Fiscal Beliefs and the Transmission of Fiscal Policy under Imperfect Knowledge*

Makoto Tanaka†

November 2, 2026

Abstract

The relationship between fiscal deficits and inflation varies considerably over time. Fiscal expansions tend to increase long-run inflation expectations, while persistent movements in deficits and government debt exhibit opposite associations with inflation and its long-run expectations. This paper studies whether evolving beliefs about future fiscal adjustment can explain these patterns and shape the transmission of fiscal policy. When households must learn the dynamics of primary surpluses and government debt, their beliefs need not imply full fiscal backing, allowing deficits and debt to generate distinct perceived wealth effects. As these beliefs evolve, identical fiscal expansions can raise or lower output and inflation, even under an unchanged policy regime. Estimating a New Keynesian model with adaptive learning using U.S. macroeconomic, fiscal, and survey data over 1970–2008, I find substantial historical variation in perceived fiscal backing, with implied wealth effects around 0.3% of GDP during the 1980s and early 2000s. Although long-run inflation expectations remain anchored near the target on average, their evolution is sensitive to changes in fiscal beliefs.

Keywords: Fiscal Policy, Inflation Expectations, Adaptive Learning, Ricardian Equivalence, Monetary-Fiscal Interactions
JEL Codes: E31, E52, E62, D84

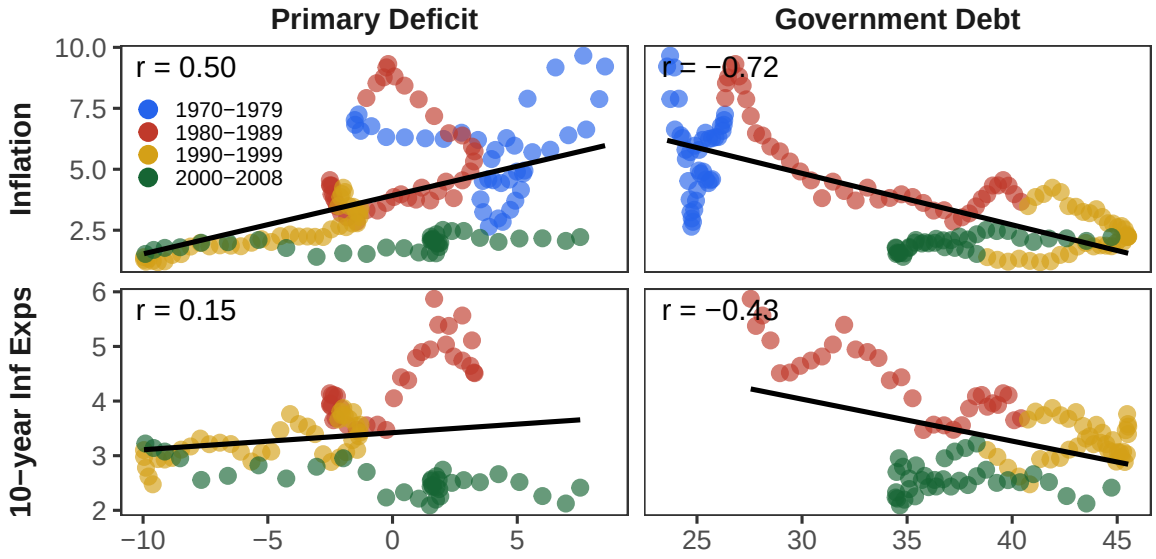
*I am deeply grateful to my advisors, Eric Leeper, Leland Farmer, and Eric Young, for invaluable guidance and support. I also thank Cristian Alonso, José Ferrer, Felipe Saffie, and seminar participants at IDE-JETRO, the Bank of England Brown Bag, the Workshop for Young Macroeconomists, and the UVA Macro Seminar for helpful comments and discussions. I gratefully acknowledge financial support from the Bankard Pre-Doctoral Fellowship. All errors are my own.

†University of Virginia, mt4xq@virginia.edu

1 Introduction

The inflationary consequences of fiscal expansions remain a central question in macroeconomics. Conventional monetary-fiscal models predict that fiscal disturbances are neutral for inflation when monetary policy targets inflation and fiscal policy stabilizes government debt. Yet the relationship between fiscal deficits and inflation varies considerably over time (Kliem, Kriwoluzky and Sarferaz, 2016). Why might a fiscal expansion generate inflation in some periods but have little effect, or even the opposite effect, in others?[1] This paper studies whether households' evolving beliefs about future fiscal adjustment can explain such variation in the transmission of fiscal policy.

Figure 1: Fiscal Trends, Inflation, and Long-Run Inflation Expectations



Note: The figure plots observed inflation and 10-year inflation expectations against estimated trends in the primary deficit and government debt over 1970Q1–2008Q3. Fiscal trends are posterior medians from a multivariate trend–cycle model. Red lines show linear fits, and (r) denotes the Pearson correlation coefficient. Inflation measures are in percentage points.

Growing empirical evidence suggests a relationship between fiscal policy and inflation even at long horizons. Using a randomized controlled trial (RCT), Coibion, Gorodnichenko and Weber (2021) find that information about future fiscal deterioration raises U.S. households' inflation expectations over a ten-year horizon. Fu, Li and Xie (2025) document that fiscal expansions raise long-run inflation expectations. Figure 1 shows that persistent deficits are positively associated with inflation and long-run inflation expectations, whereas government debt exhibits negative associations with both.[2]

These opposing relationships are intriguing because fiscal deficits and government debt are linked through the intertemporal government budget constraint. Persistent deficits imply greater

[1] Jørgensen and Ravn (2022) is closely related, finding the price level declines in response to government spending shocks.

[2] A formal multivariate trend–cycle analysis is reported in the Appendix H. The model is an extension of Del Negro, Giannone, Giannoni and Tambalotti (2017).

financing needs, raising questions about the subsequent path of debt and the fiscal adjustment required to stabilize it. If households anticipate sufficient future fiscal adjustment, government liabilities need not generate inflationary pressures. Alternatively, models featuring changes in monetary-fiscal policy regimes can generate inflation when households anticipate that outstanding liabilities will be partly revalued through inflation. In Bigio, Caramp and Silva (2024), for example, a larger debt burden raises expected inflation because it implies greater inflationary adjustment following a future monetary-fiscal reform. Yet the data exhibit the opposite relationship: persistent government debt is negatively associated with inflation and, notably, long-run inflation expectations. These patterns raise a question about how households understand the fiscal adjustment linking deficits and debt, and whether that understanding evolves over time.

Motivated by these observations, I ask whether changes in households' beliefs about fiscal adjustment can alter the transmission of fiscal policy, even when the government follows an unchanged, debt-stabilizing policy rule. The central idea is that households need not fully understand the dynamics of primary surpluses and government debt, leading them to misperceive the extent to which government liabilities are backed by future fiscal adjustment. As they learn from macroeconomic outcomes, their perceptions of fiscal backing evolve, potentially changing how fiscal disturbances affect aggregate demand and inflation.

I first characterize the subjective beliefs under which the conventional prediction of fiscal neutrality survives. I refer to these as *Ricardian beliefs*: subjective forecasts under which government liabilities are perceived to be fully backed by future fiscal adjustment and fiscal disturbances remain neutral for inflation. Such beliefs need not coincide with rational expectations or correctly identify the fiscal policy rule; instead, fiscal neutrality holds under a continuum of beliefs. I then examine whether these beliefs survive adaptive learning. When households learn only about long-run means while treating the propagation mechanism as known, initially Ricardian beliefs remain Ricardian. However, when households must also learn how primary surpluses and government debt propagate, forecast errors can move beliefs outside the Ricardian set even under an unchanged policy regime. The resulting perceived fiscal-backing gaps create wealth effects on consumption demand and inflation, making the transmission of fiscal disturbances depend on beliefs inherited from previous macroeconomic outcomes.

To assess the quantitative importance of this mechanism, I embed it in a New Keynesian model with adaptive learning. Building on Eusepi and Preston (2018), I allow households to learn both long-run conditional means and the propagation of primary surpluses and government debt. Beliefs are updated from forecast errors using constant gain recursive least squares, as in Milani (2007). I estimate the model on U.S. data over the pre-ZLB period, combining standard macroeconomic and fiscal variables with survey measures of short- and long-run inflation and nominal interest rate expectations. The survey forecasts are particularly informative about the learning mechanism because they discipline both short-run forecast errors and the revisions in long-run beliefs generated by those errors as shown in Crump, Eusepi, Moench and Preston (2023).

I use the pseudo impulse response approach of Slobodyan and Wouters (2012) to study the transmission of a fiscal policy shock across the distribution of beliefs generated by the estimated model. For a fiscal expansion corresponding to a one percentage point deterioration in the primary surplus to GDP ratio, the median responses of output, inflation, and long-run inflation expectations are modest. At other belief states, however, the model generates much larger and more persistent responses. In some cases, the effects are initially muted and emerge only gradually as the fiscal disturbance interacts with belief updating. These episodes resemble the dormant shocks of Bianchi

and Melosi (2013): a disturbance that appears innocuous on impact can have sizable effects later as it interacts with an inherited state. Here, the delayed transmission arises from the evolution of households' learned fiscal beliefs rather than changes in the underlying policy regime.

The historical U.S. estimates confirm the relevance of this mechanism. Applying the same fiscal disturbance at different points in the sample produces qualitatively different responses: a fiscal expansion raises output and inflation in some historical states but lowers them in others. Variation in perceived fiscal backing can alter not only the magnitude and persistence of fiscal transmission, but also its direction.

Beyond the transmission of individual fiscal disturbances, learning about fiscal adjustment also affects long-run inflation expectations. I compare the estimated model with a counterfactual in which households continue learning about long-run conditional means but understand how fiscal positions propagate. Simulations show that long-run inflation expectations remain close to the inflation target on average under both information structures. However, allowing households to learn fiscal propagation generates substantial differences in their conditional evolution, with deviations from the counterfactual exceeding 50 basis points in some histories. Long-run inflation expectations can remain anchored on average while exhibiting economically meaningful fluctuations associated with imperfect knowledge about fiscal adjustment.

Related Literature This paper contributes to the literature on Ricardian equivalence under imperfect knowledge. Woodford (2013) investigates the restrictions on subjective beliefs under which Ricardian equivalence holds without model consistent expectations, while Evans, Honkapohja and Mitra (2012) characterize conditions under which adaptive learning preserves Ricardian equivalence. Building on these insights, I characterize the restrictions on subjective beliefs under which both Ricardian equivalence and fiscal neutrality hold in an infinite-horizon framework, and examine whether these restrictions survive adaptive learning. Eusepi and Preston (2018) show that imperfect knowledge generates non-Ricardian wealth effects through the maturity structure and valuation of government debt, while Branch and Gasteiger (2019) study how endogenous forecasting model selection gives rise to fluctuations between Ricardian and non-Ricardian beliefs. Whereas Eusepi and Preston (2018) emphasize learning about long-run conditional means with a known propagation mechanism, I additionally allow households to learn the joint dynamics of primary surpluses and government debt. Learning about fiscal propagation can move subjective beliefs outside the Ricardian set, making the transmission of fiscal disturbances depend on households' evolving perceptions of fiscal backing. This mechanism also links fiscal policy to long-run inflation expectations and provides a structural interpretation of the low-frequency relationships between inflation, primary deficits, and government debt observed in U.S. data.

Recent survey evidence provides further motivation for studying imperfect knowledge of fiscal adjustment. Fueki, Hino, Katagiri, Katayama and Nakata (2026) document that households' joint expectations about fiscal and macroeconomic variables need not satisfy the intertemporal government budget constraint, while Maugeri and Sergeyev (2026) find that households expect a substantial share of government debt to be financed without future primary surpluses. These findings suggest that households do not necessarily perceive government liabilities as fully backed by future fiscal adjustment. This paper investigates the macroeconomic consequences of such imperfect fiscal knowledge, quantifying its implications for the transmission of fiscal disturbances and long-run inflation expectations.

The mechanism is related to the fiscal theory of the price level (FTPL), which emphasizes the valuation of government liabilities against expected future fiscal surpluses (Cochrane, 2023). Unlike the canonical FTPL mechanism, however, inflationary effects arise here under a debt-stabilizing fiscal policy that delivers fiscal neutrality under rational expectations. Households need not fully incorporate the present-value restrictions implied by government solvency into their subjective forecasts, allowing government liabilities to be perceived as net wealth. The resulting demand effects are also related to the non-Ricardian channel in Angeletos, Lian and Wolf (2024), but arise here from imperfect knowledge rather than household heterogeneity or finite horizons.

Finally, this paper relates to the literature on time-varying monetary-fiscal policy regimes. Davig and Leeper (2007) show that expectations of future policy regime changes affect the transmission of fiscal disturbances. Bianchi and Ilut (2017) demonstrate that changes in the monetary-fiscal policy mix and beliefs about fiscal backing help explain U.S. inflation dynamics, while Bianchi and Melosi (2019) emphasize uncertainty about future fiscal adjustment. In contrast, I hold the underlying policy regime fixed and show that the transmission of fiscal policy can vary endogenously as households learn about fiscal dynamics. History-dependent inflation responses need not reflect actual or anticipated changes in the monetary-fiscal policy regime.

2 An Endowment Economy

To build intuition for the role of fiscal beliefs, I consider a simple endowment economy with imperfect knowledge. Rather than imposing model consistent expectations, households are allowed to hold subjective beliefs about the joint evolution of inflation, interest rates, primary surpluses, and government debt. Following the internal rationality approach of Preston (2005) and Adam and Marcet (2011), households optimize given these beliefs and satisfy their optimality conditions, even though their subjective forecasting model need not coincide with the actual law of motion of the economy. The first objective of the theoretical analysis is therefore to construct the mapping from arbitrary subjective beliefs into equilibrium outcomes.

This mapping makes it possible to characterize precisely which subjective beliefs preserve Ricardian equivalence. I refer to these as Ricardian beliefs: beliefs under which households perceive government debt created by a fiscal expansion to be fully backed by future primary surpluses, together with beliefs about inflation and monetary policy that keep the nominal anchor intact. Ricardian equivalence does not require households to hold rational expectations; there is a broader set of subjective beliefs under which fiscal policy remains neutral. I then introduce adaptive learning to study how beliefs evolve following fiscal policy shocks. When learning preserves Ricardian beliefs, fiscal shocks remain neutral for inflation and long-run inflation expectations. When beliefs depart from this set, perceived fiscal backing changes households' consumption decisions, allowing fiscal shocks to affect inflation and the long-run nominal anchor.

2.1 Households

A household maximizes its expected utility with an arbitrary belief indicated by $\hat{E}_t^i$

$$\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \frac{C_T(i)^{1-\sigma}}{1-\sigma}, \tag{1}$$

where $\sigma > 0$, $0 < \beta < 1$, and $c_T(i)$ is the consumption of household i at period t. Define the current price level as P_t and denote the household i's real bond holding as $b_t(i) = \frac{B_t(i)}{P_t}$. Household's budget constraint, then, becomes

$$C_t(i) + \frac{b_t(i)}{R_t} + S_t(i) = Y_t(i) + \frac{b_{t-1}(i)}{\pi_t}, \tag{2}$$

where $Y_t(i)$ is an i.i.d. endowment that the household receives and $S_t(i)$ is the transfer net of lump sum taxes. The household also faces a no-Ponzi constraint

$$\lim_{T\to\infty} \hat{E}_t^i \left(\prod_{s=0}^{T-t} R_{t+s} \pi_{t+s+1}^{-1} \right)^{-1} b_T(i) \geq 0 \tag{3}$$

Households choose sequences $\{C_T(i), b_T(i)\}_{T=t}^{\infty}$ to maximize the lifetime utility (1) subject to the flow budget constraint (2) and no-Ponzi constraint (3) conditional on their beliefs.

Households only observe their own objectives, constraints and realization of aggregate variables that are exogenous to their decision problems and beyond their control. They have no knowledge of the beliefs, constraints and objectives of other agents in the economy. As a result, households are heterogeneous in their information sets; their decision problems are identical but they do know this is the case. This potentially breaks the Ricardian equivalence as is also discussed in the HANK literature, for example, in Angeletos, Lian and Wolf (2024).

2.2 Government

A government provides one period bonds and raise lump sum taxes. The government budget constraint is

$$\frac{B_t}{P_t R_t} + s_t = \frac{B_{t-1}}{P_{t-1}\pi_t}.$$

Linearize this equation around the non-stochastic steady state with 0 inflation to get

$$\beta \hat{b}_t - \beta \hat{R}_t + (1-\beta)\hat{s}_t = \hat{b}_{t-1} - \hat{\pi}_t,$$

where $\hat{x}_t \equiv \frac{X_t - X}{X}$ and $b_t \equiv \frac{B_t}{P_t}$. To avoid the confusion, I omit hats for deviations from the steady state afterwards.

2.3 Policy Rules

I assume monetary and fiscal authority employ the following policy rules

$$\begin{aligned} R_t &= \phi_\pi \pi_t \\ s_t &= \phi_b b_{t-1} + \varepsilon_t^{FP} \end{aligned}$$

where $\phi_\pi > 1$ and $1 < \phi_b < \frac{1+\beta}{1-\beta}$. This is consistent with the conventional active money and passive fiscal regime following the terminology from Leeper (1991). Although this is the true data generating process, agents might not know neither the correct functional form nor the parameters. How much agents know about the policy constitute the degree of "anchoring", which is consistent with the definition in Eusepi and Preston (2010). I assume that the only stochastic component of this economy is coming from ε_t^{FP}, which I assume is an *i.i.d.* process.

2.4 Market Clearing Conditions

I focus on a symmetric equilibrium in which households are identical, although they do not know this to be the case. Households have identical initial asset holdings, preferences, endowments, taxes, and information sets, and face the same constraints. They therefore make identical state-contingent decisions in equilibrium. This formulation follows Eusepi and Preston (2018).

Defining the aggregate consumption demand, the aggregate bond holdings, and the average beliefs as

$$c_t \equiv \int_0^1 c_t(i)\,di \quad b_t \equiv \int_0^1 b_t(i)\,di, \quad \text{and } \hat{E}_t \equiv \int_0^1 \hat{E}_t^i di,$$

the aggregate model dynamics become

$$\begin{aligned} c_t &= \underbrace{(1-\beta)\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} y_T}_{\text{Permanent Income}} \underbrace{-\frac{\beta}{\sigma}\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}(R_T - \pi_{T+1})}_{\text{Intertemporal Substitution}} \\ &\quad \underbrace{+(1-\beta)\delta\left(b_{t-1} - \pi_t - \hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)s_T - \beta(R_T - \pi_{T+1})\}\right]\right)}_{\text{Perceived Wealth Effect by Fiscal Policy}} \qquad (4) \\ R_t &= \phi_\pi \pi_t \qquad (5) \\ s_t &= \phi_b b_{t-1} + \varepsilon_t^{FP} \qquad (6) \\ b_t &= \beta^{-1}(1-(1-\beta)\phi_b)b_{t-1} - (\beta^{-1} - \phi_\pi)\pi_t - \beta^{-1}(1-\beta)\varepsilon_t^{FP}. \qquad (7) \end{aligned}$$

Define the wealth effect of fiscal policy as

$$n_{w,t} = (1-\beta)\delta\left(b_{t-1} - \pi_t - \hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)s_T - \beta(R_T - \pi_{T+1})\}\right]\right).$$

This captures the extent to which households view government debt as net wealth as opposed to Barro (1974). Under rational expectations, households correctly anticipate that outstanding government liabilities are fully backed by future primary surpluses. The perceived wealth effect therefore vanishes without requiring an adjustment in inflation.

To understand how imperfect knowledge affects the valuation of outstanding government liabilities, first consider the rational expectations benchmark, which keeps inflation unchanged.

$$b_{t-1} = (1-\beta)\mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_T.$$

Outstanding government liabilities are fully backed by the expected present discounted value of future primary surpluses.

