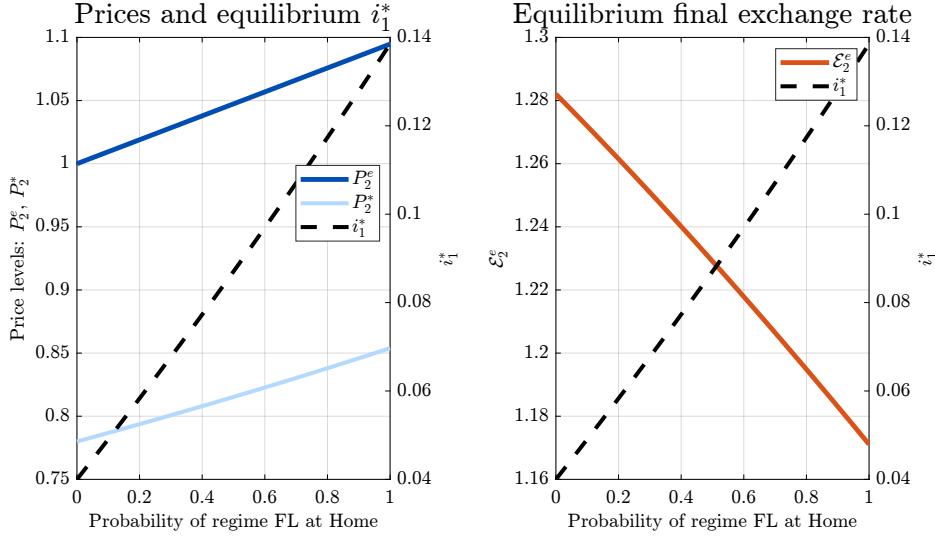


Figure 5: Comparative statics with respect to  $\psi_1$ , the probability of Home being in regime FL, for prices and equilibrium exchange rates. Calibration:  $B_1 = 1$ ,  $B_1^* = 0.15$ ,  $B_{H1}^* = B_{F1} = 0.1$ ,  $\bar{i} = 0.04$ ,  $\beta = 0.9$ ,  $\bar{T} = 1$ ,  $\bar{T}^* = 0.2$ ,  $\mu_1 = 0.05$ ,  $P_2^T = 1$ ,  $\phi_F = 0.03$ .

the Home currency in the terminal period. Effectively, this is the international extension of the mechanism presented in [Barro and Bianchi \(2024\)](#): because the relative adjustment of the Foreign fiscal position is larger in response to the deterioration of the Home fiscal condition, the bilateral exchange rate can appreciate from the perspective of Home.

## 4 Continuous-time Model

To further generalize the insights of our tractable two-period model presented in section 3, we now develop a continuous-time two-country New Keynesian model of international fiscal policy spillovers. Relative to our two-period model, we now also introduce tradable goods, allowing for fiscal policy to matter furthermore through changes to aggregate demand. Both countries have unrestricted access in purchasing goods and assets from either countries. Each country has their own intermediate and final good producing firms. Nominal rigidities are present in both countries. Both monetary and fiscal policy is operating in both countries. We provide detailed derivations in Appendix E.

### 4.1 Domestic Household Problem

The household side is an international analogue of the continuous-time New Keynesian model as set out in [Werning \(2011\)](#).

**Intratemporal Problem** There is a home (H) and foreign (F) good. We define a home consumption bundle as

$$C_t = \left[ (1 - \gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

The domestic household solves the following intratemporal problem.

$$\max_{C_{Ht}, C_{Ft}} \left[ (1 - \gamma)^{1/\eta} C_{Ht}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ft}^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)} \quad (35)$$

$$\text{s.t. } P_{Ht} C_{Ht} + P_{Ft} C_{Ft} = Z_t, \quad (36)$$

where  $P_{Ht}$  and  $P_{Ft}$  are the prices of the Home and Foreign goods in domestic currency and  $Z_t$  is total nominal expenditure.  $1 - \gamma$  measures the degree of home bias. The equations characterising the solution to the intratemporal problem of the domestic household are given by

$$C_t = \left[ (1 - \gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (37)$$

$$C_{Ht} = (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t, \quad (38)$$

$$C_{Ft} = \gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t, \quad (39)$$

$$P_t = \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]^{1/(1-\eta)}. \quad (40)$$

$C_t$  is a CES aggregate of Home and Foreign consumption bundles  $C_{Ht}$  and  $C_{Ft}$ , where  $\gamma \in (0, 1)$  is the expenditure weight on Foreign goods and  $\eta > 0$  is the elasticity of substitution. The second and third equations are the optimal demand levels implied by this aggregator: each bundle's quantity scales with total consumption and falls with its relative price with elasticity  $\eta$ . The last equation defines the dual CES price index  $P_t$  (CPI) consistent with the aggregator and these demands.

The real exchange rate  $S_t$  is defined as

$$S_t = E_t \frac{P_t^*}{P_t}, \quad (41)$$

where  $E_t$  is the nominal exchange rate. The terms of trade are given by the price of imports over the price of exports

$$\text{tot}_t = \frac{P_{Ft}}{P_{Ht}}. \quad (42)$$

**Intertemporal Problem** The domestic household chooses consumption  $C_t$  at price  $P_t$ , supplies labour  $N_t$  for the wage  $W_t$ , and chooses holding of domestic bonds  $B_t$  earning interest  $i_t$  and foreign bonds bonds  $B_t^*$  earning interest  $i_t^*$ . When holding foreign bonds, they need to take into account the exchange rate  $E_t$ . In order to introduce a wedge to break perfect risk-sharing, and therefore the [Backus and Smith \(1993\)](#) puzzle, we follow [Jiang et al. \(2023, 2024a\)](#) by introducing

a convenience yield for Home bonds. The domestic household solves the following problem:

$$\max_{\{C_t, N_t, B_t, B_t^*\}_{t \geq 0}} \int_0^\infty e^{-\rho t} \left\{ \log[C_t] - \frac{N_t^{1+\phi}}{1+\phi} + \nu(B_t; \theta) \right\} dt \quad (43)$$

$$P_t C_t + B_t + E_t B_t^* = i_t B_t + E_t i_t^* B_t^* + W_t N_t + T_t \quad (44)$$

The necessary and sufficient conditions for domestic household optimality are given by

$$C_t N_t^\phi = \frac{W_t}{P_t} \quad (45)$$

$$\frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho, \quad (46)$$

where  $\Psi_t \equiv \nu_B(B_t; \theta) P_t C_t$  is the convenience yield wedge. Because home bonds deliver utility services, the convenience yield  $\Psi_t$  raises the effective return on home bonds, altering intertemporal consumption optimality. The uncovered interest rate parity (UIP) condition is given by

$$i_t - i_t^* = \frac{\dot{E}_t}{E_t} - \Psi_t. \quad (47)$$

The interest rate differential is equal to the expected appreciation of the currency modified by the convenience yield term, which acts as a wedge in the UIP condition relative to standard models. The transversality conditions on domestic and foreign bonds are standard:

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T B_T = 0 \quad (48)$$

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T E_T B_T^* = 0. \quad (49)$$

## 4.2 Foreign Household

**Intratemporal Problem** The foreign household problem is symmetric to the domestic household problem. The CES demand function for the foreign household is

$$C_t^* = \left[ (1-\gamma)^{1/\eta} C_{Ft}^{*(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ht}^{*(\eta-1)/\eta} \right]^{\eta/(\eta-1)}. \quad (50)$$

The Foreign good gets weight  $1-\gamma$ ; the imported Home good weight  $\gamma$ , matching the degree of home-bias symmetry. To solve the intratemporal problem, we assume that the intratemporal budget constraint is

$$P_{Ft}^* C_{Ft}^* + P_{Ht}^* C_{Ht}^* = Z_t^*,$$

where  $Z_t^*$  is the within period expenditure. The optimal consumption expenditure is symmetric to the domestic household

$$C_{Ft}^* = (1 - \gamma) \left( \frac{P_{Ft}^*}{P_t^*} \right)^{-\eta} C_t^*, \quad (51)$$

$$C_{Ht}^* = \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*. \quad (52)$$

The foreign CPI is

$$P_t^* = \left[ (1 - \gamma) P_{Ft}^{*1-\eta} + \gamma P_{Ht}^{*1-\eta} \right]^{1/(1-\eta)}, \quad (53)$$

and the foreign terms of trade are given by:

$$\text{tot}_t^* = \frac{P_{Ht}^*}{P_{Ft}^*}. \quad (54)$$

**Intertemporal Problem** The intertemporal problem for the Foreign household is symmetric to the Home problem. Foreign households also enjoy a convenience yield for the Home country's bond. They maximise

$$\max_{\{C_t^*, N_t^*, B_t^*, B_t\}} \int_0^\infty e^{-\rho^* t} \left\{ \log[C_t^*] - \frac{N_t^{*1+\phi^*}}{1+\phi^*} + \nu \left( \frac{B_t}{E_t}; \theta \right) \right\} dt, \quad (55)$$

subject to the flow budget constraint

$$P_t^* C_t^* + \dot{B}_t^* + \frac{1}{E_t} \dot{B}_t = i_t^* B_t^* + \frac{1}{E_t} i_t B_t + W_t^* N_t^* + T_t^*. \quad (56)$$

The necessary and sufficient conditions for domestic household optimality are given by the Euler equation modified by the foreign's UIP wedge and a consumption-labour decision

$$\frac{\dot{C}_t^*}{C_t^*} = i_t^* - \pi_t^* + \Psi_t^* - \rho^*, \quad (57)$$

$$C_t^* N_t^{*\phi^*} = \frac{W_t^*}{P_t^*}, \quad (58)$$

where  $\Psi_t^* \equiv \nu_B \left( \frac{B_t}{E_t}; \theta \right) P_t^* C_t^*$  is the convenience yield wedge. The transversality conditions on domestic and foreign bonds are

$$\lim_{T \rightarrow \infty} e^{-\rho^* T} \lambda_T^* B_T^* = 0, \quad (59)$$

$$\lim_{T \rightarrow \infty} e^{-\rho^* T} \lambda_T^* \frac{B_T}{E_t} = 0. \quad (60)$$

## 4.3 Risk-Sharing

Following [Itskhoki and Mukhin \(2021\)](#), we can derive the risk-sharing condition between the Home and Foreign household:

$$\left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] - \dot{S}_t = \rho^* - \rho - \Psi_t^*. \quad (61)$$

This condition is obtained by differencing the home and foreign Euler equations and using the UIP condition, and it links *relative* consumption growth to movements in the real exchange rate  $S_t$ . It says that home–foreign consumption growth, net of real appreciation, equals the cross-country discount-rate gap ( $\rho^* - \rho$ ) minus the foreign convenience-yield wedge  $\Psi_t^*$ . When  $\rho = \rho^*$  and there are no convenience yields  $\Psi_t^* = 0$ , it collapses to the complete-markets benchmark of perfect risk-sharing  $\dot{C}_t/C_t - \dot{C}_t^*/C_t^* = \dot{S}_t$ . The convenience-yield wedge  $\Psi_t^*$  will resolve the [Backus and Smith \(1993\)](#) risk-sharing puzzle.

## 4.4 Domestic Final Good Producers

Final good producers are competitive and aggregate a continuum of intermediate inputs. We assume that there is a continuum of measure one of differentiated goods  $Y_{Ht}(j)$  with a Dixit-Stiglitz production function:

$$Y_{Ht} = \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \quad (62)$$

whereby  $\epsilon > 1$  is the elasticity of substitution among differentiated goods. The retailers take prices of differentiated goods  $p_{Ht}(j)$  as given. We can then define the retailer's problem as a cost minimisation problem:

$$\begin{aligned} \min_{Y_{Ht}(j)} \quad & \int_0^1 p_{Ht}(j) Y_{Ht}(j) dj \\ \text{s.t.} \quad & Y_{Ht} = \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}. \end{aligned} \quad (63)$$

With this problem, we can solve for the demand for each intermediate good  $j$  by the retailer. The demand for intermediate goods by the retailer is given by:

$$Y_{Ht}(j) = \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\frac{1}{\epsilon}} Y_{Ht} \quad (64)$$

where we define the aggregate price index as  $P_{Ht} \equiv \left[ \int_0^1 p_{Ht}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}$ .

## 4.5 Domestic Intermediate Good Producers

We look at the problem of the domestic intermediate firm  $j$ , which sets prices being aware of its own price adjustment friction. The per-period profit is their revenue minus cost of production

$$\Pi_t(p_{Ht}(j)) = p_{Ht}(j)Y_{Ht}(j) - \frac{W_t}{A_t}Y_{Ht}(j). \quad (65)$$

To introduce nominal rigidities, firms face a Rotemberg quadratic price adjustment cost ([Rotemberg, 1982](#))

$$\Theta_t(j) = \frac{\theta}{2} \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 P_{Ht} Y_{Ht}. \quad (66)$$

where  $\theta$  is the degree of price stickiness. The firm's optimal control problem is therefore to choose their pricing strategy in order to maximise present discounted profits subject to the adjustment cost

$$V_0(p_{H0}) = \max_{\{p_{Ht}(j)\}_{t \geq 0}} \int_0^\infty e^{-\int_0^t i(s)ds} \left\{ \Pi_t(p_{Ht}) - \Theta_t(j) \right\} dt \quad (67)$$

Following [Galí \(2008\)](#), we restrict our attention to symmetric domestic firm pricing

$$p_{Ht}(j) = P_{Ht}. \quad (68)$$

The price setting of firms implies that the inflation rate  $\pi_{Ht} \equiv \frac{\dot{P}_{Ht}}{P_{Ht}}$  is determined by

$$\left[ i_t - \pi_{Ht} - \frac{\dot{Y}_{Ht}}{Y_{Ht}} \right] \pi_{Ht} = \frac{\epsilon - 1}{\theta} \left[ \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t} - 1 \right] + \dot{\pi}_{Ht}. \quad (69)$$

Equation (69) is the Rotemberg price-setting ordinary differential equation for producer inflation under quadratic adjustment costs. The factor in brackets on the left-hand side is the firm's effective discount rate. Inflation increases when real marginal cost  $mc_t \equiv \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{H,t} A_t}$  exceeds its flexible-price target  $mc_t^n = 1$ , with the slope scaled by the stickiness parameter  $\theta$ . As prices become perfectly flexible  $\theta \rightarrow \infty$ , the condition collapses to  $mc_t = 1$ . The foreign final and intermediate good producers face a symmetric problem.

## 4.6 Policy

### 4.6.1 Fiscal Policy

Let  $B_t$  denote the face value of outstanding nominal government debt,  $i_t$  the instantaneous nominal policy rate,  $P_t$  the CPI, and  $G_t$  real government purchases. With nominal lump-sum taxes  $T_t$ , the consolidated flow budget is given by:

$$\dot{B}_t = i_t B_t + P_t G_t - T_t. \quad (70)$$

Define real debt  $b_t \equiv B_t/P_t$  and inflation  $\pi_t \equiv \dot{P}_t/P_t$ . Let the (real) primary surplus be  $s_t \equiv (T_t - P_t G_t)/P_t = T_t/P_t - G_t$ . Dividing by the price level  $P_t$  and using  $\dot{b}_t = \frac{\dot{B}_t}{P_t} - \pi_t b_t$  gives the real debt law of motion

$$\dot{b}_t = (i_t - \pi_t) b_t - s_t. \quad (71)$$

This linear ODE has integrating factor  $\mathcal{I}_t \equiv \exp(-\int_0^t (i_\tau - \pi_\tau) d\tau)$ , so  $\frac{d}{dt}(\mathcal{I}_t b_t) = -\mathcal{I}_t s_t$ . Integrating from  $t$  to  $T$  and imposing the no-Ponzi/transversality condition  $\lim_{T \rightarrow \infty} \mathcal{I}_T b_T = 0$  yields the government debt valuation equation, by which the real value of government debt is equal to the discounted stream of primary surpluses ([Cochrane, 2023](#))

$$\frac{B_t}{P_t} = \int_t^\infty \exp\left(-\int_t^u (i_s - \pi_s) ds\right) s_u du, \quad (72)$$

#### 4.6.2 Monetary Policy

Monetary policy follows a standard continuous-time Taylor rule:

$$i_t = r_t^n + \bar{\pi} + \phi_\pi (\pi_t - \bar{\pi}) + \phi_x x_t, \quad (73)$$

where  $\bar{\pi}$  is the inflation target,  $x_t \equiv \ln(Y_{H,t}) - \ln(Y_{H,t}^n)$  is the output gap, and  $r_t^n$  is the open-economy natural real rate.

## 4.7 Equilibrium

Goods market clearing conditions for the home and foreign good are given by:

$$Y_{Ht} = C_{Ht} + C_{Ht}^*, \quad (74)$$

$$Y_{Ft}^* = C_{Ft} + C_{Ft}^*. \quad (75)$$

The aggregate resource constraint for the home and foreign good is given by:

$$Y_{Ht} = A_t N_t, \quad (76)$$

$$Y_{Ft}^* = A_t^* N_t^*. \quad (77)$$

We can derive the real interest rate in this setting.

**Proposition 6** (Open-Economy Real Interest Rate). *The domestic natural rate of interest can be decomposed into the standard Ramsey terms and three distinct open-economy adjustment channels:*

$$r_t^n = \underbrace{(\rho + g_t)}_{\text{Ramsey}} - \underbrace{\Psi_t}_{\text{Convenience Yield}} + \underbrace{\mathcal{T}_t}_{\text{Terms-of-Trade Channel}} + \underbrace{\mathcal{R}_t}_{\text{Risk-Sharing Channel}} \quad (78)$$

where  $g_t \equiv \dot{A}_t/A_t$  is TFP growth and

$$\Psi_t \equiv \nu_B(B_t; \theta) P_t C_t$$

is the convenience yield on domestic bonds. The terms-of-trade channel,  $\mathcal{T}_t$ , reflects how changes in relative goods prices affect consumption growth, and is given by:

$$\mathcal{T}_t = \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta)\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right) \quad (79)$$

The international risk-sharing channel,  $\mathcal{R}_t$ , captures how incomplete financial markets impact consumption growth through exchange rate dynamics and financial frictions, and is given by:

$$\mathcal{R}_t = \frac{\phi}{1+\phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1-\gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right). \quad (80)$$

The natural real rate decomposes into the baseline Ramsey term plus three open-economy adjustment terms: a convenience yield that lowers the interest rate when home bonds deliver liquidity/safety, a terms-of-trade component capturing how movements in relative goods prices tilt intertemporal demand, and a risk-sharing component reflecting how real exchange-rate dynamics and financial wedges move relative consumption. In the closed-economy or unit-elasticity limits ( $\gamma \rightarrow 0$  or  $\eta \rightarrow 1$ ) and under perfect risk sharing ( $\Xi_t = 0$ ), the open-economy terms vanish and  $r_t^n$  collapses to  $\rho + g_t - \Psi_t$ .

**Proposition 7** (IS Curve). *The domestic IS curve is*

$$\dot{x}_t = (i_t - \pi_t - \rho) - g_t + \Psi_t - \mathcal{T}_t - \mathcal{R}_t, \quad (81)$$

where  $\dot{x}_t \equiv \frac{\dot{x}_t}{x_t}$  where  $x_t$  is the log deviation of actual output from its natural level:

$$x_t \equiv \ln(Y_{Ht}) - \ln(Y_{Ht}^n),$$

and recall that  $g_t$  is TFP growth,  $\Psi_t$  is the convenience yield,  $\mathcal{T}_t$  is the terms of trade effect and  $\mathcal{R}_t$  is the risk-sharing channel. The foreign IS curve is

$$\dot{x}_t^* = (i_t^* - \pi_t^* - \rho^*) - g_t^* + \Psi_t^* - \mathcal{T}_t^* - \mathcal{R}_t^*. \quad (82)$$

The output gap grows when the ex-post real rate is *below* the natural real rate. TFP growth  $g_t$  and the open-economy wedges of the terms of trade  $\mathcal{T}_t$  and risk-sharing  $\mathcal{R}_t$  raise the natural rate (tighten demand), while a higher convenience yield  $\Psi_t$  lowers the interest rate. This is the central equation linking monetary policy (via the nominal interest rate  $i_t$ ) to the real economy (via  $x_t$ ).

**Proposition 8** (Linearized NKPC). *The home linearised New Keynesian Phillips curve is*

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa [\tilde{c}_t + \phi x_t + \gamma \tau_t], \quad (83)$$

where  $\bar{\delta}_H \equiv \bar{i} - \overline{\dot{Y}_{Ht}/Y_{Ht}} - \bar{\pi}_H$  is the steady-state home discount rate,  $\tilde{c}_t \equiv \hat{C}_t - \hat{C}_t^n$  is the consumption gap,  $x_t$  is the output gap,  $\tau_t \equiv \ln \text{tot}_t - \ln \text{tot}_t^n$  is the terms-of-trade gap.

The foreign country New Keynesian Phillips curve is

$$\dot{\hat{\pi}}_{Ft}^* = -\bar{\delta}_F \hat{\pi}_{Ft}^* + \kappa [\tilde{c}_t^* + \phi^* x_t^* + \gamma \tau_t^*], \quad (84)$$

The linearised NKPC then links demand pressure into inflation dynamics: inflation decays at rate  $\bar{\delta}_H$  in the absence of cost pressures, and rises with the slope  $\kappa$  times the marginal-cost gap, here decomposed into the consumption gap  $\tilde{c}_t$ , the output gap  $x_t$  scaled by labor supply curvature  $\phi$ , and the open-economy term  $\gamma \tau_t$  capturing terms-of-trade movements.

**Formal equilibrium definition:** A competitive equilibrium is then defined as a collection of processes

$$\{C_t, N_t, Y_{H,t}, P_t, P_{H,t}, \pi_t, i_t, B_t, C_t^*, N_t^*, Y_{F,t}^*, P_t^*, P_{F,t}^*, \pi_t^*, i_t^*, B_t^*, E_t, \text{tot}_t, S_t\}$$

given exogenous processes  $\{A_t, A_t^*, s_t, s_t^*, \Psi_t, \Psi_t^*\}$  and initial conditions (including  $B_{t-}, B_{t-}^*$ ), such that households and firms are optimising and markets clear according to the equations presented throughout this section. A full definition is given in Appendix E.10.

## 4.8 Calibration and Simulation

We now calibrate our quantitative model and provide initial simulation results, focussing on (a) the role of convenience yields and (b) the fiscal contagion mechanism that we intend to highlight. Table 4 summarizes the baseline parametrization of the model, with the left panel focussing on the specification of fiscal and monetary policy, and the right-side panel parametrizing the remainder of the model.

While the parameter values on the right-hand side are all fairly standard and in line with what is commonly used in the literature, the left-hand side deserves some further explanation. The second column for the left summarizes the specification of the *monetary-led policy mix*, characterized by Taylor rules in Home and Foreign for which the monetary authority satisfies the Taylor Principle; that is, inflationary pressure is coincident with a real interest rate tightening. By this behaviour, the monetary authority induces an explosive root to the evolution of inflation, forcing the fiscal authority to follow a policy by which any deviations of the domestic debt value from steady-state are sufficiently covered by coincident changes in the marginal tax rate. By this, we set  $\psi_b > 1$  and  $\psi_b^* > 1$  in the monetary-led policy mix. In the calibration of the *fiscally-led policy mix*, given

Parameter	AM/PF	AF/PM	Targets/Sources	Parameter	Value	Targets/Sources
$\phi_\pi$	1.50	0.50	Bianchi et al. (2023)	$\kappa$	0.055	Hazell et al. (2022)
$\phi_\pi^*$	1.50	0.50	Bianchi et al. (2023)	$\phi = \phi^*$	2.00	Standard value
$\phi_x$	0.00	0.00	Bianchi et al. (2023)	$\delta = \delta^*$	0.01	Standard quarterly discount factor
$\phi_x^*$	0.00	0.00	Bianchi et al. (2023)	$\gamma$	0.25	Standard home bias
$\psi_b$	1.20	-0.20	Standard values for active/passive policy	$\eta$	2	Bajzik et al. (2019)
$\psi_b^*$	1.20	-0.20	Standard values for active/passive policy	$\Psi$	0.03	Conv. yield steady-state
				$\zeta_H$	0.9	Convenience yield-bond sensitivity

(a) Policy scenarios (AM vs AF)

(b) Baseline calibration

Table 4: Calibration: policy scenarios and baseline parameters

by the second column from the right, we violate this fiscal passivity assumption. For illustrative purposes, we do so quite severely, positing that the fiscal authority reacts with expansionary tax policy when faced with a negative deviation of its real debt valuation from steady-state. To ensure non-explosive behaviour of nominal variables, monetary policy accommodates fiscal policy in that case by forgoing an increase in the real interest rate in response to inflationary pressure, indicated by  $\phi_\pi < 1$  and  $\phi_\pi^* < 1$ .

With that calibration at hand, we now consider the model-implied reactions to changes in Home convenience yields and Home fiscal policy positions in dependence on the prevalent fiscal-monetary policy mix. That conditioning on the fiscal-monetary policy mix is relevant, as it determines the strength of relative wealth effects in response to demand-side shocks. Recall that we consider two instances here: a *monetary-led policy mix* in either country (under which the monetary authority induces a real rate tightening whenever there is positive inflationary pressure) and a *fiscally-led policy mix* in either country (under which the fiscal authority commits to deficit finance).

We begin by looking at the impact of shocks to the convenience yield of domestic bonds, captured by an exogenous change to  $\theta$ . Figure 6 shows the response of domestic and foreign output gaps, as well as of nominal variables, namely domestic and foreign inflation as well as terms-of-trade and nominal exchange rates, in response to a temporary, but persistent 100 basis point change to convenience yields on Home bonds enjoyed by Home households, by which convenience yields enjoyed by the Home household *increase*.

The black lines depict the impulse-responses under a monetary-led policy mix; that is, when the Taylor Principle holds in either of the two economies. Under this policy scenario, the quantitative effects of the policy shock are marginal, and mostly drive the terms of trade (and, by extension, the exchange rate). Since domestic bonds are considered relatively more attractive, the majority holders of Home bonds enjoy a positive relative wealth effect - in this case, these are the Home households. Because of the present home bias, this increases in particular demand for the domestic

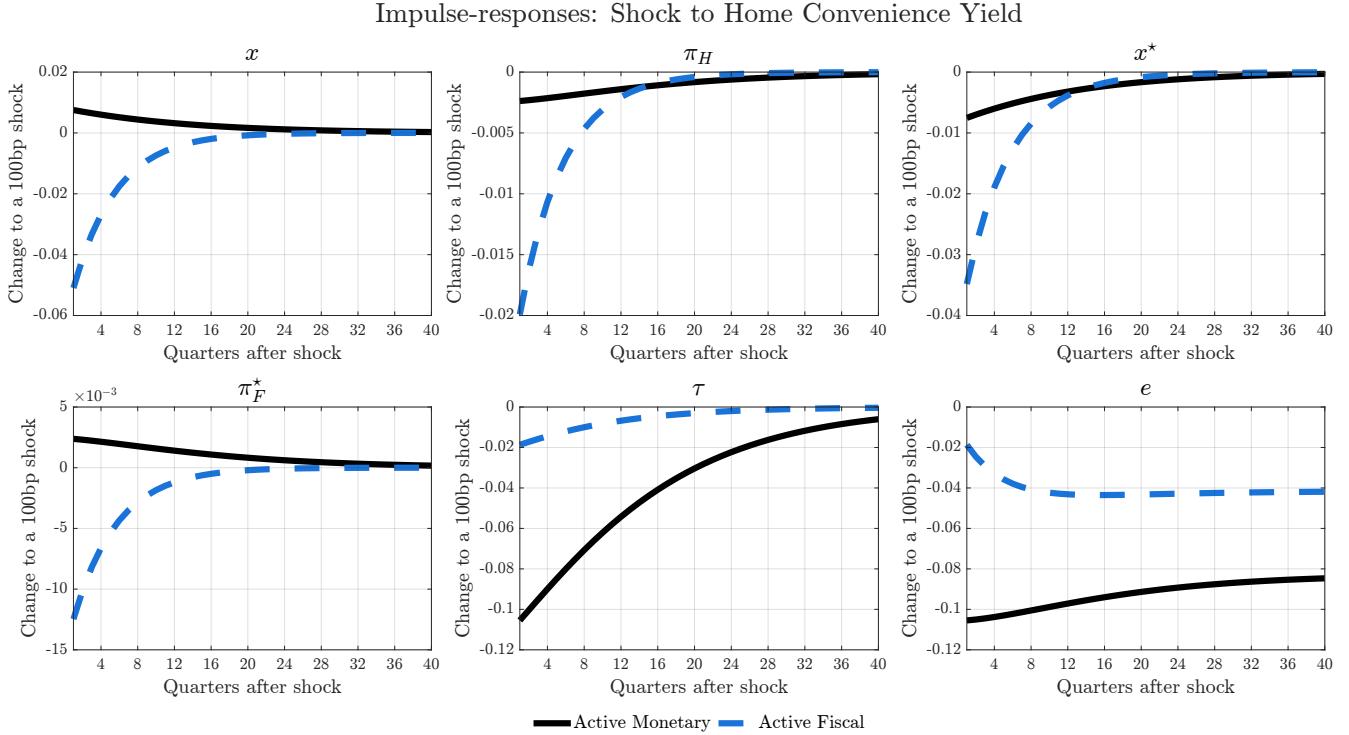


Figure 6: Impulse response functions following a Home convenience yield shock.

good, leading to a positive output gap at Home, and by extension a negative output gap at Foreign.

Under a fiscally-led policy mix (blue lines), the quantitative effects of the Home convenience yield shock on output and inflation are significantly larger, which comes through a reduction of the importance of the terms-of-trade channel. Under a fiscally-led policy mix, a Home convenience yield shock does not induce much of a change in the relative prices of Home and Foreign goods at Home, but loads more on the real output gap and, by extension, on inflation. Since a fiscally-led policy mix induces a commitment of the fiscal authority to not maintain a balanced budget, the convenience yield shock effectively constitutes a negative wealth shock for the households holding Home-issued debt. By this channel, demand in either country decreases and we observe a negative deviation of output from its steady-state level, translating to disinflationary pressure through the Phillips Curve.

We next look at the effects of an expansionary Home government spending shock,  $\nu_t^s$ . Figure 7 presents the results of this exercise.