To isolate the fiscal expectation channel, consider the special case in which households do not revise their expectations of future inflation and nominal interest rates in response to a fiscal disturbance.

$$\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}(\beta R_{T+1} - \pi_{T+1}) = 0.$$

Because aggregate output is fixed in the endowment economy, goods market clearing requires the perceived wealth effect to offset the intertemporal substitution effect. Equilibrium inflation dynamics can be described as

$$\pi_t = -\frac{1-\beta}{\beta^{-1} - \phi_\pi + \frac{\phi_\pi}{\sigma(1-\beta)\delta}} \left[\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1} - \mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1} \right].$$

This expression makes the role of fiscal beliefs transparent. Under rational expectations, households correctly anticipate the fiscal adjustment required to back outstanding government liabilities, and inflation is zero. Under imperfect knowledge, this need not be the case. Suppose the perceived fiscal backing is insufficient compared to the rational expectation,

$$\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_T - \mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_T < 0.$$

At given prices, insufficient perceived fiscal backing makes outstanding government liabilities appear to represent positive net wealth, stimulating consumption demand. Because aggregate output is fixed, this additional demand cannot be accommodated by greater production. Instead, current inflation increases, reducing the real value of inherited nominal liabilities. At the same time, the contemporaneous monetary policy response raises the nominal interest rate, affecting consumption through intertemporal substitution and returns on government debt. Equilibrium inflation therefore adjusts until these effects jointly restore goods market clearing.

This mechanism shares the intuition of the FTPL: insufficient fiscal backing of outstanding nominal liabilities calls for an increase in the price level to reduce their real value. The crucial distinction is that the fiscal authority here continues to stabilize government debt. The government's flow budget constraint holds in both economies, and the underlying monetary-fiscal policy regime is unchanged. What differs is households' understanding of the future fiscal adjustment associated with outstanding liabilities. Under imperfect knowledge, insufficient perceived backing generates wealth effects on aggregate consumption demand, requiring an endogenous price level adjustment to restore goods market clearing.[3]

3 Aggregate Dynamics and Ricardian Beliefs

Given households' subjective beliefs, aggregate dynamics differ from the rational expectations economy because households' expectations need not be consistent with the actual law of motion. This section first derives the equilibrium dynamics conditional on arbitrary subjective beliefs. It then characterizes the restriction on those beliefs under which fiscal policy remains Ricardian. I assume that the beliefs are fixed throughout this section. Their endogenous evolution through learning is introduced in Section 4.

The average subjective belief of households takes the general form:

[3] Also note that the inflationary response is inversely related to the Taylor coefficient ϕ_π. Monetary policy can mitigate the transmission from wealth effects to inflation.

$$\underbrace{\begin{pmatrix} \pi_t \\ R_t \\ s_t \\ b_t \end{pmatrix}}_{\equiv Z_t} = \bar{\omega} + \tilde{\Phi} \begin{pmatrix} \pi_{t-1} \\ R_{t-1} \\ s_{t-1} \\ b_{t-1} \end{pmatrix} + e_t,$$

where

$$\bar{\omega} = \begin{pmatrix} \omega_\pi \\ \omega_R \\ \omega_s \\ \omega_b \end{pmatrix} \quad \text{and} \quad \tilde{\Phi} = \begin{pmatrix} \varphi_{\pi\pi} & \varphi_{\pi R} & \varphi_{\pi s} & \varphi_{\pi b} \\ \varphi_{R\pi} & \varphi_{RR} & \varphi_{Rs} & \varphi_{Rb} \\ \varphi_{s\pi} & \varphi_{sR} & \varphi_{ss} & \varphi_{sb} \\ \varphi_{b\pi} & \varphi_{bR} & \varphi_{bs} & \varphi_{bb} \end{pmatrix},$$

which might not be consistent with the actual law of motion. The expectation conditional on the information available at period t, the forecasts become

$$\hat{E}_t Z_{T+1} = \left(I_4 - \tilde{\Phi}\right)^{-1} \left(I_4 - \tilde{\Phi}^{T-t+1}\right) \bar{\omega} + \tilde{\Phi}^{T-t+1} Z_t.$$

Substituting the subjective forecasts into the aggregate law of motion gives the actual equilibrium dynamics:

$$A_0 Z_t = A_1 \left[F_0\left(\beta, \tilde{\Phi}\right) \bar{\omega} + F_1\left(\beta, \tilde{\Phi}\right) Z_t\right] + A_2 Z_{t-1} + A_3 \varepsilon_t.$$

Solving for Z_t yields

$$Z_t = \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}\right) \bar{\omega} + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_2 Z_{t-1} + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_3 \varepsilon_t.$$

The detailed matrix expressions and derivation are provided in Appendix C

It is worth emphasizing that subjective beliefs enter the equilibrium only through households' forecasts. Households continue to satisfy their intertemporal optimality conditions given their beliefs. The approach preserves internal rationality emphasized in Adam and Marcet (2011) and Eusepi and Preston (2023). Households optimize given their perceived law of motion, even though that perceived law of motion need not coincide with the equilibrium law of motion it generates. The mapping from beliefs $\left(\bar{\omega}, \tilde{\Phi}\right)$ into the equilibrium dynamics makes this distinction explicit.

Proposition 1. *Conditional on the beliefs* $\left(\bar{\omega}, \tilde{\Phi}\right)$, *equilibrium admits the representation*

$$Z_t = \mathscr{M}\left(\tilde{\Phi}\right) \bar{\omega} + \mathscr{B}\left(\tilde{\Phi}\right) Z_{t-1} + \mathscr{C}\left(\tilde{\Phi}\right) \varepsilon_t,$$

where

$$\begin{aligned} \mathscr{M}\left(\tilde{\Phi}\right) &= \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}\right) \\ \mathscr{B}\left(\tilde{\Phi}\right) &= \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_2 \\ \mathscr{C}\left(\tilde{\Phi}\right) &= \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right)^{-1} A_3. \end{aligned}$$

Relative to the rational expectation economy, imperfect knowledge introduces two additional state variables: beliefs about the long-run means $\bar{\omega}$ *and beliefs about the propagation of macroeconomic variables* $\tilde{\Phi}$.

The matrices $\bar{\omega}$ and $\tilde{\Phi}$ describe households' subjective forecasting model, whereas $\mathscr{M}\left(\tilde{\Phi}\right)$, $\mathscr{B}\left(\tilde{\Phi}\right)$, and $\mathscr{C}\left(\tilde{\Phi}\right)$ describe the equilibrium law of motion generated by those beliefs. The two does not necessarily coincide. The rational expectation corresponds to a fixed point where the perceived and actual law of motion coincide.

3.1 Ricardian Beliefs and Fiscal Neutrality

Households forecast the economy using the perceived law of motion

$$Z_t = \bar{\omega} + \tilde{\Phi} Z_{t-1} + e_t.$$

As emphasized by Woodford (2013), Ricardian equivalence under subjective expectations does not require households to know the true policy rule or to form rational expectations. Rather, the relevant question is whether their subjective beliefs are consistent with the intertemporal government budget constraint. If households correctly account for the fiscal obligations associated with their government bond holdings, those liabilities need not constitute perceived net wealth.

To characterize this requirement, define

$$q' \equiv e'_\pi - \beta e'_R + (1-\beta) e'_s + \beta e'_b.$$

The government flow budget constraint can be expressed as

$$q' Z_t = e'_b Z_{t-1}.$$

For the predictable components of households' subjective forecasts to respect this constraint, their perceived law of motion must satisfy

$$q' \bar{\omega} = 0 \quad \text{and} \quad q' \tilde{\Phi} = e'_b.$$

When households' subjective forecasts satisfy these restrictions, together with the appropriate transversality condition, the perceived present value of future fiscal obligations equals the value of outstanding government liabilities. The perceived net wealth component of aggregate demand therefore vanishes. This conclusion does not require rational expectations or knowledge of the true fiscal policy rule.

The absence of perceived net wealth, however, does not by itself imply fiscal neutrality. Fiscal disturbances may still affect aggregate demand and inflation if households' subjective forecasts allow fiscal variables to influence expected future nominal conditions. I therefore characterize a class of subjective beliefs under which fiscal disturbances are neutral for inflation.

Nominal Expectations

To isolate uncertainty about fiscal dynamics, I impose two restrictions on households' nominal expectations. Let $\tilde{\Phi}_\pi$ and $\tilde{\Phi}_R$ denote the inflation and interest rate rows of $\tilde{\Phi}$. I assume

$$\tilde{\Phi}_\pi = 0 \quad \text{and} \quad \tilde{\Phi}_R = 0.$$

These restrictions prevent fiscal states from independently influencing households' forecasts of future inflation and nominal interest rates through their perceived propagation mechanism. They do not require households to form rational expectations. In particular, households may hold independent and potentially model inconsistent beliefs about long-run inflation and nominal interest rates, summarized by ω_π and ω_R. The restrictions are stronger than necessary for fiscal neutrality but simplify the analysis and correspond to the information structure maintained in the quantitative model.

Full Perceived Fiscal Backing

Under these nominal restrictions, consistency with the government budget constraint implies that the perceived propagation of primary surpluses and government debt satisfies

$$(1-\beta)\,\tilde{\Phi}_s + \beta\tilde{\Phi}_b = e_b',$$

where $\tilde{\Phi}_s$ and $\tilde{\Phi}_b$ denote the surplus and debt rows of $\tilde{\Phi}$. This restriction ensures that households perceive changes in government liabilities to be fully backed by future fiscal adjustment, without requiring them to know the precise timing or mechanism of that adjustment.

Proposition 2. *Suppose households' subjective beliefs are consistent with the government's intertemporal budget constraint and satisfy the maintained restrictions on nominal expectations. Conditional on these beliefs remaining fixed, an exogenous fiscal policy shock has no effect on aggregate demand or inflation at any horizon.*

Proof. See the Appendix. □

The proposition establishes that fiscal neutrality does not require rational expectations. Households need not correctly forecast the government's fiscal adjustment mechanism, provided their subjective forecasts jointly imply full backing of government liabilities and fiscal disturbances do not independently shift their nominal expectations.

Moreover, these conditions do not uniquely determine household's subjective beliefs.

Corollary 1. *There exists a continuum of subjective propagation mechanisms consistent with fiscal neutrality. For any admissible perceived debt dynamics $\tilde{\Phi}_b$ the surplus dynamics*

$$\tilde{\Phi}_s = \frac{e_b' - \beta\tilde{\Phi}_b}{1-\beta}$$

satisfy the full backing restriction. Together with the maintained restrictions on nominal expectations and a compatible intercept, these beliefs imply fiscal neutrality under Proposition 2.

Rational expectations are sufficient but not necessary for fiscal neutrality. Households may misperceive the persistence of government debt, the timing of future primary surpluses, or the true fiscal policy rule, while maintaining beliefs under which fiscal disturbances are neutral for inflation.

I refer to the class of subjective beliefs satisfying these restrictions as Ricardian beliefs. The distinction between Ricardian beliefs and rational expectations is that the former require consistency with the fiscal backing of government liabilities and the absence of fiscal influences on nominal forecasts, whereas the latter additionally require households' perceived law of motion to coincide with the equilibrium law of motion. The restrictions defining Ricardian beliefs are sufficient but not necessary for fiscal neutrality. The Appendix characterizes weaker conditions under which an isolated fiscal disturbance remains neutral, even when the full restrictions are not satisfied.

This characterization provides a belief based interpretation of a fiscal anchor. Related notions of fiscal anchoring appear in Eusepi and Preston (2012) and Leeper (2009). Here, the restrictions clarify what exactly households need to know in order for fiscal shocks to be insulated from inflation.

3.2 Ricardian Beliefs, Perceived Wealth Effect, and FTPL

The terminology of Ricardian beliefs differs from the conventional distinction between Ricardian and non-Ricardian households. The latter concerns household characteristics, such as planning horizons and access to financial markets, whereas Ricardian beliefs concern the content of households' subjective forecasts. In particular, Ricardian beliefs impose restrictions that ensure both that government liabilities are not perceived as net wealth and that fiscal disturbances are neutral for inflation. These restrictions do not require rational expectations, which instead require households' perceived law of motion to coincide with the equilibrium law of motion. Rational expectations and Ricardian beliefs therefore need not imply each other.

A useful example is a fiscal-dominance equilibrium. Consider the perceived law of motion

$$\tilde{\Phi}^{FD} = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & \hat{\phi}_\pi \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \hat{\phi}_\pi \end{pmatrix}$$

with $0 \leq \hat{\phi}_\pi < 1$. This corresponds to a perceived passive monetary policy rule and no systematic fiscal adjustment to debt. Under these beliefs, outstanding debt determines inflation, while the nominal interest rate adjusts following the perceived monetary policy rule. The resulting debt dynamic is stationary $b_t = \hat{\phi}_\pi b_{t-1}$. These beliefs can coincide with a rational-expectations equilibrium under fiscal dominance, despite violating the restrictions defining Ricardian beliefs.

Fiscal disturbances are no longer neutral for inflation. Nevertheless, as emphasized by Angeletos et al. (2024), the equilibrium wealth effect remains zero: the endogenous adjustment in the price level offsets the absence of future fiscal backing. Fiscal dominance illustrates that fiscal neutrality, under which fiscal disturbances are insulated from inflation, and Ricardian equivalence, understood here as the absence of an equilibrium wealth effect from government liabilities, are distinct properties. Ricardian beliefs ensure both, but violating their restrictions need not imply that both fail. How households depart from Ricardian beliefs is therefore critical for understanding the transmission of fiscal disturbances, a question examined in the following section.

4 Adaptive Learning and Wealth Effects

Section 3 characterizes the restrictions on subjective beliefs under which government liabilities are perceived to be fully backed and fiscal disturbances are neutral. I now ask whether these restrictions are preserved as households update their beliefs in response to macroeconomic outcomes. I distinguish learning about long-run means from learning about the propagation of aggregate variables and show that the preservation of Ricardian beliefs depends critically on the structure of the learning process.

I study this question under constant gain learning. Households estimate the perceived law of motion

$$Z_t = \bar{\omega}_t + \tilde{\Phi}_t Z_{t-1} + e_t.$$

I assume the constant gain learning as Milani (2007) to capture the structural changes. Learning about the intercepts $\bar{\omega}_t$ allows households' perceived long run values of inflation, interest rate, primary surpluses, and government debt to evolve over time. Learning about $\tilde{\Phi}_t$ allows households

to revise their beliefs about how deviations from these long run values propagate through the economy.

Define the regressor as $X_t = \begin{pmatrix} 1 & Z'_{t-1} \end{pmatrix}'$ and collects perceived coefficients in

$$\Psi_t = \begin{pmatrix} \bar{\omega}'_t \\ \tilde{\Phi}'_t \end{pmatrix}.$$

The perceived coefficients are updated following the recursive least square

$$\Psi_{t+1} = \Psi_t + \bar{g}\Omega_t^{-1} X_t u'_t \tag{8}$$
$$\Omega_{t+1} = \Omega_t + \bar{g}\left(X_t X'_t - \Omega_t\right) \tag{9}$$

where the one step ahead forecast error is

$$u_t \equiv Z_t - \bar{\omega}_t - \tilde{\Phi}_t Z_{t-1}$$

Following the anticipated utility approach of Kreps (1998), agents treat the current estimates $\left(\bar{\omega}_t, \tilde{\Phi}_t\right)$ as fixed when solving their decision problems and forming expectations. The evolving beliefs therefore constitute additional predetermined state variables of the equilibrium. Conditional on current beliefs,

$$\hat{E}_t Z_{T+1} = \left(I_4 - \tilde{\Phi}_t\right)^{-1}\left(I_4 - \tilde{\Phi}_t^{T-t+1}\right)\bar{\omega}_t + \tilde{\Phi}_t^{T-t+1} Z_t \tag{10}$$

Beliefs indexed by t, $\left(\bar{\omega}_t, \tilde{\Phi}_t\right)$, are estimated using information through $t-1$. At date t, households observe Z_t and form expectations conditional on the current realization while holding the perceived law of motion fixed. The resulting forecast error is used only at the end of the period to update beliefs to $\left(\bar{\omega}_{t+1}, \tilde{\Phi}_{t+1}\right)$.

4.1 Preservation of Fiscal Backing under Learning

Recall that the perceived law of motion must satisfy

$$q'\bar{\omega}_t = 0 \quad \text{and} \quad q'\tilde{\Phi}_t = e'_b.$$

These restrictions ensure that households' subjective forecasts satisfy the intertemporal government budget constraint. They are necessary for Ricardian beliefs, but are not by themselves sufficient for fiscal neutrality: households' forecasts must also satisfy the nominal propagation restrictions characterized in the preceding section.

The following proposition establishes that full perceived backing can be preserved under both intercept learning and unrestricted VAR learning.

Proposition 3. *Suppose households initially hold beliefs consistent with perceived full fiscal backing and update their forecasts using a common gain. Then:*

(i) ***Intercept learning****. If the propagation coefficients remain fixed at values satisfying the full-backing restrictions, updating the intercepts preserves full perceived fiscal backing following any equilibrium disturbance.*

(ii) ***Unrestricted VAR learning.*** *If households jointly update all intercepts and propagation coefficients using a common recursive least-squares algorithm, perceived full fiscal backing is also preserved following any equilibrium disturbance.*

Proof. Recall the forecast error is $u_t = Z_t - \bar{\omega}_t - \tilde{\Phi}_t Z_{t-1}$. Since realized outcomes satisfy the flow government budget constraint

$$q' u_t = -q' \bar{\omega}_t - \left(q' \tilde{\Phi}_t - e_b' \right) Z_{t-1}.$$

If subjective beliefs initially satisfy the full backing restrictions, then $q' u_t = 0$. Under intercept learning with common gain $\bar{g}$,

$$\bar{\omega}_{t+1} = \bar{\omega}_t + \bar{g} u_t,$$

which implies

$$q' \bar{\omega}_{t+1} = q' \bar{\omega}_t + \bar{g} q' u_t = 0.$$

Since the propagation coefficients remain fixed, perceived full backing is preserved. Under unrestricted VAR learning, let K_t denote the common RLS adjustment vector. The intercepts and propagation coefficients are updated jointly according to

$$\left(\bar{\omega}_t \quad \widetilde{\Phi}_t \right) + u_t K_t'.$$

Premultiplying by q' gives

$$q' \left(\bar{\omega}_t \quad \widetilde{\Phi}_t \right) + (q' u_t) K_t'.$$

Because $q' u_t = 0$, the full backing remain satisfied. The result follows by induction. □

Proposition 3 establishes that learning need not generate departures from perceived full fiscal backing, even when households persistently revise their beliefs about long-run outcomes or aggregate propagation. Under intercept learning, revisions to long-run means remain jointly consistent with the government budget constraint. If the fixed propagation coefficients also satisfy the nominal restrictions characterized in the preceding section, Ricardian beliefs are preserved and fiscal disturbances remain neutral.

Under unrestricted VAR learning, the common recursive least-squares algorithm also preserves perceived full backing because forecast errors inherit the government's accounting restriction. However, full backing does not necessarily imply fiscal neutrality. When households revise the propagation coefficients of inflation and nominal interest rates, fiscal disturbances may influence nominal expectations even without generating perceived net wealth effects. Unrestricted VAR learning can preserve full backing without preserving Ricardian beliefs.

4.2 Asymmetric Learning about Fiscal Adjustment

I now consider an information structure in which households maintain fixed, model consistent nominal propagation coefficients while learning how fiscal positions propagate through the economy. Specifically, the perceived propagation matrix takes the form

$$\tilde{\Phi}_t = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & \varphi_{ss,t} & \varphi_{sb,t} \\ 0 & 0 & \varphi_{bs,t} & \varphi_{bb,t} \end{pmatrix},$$

while allowing the four intercepts in $\bar{\omega}_t$ to evolve. This asymmetry isolates uncertainty about fiscal adjustment. Households can revise their forecasts of future surpluses and debt in response to observed fiscal outcomes, without revising the corresponding nominal propagation coefficients. Consequently, even when forecast errors jointly satisfy the government's accounting identity, updating only the fiscal propagation equations need not preserve the cross equation restrictions implied by full perceived backing. The quantitative model in Section 5 relaxes this restriction and allows a richer set of fiscal propagation coefficients to be learned.

Under the restricted propagation structure introduced above, departures from these restrictions can be summarized by three objects:

$$\begin{aligned} r_{\omega,t} &\equiv \omega_{\pi,t} - \beta\,\omega_{R,t} + (1-\beta)\,\omega_{s,t} + \beta\,\omega_{b,t} \\ r_{s,t} &\equiv (1-\beta)\,\varphi_{ss,t} + \beta\,\varphi_{bs,t} \\ r_{b,t} &\equiv (1-\beta)\,\varphi_{sb,t} + \beta\,\varphi_{bb,t} - 1. \end{aligned}$$

Full perceived backing requires all three to vanish. The coefficient restrictions $r_{s,t} = r_{b,t} = 0$ govern how households expect fiscal positions to propagate, while the intercept restriction $r_{\omega,t}$ ensures that their perceived long-run nominal and fiscal positions are mutually consistent.

To see why this distinction matters, suppose households initially hold Ricardian beliefs, so that

$$r_{\omega,t} = r_{s,t} = r_{b,t} = 0.$$

Let K_t denote the RLS adjustment vector for the fiscal propagation coefficients defined above. Because the nominal propagation coefficients remain fixed, revisions to the perceived fiscal propagation mechanism satisfy

$$\begin{aligned} \Delta\begin{pmatrix} r_{s,t} & r_{b,t} \end{pmatrix} &= (1-\beta)\,\Delta\tilde{\Phi}_{s,t} + \beta\,\Delta\tilde{\Phi}_{b,t} \\ &= \left[(1-\beta)\,u_{s,t} + \beta\,u_{b,t}\right] K_t' \\ &= (-u_{\pi,t} + \beta\,u_{R,t})\,K_t'. \end{aligned}$$

The final equality follows from the flow government budget constraint. It reveals that nominal forecast errors can induce revisions to households' perceived fiscal adjustment mechanism. Under unrestricted VAR learning, corresponding revisions to nominal propagation coefficients preserve the accounting restriction. Under asymmetric fiscal learning, however, nominal propagation coefficients remain fixed, so revisions to fiscal propagation need not be offset. Consequently, households can revise their beliefs about fiscal adjustment process in ways that violate full perceived backing, even though the realized government budget constraint continues to hold.

Proposition 4. *Suppose households update the four fiscal propagation coefficients while maintaining fixed nominal propagation coefficients. The full perceived fiscal backing restrictions are not generally invariant under constant gain learning. An equilibrium disturbance can move initially Ricardian beliefs outside the Ricardian set.*

The proposition identifies a mechanism through which imperfect knowledge generates departures from Ricardian beliefs even though the underlying policy regime remains unchanged. Unlike unrestricted VAR learning, asymmetric learning does not necessarily preserve the cross equation

restrictions implied by the government budget constraint. Households may correctly observe fiscal outcomes yet revise their forecasts of future fiscal adjustment in ways that are inconsistent with full perceived backing.

Once the propagation restrictions fail, forecast errors need no longer satisfy $q'u_t = 0$. In particular,

$$q'u_t = -r_{\omega,t} - r_{s,t}s_{t-1} - r_{b,t}b_{t-1}.$$

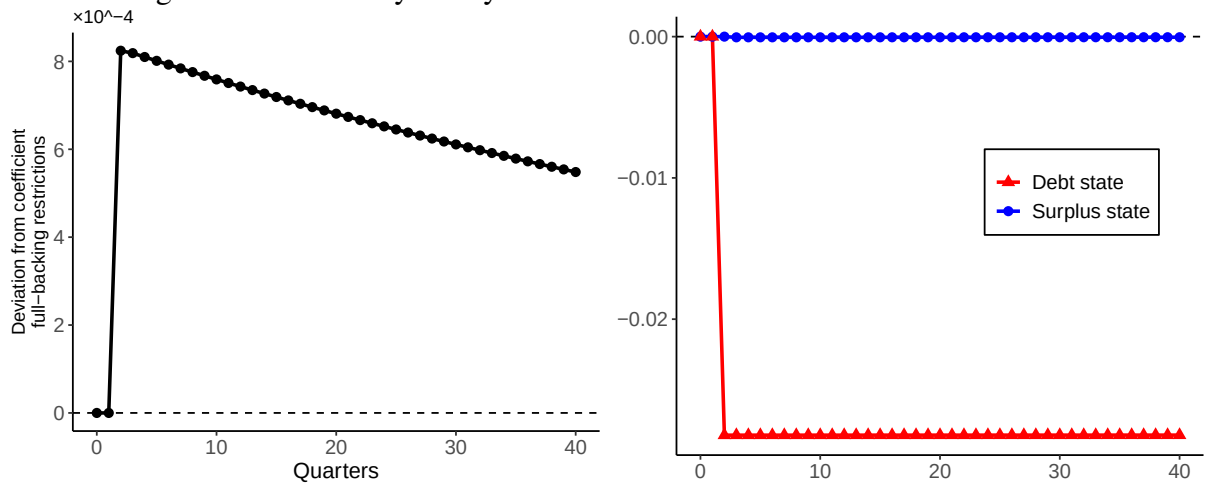
The realized government budget constraint continues to hold at every date. What changes is households' perceived mechanism through fiscal adjustment occurs. Government liabilities can therefore become perceived net wealth, allowing fiscal disturbances to affect aggregate demand and inflation through a channel absent under Ricardian beliefs.

To illustrate how asymmetric fiscal learning generates departures from full perceived backing, consider an unexpected monetary policy disturbance. A monetary tightening changes nominal interest rates, inflation, and the evolution of government liabilities. Although these outcomes satisfy the government's flow budget constraint, the resulting forecast errors can lead households to revise their beliefs about fiscal adjustment in ways that violate the full-backing restrictions. I examine this mechanism by extending the baseline model to include an i.i.d. monetary policy shock,

$$R_t = \phi_\pi \pi_t + \varepsilon_t^{MP},$$

where ε_t^{MP} is an i.i.d. monetary policy shock. All other features of the model remain unchanged.

Figure 2: A Monetary Policy Shock and Deviations from Ricardian Beliefs



Note: The figure shows the response to a one-standard-deviation contractionary monetary policy shock, starting from Ricardian beliefs. Households update the intercepts of inflation, interest rates, surplus, and debt, along with the coefficients governing perceived fiscal dynamics, using constant-gain recursive least squares. The left panel reports deviations from full backing in long-run beliefs, while the right panel reports deviations in perceived fiscal dynamics. Zero indicates full backing.

Figure 2 illustrates the mechanism following a one standard deviation contractionary monetary policy shock. Households are initialized at rational expectations beliefs, so that all three full backing restrictions are initially satisfied. On impact, the shock generates forecast errors and revisions in perceived long-run means. As established in Proposition 3, these revisions preserve full

backing because the forecast errors jointly satisfy the government budget constraint. Moreover, because lagged fiscal states are initially zero, the perceived fiscal propagation coefficients remain unchanged.

As the shock propagates, changes in inflation and nominal interest rates affect government financing and the evolution of debt. These nominal disturbances generate forecast errors in fiscal variables that are consistent with the government budget constraint. Under asymmetric learning, however, households revise only the fiscal propagation coefficients, without adjusting the corresponding nominal coefficients. Changes in government financing induced by nominal disturbances are reflected in revised beliefs about future fiscal adjustment, breaking the cross equation restrictions required for full backing. The deviation is concentrated in the debt-state restriction, reflecting the direct effects of inflation and interest rates on debt accumulation, while primary surpluses respond indirectly through fiscal adjustment. Revisions to the debt-propagation and intercept restrictions then evolve jointly through the learning process, as departures from perceived full backing feed back into subsequent forecast errors.

The experiment demonstrates that monetary disturbances can alter households' perceived fiscal backing of government liabilities even when the underlying policy regime remains unchanged. By revising their beliefs about how fiscal positions propagate, households can come to perceive government liabilities as net wealth, introducing an additional channel through which monetary disturbances affect aggregate demand and inflation.

4.3 Wealth Effects from Insufficient Perceived Fiscal Backing

The previous results establish when learning can move households away from Ricardian beliefs. I now characterize how these departures affect inflation. The decomposition distinguishes three conceptually different channel: the effect of shifting long run inflation beliefs, a wealth effect associated with the long run backing gap $r_{\omega,t}$ and a state dependent wealth effect associated with violations of the perceived full backing conditions.

Proposition 5. *Under the restricted perceived law of motion described above, inflation can be written as*

$$\begin{aligned}\pi_t \;=\; - \underbrace{\frac{\beta\omega_{R,t}-\omega_{\pi,t}}{\phi_\pi(1-\beta)}}_{\textit{Intertemporal Substitution}} \underbrace{-\frac{\sigma\delta}{\phi_\pi}\left(r_{\omega,t}+\beta r_t'\left(I-\beta\tilde{\mathscr{F}}_t\right)^{-1}\omega_{f,t}\right)}_{\textit{Persistent Wealth Effects}} \\ \underbrace{-\frac{\sigma\delta(1-\beta)}{\phi_\pi}r_t'\left(I-\beta\tilde{\mathscr{F}}_t\right)^{-1}f_t}_{\textit{State-dependent Wealth Effects}} \qquad (11)\end{aligned}$$

where

$$r_t' \equiv \begin{pmatrix} r_{s,t} & r_{b,t}\end{pmatrix} \quad \textit{and} \quad \tilde{\mathscr{F}}_t \equiv \begin{pmatrix} \varphi_{ss,t} & \varphi_{sb,t} \\ \varphi_{bs,t} & \varphi_{bb,t}\end{pmatrix},$$
$$\omega_{f,t} \equiv \begin{pmatrix} \omega_{s,t} \\ \omega_{b,t}\end{pmatrix} \quad \textit{and} \quad f_t \equiv \begin{pmatrix} s_t \\ b_t\end{pmatrix}.$$

Proof. See the appendix. □

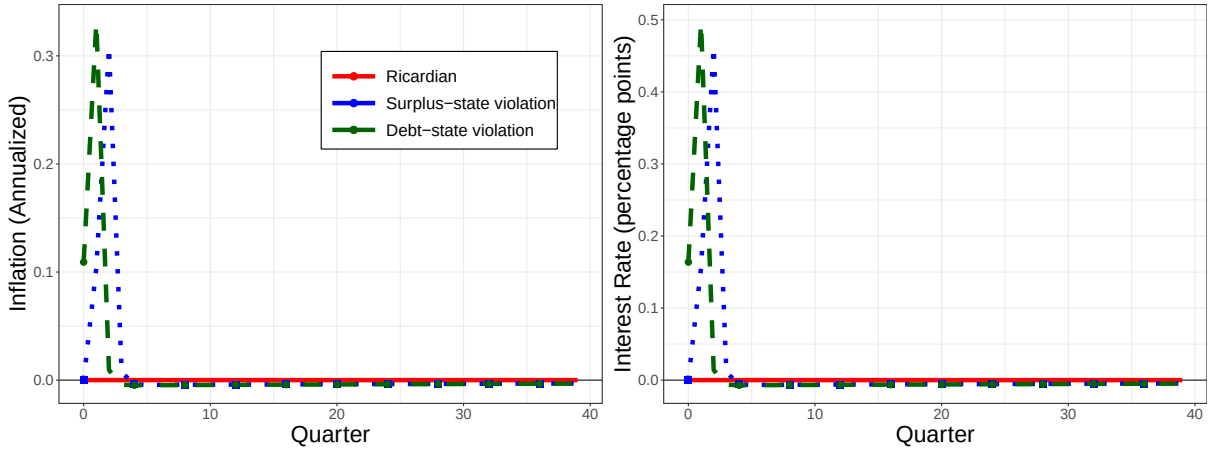
The first term is present even under Ricardian beliefs. It is the long run belief channel emphasized by Eusepi and Preston (2018): forecast errors can induce slow moving revisions in long run inflation and nominal interest rate beliefs and generate persistent inflation dynamics even when government liabilities are not perceived as net wealth.

The second term captures the perceived wealth effect arising from households' long-run nominal and fiscal beliefs. It reflects both direct inconsistencies among their perceived intercepts, measured by $r_{\omega,t}$ and the propagation of these intercepts through subjective fiscal dynamics when $r_t' \neq 0$. When the resulting composite backing gap is negative, households perceive future fiscal adjustment to be insufficient relative to the nominal valuation of government liabilities. Government liabilities are then perceived as net wealth, increasing desired consumption and equilibrium inflation. Coefficient learning provides a mechanism through which this gap can emerge: violations of the state dependent backing restrictions alter forecast errors. Because this component depends on learned beliefs rather than directly on current fiscal positions, the resulting wealth effect can persist even after the disturbance that originally triggered learning has dissipated.

The final term captures the more conventional state dependent perceived wealth effect. Violations of $r_{s,t} = 0$ or $r_{b,t} = 0$ matter to the extent that the economy currently carries fiscal positions to which those perceived propagation coefficients apply. These terms depend jointly on the backing restriction and the fiscal state.

Lemma 1. *Conditional on the subjective beliefs prevailing at date t, the inflation response to a fiscal disturbance depends on the perceived fiscal backing gaps $r_{s,t}$ and $r_{b,t}$ and on the perceived propagation matrix $\tilde{\mathcal{F}}_t$. Consequently, two economies with identical structural parameters and policy rules can exhibit different inflation responses to the same fiscal disturbance solely because households hold different beliefs about the future fiscal adjustment associated with current surpluses and debt. Under Ricardian beliefs, $r_{s,t} = r_{b,t} = 0$, so this state-dependent fiscal valuation channel vanishes.*

Figure 3: Impulse Responses under Different Perceived Backing



Note: The figure shows impulse responses to a one-standard-deviation fiscal expansion under three initial belief configurations: Ricardian beliefs (full perceived backing), a surplus-state violation, and a debt-state violation. Households update their beliefs using constant gain recursive least squares with gain $g = 0.03$. Parameters are $\beta = 0.99$, $\delta = 2.4$(government debt equal to 60% of annual GDP), $\phi_\pi = 1.5$, $\phi_b = 2$, and $1/\sigma = 0.3$. Inflation responses are expressed in annualized percentage points.

Figure 3 provides a simple illustration of these two margins. I consider a one standard deviation fiscal expansion and compare a Ricardian benchmark with two initial departures from perceived full backing. The first perturbs the surplus state restriction, so that a current deficit is perceived to generate more future debt than under full backing. The second perturbs the debt state restriction, so that outstanding debt is perceived to induce insufficient future surplus adjustment. Subjective beliefs about inflation and monetary policy dynamics are held at their rational-expectations values in all three cases.

The impulse responses are intended only to illustrate the mechanism characterized in Proposition 5, rather than to provide a quantitative assessment of the effects of fiscal policy. In each experiment, households subsequently update the four perceived long-run means and the four coefficients governing surplus and debt dynamics using constant-gain recursive least squares, with $g = 0.03$. The cases therefore differ only in the initial fiscal-backing restriction that is violated; thereafter, beliefs evolve according to the same learning rule.

The Persistence of Beliefs and Long Run Inflation Expectations

So far, I have focused on how departures from perceived full backing alter the response of inflation to fiscal disturbances at finite horizons. I now ask whether the same mechanism can generate a persistent misalignment in households' long-run inflation expectations. By misalignment, I mean a departure of the long-run inflation rate implied by households' beliefs from the zero-inflation steady state.

Given beliefs at date t, the limiting forecast is

$$\lim_{T\to\infty} \hat{E}_t Z_T = \left(I_4 - \tilde{\Phi}_t\right)^{-1} \bar{\omega}_t.$$

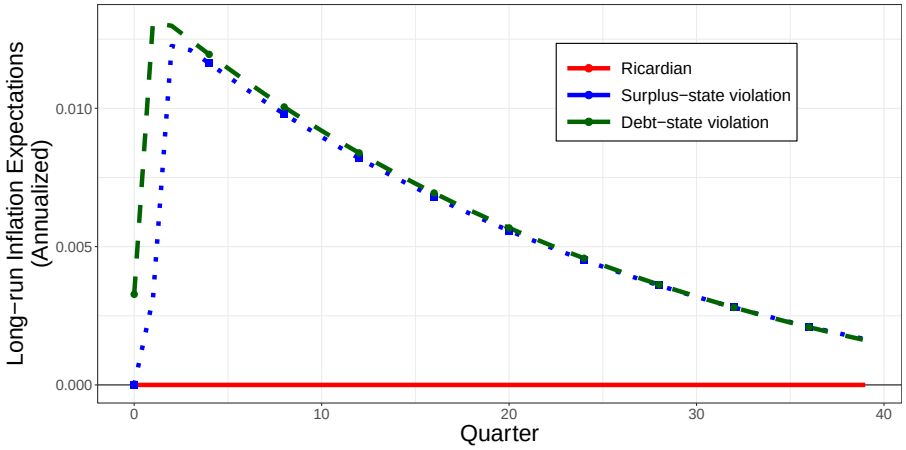
provided that $\tilde{\Phi}_t$ is stable. I use the inflation component of this limiting forecast as the model's measure of long-run inflation expectations. This object strips out the transitory dynamics associated with the current state and captures instead the long-run inflation rate implied by households' current beliefs. This distinction is particularly transparent under rational expectations. Iterating the perceived law of motion forward gives

$$\begin{aligned}\lim_{T\to\infty} \hat{E}_t Z_T &= \left(I_4 - \tilde{\Phi}_t\right)^{-1} \left(I_4 - \tilde{\Phi}_t^{T-t+1}\right) \underbrace{\bar{\omega}_t}_{=0} + \underbrace{\tilde{\Phi}_t^{T-t+1}}_{\to 0} Z_{t-1} \\ &= 0.\end{aligned}$$

Under the rational expectations benchmark, $\bar{\omega}_t = 0$, while stability implies $\tilde{\Phi}^{T-t+1} \to 0$. Long-run expectations therefore remain at their steady state values regardless of the current fiscal disturbance. Under learning, forecast errors generated by the fiscal expansion update both the perceived long-run means, $\bar{\omega}_t$, and the perceived fiscal dynamics, $\tilde{\Phi}_{s,t}$ and $\tilde{\Phi}_{b,t}$. A transitory fiscal disturbance can therefore alter the long-run inflation rate implied by households' beliefs.

I evaluate this long-run forecast following the same one-standard-deviation fiscal expansion considered above and under the same three initial belief configurations: Ricardian beliefs, the surplus-state violation, and the debt-state violation. Households continue to update their beliefs using constant-gain learning with $g = 0.03$. Figure 4 reports the inflation component of the limiting forecast.

Figure 4: A Fiscal Policy Shock and Misalignment in Long-Run Inflation Expectations



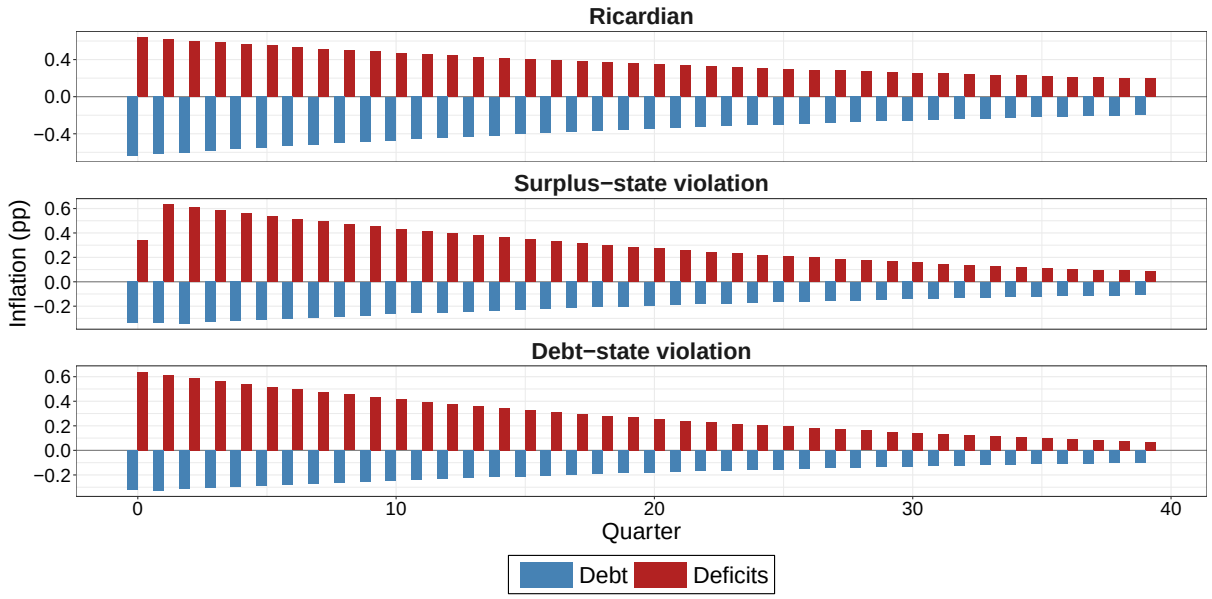
Note: The figure shows the response of long-run inflation expectations to a one-standard-deviation fiscal expansion under three initial belief configurations: Ricardian beliefs (full perceived backing), a surplus-state violation, and a debt-state violation. Households update their perceived long-run means and fiscal dynamics using constant gain recursive least squares, while inflation and monetary policy beliefs remain fixed. Parameters are $g = 0.03$, $\beta = 0.99$, $\delta = 2.4$*(government debt equal to 60% of annual GDP),* $\phi_\pi = 1.5$, $\phi_b = 2$, *and* $1/\sigma = 0.3$. *Long-run inflation expectations are expressed in percentage-point deviations from steady state.*

The figure shows that departures from perceived full backing can translate an i.i.d. fiscal policy shock into a persistent misalignment of long-run inflation expectations. The fiscal shock disappears after the impact period. Under Ricardian beliefs, long-run inflation expectations remain aligned with the zero-inflation steady state. When perceived full backing fails, government liabilities are instead perceived as net wealth, generating an inflationary response. The resulting forecast errors induce households to update their perceived long-run means and fiscal dynamics, causing part of the inflationary effect to become embedded in their long-run inflation expectations. Although the peak misalignment is only around 0.01 percentage point in this illustrative calibration, its subsequent decay is remarkably slow with an implied half-life of 4 years. Thus, imperfect fiscal beliefs provide a mechanism through which a transitory fiscal disturbance can generate a highly persistent component of expected inflation.