Consider first the case of a monetary-led policy mix (red solid line). The real effect of the sizeable government spending increase is virtually zero. Because households are Ricardian in this setting, they know that the government spending increase does not bear any relevance for their true household wealth, so no real expansion can be observed. Government spending merely crowds out private spending. Because of the underlying tightening of real interest rates induced by the central bank in response to the expansionary fiscal measure, the Home output gap even turns slightly

### Impulse-responses: Shock to Home Govt. Spending

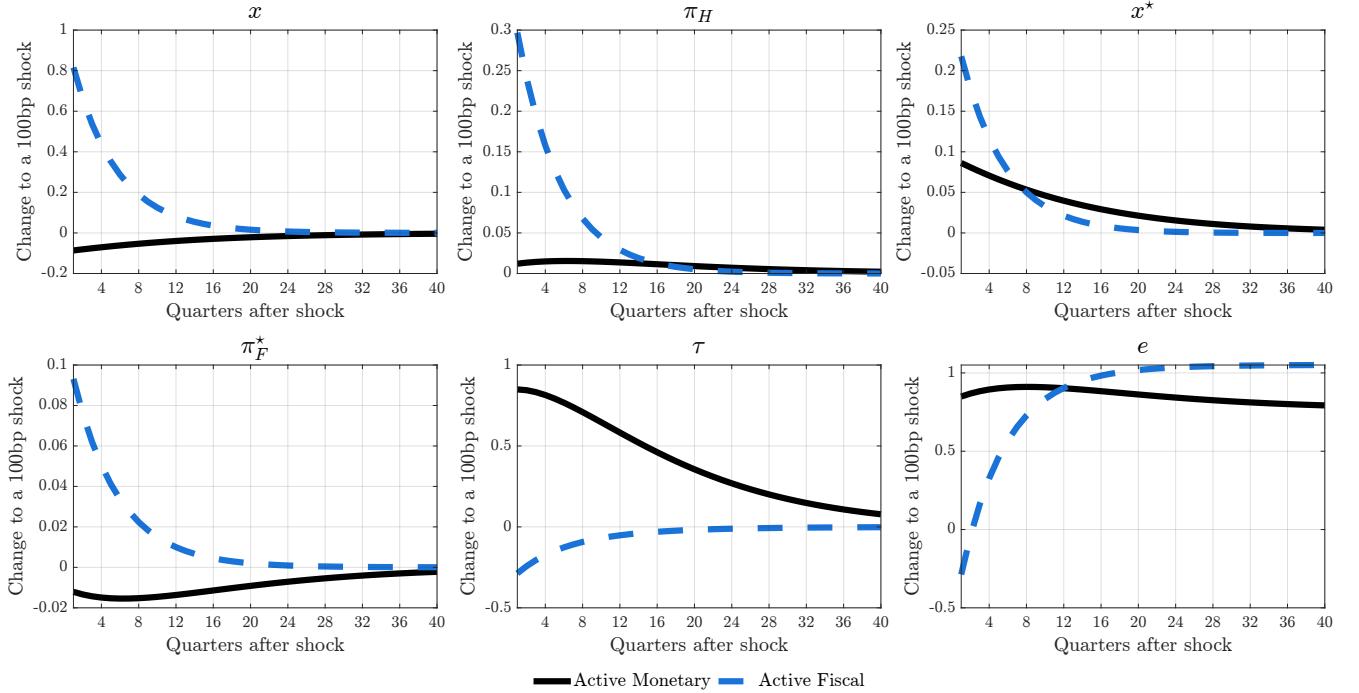


Figure 7: Impulse response functions following an expansionary Home government spending shock

negative. Instead, the shock mostly transmits to a deterioration in the terms-of-trade from the perspective of Home, coincident with an exchange rate depreciation. This allows a slight expansion of Foreign output, contributing to a slight increase in Foreign inflation.

Once we switch the policy mix to a fiscally-led scenario, the fiscal spending measure is barely crowding out private consumption, since households do not perceive the fiscal expansion as neutral to their wealth. Correspondingly, Home inflation increases significantly through the Phillips Curve. Foreign output and inflation, in turn, are boosted through two distinct channels: the first, direct channel is that a part of the Home household consumption basket consists of both Home and Foreign goods, and Home households increasing their demand for Foreign goods spurs positive Foreign output gaps and inflation. The second effect is rooted in the valuation of the two types of government debt: because of the fiscal expansion at Home, foreign debt is a relatively more attractive savings vehicle. In short, the Foreign country receives a net financial inflow, leading to a permanent appreciation of its exchange rate (bottom right panel). By this, the current majority holders of Foreign government debt, which are Foreign households, enjoy a positive wealth effect. This effect in turn translates to an increase in local demand and, thereby, an increase in the inflation rate at Foreign. Additionally, the inflationary pressure induces at least a partial tightening of nominal interest rates at Foreign, thereby increasing the cost of borrowing for the Foreign fiscal authority, further contributing to inflationary pressure in Foreign.

In sum, the government spending increase here exhibits the type of *fiscal contagion* that we

intended to isolate: a Home government spending increase translates to Home inflation, a long-lasting Home depreciation, *and* Foreign inflation through (i) a relative positive wealth effect on behalf of the Foreign household and (ii) increased costs of borrowing for the Foreign government.

## 4.9 Estimation

As a final exercise, we now conduct a full-information maximum-likelihood estimation of the model. We estimate the model in quarterly frequency, starting in 1997-Q1 (after the Bank of England obtained full operational independence) until 2024-Q4.

For the estimation, we use data obtained through FRED. We use conventional output gap estimates for the U.S. and the U.K., and use a de-meaned quarterly inflation measure. The terms-of-trade are derived using the USD-GBP spot exchange rate, adjusted through the relative import/export price levels derived through the nominal and real import/export quantities. Total and local bond issuances are defined as the demeaned quarter-on-quarter growth rates in observed market values of total bond stocks.

In sum, we conduct our estimation on 8 data series (Home/Foreign output gap, Home/Foreign local inflation, terms of trade, Home/Foreign total bond issuance, quantity of Home bonds held at Home) for the U.S. (Home) and the U.K. (Foreign), varying the policy parameters  $\phi_\pi$ ,  $\phi_x$ ,  $\phi_\pi^*$ ,  $\phi_x^*$ ,  $\psi_b$ , and  $\psi_b^*$ , as well as the convenience yield shifters  $\zeta_H$  and  $\zeta_F$ , and the elasticity of substitution between Home and Foreign goods  $\eta$ . In addition, we vary the persistence and standard deviations of all six shock processes and allow for the existence of measurement error in the convenience yield and the Foreign output gap, as those data measures are relatively imprecisely estimated. Finally, we remain agnostic as to whether either policy authority is active/passive in each country, forgoing any strict priors on these quantities.

Policy and convenience yield parameters			Shock persistence & s.d.		
Parameter	Estimate	Std. Error	Parameter	Estimate	Std. Error
$\phi_\pi$	0.9141	0.0146	$\rho_\theta$	0.3990	0.0000
$\phi_\pi^*$	0.9806	0.0021	$\rho_\theta^*$	0.9804	0.0322
$\phi_x$	0.0082	0.0043	$\rho_{\hat{g}}$	0.8137	0.0357
$\phi_x^*$	-0.0089	0.0035	$\rho_{\hat{g}}^*$	0.7655	0.0122
$\psi_b$	0.0373	0.0192	$\rho_\nu$	0.8917	0.1990
$\psi_b^*$	-0.0818	0.0439	$\rho_\nu^*$	0.9643	0.0277
$\zeta_H$	0.8903	0.0000	$\sigma_{e,\theta}$	0.0001	0.0000
$\Psi$	0.2210	0.0329	$\sigma_{e,\theta}^*$	0.1133	0.0000
			$\sigma_{e,\nu}$	0.0636	0.0000
			$\sigma_{e,\nu}^*$	0.1204	0.0348

*Log-likelihood:* -555.313

Table 5: Maximum Likelihood Estimates using U.S. and U.K. data since 1997

Table 5 presents the results of the estimation. Both in the U.S. and the U.K., the estimation of the model using the data favours a *fiscally-led policy mix*, with marginal tax rates being relatively unreactive to deviations of the value of domestic government debt from steady-state, and with the Taylor principle not being satisfied. Estimated steady-state convenience yields are relatively high, validating their use as the principal tool breaking perfect cross-country risk sharing. The estimates of the persistence and standard deviations of the shocks are also fairly standard, although the estimate for the persistence and standard deviation of Home convenience yield shocks are each surprisingly low.

With that estimation at hand, we now intend to decompose the historical variation in the key nominal variables of interests: Home (U.S.) inflation, Foreign (U.K.) inflation, and exchange rates, captured here through the terms-of-trade. Figure 8 presents the decomposition of the individual contributors to movements of nominal U.S. and U.K. variables since 2015.

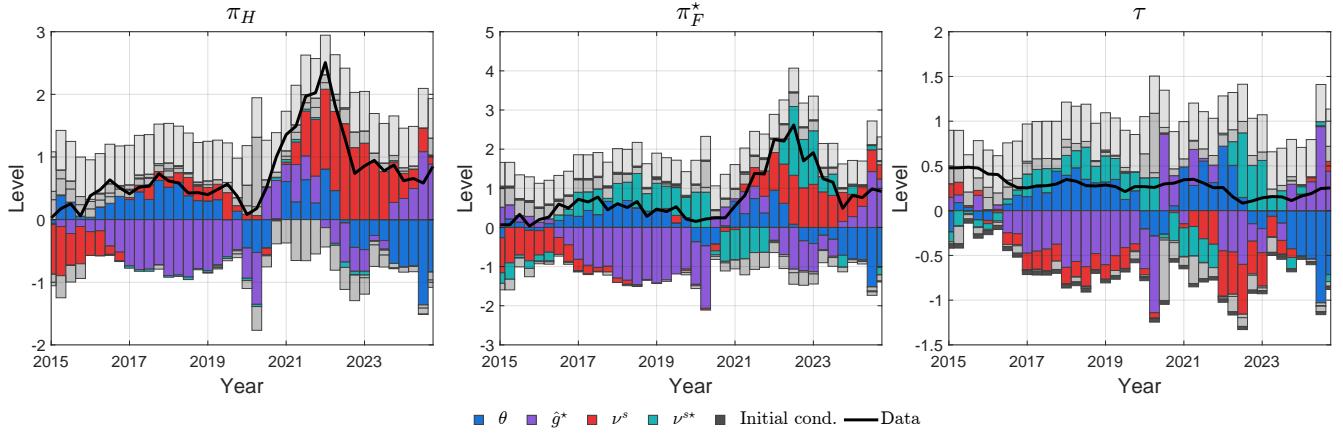


Figure 8: Historical shock decomposition implied by the model.

The grey bars represent estimated initial conditions, and the white bars estimate the sum of other shock components that contribute, on aggregate, relatively little. The coloured bars represent the contributions of each shock component in line with the depicted legend. In a nutshell, the post-Covid fiscal expansion in the U.S. (red bars) appears to have contributed predominantly to U.S. inflation, making up 30% of the total inflationary pressure observed in the U.S. in the years 2021-2023. At the same time, the post-Covid fiscal expansion in the U.K. (light blue bars) has contributed particularly to inflation in the U.K., making up 20% of the total inflationary pressure observed in the U.K. in the years 2021-2023. The U.S. fiscal expansion primarily contributed to a depreciation of U.S. terms-of-trade in that same period, while the U.K. fiscal expansion contributed to an appreciation of U.S. terms-of-trade.

The novel mechanism highlighted in this paper is how deficits in the U.S. (red bars) can impact inflation in the U.K., the Foreign country (centre panel). Through the mechanisms highlighted in the discussion of the IRFs (positive relative wealth effect due to higher demand for Foreign good

and relative deterioration of the U.K. fiscal position), the fiscal expansion in the U.S. spilled over to U.K. inflation rates, contributing in total to almost 2.5 percentage points of the total inflationary pressure observed in the U.K. since 2021.

Complementing this decomposition is figure 9, depicting the hypothetical evolution of the output gaps, inflation rates, Home bond issuance, and the nominal exchange rate if the deficits observed in the U.S. were halved since 2021. This exercise confirms the intuition and discussion behind figure 8, highlighting additionally how the reduced fiscal expansion could have contributed to less of an overshooting of output above its natural level, as well as how U.S. fiscal policy contributed to the deterioration of the USD relative to the GBP since 2021.

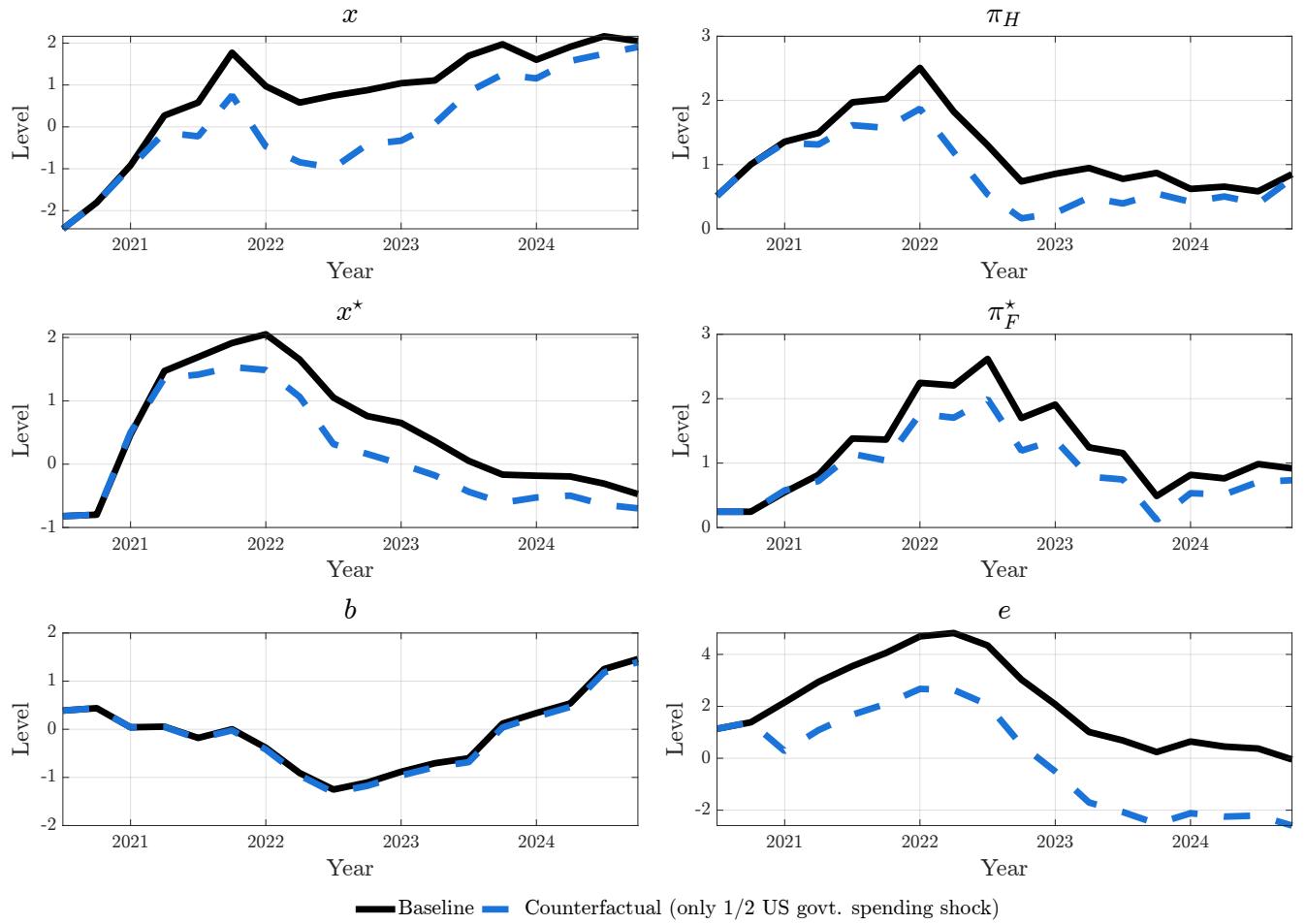


Figure 9: Counterfactual: halving the U.S. fiscal deficit since 2021.

## 5 Conclusion

This paper shows that fiscal sustainability in an open economy is jointly disciplined by expected primary surpluses and by the currency-denominated discount factor global investors apply to those surpluses, which, by extension, link fiscal surpluses to exchange rates. Using market-value debt data for the United Kingdom and the United States since 1975, we apportion roughly 50 percent of unexpected year-to-year changes in the U.K. debt ratio to revisions in surplus expectations and the remaining 50 percent to discount-rate news, with the latter being split across global yields, real-exchange-rate revisions, and time-varying UIP premia. The revisions in surplus expectations, in turn, are highly correlated to corresponding revisions in observed exchange rates. A tractable two-country model rationalises these findings: expected fiscal shocks in a financial hegemon propagate internationally through exchange-rate adjustments that feed directly into the real discount rates faced by other sovereigns, generating what we term “fiscal contagion.” In the model, the core mechanism is that deficits in the financial hegemon cause a spillover to the cost of borrowing for the government of the other economy, yielding an expected future appreciation of the hegemon’s currency that equates cross-country financial flows over a finite horizon. By this mechanism, the current market value of bonds in the non-hegemon economy decreases, leading additionally to an international transmission of fiscal inflation.

These results carry three policy implications. First, debt-management strategies that focus narrowly on flow deficits risk misdiagnosing solvency when large portions of debt dynamics stem from repricing of existing liabilities. Second, credible policies that stabilise the currency-denominated discount factor—through inflation control, anchoring of FX risk premia, or issuance in a diversified mix of currencies—can materially ease the fiscal burden even when deficits are large. Third, prudent coordination of fiscal and exchange-rate policies can mitigate cross-border spillovers; ignoring them risks pro-cyclical tightening just when domestic stabilisation is most needed.

# References

- Alberola, E., Cantu Garcia, C., Cavallino, P., and Mirkov, N. (2021). Fiscal Regimes and the Exchange Rate. *Bank for International Settlements WP no. 950*.
- Angeletos, G.-M., Lian, C., and Wolf, C. K. (2024). Can Deficits Finance Themselves? *Econometrica*, 92(5):1351–1390.
- Atkeson, A. and Burstein, A. (2008). Pricing-to-market, Trade Costs, and International Relative Prices. *American Economic Review*, 98(5):1998–2031.
- Bacchetta, P. and Van Wincoop, E. (2004). A Scapegoat Model of Exchange-Rate Fluctuations. *American Economic Review*, 94(2):114–118.
- Backus, D. K. and Smith, G. W. (1993). Consumption and Real Exchange Rates in Dynamic Economies with Non-traded Goods. *Journal of International Economics*, 35(3–4):297–316.
- Bajzik, J., Havranek, T., Irsova, Z., and Schwarz, J. (2019). The Elasticity of Substitution Between Domestic and Foreign Goods: A Quantitative Survey.
- Banerjee, R., Boctor, V., Mehrotra, A. N., and Zampolli, F. (2022). *Fiscal Deficits and Inflation Risks: The Role of Fiscal and Monetary Regimes*. Bank for International Settlements, Monetary and Economic Department.
- Barro, R. J. and Bianchi, F. (2024). Fiscal Influences on Inflation in OECD Countries, 2020-2023. *NBER Working Paper*, (31838).
- Bassetto, M., Benzoni, L., and Hall, J. (2024). On the Mechanics of Fiscal Inflations. Technical report, Working Paper.
- Bassetto, M. and Cui, W. (2018). The Fiscal Theory of the Price Level in a World of Low Interest Rates. *Journal of Economic Dynamics and Control*, 89:5–22.
- Bassetto, M. and Miller, D. S. (2025). A Monetary-Fiscal Theory of Sudden Inflations. *The Quarterly Journal of Economics*, pages 1–42.
- Benigno, P. and Missale, A. (2004). High Public Debt in Currency Crises: Fundamentals Versus Signaling Effects. *Journal of International Money and Finance*, 23(2):165–188.
- Bergin, P. R. (2000). Fiscal Solvency and Price Level Determination in a Monetary Union. *Journal of Monetary Economics*, 45(1):37–53.

- Bianchi, F., Faccini, R., and Melosi, L. (2023). A Fiscal Theory of Persistent Inflation. *The Quarterly Journal of Economics*, 138(4):2127–2179.
- Bigio, S., Caramp, N., and Silva, D. (2024). Sticky Inflation: Monetary Policy when Debt Drags Inflation Expectations. Technical report, National Bureau of Economic Research WP no. w33190.
- Bodenstein, M., Cuba-Borda, P. A., Gornemann, N. M., and Presno, I. (2024). Exchange Rate Disconnect and the Trade Balance. Technical report, Board of Governors of the Federal Reserve System (US).
- Bordo, M. D., Bush, O., and Thomas, R. (2022). “Muddling Through or Tunnelling Through?” UK Monetary and Fiscal Exceptionalism During the Great Inflation. *Working Paper*.
- Cairns, A. and Wilkie, D. (2023). British Government Securities Database. Data retrieved from the Heriot-Watt University Institute and Faculty of Actuaries, <https://www.macs.hw.ac.uk/~andrewc/gilts/>.
- Campbell, J. Y. and Shiller, R. J. (1988). The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors. *The Review of Financial Studies*, 1(3):195–228.
- Campos, R. G., Fernández-Villaverde, J., Nuño, G., and Paz, P. (2024). Navigating by Falling Stars: Monetary Policy with Fiscally Driven Natural Rates. Technical report, National Bureau of Economic Research.
- Caramp, N. and Silva, D. H. (2023). Fiscal Policy and the Monetary Transmission Mechanism. *Review of Economic Dynamics*, 51:716–746.
- Chari, V. V., Kehoe, P. J., and McGrattan, E. R. (2002). Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates? *The Review of Economic Studies*, 69(3):533–563.
- Chen, X., Leeper, E. M., and Leith, C. (2022a). Strategic Interactions in US Monetary and Fiscal Policies. *Quantitative Economics*, 13(2):593–628.
- Chen, Z., Jiang, Z., Lustig, H., Van Nieuwerburgh, S., and Xiaolan, M. Z. (2022b). Exorbitant Privilege Gained and Lost: Fiscal Implications. Technical report, National Bureau of Economic Research.
- Cochrane, J. (2023). *The Fiscal Theory of the Price Level*. Princeton University Press.
- Cochrane, J. H. (2018). Stepping on a Rake: The Fiscal Theory of Monetary Policy. *European Economic Review*, 101:354–375.

- Cochrane, J. H. (2019). The Value of Government Debt. NBER Working Papers 26090, National Bureau of Economic Research, Inc.
- Cochrane, J. H. (2022a). Fiscal Histories. *Journal of Economic Perspectives*, 36(4):125–46.
- Cochrane, J. H. (2022b). The Fiscal Roots of Inflation. *Review of Economic Dynamics*, 45:22–40.
- Corsetti, G., Dedola, L., and Leduc, S. (2008). International Risk Sharing and the Transmission of Productivity Shocks. *The Review of Economic Studies*, 75(2):443–473.
- Corsetti, G. and Maćkowiak, B. (2006). Fiscal Imbalances and the Dynamics of Currency Crises. *European Economic Review*, 50(5):1317–1338.
- Corsetti, G. and Maćkowiak, B. (2024). Gambling to Preserve Price (and Fiscal) Stability. *IMF Economic Review*, 72(1):32–57.
- Crump, R. K., Eusepi, S., Moench, E., and Preston, B. (2025). How do we Learn about the Long Run? Technical report, Working Paper No. 1150, Federal Reserve Bank of New York.
- Ding, X. and Jiang, Z. (2024). Monetary-Fiscal Coordination with International Hegemon. Technical report, National Bureau of Economic Research.
- Duarte, M. (2003). Why Don't Macroeconomic Quantities Respond to Exchange Rate Variability? *Journal of Monetary Economics*, 50(4):889–913.
- Dupor, B. (2000). Exchange Rates and the Fiscal Theory of the Price Level. *Journal of Monetary Economics*, 45(3):613–630.
- Ellison, M. and Scott, A. (2020). Managing the UK National Debt: 1694–2018. *American Economic Journal: Macroeconomics*, 12(3):227–257.
- Engel, C. and West, K. D. (2005). Exchange Rates and Fundamentals. *Journal of Political Economy*, 113(3):485–517.
- Fama, E. F. (1984). Forward and Spot Exchange Rates. *Journal of Monetary Economics*, 14(3):319–338.
- Galí, J. (2008). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton University Press, Princeton, NJ / Oxford, UK.
- Gopinath, G. and Itskhoki, O. (2022). Dominant Currency Paradigm: A Review. *Handbook of International Economics*, 6:45–90.

- Hall, G. J. and Sargent, T. J. (2011). Interest Rate Risk and Other Determinants of Post-WWII US Government Debt/GDP Dynamics. *American Economic Journal: Macroeconomics*, 3(3):192–214.
- Hazell, J., Herreno, J., Nakamura, E., and Steinsson, J. (2022). The Slope of the Phillips Curve: Evidence from US States. *The Quarterly Journal of Economics*, 137(3):1299–1344.
- Hazell, J. and Hobler, S. (2024). Do Deficits Cause Inflation? A High Frequency Narrative Approach. *mimeo*.
- HM Treasury (2025). Forecasts for the UK Economy. Data retrieved from the official webpage of the UK government, <https://www.gov.uk/government/collections/data-forecasts>.
- Itskhoki, O. (2021). The Story of the Real Exchange Rate. *Annual Review of Economics*, 13(1):423–455.
- Itskhoki, O. and Mukhin, D. (2021). Exchange Rate Disconnect in General Equilibrium. *Journal of Political Economy*, 129(8):2183–2232.
- Jiang, Z. (2021). US Fiscal Cycle and the Dollar. *Journal of Monetary Economics*, 124:91–106.
- Jiang, Z. (2022). Fiscal Cyclicalities and Currency Risk Premia. *The Review of Financial Studies*, 35(3):1527–1552.
- Jiang, Z., Krishnamurthy, A., and Lustig, H. (2021). Foreign Safe Asset Demand and the Dollar Exchange Rate. *The Journal of Finance*, 76(3):1049–1089.
- Jiang, Z., Krishnamurthy, A., and Lustig, H. (2023). Implications of Asset Market Data for Equilibrium Models of Exchange Rates. Technical report, National Bureau of Economic Research.
- Jiang, Z., Krishnamurthy, A., Lustig, H., and Sun, J. (2024a). Convenience Yields and Exchange Rate Puzzles. Technical report, National Bureau of Economic Research.
- Jiang, Z., Lustig, H., Van Nieuwerburgh, S., and Xiaolan, M. Z. (2024b). The US Public Debt Valuation Puzzle. *Econometrica*, 92(4):1309–1347.
- Kaplan, G., Nikolakoudis, G., and Violante, G. L. (2024). Price Level and Inflation Dynamics in Heterogeneous Agent Economies. *National Bureau of Economic Research WP no. w31433*.
- Kawalec, T. (2025). Debt Indexation, Determinacy, and Inflation. Working paper. Available online at <https://tobiaskawalec.com/files/DIDI.pdf>.
- Kekre, R. and Lenel, M. (2024). Exchange Rates, Natural Rates, and the Price of Risk. *University of Chicago, Becker Friedman Institute for Economics Working Paper*, (2024-114).

- 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 Leith, C. (2016). Understanding Inflation as a Joint Monetary–Fiscal Phenomenon. In *Handbook of Macroeconomics*, volume 2, pages 2305–2415. Elsevier.
- Lucas, R. E. and Stokey, N. L. (1983). Optimal fiscal and monetary policy in an economy without capital. *Journal of Monetary Economics*, 12(1):55–93.
- Mac Mullen, M. (2025). Fiscal Policy, Portfolio Frictions, and International Transmission. *mimeo*.
- Meese, R. A. and Rogoff, K. (1983). Empirical Exchange Rate Models of the Seventies: Do They Fit out of Sample? *Journal of International Economics*, 14(1-2):3–24.
- Miao, J. and Su, D. (2024). Fiscal and Monetary Policy Interactions in a Model with Low Interest Rates. *American Economic Journal: Macroeconomics*, 16(4):35–76.
- Mincer, J. A. and Zarnowitz, V. (1969). The Evaluation of Economic Forecasts. In *Economic Forecasts and Expectations: Analysis of Forecasting Behavior and Performance*, pages 3–46. NBER.
- Müller, K., Xu, C., Lehbib, M., and Chen, Z. (2025). The Global Macro Database: A New International Macroeconomic Dataset. Available at SSRN 5121271.
- Reichlin, L., Ricco, G., and Tarbé, M. (2023). Monetary–Fiscal Crosswinds in the European Monetary Union. *European Economic Review*, 151:104328.
- Rogoff, K. (1996). The Purchasing Power Parity Puzzle. *Journal of Economic Literature*, 34(2):647–668.
- Rogoff, K. (2025). *Our Dollar, Your Problem: An Insider’s View of Seven Turbulent Decades of Global Finance, and the Road Ahead*. Yale University Press.
- Rotemberg, J. J. (1982). Monopolistic Price Adjustment and Aggregate Output. *Review of Economic Studies*, 49(4):517–531.
- Sargent, T. J. and Wallace, N. (1981). Some Unpleasant Monetarist Arithmetic. *Federal Reserve Bank of Minneapolis Quarterly Review*, 5(3):1–17.
- Schmitt-Grohé, S. and Uribe, M. (2003). Closing Small Open Economy Models. *Journal of International Economics*, 61(1):163–185.
- Sims, C. A. (1997). Fiscal Foundations of Price Stability in Open Economies. Available at SSRN 75357.

- Sims, C. A. (1999). The Precarious Fiscal Foundations of EMU. *De Economist*, 147(4):415–436.
- Smets, F. and Wouters, R. (2024). Fiscal Backing, Inflation and US Business Cycles. *mimeo*.
- Valchev, R. (2020). Bond Convenience Yields and Exchange Rate Dynamics. *American Economic Journal: Macroeconomics*, 12(2):124–166.
- Werning, I. (2011). Managing a Liquidity Trap: Monetary and Fiscal Policy. NBER Working Paper 17344, National Bureau of Economic Research. Working Paper.
- Woodford, M. (1995). Price-Level Determinacy Without Control of a Monetary Aggregate. In *Carnegie-Rochester Conference Series on Public Policy*, volume 43, pages 1–46. Elsevier.
- Woodford, M. (1998). Control of the Public Debt: A Requirement for Price Stability? In *The Debt Burden and its Consequences for Monetary Policy: Proceedings of a Conference held by the International Economic Association at the Deutsche Bundesbank, Frankfurt, Germany*, pages 117–158. Springer.