Fiscal Beliefs: Opposing Contributions, Imperfect Cancellation.

Figure 5 illustrates the economic mechanism underlying the preceding results by decomposing the inflation response to a fiscal expansion into the contributions of expected deficits and government debt. The two components have opposing effects on households' perceived wealth. Expectations of persistent fiscal deficits imply lower future primary surpluses and therefore smaller future tax obligations, increasing perceived wealth and consumption demand. On the other hand, expectations of persistently higher government debt imply that households must accumulate more government assets in the future, reducing current consumption demand. These opposing wealth effects translate into positive and negative contributions to inflation, respectively.

Figure 5: Deficits and Debt Contributions to Inflation



Note: The figure decomposes the fiscal intercept contribution to inflation into components associated with households' beliefs about persistent primary deficits (red) and government debt (blue), following a unit fiscal expansion. The three panels compare Ricardian beliefs with two departures from perceived full fiscal backing: a surplus-state violation, which alters how current surpluses predict future fiscal positions, and a debt-state violation, which alters the perceived adjustment to outstanding debt. Persistent deficits imply weaker expected fiscal backing and contribute positively to inflation, while higher debt signals future primary surplus adjustment and contributes negatively. Under Ricardian beliefs, these opposing contributions cancel exactly in equilibrium, leaving no fiscal wealth effect on inflation. When perceived full backing is violated, the contributions retain their opposite signs but no longer fully offset, generating a positive net inflation contribution. The magnitude of this effect depends on how households perceive fiscal adjustment.

Under Ricardian beliefs, these contributions offset exactly. Although a fiscal expansion generates persistent movements in deficits and government debt, households understand their present-value relationship: the additional liabilities are fully backed by future fiscal adjustment. Neither component independently affects equilibrium inflation. The top panel of Figure 5 illustrates this cancellation. Fiscal neutrality does not require that deficits or debt have no implications for households' consumption decisions individually, but rather that their perceived wealth effects are mutually consistent.

This cancellation need not survive when households are uncertain about fiscal adjustment process. The middle and bottom panels illustrate departures from the perceived full backing restrictions associated with the surplus and debt states, respectively. In both cases, the positive contribution from expected deficits is no longer fully offset by the negative contribution from expected debt, generating a positive and persistent inflation response. The underlying fiscal policy rule remains unchanged. What changes is households' perception of the relationship between current fiscal conditions and future fiscal adjustment. Thus, fiscal disturbances can affect inflation not because government liabilities are objectively unbacked, but because households do not fully internalize the fiscal adjustment that backs them.

5 A Medium Scale New Keynesian Model

Households

The economy is populated by a continuum of households which seeks to maximize future expected discounted utility

$$\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left[\frac{(C_T(i)+g)^{1-\sigma}}{1-\sigma} - h_T^i \right]$$

where utility depends on a consumption index, $C_T(i)$, the amount of labor supplied for the production of each good j, h_T^i, and the quantity of government expenditure $g > 0$. The consumption index, C_T^i, is the CES aggregator of the economy's available goods and has associated price index written, respectively, as

$$C_t(i) \equiv \left[\int_0^1 c_t^i(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \quad \text{and} \quad P_t \equiv \left[\int_0^1 p_t(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$$

where $\theta > 1$ is the elasticity of substitution between any two goods and $c_t^i(j)$ and $p_t(j)$ denote household i's consumption and the price of good j. The discount factor is assumed to satisfy $0 < \beta < 1$.

Asset markets are assumed to be incomplete. The only asset in non-zero net supply is government debt. The household's flow budget constraint is

$$C_t(i) + \frac{B_t(i)}{R_t P_t} \leq \pi_t^{-1} \frac{B_{t-1}(i)}{P_{t-1}} + \frac{W_t}{P_t} h_t^i + \Pi_t - S_t,$$

where R_t is the gross one period nominal interest rate. $B_t(i)$ represents one period nominal government debt and Π_t i the profits, S_t will be the government surpluses net of transfers, or primary surpluses set by a fiscal policy rule. Period nominal income is

$$P_t Y_t(i) = W_t h_t^i + \int_0^1 \Pi_t(j) dj$$

for each household i. Household's optimal consumption and portfolio choice must also satisfy the No-Ponzi condition

$$\lim_{T \to \infty} \hat{E}_t^i \left(\prod_{s=0}^{T-t} R_{t+s} \pi_{t+s+1}^{-1} \right)^{-1} \frac{B_T(i)}{P_T} \geq 0.$$

Firms

There is a continuum of monopolistically competitive firms. Each differentiated consumption good is produced according to linear production function

$$y_t(j) = A_t h_t(j),$$

where A_t denotes an aggregate technology shock. Each firm faces a demand curve

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\theta_t} Y_t,$$

where Y_t denotes aggregate output, and follows the price setting a la Calvo, where prices can be optimally chosen in any period with probability $0 < 1-\alpha < 1$. A price is chose to maximize the expected discounted value of profits

$$\hat{E}_t^j \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T} \Pi_T^j(p),$$

where the stochastic discount factor, $Q_{t,T} = \beta^{T-t} P_t Y_t / (P_T Y_T)$ for $T \geq t$, values future profits

$$\Pi_T^j(p) = \left(p - \frac{W_T}{A_T}\right)\left(\frac{p}{P_T}\right)^{-\theta_T} Y_T.$$

Denote the optimal price p_t^*. Since all firms changing prices in period t face identical decision problems, the aggregate price index evolves according to

$$P_t = \left[\alpha P_{t-1}^{1-\theta_t} + (1-\alpha)(p_t^*)^{1-\theta_t}\right]^{\frac{1}{1-\theta_t}}.$$

Log-linearizing the first order condition for the optimal price gives

$$\hat{p}_t = \hat{E}_t^i \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} \left[(1-\alpha\beta)\widehat{mc}_T + \alpha\beta\pi_{T+1}\right]$$

where $\hat{p}_t = \log(p_t^*/P_t)$ and $\widehat{mc}_t = \log(mc_t/\overline{mc})$ is average marginal costs. Each firm's current price depends on the expected future path of real marginal costs and inflation. The higher the degree of nominal rigidity, the greater the weight on future inflation in determining current prices. The average marginal cost is defined as

$$mc_t = \frac{W_t}{A_t P_t} = \frac{Y_t}{A_t},$$

where the second equality comes from the household's labor supply decision. Log-linearizing provides

$$\widehat{mc}_t = \hat{Y}_t - \hat{a}_t,$$

where $a_t = \log A_t$. Thus current prices depend on expected future demand, inflation and technology.

Government Policy

The central bank implements monetary policy using the interest rate rule

$$R_t = (R_{t-1})^{\rho_i}\left[\bar{R}\left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi} X_t^{\phi_x^R}\right]^{1-\rho_i} e^{m_t},$$

where $\phi_\pi \geq 0$.

The fiscal authority finances government purchase of g per period by issuing public debt and levying lump-sum taxes. Denoting B_{t-1} as the outstanding government debt at the beginning of

any period t, and assuming for simplicity that the public debt is comprised entirely of one-period riskless nominal Treasury bills, government liabilities evolve

$$\frac{B_t}{R_t} = B_{t-1} + gP_t - T_t,$$

which can be rewritten as

$$\frac{b_t}{R_t} + s_t = \frac{b_{t-1}}{\pi_t},$$

where $s_t = T_t/P_t - g$ denotes the primary surplus and $b_t = B_t/P_t$ represents the real value of the public debt. The government's flow budget constraint satisfies the log-linear approximation

$$\beta\hat{b}_t - \beta\hat{R}_t + (1-\beta)\hat{s}_t = \hat{b}_{t-1} - \hat{\pi}_t.$$

The model is closed with an assumption on the path of primary surpluses $\{s_t\}$. Analogous to the monetary authority, it is assumed that the fiscal authority adjusts the primary surplus according to the one-parameter family of rules

$$s_t = (s_{t-1})^{\rho_s}\left[\bar{s}\left(\frac{b_{t-1}}{\bar{b}}\right)^{\phi_b} X_t^{\phi_x^s}\right]^{1-\rho_s} e^{f_t}$$

where $\bar{s}, \bar{b} > 0$ are constants coinciding with the steady state level primary surplus and the public debt respectively. $\phi_b \geq 0$ is a policy parameter.

Market Clearing and Aggregate Dynamics

General equilibrium requires goods market clearing,

$$\int_0^1 C_t(i)\,di + g = C_t + g = Y_t.$$

This relation satisfies the log-linear approximation

$$\frac{\bar{C}}{\bar{Y}}\int_0^1 \hat{C}_t(i)\,di = \frac{\bar{C}}{\bar{Y}}\hat{C}_t = \hat{Y}_t.$$

It is useful to characterize the natural rate of output, the level of output that would prevail absent nominal rigidities under rational expectations. Under these assumptions, optimal price setting implies the log-linear approximation

$$\hat{Y}_t^n = \hat{a}_t.$$

Movements in the natural rate of output is determined by variations in aggregate technology shocks. Using this definition, aggregate dynamics of the economy can be characterized in terms of deviations from the flexible price equilibrium. Finally, asset market clearing requires

$$\int_0^1 B_t(i)\,di = B_t \quad \text{and} \quad \int_0^1 \hat{b}_t(i)\,di = \hat{b}_t,$$

implying the sum of individual holdings of the public debt equals the supply of one-period bonds.

Aggregating household and firm decisions provides

$$\begin{aligned}\hat{x}_t &= (1-\beta)\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}\hat{x}_{T+1}-\frac{\beta}{\sigma}\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}\left(R_T-\pi_{T+1}-\hat{r}_T^n\right)+\\ &+ \beta^{-1}(1-\beta)\delta\left(\hat{b}_{t-1}-\pi_t-\hat{E}_t^i\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{(1-\beta)\hat{s}_T-\beta\left(R_T-\pi_{T+1}\right)\right\}\right]\right)\end{aligned}$$

and

$$\pi_t=\kappa\hat{x}_t+\hat{E}_t\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\kappa\alpha\beta\hat{x}_{T+1}+(1-\alpha)\beta\pi_{T+1}\right]-\frac{\kappa}{\bar{\theta}-1}\hat{\theta}_t$$

where $\int_0^1\hat{E}_t^i di=\hat{E}_t$ gives average expectations; $\hat{x}_t=\hat{Y}_t-\hat{Y}_t^n$ denotes the log-deviation of output from its natural rate; $\hat{r}_t^n=\hat{Y}_{t+1}^n-\hat{Y}_t^n$ the corresponding natural rate of interest, which is assumed to be an i.i.d process, and $\kappa=(1-\alpha)(1-\alpha\beta)\alpha^{-1}>0$.

The average expectations operator does not satisfy the law of iterated expectations due to the assumption of completely imperfect common knowledge on the part of all households and firms. Because agents do not know the beliefs, objectives and constraints of other households and firms in the economy, they cannot infer aggregate probability laws.

Equilibrium

Equilibrium requires all goods, labor and asset markets to clear. Given exogenous processes $\left\{\hat{r}_t^n,\hat{\theta}_t,\varepsilon_t^{MP},\varepsilon_t^{FP},\varepsilon_t^r\right\}$, equilibrium then is a sequence of prices $\{P_t,W_t,R_t\}$ and allocation $\{C_t,N_t,Y_t,\Pi_t,B_t\}$ satisfying individual optimality and market clearing conditions.

The equilibrium condition can be summarized by

$$\begin{aligned}\hat{x}_t &= (1-\beta)\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\hat{x}_{T+1}-\frac{\beta}{\sigma}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(R_T-\pi_{T+1}-\hat{r}_T^n\right)+\\ &+ \beta^{-1}(1-\beta)\delta\left(\hat{b}_{t-1}-\pi_t-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{(1-\beta)\hat{s}_T-\beta\left(R_T-\pi_{T+1}\right)\right\}\right]\right)\\ \pi_t &= \kappa\hat{x}_t+\hat{E}_t\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\kappa\alpha\beta\hat{x}_{T+1}+(1-\alpha)\beta\pi_{T+1}\right]-\frac{\kappa}{\bar{\theta}-1}\hat{\theta}_t\\ R_t &= \rho_i R_{t-1}+(1-\rho_i)\left(\phi_\pi\pi_t+\phi_x^i\hat{x}_t\right)+\varepsilon_t^{MP}\\ \hat{s}_t &= \rho_s\hat{s}_{t-1}+(1-\rho_s)\left(\phi_b\hat{b}_{t-1}+\phi_x^s\hat{x}_t\right)+\varepsilon_t^{FP}\\ \beta\hat{b}_t &= \hat{b}_{t-1}+\beta R_t-(1-\beta)\hat{s}_t-\pi_t\\ \hat{r}_t^n &= \rho_r\hat{r}_{t-1}^n+\varepsilon_t^r\end{aligned}$$

while the infinite horizon expectations are pined down by

$$\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}Z_{T+1}=\left(I-\tilde{\Phi}_t\right)^{-1}\left[(1-\beta)^{-1}I-\tilde{\Phi}_t\left(1-\beta\tilde{\Phi}_t\right)^{-1}\right]\bar{\omega}_t+\tilde{\Phi}_t\left(1-\beta\tilde{\Phi}_t\right)^{-1}Z_t$$

and the belief updating is through the recursive least squares

$$\begin{aligned}\Psi_{t+1} &= \Psi_t + \bar{g}\Omega_t^{-1} X_t \left(Z_t - \Psi_t' X_t\right)' \\ \Omega_{t+1} &= \Omega_t + \bar{g}\left(X_t X_t' - \Omega_t\right)\end{aligned}$$

where $\Psi_t = \begin{pmatrix} \bar{\omega}_t' \\ \tilde{\Phi}_t' \end{pmatrix}$ and $X_t = \begin{pmatrix} 1 & Z_{t-1}' \end{pmatrix}'$. As in Section 4, households update their perceived coefficients using constant-gain recursive least squares. In the quantitative model, learning is restricted to five intercepts and the propagation coefficients for primary surpluses and government debt, while the remaining coefficients are held fixed at their rational expectations values. Beliefs used in period t are predetermined, with observations at t updating beliefs for period $t+1$.

Calibrated Parameters

The long-run mean of inflation and the short-term interest rate in the measurement equation are set equal to 2 and 4 percent. $\bar{\theta}$ is set to be 5, which is equivalent to 25 percent markup in the steady state. δ is calibrated for the quarterly frequency, meaning 35 percent steady state debt to output ratio results in $\delta = 1.4$.

Estimation

Let the vector of structural parameters be

$$\Theta = \left\{\sigma, \kappa, \alpha, \phi_\pi, \phi_x, \phi_b, \phi_y, \rho_i, \rho_s, \rho_r, \rho_{MP}, \rho_{FP}, \rho_\theta, \sigma_{MP}, \sigma_{FP}, \sigma_r, \sigma_\theta, \bar{g}\right\}.$$

Conditional on Θ, the model admits the state space representation

$$Z_t = T_{0,t}(\Theta)\,\bar{\omega}_t + T_{1,t}(\Theta)\,Z_{t-1} + T_{\varepsilon,t}(\Theta)\,\varepsilon_t,$$

where the transition matrices $T_{0,t}(\Theta)$, $T_{1,t}(\Theta)$, and $T_{\varepsilon,t}(\Theta)$ are obtained from the structural equilibrium conditions and time-varying through the evolution of agents' beliefs. The corresponding observation equation is given by

$$Y_t = \mu_t(\Theta) + H_t(\Theta)\,Z_t + o_t,$$

where Y_t collects the observed macroeconomic and survey data, and o_t denotes measurement errors. The loading matrix $H_t(\Theta)$ depends on the structural parameters because the observation vector includes survey expectations, which are linked to model-implied forecasts generated by the learning mechanism. Consequently, the observation equation maps both realized macroeconomic outcomes and expectations data into the model's latent state vector.

Data

I estimate the model using quarterly U.S. data over the pre zero lower bound (ZLB) period. The data combine macroeconomic and fiscal outcomes with survey measures of short- and long-run expectations. Macroeconomic outcomes consist of the output gap, measured as real GDP relative

to CBO potential output; annualized quarterly CPI inflation; and the three-month Treasury bill rate. Fiscal outcomes consist of the primary surplus relative to the market value of publicly held government debt and publicly held government debt relative to GDP.

To discipline households' subjective beliefs, I use expectations from the Survey of Professional Forecasters (SPF). Short-run expectations are measured using one quarter ahead forecasts of CPI inflation and the three-month Treasury bill rate. Long-run expectations are measured using the expected average CPI inflation rate over the next ten years and the expected annual-average return on three-month Treasury bills over the same horizon. The combination of realized outcomes and survey forecasts is particularly useful in the learning model: realized macroeconomic and fiscal outcomes discipline the perceived law of motion, while survey expectations provide direct information about the beliefs implied by that law.

I restrict the baseline structural estimation to the pre-ZLB sample. Extending the structural model beyond this period raises two additional complications. First, the ZLB breaks the baseline monetary policy specification based on the short-term interest rate. Second, the post-ZLB period contains exceptionally large fiscal forecast errors. In the learning model, these forecast errors directly affect belief updating and therefore place substantial discipline on the estimated learning gain and the evolution of perceived fiscal dynamics. The reduced-form evidence in Appendix H can accommodate the post-ZLB period by using the 10 year Treasury yield and fixing the relevant belief coefficients while allowing the fiscal intercepts to evolve more flexibly. The structural model does not have this flexibility without changing the specification of the learning process. I therefore focus the structural estimation on the pre-ZLB period and leave a structural treatment of the ZLB and large post-ZLB fiscal forecast errors for future work.

Prior and Posterior Distributions

Table 1 and 2 provide details on the prior and posterior distributions. The priors for the exogenous shock processes follow inverse-gamma distributions. The persistence of the autocorrelated processes follow a beta distribution. The priors for the parameters of the monetary policy reaction function are based on the Taylor rule, while the parameters of the fiscal policy reaction function are consistent with a passive fiscal regime.

Following Eusepi and Preston (2018), I adapt a gamma distribution with mean 2 and a fairly large standard deviation 0.5 for the inverse intertemporal elasticity of substitution of consumption σ. I separately identify the slope of the Phillips curve, κ, with a peta prior distribution with mean 0.3 and standard deviation of 0.15. I assume the constant-gain coefficient has a log-normal prior distribution with mean 0.05 and standard deviation of 0.02, which is largely consistent with the learning literature.