# A Omitted Proofs of Simple Model

**Domestic Household.** The household problem can be solved with a standard Lagrangian. For the domestic household,

$$\mathcal{L} = \mathbb{E}_t \sum_{t=1}^2 \beta^t [u(c_t) - L_t + \lambda_t (B_{Ht-1}(1 + \bar{i}) + b_{Ft-1}(1 + i_{t-1}^*) \mathcal{E}_t + P_t L_t - B_{Ht} - B_{Ft} \mathcal{E}_t - P_t(c_t + T_t))],$$

yielding the standard first-order conditions:

$$\begin{aligned} \left[ \frac{\partial \mathcal{L}}{\partial c_t} \right] &: u'(c_t) - P_t \lambda_t = 0, \\ \left[ \frac{\partial \mathcal{L}}{\partial L_t} \right] &: -1 + P_t \lambda_t = 0, \\ \left[ \frac{\partial \mathcal{L}}{\partial B_{Ht}} \right] &: -\lambda_t + \beta \mathbb{E}_t \lambda_{t+1} (1 + \bar{i}) = 0, \\ \left[ \frac{\partial \mathcal{L}}{\partial B_{Ft}} \right] &: -\lambda_t \mathcal{E}_t + \beta \mathbb{E}_t \lambda_{t+1} \mathcal{E}_{t+1} (1 + i_t^*) = 0. \end{aligned}$$

**Foreign Household.** For the Foreign household, the Lagrangian is given by:

$$\begin{aligned} \mathcal{L}^* &= \mathbb{E}_t \sum_{t=1}^2 \beta^t \left[ u(c_t^*) - L_t^* - \phi_F \frac{B_{Ht}^*}{P_t^*} \right. \\ &\quad \left. + \lambda_t^* \left( \frac{B_{Ht-1}^*}{\mathcal{E}_t} (1 + \bar{i}) + B_{Ft-1}^* (1 + i_{t-1}^*) + P_t^* L_t^* - B_{Ht}^* \mathcal{E}_t - B_{Ft}^* - P_t^*(c_t^* + T_t^*) \right) \right], \end{aligned}$$

yielding the first-order conditions:

$$\begin{aligned} \left[ \frac{\partial \mathcal{L}^*}{\partial c_t^*} \right] &: u'(c_t^*) - P_t^* \lambda_t^* = 0, \\ \left[ \frac{\partial \mathcal{L}^*}{\partial L_t^*} \right] &: -1 + P_t^* \lambda_t^* = 0, \\ \left[ \frac{\partial \mathcal{L}^*}{\partial B_{Ht}^*} \right] &: -\phi_F \frac{1}{P_t^*} - \lambda_t^* \frac{1}{\mathcal{E}_t} + \beta \mathbb{E}_t \frac{\lambda_{t+1}^*}{\mathcal{E}_{t+1}} (1 + \bar{i}) = 0, \\ \left[ \frac{\partial \mathcal{L}^*}{\partial B_{Ft}^*} \right] &: -\lambda_t^* + \beta \mathbb{E}_t \lambda_{t+1}^* (1 + i_t^*) = 0. \end{aligned}$$

## Proof of Proposition (3)

*Proof.* We take equation (22) and rewrite it to:

$$(1 + i_1^*) = \frac{\mathcal{E}_1}{\beta \mathbb{E}_1 \left[ \frac{P_1}{P_2} \mathcal{E}_2 \right]}.$$

We now insert here equation (23) after rewriting it to  $\frac{\mathcal{E}_2}{P_2} = \frac{1}{P_2^*} \frac{(1+\bar{i})}{(1+i_1^*)} \frac{B_{H1}^*}{B_{F1}}$ , yielding:

$$\mathcal{E}_1 = \beta \frac{P_1}{P_2^*} (1 + \bar{i}) \frac{B_{H1}^*}{B_{F1}}.$$

Use now equation (21) to replace  $\mathcal{E}_1$  to obtain:

$$\frac{1}{\beta(1 + \bar{i}) \mathbb{E}_1 \left[ \frac{P_1^*}{P_2^*} \frac{1}{\mathcal{E}_2} \right] - \phi_F} = \beta \frac{P_1}{P_2^*} (1 + \bar{i}) \frac{B_{H1}^*}{B_{F1}}.$$

Replacing  $\mathcal{E}_2$  again:

$$\frac{1}{\beta(1 + \bar{i}) \mathbb{E}_1 \left[ \frac{P_1^*}{P_2^*} (1 + i_1^*) \frac{B_{F1}}{B_{H1}^*} \right] - \phi_F} = \beta \frac{P_1}{P_2^*} (1 + \bar{i}) \frac{B_{H1}^*}{B_{F1}}.$$

We now replace the price levels (both materialized and expected) using equations (24), (27), (28), (29), and (30) to obtain:

$$\frac{1}{\beta \frac{1}{\bar{T}} \frac{B_1^*}{\bar{T}^*} \left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1+\bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right] (1 + i_1^*) \frac{B_{F1}}{B_{H1}^*} - \phi_F} = \frac{1}{\left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1+\bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right] (1 + i_1^*) B_1^*} (1 + \bar{i}) \frac{B_{H1}^*}{B_{F1}}. \quad (1)$$

Note here that for  $\phi_F = 0$ ,  $(1 + i_1^*)$  would drop out everywhere and equilibrium would require  $\bar{i} = 0$ , such that we are nesting the expected results of models without such a reduced-form UIP wedge. Rewriting this expression, we obtain a closed-form solution for the foreign interest rate in equilibrium that applies for bonds issued in period 1:

$$(1 + i_1^*) = \phi_F \frac{(1 + \bar{i})}{\bar{i}} \frac{\bar{T}^*}{B_1^*} \frac{B_{H1}^*}{B_{F1}} \frac{1}{\left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1+\bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right]}. \quad (2)$$

□

## Proof of Corollary 4

*Proof.* Simply taking the first derivative of equation (32) yields:

$$\frac{\partial(1 + i_1^*)}{\partial \psi_1} = -\phi_F \frac{(1 + \bar{i})}{\bar{i}} \frac{\bar{T}^*}{B_1^*} \frac{B_{H1}^*}{B_{F1}} \left( \frac{1}{\left[ \psi_1 \frac{\bar{T} - \mu_1}{B_1(1+\bar{i})} + (1 - \psi_1) \frac{1}{P_2^T} \right]} \right)^2 \left( \frac{\bar{T} - \mu_1}{B_1(1+\bar{i})} - \frac{1}{P_2^T} \right).$$

Now, the assumption that  $P_2|_{FL} > P_2|_{ML}$  means that  $\frac{B_1(1+\bar{i})}{\bar{T}-\mu_1} > P_2^T$ , which in turn implies  $\frac{\bar{T}-\mu_1}{B_1(1+\bar{i})} < \frac{1}{P_2^T}$ . Therefore, the last bracket is negative, negating the initial minus sign. All other elements are positive, hence this partial derivative is indeed always larger than zero.  $\square$

## B Appendix: Empirical Framework Microfoundation

**Environment** We consider a world composed of two ex-ante identical economies, labelled Home (H) and Foreign (F). A single traded good serves as the numéraire, so purchasing-power parity holds by construction. Each country is endowed with a constant flow of output,  $Y_t = \bar{Y}$ , which it consumes in equilibrium because there are no production or storage technologies. The representative household in either country maximises discounted expected utility where the coefficient of relative risk aversion  $\gamma > 0$  and discount factor  $\beta \in (0, 1)$  are common across countries.

Governments in both economies issue one-period nominal bonds denominated in their respective currencies and finance exogenous primary surpluses (or deficits) through lump-sum taxes; there are no distortionary instruments. The monetary authority sets the nominal interest rate at which the bonds are issued. Capital markets are frictionless and complete for the two assets under consideration: households in either country can freely trade both Home- and Foreign-currency bonds. Apart from these bonds, no other financial assets or contingent claims are available, and there are no costs of international portfolio adjustment.

With only one good, *purchasing-power parity (PPP)* holds every period

$$\mathcal{E}_t = \frac{P_t}{P_t^*}, \quad \pi_t - \pi_t^* = \Delta e_t,$$

where  $\mathcal{E}_t$  is the nominal exchange rate (H-currency per F-currency),  $P_t$  and  $P_t^*$  are price levels,  $\pi_t = \log P_t - \log P_{t-1}$  and  $e_t = \log \mathcal{E}_t$ .

### B.1 Household Problem

Let  $B_t^H$  denote end-of-period holdings of H-currency bonds bought at  $t$  (i.e. payoff of 1 unit of H-currency at  $t+1$ ). Let  $B_t^F$  denote end-of-period holdings of F-currency bonds bought at  $t$  (i.e. payoff of 1 unit of F-currency at  $t+1$ ). Finally, let  $Q_t^H = 1/(1+i_t)$ ,  $Q_t^F = 1/(1+i_t^*)$  be bond prices.

The *nominal* flow budget constraint of a Home household is

$$P_t C_t + Q_t^H B_t^H + Q_t^F \mathcal{E}_t B_t^F = P_t Y_t + B_{t-1}^H + \mathcal{E}_t B_{t-1}^F + P_t T_t, \quad (3)$$

where  $T_t$  is the lump-sum transfer (tax if negative). The Foreign household has the starred ana-

logue. Each household chooses  $\{C_t, B_t^H, B_t^F\}_{t \geq 0}$  to maximise

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma},$$

subject to equation (3) and no-Ponzi conditions. Let  $\lambda_t$  be the nominal marginal utility. The first-order conditions are

$$\lambda_t Q_t^H = \beta \mathbb{E}_t[\lambda_{t+1}], \quad \lambda_t Q_t^F \mathcal{E}_t = \beta \mathbb{E}_t[\lambda_{t+1} S_{t+1}]. \quad (4)$$

Additionally, the transversality condition for holdings of home and foreign bonds are

$$\lim_{T \rightarrow \infty} \mathbb{E}_t[\beta^T \lambda_{t+T} B_{t+T}^H] = 0, \quad \lim_{T \rightarrow \infty} \mathbb{E}_t[\beta^T \lambda_{t+T} S_{t+T} B_{t+T}^F] = 0.$$

Because  $\lambda_t = U'(C_t)/P_t = C_t^{-\gamma}/P_t$ , equation (4) yields the Euler equation for the home bond and the foreign bond

$$1 = \beta \mathbb{E}_t \left[ \left( \frac{C_t}{C_{t+1}} \right)^{\gamma} \frac{(1+i_t)}{\Pi_{t+1}} \right], \quad (5)$$

$$1 = \beta \mathbb{E}_t \left[ \left( \frac{C_t}{C_{t+1}} \right)^{\gamma} \frac{(1+i_t^*)}{\Pi_{t+1}} \frac{S_{t+1}}{S_t} \right]. \quad (6)$$

Log-linearising around a symmetric steady state ( $C_t = \bar{C}$ ) and dividing the two FOCs deliver the *uncovered-interest-parity (UIP)* condition

$$i_t - i_t^* = \mathbb{E}_t[\Delta e_{t+1}], \quad (7)$$

where  $\Delta e_{t+1} = e_{t+1} - e_t = \log S_{t+1} - \log \mathcal{E}_t$ .

**Symmetric risk-sharing** The economy features a single tradable good, frictionless capital markets with freely traded home and foreign bonds, and representative households in each country with identical preferences. This structure ensures that the real exchange rate is pinned to the ratio of the countries' marginal utilities of consumption. Given the single-good assumption, the real exchange rate is constant and equal to one, which in equilibrium requires the marginal utility of consumption to be equalised across both countries at all times.

With one good and identical preferences, equilibrium implies  $C_t = C_t^*$ , so the two Euler equations collapse to one and consumption is fixed at the endowment level. Because households share an identical utility function, the equalisation of their marginal utilities directly implies that their consumption levels must also be equal,  $C_t = C_t^*$ . This condition represents a state of perfect risk-sharing, where households use international asset trade to completely insure themselves against any country-specific shocks, resulting in identical consumption paths. In the context of this specific

endowment economy, where output is constant and goods markets must clear, this further implies that consumption in each country is fixed at the constant endowment level. This removes all real-side volatility, thereby allowing the analysis to focus exclusively on how fiscal policy and government financing decisions drive nominal asset prices and the exchange rate.

## B.2 Fiscal and Monetary Authority

The starting point is the nominal flow identity for the home government. Debt this period is equal to the principal plus interest on last period debt plus government surpluses

$$B_t = (1 + i_{t-1})B_{t-1} + P_t G_t - P_t T_t.$$

To derive the real budget constraint, we first divide the nominal budget constraint by the price level  $P_t$ :

$$\frac{B_t}{P_t} = (1 + i_{t-1}) \frac{B_{t-1}}{P_t} + \frac{P_t(G_t - T_t)}{P_t}$$

Using the definitions for real debt,  $b_t \equiv \frac{B_t}{P_t}$ , and the real primary surplus,  $s_t \equiv T_t - G_t$ , the equation becomes:

$$b_t = (1 + i_{t-1}) \frac{B_{t-1}}{P_t} - s_t$$

To express this in terms of lagged real debt, we rewrite  $\frac{B_{t-1}}{P_t}$  as  $\frac{B_{t-1}}{P_{t-1}} \cdot \frac{P_{t-1}}{P_t}$ , which is equal to  $b_{t-1}/\Pi_t$ , where  $\Pi_t = P_t/P_{t-1}$  is the gross inflation rate.

$$b_t = (1 + i_{t-1}) \frac{b_{t-1}}{\Pi_t} - s_t$$

The term  $\frac{1+i_{t-1}}{\Pi_t}$  is the gross real interest rate,  $1 + r_{t-1}$ . This gives the exact law of motion for real government debt:

$$b_t = (1 + r_{t-1})b_{t-1} - s_t. \quad (8)$$

By symmetry, the law of motion for government debt in the foreign country is

$$b_t^* = (1 + r_{t-1}^*)b_{t-1}^* - s_t^*, \quad (9)$$

where  $1 + r_{t-1}^* \equiv \frac{1+i_{t-1}^*}{\Pi_t^*}$  is the gross real return rate.

The present-value government budget constraint is derived from the government's fundamental solvency condition. The principle is that the real value of outstanding debt at the start of period  $t$ ,  $B_{t-1}/P_t$ , must equal the expected present value of all future primary surpluses. Future real surpluses ( $s_{t+j}$ ) are discounted using the household's stochastic discount factor (SDF). With constant consumption, the nominal SDF from  $t+j$  to  $t$  simplifies to  $\mathcal{M}_{t,t+j} = \beta^j \frac{P_t}{P_{t+j}}$ . Following asset pricing logic, the nominal value of debt,  $B_{t-1}$ , must equal the sum of expected future nominal

surpluses,  $P_{t+j}s_{t+j}$ , discounted by the nominal SDF:

$$B_{t-1} = \mathbb{E}_t \sum_{j=0}^{\infty} \tilde{M}_{t,t+j}(P_{t+j}s_{t+j}).$$

Through further algebra and dividing by the price level,  $P_t$  we arrive at the government debt valuation equation:<sup>11</sup>

$$\frac{B_{t-1}}{P_t} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j s_{t+j}. \quad (10)$$

By symmetry, the foreign country's government debt valuation equation follows

$$\frac{B_{t-1}^*}{P_t^*} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j s_{t+j}^*. \quad (11)$$

In an *active-fiscal / passive-monetary* regime, equation (10) and (11) determines  $P_t, P_t^*$ : lower expected surpluses must be financed by higher price levels. The monetary authority follows a Taylor rule for both countries

$$1 + i_t = (1 + \bar{i}) \left( \frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_\pi} e^{\varepsilon_t^m}, \quad (12)$$

$$1 + i_t^* = (1 + \bar{i}^*) \left( \frac{\Pi_t^*}{\bar{\Pi}} \right)^{\phi_\pi^*} e^{\varepsilon_t^{m*}}, \quad (13)$$

where  $\bar{\Pi}$  is the common steady-state inflation target,  $\phi_\pi, \phi_\pi^*$  are policy feedback coefficients and  $\varepsilon_t^m, \varepsilon_t^{m*}$  policy-shock innovations. Log-linearising around the deterministic steady state gives

$$\hat{i}_t = \phi_\pi \hat{\pi}_t + \varepsilon_t^m, \quad (14)$$

$$\hat{i}_t^* = \phi_\pi^* \hat{\pi}_t^* + \varepsilon_t^{m*}. \quad (15)$$

**Market-Clearing Conditions** The goods market clearing condition in both countries is

$$C_t = Y_t = \bar{Y}, \quad C_t^* = Y_t^* = \bar{Y}. \quad (16)$$

The (home) bond market clearing condition is

$$B_t = B_t^H + B_t^{*H}, \quad (17)$$

whilst the foreign bond market clearing condition is

$$B_t^* = B_t^F + B_t^{*F}. \quad (18)$$

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<sup>11</sup>Alternatively, we could have iterated the household's budget constraint forward, impose market clearing and invoke the household's transversality condition to arrive at the government debt valuation equation.

Purchasing-power parity is

$$\mathcal{E}_t = \frac{P_t}{P_t^*}. \quad (19)$$

The nominal exchange rate is

$$\pi_t - \pi_t^* = \Delta e_t. \quad (20)$$

### B.3 Equilibrium

For any variable  $X_t$  define the percentage deviation  $\hat{x}_t \equiv \log\left(\frac{X_t}{\bar{X}}\right)$ . At the deterministic steady state

$$\bar{C} = \bar{Y}, \quad \bar{\Pi} = \bar{\Pi}^* = 1, \quad \bar{i} = \bar{i}^* = r, \quad \bar{S} = 1, \quad \bar{s} = \bar{s}^* = 0,$$

while  $(\bar{b}, \bar{b}^*)$  are free long-run debt ratios. Then equilibrium is the set of endogenous variables

$$\{\hat{\pi}_t, \hat{\pi}_t^*, \hat{i}_t, \hat{i}_t^*, \Delta \hat{e}_t, \hat{b}_t, \hat{b}_t^*\}.$$

The equilibrium conditions are:

1. Home Fisher Equation:  $\hat{i}_t = \mathbb{E}_t \hat{\pi}_{t+1}$
2. Foreign Fisher Equation:  $\hat{i}_t^* = \mathbb{E}_t \hat{\pi}_{t+1}^*$
3. UIP condition:  $\hat{i}_t - \hat{i}_t^* = \mathbb{E}_t \Delta \hat{e}_{t+1} + \varphi_t$
4. PPP condition:  $\hat{\pi}_t - \hat{\pi}_t^* = \Delta \hat{e}_t$
5. Home debt equation:  $\rho \hat{b}_{t+1} = \hat{b}_t + \hat{i}_t - \hat{\pi}_{t+1} - \hat{s}_{t+1}$
6. Foreign debt equation:  $\rho \hat{b}_{t+1}^* = \hat{b}_t^* + \hat{i}_t^* - \hat{\pi}_{t+1}^* - \hat{s}_{t+1}^*$
7. Home Taylor rule:  $\hat{i}_t = \phi_\pi \hat{\pi}_t + \varepsilon_t^m$
8. Foreign Taylor rule:  $\hat{i}_t^* = \phi_\pi^* \hat{\pi}_t^* + \varepsilon_t^{m*}$

We have the 5 shocks  $(\hat{s}_{t+1}, \hat{s}_{t+1}^*, \varepsilon_t^m, \varepsilon_t^{m*}, \varphi_t)$ . We have 7 endogenous variables and 8 equations. With “passive” Taylor coefficients ( $0 < \phi_\pi, \phi_\pi^* < 1$ ), Blanchard–Kahn conditions yield a unique stable solution.

### B.4 Derivation of the linearised government debt value equation

*Proof.* We break this proof up into multiple steps.

Recall that the nonlinear nominal budget constraint is given by

$$M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)} = P_{t+1} s p_{t+1} + M_{t+1} + \sum_{j=1}^{\infty} Q_{t+1}^{(t+1+j)} B_{t+1}^{(t+1+j)}.$$

Here,  $s p_{t+1}$  is the *real primary surplus* (i.e. does *not* include interest payments). At the beginning of period  $t+1$ , money  $M_t$  and bonds  $B_t^{(t+1+j)}$  are outstanding.

Recall by definition that the nominal return on the portfolio of government debt (holding period returns) is

$$R_{t+1}^n \equiv \frac{M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)}}{M_t + \sum_{j=1}^{\infty} Q_t^{(t+j)} B_t^{(t+j)}}.$$

We can re-arrange this

$$R_{t+1}^n \left( M_t + \sum_{j=1}^{\infty} Q_t^{(t+j)} B_t^{(t+j)} \right) = M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)}.$$

Re-write the index on the left-hand side

$$R_{t+1}^n \left( M_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)} \right) = M_t + \sum_{j=0}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)}$$

Use the definition of the nominal end-of-period market value of debt

$$V_t \equiv M_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)},$$

to get

$$M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)} = R_{t+1}^n V_t.$$

Plug into equation (5) to get

$$R_{t+1}^n V_t = P_{t+1} s p_{t+1} + M_{t+1} + \sum_{j=1}^{\infty} Q_{t+1}^{(t+1+j)} B_{t+1}^{(t+1+j)}.$$

For the right-hand side, note that we can iterate the nominal end-of-period market value of debt one period forward to get

$$V_{t+1} \equiv M_{t+1} + \sum_{j=0}^{\infty} Q_{t+1}^{(t+2+j)} B_{t+1}^{(t+2+j)}.$$

We can rewrite the index

$$V_{t+1} = M_{t+1} + \sum_{j=1}^{\infty} Q_{t+1}^{(t+1+j)} B_{t+1}^{(t+1+j)}.$$

Therefore can plug this in to conclude

$$V_{t+1} = R_{t+1}^n V_t - P_{t+1} s p_{t+1}. \quad (21)$$

The nominal value of government debt is increased by the nominal rate of return, and decreased by primary surpluses.

**Step 2. Introduce stationarity.** First, divide through by  $P_{t+1}$

$$\begin{aligned} &\leftrightarrow V_{t+1} = V_t R_{t+1}^n - P_{t+1} s p_{t+1} \\ &\leftrightarrow \frac{V_{t+1}}{P_{t+1}} = V_t \frac{R_{t+1}^n}{P_{t+1}} - s p_{t+1} \\ &\leftrightarrow \frac{V_{t+1}}{P_{t+1}} = V_t \frac{R_{t+1}^n}{P_t} \frac{P_t}{P_{t+1}} - s p_{t+1} \\ &\Rightarrow \frac{V_t}{P_t} R_{t+1}^n \frac{P_t}{P_{t+1}} = \frac{V_{t+1}}{P_{t+1}} + s p_{t+1}. \end{aligned}$$

Next, divide by output at time  $t + 1$

$$\begin{aligned} &\leftrightarrow \frac{V_t}{P_t} R_{t+1}^n \frac{P_t}{P_{t+1}} \frac{1}{Y_{t+1}} = \frac{V_{t+1}}{Y_{t+1} P_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \\ &\leftrightarrow \frac{V_t}{P_t} R_{t+1}^n \frac{P_t}{P_{t+1}} \frac{Y_t}{Y_{t+1}} \frac{1}{Y_t} = \frac{V_{t+1}}{Y_{t+1} P_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \\ &\leftrightarrow \frac{V_t}{P_t Y_t} R_{t+1}^n \frac{P_t}{P_{t+1}} \frac{Y_t}{Y_{t+1}} = \frac{V_{t+1}}{Y_{t+1} P_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \\ &\leftrightarrow \frac{V_t}{P_t Y_t} R_{t+1}^n \frac{1}{\Pi_{t+1}} \frac{1}{G_{t+1}} = \frac{V_{t+1}}{Y_{t+1} P_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \\ &\Rightarrow \boxed{\frac{V_t}{P_t Y_t} R_{t+1}^n \frac{1}{\Pi_{t+1}} \frac{1}{G_{t+1}} = \frac{V_{t+1}}{P_{t+1} Y_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}}}, \end{aligned}$$

where we defined GDP growth  $G_{t+1} \equiv \frac{Y_{t+1}}{Y_t}$  and inflation rate  $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ .

**Step 3. Campbell-Shiller linearisation.** Take logs of both sides to get

$$\begin{aligned} &\log \left( \frac{V_t}{P_t Y_t} R_{t+1}^n \frac{1}{\Pi_{t+1}} \right) = \log \left( \frac{V_{t+1}}{P_{t+1} Y_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \right) \\ &\Rightarrow \log \left( \frac{V_t}{P_t Y_t} \right) + \log (R_{t+1}^n) - \log (G_{t+1}) - \log (\Pi_{t+1}) = \log \left( \frac{V_{t+1}}{P_{t+1} Y_{t+1}} + \frac{s p_{t+1}}{Y_{t+1}} \right). \end{aligned}$$

We define

- $v_t \equiv \log \left( \frac{V_t}{P_t Y_t} \right)$ ,
- $r_{t+1}^n \equiv \log (R_{t+1}^n)$ ,

- $\pi_{t+1} \equiv \log(\Pi_{t+1})$ ,
- $g_{t+1} \equiv \log(G_{t+1})$ .

So we get

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \log\left(\frac{V_{t+1}}{P_{t+1}Y_{t+1}} + \frac{sp_{t+1}}{Y_{t+1}}\right).$$

Finally, define the new variable  $sy_{t+1} \equiv \frac{sp_{t+1}}{Y_{t+1}}$ .

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \log\left(sy_{t+1} + \frac{V_{t+1}}{P_{t+1}Y_{t+1}}\right).$$

We linearise this equation in the *level* of the surplus, not its log since the surplus may be negative. We Taylor expand the right-hand side of the above expression around the steady-state values  $(sy, v)$ :

$$\begin{aligned} \log\left\{sy_{t+1} + \frac{V_{t+1}}{P_{t+1}}\right\} &= \log\left\{sy_{t+1} + \exp\left(\log\left\{\frac{V_{t+1}}{P_{t+1}}\right\}\right)\right\} \\ &= \log\left\{sy_{t+1} + e^{v_{t+1}}\right\} \\ &\approx \log\left\{sy + e^v\right\} + \frac{1}{sy + e^v}(sy_{t+1} - sy) + \frac{e^v}{sy + e^v}(v_{t+1} - v) \\ &= \left[\log\left\{sy + e^v\right\} - \frac{1}{sy + e^v}sy - \frac{e^v}{sy + e^v}v\right] + \frac{1}{sy + e^v}sy_{t+1} + \frac{e^v}{sy + e^v}v_{t+1} \\ &= \left[\log\left\{sy + e^v\right\} - \frac{e^v}{sy + e^v}[v + sye^{-v}]\right] + \frac{1}{sy + e^v}sy_{t+1} + \frac{e^v}{sy + e^v}v_{t+1}. \end{aligned}$$

Therefore, the linearisation is

$$\log\left\{sy_{t+1} + \frac{V_{t+1}}{P_{t+1}}\right\} = \left[\log\left\{sy + e^v\right\} - \frac{e^v}{sy + e^v}[v + sye^{-v}]\right] + \frac{1}{sy + e^v}sy_{t+1} + \frac{e^v}{sy + e^v}v_{t+1}.$$

We first compute the steady-state relationships. First, do the following manipulation

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \log\left\{sy_{t+1} + \exp\left(\log\left\{\frac{V_{t+1}}{P_{t+1}Y_{t+1}}\right\}\right)\right\}.$$

Now evaluate at steady state

$$\begin{aligned}
&\leftrightarrow v + r^n - \pi - g = \log\{sy + e^v\} \\
&\leftrightarrow r^n - \pi - g = \log\{sy + e^v\} - v \\
&\leftrightarrow r^n - \pi - g = \log\{sy + e^v\} - \log\{e^v\} \\
&\leftrightarrow r^n - \pi - g = \log\left(\frac{sy + e^v}{e^v}\right) \\
&\leftrightarrow \frac{sy + e^v}{e^v} = e^{r^n - \pi - g} \\
\Rightarrow & \boxed{\frac{e^v}{sy + e^v} = e^{\pi + g - r^n}}.
\end{aligned}$$

Now we substitute steady-state values into the Taylor expansion. Using

$$\log\{sy + e^v\} = v + r^n - \pi - g, \quad \frac{1}{sy + e^v} = \frac{e^{\pi + g - r^n}}{e^v}, \quad \frac{e^v}{sy + e^v} = e^{\pi + g - r^n},$$

we can plug this into the right-hand side of the linearisation

$$\log\left\{sy_{t+1} + \frac{V_{t+1}}{P_{t+1}}\right\} = \left[\log\{sy + e^v\} - \frac{e^v}{sy + e^v} [v + sye^{-v}]\right] + \frac{1}{sy + e^v} sy_{t+1} + \frac{e^v}{sy + e^v} V_{t+1}.$$

to get the right-hand side to be

$$[(v + r^n - \pi - g) - e^{\pi + g - r^n}(v + sye^{-v})] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1}.$$

We now do some algebra on this right-hand side

$$\begin{aligned}
&\leftrightarrow [(v + r^n - \pi - g) - e^{\pi + g - r^n}(v + sye^{-v})] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1} \\
&\leftrightarrow [(v + r^n - \pi - g) - e^{\pi + g - r^n}(v + sye^{-v} + 1 - 1)] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1} \\
&\leftrightarrow [(v + r^n - \pi - g) - \underbrace{e^{\pi + g - r^n}\left(v + \frac{sy + e^v}{e^v} - 1\right)}_{= \frac{e^v}{sy + e^v}}] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1} \\
&\leftrightarrow [(v + r^n - \pi - g) - \underbrace{\frac{e^v v}{sy + e^v}}_{= e^{\pi + g - r^n}} - \underbrace{\frac{e^v}{sy + e^v} \frac{sy + e^v}{e^v}}_{= 1} + \frac{e^v}{sy + e^v}] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1} \\
&\leftrightarrow [(v + r^n - \pi - g) - \underbrace{\frac{e^v}{sy + e^v} v}_{= e^{\pi + g - r^n}} - 1 + \underbrace{\frac{e^v}{sy + e^v}}_{= e^{\pi + g - r^n}}] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1} \\
&\leftrightarrow [(v + r^n - \pi - g) - e^{\pi + g - r^n} v - 1 + e^{\pi + g - r^n}] + \frac{e^{\pi + g - r^n}}{e^v} sy_{t+1} + e^{\pi + g - r^n} V_{t+1}.
\end{aligned}$$

Now define

$$\rho \equiv e^{\pi+g-r^n}.$$

Plug this in

$$\begin{aligned} &\leftrightarrow \left[ (v + r^n - \pi - g) - \rho v + \rho - 1 \right] + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1} \\ &\leftrightarrow \left[ (r^n - \pi - g) + v(1 - \rho) + (\rho - 1) \right] + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1} \\ &\leftrightarrow \left[ (r^n - \pi - g) + v(1 - \rho) - (1 - \rho) \right] + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1} \\ &\Rightarrow \boxed{(r^n - \pi - g) + (1 - \rho)(v - 1) + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1}}. \end{aligned}$$

So now go back to

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \log \left( s y_{t+1} + \frac{V_{t+1}}{P_{t+1} Y_{t+1}} \right).$$

Plug in our log-linearised expression for the right-hand side

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = (r^n - \pi - g) + (1 - \rho)(v - 1) + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1}.$$

We suppress the small constant terms (since we treat all variables as mean-zero).

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \underbrace{\left[ (r^n - \pi - g) + (1 - \rho)(v - 1) \right]}_{\text{tiny constant}} + \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1}.$$

Therefore,

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = \frac{\rho}{e^v} s y_{t+1} + \rho v_{t+1}. \quad (\text{A.11}')$$

Define the scaled surplus innovation

$$s_{t+1} \equiv \frac{\rho}{e^v} s y_{t+1},$$

so that the equation becomes

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = s_{t+1} + \rho v_{t+1}.$$

Finally, re-arrange to get the linearised flow identity

$$\boxed{\rho v_{t+1} = v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} - s_{t+1}}$$

□

## B.5 Further relegated details on the VAR framework

Here, we present the derivations underpinning the VAR model estimated in section 2. The derivations generally lean on [Cochrane \(2019\)](#), which we extend straightforwardly to an open economy framework.

We begin by a brief description of the historical episodes examined in figure 10, through which we are able to procure a narrative of major U.K. fiscal episodes, in line with [Ellison and Scott \(2020\)](#).

**Great-Inflation era and the first peacetime deficits (1970–1978).** From 1972 the plotted ratio turns persistently negative, bottoming near  $-0.15$ . This occurred during the March 1972 “dash-for-growth” budget, which combined large tax cuts with relaxed credit controls; borrowing requirements jumped to £3.4 billion—then 5% of GDP. The demand boom collided with the 1973 oil shock, pushing CPI inflation into double digits, real wages negative, and gilt yields to post-war highs. For the first time in three centuries Britain ran substantial primary deficits outside of wartime. Market participants began to price a fiscal dominance regime: Sterling sold off, gilt investors demanded an inflation premium, and the surplus-over-debt ratio remained below zero until the 1976 IMF program.

**Thatcher consolidation, the ERM Crisis, and 1990s Expansion (1979–2000).** After 1979 the series climbs back into positive surpluses territory. The 1980 Medium-Term Financial Strategy imposed cash limits on departmental spending, turning a structural deficit into a modest surplus within four years. There were subsequent positive surpluses during the Thatcher administration. However, the sharp dip around 1992–93 reflects the twin blows of a deep domestic recession and “Black Wednesday”. When speculative pressure forced Sterling out of the Exchange Rate Mechanism, the Treasury raised base rates to 15% in a failed defence of the parity; output contracted and tax receipts collapsed. The surplus-over-debt ratio falls accordingly. On the valuation side, the real exchanged rate dropped 15% within weeks, instantly re-inflating the domestic-currency value of foreign-currency gilts and widening the implied deficit in Figure 10. The subsequent adoption of inflation targeting stabilised expectations, and the ratio drifted back towards zero by 1995.

Between 1996 and 2000 the surplus series drifted close to balance. Robust productivity growth, a high tax base and restrained departmental spending kept the cash deficit near zero. At the same time, falling global real rates reduced the discount factor applied to future surpluses, so only tiny primary surpluses were required to keep the ratio flat. Flows and valuations move in opposite directions, leaving the debt ratio broadly unchanged.

**Global Financial Crisis and its aftermath (2008–2013).** Figure 10 records the deepest post-war trough during 2009–12. GDP fell 4.5% in 2009, policy aimed at stabilising the banking system pushed the headline deficit above 10% of GDP, and automatic stabilisers added another 2 percentage points to deficits. Meanwhile, Bank of England gilt purchases suppressed real yields to multi-decade lows, which the accounting identity treats as requiring even larger negative surpluses to match the observed market value of debt. Public-sector net debt jumped from 41% to 81% of GDP, the largest peace-time increase on record.

**Pre-Covid recovery and Covid shock (2013–2021).** From 2013 the coalition’s fiscal consolidation and a stabilisation of real rates nudged the ratio back toward zero, but the path is flat rather than rising: low discount factors mean a balanced-budget stance is sufficient for debt stabilisation without the large primary surpluses seen in the 1980s. Modest surpluses in 2017–19 briefly lift the ratio into positive territory, but the Covid-19 pandemic reverses the gains. We see in the early pandemic period that implied surpluses soars to 40% of market value of debt, which seems paradoxical after the large fiscal stimulus packages announced during the pandemic. Emergency spending, furlough schemes and revenue shortfalls generate a deficit of 14.6% of GDP in 2020. Yet in Figure 10 the 2020 point *rises* to +0.42. The explanation lies in the valuation channel: gilt real yields turned sharply negative and inflation picked up, generating a large *implied* surplus in present-value terms even as the cash balance deteriorated. The post-Covid fiscal expansion was cushioned by deeply negative real rates, easing near-term debt-sustainability concerns. This is a [Lucas and Stokey \(1983\)](#) state-contingent financing of debt through surprise inflation. The episode encapsulates the fiscal-theory message: debt dynamics hinge on the path of discount factors and prices as much as on the arithmetic of tax minus spending.

Taken together, Figure 10 shows that shifts in the surplus-over-debt ratio align closely with the regime breaks and policy narratives documented by [Bordo et al. \(2022\)](#). Episodes that placed acute pressure on public finances, such as war financing, the 1970s stagflation, or the Global Financial Crisis—drives the surplus ratio deep into negative territory, whereas phases of deliberate consolidation or windfall receipts keeps surpluses persistently positive. Crucially, the accounting framework highlights that shifts in valuation terms—unexpected inflation and movements in discount rates—can do as much of the adjustment work as the cash-flow surpluses in reconciling the government budget constraint.

### B.5.1 Additional details on the backward decomposition

The present-value identity in section 2 turns a sequence of forward flows into one equilibrium condition we can take to the data and decompose visually into economically meaningful pieces. We here derive how this identity can be derived.

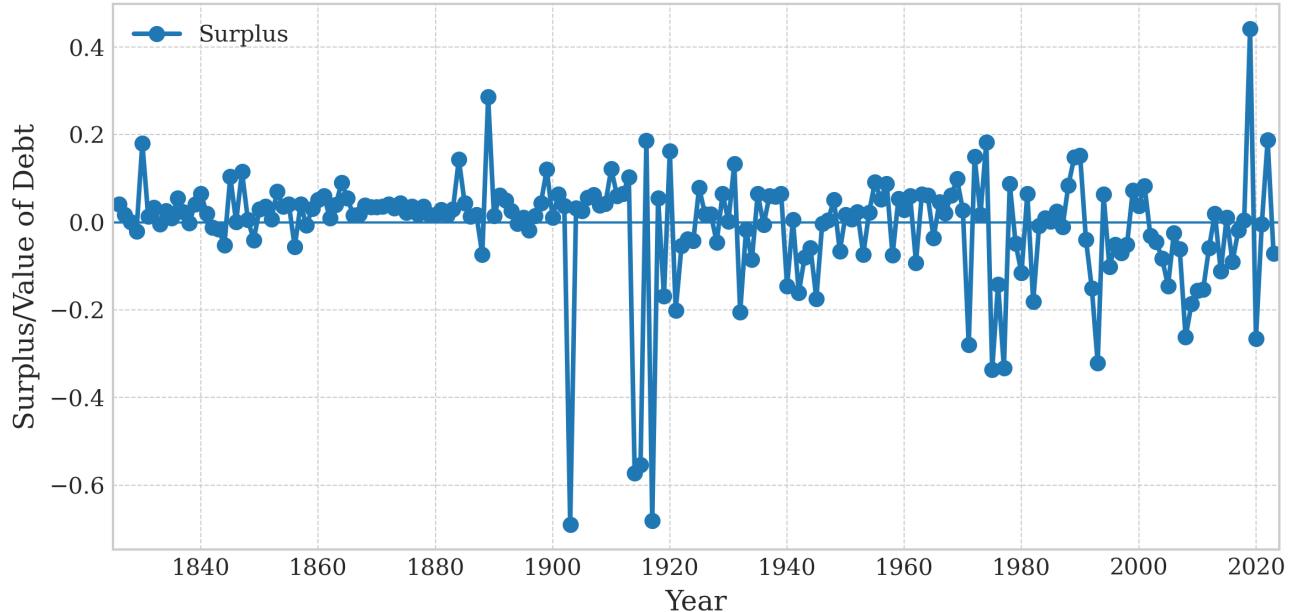


Figure 10: Implied U.K. surpluses to ensure government flow identity holds.

To this end, we iterate both flow identities forward to arrive at present-value identities for the home and foreign debt

$$v_t^H = \sum_{j=1}^{\infty} \rho_H^{j-1} s_{t+j}^H + \sum_{j=1}^{\infty} \rho_H^{j-1} g_{t+j}^H - \sum_{j=1}^{\infty} \rho_H^{j-1} [r_{t+j}^{n,F} + \Delta e_{t+j} + \varphi_{t+j} - \pi_{t+j}^H], \quad (22)$$

$$v_t^F = \sum_{j=1}^{\infty} \rho_F^{j-1} s_{t+j}^F + \sum_{j=1}^{\infty} \rho_F^{j-1} g_{t+j}^F - \sum_{j=1}^{\infty} \rho_F^{j-1} [r_{t+j}^{n,F} - \pi_{t+j}^F]. \quad (23)$$

Investors price U.S. and U.K. bonds jointly. Persistent Dollar appreciation or a sustained fall in the UIP premium lowers the discount factor for U.S. surpluses while raising it for U.K. surpluses, binding the two budget constraints in expectation. We can rewrite the forward identity for the home country

$$\begin{aligned} v_t^H = & \sum_{j \geq 1} \rho_H^{j-1} s_{t+j}^H + \sum_{j \geq 1} \rho_H^{j-1} g_{t+j}^H - \sum_{j \geq 1} \rho_H^{j-1} r_{t+j}^{n,F} \\ & - \sum_{j \geq 1} \rho_H^{j-1} \Delta e_{t+j} - \sum_{j \geq 1} \rho_H^{j-1} \varphi_{t+j} + \sum_{j \geq 1} \rho_H^{j-1} \pi_{t+j}^H. \end{aligned} \quad (24)$$

Equation (24) also holds ex-ante. Therefore, we can take expectations based on information at

time  $t$  to arrive at

$$v_t^H = \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} s_{t+j}^H \right]}_{PV_t^{(s)}} + \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} g_{t+j}^H \right]}_{PV_t^{(g)}} - \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} r_{t+j}^{n,F} \right]}_{PV_t^{(r)}} \\ - \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} \Delta e_{t+j} \right]}_{PV_t^{(\Delta e)}} - \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} \varphi_{t+j} \right]}_{PV_t^{(\varphi)}} + \underbrace{\mathbb{E}_t \left[ \sum_{j \geq 1} \rho_H^{j-1} \pi_{t+j}^H \right]}_{PV_t^{(\pi)}}, \quad (25)$$

where  $\rho_H \simeq 0.97$  is the annual Campbell–Shiller discount factor. For plotting it is convenient to gather the real discount-rate pieces as

$$PV_t^{(d)} \equiv PV_t^{(r)} - PV_t^{(\pi)}, .$$

Equation (25) can therefore be written

$$v_t^H = PV_t^{(s)} + PV_t^{(g)} + PV_t^{(\pi)} - [PV_t^{(r)} + PV_t^{(\Delta e)} + PV_t^{(\varphi)}]. \quad (26)$$

Our goal is to turn the forward-looking identity in eq. (26) into *measurable* objects that can be tracked year by year.

In observing the trends in the evolution of U.K. debt (figure 2), five distinct episodes emerge.

**The Sterling crisis, 1975–1981.** The orange  $-s$  line rises rapidly—large primary deficits—yet the blue  $v$  line increases only modestly. The gap is filled by the purple REER series and the steeply negative pink  $-\pi$  series: a cumulative 25% depreciation and double-digit inflation erode the real value of gilts. [Bordo et al. \(2022\)](#) date this as the first peacetime episode of fiscal dominance since the 1690s; Figure 2 shows that the adjustment came predominantly through the price level and the exchange rate rather than through a fiscal retrenchment.

**North-Sea revenue and disinflation, 1982–2001.** During the Thatcher and early New-Labour years the orange  $-s$  flattens, reflecting small primary surpluses, while the red  $r^n$  climbs as global real rates rise with the Volcker disinflation. The green  $r^n - \pi - g$  bundle therefore pulls the blue  $v$  line *up* even in the face of favourable flows. Discount rates dominate: roughly half of the cumulative drift in debt over these two decades is valuation rather than cash-flow driven.

**ERM exit and “stop-go” 1992–1996.** The purple REER line kinks upward with Sterling’s 1992 departure from the Exchange-Rate Mechanism, while the red  $r^n$  line drops as gilts rally. These offsetting valuation effects leave the blue debt path broadly unchanged, masking the cyclical widening and subsequent narrowing of primary balances.

**Global Financial Crisis, 2007–2013.** The financial crisis creates the largest wedge of the sample. Primary deficits widen sharply (orange), and at the same time the red  $r^n$  line *falls* as world safe real rates plunge. The two forces reinforce each other, pushing the blue debt series sharply higher. Using a similar exercise, [Cochrane \(2019\)](#) notes that in the U.S. decomposition about 52 % of the post-2008 rise in debt is discount-rate news; the U.K. share is similar *only* once exchange-rate channels are included, hinting at different debt dynamics for financial hegemons relative to smaller open economies.

**Pandemic shock, 2020–2022.** Covid-19 generates record cash deficits but also a large valuation gain: gilt real yields turn deeply negative, inflation re-accelerates (pink becomes more negative), and the brown UIP curve spikes as investors demand a wider risk premium on Sterling assets. Roughly one half of the pandemic-era debt increase is therefore absorbed by prices rather than by flows. Hence, negative real rates cushioned the fiscal expansion during this period.

### B.5.2 Key macroeconomic episodes through the lens of the forward decomposition

We here present key U.K. macroeconomic historical episodes through the lens of the forward decomposition, following figure 3.

**ERM crisis (1992–2001).** A one-off 15 % Sterling depreciation pushes the REER path upward; the UIP premium widens, making Sterling assets riskier. Expected surpluses dip with the recession but rebound rapidly after 1997, leaving the overall debt valuation little changed.

**Global Financial Crisis (2008–2012).** Markets price a decade of large primary deficits (orange plummet) and a near-zero real discount rate (green surge). The two forces reinforce each other, driving  $v_t$  sharply higher.

**Austerity, Brexit, and Covid (2013–2021).** From 2013 the  $s$  path steepens as headline plans envisaged medium-term surpluses. In mid-2016 the REER line drops and UIP becomes negative: investors demand a higher Sterling risk premium, mechanically reducing today's debt value. At the start of the pandemic, emergency spending in 2020 raises  $s$  and  $v_t$  above 0.8 log points, yet the discount-rate term stays positive because gilt real yields plunge below -2%.

### B.5.3 Variance–Decomposition

Equation (24) writes the scaled market-value of debt  $v_t^H$  as the sum of six discounted forward series. We can also construct the variance decomposition in order to ask how much of the unconditional

variance of  $v_t^H$  comes from each of those six factors. Taking equation (24), abusing notation, we can take variance

$$\text{var}(v) = \text{cov}(v, \Sigma s) - \text{cov}[v, \Sigma(r^f + \Delta rer + uip - \pi - g)].$$

We then break the second covariance into its five sub-covariances. Dividing by  $\text{var}(v)$  converts each component into variance shares.

Following [Cochrane \(2019\)](#), we construct two alternative versions of the data series before performing the variance calculations. We construct the innovation series as follows. For each variable  $x_t$  the innovation is  $\tilde{x}_t = x_t - \mathbb{E}_{t-1}[x_t]$ , obtained from the same VAR that underlies the forward decomposition. Cumulating the innovations isolates the portion of debt dynamics that was *unanticipated* at the time. This is an accounting of “news” rather than levels.

We also constructed a filtered series. We apply the high-pass operator

$$\theta(L) = 1 - \frac{1}{3}(L + L^2 + L^3)$$

to each raw series. Concretely, for debt we compute  $\tilde{v}_t = v_t - \frac{1}{3}(v_{t-1} + v_{t-2} + v_{t-3})$ , and analogously for  $s, \pi, g, r^{n,F}, \Delta e, \varphi$ . The filter removes low-frequency swings, such as wartime run-ups and long post-war declines, which dominate the unconditional variance but carry little business-cycle information. What remains is a medium-frequency measure that moves with recessions and policy cycles. Because identity (24) is algebraic, we may filter *after* forming the identity; all terms still add up exactly.

Throughout the paper we report results for all three datasets: the plain raw sums, the innovation sums that isolate true surprises, and the filtered sums that highlight cyclical movements,. The results are shown in Table 1. A positive covariance means that variable raises the variance of debt; a negative number means it moves opposite to debt, dampening variance. For compactness we report the five valuation channels with the same sign as they enter equation (24); e.g.  $\Sigma r^f$  enters with a minus sign, so its covariance appears negative in the table. Row 2 plus Row 3 equals 1 by construction. Rows 4–8 sum to Row 3. This ensures the decomposition is internally consistent for every perspective.

**Main findings.** We summarise now the main variance decomposition results, presented in Table 6.

1. *Surplus news dominate.* In all three lenses the covariance between  $v_t$  and the surplus present value accounts for the largest share of variance: 83% in Plain, 94% in Innovation, and 89% in Filtered. This aligns with a FTPL-style prediction that revisions in expected primary surpluses are the primary driver of debt valuation.

	Plain	Innovation	Filtered
$\text{var}(v)$	1.000	1.000	1.000
$\text{cov}(v, \Sigma s)$	0.832	0.940	0.890
$-\text{cov}[v, \Sigma(r^f + \Delta \text{rer} + \text{uip} - \pi - g)]$	0.168	0.060	0.110
$\text{cov}(v, \Sigma r^f)$	-0.452	-0.421	-0.328
$\text{cov}(v, \Sigma \Delta \text{rer})$	0.012	-0.000	0.061
$\text{cov}(v, \Sigma \text{uip})$	-0.275	-0.137	-0.230
$\text{cov}(v, \Sigma \pi)$	-0.406	-0.415	-0.262
$\text{cov}(v, \Sigma g)$	-0.142	-0.082	-0.125

Table 6: Variance decomposition

2. *Valuation channels offset surpluses but never overturn them.* The combined contribution of discount-rate, exchange-rate and other valuation terms is negative, reducing the explanatory share of surpluses by about 17% (Plain) to 6% (Innovation). Thus when surplus expectations improve, required returns typically rise, inflation expectations fall, or UIP premia widen—attenuating the impact on  $v_t$ , but not reversing it.
3. *Discount-rate effects are the single largest offset.* The covariance with  $\Sigma r^f$  is  $-0.45$  in Plain and  $-0.42$  in Innovation: periods in which nominal discount rates are expected to be high coincide with lower debt valuations, as standard asset pricing intuition suggests.
4. *UIP and inflation channels matter materially.* Unexpected declines in the UIP premium ( $-0.28$  Plain) or in future inflation ( $-0.41$ ) both push  $v_t$  upward, but their magnitudes are about half that of the discount-rate channel.
5. *Real-exchange-rate news are small on average.* The covariance with  $\Sigma \Delta \text{rer}$  is near zero in Innovation, implying that shocks to the expected path of the real exchange rate rarely move debt valuation contemporaneously. The Filtered view allocates a modest 6% share, suggesting slower-moving terms-of-trade trends do play some role.
6. *Growth news are modest and negative.* Better expected growth raises the denominator (future consumption) faster than the numerator (real surpluses), so  $v_t$  co-moves negatively with  $\Sigma g$  (about  $-0.14$  in Plain).

Overall, the decomposition shows that, even in an open-economy setting with currency and risk-premium channels, fiscal news remain the dominant force, while financial variables primarily modulate its impact through discounting rather than overturning it.

## C Additional details on the Vector Autoregression results

Complementing section 2.2, we provide additional results akin to the 'reverse regression' approach from [Engel and West \(2005\)](#) and [Jiang \(2021\)](#).

$$\frac{s_{t+k}^i}{B_{t+k}^i} = \alpha^{(k)} + \beta^{(k)} \Delta \log e_t^{(-i)/i} + \delta_1^{(k)} \frac{s_t^i}{B_t^i} + \delta_2^{(k)} \Delta \frac{s_t^i}{B_t^i} + \gamma_1^{(k)} \frac{s_t^{-i}}{B_t^{-i}} + \gamma_2^{(k)} \Delta \frac{s_t^{-i}}{B_t^{-i}} + \varepsilon_{t+k}^i, \quad (27)$$

that is; we test the link between the deficit/debt-ratio at time  $t+k$  and the change in the real exchange rate as well as the level and the first-difference of *both* domestic and foreign deficit/debt-ratio levels. The results of this exercise are presented in table 7 and figure 11 for the U.K. and in table 8 and figure 12 for the U.S. In a nutshell, current appreciations are related to smaller local government deficits, but in the case of the U.K., the phenomenon is reversing at very long horizons.

	Dependent variable: deficit-to-debt ratio at $t+k$							
	k=1	k=2	k=3	k=4	k=5	k=6	k=7	k=8
$\Delta$ REER	0.129 (0.104)	0.149 (0.092)	0.122 (0.080)	0.296*** (0.086)	0.067 (0.051)	-0.081 (0.054)	-0.086 (0.065)	-0.126** (0.060)
$\frac{s}{B}$ -UK	0.187 (0.256)	-0.491** (0.201)	-0.858*** (0.224)	-1.109*** (0.200)	-0.905** (0.410)	-0.287 (0.260)	-0.142 (0.289)	-0.219 (0.478)
$\Delta \frac{s}{B}$ -UK	0.184 (0.202)	0.090 (0.276)	0.729** (0.348)	0.729* (0.405)	0.689 (0.584)	1.389** (0.626)	0.604 (0.461)	0.706 (0.608)
$\frac{s}{B}$ -US	0.481** (0.194)	0.814*** (0.229)	0.827*** (0.256)	0.897*** (0.188)	0.684 (0.421)	-0.005 (0.281)	-0.125 (0.291)	-0.192 (0.409)
$\Delta \frac{s}{B}$ -US	-0.073 (0.246)	-0.018 (0.220)	-0.647* (0.386)	-0.960 (0.588)	-0.752 (0.673)	-0.824 (0.667)	-0.038 (0.458)	-0.149 (0.560)
Constant	-0.010 (0.010)	-0.024 (0.015)	-0.048*** (0.016)	-0.058*** (0.010)	-0.067*** (0.016)	-0.095*** (0.012)	-0.097*** (0.013)	-0.109*** (0.017)
Obs.	29	28	27	26	25	24	23	22
R <sup>2</sup>	0.659	0.436	0.365	0.548	0.287	0.354	0.251	0.387
Adj. R <sup>2</sup>	0.585	0.308	0.214	0.435	0.099	0.175	0.030	0.195

Table 7: UK: [Engel and West \(2005\)](#)-style regressions for the deficit-to-debt ratio. Newey-West standard errors in parentheses. \* $p<0.1$ ; \*\* $p<0.05$ ; \*\*\* $p<0.01$ .

	Dependent variable: deficit-to-debt ratio at $t+k$							
	k=1	k=2	k=3	k=4	k=5	k=6	k=7	k=8
$\Delta$ REER	-0.051 (0.090)	0.106 (0.131)	0.110 (0.103)	0.077 (0.076)	0.061 (0.093)	0.029 (0.094)	0.025 (0.079)	-0.026 (0.078)
$\frac{s}{B}$ -UK	-0.183*** (0.070)	-0.407*** (0.109)	-0.581*** (0.135)	-0.544*** (0.138)	-0.500*** (0.175)	-0.482** (0.190)	-0.455** (0.181)	-0.412* (0.225)
$\Delta \frac{s}{B}$ -UK	0.284*** (0.096)	0.405* (0.215)	0.413** (0.191)	0.283 (0.220)	0.126 (0.217)	0.131 (0.250)	-0.020 (0.361)	-0.169 (0.432)
$\frac{s}{B}$ -US	0.726*** (0.108)	0.453*** (0.171)	0.345** (0.170)	0.263** (0.128)	0.306** (0.121)	0.350** (0.155)	0.354* (0.193)	0.282 (0.197)
$\Delta \frac{s}{B}$ -US	0.139 (0.123)	0.057 (0.183)	-0.130 (0.197)	-0.322* (0.169)	-0.267* (0.160)	-0.301 (0.219)	0.001 (0.270)	0.140 (0.261)
Constant	-0.038*** (0.012)	-0.079*** (0.018)	-0.100*** (0.016)	-0.103*** (0.015)	-0.095*** (0.016)	-0.088*** (0.016)	-0.087*** (0.019)	-0.093*** (0.026)
Obs.	52	51	50	49	48	47	46	45
R <sup>2</sup>	0.624	0.374	0.329	0.293	0.254	0.244	0.230	0.204
Adj. R <sup>2</sup>	0.583	0.305	0.253	0.211	0.165	0.152	0.133	0.102

Table 8: US: Engel and West (2005)-style regressions for the deficit-to-debt ratio. Newey-West standard errors in parentheses. \* $p<0.1$ ; \*\* $p<0.05$ ; \*\*\* $p<0.01$ .

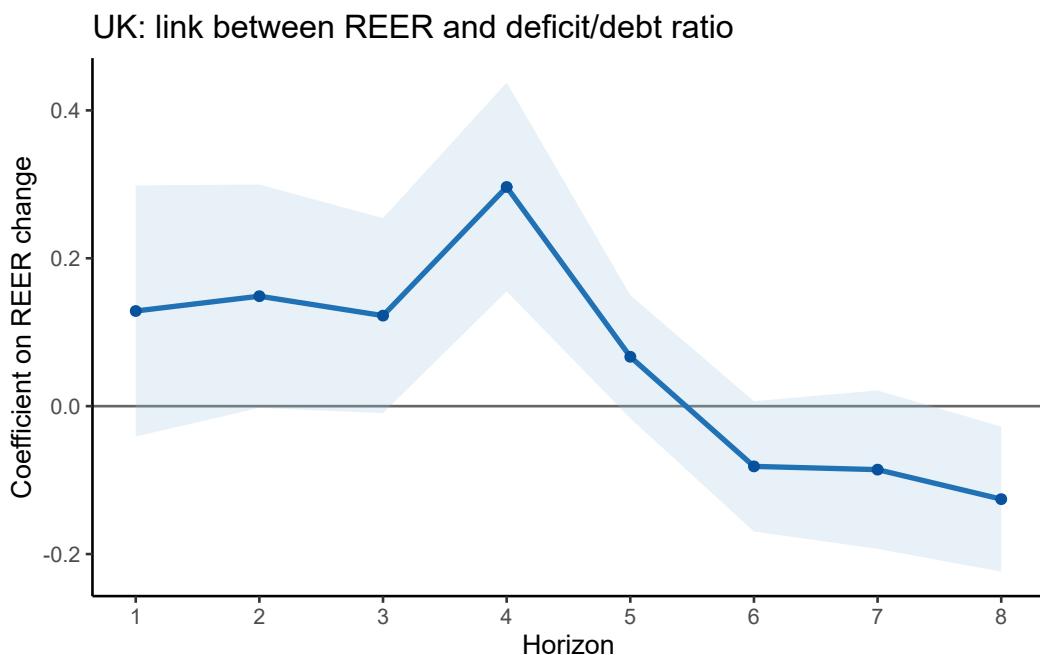


Figure 11: Engel and West (2005)-style reverse regression for the U.K.

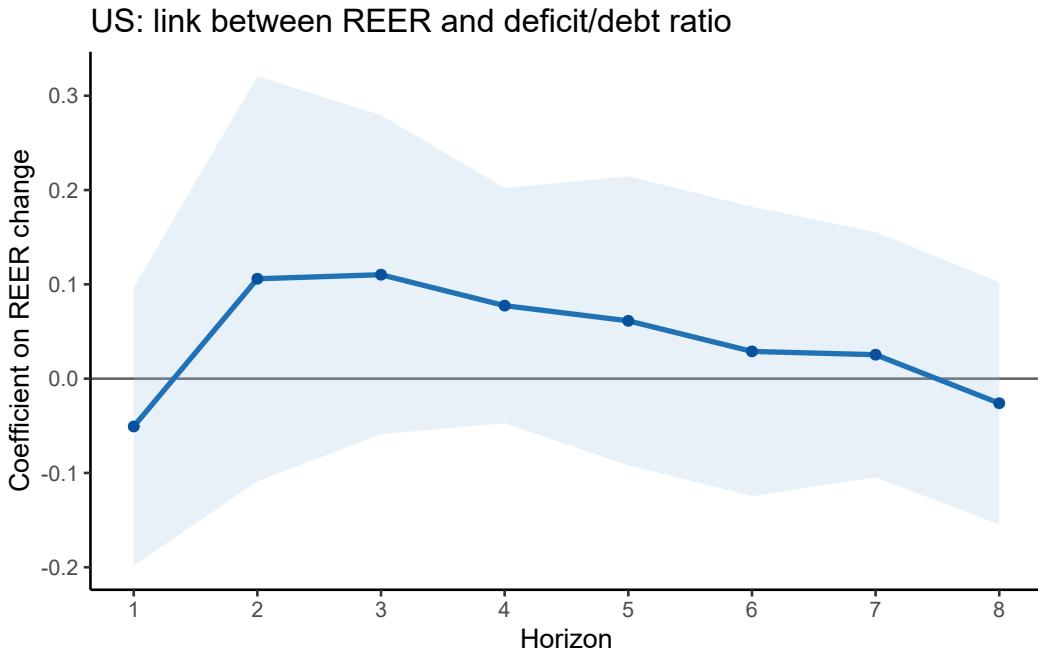


Figure 12: [Engel and West \(2005\)](#)-style reverse regression for the U.S.

## D Private sector deficit forecast revisions

In this section, we present more in-depth evidence in favour of a direct link between deficits, exchange rates, and inflation, in line with the predication implied by a government debt valuation equation, and supporting the results of section 2 by using private-sector data on deficit expectations in place of the deficit innovations recovered in the VAR framework of section 2. To that goal, we now turn to a novel dataset of financial forecasters in the United Kingdom, evaluating to which degree forecasters link deficits, exchange rates, and inflation, and whether a stronger link corresponds to an improved forecast performance. A part of our contribution is the assembly of a near-30-year-long dataset of macroeconomic forecasts made by private forecasters in the United Kingdom, which has henceforth not been created to the best of our knowledge.

This exercise is broadly in the line of work of [Cochrane \(2018\)](#) and [Barro and Bianchi \(2024\)](#): we use an *innovation representation* of the government debt valuation equation in the context of international holdings of government debt to inform forecast revisions pinning down a plausible link between deficits and exchange rates.

## Data

The data that we use in this section is the universe of private sector forecasts on various macroeconomic variables, collected by the U.K. Treasury ([HM Treasury, 2025](#)). While aggregate data

on average forecasts is available in machine-readable format, the individual forecasts were initially not available as such. We hand-collected all forecaster-specific data since September 1997 on a monthly basis. Further details on the data are reported in appendix F.

In the process of collecting the data, the U.K. Treasury asks a select number of banks and financial institutions (labelled 'City Forecasters') as well as a large number of independent forecasting bodies without direct vested interest (labelled 'Non-City forecasters') about their same-year and one-year-ahead predictions for a battery of macroeconomic and financial variables. Not all forecasters update their forecasts each month, but the median forecaster who is in the sample for at least three years provides updates multiple times over the year. Of particular interest to us are the forecasts on sovereign deficits (officially "Public Sector Net Borrowing", or PSNB), exchange rates, real interest rates (recovered through the corresponding forecasts made on the Bank of England lending rate and CPI/RPI inflation), and of output growth. Let  $T$  be the forecast horizon,  $t - 1$  be the date of the previous forecast, and  $t$  be the current date. Then, we estimate generally a type of the following specification:

$$\Delta \mathbb{E}_{it} \mathcal{E}_{(T-j) \rightarrow T} = \beta_0 + \beta_1 \Delta \mathbb{E}_{it} (-\hat{s}_T) + \beta_2 \Delta \mathbb{E}_{it} \hat{y}_T + \beta_3 \Delta \mathbb{E}_{it} \hat{r}_T + \Gamma Z_{it} + \varepsilon_{it}. \quad (28)$$

Our main specification, equation (28), deserves some explanation.  $\Delta \mathbb{E}_{it} \hat{\mathcal{E}}_{(T-12) \rightarrow T}$  on the left-hand side captures the forecast revision from  $t - 1$  to  $t$  ( $\Delta \mathbb{E}_{it}$ ) of the expected change in the exchange rate from the end-of-last-year (which was  $j$  months ago) until the end of the year, which is the time period  $T$ . On the right-hand side, we have a firm-specific fixed-effect  $\alpha_i$ .<sup>12</sup> Next,  $\beta_1$  describes the main coefficient of interest, showing the effect of revisions in expected deficits (negative surpluses) for the year ending at  $T$ . The next coefficients  $\beta_2$  and  $\beta_3$  are symmetrically the coefficients on revisions of output growth and the expected real interest rate earned in the year ending at period  $T$ . Finally,  $\Gamma Z_{it}$  captures further control variables, and  $\varepsilon_{it}$  is the estimation error. The fact that we generally control for other forecast revisions in the estimation process of forecast revisions is thus both informed by economic theory *and* in line with evidence presented by Crump et al. (2025) that forecast revisions are occurring jointly, with important effects being missed when considering only mutual pairs of such revisions.