Table 1: Prior and Posterior Distributions for Structural Parameters

	Prior			Posterior	
Parameter	Distribution	Mean	Std.	Median	[5%, 95%]
α	Beta	0.75	0.05	0.80	[0.76, 0.87]
σ	Gamma	2.0	0.5	8.30	[7.94, 8.71]
κ	Beta	0.3	0.1	0.021	[0.019, 0.023]
ρ_i	Beta	0.5	0.08	0.85	[0.83, 0.86]
ρ_s	Beta	0.7	0.16	0.56	[0.49, 0.66]
g	Log Normal	0.05	0.02	0.041	[0.040, 0.042]
ϕ_π	Log Normal	1.6	0.7	1.63	[1.59, 1.66]
ϕ_b	Log Normal	2.2	0.9	2.34	[1.78, 2.62]
ϕ_x	Log Normal	0.13	0.04	0.25	[0.23, 0.30]
ϕ_y	Log Normal	0.13	0.04	0.13	[0.08, 0.20]

Table 2: Prior and Posterior Distributions for Shock Processes

	Prior			Posterior	
Parameter	Distribution	Mean	Std.	Median	[5%, 95%]
ρ_r	Beta	0.8	0.12	0.632	[0.58, 0.64]
ρ_{MP}	Beta	0.5	0.2	0.14	[0.09, 0.21]
ρ_{FP}	Beta	0.5	0.2	0.77	[0.72, 0.83]
ρ_θ	Beta	0.5	0.2	0.71	[0.61, 0.76]
σ_{MP}	Inv.Gamma	0.5	0.2	0.02	[0.02, 0.03]
σ_{FP}	Inv.Gamma	1	0.5	0.53	[0.40, 0.66]
σ_r	Inv.Gamma	0.1	0.2	0.07	[0.06, 0.07]
σ_θ	Inv.Gamma	0.25	0.2	0.82	[0.78, 0.88]
me_x	Inv.Gamma	0.5	0.3	0.05	[0.02, 0.13]
me_π	Inv.Gamma	0.1	0.1	0.08	[0.03, 0.26]
me_R	Inv.Gamma	0.1	0.1	0.40	[0.32, 0.47]
me_s	Inv.Gamma	0.1	0.006	0.05	[0.04, 0.05]
me_b	Inv.Gamma	0.1	0.006	0.004	[0.004, 0.005]
$me_{E\pi,1q}$	Inv.Gamma	0.8	0.5	1.41	[1.36, 1.56]
$me_{ER,1q}$	Inv.Gamma	0.8	0.5	0.16	[0.10, 0.23]
$me_{E\pi,10y}$	Inv.Gamma	0.25	0.2	0.67	[0.61, 0.72]
$me_{ER,10y}$	Inv.Gamma	0.5	0.39	0.54	[0.46, 0.58]

Table 1 and 2 also show the median and 95 percentiles of the posterior distributions. The shocks have lower persistence than usually found in the estimated DSGE model, consistent with the finding in the literature that leaning absorbs some of low-frequency variation in the data. The estimated intertemporal elasticity of substitution, σ^{-1}, is low while consistent with the upper end of the estimate in Eusepi and Preston (2018). The estimated slope of the Phillips curve is very flat despite the sample ranges from 1970 to 2008. This seems to reflect the fact that the low transmission of the perceived wealth to inflation during these periods.

6 Results

The remaining sections of the paper investigate the implications of the estimated model, particularly concerning how the transmission of fiscal policy changes depending on the inherited beliefs about how the government adjusts outstanding liabilities and their effects on output, inflation, and long-run inflation expectations. I first describe how the median impulse responses look like to unexpected fiscal expansion, corresponding to roughly 1 percent deterioration of surplus to GDP

ratio and cost push shock. Impulse responses to the rest of the shocks will be described in the Appendix. I then investigate how the imperfect knowledge about the adjustment process of surplus and debt shapes output, inflation, long-run inflation expectations, and the transmission of fiscal policy historically in the U.S. At the end, I construct the counterfactual to reveal the policy implications.

6.1 Simulated Impulse Responses

Because beliefs evolve endogenously under adaptive learning, the effect of a structural shock depends on the history at which the shock occurs. I characterize model dynamics using simulated impulse responses. For each experiment, I first draw a sequence of structural innovations and simulate a baseline economy. I then simulate a second economy using the identical sequence of innovations, except that an additional structural shock is introduced at a specified date. The two economies are identical up to the shock date and enter the experiment with the same endogenous states and beliefs. After the shock, however, beliefs are updated separately in the two economies because the shock changes realized outcomes and hence subsequent forecast errors. The response for a given simulated history is defined as the difference between the shocked and baseline trajectories.

I repeat this paired simulation across many histories and report the pointwise median response at each horizon. Structural parameters are held fixed at their posterior median estimates. This procedure integrates over the different belief configurations generated by past macroeconomic histories while preserving the endogenous feedback from shocks to forecast errors, belief updating, and subsequent equilibrium outcomes. The resulting responses are history dependent: unlike conventional impulse responses in a linear rational expectations model, the propagation mechanism need not remain fixed after the initial shock.

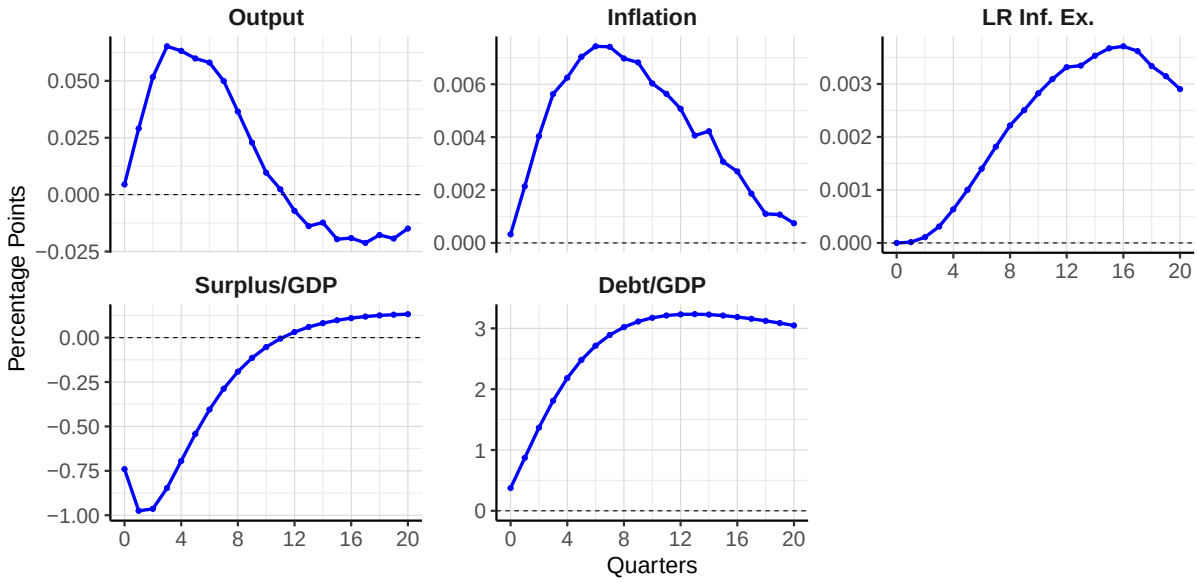
This simulation procedure is standard in models in which learning or other nonlinear state variables make impulse responses depend on the history of the economy. Koop, Pesaran and Potter (1996) develop generalized impulse responses for nonlinear systems by comparing conditional paths with and without a shock; in such environments responses generally depend on the initial state and shock history. Closely related implementations appear in the adaptive learning literature. For example, Eusepi and Preston (2011) generate impulse responses by simulating the learning model twice with identical histories, introducing the shock in only one trajectory, and taking the difference between the two simulated paths; they repeat the exercise over simulated histories and report the pointwise median response. Slobodyan and Wouters (2012) similarly refer to "impulse responses with simulated beliefs" and describe pseudo-impulse responses in which the shock is introduced and the model is traced forward while beliefs themselves continue to change.

Fiscal Policy Shock

To examine the quantitative implications of learning for fiscal policy transmission, I simulate 1,000 economies using the posterior median parameter estimates. Each economy starts from rational expectations beliefs and evolves for 58 quarters under randomly drawn structural innovations, allowing households to update their beliefs through learning. In quarter 59, I introduce an unexpected fiscal expansion corresponding to a two standard deviation negative fiscal policy innovation, or roughly a 1 percentage point deterioration in the primary surplus to GDP ratio. For each simulated

history, I compare the economy with the fiscal expansion to a baseline economy with identical initial conditions and structural innovations, except for the additional fiscal shock.

Figure 6: Median Impulse Responses to a Fiscal Policy Shock



Note: The figure reports median simulated impulse responses to a $-2\sigma_{FP}$ fiscal policy shock, corresponding to approximately a 1 percentage point decline in the primary surplus to GDP ratio at the peak. The shock is a fiscal expansion: a negative fiscal policy innovation lowers the primary surplus and raises government debt. Structural parameters are fixed at their posterior median estimates. For each simulation, the shocked economy is compared with an otherwise identical baseline economy subject to the same sequence of structural innovations, while beliefs are updated independently in the two economies following the fiscal shock. The reported responses are the median shocked minus baseline differences across simulated histories. Inflation and long-run inflation expectations are expressed at annual rates; the output gap, primary surplus to GDP ratio, and debt to GDP ratio are reported in percentage points. Long-run inflation expectations are measured by the learned inflation intercept, $\omega_{\pi,t}$.

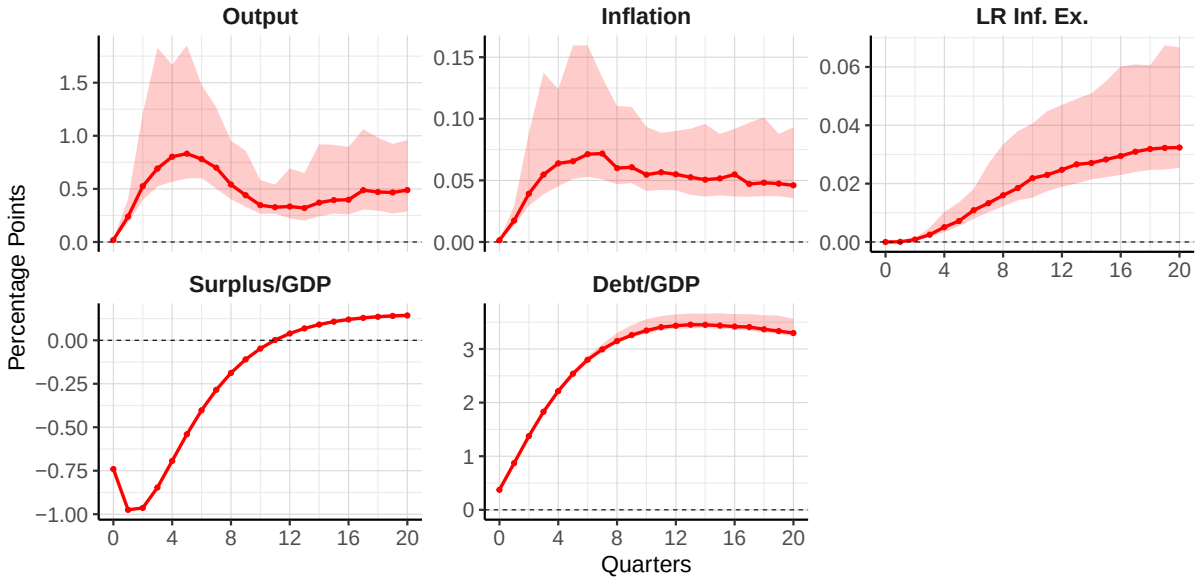
Figure 6 reports the pointwise median impulse responses across these simulations. Since structural parameters and the size of the fiscal disturbance are fixed, the dispersion across responses reflects differences in simulated macroeconomic histories and the associated evolution of beliefs, rather than posterior parameter uncertainty. The median responses characterize the typical response across simulated histories.

The first three panels describe the responses in output, inflation, and long-run inflation expectations; the last one is measured by the perceived intercepts ω_t^{π}. The last two figures describe the evolution of surplus to GDP ratio and debt to GDP ratio. The figure shows that the effects of an unexpected fiscal expansion are modest in a typical economy although one percent deficit shock indeed raises output, inflation, and long-run inflation expectations. At first glance, these results seem at odds with the central claim of the paper that fiscal beliefs critically alter the transmission of fiscal policy. However, this conclusion is premature.

I investigate the upper tail of the impulse response distribution to the same fiscal policy shock, focusing on responses between the 95th and 99th percentiles at each horizon. The solid line represents the median response within this percentile range, computed pointwise. Across simulations,

the structural parameters, policy rules, and size of the fiscal disturbance are held fixed. Instead, different histories of structural innovations lead households to revise their beliefs about fiscal propagation and future fiscal adjustment. As a result, the same fiscal expansion can generate different responses depending on what households have previously observed and learned.

Figure 7: Upper-Tail Impulse Responses to a Fiscal Policy Shock



Note: The figure reports pointwise quantiles of simulated impulse responses to an expansionary fiscal policy shock. Each response is computed as the difference between a shocked and baseline economy, holding initial conditions and all other structural innovations identical. The responses therefore capture the incremental effects of the fiscal disturbance, including its interaction with subsequent learning dynamics. Quantiles are computed separately at each horizon and need not correspond to individual simulated trajectories.

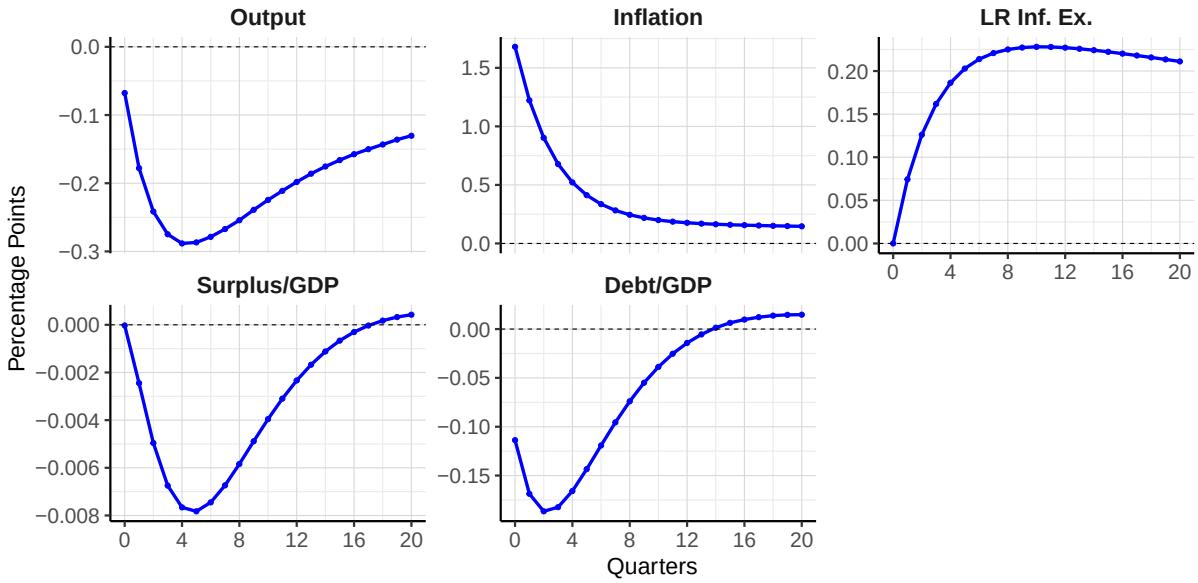
Figure 7 shows that fiscal expansions can generate substantially larger responses in output, inflation, and long-run inflation expectations in the upper tail of the distribution, with sizable effects possible even at longer horizons. These outcomes arise without changes in structural parameters or the underlying monetary and fiscal policy rules. Instead, past shocks and the resulting belief revisions alter households' perceptions of future fiscal adjustment, allowing the same fiscal expansion to produce different wealth effects. The pointwise quantiles summarize the distribution of responses at each horizon rather than individual simulated trajectories. The magnitude of the response in long-run inflation expectations is comparable to the empirical evidence documented by Fu et al. (2025). This illustrates how uncertainty about fiscal adjustment can amplify the transmission of fiscal disturbances and propagate their effects to long-run inflation expectations.

Cost Push Shock

As a benchmark for the estimated model's propagation mechanism, Figure 8 reports the median impulse responses to a positive cost-push shock. The responses exhibit the conventional New Keynesian pattern. Higher production costs generate an immediate increase in inflation and a contraction in output. Monetary policy responds to higher inflation by raising nominal interest

rates, which restrains aggregate demand. Inflation gradually declines toward its steady state, while output recovers more slowly. These dynamics are broadly consistent with the baseline responses to a price markup shock in Eusepi and Preston (2018).

Figure 8: Impulse Responses to a Fiscal Policy Shock in Upper Tail Economies



Note: The figure reports median simulated impulse responses to a one standard deviation cost-push shock, $-\sigma_\theta$, which is inflationary under the model's sign convention. Structural parameters are fixed at their posterior median estimates. For each simulation, the shocked economy is compared with an otherwise identical baseline economy subject to the same sequence of structural innovations, with beliefs updated independently in the two economies following the cost-push shock. Responses are the median shocked-minus-baseline differences across simulated histories. Inflation and long-run inflation expectations are reported at annual rates, while the output gap, primary surplus to GDP ratio, and debt to GDP ratio are reported in percentage points. Long-run inflation expectations are measured by the learned inflation intercept, $\omega_{\pi,t}$.

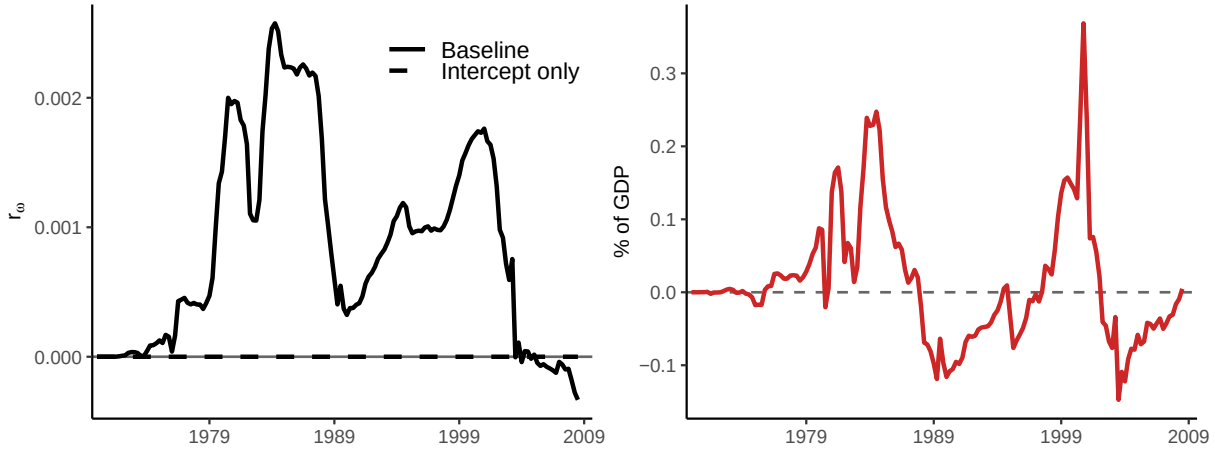
The model also generates a gradual and persistent increase in long-run inflation expectations. Under imperfect knowledge, the inflation surprise leads households to revise their beliefs about the long-run inflation rate, allowing a transitory cost-push shock to affect expectations at longer horizons. The primary surplus and government debt ratios decline temporarily before recovering. Overall, the responses suggest that the estimated model preserves the familiar transmission mechanism of a cost-push shock, while allowing learning to generate additional persistence in long-run inflation expectations.

6.2 Expectations and Wealth Effects

To assess the historical relevance of the perceived fiscal-backing mechanism, Figure 9 reports the evolution of the long-run full backing restriction and its implications for aggregate demand. Recall that the restriction is defined as

$$r_{\omega,t} = \omega_{\pi,t} - \beta\,\omega_{R,t} + (1-\beta)\,\omega_{s,t} + \beta\,\omega_{b,t}.$$

Figure 9: Expectations and Historical Wealth Effects



Note: The left panel shows how coefficient learning generates perceived fiscal wealth by breaking the long-run backing restriction; intercept-only learning preserves the restriction. The right panel quantifies the resulting wealth effect as the baseline-minus-intercept-only difference in output. The wealth effect reflects both long-run and state-dependent departures from full backing. Since natural output is constant, the output difference is expressed as a percent of GDP.

Under Ricardian beliefs, this expression is identically zero. As established in the theoretical analysis, learning only about long-run conditional means preserves this restriction when households understand the process of fiscal adjustment. The left panel confirms this result: the intercept only specification maintains $r_{\omega,t} = 0$ throughout the sample. When households also learn the propagation of fiscal variables, the restriction is no longer preserved. The baseline model exhibits substantial and persistent deviations from zero, indicating that households' long-run fiscal and nominal forecasts need not remain mutually consistent with full perceived backing.

The right panel illustrates the corresponding implications for aggregate demand. It reports the difference in output between the baseline model and the counterfactual in which households learn only about long-run conditional means. This difference measures the equilibrium output effect associated with relaxing the restrictions on perceived fiscal propagation. The effect varies considerably over time, reaching approximately 0.2--0.3 percent of GDP during parts of the 1980s and early 2000s, and turning negative during other periods.

Next, to measure the state dependent evolution of perceived fiscal backing, I use the deviations from the full-backing restriction. For the surplus and debt states,

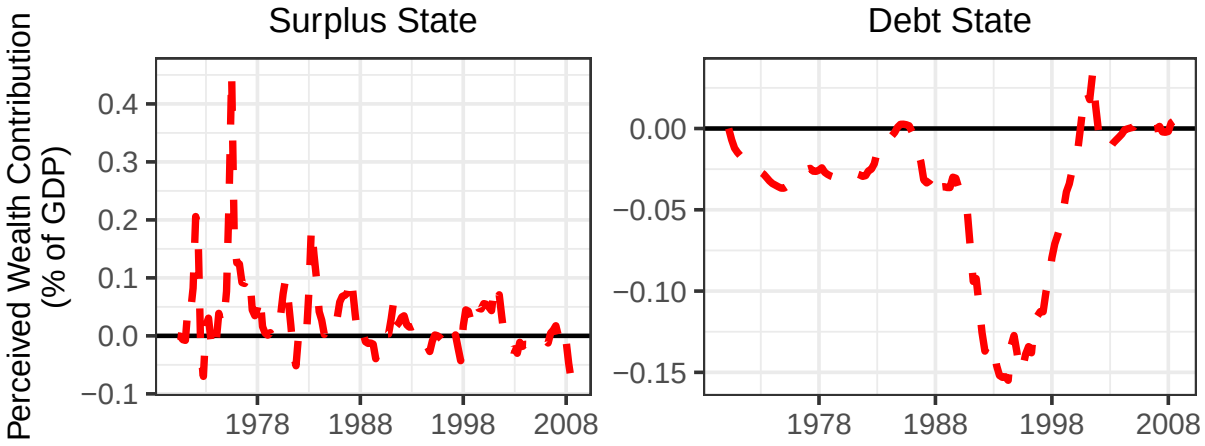
$$r_{s,t} = \beta\left(\varphi_{bs,t} - \varphi^*_{bs,t}\right) \quad \text{and} \quad r_{b,t} = (1-\beta)\left(\varphi_{sb,t} - \varphi^*_{sb,t}\right)$$

Both gaps are zero under full perceived backing. Because their economic interpretation depends on the fiscal position to which they apply, I report the corresponding state-weighted deviations,

$$W_{s,t} = r_{s,t}\hat{s}_{t-1} \quad \text{and} \quad W_{b,t} = r_{b,t}\hat{b}_{t-1}.$$

I convert these state-weighted deviations into shares of steady-state GDP to provide an economically interpretable measure of the magnitude of perceived over or under backing. Positive values indicate insufficient perceived backing and an associated positive wealth effect, while negative values indicate excess perceived backing and an associated negative wealth effect.

Figure 10: Historical Contribution of Insufficient Backing to Wealth Effects



Note: The figure reports the historical contribution of the surplus and debt states to households' perceived net wealth from government liabilities, expressed as a percentage of GDP. Each contribution combines the estimated deviation from the perceived full-backing restriction with the corresponding fiscal state. The surplus state contribution captures perceived wealth arising from how households expect current primary surpluses to affect future fiscal positions, while the debt state contribution captures perceived wealth arising from expected fiscal adjustment to outstanding government debt. Positive values indicate that the corresponding fiscal state increases perceived net wealth, whereas negative values indicate a reduction. Both contributions are zero when households' beliefs satisfy the relevant full-backing restrictions.

Figure 10 shows substantial variation in the wealth effects associated with perceived fiscal backing over the pre-ZLB sample. The surplus state generates a positive wealth effect throughout much of the sample. The estimated backing gap along this dimension remains negative, so fiscal deficits are perceived to generate more subsequent debt than would be consistent with full backing. This effect is particularly pronounced during the Great Inflation, when the perceived wealth contribution from the deficit reaches about 0.6 percent of steady-state GDP. The contribution subsequently declines as perceived fiscal dynamics move closer to full backing.

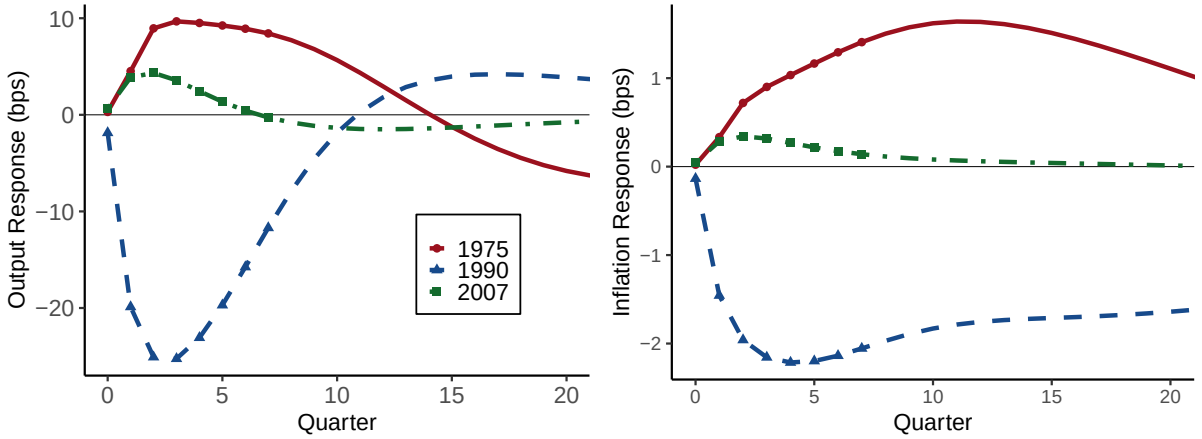
The debt state, by contrast, generates a predominantly negative wealth effect. Early in the sample, the debt-state backing gap is negative, but debt is also below its steady-state level. The interaction of these two deviations therefore produces a negative rather than positive wealth effect. As debt moves toward and eventually above its steady-state level, the perceived backing gap improves and crosses to the other side of the full-backing benchmark. These offsetting movements keep the wealth contribution from the debt state relatively small and generally negative.

6.3 The History Dependent Transmission and Fiscal Policy

The preceding section documents substantial historical variation in households' perceived fiscal backing and associated wealth effects. I now ask whether this variation changes the transmission of fiscal policy. The experiment applies the same one standard deviation fiscal policy innovation at different dates in the estimated sample, initializing the economy at the beliefs prevailing at each date. Structural parameters and the monetary and fiscal policy rules are held fixed across experiments. This implies differences in the impulse responses reflect differences in households' beliefs rather than changes in the underlying policy regime.

Figure 11 reports output and inflation responses to an identical fiscal expansion evaluated at three historical belief states: 1975, 1990, and 2007. The transmission of the fiscal disturbance varies substantially across these dates, not only in magnitude but also in sign. Under beliefs prevailing in 1975, the fiscal expansion raises output and inflation, whereas under beliefs prevailing in 1990, the same disturbance was contractionary in output and inflation. By 2007, the inflation response becomes positive again, although considerably smaller than in 1975.

Figure 11: History Dependent Transmission of a Fiscal Policy Shock



Note: The figure reports output and inflation responses to an identical fiscal policy shock corresponding to approximately a 1 percentage point decline in the primary surplus to GDP ratio at the peak, evaluated using estimated household beliefs prevailing in 1975, 1990, and 2007. Both responses are measured in basis points. Each experiment starts from the corresponding historical belief state, with beliefs subsequently updated through constant-gain learning. Structural parameters and monetary and fiscal policy rules are held fixed across experiments. The fiscal expansion raises output and inflation under 1975 beliefs, lowers output and inflation under 1990 beliefs, and generates a smaller positive response under 2007 beliefs. Differences in the responses reflect historical variation in households' perceived fiscal backing and the subsequent evolution of beliefs, rather than changes in the underlying policy regime.

This history dependence follows directly from the theoretical decomposition in Section 4. For given beliefs, the fiscal component of inflation depends on the long-run backing gap $r_{\omega,t}$ and on the state-dependent backing gaps $r_{s,t}$ and $r_{b,t}$. A fiscal innovation changes the surplus and debt states, whose perceived wealth implications depend on whether households expect the resulting government liabilities to be fully backed by future fiscal adjustment. When perceived backing is insufficient, the fiscal expansion generates a positive wealth effect, stimulating aggregate demand and inflation. Conversely, when households perceive fiscal adjustment to more than offset the additional liabilities, the resulting negative wealth effect can reduce aggregate demand and inflation. Historical variation in fiscal beliefs can reverse the sign of the inflation response, rather than merely amplify or attenuate it.

The differences also persist beyond the initial response because beliefs themselves evolve after the shock. Once a fiscal disturbance generates inflation under non-Ricardian beliefs, the resulting forecast errors lead households to revise their perceived long-run dynamics. The response depends not only on the initial fiscal state but also on the initial belief state from which learning begins. This mechanism generates history dependent transmission without requiring changes in structural parameters or the underlying policy rules.

The magnitude of the direct effect is nevertheless modest. The main quantitative implication of imperfect fiscal knowledge is therefore not that a typical fiscal innovation generates a large burst of inflation. Rather, fiscal beliefs make the transmission of macroeconomic disturbances state dependent and allow their inflationary consequences to feed gradually into long-run beliefs. The next section evaluates the cumulative historical importance of this channel by eliminating fiscal uncertainties while replaying the observed sequence of shocks.

6.4 Fiscal Learning and Long-Run Inflation Expectations

The previous analysis shows that the transmission of fiscal disturbances depends on households' inherited beliefs about future fiscal adjustment. I now examine whether this information friction also matters for the evolution of long-run inflation expectations. In particular, does learning about fiscal propagation undermine the ability of monetary policy to anchor long-run inflation expectations?

To isolate this mechanism, I compare the estimated model with a counterfactual in which households continue learning about long-run conditional means but hold their fiscal propagation beliefs fixed at their rational expectations values. As established in the theoretical analysis, intercept learning preserves Ricardian beliefs when the perceived propagation mechanism is consistent with full fiscal backing. In contrast, learning about fiscal propagation can move beliefs outside the Ricardian set, allowing fiscal disturbances to generate perceived wealth effects.

I simulate 1,000 economies under each information structure, using the estimated structural parameters and identical sequences of structural disturbances. Each economy is simulated for 150 quarters, with the first 100 quarters discarded as burn-in. I retain histories satisfying the stability restriction on households' subjective forecasts and compute their ten-year average inflation expectations. The counterfactual isolates the consequences of learning about fiscal propagation while allowing households to continue revising their expectations of long-run economic conditions.

Table 3: Fiscal Learning and Long-Run Inflation Expectations

Absolute Difference Ten-Year Expectations	Basis Points
Median	5.05
90th Percentile	18.17
95th Percentile	26.50
99th Percentile	56.53
$P(> 25bps)$	5.54%
$P(> 50bps)$	1.39%

Note: The table reports the distribution of absolute differences in ten-year average inflation expectations between the baseline model and the intercept learning counterfactual under identical structural shocks. The statistics are computed across retained quarters and simulated economies satisfying the model's admissibility restriction.

The unconditional distributions of long-run inflation expectations are nearly identical across

the two information structures, with expectations remaining centered around the inflation target on average. However, this similarity conceals potentially substantial differences conditional on the history of macroeconomic outcomes. Table 3 shows that the median absolute difference is 5 basis points, but the difference exceeds 25 basis points in approximately 5.5 percent of simulated observations and 50 basis points in approximately 1.4 percent. Moreover, these deviations can be positive or negative, consistent with the possibility that households perceive either insufficient or excessive fiscal backing.

These findings suggest that learning about fiscal propagation need not generate a systematic inflation bias or substantially alter the unconditional distribution of long-run inflation expectations. Instead, it makes their evolution dependent on inherited fiscal beliefs. Even when monetary policy anchors long-run inflation expectations on average, uncertainty about the fiscal adjustment process introduces an additional source of history-dependent variation in those expectations.

7 Conclusion

This paper studies how much households need to know about fiscal policy for fiscal disturbances to remain neutral. I show that rational expectations and knowledge of the true fiscal policy rule are not necessary. Fiscal neutrality holds under a continuum of subjective beliefs in which government liabilities are perceived to be fully backed by future fiscal adjustment. Learning about long-run outcomes preserves this property when households understand how fiscal positions propagate. When households must also learn these dynamics, however, forecast errors can break perceived full backing, generating wealth effects on aggregate demand and inflation even under a debt stabilizing fiscal regime.

I assess the quantitative importance of this mechanism in an estimated New Keynesian model using U.S. pre-ZLB data. Estimated fiscal beliefs vary substantially over time, making the transmission of identical fiscal disturbances depend on the history of macroeconomic outcomes. In some historical states, fiscal expansions raise output and inflation, while in others their effects are weaker or even reversed. Beyond the transmission of individual fiscal disturbances, simulations show that long-run inflation expectations remain anchored near the target on average, but learning about fiscal propagation generates substantial history-dependent deviations from the benchmark in which fiscal propagation is understood.

These findings highlight a distinction between fiscal policy and beliefs about fiscal policy. Even when the government stabilizes debt, households need not correctly perceive the future adjustment backing its liabilities. The transmission of fiscal disturbances and the evolution of long-run inflation expectations therefore depend not only on the policy regime in place, but also on what households have learned about future fiscal adjustment.

References

Adam, Klaus and Albert Marcet, "Internal rationality, imperfect market knowledge and asset prices," *Journal of Economic Theory*, 2011, *146* (3), 1224–1252.

Angeletos, George-Marios, Chen Lian, and Christian K Wolf, "Deficits and Inflation: HANK meets FTPL," 2024.

Barro, Robert J, "Are government bonds net wealth?," *Journal of political economy*, 1974, *82* (6), 1095–1117.

Bianchi, Francesco and Cosmin Ilut, "Monetary/fiscal policy mix and agents' beliefs," *Review of economic Dynamics*, 2017, *26*, 113–139.

_ **and Leonardo Melosi**, "Dormant shocks and fiscal virtue," *NBER Macroeconomics Annual*, 2013, *28* (1), 1–46.

_ **and** _ , "The dire effects of the lack of monetary and fiscal coordination," *Journal of Monetary Economics*, 2019, *104*, 1–22.

Bigio, Saki, Nicolas Caramp, and Dejanir Silva, "Sticky inflation: Monetary policy when debt drags inflation expectations," Technical Report, National Bureau of Economic Research 2024.

Branch, William A and Emanuel Gasteiger, "Endogenously (non-) Ricardian beliefs," Technical Report, ECON WPS 2019.

Cochrane, John H, *The Fiscal Theory of the Price Level*, Princeton University Press, 2023.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber, "Fiscal Policy and Households' Inflation Expectations: Evidence from a Randomized Control Trial," Technical Report, National Bureau of Economic Research 2021.

Crump, Richard K, Stefano Eusepi, Emanuel Moench, and Bruce Preston, "The Term Structure of Expectations," in "Handbook of Economic Expectations," Elsevier, 2023, pp. 507–540.

Davig, Troy and Eric M Leeper, "Generalizing the Taylor principle," *American Economic Review*, 2007, *97* (3), 607–635.

Durbin, James and Siem Jan Koopman, "A simple and efficient simulation smoother for state space time series analysis," *Biometrika*, 2002, *89* (3), 603–616.

Eusepi, Stefano and Bruce Preston, "Central bank communication and expectations stabilization," *American Economic Journal: Macroeconomics*, 2010, *2* (3), 235–271.

_ **and** _ , "Expectations, learning, and business cycle fluctuations," *American Economic Review*, 2011, *101* (6), 2844–2872.

_ **and** _ , "Debt, Policy Uncertainty, and Expectations Stabilization," *Journal of the European Economic Association*, 2012, *10* (4), 860–886.

_ **and** _ , "Fiscal Foundations of Inflation: Imperfect Knowledge," *American Economic Review*, 2018, *108* (9), 2551–2589.

_ **and** _ , "A Short History in Defence of Adaptive Learning," Technical Report, Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy,The Australian National University 2023.

_ **, Marc Giannoni, and Bruce Preston**, "On the Limits of Monetary Policy," *University of Melbroune Manuscript*, 2020.

Evans, George W, Seppo Honkapohja, and Kaushik Mitra, "Does Ricardian equivalence hold when expectations are not rational?," *Journal of Money, Credit and Banking*, 2012, *44* (7), 1259–1283.

Fu, Julie Zhiyu, Jian Li, and Yinxi Xie, "Convenience yield, inflation expectations, and public debt growth," *The Review of Financial Studies*, 2025, p. hhaf093.

Fueki, Takuji, Masashi Hino, Mitsuru Katagiri, Munechika Katayama, and Taisuke Nakata, *The Perceived Government Budget Constraint* 2026.

Jarociński, Marek, "A note on implementing the Durbin and Koopman simulation smoother," *Computational Statistics & Data Analysis*, 2015, *91*, 1–3.

Jørgensen, Peter L and Søren H Ravn, "The inflation response to government spending shocks: A fiscal price puzzle?," *European Economic Review*, 2022, *141*, 103982.

Kliem, Martin, Alexander Kriwoluzky, and Samad Sarferaz, "On the Low-frequency Relationship between Public Deficits and Inflation," *Journal of Applied Econometrics*, 2016, *31* (3), 566–583.

Koop, Gary, M Hashem Pesaran, and Simon M Potter, "Impulse response analysis in nonlinear multivariate models," *Journal of econometrics*, 1996, *74* (1), 119–147.

Kreps, David M, "Anticipated utility and dynamic choice," *Econometric Society Monographs*, 1998, *29*, 242–274.

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

_ , "Anchoring fiscal expectations," Technical Report, National Bureau of Economic Research 2009.

Maugeri, Gabriele and Dmitriy Sergeyev, "Perceived Budget Constraint of the Government," Technical Report, CEPR Discussion Paper 21843 2026.

Milani, Fabio, "Expectations, learning and macroeconomic persistence," *Journal of Monetary Economics*, 2007, *54* (7), 2065–2082.

Negro, Marco Del, Domenico Giannone, Marc P Giannoni, and Andrea Tambalotti, "Safety, liquidity, and the natural rate of interest," *Brookings Papers on Economic Activity*, 2017, *2017* (1), 235–316.

Preston, Bruce, "Learning about Monetary Policy Rules when Long-Horizon Expectations Matter," *International Journal of Central Banking*, 2005, *1* (2).

Slobodyan, Sergey and Raf Wouters, "Learning in an estimated medium-scale DSGE model," *Journal of Economic Dynamics and control*, 2012, *36* (1), 26–46.

Woodford, Michael, "Macroeconomic analysis without the rational expectations hypothesis," *Annu. Rev. Econ.*, 2013, *5* (1), 303–346.