## Results

We now present our results. First, we establish that forecasters on average link revisions indicating larger deficits to corresponding depreciations. Additionally, we provide evidence that those forecasters whose forecast revisions are closer aligned with the deficit-exchange rate-mechanism are, on average, also better in terms of their own exchange rate forecasting performance, rationalizing

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<sup>12</sup>We also control for alternative specifications with a joint firm-year fixed-effect, as per the tables below.

the link between deficits and exchange rates from the perspective of mutual innovations.

	Outcome: $\Delta\mathbb{E}(\mathcal{E}_{\text{Sterling Basket}})$				
	(1)	(2)	(3)	(4)	(5)
$\Delta\mathbb{E}(\text{PSNB})$	-0.0005** (0.0002)	-0.0005** (0.0002)	-0.0005** (0.0002)	-0.0005** (0.0002)	-0.0002*** ( $5.6 \times 10^{-5}$ )
$\Delta\mathbb{E}(g_Y)$	0.0043** (0.0018)	0.0053*** (0.0018)	0.0024 (0.0022)	0.0033 (0.0021)	0.0047*** (0.0011)
$\Delta\mathbb{E}(r_{t+1})$	0.0037* (0.0018)	0.0040** (0.0017)			0.0001 (0.0010)
$\Delta\mathbb{E}(i_{t+1})$			0.0133*** (0.0038)	0.0141*** (0.0034)	
$\Delta\mathbb{E}(\pi_{RPI,t+1})$			-0.0017 (0.0015)	-0.0020 (0.0014)	
Observations	6,433	6,433	6,433	6,433	5,041
R <sup>2</sup>	0.03265	0.01379	0.03565	0.01745	0.16020
Forecaster-year joint FE	✓		✓		✓
Forecaster FE		✓		✓	

Table 9: Forecast revision regressions across the universe of forecast data. \* $p<0.1$ ; \*\* $p<0.05$ ; \*\*\* $p<0.01$ ; firm-clustered standard errors in parentheses.

Table 9 relates changes in the end-of-year exchange rate forecasts to concurrent changes in other forecasts, with a set of fixed effects as specified below. The link between deficit expectation revisions and exchange rate expectation revisions is broadly robust across our specifications. In numbers, a 1 billion GBP (in 2018 GBP terms) increase in deficit expectations corresponds to a 0.05 percentage point *decrease* in end-of-year expectations of weighted exchange rates. Given that forecast revisions can amount to 100 billion GBP (as evidenced in the appendix figure 16), we can think of this mechanism as being also economically significant in addition to statistical significance.

In figure 13, we visualize the main point made by table 9: conditional on firm-specific effects and other forecast updates, we generally observe a negative relation between exchange rate forecast revisions and deficit forecast revisions. Thus, a higher deficit forecast corresponds *ceteris paribus* to a downwards revision in expected year-end exchange rates.

The results of table 9 and figure 13 partial out forecaster-specific effects. However, there is substantial heterogeneity across forecasters in how they link deficits to exchange rate revisions. This informs a further interesting question: if a forecaster presumes a tighter link between deficits and depreciations, does that correspond also to a better ability of forecasting exchange rates? We now address this question, borrowing the definition of Mincer and Zarnowitz (1969) to evaluate what makes a *good* forecast.

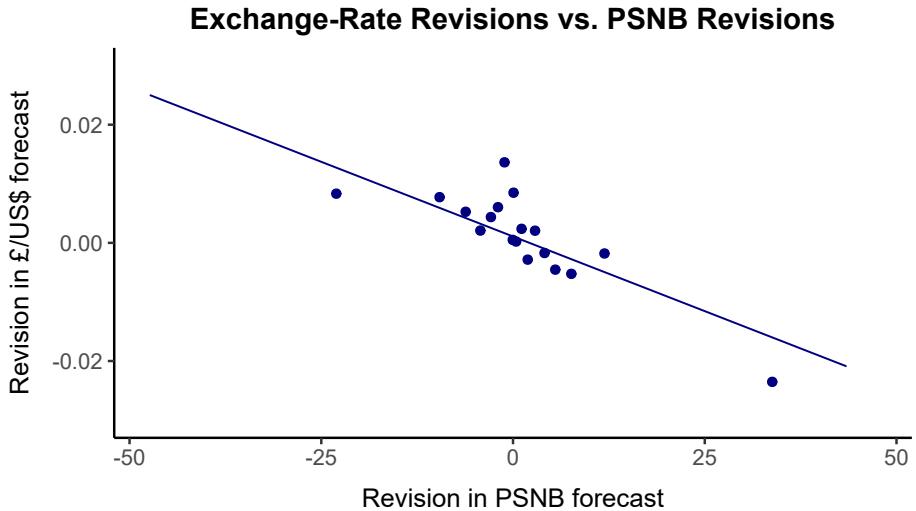


Figure 13: Binned scatter plot showing the partial correlation between deficit forecast revisions and exchange rate forecast revisions, partialling out firm fixed-effects and forecast revisions for output and real interest rates.

In detail, we proceed as follows: First, we estimate *within each firm* the following specification:

$$\mathcal{E}_T = \alpha_{i0} + \alpha_{i1}\mathbb{E}_{it}(\mathcal{E}_T) + e_i,$$

to recover the estimate  $\alpha_{i1}$ , which captures the degree to which the forecasts made by forecaster  $i$  match the actual outcome of the exchange rate index. A perfect forecaster would obtain  $\alpha_{i0} = 0$  and  $\alpha_{i1} = 1$ . We then rank the coefficients  $\alpha_{i1}$  in terms of their absolute distance from 1, and check to which degree this "rank" (which is tantamount to forecasting performance) relates to the coefficient  $\beta_{i1}$  recovered from a firm-specific estimation of equation (28), which therefore comes without firm-specific fixed effects. Having recovered both these elements, we estimate:

$$\hat{\beta}_{i1} = \gamma_1 \text{rank}(|\hat{\alpha}_{i1} - 1|) + u_i, \quad (29)$$

with the estimated coefficient  $\hat{\gamma}_1$  being indicative whether better forecasters are actually characterized as those who link deficits broadly 'more' to exchange rate revaluations. We present the results of this estimation in table 10.

The coefficients for the full sample as well as the coefficients for the restricted sample (where we estimate the firm-specific deficit-exchange-rate link only for firms appearing in at least 10 years) support the notion that forecasters whose models predicate a closer link between deficits and depreciations are also the forecasters whose exchange rate forecasting performance is, on average, better. Thus, it appears that leaning into models of exchange rate determination informed by the government debt valuation equation is a rational way of forecasting exchange rates, conditional on any given information set available at time  $t$ . While this is clearly *not* a test of the government

Dependent variable: $\hat{\beta}_{PSNB,ER}$		
Filtered ( $n \geq 10$ obs.)	Full sample	
	(1)	(2)
rank( $ \hat{\alpha}_{i1} - 1 $ )	0.838*** (0.157)	0.809*** (0.220)
Observations	52	61
R <sup>2</sup>	0.337	0.100
F Statistic	25.936***	6.648**

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Heteroscedasticity-robust standard errors in parentheses.

Table 10: Rank regressions depicting the link between forecast accuracy and the firm-specific regression coefficient linking forecast revisions in deficits to forecast revisions in exchange rate

debt valuation equation as such, it lends support to the idea of focussing on deficits and deficit expectations when trying to determine expected movements in exchange rates.

Our empirical evidence informed by forecast revisions in the U.K. across almost 30 years helped us establish two major facts: one, exchange rates contribute significantly to the revision of the equilibrium value of government debt in open economies; and second, the link between fiscal deficits and exchange rates implied by the government debt valuation equation appears to be not only present in the forecasts made by firms with a vested interest in the valuation of government debt, but those firms that are more heavily leaning into determining exchange rates with the help of the mechanisms implied by the debt valuation equation are also, on average, better forecasters. Equipped with those two pieces of evidence, we now move on to rationalize our findings theoretically: first, with a tractable model isolating our main mechanism linking between fiscal policy and exchange rates; and second, with a full-scale general equilibrium model allowing for rich international trade patterns.

# E Derivation of the international continuous-time New Keynesian Model

## E.1 Domestic Household Problem

**Intratemporal Problem** There is a home and a foreign good. We define a home consumption bundle as

$$C_t = \left[ (1 - \gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

The domestic household solves the following intratemporal problem.

$$\max_{C_{Ht}, C_{Ft}} \left[ (1 - \gamma)^{1/\eta} C_{Ht}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ft}^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)} \quad (30)$$

$$\text{s.t. } P_{Ht} C_{Ht} + P_{Ft} C_{Ft} = Z_t, \quad (31)$$

where  $P_{Ht}$  and  $P_{Ft}$  are the prices of the Home and Foreign goods in domestic currency and  $Z_t$  is total nominal expenditure.  $1 - \gamma$  measures the degree of home bias.

The equations characterising the intratemporal problem of the domestic household are given by

$$C_t = \left[ (1 - \gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (32)$$

$$C_{Ht} = (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t, \quad (33)$$

$$C_{Ft} = \gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t, \quad (34)$$

$$P_t = \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]^{1/(1-\eta)}. \quad (35)$$

We take first order conditions. Let  $\zeta_t$  be the multiplier on the budget constraint. Form the Lagrangian

$$\mathcal{L} = \left[ (1 - \gamma)^{1/\eta} C_{Ht}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ft}^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)} - \zeta_t (P_{Ht} C_{Ht} + P_{Ft} C_{Ft} - Z_t).$$

Take first order conditions with respect to  $C_{Ht}$  and  $C_{Ft}$ . We have

$$\frac{\partial \mathcal{L}}{\partial C_{Ht}} = 0 \implies \left[ (1 - \gamma)^{1/\eta} C_{Ht}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ft}^{(\eta-1)/\eta} \right]^{1/(\eta-1)} (1 - \gamma)^{1/\eta} C_{Ht}^{-1/\eta} = \zeta_t P_{Ht}, \quad (36)$$

$$\frac{\partial \mathcal{L}}{\partial C_{Ft}} = 0 \implies \left[ (1 - \gamma)^{1/\eta} C_{Ht}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ft}^{(\eta-1)/\eta} \right]^{1/(\eta-1)} \gamma^{1/\eta} C_{Ft}^{-1/\eta} = \zeta_t P_{Ft}. \quad (37)$$

We now simplify the intratemporal problem. Start from equation (36).

$$\begin{aligned}
& \left[ \underbrace{(1-\gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}}}_{=C_t^{\frac{\eta-1}{\eta}}} \right]^{\frac{1}{\eta-1}} (1-\gamma)^{\frac{1}{\eta}} C_{Ht}^{-\frac{1}{\eta}} = \zeta P_{Ht} \\
\Leftrightarrow & C_t^{\frac{1}{\eta}} C_{Ht}^{-\frac{1}{\eta}} (1-\gamma)^{\frac{1}{\eta}} = \zeta P_{Ht} \\
\Rightarrow & C_{Ht} = (1-\gamma)(\zeta P_{Ht})^{-\eta} C_t.
\end{aligned}$$

Do the analogous steps for equation (37) to get

$$C_{Ft} = \gamma(\zeta P_{Ft})^{-\eta} C_t.$$

Take the ratio and re-arrange:

$$\begin{aligned}
\frac{C_{Ht}}{C_{Ft}} &= \frac{(1-\gamma)(\zeta P_{Ht})^{-\eta} C_t}{\gamma(\zeta P_{Ft})^{-\eta} C_t} \\
\Leftrightarrow \frac{C_{Ht}}{C_{Ft}} &= \frac{(1-\gamma)(P_{Ht})^{-\eta}}{\gamma(P_{Ft})^{-\eta}} \\
\Leftrightarrow \frac{C_{Ht}}{C_{Ft}} &= \frac{1-\gamma}{\gamma} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{-\eta} \\
\Rightarrow C_{Ht} &= C_{Ft} \frac{1-\gamma}{\gamma} \left( \frac{P_{Ft}}{P_{Ht}} \right)^{\eta}.
\end{aligned}$$

Substitute the demand ratio  $C_{Ht}$  into the CES aggregator consumption bundle:

$$\begin{aligned}
C_t &= \left[ (1-\gamma)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
\Leftrightarrow C_t &= \left[ (1-\gamma)^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \left( \frac{1-\gamma}{\gamma} \right)^{\frac{\eta-1}{\eta}} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{1-\eta} + \gamma^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
\Leftrightarrow C_t &= C_{Ft} \left[ (1-\gamma)^{\frac{1}{\eta}} \left( \frac{1-\gamma}{\gamma} \right)^{\frac{\eta-1}{\eta}} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{1-\eta} + \gamma^{\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
\Leftrightarrow C_t &= C_{Ft} \left[ (1-\gamma) \left( \frac{1}{\gamma} \right)^{\frac{\eta-1}{\eta}} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{1-\eta} + \gamma^{\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
\Leftrightarrow C_t &= C_{Ft} \left[ (1-\gamma) (\gamma)^{\frac{1-\eta}{\eta}} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{1-\eta} + \gamma^{\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
\Leftrightarrow C_t^{\frac{\eta-1}{\eta}} &= C_{Ft}^{\frac{\eta-1}{\eta}} \left[ (1-\gamma) (\gamma)^{\frac{1-\eta}{\eta}} \left( \frac{P_{Ht}}{P_{Ft}} \right)^{1-\eta} + \gamma^{\frac{1}{\eta}} \right] \\
\Leftrightarrow C_t^{\frac{\eta-1}{\eta}} &= C_{Ft}^{\frac{\eta-1}{\eta}} P_{Ft}^{\eta-1} \left[ (1-\gamma) (\gamma)^{\frac{1-\eta}{\eta}} P_{Ht}^{1-\eta} + \gamma^{\frac{1}{\eta}} P_{Ft}^{1-\eta} \right] \\
\Leftrightarrow C_t^{\frac{\eta-1}{\eta}} &= C_{Ft}^{\frac{\eta-1}{\eta}} P_{Ft}^{\eta-1} (\gamma)^{\frac{1-\eta}{\eta}} \underbrace{\left[ (1-\gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]}_{=P_t^{1-\eta}} \\
\Leftrightarrow C_t^{\frac{\eta-1}{\eta}} &= C_{Ft}^{\frac{\eta-1}{\eta}} P_{Ft}^{\eta-1} (\gamma)^{\frac{1-\eta}{\eta}} P_t^{1-\eta} \\
\Leftrightarrow C_{Ft}^{\frac{\eta-1}{\eta}} &= (\gamma)^{\frac{\eta-1}{\eta}} C_t^{\frac{\eta-1}{\eta}} \left( \frac{P_{Ft}}{P_t} \right)^{1-\eta} \\
\Rightarrow C_{Ft} &= \gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t
\end{aligned}$$

We can repeat the same derivations by plugging in  $C_{Ft}$  into the CES aggregator to arrive at

$$C_{Ht} = (1-\gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t.$$

Therefore we have

$$C_{Ht} = (1-\gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t, \quad (38)$$

$$C_{Ft} = \gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t. \quad (39)$$

where  $P_t$  is defined next. We can verify that  $P_t \equiv [(1-\gamma)P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta}]^{\frac{1}{1-\eta}}$  is the domestic CPI. By definition, domestic CPI is defined as the price of one unit of consumption, it therefore follows

by plugging in the optimal demands in equation (39) into the budget constraint:

$$\begin{aligned}
& P_{Ht}C_{Ht} + P_{Ft}C_{Ft} = Z_t \\
\Leftrightarrow & P_{Ht}C_{Ht} + P_{Ft}C_{Ft} = P_t C_t \\
\Leftrightarrow & P_{Ht}(1-\gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t + P_{Ft}\gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t = P_t C_t \\
\Leftrightarrow & P_{Ht}^{1-\eta}(1-\gamma)P_t^\eta C_t + P_{Ft}^{1-\eta}\gamma P_t^\eta C_t = P_t C_t \\
\Leftrightarrow & P_{Ht}^{1-\eta}(1-\gamma)P_t^\eta + P_{Ft}^{1-\eta}\gamma P_t^\eta = P_t \\
\Leftrightarrow & P_{Ht}^{1-\eta}(1-\gamma) + P_{Ft}^{1-\eta}\gamma = P_t^{1-\eta} \\
\Leftrightarrow & P_t^{1-\eta} = (1-\gamma)P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \\
\Rightarrow & P_t = [(1-\gamma)P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta}]^{\frac{1}{1-\eta}}.
\end{aligned}$$

Therefore, domestic CPI is defined as

$$P_t = [(1-\gamma)P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta}]^{1/(1-\eta)}. \quad (40)$$

Finally, the real exchange rate is defined as

$$S_t = E_t \frac{P_t^*}{P_t}, \quad (41)$$

where  $E_t$  is the nominal exchange rate. The terms of trade are the price of imports over the price of exports

$$\text{tot}_t = \frac{P_{Ft}}{P_{Ht}}. \quad (42)$$

**Intertemporal Problem** The household chooses consumption  $C_t$  at price  $P_t$ , supplies labour  $N_t$  for the wage  $W_t$ , and chooses holding of domestic bonds  $B_t$  earning interest  $i_t$  and foreign bonds bonds  $B_t^*$  earning interest  $i_t^*$ .

$$\max_{\{C_t, N_t, B_t, B_t^*\}_{t \geq 0}} \int_0^\infty e^{-\rho t} \left\{ \log[C_t] - \frac{N_t^{1+\phi}}{1+\phi} + \nu(B_t; \theta) \right\} dt \quad (43)$$

$$P_t C_t + \dot{B}_t + E_t \dot{B}_t^* = i_t B_t + E_t i_t^* B_t^* + W_t N_t + T_t \quad (44)$$

The necessary and sufficient conditions for domestic household optimality are given by

$$C_t N_t^\phi = \frac{W_t}{P_t} \quad (45)$$

$$\frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho, \quad (46)$$

where  $\Psi_t \equiv \nu_B(B_t; \theta)P_t C_t$  is the convenience yield wedge. The UIP condition is given by

$$i_t - i_t^* = \frac{\dot{E}_t}{E_t} - \Psi_t. \quad (47)$$

The transversality conditions on domestic and foreign bonds are

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T B_T = 0 \quad (48)$$

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T E_T B_T^* = 0. \quad (49)$$

The current valued Hamiltonian is

$$\mathcal{H}(B_t; C_t; \lambda_t) = \left[ \log[C_t] - \frac{N_t^{1+\phi}}{1+\phi} + \nu(B_t; \theta) \right] + \lambda_t \left[ i_t B_t + E_t i_t^* B_t^* + W_t N_t + T_t - P_t C_t \right] \quad (50)$$

The first order conditions are:

$$\begin{aligned} [C_t] : \quad & \frac{1}{C_t} = P_t \lambda_t \\ [N_t] : \quad & N_t^\phi = \lambda_t W_t \\ [B_t] : \quad & \dot{\lambda}_t = \rho \lambda_t - [\lambda_t i_t] - \nu_B(B_t; \theta) \\ [B_t^*] : \quad & \dot{\lambda}_t E_t + \lambda_t \dot{E}_t = \rho \lambda_t E_t - \lambda_t E_t i_t^*. \end{aligned}$$

Combine the first two

$$N_t^\phi = \frac{1}{P_t C_t} W_t$$

Therefore

$$C_t N_t^\phi = \frac{W_t}{P_t}$$

We want  $\dot{\lambda}_t$ . Take

$$\begin{aligned}
& \frac{1}{C_t} = P_t \lambda_t \\
\Leftrightarrow & \lambda_t = \frac{1}{P_t C_t} \\
\Leftrightarrow & \frac{d}{dt} \lambda_t = \frac{d}{dt} \frac{1}{P_t C_t} \\
\Leftrightarrow & \dot{\lambda}_t = \frac{d}{dt} \left[ \frac{1}{P_t C_t} \right] \\
\Leftrightarrow & \dot{\lambda}_t = \frac{d}{dt} \left[ P_t C_t \right]^{-1} \\
\Leftrightarrow & \dot{\lambda}_t = -1 \left[ P_t C_t \right]^{-2} \left[ \frac{d}{dt} P_t C_t \right] \\
\Leftrightarrow & \dot{\lambda}_t = -1 \left[ P_t C_t \right]^{-2} \left[ \dot{P}_t C_t + P_t \dot{C}_t \right] \\
\Leftrightarrow & \dot{\lambda}_t = -\frac{\dot{P}_t C_t}{[P_t C_t]^2} - \frac{P_t \dot{C}_t}{[P_t C_t]^2} \\
\Leftrightarrow & \dot{\lambda}_t = -\frac{\dot{P}_t}{P_t^2 C_t} - \frac{\dot{C}_t}{P_t C_t^2}
\end{aligned}$$

Recall from the first order condition for consumption that

$$\lambda_t = \frac{1}{P_t C_t}.$$

So we can plug this in

$$\begin{aligned}
& \Leftrightarrow \dot{\lambda}_t = -\frac{\dot{P}_t}{P_t^2 C_t} - \frac{\dot{C}_t}{P_t C_t^2} \\
& \Leftrightarrow \dot{\lambda}_t = -\frac{\dot{P}_t}{P_t} \lambda_t - \frac{\dot{C}_t}{C_t} \lambda_t \\
\Rightarrow & \frac{\dot{\lambda}_t}{\lambda_t} = -\frac{\dot{P}_t}{P_t} - \frac{\dot{C}_t}{C_t}.
\end{aligned}$$

Define the inflation rate as

$$\pi_t = \frac{\dot{P}_t}{P_t}.$$

Plug this back in

$$\begin{aligned}
& \Leftrightarrow \frac{\dot{\lambda}_t}{\lambda_t} = -\frac{\dot{P}_t}{P_t} - \frac{\dot{C}_t}{C_t} \\
\Rightarrow & \frac{\dot{\lambda}_t}{\lambda_t} = -\pi_t - \frac{\dot{C}_t}{C_t}.
\end{aligned}$$

Plug this into the domestic bonds first order condition

$$\begin{aligned}
&\Leftrightarrow \dot{\lambda}_t = \rho\lambda_t - [\lambda_t i_t] - \nu_B(B_t; \theta) \\
&\Leftrightarrow \frac{\dot{\lambda}_t}{\lambda_t} = \rho - i_t - \nu_B(B_t; \theta) \frac{1}{\lambda_t} \\
&\Leftrightarrow -\pi_t - \frac{\dot{C}_t}{C_t} = \rho - i_t - \nu_B(B_t; \theta) P_t C_t \\
&\Leftrightarrow \frac{\dot{C}_t}{C_t} = i_t - \pi_t + \nu_B(B_t; \theta) P_t C_t - \rho \\
&\Rightarrow \frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho,
\end{aligned}$$

where  $\Psi_t \equiv \nu_B(B_t; \theta) P_t C_t$  is the convenience yield wedge.

Finally, go to the foreign bond FOC

$$\dot{\lambda}_t E_t + \lambda_t \dot{E}_t = \rho \lambda_t E_t - \lambda_t E_t i_t^*.$$

Divide by  $\lambda_t E_t$

$$\frac{\dot{\lambda}_t}{\lambda_t} + \frac{\dot{E}_t}{E_t} = \rho - i_t^*.$$

Substitute in  $\frac{\dot{\lambda}_t}{\lambda_t} = -\pi_t - \frac{\dot{C}_t}{C_t}$  to get

$$-\pi_t - \frac{\dot{C}_t}{C_t} + \frac{\dot{E}_t}{E_t} = \rho - i_t^*.$$

Therefore we have

$$\frac{\dot{C}_t}{C_t} = i_t^* - \pi_t + \frac{\dot{E}_t}{E_t} - \rho.$$

Combine this with the Euler equation characterizing domestic bonds

$$\begin{aligned}
&\Leftrightarrow \frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho \\
&\Leftrightarrow i_t^* - \pi_t + \frac{\dot{E}_t}{E_t} - \rho = i_t - \pi_t + \Psi_t - \rho \\
&\Leftrightarrow i_t^* + \frac{\dot{E}_t}{E_t} = i_t + \Psi_t \\
&\Rightarrow i_t - i_t^* = \frac{\dot{E}_t}{E_t} - \Psi_t.
\end{aligned}$$

This is the UIP condition where because domestic bonds deliver utility, investors require lower financial returns on them

$$i_t - i_t^* = \frac{\dot{E}_t}{E_t} - \Psi_t.$$

Finally we have the no-transversality condition on both domestic and foreign bonds

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T B_T = 0$$

$$\lim_{T \rightarrow \infty} e^{-\rho T} \lambda_T E_T B_T^* = 0.$$

## E.2 Foreign Household

**Intratemporal Problem** The foreign household problem is symmetric to the domestic household problem. The CES demand function for the foreign household is

$$C_t^* = \left[ (1 - \gamma)^{1/\eta} C_{Ft}^{*(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ht}^{*(\eta-1)/\eta} \right]^{\eta/(\eta-1)}. \quad (51)$$

The Foreign good gets weight  $1 - \gamma$ ; the imported U.S. good weight  $\gamma$ , matching the degree of home-bias symmetry. To solve the intratemporal problem, we assume that the intratemporal budget constraint is

$$P_{Ft}^* C_{Ft}^* + P_{Ht}^* C_{Ht}^* = Z_t^*,$$

where  $Z_t^*$  is the within period expenditure. The optimal consumption expenditure is symmetric to the domestic household

$$C_{Ft}^* = (1 - \gamma) \left( \frac{P_{Ft}^*}{P_t^*} \right)^{-\eta} C_t^*, \quad (52)$$

$$C_{Ht}^* = \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*. \quad (53)$$

The foreign CPI is

$$P_t^* = \left[ (1 - \gamma) P_{Ft}^{*1-\eta} + \gamma P_{Ht}^{*1-\eta} \right]^{1/(1-\eta)}. \quad (54)$$

The foreign terms of trade are

$$\text{tot}_t^* = \frac{P_{Ht}^*}{P_{Ft}^*}. \quad (55)$$

The equations characterising the intratemporal problem of the foreign household is

$$C_t^* = \left[ (1 - \gamma)^{1/\eta} C_{Ft}^{*(\eta-1)/\eta} + \gamma^{1/\eta} C_{Ht}^{*(\eta-1)/\eta} \right]^{\eta/(\eta-1)}, \quad (56)$$

$$C_{Ft}^* = (1 - \gamma) \left( \frac{P_{Ft}^*}{P_t^*} \right)^{-\eta} C_t^*, \quad (57)$$

$$C_{Ht}^* = \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*, \quad (58)$$

$$P_t^* = \left[ (1 - \gamma) P_{Ft}^{*1-\eta} + \gamma P_{Ht}^{*1-\eta} \right]^{1/(1-\eta)}. \quad (59)$$

**Intertemporal Problem** The intertemporal problem for the foreign household is symmetric. They maximise the following

$$\max_{\{C_t^*, N_t^*, B_t^*\}} \int_0^\infty e^{-\rho^* t} \left\{ \log[C_t^*] - \frac{N_t^{*1+\phi^*}}{1+\phi^*} + \nu \left( \frac{B_t}{E_t}; \theta \right) \right\} dt, \quad (60)$$

The flow budget constraint is

$$P_t^* C_t^* + \dot{B}_t^* + \frac{1}{E_t} \dot{B}_t = i_t^* B_t^* + \frac{1}{E_t} i_t B_t + W_t^* N_t^* + T_t^*. \quad (61)$$

The necessary and sufficient conditions for domestic household optimality are given by

$$\frac{\dot{C}_t^*}{C_t^*} = i_t^* - \pi_t^* + \Psi_t^* - \rho^*, \quad (62)$$

$$C_t^* N_t^{*\phi^*} = \frac{W_t^*}{P_t^*}, \quad (63)$$

where  $\Psi_t^* \equiv \nu_B \left( \frac{B_t^*}{E_t}; \theta \right) P_t^* C_t^*$  is the convenience yield wedge. The transversality conditions on domestic and foreign bonds are

$$\lim_{T \rightarrow \infty} e^{-\rho^* T} \lambda_T^* B_T^* = 0, \quad (64)$$

$$\lim_{T \rightarrow \infty} e^{-\rho^* T} \lambda_T^* \frac{B_T}{E_t} = 0. \quad (65)$$

The problem is overall symmetric to the domestic household problem.

### E.3 Risk-Sharing

**Lemma 1** (Risk-Sharing). *The risk-sharing condition is given by*

$$\left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] - \dot{S}_t = \rho^* - \rho - \Psi_t^*. \quad (66)$$

*Proof.* The two Euler equations for the home and foreign household alongside the UIP condition is

$$\begin{aligned} \frac{\dot{C}_t}{C_t} &= i_t - \pi_t + \Psi_t - \rho, \\ \frac{\dot{C}_t^*}{C_t^*} &= i_t^* - \pi_t^* + \Psi_t^* - \rho^* \\ i_t - i_t^* &= \frac{\dot{E}_t}{E_t} - \Psi_t. \end{aligned}$$

Difference the two Euler equations

$$\frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} = i_t - i_t^* + \pi_t^* - \pi_t + \Psi_t - \Psi_t^* - \rho + \rho^*.$$

The real exchange rate was defined as

$$S_t = E_t \frac{P_t^*}{P_t}.$$

The growth of the real exchange rate is

$$\dot{S}_t = \frac{\dot{E}_t}{E_t} + \pi_t^* - \pi_t.$$

Substitute in the UIP condition

$$\dot{S}_t = i_t - i_t^* + \pi_t^* - \pi_t + \Psi_t.$$

Subtract the growth of the exchange rate with the difference of the Euler equation with

$$\begin{aligned} \dot{S}_t - \left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] &= i_t - i_t^* + \pi_t^* - \pi_t + \Psi_t - [i_t - i_t^* + \pi_t^* - \pi_t + \Psi_t - \Psi_t^* - \rho + \rho^*] \\ \leftrightarrow \quad \dot{S}_t - \left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] &= -[-\Psi_t^* - \rho + \rho^*] \\ \leftrightarrow \quad \dot{S}_t - \left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] &= \Psi_t^* + \rho - \rho^* \\ \Rightarrow \quad \left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] - \dot{S}_t &= \rho^* - \rho - \Psi_t^*. \end{aligned}$$

□

## E.4 Domestic Final Good Producers

Final good producers are competitive and aggregate a continuum of intermediate inputs. We assume that there is a continuum of measure one of differentiated goods  $Y_{Ht}(j)$ , aggregated according to:

$$Y_{Ht} = \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \quad (67)$$

whereby  $\epsilon > 1$  is the elasticity of substitution among differentiated goods. The retailers take prices of differentiated goods  $p_{Ht}(j)$  as given. We can then define the retailer's minimisation problem.