A Shifting Endpoints Model

The first order condition implies the standard Euler equation given the belief

$$1=\beta\hat{E}_t^i\left[\left(\frac{C_{t+1}(i)}{C_t(i)}\right)^{-\sigma}\frac{R_t}{\pi_{t+1}}\right].$$

Linearize it around the deterministic steady state to get

$$c_t(i)=\hat{E}_t^i c_{t+1}(i)-\frac{1}{\sigma}\hat{E}_t^i(R_t-\pi_{t+1}).$$

Linearizing household's budget constraint gives

$$\delta^{-1}c_t(i)+\beta b_t(i)-\beta R_t+(1-\beta)s_t(i)=\delta^{-1}y_t(i)+b_{t-1}(i)-\pi_t,$$

where $\delta=\frac{b}{y}$ represents the average indebtedness of the economy. Iterating this equation forward to get

$$b_{t-1}(i)=\hat{E}_t^i\left[\delta^{-1}\sum_{T=t}^{\infty}\beta^{T-t}(c_T(i)-y_T(i))+\pi_t+\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)s_T(i)-\beta(R_T-\pi_{T+1})\}\right]$$

Rearranging it yields

$$\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}c_T(i)=\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}y_T(i)+\delta\left(b_{t-1}(i)-\pi_t-\hat{E}_t^i\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)s_T(i)-\beta(R_T-\pi_{T+1})\}\right]\right) \tag{12}$$

To get the optimal consumption, iterate the Euler equation forward

$$\hat{E}_t^i c_T(i)=c_t(i)+\frac{1}{\sigma}\hat{E}_t^i\sum_{j=t}^{T-1}(R_j-\pi_{j+1})$$

Substitute this into the (12) to get the optimal consumption in spirit of the permanent income

$$\begin{aligned}c_t(i) &= (1-\beta)\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}y_T(i)-\frac{\beta}{\sigma}\hat{E}_t^i\sum_{T=t}^{\infty}\beta^{T-t}(R_T-\pi_{T+1})\\ &+ (1-\beta)\delta\left(b_{t-1}(i)-\pi_t-\hat{E}_t^i\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)s_T(i)-\beta(R_T-\pi_{T+1})\}\right]\right)\end{aligned} \tag{13}$$

Following Eusepi, Giannoni and Preston (2020), I assume that each agent acts as an econometrician and uses an identical "shifting end-points" model to forecast. This implies that households have a dogmatic prior $\Phi=\mathbf{0}$. They observe the current interest rate, inflation, surplus, and debt, but cannot distinguish persistent shocks from transitory shocks. Agents estimate $\omega_{t+1}\equiv\hat{E}_t(\bar{\omega}_{t+1}|\pi_t,R_t,s_t,b_t,\omega_t)$ at the end of the period using the steady-state Kalman filter

$$\omega_{t+1}^{\pi} = \omega_t^{\pi}+\bar{g}(\pi_t-\omega_t^{\pi}) \tag{14}$$
$$\omega_{t+1}^{R} = \omega_t^{R}+\bar{g}(R_t-\omega_t^{R}) \tag{15}$$
$$\omega_{t+1}^{s} = \omega_t^{s}+\bar{g}(s_t-\omega_t^{s}) \tag{16}$$
$$\omega_{t+1}^{b} = \omega_t^{b}+\bar{g}\left(b_t-\omega_t^{b}\right) \tag{17}$$

Substitute policy rules into equation (13) as actual law of motions and aggregate over households to get

$$c_t = (1-\beta)\, y_t - \frac{\beta}{\sigma}\phi_\pi \pi_t - \beta\,(1-\beta)\,\delta b_t - \frac{\beta}{\sigma\,(1-\beta)}\left(\beta\,\omega_t^R - \omega_t^\pi\right) - (1-\beta)\,\delta\left(\beta\,\omega_t^s + \frac{\beta}{1-\beta}\omega_t^\pi - \frac{\beta^2}{1-\beta}\omega_t^R\right)$$

Imposing the equilibrium condition $c_t = y_t$ reveals the dynamics of the model summarized by

$$\begin{aligned}
\pi_t &= -\sigma\phi_\pi^{-1} y_t - \frac{1}{\phi_\pi\,(1-\beta)}\left(\beta\,\omega_t^R - \omega_t^\pi\right) + \frac{\sigma\delta\,(1-\beta)}{\phi_\pi}\left\{b_t - \omega_t^s + \frac{1}{1-\beta}\left(\beta\,\omega_t^R - \omega_t^\pi\right)\right\} && (18)\\
R_t &= \phi_\pi \pi_t && (19)\\
s_t &= \phi_b b_{t-1} + \varepsilon_t^{FP} && (20)\\
b_t &= \beta^{-1}\left(1-(1-\beta)\,\phi_b\right) b_{t-1} - \left(\beta^{-1} - \phi_\pi\right)\pi_t - \beta^{-1}\,(1-\beta)\,\varepsilon_t^{FP}, && (21)
\end{aligned}$$

and the Kalman filter specified by equation (14)-equation (17) to pin down each expectation. The inflation dynamics make it clear that it nests the rational expectation equilibrium. It is also worth mentioning that anticipated utility, a type of irrationality can generate the real effect of monetary policy without nominal rigidities. Combine equation (18) and equation (21) to express the inflation dynamics as a function of state variables and exogenous shocks:

$$\pi_t = \varphi_1 b_{t-1} - \varphi_2 \omega_t^s - \varphi_3\left(\beta\,\omega_t^R - \omega_t^\pi\right) - \varphi_4 \varepsilon_t^{FP},$$

where

$$\begin{aligned}
\varphi_1 &= \frac{\sigma\delta\,(1-\beta)\,(1-(1-\beta)\,\phi_b)}{\beta\,\xi}\\
\varphi_2 &= \frac{\sigma\delta\,(1-\beta)}{\xi}\\
\varphi_3 &= \frac{1-\sigma\delta\,(1-\beta)}{(1-\beta)\,\xi}\\
\varphi_4 &= \frac{\sigma\delta\,(1-\beta)^2}{\beta\,\xi}
\end{aligned}$$

with $\xi \equiv \phi_\pi - \sigma\delta\,(1-\beta)\left(\phi_\pi - \beta^{-1}\right)$. For exposition, I assume that $y_t = 0$ in all horizons. The Ricardian equivalence breaks down in two ways. Because all beliefs are state variables, they cannot adjust instantaneously in response to shocks. Perceived wealth effects are typically not zero in the short-run as households do not know the true economic structure.

Substituting equation (18)-equation (21) into the updating rule to get

$$\begin{pmatrix} \omega_{t+1}^\pi \\ \omega_{t+1}^R \\ \omega_{t+1}^s \\ \omega_{t+1}^b \end{pmatrix} = \begin{pmatrix} 1-\bar{g}\,(1-\varphi_3) & -\bar{g}\varphi_3\beta & -\bar{g}\varphi_2 & 0 \\ \bar{g}\phi_\pi\varphi_3 & 1-\bar{g}\,(1+\phi_\pi\varphi_3\beta) & -\bar{g}\phi_\pi\varphi_2 & 0 \\ 0 & 0 & 1-\bar{g} & 0 \\ -\bar{g}\left(\beta^{-1}-\phi_\pi\right)\varphi_3 & \bar{g}\left(\beta^{-1}-\phi_\pi\right)\varphi_3\beta & -\bar{g}\left(\beta^{-1}-\phi_\pi\right)\varphi_2 & 1-\bar{g} \end{pmatrix} \begin{pmatrix} \omega_t^\pi \\ \omega_t^R \\ \omega_t^s \\ \omega_t^b \end{pmatrix}$$

The E-Stability requires

$$-1 + \bar{g}\phi_\pi\varphi_3\beta + \bar{g}\,(1-\varphi_3) < 1,$$

which yields the lower bound for the monetary policy parameter

$$\phi_\pi > \frac{1-\beta^{-1}(1-\beta)\sigma\delta}{1-(1-\beta)\sigma\delta}.$$

This condition is satisfied most of the time as $\beta^{-1}(1-\beta)\sigma\delta > (1-\beta)\sigma\delta$ and when the steady state is the zero debt economy, $\delta = 0$, then this condition coincides with the Taylor principle.

B Anticipated Utility and Forecasting

In this section, I discuss whether E-stability is ensured in the model. To this end, I simulate the endowment model with a sequence of i.i.d. shocks to see if the fiscal anchor converges around the true value. Note that with constant gain, the estimate becomes the ergodic distribution around the true value.

Private agents form expectations by

$$\hat{E}_t Z_{T+1} = \left(I_4 - \tilde{\Phi}_t\right)^{-1}\left(I_4 - \tilde{\Phi}_t^{T-t+1}\right)\bar{\omega}_t + \tilde{\Phi}_t^{T-t+1} Z_t.$$

This can be derived from the anticipated utility approach:

$$\begin{aligned}
Z_{T+1} &= \bar{\omega}_t + \tilde{\Phi}_t Z_T + e_{T+1} \\
&= \bar{\omega}_t + \tilde{\Phi}_t\left(\bar{\omega}_t + \tilde{\Phi}_t Z_{T-1} + e_T\right) + e_{T+1} \\
&= \bar{\omega}_t + \tilde{\Phi}_t\bar{\omega}_t + \tilde{\Phi}_t^2 Z_{T-1} + \tilde{\Phi}_t e_T + e_{T+1} \\
&= \left(\bar{\omega}_t + \tilde{\Phi}_t\bar{\omega}_t + \cdots + \tilde{\Phi}_t^{T-t}\bar{\omega}_t\right) + \tilde{\Phi}_t^{T-t+1} Z_t + \sum_{j=0}^{T}\tilde{\Phi}_t^{T-j} e_{T-j+1} \\
&= \left(I_4 - \tilde{\Phi}_t\right)^{-1}\left(I_4 - \tilde{\Phi}_t^{T-t+1}\right)\bar{\omega}_t + \tilde{\Phi}_t^{T-t+1} Z_t + \sum_{j=0}^{T}\tilde{\Phi}_t^{T-j} e_{T-j+1}.
\end{aligned}$$

Note that $\hat{E}_t$ does contain the information of Z_t. The discounted sum of this object is then

$$\begin{aligned}
\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t} Z_{T+1} &= \left(I_4 - \tilde{\Phi}_t\right)^{-1}\sum_{T=t}^{\infty}\beta^{T-t}\left(I_4 - \tilde{\Phi}_t^{T-t+1}\right)\bar{\omega}_t + \sum_{T=t}^{\infty}\beta^{T-t}\tilde{\Phi}_t^{T-t+1} Z_t \\
&= \left(I_4 - \tilde{\Phi}_t\right)^{-1}\sum_{T=t}^{\infty}\beta^{T-t} I_4\bar{\omega}_t - \left(I_4 - \tilde{\Phi}_t\right)^{-1}\sum_{T=t}^{\infty}\beta^{T-t}\tilde{\Phi}_t^{T-t+1}\bar{\omega}_t + \sum_{T=t}^{\infty}\beta^{T-t}\tilde{\Phi}_t^{T-t+1} Z_t \\
&= \left(I_4 - \tilde{\Phi}_t\right)^{-1}\left[(1-\beta)^{-1} I_4 - \tilde{\Phi}_t\left(1-\beta\tilde{\Phi}_t\right)^{-1}\right]\bar{\omega}_t + \tilde{\Phi}_t\sum_{T=t}^{\infty}\beta^{T-t}\tilde{\Phi}_t^{T-t} Z_t \\
&= \left(I_4 - \tilde{\Phi}_t\right)^{-1}\left[(1-\beta)^{-1} I_4 - \tilde{\Phi}_t\left(1-\beta\tilde{\Phi}_t\right)^{-1}\right]\bar{\omega}_t + \tilde{\Phi}_t\left(1-\beta\tilde{\Phi}_t\right)^{-1} Z_t
\end{aligned}$$

The model dynamics are represented by (4) - (7) with the discounted sum of future expectations are replaced by the above expression and the economy is hit by a sequence of i.i.d. shocks.

C Proof of Proposition 1

To compute the inflation dynamics, I rearrange

$$\begin{aligned}
0 &= -\frac{\beta}{\sigma}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(R_T-\pi_{T+1}\right)+\left(1-\beta\right)\delta\left(b_{t-1}-\pi_t-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{\left(1-\beta\right)s_T-\beta\left(R_T-\pi_{T+1}\right)\right\}\right]\right)\\
&= -\frac{\beta}{\sigma}R_t-\frac{\beta}{\sigma}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)\\
&+ \left(1-\beta\right)\delta\left(b_{t-1}-\pi_t-\left(1-\beta\right)s_t+\beta R_t-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{\left(1-\beta\right)\beta s_{T+1}-\beta\left(\beta R_{T+1}-\pi_{T+1}\right)\right\}\right]\right)\\
&= -\frac{\beta\phi_\pi}{\sigma\delta\left(1-\beta\right)}\pi_t-\frac{\beta}{\sigma\delta\left(1-\beta\right)}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)\\
&+ \beta b_t-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{\left(1-\beta\right)\beta s_{T+1}-\beta\left(\beta R_{T+1}-\pi_{T+1}\right)\right\}\right]\\
&= -\frac{\beta\phi_\pi}{\sigma\delta\left(1-\beta\right)}\pi_t-\frac{\beta}{\sigma\delta\left(1-\beta\right)}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)\\
&+ \left(1-\left(1-\beta\right)\phi_b\right)b_{t-1}-\left(1-\beta\phi_\pi\right)\pi_t-\left(1-\beta\right)\varepsilon_t^{FP}-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{\left(1-\beta\right)\beta s_{T+1}-\beta\left(\beta R_{T+1}-\pi_{T+1}\right)\right\}\right]
\end{aligned}$$

$$\begin{aligned}
\left(1+\beta\phi_\pi\frac{\left(1-\sigma\delta\left(1-\beta\right)\right)}{\sigma\delta\left(1-\beta\right)}\right)\pi_t &= \underbrace{\left(1-\left(1-\beta\right)\phi_b\right)b_{t-1}}_{\text{Observable}}-\\
&- \underbrace{\frac{\beta}{\sigma\delta\left(1-\beta\right)}\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)-\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{\left(1-\beta\right)\beta s_{T+1}-\beta\left(\beta R_{T+1}-\pi_{T+1}\right)\right\}\right]}_{\text{Pined Down by the Subjective Belief}}\\
&- \left(1-\beta\right)\varepsilon_t^{FP}
\end{aligned}$$

$$\pi_t = \varphi_1 b_{t-1}-\left(1-\beta\right)\varphi_2\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}s_{T+1}-\left(1-\beta\right)\varphi_3\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)-\varphi_4\varepsilon_t^{FP} \quad (22)$$

The data generating process in this setting can be described as

$$\begin{aligned}
\pi_t &= \varphi_1 b_{t-1}-\left(1-\beta\right)\varphi_2\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}s_{T+1}-\left(1-\beta\right)\varphi_3\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)-\varphi_4\varepsilon_t^{FP}\\
R_t &= \phi_\pi\pi_t\\
s_t &= \phi_b b_{t-1}+\varepsilon_t^{FP}\\
b_t &= \beta^{-1}\left[\left(1-\left(1-\beta\right)\phi_b\right)b_{t-1}-\left(1-\beta\phi_\pi\right)\pi_t\right]-\beta^{-1}\left(1-\beta\right)\varepsilon_t^{FP}.
\end{aligned}$$

Then the equilibrium dynamics will be characterized by

$$A_0 Z_t = A_1\left[F_0\left(\beta,\tilde{\Phi}_t\right)\bar{\omega}_t+F_1\left(\beta,\tilde{\Phi}_t\right)Z_t\right]+A_2 Z_{t-1}+A_3\varepsilon_t.$$

Solving for the equilibrium dynamics Z_t yields

$$Z_t = \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}_t\right) \bar{\omega}_t + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_2 Z_{t-1} + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_3 \varepsilon_t$$

where

$$\begin{aligned}
A_0 &= \begin{pmatrix} 1 & 0 & 0 & 0 \\ -\phi_\pi & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \beta^{-1} - \phi_\pi & 0 & 0 & 1 \end{pmatrix} \\
A_1 &= \begin{pmatrix} (1-\beta)\varphi_3 & -\beta(1-\beta)\varphi_3 & -(1-\beta)\varphi_2 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \\
A_2 &= \begin{pmatrix} 0 & 0 & 0 & \varphi_1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_b \\ 0 & 0 & 0 & \beta^{-1}(1-(1-\beta)\phi_b) \end{pmatrix} \\
A_3 &= \begin{pmatrix} 0 & 0 & 0 & -\varphi_4 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -\beta^{-1}(1-\beta) \end{pmatrix}
\end{aligned}$$

and

$$F_0\left(\beta, \tilde{\Phi}_t\right) = \left(I_4 - \tilde{\Phi}_t\right)^{-1} \left[(1-\beta)^{-1} I_4 - \tilde{\Phi}_t \left(1 - \beta\tilde{\Phi}_t\right)^{-1}\right] \qquad F_1\left(\beta, \tilde{\Phi}_t\right) = \tilde{\Phi}_t \left(1 - \beta\tilde{\Phi}_t\right)^{-1}.$$

D Proof of Proposition 2

Let $c^{FP} = \mathscr{C}_{FP}\left(\tilde{\Phi}\right)$ denote equilibrium response to a unit fiscal policy shock. From the equilibrium system,

$$\left[A_0 - A_1 F_1\left(\beta, \tilde{\Phi}\right)\right] c^{FP} = \begin{pmatrix} -\varphi_4 & 0 & 1 & -\frac{1-\beta}{\beta} \end{pmatrix}'.$$

Because A_1 only contains non zero elements in the first row, the remaining equations imply

$$\begin{aligned}
c_R^{FP} &= \phi_\pi c_\pi^{FP} \\
c_s^{FP} &= 1,
\end{aligned}$$

and

$$c_b^{FP} = -\frac{1-\beta}{\beta} - \left(\beta^{-1} - \phi_\pi\right) c_\pi^{FP}.$$

Sufficiency

Suppose beliefs are Ricardian. Consider first the candidate neutral impact response $c_\pi^{FP} = 0$. The monetary policy rule then implies $c_R^{FP} = 0$, so the contemporaneous response lies entirely in the fiscal subspace. Because inflation and nominal interest rate expectations are fiscally anchored, the first two rows of $\tilde{\Phi}$ have zero loadings on primary surpluses and government debt. Hence a perceived state containing only fiscal components generates no expected inflation or nominal-interest-rate response. By induction, $x_T = \tilde{\Phi}^T c^{FP}$ contains only fiscal components for every $T \geq t$. The expected real rate channel therefore vanishes at every horizon.

It remains to consider the perceived wealth effect of the fiscal disturbance. Under zero impact inflation, the contemporaneous response is

$$c^{FP} = \begin{pmatrix} 0 & 0 & 1 & -\frac{1-\beta}{\beta} \end{pmatrix}'.$$

Let

$$x_h = \tilde{\Phi}^h c^{FP}$$

denote the perceived state h periods after the shock. Full perceived fiscal backing requires

$$(1-\beta)\, e_s' x_{h+1} + \beta e_b' x_{h+1} = e_b' x_h$$

for every $h \geq 0$. Multiplying by β^h and summing over all horizons gives

$$(1-\beta) \sum_{h=0}^{\infty} \beta^h e_s' x_{h+1} + \beta \sum_{h=0}^{\infty} \beta^h e_b' x_{h+1} = \sum_{h=0}^{\infty} \beta^h e_b' x_h.$$

The debt term telescope, so

$$(1-\beta) \sum_{h=0}^{\infty} \beta^h e_s' x_{h+1} = e_b' c^{FP}.$$

Since

$$e_b' c^{FP} = -\frac{1-\beta}{\beta},$$

it follows that

$$(1-\beta) \sum_{h=0}^{\infty} \beta^h e_s' \tilde{\Phi}^{h+1} c^{FP} = -\frac{1}{\beta}.$$

The households perceive the fiscal expansion to be followed by exactly the future primary surplus adjustment required to back the resulting government liabilities. The inflation equation on impact becomes

$$c_\pi^{FP} = -\varphi_4 - (1-\beta)\, \varphi_2 \left(-\frac{1}{\beta} \right).$$

Using the structural relationship $(1-\beta)\, \varphi_2 = \beta\, \varphi_4$,

$$c_\pi^{FP} = 0.$$

Hence the direct effect of the fiscal innovation is exactly offset by the future fiscal adjustment households expect to back the associated government liabilities.

The same argument applies recursively. Fiscal anchoring of inflation and nominal-interest-rate expectations makes the fiscal subspace invariant under the perceived forecasting system: whenever the state generated by the fiscal disturbance has zero inflation and nominal-interest-rate components, its perceived successor does as well. Hence the disturbance cannot generate future expected inflation or expected nominal-rate movements through the forecasting system. Full perceived fiscal backing guarantees that, from every such state, the perceived future primary-surplus adjustment exactly offsets the value of outstanding government liabilities. The fiscal disturbance therefore produces neither a perceived wealth effect nor a nominal-expectations effect at subsequent horizons. Inflation remains unchanged along the entire path generated by the fiscal shock.

E Proof of Lemma 1

Let

$$\mathscr{F} = \text{span}\left\{c_t^{FP}, c_{t+1}^{FP}, c_{t+2}^{FP}, \ldots\right\}$$

denote the subspace of states generated by an i.i.d fiscal policy shock from the steady state. Fiscal neutrality restricts beliefs only through their action on states belonging to $\mathscr{F}$.

For example, let r' denote the deviation of the perceived full backing restriction from zero,

$$r' = \lambda' \tilde{\Phi} - e_b'.$$

Global full backing requires $r' = 0$. By contrast, neutrality of the i.i.d fiscal policy shock only requires

$$r' c_T^{FP} = 0$$

for every state $c_T^{FP} \in \mathscr{F}$. Equivalently,

$$r' v = 0 \; \forall v \in \mathscr{F}.$$

The same argument applies to deviations form the fiscal anchoring and monetary consistency restrictions. An i.i.d fiscal policy shock experiment identifies the Ricardian restrictions only on $\mathscr{F}$. Unless $\mathscr{F}$ spans the entire state space, neutrality does no imply the corresponding global restrictions.