The cost minimisation problem facing the retailer is given by:

$$\begin{aligned} \min_{Y_{Ht}(j)} \quad & \int_0^1 p_{Ht}(j) Y_{Ht}(j) dj \\ \text{s.t.} \quad & Y_{Ht} = \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}. \end{aligned} \tag{68}$$

With this problem, we can solve for the demand for each intermediate good  $j$  by the retailer.

The demand for intermediate goods by the retailer is given by:

$$Y_{Ht}(j) = \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} Y_{Ht} \tag{69}$$

whereby we define the aggregate price index  $P_{Ht} \equiv \left[ \int_0^1 p_{Ht}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}$ .

The retailer's first order condition is given by:

$$p_{Ht}(j) = \lambda_t Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}}. \tag{70}$$

The **Lagrangian** is given by:

$$\mathcal{L} = \int_0^1 p_{Ht}(j) Y_{Ht}(j) dj - \lambda_t \left\{ \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} - Y_{Ht} \right\}.$$

We take a first order condition with respect to  $Y_{Ht}(j)$ :

$$\begin{aligned} \left[ \frac{\partial \mathcal{L}}{\partial Y_{Ht}(j)} \right] : \quad & p_{Ht}(j) - \lambda_t \frac{\partial}{\partial Y_{Ht}(j)} \left\{ \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} - Y_{Ht} \right\} = 0 \\ \leftrightarrow \quad & p_{Ht}(j) - \lambda_t \left[ \left\{ \frac{\epsilon}{\epsilon-1} \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}-1} \cdot \frac{\epsilon-1}{\epsilon} Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}-1} \right\} - 0 \right] = 0 \\ \leftrightarrow \quad & p_{Ht}(j) - \lambda_t \left[ \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}-1} Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}-1} \right] = 0 \\ \leftrightarrow \quad & p_{Ht}(j) - \lambda_t \left[ \underbrace{\left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{1}{\epsilon-1}}}_{=Y_{Ht}^{\frac{1}{\epsilon}}} Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}-1} \right] = 0 \\ \leftrightarrow \quad & p_{Ht}(j) - \lambda_t \left[ Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}-1} \right] = 0 \\ \Rightarrow \quad & p_{Ht}(j) - \lambda_t \left[ Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}} \right] = 0. \end{aligned}$$

Now, if we go back the retailer's cost minimisation problem, we can derive the value of the Lagrange multiplier.

The Lagrange multiplier for the retailer is the aggregate price level  $P_{Ht}$ :

$$\lambda_t = P_{Ht}. \quad (71)$$

The demand for intermediate goods by the retailer is given by:

$$Y_{Ht}(j) = \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} Y_{Ht}. \quad (72)$$

Take the retailer's FOC in equation (70):

$$p_{Ht}(j) = \lambda_t Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}},$$

and then plug in the Lagrange multiplier being the aggregate price index equation (71):

$$p_{Ht}(j) = P_{Ht} Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}}.$$

Now re-arrange for the demand for intermediate good  $j$ ,  $Y_{Ht}(j)$ :

$$\begin{aligned} p_{Ht}(j) &= P_{Ht} Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}} \\ \Leftrightarrow \frac{p_{Ht}(j)}{P_{Ht}} &= Y_{Ht}^{\frac{1}{\epsilon}} Y_{Ht}(j)^{-\frac{1}{\epsilon}} \\ \Leftrightarrow \frac{p_{Ht}(j)}{P_{Ht}} &= \left( \frac{Y_{Ht}}{Y_{Ht}(j)} \right)^{\frac{1}{\epsilon}} \\ \Leftrightarrow \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{\epsilon} &= \frac{Y_{Ht}}{Y_{Ht}(j)} \\ \Rightarrow Y_{Ht}(j) &= \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} Y_{Ht}. \end{aligned}$$

We are now interested in deriving what is the aggregate price level of goods  $P_{Ht}$  in this economy as a function of the individual intermediate good prices  $p_{Ht}(j)$ .

The aggregate price index is a non-linear combination of differentiated goods:

$$P_{Ht} = \left[ \int_0^1 p_{Ht}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}} \quad (73)$$

To see that result, take the Dixit-Stiglitz production function (67)

$$Y_{Ht} = \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}.$$

Plug in the demand for intermediate goods and re-arrange

$$\begin{aligned}
Y_{Ht} &= \left[ \int_0^1 Y_{Ht}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \\
\Leftrightarrow Y_{Ht} &= \left[ \int_0^1 \left[ \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} Y_{Ht} \right]^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \\
\Leftrightarrow Y_{Ht} &= \left[ \int_0^1 \left[ \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} \right]^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} Y_{Ht} \\
\Leftrightarrow 1 &= \left[ \int_0^1 \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{1-\epsilon} dj \right]^{\frac{\epsilon}{\epsilon-1}} \\
\Leftrightarrow 1 &= \left[ P_{Ht}^{-(1-\epsilon)} \int_0^1 [p_{Ht}(j)]^{1-\epsilon} dj \right]^{\frac{\epsilon}{\epsilon-1}} \\
\Leftrightarrow 1 &= P_{Ht}^{\epsilon} \left[ \int_0^1 [p_{Ht}(j)]^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}} \\
\Rightarrow P_{Ht} &= \left[ \int_0^1 p_{Ht}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}.
\end{aligned}$$

Note that  $P_{Ht}$  in equation (73) is the producer price of one unit of home final good. Meanwhile,  $P_t$  in equation (35) is the consumer price index and is the price of the household's CES consumption basket of home and foreign goods.

## E.5 Domestic Intermediate Good Producers

We now look at the domestic intermediate firm  $j$ , which sets a price on its own offered good being aware of facing price adjustment costs. The per period profit is

$$\Pi_t(p_{Ht}(j)) = p_{Ht}(j)Y_{Ht}(j) - \frac{W_t}{A_t}Y_{Ht}(j). \quad (74)$$

Plug in the final good provider demand for intermediate goods

$$Y_{Ht}(j) = \left[ \frac{p_{Ht}(j)}{P_{Ht}} \right]^{-\epsilon} Y_{Ht},$$

to get

$$\Pi_t(p_{Ht}(j)) = p_{Ht}(j) \left( \frac{p_{Ht}(j)}{P_t} \right)^{-\epsilon} Y_{Ht} - \frac{W_t}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht}.$$

We use a Rotemberg quadratic price adjustment cost

$$\Theta_t(j) = \frac{\theta}{2} \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 P_{Ht} Y_{Ht}. \quad (75)$$

where  $\theta$  is the degree of price stickiness. The firm's optimal control problem is

$$V_0(p_{H0}) = \max_{\{p_{Ht}(j)\}_{t \geq 0}} \int_0^\infty e^{-\int_0^t i(s)ds} \left\{ \Pi_t(p_{Ht}) - \Theta_t(j) \right\} dt \quad (76)$$

The state variable is  $p_{Ht}(j)$ , the control variable is  $\dot{p}_{Ht}(j)$ , and the co-state variable is  $\eta_t$ . In setting up the Hamiltonian, we note that the law of motion for  $p_{Ht}$  is trivially given by

$$\dot{p}_{Ht}(j) = \dot{p}_{Ht}(j).$$

We can form the current value Hamiltonian as

$$\mathcal{H}(p_{Ht}(j); \dot{p}_{Ht}(j); \eta_t) = \left[ p_{Ht}(j) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} - \frac{W_t}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} \right] - \left[ \frac{\theta}{2} \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 P_{Ht} Y_{Ht} \right] + \eta_t \dot{p}_{Ht}(j). \quad (77)$$

Necessary and sufficient conditions for firm optimality conditions

$$\theta \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht} = \eta_t \quad (78)$$

$$\dot{\eta}_t = i_t \eta_t - \left[ (1 - \epsilon) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \epsilon \frac{W_t}{p_{Ht}(j)} \frac{1}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \theta \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht} \right]. \quad (79)$$

The first order condition with respect to the control variable  $\dot{p}_{Ht}(j)$  is:

$$[\dot{p}_{Ht}(j)] : -\theta \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \left( \frac{1}{p_{Ht}(j)} \right) P_{Ht} Y_{Ht} + \eta_t = 0.$$

The envelope condition with respect to the state variable  $p_{Ht}(j)$  is given by

$$\dot{\eta}_t = i_t \eta_t - \mathcal{H}_{p_H}$$

where  $\mathcal{H}_{p_H}$  is the current valued Hamiltonian differentiated with respect to state variable  $p_{Ht}(j)$ :

$$\begin{aligned} \mathcal{H}_p &= \frac{\partial}{\partial p_H} \left( \left[ p_{Ht}(j) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} - \frac{W_t}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} \right] - \left[ \frac{\theta}{2} \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 P_{Ht} Y_{Ht} \right] + \eta_t \dot{p}_{Ht}(j) \right) \\ &\leftrightarrow \frac{\partial}{\partial p_H} \left( \left[ (p_{Ht}(j))^{1-\epsilon} \left( \frac{1}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} - \frac{W_t}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} \right] - \left[ \frac{\theta}{2} \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 P_{Ht} Y_{Ht} \right] + \eta_t \dot{p}_{Ht}(j) \right) \\ &\leftrightarrow (1 - \epsilon) \frac{p_{Ht}(j)^{-\epsilon}}{P_{Ht}^{-\epsilon}} Y_{Ht} - (-\epsilon) \frac{W_t}{A_t} \frac{p_{Ht}(j)^{-\epsilon-1}}{P_{Ht}^{-\epsilon}} Y_{Ht} - \frac{\theta}{2} (2) \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right) \left( -\frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)^2} \right) P_{Ht} Y_{Ht} \\ &\leftrightarrow (1 - \epsilon) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \epsilon \frac{W_t}{A_t} p_{Ht}(j)^{-1} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \theta \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 \left( \frac{1}{p_{Ht}(j)} \right) P_{Ht} Y_{Ht} \\ &\Rightarrow (1 - \epsilon) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \epsilon \frac{W_t}{p_{Ht}(j)} \frac{1}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \theta \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht}. \end{aligned}$$

So plugging this back into the first order condition for the state variable, we get

$$\dot{\eta}_t = i_t \eta_t - \left[ (1 - \epsilon) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \epsilon \frac{W_t}{p_{Ht}(j)} \frac{1}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \theta \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht} \right].$$

We restrict our attention to symmetric domestic firm pricing.

**Assumption 2** (Symmetric Equilibrium). *We restrict attention to the symmetric equilibrium*

$$p_{Ht}(j) = P_{Ht}. \quad (80)$$

The symmetric equilibrium must feature the following conditions pinning down the firm pricing decision:

$$\theta \pi_{Ht} Y_{Ht} = \eta_t \quad (81)$$

$$\dot{\eta}_t = i_t \eta_t - \left[ (1 - \epsilon) Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \frac{1}{A_t} Y_{Ht} + \theta \pi_{Ht}^2 Y_{Ht} \right]. \quad (82)$$

where we define the producer inflation rate as  $\pi_{Ht} \equiv \frac{\dot{P}_{Ht}}{P_{Ht}}$ .

Take the firm optimality condition for control variable and impose symmetry  $p_{Ht}(j) = P_{Ht}$

$$\begin{aligned} & \theta \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht} = \eta_t \\ \Leftrightarrow & \theta \frac{\dot{P}_{Ht}}{P_{Ht}} \frac{P_{Ht}}{P_{Ht}} Y_{Ht} = \eta_t \\ \Leftrightarrow & \underbrace{\theta \frac{\dot{P}_{Ht}}{P_{Ht}}}_{=\pi_{Ht}} Y_{Ht} = \eta_t \\ \Rightarrow & \theta \pi_{Ht} Y_{Ht} = \eta_t. \end{aligned}$$

We now determine the time-derivative of  $\eta_t$ .

$$\begin{aligned} \dot{\eta}_t &= i_t \eta_t - \left[ (1 - \epsilon) \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \epsilon \frac{W_t}{p_{Ht}(j)} \frac{1}{A_t} \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\epsilon} Y_{Ht} + \theta \left( \frac{\dot{p}_{Ht}(j)}{p_{Ht}(j)} \right)^2 \frac{P_{Ht}}{p_{Ht}(j)} Y_{Ht} \right] \\ &= i_t \eta_t - \left[ (1 - \epsilon) \underbrace{\left( \frac{P_{Ht}}{P_{Ht}} \right)^{-\epsilon}}_{=1} Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \underbrace{\frac{1}{A_t} \left( \frac{P_{Ht}}{P_{Ht}} \right)^{-\epsilon}}_{=1} Y_{Ht} + \theta \underbrace{\left( \frac{\dot{P}_{Ht}}{P_{Ht}} \right)^2}_{\equiv \pi_{Ht}} \underbrace{\frac{P_{Ht}}{P_{Ht}}}_{=1} Y_{Ht} \right] \\ &= i_t \eta_t - \left[ (1 - \epsilon) Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \frac{1}{A_t} Y_{Ht} + \theta \pi_{Ht}^2 Y_{Ht} \right]. \end{aligned}$$

The price setting of firms implies that the inflation rate  $\pi_{Ht} \equiv \frac{\dot{P}_{Ht}}{P_{Ht}}$  is determined by

$$\left[ i_t - \pi_{Ht} - \frac{\dot{Y}_{Ht}}{Y_{Ht}} \right] \pi_{Ht} = \frac{\epsilon - 1}{\theta} \left[ \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht}} \frac{1}{A_t} - 1 \right] + \dot{\pi}_{Ht}. \quad (83)$$

We want to evaluate the firm's symmetric equilibrium condition:

$$\dot{\eta}_t = i_t \eta_t - \left[ (1 - \epsilon) Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \frac{1}{A_t} Y_{Ht} + \theta \pi_{Ht}^2 Y_{Ht} \right].$$

We can use the firm's symmetric equilibrium condition for the control variable and differentiate with respect to time

$$\begin{aligned} \eta_t &= \theta \pi_{Ht} Y_{Ht} \\ \Leftrightarrow \quad \frac{d}{dt} \eta_t &= \frac{d}{dt} \left( \theta \pi_{Ht} Y_{Ht} \right) \\ \Leftrightarrow \quad \dot{\eta}_t &= \theta \frac{d}{dt} \left( \pi_{Ht} Y_{Ht} \right) \\ \Rightarrow \quad \dot{\eta}_t &= \theta \dot{\pi}_{Ht} Y_{Ht} + \theta \pi_{Ht} \dot{y}_t. \end{aligned}$$

Now plug this back into the firm's symmetric equilibrium condition

$$\begin{aligned} \dot{\eta}_t &= i_t \eta_t - \left[ (1 - \epsilon) Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \frac{1}{A_t} Y_{Ht} + \theta \pi_{Ht}^2 Y_{Ht} \right] \\ \Leftrightarrow \quad \theta \dot{\pi}_{Ht} Y_{Ht} + \theta \pi_{Ht} \dot{y}_t &= i_t [\theta \pi_{Ht} Y_{Ht}] - \left[ (1 - \epsilon) Y_{Ht} + \epsilon \frac{W_t}{P_{Ht}} \frac{1}{A_t} Y_{Ht} + \theta \pi_{Ht}^2 Y_{Ht} \right] \\ \Leftrightarrow \quad \dot{\pi}_{Ht} + \pi_{Ht} \frac{\dot{y}_t}{Y_{Ht}} &= i_t \pi_{Ht} - \frac{(1 - \epsilon)}{\theta} - \frac{\epsilon W_t}{\theta P_{Ht} A_t} - \pi_{Ht}^2 \\ \Leftrightarrow \quad \dot{\pi}_{Ht} + \frac{(1 - \epsilon)}{\theta} + \frac{\epsilon W_t}{\theta P_{Ht} A_t} &= i_t \pi_{Ht} - \frac{\dot{y}_t}{Y_{Ht}} \pi_{Ht} - \pi_{Ht} \pi_{Ht} \\ \Leftrightarrow \quad \dot{\pi}_{Ht} + \frac{(1 - \epsilon)}{\theta} + \frac{\epsilon W_t}{\theta P_{Ht} A_t} &= \left[ i_t - \frac{\dot{y}_t}{Y_{Ht}} - \pi_{Ht} \right] \pi_{Ht} \\ \Leftrightarrow \quad \dot{\pi}_{Ht} - \frac{(\epsilon - 1)}{\theta} + \frac{\epsilon - 1}{\theta} \left( \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t} \right) &= \left[ i_t - \frac{\dot{y}_t}{Y_{Ht}} - \pi_{Ht} \right] \pi_{Ht} \\ \Rightarrow \quad \dot{\pi}_{Ht} + \frac{\epsilon - 1}{\theta} \left[ \left( \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t} \right) - 1 \right] &= \left[ i_t - \frac{\dot{y}_t}{Y_{Ht}} - \pi_{Ht} \right] \pi_{Ht} \end{aligned}$$

## E.6 Foreign Final Good Producers

Final good producers are competitive and aggregate a continuum of intermediate inputs. We assume that there is a continuum of measure one of differentiated goods  $Y_{Ft}^*(j)$  according to:

$$Y_{Ft}^* = \left[ \int_0^1 Y_{Ft}^*(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \tag{84}$$

whereby  $\epsilon > 1$  is the elasticity of substitution among differentiated goods.

The demand for foreign intermediate goods by the retailer is given by:

$$Y_{Ft}^*(j) = \left[ \frac{p_{Ft}^*(j)}{P_{Ft}^*} \right]^{-\epsilon} Y_{Ft}^* \quad (85)$$

whereby we define the aggregate price index  $P_{Ft}^* \equiv \left[ \int_0^1 p_{Ft}^*(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}$ .

## E.7 Foreign Intermediate Good Producers

The discussion is symmetric to the Home intermediate good producers.

**Assumption 3** (Symmetric Equilibrium). *We restrict attention to the symmetric equilibrium*

$$p_{Ft}^*(j) = P_{Ft}^*. \quad (86)$$

The price setting of firms implies that the inflation rate  $\pi_{Ft}^* \equiv \frac{\dot{P}_{Ft}^*}{P_{Ft}^*}$  is determined by

$$\left[ i_t^* - \pi_{Ft}^* - \frac{\dot{y}_{Ft}^*}{Y_{Ft}^*} \right] \pi_{Ft}^* = \frac{\epsilon - 1}{\theta} \left[ \frac{\epsilon}{\epsilon - 1} \frac{W_t^*}{P_{Ft}^*} \frac{1}{A_t^*} - 1 \right] + \dot{\pi}_{Ft}^*. \quad (87)$$

## E.8 Equilibrium

The aggregate home price index is

$$P_{Ht} = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{A_t}. \quad (88)$$

The aggregate foreign price index is

$$P_{Ft}^* = \frac{\epsilon}{\epsilon - 1} \frac{W_t^*}{A_t^*}. \quad (89)$$

Take the home firm optimality condition for pricing

$$p_{Ht}(j) = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{A_t}.$$

Impose the symmetric pricing equilibrium assumption  $p_{Ht}(j) = P_{Ht}$ . Analogously, for the foreign firm pricing optimality condition

$$p_{Ft}^*(j) = \frac{\epsilon}{\epsilon - 1} \frac{W_t^*}{A_t^*},$$

and impose the symmetry assumption  $p_{Ft}^*(j) = P_{Ft}^*$ .

The goods market clearing conditions for the home and foreign good are

$$Y_{Ht} = C_{Ht} + C_{Ht}^*, \quad (90)$$

$$Y_{Ft}^* = C_{Ft} + C_{Ft}^*. \quad (91)$$

The aggregate resource constraints on each economy's good are given by:

$$Y_{Ht} = A_t N_t, \quad (92)$$

$$Y_{Ft}^* = A_t^* N_t^*. \quad (93)$$

Take the domestic intermediate good firm production function

$$Y_{Ht}(j) = A_t n_t(j),$$

and integrate over  $j$

$$\int_0^1 Y_{Ht}(j) dj = \int_0^1 A_t n_t(j) dj.$$

This gives

$$Y_{Ht} = A_t N_t.$$

Likewise, for the Foreign good:

$$Y_{Ft}^* = A_t^* N_t^*.$$

**Assumption 4** (Law of One Price). *The law of one price holds*

$$P_{Ht} = E_t P_{Ht}^*. \quad (94)$$

$$P_{Ft} = E_t P_{Ft}^*. \quad (95)$$

$$(96)$$

**Remark 5.** *The stronger condition of purchasing power parity holds if we assume that the home bias is identical in both countries which then implies*

$$P_t = E_t P_t^*. \quad (97)$$

**Lemma 6** (Output). *Output as a function of markups, terms of in both countries is given by*

$$Y_{Ht} = A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1+\phi}} \{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}\}^{\frac{1}{1+\phi}}, \quad (98)$$

$$Y_{Ft}^* = A_t^* \left[ \frac{\epsilon - 1}{\epsilon} \right]^{\frac{1}{1+\phi^*}} [(1 - \gamma) + \gamma (\text{tot}_t^*)^{1-\eta}]^{-\frac{1}{1+\phi^*}} \{(1 - \gamma) + \gamma S_t e^{\Xi_t}\}^{\frac{1}{1+\phi^*}}. \quad (99)$$

*Proof.* We know that the domestic price index from equation (88) is

$$P_{Ht} = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{A_t}.$$

Re-arrange this

$$A_t = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht}}.$$

Multiply and divide by  $P_t$  to get

$$\frac{W_t}{P_t} = \frac{(\epsilon - 1)}{\epsilon} \frac{P_{Ht}}{P_t} A_t.$$

We also have the household's labour supply decision

$$C_t N_t^\phi = \frac{W_t}{P_t}.$$

So combine them to get

$$\begin{aligned} C_t N_t^\phi &= \frac{W_t}{P_t} \\ \Leftrightarrow C_t N_t^\phi &= \frac{(\epsilon - 1)}{\epsilon} \frac{P_{Ht}}{P_t} A_t \end{aligned}$$

Re-arrange for  $A_t$

$$A_t = \frac{\epsilon}{\epsilon - 1} C_t N_t^\phi \frac{P_t}{P_{Ht}}.$$

Next, recall the aggregate resource constraint

$$Y_{Ht} = A_t N_t \Rightarrow N_t = \frac{Y_{Ht}}{A_t}.$$

We plug this in

$$A_t = \frac{\epsilon}{\epsilon - 1} C_t \left[ \frac{Y_{Ht}}{A_t} \right]^\phi \frac{P_t}{P_{Ht}}.$$

Then re-arrange for aggregate home consumption

$$C_t = \frac{\epsilon - 1}{\epsilon} \frac{P_{Ht}}{P_t} A_t^{1+\phi} Y_{Ht}^{-\phi}.$$

We want to find an expression for  $C_t$ . The domestic CPI definition is

$$P_t = \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]^{1/(1-\eta)}.$$

Re-arrange

$$\begin{aligned}
P_t &= \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]^{1/(1-\eta)} \\
\Leftrightarrow P_t^{1-\eta} &= \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right] \\
\Leftrightarrow \left( \frac{P_t}{P_{Ht}} \right)^{1-\eta} &= (1 - \gamma) + \gamma \left( \frac{P_{Ft}}{P_{Ht}} \right)^{1-\eta} \\
\Leftrightarrow \left( \frac{P_t}{P_{Ht}} \right)^{1-\eta} &= (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \\
\Leftrightarrow \left( \frac{P_t}{P_{Ht}} \right) &= [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{1}{1-\eta}} \\
\Rightarrow \frac{P_{Ht}}{P_t} &= [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1-\eta}}.
\end{aligned}$$

The home and foreign demand for the home good are given by

$$\begin{aligned}
C_{Ht} &= (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t \\
C_{Ht}^* &= \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*.
\end{aligned}$$

Plug both into the home goods market clearing condition

$$\begin{aligned}
Y_{Ht} &= C_{Ht} + C_{Ht}^* \\
\Rightarrow Y_{Ht} &= (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t + \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*.
\end{aligned}$$

Since the home bias parameter is the same for both countries, purchasing power parity holds

$$P_t = E_t P_t^*.$$

So then use PPP and the law of one price

$$\boxed{\frac{P_{Ht}^*}{P_t^*} = \frac{P_{Ht} E_t^{-1}}{P_t E_t^{-1}} = \frac{P_{Ht}}{P_t}.}$$

Plug this back in in addition to the terms of trade

$$\begin{aligned}
Y_{Ht} &= (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t + \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^* \\
&= (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t + \gamma \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t^* \\
&= \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} [(1 - \gamma) C_t + \gamma C_t^*] \\
&= [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma) C_t + \gamma C_t^*].
\end{aligned}$$

Therefore

$$Y_{Ht} = [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma)C_t + \gamma C_t^*].$$

We now want to use the risk-sharing condition to eliminate  $C_t^*$ . First recall the risk-sharing condition

$$\left[ \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right] - \dot{S}_t = \rho^* - \rho - \Psi_t^*.$$

Then recall that

$$\begin{aligned} \frac{\dot{C}_t}{C_t} &= \frac{d}{dt} [\ln C_t], \\ \frac{\dot{C}_t^*}{C_t^*} &= \frac{d}{dt} [\ln C_t^*], \\ \dot{S}_t &= \frac{d(\ln S_t)}{dt}, \end{aligned}$$

where for  $\dot{S}_t$ , it holds by definition. So then the risk-sharing condition is

$$\frac{d}{dt} (\ln C_t - \ln C_t^* - \ln S_t) = \rho^* - \rho - \Psi_t^*.$$

The next step is to integrate both sides of the differential equation from an initial time  $t = 0$  to a later time  $t$ . We use  $u$  as the integration variable.

$$\int_0^t \frac{d}{du} (\ln C_u - \ln C_u^* - \ln S_u) du = \int_0^t (\rho^* - \rho - \Psi_u^*) du$$

The integral on the left side, being the integral of a derivative, simplifies to the difference of the function evaluated at the endpoints:

$$[\ln C_u - \ln C_u^* - \ln S_u]_0^t = (\ln C_t - \ln C_t^* - \ln S_t) - (\ln C_0 - \ln C_0^* - \ln S_0)$$

The integral on the right side is:

$$\int_0^t (\rho^* - \rho) du - \int_0^t \Psi_u^* du = (\rho^* - \rho)t - \int_0^t \Psi_u^* du$$

Equating the two sides gives:

$$(\ln C_t - \ln C_t^* - \ln S_t) - (\ln C_0 - \ln C_0^* - \ln S_0) = (\rho^* - \rho)t - \int_0^t \Psi_u^* du$$

Define a constant,  $K$ , that collects all the initial condition terms

$$K \equiv \ln C_0 - \ln C_0^* - \ln S_0$$

Moving this to the right side of the integrated equation gives:

$$\ln C_t - \ln C_t^* - \ln S_t = (\rho^* - \rho)t - \int_0^t \Psi_u^* du + K$$

Now introduce  $\Xi_t$  where the constant  $K$  is absorbed into  $\Xi_t$

$$\Xi_t \equiv (\rho^* - \rho)t - \int_0^t \Psi_u^* du + K$$

Using this definition, the integrated equation is written compactly as:

$$\ln C_t - \ln C_t^* - \ln S_t = \Xi_t$$

The final step is to solve for  $C_t^*$  from the logarithmic equation. We first isolate the  $\ln C_t^*$  term:

$$\ln C_t^* = \ln C_t - \ln S_t - \Xi_t$$

Now, we exponentiate both sides to remove the logarithms:

$$e^{\ln C_t^*} = e^{(\ln C_t - \ln S_t - \Xi_t)}$$

Using the property that  $e^{a+b} = e^a e^b$  and  $e^{\ln x} = x$ :

$$\begin{aligned} C_t^* &= e^{\ln C_t} \cdot e^{-\ln S_t} \cdot e^{-\Xi_t} \\ C_t^* &= C_t \cdot (e^{\ln S_t})^{-1} \cdot e^{-\Xi_t} \end{aligned}$$

This gives the final expression for foreign consumption  $C_t^*$  in level form:

$$C_t^* = C_t S_t^{-1} e^{-\Xi_t}.$$

So if we go back to

$$Y_{Ht} = [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma) C_t + \gamma C_t^*].$$

We have

$$Y_{Ht} = [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma) C_t + \gamma C_t S_t^{-1} e^{-\Xi_t}].$$

Which simplifies

$$Y_{Ht} = C_t [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}].$$

So now go back and use

$$C_t = \frac{\epsilon - 1}{\epsilon} \frac{P_{Ht}}{P_t} A_t^{1+\phi} Y_{Ht}^{-\phi}.$$

We therefore have

$$\begin{aligned}
Y_{Ht} &= C_t \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} \left[ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right] \\
\Leftrightarrow Y_{Ht} &= \frac{\epsilon - 1}{\epsilon} \frac{P_{Ht}}{P_t} A_t^{1+\phi} Y_{Ht}^{-\phi} \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} \left[ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right] \\
\Leftrightarrow Y_{Ht}^{1+\phi} &= \frac{\epsilon - 1}{\epsilon} \frac{P_{Ht}}{P_t} A_t^{1+\phi} \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} \left[ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right] \\
\Leftrightarrow Y_{Ht} &= A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} \left[ \frac{P_{Ht}}{P_t} \right]^{\frac{1}{1+\phi}} \left\{ \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} \left[ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right] \right\}^{\frac{1}{1+\phi}} \\
\Leftrightarrow Y_{Ht} &= A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} \left[ \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{-\frac{1}{1-\eta}} \right]^{\frac{1}{1+\phi}} \left\{ \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} \left[ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right] \right\}^{\frac{1}{1+\phi}} \\
\Rightarrow Y_{Ht} &= A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right]^{-\frac{1}{1+\phi}} \left\{ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right\}^{\frac{1}{1+\phi}}.
\end{aligned}$$

where in the last line, we used in the exponents

$$\frac{-1}{(1 - \eta)(1 + \phi)} + \frac{\eta}{(1 - \eta)(1 + \phi)} = -\frac{1}{1 + \phi}.$$

The result for  $Y_{Ft}$  holds by symmetry where we use the foreign CPI is

$$P_t^* = \left[ (1 - \gamma) P_{Ft}^{*1-\eta} + \gamma P_{Ht}^{*1-\eta} \right]^{1/(1-\eta)}.$$

The foreign terms of trade are

$$\text{tot}_t^* = \frac{P_{Ht}^*}{P_{Ft}^*}.$$

□

**Proposition 7** (Open-Economy Real Interest Rate). *The domestic natural rate of interest can be decomposed into the standard Ramsey terms and three distinct open-economy adjustment channels:*

$$r_t^n = (\rho + g_t) - \underbrace{\Psi_t}_{\text{Convenience Yield}} + \underbrace{\mathcal{T}_t}_{\text{Terms-of-Trade Channel}} + \underbrace{\mathcal{R}_t}_{\text{Risk-Sharing Channel}} \quad (100)$$

where  $g_t \equiv \dot{A}_t/A_t$  is TFP growth and  $\Psi_t$  is the convenience yield on domestic bonds. The terms-of-trade channel,  $\mathcal{T}_t$ , reflects how changes in relative goods prices affect consumption growth, and is given by:

$$\mathcal{T}_t = \left( \frac{\phi}{1 + \phi} - \frac{1}{1 - \eta} \right) \frac{\gamma(1 - \eta) \text{tot}_t^{1-\eta}}{(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right) \quad (101)$$

The international risk-sharing channel,  $\mathcal{R}_t$ , captures how incomplete financial markets impact consumption growth through exchange rate dynamics and financial frictions, and is given by:

$$\mathcal{R}_t = \frac{\phi}{1 + \phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right). \quad (102)$$

*Proof.* Take the domestic Euler equation

$$\frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho.$$

Re-arrange for the real rate  $r_t \equiv i_t - \pi_t$

$$r_t = \rho + \frac{\dot{C}_t}{C_t} - \psi_t.$$

Take the labour supply condition

$$C_t N_t^\phi = \frac{W_t}{P_t}.$$

Plug in the resource constraint

$$Y_{Ht} = A_t N_t,$$

into the labour supply condition to get

$$\frac{W_t}{P_t} = C_t \left[ \frac{Y_{Ht}}{A_t} \right]^\phi.$$

Then plug into the Dixit-stiglitz pricing

$$P_{Ht} = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{A_t},$$

to get

$$P_{Ht} = \frac{\epsilon}{\epsilon - 1} \frac{P_t C_t}{A_t} \left[ \frac{Y_{Ht}}{A_t} \right]^\phi.$$

Re-arrange for  $C_t$

$$C_t = \frac{\epsilon - 1}{\epsilon} \frac{P_{Ht}}{P_t} A_t^{1+\phi} Y_{Ht}^{-\phi}.$$

We previously showed

$$\frac{P_{Ht}}{P_t} = G_t^{-\frac{1}{1-\eta}}(\text{tot}_t) \equiv [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1-\eta}},$$

and

$$Y_{Ht} = A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1+\phi}} \{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}\}^{\frac{1}{1+\phi}}.$$

So therefore

$$C_t = \frac{\epsilon - 1}{\epsilon} G_t^{-\frac{1}{1-\eta}}(\text{tot}_t) A_t^{1+\phi} \left[ A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1+\phi}} \{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}\}^{\frac{1}{1+\phi}} \right]^{-\phi}.$$

This simplifies to

$$C_t = \left[ \frac{\epsilon - 1}{\epsilon} \right]^{\frac{1}{1+\phi}} G_t^{-\frac{1}{1-\eta}}(\text{tot}_t) A_t \left[ G_t^{-\frac{1}{1+\phi}}(\text{tot}_t) \{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}\}^{\frac{1}{1+\phi}} \right]^{-\phi},$$

which becomes

$$C_t = \left[ \frac{\epsilon - 1}{\epsilon} \right]^{\frac{1}{1+\phi}} G_t^{\frac{\phi}{1+\phi} - \frac{1}{1-\eta}} (\text{tot}_t) A_t \left\{ (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t} \right\}^{\frac{-\phi}{1+\phi}}.$$

Take logs of both sides

$$\log(C_t) = \frac{1}{1+\phi} \log \left[ \frac{\epsilon - 1}{\epsilon} \right] + \left[ \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right] \log [G_t] + \log [A_t] - \frac{\phi}{1+\phi} \log [(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}]$$

Differentiate with respect to  $t$  and use  $\frac{\dot{X}_t}{X_t} = \frac{d}{dt} \log(X_t)$ . So then we see that the first term on the right-hand side is 0. The third term clearly evaluates to

$$\frac{d}{dt} \log[A_t] = \frac{\dot{A}_t}{A_t}.$$

For the second term, the log expression is:

$$\left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \ln [G_t]$$

To differentiate this, we keep the constant coefficient and differentiate  $\ln(G_t)$  using the chain rule:

$$\frac{d}{dt} \left\{ \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \ln [G_t] \right\} = \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\dot{G}_t}{G_t}$$

To find  $\frac{\dot{G}_t}{G_t}$ , we first differentiate  $G_t = (1 - \gamma) + \gamma \text{tot}_t^{1-\eta}$  with respect to time:

$$\dot{G}_t = \frac{dG_t}{dt} = 0 + \gamma(1 - \eta) \text{tot}_t^{-\eta} \cdot \dot{\text{tot}}_t$$

Therefore, the growth rate is:

$$\begin{aligned} \frac{\dot{G}_t}{G_t} &= \frac{\gamma(1 - \eta) \text{tot}_t^{-\eta} \dot{\text{tot}}_t}{(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}} \\ &= \frac{\gamma(1 - \eta) \text{tot}_t^{1-\eta}}{(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right) \end{aligned}$$

Hence

$$\frac{\dot{G}_t}{G_t} = \frac{\gamma(1 - \eta) \text{tot}_t^{1-\eta}}{(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right).$$

For the fourth term, we have

$$-\frac{\phi}{1+\phi} \ln [(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}]$$

Let's define  $Z_t \equiv (1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}$  for clarity. The term is  $-\frac{\phi}{1+\phi} \ln(Z_t)$ . The derivative is

$$-\frac{\phi}{1+\phi} \frac{\dot{Z}_t}{Z_t}.$$

To find  $\dot{Z}_t$ , we differentiate  $Z_t$  with respect to time, which requires the product rule on  $S_t^{-1} e^{-\Xi_t}$ :

$$\begin{aligned}\dot{Z}_t &= \frac{dZ_t}{dt} = \gamma \left[ \left( \frac{d}{dt} S_t^{-1} \right) e^{-\Xi_t} + S_t^{-1} \left( \frac{d}{dt} e^{-\Xi_t} \right) \right] \\ &= \gamma [(-S_t^{-2} \dot{S}_t) e^{-\Xi_t} + S_t^{-1} (e^{-\Xi_t} (-\dot{\Xi}_t))]\end{aligned}$$

Factoring out common terms gives:

$$\dot{Z}_t = -\gamma S_t^{-1} e^{-\Xi_t} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right)$$

Therefore, the growth rate of  $Z_t$  is:

$$\frac{\dot{Z}_t}{Z_t} = \frac{-\gamma S_t^{-1} e^{-\Xi_t}}{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right)$$

Combine the results to arrive at consumption growth rate being

$$\frac{\dot{C}_t}{C_t} = \frac{\dot{A}_t}{A_t} + \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\dot{G}_t}{G_t} - \frac{\phi}{1+\phi} \frac{\dot{Z}_t}{Z_t}.$$

And plug in our expressions to get

$$\frac{\dot{C}_t}{C_t} = \frac{\dot{A}_t}{A_t} + \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta)\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right) + \frac{\phi}{1+\phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1-\gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right).$$

So then go back to the Euler equation

$$r_t = \rho + \frac{\dot{C}_t}{C_t} - \psi_t.$$

And plug in our expression for consumption growth

$$r_t = \rho + \frac{\dot{A}_t}{A_t} + \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\dot{G}_t}{G_t} - \frac{\phi}{1+\phi} \frac{\dot{Z}_t}{Z_t} - \psi_t.$$

Finally for notation, define the terms-of-trade channel  $\mathcal{T}_t \equiv \frac{\dot{G}_t}{G_t}$  and the risk-sharing channel  $\mathcal{R}_t \equiv \frac{\dot{Z}_t}{Z_t}$ . Also this is the real rate under the flexible setting so it is actually the natural rate

$$r_t^n = \rho + \frac{\dot{A}_t}{A_t} + \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\dot{G}_t}{G_t} - \frac{\phi}{1+\phi} \frac{\dot{Z}_t}{Z_t} - \psi_t.$$

□

**Remark 8.** Note that as  $\gamma \rightarrow 0$  where we have full home-bias, this formula collapses back into the closed economy setting  $r_t = \rho - \Psi_t + \dot{A}_t/A_t$ . Additionally, if we have unit elasticity  $\eta \rightarrow 1$ , we remove the terms-of-trade dynamics.

**Theorem 9** (Integral Representation of the Non-Linear Phillips Curves). *Home producer price inflation,  $\pi_{Ht}$ , is the expected present discounted value of future real marginal costs:*

$$\pi_{Ht} = \int_t^\infty e^{-\int_t^u (i_s - \frac{\dot{Y}_{Hs}}{Y_{Hs}} - \pi_{Hs}) ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du, \quad (103)$$

where the real marginal cost,  $mc_t$ , is given by:

$$mc_t \equiv \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t}. \quad (104)$$

Foreign producer price inflation,  $\pi_{F,t}^*$ , is the expected present discounted value of future foreign real marginal costs:

$$\pi_{F,t}^* = \int_t^\infty e^{-\int_t^u (i_s^* - \frac{\dot{Y}_{Fs}^*}{Y_{Fs}^*} - \pi_{Fs}^*) ds} \frac{\epsilon - 1}{\theta} (mc_u^* - 1) du, \quad (105)$$

where the foreign real marginal cost,  $mc_t^*$ , is given by:

$$mc_t^* \equiv \frac{\epsilon}{\epsilon - 1} \frac{W_t^*}{P_{F,t}^* A_t}. \quad (106)$$

*Proof.* We start from the price-setting equation derived from the sticky-price producer firm's problem:

$$\dot{\pi}_{Ht} + \frac{\epsilon - 1}{\theta} \left[ \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t} - 1 \right] = \left[ i_t - \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \pi_{Ht} \right] \pi_{Ht}$$

This is a non-linear Riccati equation. To solve it without linearization, we can use an integrating factor as it is a first-order ODE that is quadratic in inflation  $\pi_{Ht}$ . Move all terms involving  $\pi_{Ht}$  to the left side and define the firm's markup-adjusted real marginal cost as  $mc_t \equiv \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t}$ .

$$\dot{\pi}_{Ht} - \left[ i_t - \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \pi_{Ht} \right] \pi_{Ht} = -\frac{\epsilon - 1}{\theta} (mc_t - 1)$$

We define the firm's full, effective discount rate as  $\delta_t$ . This rate is endogenous because it depends on inflation itself:

$$\delta_t \equiv i_t - \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \pi_{Ht}$$

Substituting this definition allows us to write the equation in a form suitable for an integrating factor:

$$\dot{\pi}_{Ht} - \delta_t \pi_{Ht} = -\frac{\epsilon - 1}{\theta} (mc_t - 1)$$

The integrating factor,  $I_t$ , is defined based on the coefficient of the  $\pi_{Ht}$  term:

$$I_t = e^{\int_0^t -\delta_s ds} = e^{-\int_0^t (i_s - \frac{\dot{Y}_{Hs}}{Y_{Hs}} - \pi_{Hs}) ds}$$

Multiplying the equation by the integrating factor  $I_t$  allows the left side to be expressed as a single derivative. We then integrate from  $t$  to  $\infty$  to find the stable forward-looking solution.

$$\begin{aligned} \dot{\pi}_{Ht} - \delta_t \pi_{Ht} &= -\frac{\epsilon - 1}{\theta} (mc_t - 1) \\ \leftrightarrow e^{\int_0^t -\delta_s ds} \dot{\pi}_{Ht} - e^{\int_0^t -\delta_s ds} \delta_t \pi_{Ht} &= -e^{\int_0^t -\delta_s ds} \frac{\epsilon - 1}{\theta} (mc_t - 1) \\ \leftrightarrow \frac{d}{dt} \left( e^{-\int_0^t \delta_s ds} \pi_{Ht} \right) &= -e^{-\int_0^t \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_t - 1) \\ \leftrightarrow \int_t^\infty \frac{d}{du} \left( e^{-\int_0^u \delta_s ds} \pi_{Hu}(u) \right) du &= - \int_t^\infty e^{-\int_0^u \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du \\ \leftrightarrow \left[ e^{-\int_0^u \delta_s ds} \pi_{Hu}(u) \right]_t^\infty &= - \int_t^\infty e^{-\int_0^u \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du \end{aligned}$$

Applying the no-bubble (transversality) condition,  $\lim_{u \rightarrow \infty} e^{-\int_0^u \delta_s ds} \pi_{Hu}(u) = 0$ , gives:

$$\begin{aligned} -e^{-\int_0^t \delta_s ds} \pi_{Ht} &= - \int_t^\infty e^{-\int_0^u \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du \\ \pi_{Ht} &= e^{\int_0^t \delta_s ds} \int_t^\infty e^{-\int_0^u \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du \end{aligned}$$

Combining the exponential terms gives the final integral equation for inflation:

$$\pi_{Ht} = \int_t^\infty e^{-\int_t^u \delta_s ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du$$

Substituting the definition of  $\delta_s$  back in yields the complete, implicit solution:

$$\pi_{Ht} = \int_t^\infty e^{-\int_t^u \left( i_s - \frac{\dot{Y}_{Hs}}{Y_{Hs}} - \pi_{Hs} \right) ds} \frac{\epsilon - 1}{\theta} (mc_u - 1) du.$$

□

**Proposition 10** (Output Growth). *Output growth is given by IS term, terms-of-trade and risk-sharing channels*

$$\frac{\dot{Y}_{Ht}}{Y_{Ht}} = (i_t - \pi_t + \Psi_t - \rho) - \frac{(1 + \phi)}{1 + \phi \eta} \mathcal{T}_t - \frac{1 + \phi}{\phi} \mathcal{R}_t. \quad (107)$$

*Foreign output growth is given by the foreign IS term, and the corresponding terms-of-trade and risk-sharing channels:*

$$\frac{\dot{Y}_{F,t}^*}{Y_{F,t}^*} = (i_t^* - \pi_t^* + \Psi_t^* - \rho^*) - \frac{1 + \phi^*}{1 + \phi^* \eta} \mathcal{T}_t^* - \frac{1 + \phi^*}{\phi^*} \mathcal{R}_t^*. \quad (108)$$

*Proof.* The market-clearing condition for home-produced goods is that they must be purchased by

either domestic or foreign households:

$$Y_{Ht} = C_{Ht} + C_{Ht}^*$$

The derivation starts with the equation for total home output ( $Y_{Ht}$ ), which is determined by the sum of home and foreign demand. This is expressed in terms of each country's total consumption basket ( $C_t$  and  $C_t^*$ ) and the terms of trade ( $\text{tot}_t$ ).

$$Y_{Ht} = [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} [(1 - \gamma)C_t + \gamma C_t^*]$$

Use the risk-sharing condition to express foreign consumption ( $C_t^*$ ) in terms of domestic consumption ( $C_t$ ), the real exchange rate ( $S_t$ ), and the risk-sharing wedge ( $\Xi_t$ )

$$C_t^* = C_t S_t^{-1} e^{-\Xi_t}$$

Combine the risk-sharing condition and the goods market clearing condition. We then get

$$Y_{Ht} = C_t \cdot [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} \cdot [(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}]$$

To get from levels to growth rates, we take the natural logarithm of the equation and then differentiate with respect to time. Using the rule that for any variable  $X$ ,  $d(\ln(X))/dt = \dot{X}/X$ , we get:

$$\frac{\dot{Y}_{Ht}}{Y_{Ht}} = \frac{\dot{C}_t}{C_t} + \frac{d}{dt} \left( \ln \left( [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} \right) \right) + \frac{d}{dt} \left( \ln ((1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}) \right)$$

This equation shows that the growth rate of domestic output is equal to the growth rate of domestic consumption plus two adjustment terms that capture open-economy effects. Then recall the domestic household's Euler equation

$$\frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho.$$

Now, we can replace the consumption growth rate term,  $\frac{\dot{C}_t}{C_t}$ , with the domestic household's Euler equation:

$$\begin{aligned} \frac{\dot{Y}_{Ht}}{Y_{Ht}} &= \underbrace{(i_t - \pi_t + \Psi_t - \rho)}_{\text{Standard IS Channel (from Consumption)}} + \underbrace{\frac{d}{dt} \left( \ln \left( [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} \right) \right)}_{\text{Terms-of-Trade Channel}} \\ &\quad + \underbrace{\frac{d}{dt} \left( \ln ((1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}) \right)}_{\text{Expenditure-Switching Channel}} \end{aligned}$$

For the terms-of-trade channel, we need to differentiate

$$\ln \left( [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} \right) = \frac{\eta}{1-\eta} \ln \left( [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}] \right) = \frac{\eta}{1-\eta} \ln G_t.$$

We previously showed

$$\frac{d}{dt} \ln G_t = \frac{\dot{G}_t}{G_t} = \frac{\gamma(1-\eta)\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right).$$

So then

$$\frac{d}{dt} \frac{\eta}{1-\eta} \ln G_t = \frac{\eta\gamma\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right).$$

We previously defined

$$\mathcal{T}_t = \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta)\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right),$$

so then we can write

$$\frac{\eta\gamma\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right) = \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right)^{-1} \frac{1}{(1-\eta)} \mathcal{T}_t.$$

Combine the terms inside the parentheses by finding a common denominator, which is  $(1+\phi)(1-\eta)$ :

$$\begin{aligned} \frac{\phi}{1+\phi} - \frac{1}{1-\eta} &= \frac{\phi(1-\eta) - 1(1+\phi)}{(1+\phi)(1-\eta)} \\ &= \frac{\phi - \phi\eta - 1 - \phi}{(1+\phi)(1-\eta)} \\ &= \frac{-1 - \phi\eta}{(1+\phi)(1-\eta)} \end{aligned}$$

Invert the expression:

$$\left( \frac{-1 - \phi\eta}{(1+\phi)(1-\eta)} \right)^{-1} = \frac{(1+\phi)(1-\eta)}{-1 - \phi\eta} = -\frac{(1+\phi)(1-\eta)}{1 + \phi\eta}$$

Multiply by the remaining term and cancel out the  $(1 - \eta)$  term:

$$\begin{aligned} &\left( -\frac{(1+\phi)(1-\eta)}{1 + \phi\eta} \right) \frac{1}{(1-\eta)} \mathcal{T}_t \\ &= -\frac{(1+\phi)}{1 + \phi\eta} \mathcal{T}_t. \end{aligned}$$

Therefore we have

$$\ln \left( [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{\frac{\eta}{1-\eta}} \right) = -\frac{(1+\phi)}{1 + \phi\eta} \mathcal{T}_t.$$

For the expenditure switching channel

$$\frac{d}{dt} \left( \ln ((1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}) \right) = \frac{d}{dt} \ln Z_t = \frac{\dot{Z}_t}{Z_t} = \frac{-\gamma S_t^{-1} e^{-\Xi_t}}{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right).$$

We previously defined risk-sharing channel

$$\mathcal{R}_t = \frac{\phi}{1 + \phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right).$$

So then

$$\frac{-\gamma S_t^{-1} e^{-\Xi_t}}{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right) = -\frac{1 + \phi}{\phi} \mathcal{R}_t.$$

Recall that the last two terms is the terms-of-trade channel  $\mathcal{T}_t$  and the risk-sharing channel  $\mathcal{R}_t$ .

We therefore get

$$\frac{\dot{Y}_{Ht}}{Y_{Ht}} = (i_t - \pi_t + \Psi_t - \rho) - \frac{(1 + \phi)}{1 + \phi \eta} \mathcal{T}_t - \frac{1 + \phi}{\phi} \mathcal{R}_t.$$

□

**Theorem 11** (IS Curve). *The domestic IS curve is*

$$\dot{x}_t = (i_t - \pi_t - \rho) - g_t + \Psi_t - \mathcal{T}_t - \mathcal{R}_t, \quad (109)$$

where  $\dot{x}_t \equiv \frac{\dot{x}_t}{x_t}$  where  $x_t$  is the log deviation of actual output from its natural level:

$$x_t \equiv \ln(Y_{Ht}) - \ln(Y_{Ht}^n),$$

and recall that  $g_t$  is TFP growth,  $\Psi_t$  is the convenience yield,  $\mathcal{T}_t$  is the terms of trade effect and  $\mathcal{R}_t$  is the risk-sharing channel. The foreign IS curve is

$$\dot{x}_t^* = (i_t^* - \pi_t^* - \rho^*) - g_t^* + \Psi_t^* - \mathcal{T}_t^* - \mathcal{R}_t^*. \quad (110)$$

*Proof.* The natural level of home output under flexible prices is

$$Y_{Ht}^n = A_t \left( \frac{\epsilon - 1}{\epsilon} \right)^{\frac{1}{1+\phi}} [(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}]^{-\frac{1}{1+\phi}} \{(1 - \gamma) + \gamma S_t^{-1} e^{-\Xi_t}\}^{\frac{1}{1+\phi}}.$$

Then the evolution of the natural rate of output is

$$\frac{\dot{Y}_{Ht}^n}{Y_{Ht}^n} = (r_t^n + \Psi_t - \rho) - \frac{(1 + \phi)}{1 + \phi \eta} \mathcal{T}_t - \frac{1 + \phi}{\phi} \mathcal{R}_t.$$

Actual output growth is given by

$$\frac{\dot{Y}_{Ht}}{Y_{Ht}} = (i_t - \pi_t + \Psi_t - \rho) - \frac{1 + \phi}{1 + \phi \eta} \mathcal{T}_t - \frac{1 + \phi}{\phi} \mathcal{R}_t.$$

Now define the output gap  $x_t$  as the log deviation of actual output from its natural level:

$$x_t \equiv \ln(Y_{Ht}) - \ln(Y_{Ht}^n).$$

The evolution of the output gap ( $\dot{x}_t$ ) is the difference between the growth rate of actual output and the growth rate of natural output:

$$\dot{x}_t = \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \frac{\dot{Y}_{Ht}^n}{Y_{Ht}^n}$$

Substituting these into the equation for  $\dot{x}_t$ :

$$\begin{aligned}\dot{x}_t &= \left[ (i_t - \pi_t + \Psi_t - \rho) - \frac{1+\phi}{1+\phi\eta} \mathcal{T}_t - \frac{1+\phi}{\phi} \mathcal{R}_t \right] \\ &\quad - \left[ (r_{n,t} + \Psi_t - \rho) - \frac{1+\phi}{1+\phi\eta} \mathcal{T}_t - \frac{1+\phi}{\phi} \mathcal{R}_t \right]\end{aligned}$$

The terms cancel out to leave

$$\dot{x}_t = (i_t - \pi_t) - r_t^n.$$

Now recall we previously showed that the domestic natural rate of interest can be decomposed into the standard Ramsey terms and three distinct open-economy adjustment channels:

$$r_t^n = (\rho + g_t) - \underbrace{\Psi_t}_{\text{Convenience Yield}} + \underbrace{\mathcal{T}_t}_{\text{Terms-of-Trade Channel}} + \underbrace{\mathcal{R}_t}_{\text{Risk-Sharing Channel}}$$

where  $g_t \equiv \dot{A}_t/A_t$  is TFP growth and  $\Psi_t$  is the convenience yield on domestic bonds. The terms-of-trade channel,  $\mathcal{T}_t$ , reflects how changes in relative goods prices affect consumption growth, and is given by:

$$\mathcal{T}_t = \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta)\text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma\text{tot}_t^{1-\eta}} \left( \frac{\dot{\text{tot}}_t}{\text{tot}_t} \right)$$

The international risk-sharing channel,  $\mathcal{R}_t$ , captures how incomplete financial markets impact consumption growth through exchange rate dynamics and financial frictions, and is given by:

$$\mathcal{R}_t = \frac{\phi}{1+\phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1-\gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \dot{\Xi}_t \right).$$

So plug this into the IS curve to get

$$\dot{x}_t = (i_t - \pi_t - \rho) - g_t + \Psi_t - \mathcal{T}_t - \mathcal{R}_t.$$

□

The output gap expands ( $\dot{x}_t > 0$ ) whenever the actual real interest rate is below the natural real interest rate, and contracts when it is above. This is the central equation linking monetary policy

(via nominal interest rate  $i_t$ ) to the real economy (via  $x_t$ ).

**Theorem 12** (Linearized NKPC). *The home linearised New Keynesian Phillips curve is*

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa [\tilde{c}_t + \phi x_t + \gamma \tau_t], \quad (111)$$

where  $\bar{\delta}_H \equiv \bar{i} - \overline{\dot{Y}_{Ht}/Y_{Ht}} - \bar{\pi}_H$ ,  $\tilde{c}_t \equiv \hat{C}_t - \hat{C}_t^n$  is the consumption gap,  $x_t$  is the output gap,  $\tau_t \equiv \ln \text{tot}_t - \ln \text{tot}_t^n$  is the terms-of-trade gap.

The foreign country New Keynesian Phillips curve is

$$\dot{\hat{\pi}}_{Ft}^* = -\bar{\delta}_F \hat{\pi}_{Ft}^* + \kappa [\tilde{c}_t^* + \phi^* x_t^* + \gamma \tau_t^*], \quad (112)$$

*Proof.* First start from the Rotemberg price-setting ODE

$$\dot{\pi}_{Ht} + \left( i_t - \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \pi_{Ht} \right) \pi_{Ht} = \frac{\epsilon - 1}{\theta} \left( \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t} - 1 \right).$$

To simplify notation, define

$$\begin{aligned} \delta_t &= i_t - \frac{\dot{Y}_{Ht}}{Y_{Ht}} - \pi_{Ht}, \\ mc_t &= \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t}, \\ \kappa &= \frac{\epsilon - 1}{\theta}. \end{aligned}$$

Therefore we have

$$\dot{\pi}_{Ht} = -\delta_t \pi_{Ht} + \kappa (mc_t - 1).$$

To linearize around steady state, we first write each variable as a steady-state deviation:

$$\pi_{Ht} = \bar{\pi}_H + \hat{\pi}_{Ht}, \quad \delta_t = \bar{\delta}_H + \hat{\delta}_t, \quad mc_t = 1 + \widehat{mc}_t,$$

with bars denoting steady state values and hats denoting first-order deviations. Recall that linearisation is invariant to an affine relabelling of variables. Recall that the steady state marginal cost is  $\bar{mc} = 1$ . Since  $\bar{\pi}_H$  is constant,

$$\dot{\pi}_{Ht} = \dot{\hat{\pi}}_{Ht}.$$

Substitute the expressions in:

$$\dot{\hat{\pi}}_{Ht} = -(\bar{\delta}_H + \hat{\delta}_t)(\bar{\pi}_H + \hat{\pi}_{Ht}) + \kappa((1 + \widehat{mc}_t) - 1).$$

Expand the product:

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \bar{\pi}_H - \bar{\delta}_H \hat{\pi}_{Ht} - \bar{\pi}_H \hat{\delta}_t - \hat{\delta}_t \hat{\pi}_{Ht} + \kappa \widehat{mc}_t.$$

By linearisation, we drop the second-order term  $-\hat{\delta}_t \hat{\pi}_{Ht}$ . Now impose zero steady-state inflation,  $\bar{\pi}_H = 0$ . Then

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa \widehat{mc}_t.$$

Also, we know that under flexible prices, the natural (flexible price) marginal cost is

$$mc_t^n = 1.$$

Also recall that marginal cost at steady state  $\bar{mc} = 1$ . So then the natural marginal cost deviation is 0

$$\widehat{mc}_t^n = \ln(mc_t^n) - \ln(\bar{mc}) = \ln(1) - \ln(1) = 0.$$

So then the marginal cost gap is equal to the marginal cost deviation from steady state

$$\begin{aligned}\widehat{mc}_t^{\text{gap}} &\equiv \ln(mc_t) - \ln(mc_t^n) \\ &= \ln(mc_t) - 0 \\ &= \ln(mc_t) \\ &= \ln(mc_t) - \underbrace{\ln(\bar{mc})}_{=0} \\ &= \widehat{mc}_t.\end{aligned}$$

Therefore

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa \widehat{mc}_t^{\text{gap}}.$$

This is the desired first-order linearization around a zero-inflation steady state.

Next, linearize real marginal cost. Using intratemporal optimality  $W_t/P_t = C_t N_t^\phi$  and rewrite as

$$\frac{W_t}{P_{Ht}} = C_t N_t^\phi \frac{P_t}{P_{Ht}}.$$

Linearise to get

$$\Rightarrow \widehat{W}_t - \widehat{P}_{Ht} = \widehat{C}_t + \phi \widehat{N}_t + (\widehat{P}_t/\widehat{P}_{Ht}).$$

Take the marginal cost

$$mc_t = \frac{\epsilon}{\epsilon - 1} \frac{W_t}{P_{Ht} A_t}.$$

Linearise this and substitute in the household optimality condition

$$\widehat{mc}_t = (\widehat{W}_t - \widehat{P}_{Ht}) - \widehat{A}_t = \widehat{C}_t + \phi \widehat{N}_t + (\widehat{P}_t/\widehat{P}_{Ht}) - \widehat{A}_t.$$

Since  $Y_{Ht} = A_t N_t$ , then  $\widehat{N}_t = \widehat{Y}_{Ht} - \widehat{A}_t$ , giving

$$\widehat{mc}_t = \widehat{C}_t + \phi \widehat{Y}_{Ht} + (\widehat{P}_t/\widehat{P}_{Ht}) - (1 + \phi) \widehat{A}_t.$$

Analogously, define the natural (flexible price) marginal cost as

$$\widehat{mc}_t^n = \widehat{C}_t^n + \phi \widehat{Y}_{Ht}^n + \left( \widehat{\frac{P_t^n}{P_{Ht}^n}} \right) - (1 + \phi) \widehat{A}_t^n.$$

And noting that  $\widehat{A}_t = \widehat{A}_t^n$ , we have that the marginal cost gap

$$\widehat{mc}_t^{\text{gap}} \equiv \widehat{mc}_t - \widehat{mc}_t^n = \left( \widehat{C}_t - \widehat{C}_t^n \right) + \left( \phi \widehat{Y}_{Ht} - \phi \widehat{Y}_{Ht}^n \right) + \left( \widehat{\frac{P_t}{P_{Ht}}} - \widehat{\left( \frac{P_t^n}{P_{Ht}^n} \right)} \right).$$

We now want to log-linearise the CPI–PPI wedge  $P_t/P_{Ht}$  and map it into the terms of trade. With

$$P_t = \left[ (1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}, \quad \text{tot}_t \equiv \frac{P_{F,t}}{P_{Ht}},$$

we have

$$\ln \frac{P_t}{P_{Ht}} = \frac{1}{1-\eta} \ln \left[ (1 - \gamma) + \gamma \text{tot}_t^{1-\eta} \right].$$

Therefore taking the partial derivative

$$\frac{\partial \ln(P_t/P_{Ht})}{\partial \ln \text{tot}_t} = \frac{\gamma \text{tot}_t^{1-\eta}}{(1 - \gamma) + \gamma \text{tot}_t^{1-\eta}},$$

and, evaluating at a symmetric steady state where  $\bar{P}_H = \bar{P}_F$ , this implies  $\overline{\text{tot}} = 1$ , and therefore steady state

$$\frac{\partial \ln(P_t/P_{Ht})}{\partial \ln \text{tot}_t} \Big|_{\overline{\text{tot}}=1} = \frac{\gamma (1)^{1-\eta}}{(1 - \gamma) + \gamma (1)^{1-\eta}} = \gamma.$$

So then a first-order Taylor expansion of  $\ln \left( \frac{P_t}{P_{Ht}} \right)$  is

$$\ln \left( \frac{P_t}{P_{Ht}} \right) \approx \ln \left( \frac{\bar{P}}{\bar{P}_H} \right) + \gamma (\ln \text{tot}_t - \ln \text{tot})$$

In the natural (flexible-price) economy, this is

$$\ln \left( \frac{P_t^n}{P_{Ht}^n} \right) \approx \ln \left( \frac{\bar{P}^n}{\bar{P}_H^n} \right) + \gamma (\ln \text{tot}_t^n - \ln \text{tot}^n).$$

Then if we take the difference

$$\ln \left( \frac{P_t}{P_{Ht}} \right) - \ln \left( \frac{P_t^n}{P_{Ht}^n} \right) = \gamma [(\ln \text{tot}_t - \ln \text{tot}) - (\ln \text{tot}_t^n - \ln \text{tot}^n)] = \gamma [\ln \text{tot}_t - \ln \text{tot}_t^n].$$

So therefore

$$\underbrace{\ln \left( \frac{P_t}{P_{Ht}} \right) - \ln \left( \frac{P_t^n}{P_{Ht}^n} \right)}_{\equiv \left( \frac{P_t}{P_{Ht}} \right)^{\text{gap}}} = \gamma \left[ \underbrace{\ln \text{tot}_t - \ln \text{tot}_t^n}_{\equiv \tau_t} \right],$$

where we define the terms-of-trade gap as

$$\tau_t \equiv \ln \text{tot}_t - \ln \text{tot}_t^n,$$

and the CPI-PPI wedge gap

$$\left( \frac{P_t}{P_{Ht}} \right)^{\text{gap}} \equiv \ln \left( \frac{P_t}{P_{Ht}} \right) - \ln \left( \frac{P_t^n}{P_{Ht}^n} \right).$$

So therefore the CPI-PPI wedge gap is

$$\left( \frac{P_t}{P_{Ht}} \right)^{\text{gap}} = \gamma \tau_t.$$

Then use

$$\left( \widehat{\frac{P_t}{P_{Ht}}} - \widehat{\left( \frac{P_t^n}{P_{Ht}^n} \right)} \right) = \left( \frac{P_t}{P_{Ht}} \right)^{\text{gap}}.$$

So then the marginal cost gap becomes

$$\widehat{mc}_t^{\text{gap}} = \left( \widehat{C}_t - \widehat{C}_t^n \right) + \phi \left( \widehat{Y}_{Ht} - \widehat{Y}_{Ht}^n \right) + \gamma \tau_t.$$

Then recall that the output gap

$$x_t \equiv \ln(Y_{Ht}) - \ln(Y_{Ht}^n) = \widehat{Y}_{Ht} - \widehat{Y}_{Ht}^n.$$

So marginal cost gap is

$$\widehat{mc}_t^{\text{gap}} = \left( \widehat{C}_t - \widehat{C}_t^n \right) + \phi x_t + \gamma \tau_t.$$

So plug this into the linearised pricing ODE

$$\begin{aligned} \dot{\hat{\pi}}_{Ht} &= -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa \widehat{mc}_t^{\text{gap}} \\ &= -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa \left[ \underbrace{\left( \widehat{C}_t - \widehat{C}_t^n \right)}_{\equiv \tilde{c}_t} + \phi x_t + \gamma \tau_t \right]. \end{aligned}$$

So therefore

$$\dot{\hat{\pi}}_{Ht} = -\bar{\delta}_H \hat{\pi}_{Ht} + \kappa [\tilde{c}_t + \phi x_t + \gamma \tau_t].$$

□

## E.9 Policy

**Fiscal Policy** Let  $B_t$  denote the face value of outstanding nominal government debt,  $i_t$  the instantaneous nominal policy rate,  $P_t$  the CPI, and  $G_t$  real government purchases. With lump-sum

taxes  $T_t$  (nominal), the consolidated nominal flow budget is

$$\dot{B}_t = i_t B_t + P_t G_t - T_t. \quad (113)$$

Define real debt  $b_t \equiv B_t/P_t$  and inflation  $\pi_t \equiv \dot{P}_t/P_t$ . Let the (real) primary surplus be  $s_t \equiv (T_t - P_t G_t)/P_t = T_t/P_t - G_t$ . Dividing (113) by  $P_t$  and using  $\dot{b}_t = \frac{\dot{B}_t}{P_t} - \pi_t b_t$  gives the real debt law of motion

$$\dot{b}_t = (i_t - \pi_t) b_t - s_t. \quad (114)$$

This linear ODE has integrating factor  $\mathcal{I}_t \equiv \exp(-\int_0^t (i_\tau - \pi_\tau) d\tau)$ , so  $\frac{d}{dt}(\mathcal{I}_t b_t) = -\mathcal{I}_t s_t$ . Integrating from  $t$  to  $T$  and imposing the no-Ponzi/transversality condition  $\lim_{T \rightarrow \infty} \mathcal{I}_T b_T = 0$  yields the forward solution (government debt valuation)

$$b_t = \int_t^\infty \exp\left(-\int_t^u (i_s - \pi_s) ds\right) s_u du, \quad \frac{B_t}{P_t} = \int_t^\infty e^{-\int_t^u i_s ds} \frac{T_u - P_u G_u}{P_u} du. \quad (115)$$

**Monetary Policy** Monetary policy follows a continuous-time Taylor rule with an inflation coefficient strictly below one:

$$i_t = r_t^n + \bar{\pi} + \phi_\pi (\pi_t - \bar{\pi}) + \phi_x x_t, \quad 0 \leq \phi_\pi < 1, \quad \phi_x \geq 0, \quad (116)$$

where  $\bar{\pi}$  is the inflation target,  $x_t \equiv \ln(Y_{H,t}) - \ln(Y_{H,t}^n)$  is the output gap, and  $r_t^n$  is the open-economy natural real rate. The ex-post real rate entering the discount kernel is

$$i_t - \pi_t = r_t^n + (\phi_\pi - 1) \hat{\pi}_t + \phi_x x_t, \quad \hat{\pi}_t \equiv \pi_t - \bar{\pi}. \quad (117)$$

**Debt Valuation** Substituting (117) into (72) gives

$$b_t = \int_t^\infty \exp\left(-\int_t^u [r_\tau^n + (\phi_\pi - 1) \hat{\pi}_\tau + \phi_x x_\tau] d\tau\right) s_u du. \quad (118)$$

Evaluated just before issuance at time  $t$  (so  $B_{t-}$  is predetermined), the CPI adjusts on impact to satisfy

$$\frac{B_{t-}}{P_t} = \int_t^\infty \exp\left(-\int_t^u [r_\tau^n + (\phi_\pi - 1) \hat{\pi}_\tau + \phi_x x_\tau] d\tau\right) s_u du,$$

pinning down  $P_t$  from fiscal solvency when  $\phi_\pi < 1$ . For Foreign,

$$\frac{B_t^*}{P_t^*} = \int_t^\infty \exp\left(-\int_t^u [r_\tau^{n*} + (\phi_\pi^* - 1) \hat{\pi}_\tau^* + \phi_x^* x_\tau^*] d\tau\right) s_u^* du.$$

## E.10 Equilibrium

Given exogenous processes  $\{A_t, A_t^*, s_t, s_t^*, \Psi_t, \Psi_t^*\}$  and initial conditions (including  $B_{t-}, B_{t-}^*$ ), an equilibrium is a collection of processes

$$\{C_t, N_t, Y_{Ht}, P_t, P_{Ht}, \pi_t, i_t, B_t, C_t^*, N_t^*, Y_{Ft}^*, P_t^*, P_{Ft}^*, \pi_t^*, i_t^*, B_t^*, E_t, \text{tot}_t, S_t\}$$

that satisfy the following conditions:

### 1. Households (Home and Foreign).

*Intratemporal optimality (labor supply):*

$$C_t N_t^\phi = \frac{W_t}{P_t}, \quad C_t^* (N_t^*)^{\phi^*} = \frac{W_t^*}{P_t^*}.$$

*Euler equations with convenience yield:*

$$\frac{\dot{C}_t}{C_t} = i_t - \pi_t + \Psi_t - \rho, \quad \frac{\dot{C}_t^*}{C_t^*} = i_t^* - \pi_t^* + \Psi_t^* - \rho^*.$$

*UIP and risk sharing:*

$$i_t - i_t^* = \frac{\dot{E}_t}{E_t} - \Psi_t, \quad \left( \frac{\dot{C}_t}{C_t} - \frac{\dot{C}_t^*}{C_t^*} \right) - \frac{\dot{S}_t}{S_t} = \rho^* - \rho - \Psi_t^*,$$

where  $S_t \equiv E_t P_t^* / P_t$  is the real exchange rate.

*CES demands and CPI (Home):*

$$C_{Ht} = (1 - \gamma) \left( \frac{P_{Ht}}{P_t} \right)^{-\eta} C_t, \quad C_{Ft} = \gamma \left( \frac{P_{Ft}}{P_t} \right)^{-\eta} C_t,$$

$$P_t = [(1 - \gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta}]^{\frac{1}{1-\eta}}.$$

*CES demands and CPI (Foreign, symmetric):*

$$C_{Ft}^* = (1 - \gamma) \left( \frac{P_{Ft}^*}{P_t^*} \right)^{-\eta} C_t^*, \quad C_{Ht}^* = \gamma \left( \frac{P_{Ht}^*}{P_t^*} \right)^{-\eta} C_t^*,$$

$$P_t^* = [(1 - \gamma) (P_{Ft}^*)^{1-\eta} + \gamma (P_{Ht}^*)^{1-\eta}]^{\frac{1}{1-\eta}}.$$

### 2. Firms and price setting.

*Final-good aggregation and PPI (Home):*

$$P_{Ht} = \left( \int_0^1 p_{Ht}(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}, \quad Y_{Ht}(j) = \left( \frac{p_{Ht}(j)}{P_{Ht}} \right)^{-\varepsilon} Y_{Ht}.$$

*Foreign (symmetric):*

$$P_{Ft}^* = \left( \int_0^1 p_{Ft}^*(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}, \quad Y_{Ft}^*(j) = \left( \frac{p_{Ft}^*(j)}{P_{Ft}^*} \right)^{-\varepsilon} Y_{Ft}^*.$$

*Technology and feasibility:*

$$Y_{Ht} = A_t N_t, \quad Y_{Ft}^* = A_t^* N_t^*.$$

*Real marginal costs:*

$$mc_t \equiv \frac{\varepsilon}{\varepsilon - 1} \frac{W_t}{P_{Ht} A_t}, \quad mc_t^* \equiv \frac{\varepsilon}{\varepsilon - 1} \frac{W_t^*}{P_{Ft}^* A_t^*}.$$

*Price setting kernels:*

$$\begin{aligned} \left( i_t - \pi_{Ht} - \frac{\dot{Y}_{Ht}}{Y_{Ht}} \right) \pi_{Ht} &= \frac{\varepsilon - 1}{\theta} (mc_t - 1) - \dot{\pi}_{Ht}, \\ \left( i_t^* - \pi_{Ft}^* - \frac{\dot{Y}_{Ft}^*}{Y_{Ft}^*} \right) \pi_{Ft}^* &= \frac{\varepsilon - 1}{\theta} (mc_t^* - 1) - \dot{\pi}_{Ft}^*. \end{aligned}$$

*Integral representation of the nonlinear NKPCs:*

$$\begin{aligned} \pi_{Ht} &= \int_t^\infty \exp \left\{ - \int_t^u \left[ i_s - \frac{\dot{Y}_{Hs}}{Y_{Hs}} - \pi_{Hs} \right] ds \right\} \frac{\varepsilon - 1}{\theta} (mc_u - 1) du, \\ \pi_{Ft}^* &= \int_t^\infty \exp \left\{ - \int_t^u \left[ i_s^* - \frac{\dot{Y}_{Fs}^*}{Y_{Fs}^*} - \pi_{Fs}^* \right] ds \right\} \frac{\varepsilon - 1}{\theta} (mc_u^* - 1) du. \end{aligned}$$

### 3. Technology, feasibility, and market clearing.

*Goods market clearing (each good):*

$$Y_{Ht} = C_{Ht} + C_{Ht}^*, \quad Y_{Ft}^* = C_{Ft} + C_{Ft}^*.$$

*Law of One Price (good level):*

$$P_{Ht} = E_t P_{Ht}^*, \quad P_{Ft} = E_t P_{Ft}^*.$$

*Terms of trade and identity:*

$$\text{tot}_t \equiv \frac{P_{Ft}}{P_{Ht}}, \quad \tau_t \equiv \ln \text{tot}_t = \ln P_{Ft} - \ln P_{Ht}, \quad \dot{\tau}_t = \pi_{Ft} - \pi_{Ht}.$$

### 4. Natural real rate and IS equations.

*Natural real rate decomposition (flex-price allocation):*

$$r_t^n = (\rho + g_t) - \Psi_t + T_t + R_t, \quad g_t \equiv \frac{\dot{A}_t}{A_t},$$

$$\begin{aligned} T_t &= \left( \frac{\phi}{1+\phi} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta) \text{tot}_t^{1-\eta}}{(1-\gamma) + \gamma \text{tot}_t^{1-\eta}} \frac{\dot{\text{tot}}_t}{\text{tot}_t}, \\ R_t &= \frac{\phi}{1+\phi} \frac{\gamma S_t^{-1} e^{-\Xi_t}}{(1-\gamma) + \gamma S_t^{-1} e^{-\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \frac{\dot{\Xi}_t}{\Xi_t} \right), \end{aligned}$$

with  $S_t \equiv E_t P_t^* / P_t$ . Foreign analogues  $r_t^{n*}, T_t^*, R_t^*$  are defined symmetrically.

$$r_t^{n*} = (\rho^* + g_t^*) - \Psi_t^* + T_t^* + R_t^*, \quad g_t^* \equiv \frac{\dot{A}_t^*}{A_t^*}.$$

$$\begin{aligned} T_t^* &= \left( \frac{\phi^*}{1+\phi^*} - \frac{1}{1-\eta} \right) \frac{\gamma(1-\eta) (\text{tot}_t^*)^{1-\eta}}{(1-\gamma) + \gamma (\text{tot}_t^*)^{1-\eta}} \frac{\dot{\text{tot}}_t^*}{\text{tot}_t^*}, \quad \text{tot}_t^* \equiv \frac{P_{Ht}^*}{P_{Ft}^*}, \\ R_t^* &= \frac{\phi^*}{1+\phi^*} \frac{\gamma S_t e^{\Xi_t}}{(1-\gamma) + \gamma S_t e^{\Xi_t}} \left( \frac{\dot{S}_t}{S_t} + \frac{\dot{\Xi}_t}{\Xi_t} \right), \quad S_t \equiv \frac{E_t P_t^*}{P_t}. \end{aligned}$$

*IS curve for the Home output gap*  $x_t \equiv \ln Y_{Ht} - \ln Y_{Ht}^n$ :

$$\dot{x}_t = (i_t - \pi_t) - r_t^n, \quad \text{equivalently} \quad \dot{x}_t = (i_t - \pi_t - \rho) - g_t + \Psi_t - T_t - R_t.$$

*IS curve for the Foreign output gap*  $x_t^* \equiv \ln Y_{Ft}^* - \ln (Y_{Ft}^{n,*})$ :

$$\dot{x}_t^* = (i_t^* - \pi_t^*) - r_t^{n*}, \quad \text{equivalently} \quad \dot{x}_t^* = (i_t^* - \pi_t^* - \rho^*) - g_t^* + \Psi_t^* - T_t^* - R_t^*.$$

## 5. Policy blocks.

*Monetary policy (Home):*

$$i_t = r_t^n + \bar{\pi} + \phi_\pi(\pi_t - \bar{\pi}) + \phi_x x_t, \quad 0 \leq \phi_\pi < 1, \phi_x \geq 0,$$

$$i_t - \pi_t = r_t^n + (\phi_\pi - 1)\hat{\pi}_t + \phi_x x_t, \quad \hat{\pi}_t \equiv \pi_t - \bar{\pi},$$

*Monetary policy (Foreign):*

$$i_t^* = r_t^{n*} + \bar{\pi}^* + \phi_\pi^*(\pi_t^* - \bar{\pi}^*) + \phi_x^* x_t^*, \quad 0 \leq \phi_\pi^* < 1, \phi_x^* \geq 0,$$

$$i_t^* - \pi_t^* = r_t^{n*} + (\phi_\pi^* - 1)\hat{\pi}_t^* + \phi_x^* x_t^*, \quad \hat{\pi}_t^* \equiv \pi_t^* - \bar{\pi}^*.$$

*Fiscal block (Home):*

$$\dot{b}_t = (i_t - \pi_t)b_t - s_t, \quad b_t \equiv \frac{B_t}{P_t},$$

$$b_t = \int_t^\infty \exp \left\{ - \int_t^u [r_\tau^n + (\phi_\pi - 1)\hat{\pi}_\tau + \phi_x x_\tau] d\tau \right\} s_u du,$$

*Fiscal block (Foreign):*

$$\begin{aligned} \dot{b}_t^* &= (i_t^* - \pi_t^*) b_t^* - s_t^*, \quad b_t^* \equiv \frac{B_t^*}{P_t^*}, \\ b_t^* &= \int_t^\infty \exp \left\{ - \int_t^u [r_\tau^{n,*} + (\phi_\pi^* - 1)\hat{\pi}_\tau^* + \phi_x^* x_\tau^*] d\tau \right\} s_u^* du. \end{aligned}$$

## 6. External asset pricing and exchange rate.

*Exchange-rate level as a ratio of fiscal present values:*

$$\begin{aligned} \mathcal{S}_t &\equiv \int_t^\infty \exp \left\{ - \int_t^u [r_\tau^n + (\phi_\pi - 1)\hat{\pi}_\tau + \phi_x x_\tau] d\tau \right\} s_u du, \\ \mathcal{S}_t^* &\equiv \int_t^\infty \exp \left\{ - \int_t^u [r_\tau^{n,*} + (\phi_\pi^* - 1)\hat{\pi}_\tau^* + \phi_x^* x_\tau^*] d\tau \right\} s_u^* du, \\ E_t &= \frac{B_{t-}}{B_{t-}^*} \cdot \frac{\mathcal{S}_t^*}{\mathcal{S}_t} \quad (\text{under PPP}). \end{aligned}$$

*Exchange-rate growth decomposition:*

$$\frac{\dot{E}_t}{E_t} = (r_t^{n*} - r_t^n) + (\phi_\pi^* - 1)\hat{\pi}_t^* - (\phi_\pi - 1)\hat{\pi}_t + \phi_x^* x_t^* - \phi_x x_t + \left( \frac{s_t}{\mathcal{S}_t} - \frac{s_t^*}{\mathcal{S}_t^*} \right).$$

## E.11 Final linearised system

### Home block

$$\dot{x}_t = (\phi_\pi - 1)\hat{\pi}_t + \phi_x x_t - \hat{r}_t^n, \quad (119)$$

$$\dot{\hat{\pi}}_{H,t} = -\bar{\delta}_H \hat{\pi}_{H,t} + \kappa (\tilde{c}_t + \phi x_t + \gamma \tau_t), \quad (120)$$

$$\hat{r}_t^n = (g_t - \bar{g}) - \Psi_t + T_t + R_t. \quad (121)$$

### Foreign block (symmetric)

$$\dot{x}_t^* = (\phi_\pi^* - 1)\hat{\pi}_t^* + \phi_x^* x_t^* - \hat{r}_t^{n*}, \quad (122)$$

$$\dot{\hat{\pi}}_{F,t}^* = -\bar{\delta}_F^* \hat{\pi}_{F,t}^* + \kappa^* (\tilde{c}_t^* + \phi^* x_t^* + \gamma^* \tau_t), \quad (123)$$

$$\hat{r}_t^{n*} = (g_t^* - \bar{g}^*) - \Psi_t^* + T_t^* + R_t^*. \quad (124)$$

### Open-economy wedges and identities

$$\tau_t = \ln P_{F,t} - \ln P_{H,t}, \quad \dot{\tau}_t = \hat{\pi}_{F,t} - \hat{\pi}_{H,t}, \quad (125)$$

$$i_t - i_t^* = \hat{e}_t - \Psi_t, \quad \text{under PPP: } \hat{e}_t = \hat{\pi}_t - \hat{\pi}_t^*. \quad (126)$$

## Monetary policy

$$\hat{i}_t = \hat{r}_t^n + \phi_\pi \hat{\pi}_t + \phi_x x_t, \quad 0 \leq \phi_\pi < 1, \quad (127)$$

$$\hat{i}_t^* = \hat{r}_t^{n*} + \phi_\pi^* \hat{\pi}_t^* + \phi_x^* x_t^*, \quad 0 \leq \phi_\pi^* < 1. \quad (128)$$

## Fiscal policy

$$\dot{\hat{b}}_t = \bar{b} [(\phi_\pi - 1) \hat{\pi}_t + \phi_x x_t + \hat{r}_t^n] - \hat{s}_t, \quad \bar{b} \equiv \bar{B}/\bar{P},$$

$$\dot{\hat{b}}_t^* = \bar{b}^* [(\phi_\pi^* - 1) \hat{\pi}_t^* + \phi_x^* x_t^* + \hat{r}_t^{n*}] - \hat{s}_t^*, \quad \bar{b}^* \equiv \frac{\bar{B}^*}{\bar{P}^*}$$

## Shock processes

$$\dot{s}_t = -\varphi_s (s_t - \bar{s}) + \sigma_s \varepsilon_t^s, \quad s_t^* = -\varphi_s^* (s_t^* - \bar{s}^*) + \sigma_s^* \varepsilon_t^{s*}, \quad (129)$$

$$\dot{g}_t = -\varphi_g (g_t - \bar{g}) + \sigma_g \varepsilon_t^g, \quad g_t^* = -\varphi_g^* (g_t^* - \bar{g}^*) + \sigma_g^* \varepsilon_t^{g*}, \quad (130)$$

$$\dot{\Psi}_t = -\varphi_\Psi \Psi_t + \sigma_\Psi \varepsilon_t^\Psi, \quad \dot{\Psi}_t^* = -\varphi_\Psi^* \Psi_t^* + \sigma_\Psi^* \varepsilon_t^{\Psi*}. \quad (131)$$

**Compact state space.** Stack  $z_t \equiv [x_t, \hat{\pi}_{H,t}, x_t^*, \hat{\pi}_{F,t}^*, \tau_t, \hat{e}_t, \hat{b}_t, \hat{b}_t^*]'$ , shocks  $u_t \equiv [g_t - \bar{g}, g_t^* - \bar{g}^*, \Psi_t, \Psi_t^*, s_t - \bar{s}, s_t^* - \bar{s}^*]'$ . Then

$$\dot{z}_t = A z_t + B u_t, \quad z(t) = e^{At} z(0) + \int_0^t e^{A(t-s)} B u_s ds.$$

## F Further details on the forecast data in section D

To make more sense of the novel forecast dataset provided in section D, we add some more descriptive statistics related to the forecast dataset in this part of the appendix. Overall, we have 88 unique forecasters in our data-sample, spanning almost 28 complete years (Sep-1997 until Jun-2025) yielding a total of 15,089 unique forecaster-month observations that contain at least some novel forecast being made.<sup>13</sup>

Figure 14 provides information on the number of unique forecasters appearing in the data and providing novel forecasts at least once a year. We observe a steady downwards trend in the number of forecasters who provide sufficient information to be considered in our analysis. With the exception of the two most recent years, however, there are continually at least 30 individual forecasters available in each year that provide at least one sufficient set of forecasts to be considered in the analysis.

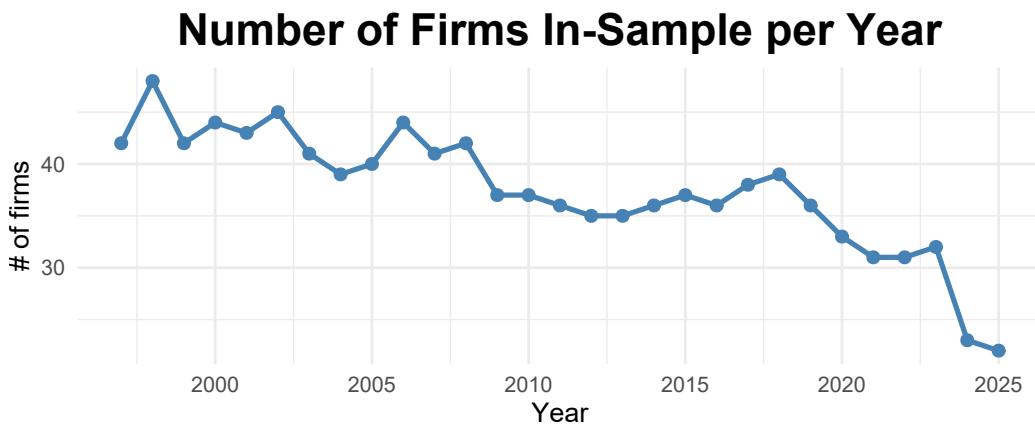


Figure 14: Number of unique forecasters appearing in the data in each year.

Of particular interest, of course, is the frequency of forecast revisions. Forecasts are made in rolling two-year windows, and so the number of forecast changes *within* a given year is informative for the number of valid observations that we can obtain. Figure 15 provides this information, showing how often firms in the sample on average revise their forecasts for a given forecasting window. Conditioning on the forecasters who provide sufficiently complete observations of forecasts, we observe a relatively high number of forecast revisions, averaging 6-8 per year per forecaster. These within-year forecast revisions are the centre of the analysis in section D.

In table 11 we provide information on the average forecast revisions in the sample of forecasters. Generally, the median revision of each individual variable is centred around zero. Since the mean

<sup>13</sup>In the data, we generally drop the forecasts made by the European Commission, the OECD, and the IMF, since their forecasts reflect general model estimates that are relatively non-reflective of novel information coming in at monthly frequencies.

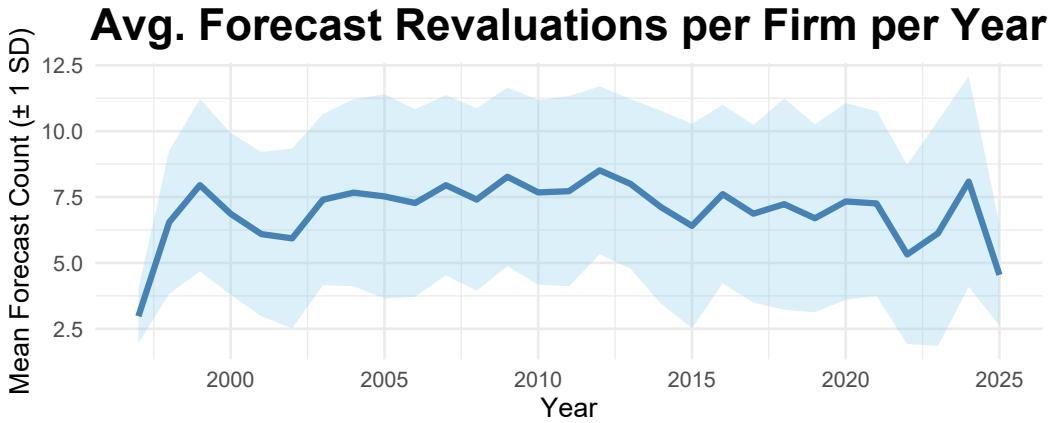


Figure 15: Number of forecast revisions per firm per year, on average. Shaded bands indicate one standard deviation around the mean of per-firm forecast revisions

of the PSNB (deficit) forecast revisions is larger than the median, this indicates a possible slight right-skew in the distribution of forecast revisions. Overall, forecasters appear to stick to their original forecasts (made at the beginning of a given forecast year), unless they are receiving novel information that forces them to amend their forecasts in accordance with their needs.

Variable	Mean	Median	SD	Q1	Q3
$\Delta \mathbb{E}_t(\text{PSNB})$ (in GBP Billion)	1.111	0.000	13.188	-0.995	1.848
$\Delta \mathbb{E}_t(g_Y)$ (in %)	-0.052	0.000	0.616	-0.100	0.100
$\Delta \mathbb{E}_t(\pi_{RPI})$ (in p.p.)	0.027	0.000	0.580	-0.100	0.200
$\Delta \mathbb{E}_t(\mathcal{E})$ (in %)	0.000	0.000	0.057	-0.003	0.008

Table 11: Summary Statistics for forecast revisions across the entire sample.

Given our particular interest in the forecasts of deficits (PSNB) and of exchange rates, figure 16 depicts the distribution of forecast revisions in both variables across time. As is to be expected, the average forecast revision is generally not significantly different from zero, but there is substantial disagreement in terms of the actual revisions. In terms of the forecasts for the exchange rate (right-hand panel), the Brexit episode stands out as one of consensus expectations of depreciation. As for deficit (PSNB) forecasts, the Covid-episode and the subsequent stimulus packages were generally underestimated when forecasts were made, followed by a gradual upwards revision of deficit expectations alongside each individual year.

To complement the depiction of the forecasts, we also consider the average of the *actual* forecasts made by the forecasters. Table 12 summarizes the average forecasts of our four main variables of interest. Since 1997, average annual deficits were predicted to hover around 60 billion GBP in real (2018) terms, while real output growth has been predicted to remain on average at slightly below 2%. In contrast, retail price inflation expectations were closer to 3 percentage points, while the average exchange rate index reflects broad expectations of depreciations relative to the

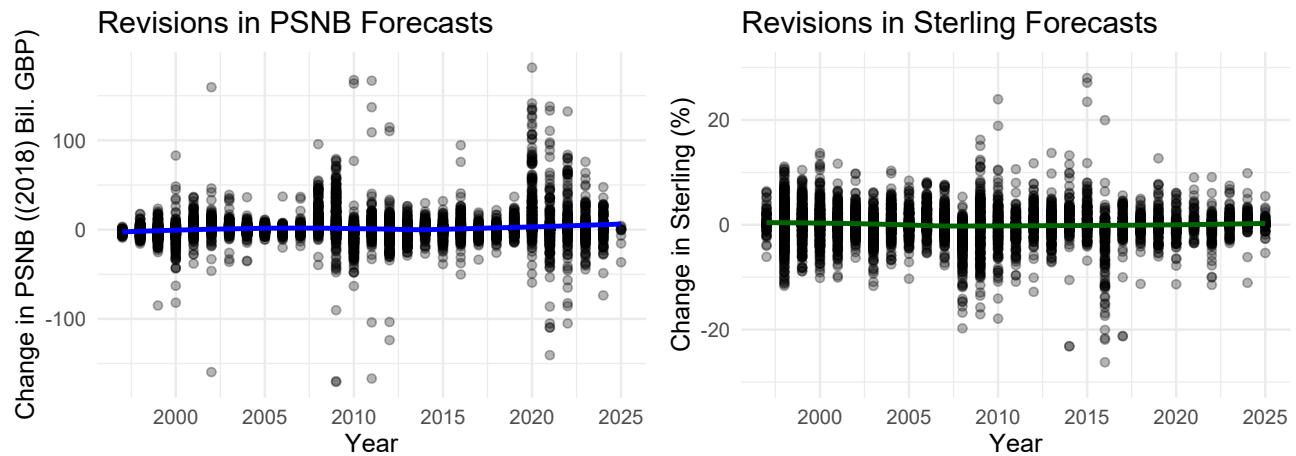


Figure 16: Distribution of forecast revisions in exchange rates and deficits over time.

benchmark period, which here is January 2005.

Variable	Mean	Median	SD	Q1	Q3
PSNB (in GBP Billion)	60.241	43.575	54.801	26.318	90.074
$g_Y$ (in %)	1.749	1.900	2.003	1.200	2.600
$\pi_{RPI}$ (in p.p.)	2.881	2.800	1.446	2.300	3.400
$\mathcal{E}_{\text{Sterling Basket}}$ (in %)	90.889	92.600	9.446	82.100	98.931

Table 12: Summary statistics of actual forecasts made by forecasters