In the current setting, neutrality necessarily implies $c_{\pi,T}^{FP} = c_{R,T}^{FP} = 0$, so the relevant states take the form

$$c_T^{FP} = \begin{pmatrix} 0 & 0 & c_{s,T}^{FP} & c_{b,T}^{FP} \end{pmatrix}'.$$

Hence $\mathscr{F}$ is contained in the two dimensional fiscal subspace

$$\mathscr{S}_F = \text{span}\{e_s, e_b\}\ .$$

Moreover, the impact fiscal state and its one period propagation are linearly independent, so they span $\mathscr{S}_F$. Therefore neutrality at all horizons identifies exactly the restrictions of Definition 4 on the fiscal columns of $\tilde{\Phi}$, but places no restriction on the departures from Ricardian beliefs that operate only through inflation or nominal interest rate.

F E-Stability under General Learning

The true data generating process implied by agents' perceived law of motion is

$$Z_t = \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}_t\right) \bar{\omega}_t + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_2 Z_{t-1} + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_3 \varepsilon_t.$$

Define

$$\begin{aligned} \mathscr{M}\left(\tilde{\Phi}\right) &\equiv \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}_t\right) \\ \mathscr{B}\left(\tilde{\Phi}\right) &\equiv \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_2. \end{aligned}$$

Then the actual law of motion can be written compactly as

$$Z_t = \mathscr{M}\left(\tilde{\Phi}_t\right) \bar{\omega}_t + \mathscr{B}\left(\tilde{\Phi}_t\right) Z_{t-1} + \left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_3 \varepsilon_t.$$

The stability under learning depends on the interaction between agents' perceived law of motion,

$$Z_t = \bar{\omega}_t + \tilde{\Phi}_t Z_{t-1} + e_t,$$

and the actual law of motion characterized by the mappings $\mathscr{M}\left(\tilde{\Phi}_t\right)$ and $\mathscr{B}\left(\tilde{\Phi}_t\right)$. These two coincide only at the rational expectations fixed point. Under recursive learning, the associated T-map is therefore

$$T\left(\bar{\omega}, \tilde{\Phi}\right) = \begin{pmatrix} \mathscr{M}\left(\tilde{\Phi}\right) \bar{\omega} \\ \mathscr{B}\left(\tilde{\Phi}\right) \end{pmatrix}.$$

Following the standard E-stability analysis of adaptive learning models, the continuous-time differential equation associated with the T-map is

$$\begin{aligned} \frac{d\bar{\omega}}{d\tau} &= \left[\mathscr{M}\left(\tilde{\Phi}\right) - I\right] \bar{\omega} \\ \frac{d\tilde{\Phi}}{d\tau} &= \mathscr{B}\left(\tilde{\Phi}\right) - \tilde{\Phi} \end{aligned}$$

Because the constant term enters linearly and separately from the slope coefficients, the E-stability analysis decomposes into two independent subsystems. I consider these separately below.

Constant

To obtain the E-stability condition for the constant term, the real parts of all eigenvalues of $\mathscr{M}\left(\Phi^*\right) - I$ must be negative. Since all eigenvalues except one are -1, the necessary and sufficient condition for the E-stability is

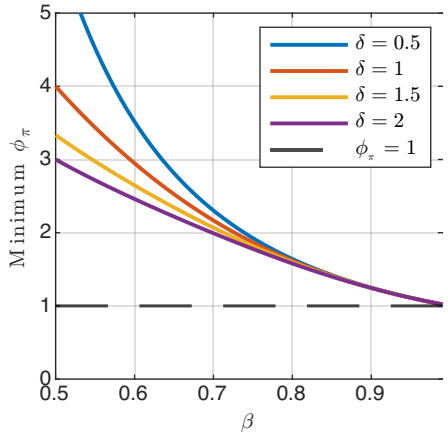
$$\frac{\left\{(1-\beta)\beta\varphi_3 + \varphi_2\right\}(1 - \beta\phi_\pi) + (1-\beta)\beta}{(1-\beta)\left(\beta + \varphi_2\left(\beta\phi_\pi - 1\right)\right)} < 0.$$

Corollary 2. *Assuming* $(1-\beta)\left(\beta + \varphi_2\left(\beta\phi_\pi - 1\right)\right) > 0$*, substituting the definition of* φ_2 *and* φ_3 *yields the sufficient condition*

$$\phi_\pi > \frac{\beta + 2\sigma\delta\left(1-\beta\right)^2}{\beta\left[2\beta - 1 + 2\sigma\delta\left(1-\beta\right)^2\right]}.$$

The sufficient condition depends on the steady-state debt-to-GDP ratio δ. In particular, higher steady-state debt weakens the additional restriction relative to the standard Taylor principle as indicated by the following figure.

Figure 12: E-Stability Condition with Different Steady State Debt to GDP Ratio



Coefficients

To derive the E-stability condition for coefficient-learning analytically, restrict beliefs to the fourth column of the perceived law of motion:

$$\tilde{\Phi} = \kappa e_4' \quad \kappa = \begin{pmatrix} \kappa_\pi \\ \kappa_R \\ \kappa_s \\ \kappa_b \end{pmatrix} \quad e_4 = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}.$$

Thus,

$$\tilde{\Phi} = \begin{pmatrix} 0 & 0 & 0 & \kappa_\pi \\ 0 & 0 & 0 & \kappa_R \\ 0 & 0 & 0 & \kappa_s \\ 0 & 0 & 0 & \kappa_b \end{pmatrix}.$$

This restriction is consistent with the minimal-state-variable solution (MSV), since at the rational expectations equilibrium,

$$\Phi^* = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_b \\ 0 & 0 & 0 & \beta^{-1}\left[1-(1-\beta)\phi_b\right] \end{pmatrix} = \kappa^* e_4',$$

where $\kappa^* = \begin{pmatrix} 0 & 0 & \phi_b & \beta^{-1}\left[1-(1-\beta)\phi_b\right] \end{pmatrix}'$. Given beliefs $\tilde{\Phi} = \kappa e_4'$, the ALM is

$$Z_t = \mathscr{M}(\kappa_t)\,\bar{\omega}_t + \mathscr{B}(\kappa_t)\,Z_{t-1} + \left(A_0 - A_1 F_1\left(\beta, \kappa_t e_4'\right)\right)^{-1} A_3 \varepsilon_t.$$

Since agents only learn the fourth column, the relevant T-map is the fourth column of the ALM coefficient matrix:

$$T_\kappa(\kappa) = \mathscr{B}(\kappa) e_4.$$

Therefore the ODE becomes

$$\frac{d\kappa}{d\tau} = T_\kappa(\kappa) - \kappa = \mathscr{B}(\kappa_t) e_4 - \kappa.$$

Linearizing around κ^*,

$$\frac{d(\kappa - \kappa^*)}{d\tau} = [D_\kappa T_\kappa(\kappa^*) - I_4](\kappa - \kappa^*).$$

Hence coefficient learning is locally E-stable if and only if all eigenvalues of

$$J_\kappa \equiv D_\kappa T_\kappa(\kappa^*) - I_4$$

have negative real parts.

Given beliefs $\tilde{\Phi} = \kappa e_4'$, agents perceive only the fourth column of the law of motion to be unknown. Because the state evolves only through b_{t-1} in the MSV, repeated substitution implies that future expectations inherit a simple geometric structure. In particular,

$$\tilde{\Phi}^j = \kappa_b^{j-1} \kappa e_4', \ j \geq 1.$$

Therefore, the discounted sums appearing in the equilibrium conditions become

$$\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1} = \frac{\kappa_s}{1 - \beta \kappa_b} b_t,$$

and

$$\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} (\beta R_{T+1} - \pi_{T+1}) = \frac{\beta \kappa_R - \kappa_\pi}{1 - \beta \kappa_b} b_t.$$

Substituting these expressions into the inflation equation yields

$$\pi_t = \varphi_1 b_{t-1} - \frac{(1-\beta)[\varphi_2 \kappa_s + \varphi_3(\beta \kappa_R - \kappa_\pi)]}{1 - \beta \kappa_b} b_t.$$

Define

$$\alpha(\kappa) \equiv \frac{(1-\beta)[\varphi_2 \kappa_s + \varphi_3(\beta \kappa_R - \kappa_\pi)]}{1 - \beta \kappa_b}.$$

Then inflation can be written compactly as $\pi_t = \varphi_1 b_{t-1} - \alpha(\kappa) b_t$. Using the government debt dynamics,

$$b_t = a b_{t-1} - c \pi_t,$$

where

$$a \equiv \beta^{-1}[1 - (1-\beta)\phi_b] \quad \text{and} \quad c \equiv \beta^{-1}(1 - \beta \phi_\pi).$$

Substituting this into the inflation dynamics and solve for π_t,

$$\pi_t = \frac{\varphi_1 - a\alpha(\kappa)}{1 - c\alpha(\kappa)} b_{t-1}.$$

Therefore, the implied law of motion for the fourth column is

$$T_{\kappa}(\kappa) = \mathscr{B}(\kappa) e_4 = \begin{pmatrix} \frac{\varphi_1 - a\alpha(\kappa)}{1 - c\alpha(\kappa)} \\ \phi_\pi \frac{\varphi_1 - a\alpha(\kappa)}{1 - c\alpha(\kappa)} \\ \phi_b \\ a - c\frac{\varphi_1 - a\alpha(\kappa)}{1 - c\alpha(\kappa)} \end{pmatrix}.$$

Evaluating the Jacobian $D_{\kappa} T_k(\kappa^*)$ at the rational expectations equilibrium shows that three eigenvalues are equal to zero, while the remaining eigenvalue is

$$\frac{(\beta\phi_\pi - 1)[1 - (1-\beta)\phi_b]}{\beta\phi_\pi\phi_b(\beta - 1)},$$

which implies the necessary and sufficient condition

$$\phi_\pi > \frac{1 - (1-\beta)\phi_b}{\beta}.$$

When $\beta \to 1$, this essentially converges to the Taylor principle.

G Proof of Proposition 5

Consider the endowment economy with no endowment shock, so that $y_t = 0$. Market clearing requires $c_t = y_t = 0$. Combining the aggregate consumption with monetary and fiscal policy rules gives the inflation equation derived in Appendix section §C:

$$\pi_t = \varphi_1 b_{t-1} - (1-\beta)\varphi_2 \hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1} - (1-\beta)\varphi_3 \hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}(\beta R_{T+1} - \pi_{T+1}) - \varphi_4 \varepsilon_t^{FP}.$$

Define

$$\begin{aligned} \mathscr{S}_t &\equiv \hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1} \\ Q_t &\equiv \hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}(\beta R_{T+1} - \pi_{T+1}). \end{aligned}$$

Then,

$$\pi_t = \varphi_1 b_{t-1} - (1-\beta)\varphi_2 \mathscr{S}_t - (1-\beta)\varphi_3 Q_t - \varphi_4 \varepsilon_t^{FP}.$$

The linearized government budget constraint,

$$b_t = \beta^{-1}[1 - (1-\beta)\phi_b] b_{t-1} - \left(\beta^{-1} - \phi_\pi\right)\pi_t - \beta^{-1}(1-\beta)\varepsilon_t^{FP}$$

can be rewritten as

$$\varphi_2\left[b_t + \left(\beta^{-1} - \phi_\pi\right)\pi_t\right] = \varphi_1 b_{t-1} - \varphi_4 \varepsilon_t^{FP},$$

using

$$\varphi_1 = \varphi_2 \beta^{-1} [1 - (1-\beta)\phi_b] \quad \text{and} \quad \varphi_4 = \varphi_2 \beta^{-1} (1-\beta).$$

Substitute the expression into the inflation dynamics to get

$$\begin{aligned} \pi_t &= \varphi_2 \left[b_t + \left(\beta^{-1} - \phi_\pi \right) \pi_t \right] - (1-\beta)\varphi_2 \mathscr{S}_t - (1-\beta)\varphi_3 Q_t \\ \left[1 - \varphi_2 \left(\beta^{-1} - \phi_\pi \right) \right] \pi_t &= \varphi_2 [b_t - (1-\beta)\mathscr{S}_t] - (1-\beta)\varphi_3 Q_t. \end{aligned}$$

Using the structural relationship that $1 - \varphi_2 \left(\beta^{-1} - \phi_\pi \right) = \phi_\pi \xi^{-1}$,

$$\pi_t = \frac{\sigma\delta(1-\beta)}{\phi_\pi} [b_t - (1-\beta)\mathscr{S}_t] - \frac{1 - \sigma\delta(1-\beta)}{\phi_\pi} Q_t.$$

This equation separates the perceived fiscal backing channel from the expected real rate channel. Defined the perceived fiscal backing shortfall

$$\mathscr{G}_t \equiv b_t - (1-\beta)\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} s_{T+1}.$$

Then

$$\pi_t = \frac{\sigma\delta(1-\beta)}{\phi_\pi} \mathscr{G}_t - \frac{1 - \sigma\delta(1-\beta)}{\phi_\pi} Q_t.$$

Notice that the fiscal policy shock ε_t^{FP} no longer appears separately. It affects inflation only through the fiscal position and the beliefs used to value that position.

Under the restricted perceived law of motion,

$$\hat{E}_t x_{t+1} = \mathscr{F}_t x_t,$$

where

$$x_t \equiv \begin{pmatrix} 1 \\ s_t \\ b_t \end{pmatrix} \text{and} \mathscr{F}_t \equiv \begin{pmatrix} 1 & 0 & 0 \\ \omega_{s,t} & \varphi_{ss,t} & \varphi_{sb,t} \\ \omega_{b,t} & \varphi_{bs,t} & \varphi_{bb,t} \end{pmatrix}.$$

Under anticipated utility, households treat $\mathscr{F}_t$ as fixed when forming forecast at t : $\hat{E}_t x_{t+j} = \mathscr{F}_t^j x_t$. Define

$$\lambda' \equiv (1-\beta) e_s' + \beta e_b'$$

and

$$r_t' \equiv \lambda' \mathscr{F}_t - e_b'.$$

For any horizon $j \geq 0$,

$$r_t' \mathscr{F}_t^j x_t = (1-\beta)\hat{E}_t s_{t+j+1} + \beta \hat{E}_t b_{t+j+1} - \hat{E}_t b_{t+j}.$$

Multiply this equation by β^j and sum over $j \geq 0$. The debt terms telescope:

$$\begin{aligned} \sum_{j=0}^{\infty} \beta^j r_t' \mathscr{F}_t^j x_t &= (1-\beta) \sum_{j=0}^{\infty} \beta^j \hat{E}_t s_{t+j+1} \\ &+ \underbrace{\beta \sum_{j=0}^{\infty} \beta^j \hat{E}_t b_{t+j+1} - \sum_{j=0}^{\infty} \beta^j \hat{E}_t b_{t+j}}_{=-b_t}. \end{aligned}$$

Therefore the expression reduces to

$$\sum_{j=0}^{\infty} \beta^j r_t' \mathscr{F}_t^j x_t = (1-\beta)\,\mathscr{S}_t - b_t = -\mathscr{G}_t.$$

Provided $(I - \beta\,\mathscr{F}_t)$ is invertible,

$$\mathscr{G}_t = -r_t'\,(I - \beta\,\mathscr{F}_t)^{-1}\,x_t.$$

Expanding r_t,

$$r_t = \begin{pmatrix} (1-\beta)\,\omega_{s,t} + \beta\,\omega_{b,t} \\ (1-\beta)\,\varphi_{ss,t} + \beta\,\varphi_{bs,t} \\ (1-\beta)\,\varphi_{sb,t} + \beta\,\varphi_{bb,t} - 1 \end{pmatrix}.$$

Thus the perceived fiscal backing shortfall depends jointly on the intercept restriction, the surplus state restriction, the debt state restriction, the current fiscal position, and the perceived persistence of the fiscal system.

Because the inflation and interest rate propagation coefficients are held at their rational expectations values while their intercepts may be learned

$$\hat{E}_t \pi_{t+j} = \omega_{\pi,t} \quad \text{and} \quad \hat{E}_t R_{t+j} = \omega_{R,t},$$

the expected real interest rate term becomes

$$\mathscr{Q}_t = \hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}\,(\beta R_{T+1} - \pi_{T+1}) = \frac{\beta\,\omega_{R,t} - \omega_{\pi,t}}{1-\beta}.$$

Combining the expression to get the result

$$\pi_t = -\frac{\sigma\delta\,(1-\beta)}{\phi_\pi} r_t'\,(I - \beta\,\mathscr{F}_t)^{-1}\,x_t - \frac{1 - \sigma\delta\,(1-\beta)}{\phi_\pi\,(1-\beta)}\,(\beta\,\omega_{R,t} - \omega_{\pi,t}).$$

To distinguish revisions in long-run beliefs that preserve Ricardian valuation from those violate it, define the long run Ricardian restriction

$$r_{\omega,t} \equiv \omega_{\pi,t} - \beta\,\omega_{R,t} + (1-\beta)\,\omega_{s,t} + \beta\,\omega_{b,t}.$$

The fiscal intercept component can be written as

$$(1-\beta)\,\omega_{s,t} + \beta\,\omega_{b,t} = \beta\,\omega_{R,t} - \omega_{\pi,t} + r_{\omega,t}.$$

The restriction r_t' can rewritten as

$$r_t = (\beta\,\omega_{R,t} - \omega_{\pi,t})\,e_1' + r_{\omega,t} e_1' + r_{s,t} e_s' + r_{b,t} e_b'.$$

Substituting this expression into the inflation equation gives

$$\begin{aligned} \pi_t &= -\frac{\sigma\delta\,(1-\beta)}{\phi_\pi}\,(\beta\,\omega_{R,t} - \omega_{\pi,t})\,e_1'\,(I - \beta\,\mathscr{F}_t)^{-1}\,x_t \\ &- \frac{1 - \sigma\delta\,(1-\beta)}{\phi_\pi\,(1-\beta)}\,(\beta\,\omega_{R,t} - \omega_{\pi,t}) \\ &- \frac{\sigma\delta\,(1-\beta)}{\phi_\pi} r_{\omega,t} e_1'\,(I - \beta\,\mathscr{F}_t)^{-1}\,x_t \\ &- \frac{\sigma\delta\,(1-\beta)}{\phi_\pi}\left[r_{s,t} e_s' + r_{b,t} e_b'\right](I - \beta\,\mathscr{F}_t)^{-1}\,x_t. \end{aligned}$$

Because the first row of the augmented perceived transition matrix is $\begin{pmatrix} 1 & 0 & 0 \end{pmatrix}$, $e_1' \mathscr{F}_t = e_1'$. This implies that $e_1'(I - \beta \mathscr{F}_t) = (1-\beta) e_1'$. Noticing that $e_1 = (1-\beta) e_1' (I - \beta \mathscr{F}_t)^{-1}$

$$e_1' (I - \beta \mathscr{F}_t)^{-1} = \frac{1}{1-\beta} e_1'.$$

Because $e_1' x_t = 1$, first three terms of the expression simplify to

$$\pi_t = -\frac{\beta \omega_{R,t} - \omega_{\pi,t}}{\phi_\pi (1-\beta)} - \frac{\sigma\delta}{\phi_\pi} r_{\omega,t} - \frac{\sigma\delta(1-\beta)}{\phi_\pi} \left[r_{s,t} e_s' + r_{b,t} e_b' \right] (I - \beta \mathscr{F}_t)^{-1} x_t.$$

The third term can be further reduced by the fact that

$$\begin{pmatrix} e_s' \\ e_b' \end{pmatrix} (I - \beta \mathscr{F}_t)^{-1} x_t = \left(I - \beta \tilde{\mathscr{F}}_t \right)^{-1} \left(f_t + \frac{\beta}{1-\beta} \omega_{f,t} \right).$$

Substituting the expression to get the desired result.

H Trend-Cycle Decomposition with Common Trends

A central prediction of models that rely on fiscal dominance to break Ricardian equivalence is that persistent fiscal imbalances should be inflationary. When agents believe that government debt will ultimately be stabilized through inflation rather than future fiscal adjustment, both realized inflation and long-run inflation expectations rise. Yet the empirical evidence on this mechanism remains mixed. While large fiscal expansions are often followed by higher inflation, the relationship between public debt and inflation at low frequencies is weak or unstable in U.S. data.

This section provides new empirical evidence on this discrepancy by estimating a multivariate trend–cycle decomposition that isolates the persistent fiscal components relevant for expectation formation. The main finding is that persistent deficits raise both inflation and long-run inflation expectations, whereas debt does not. This pattern is difficult to reconcile with standard fiscal-dominance mechanisms but is naturally consistent with models in which beliefs about future fiscal adjustment—rather than debt levels per se—anchor long-run inflation expectations.

A natural starting point for studying the low-frequency connection between fiscal policy and inflation is Kliem, Kriwoluzky and Sarferaz (2016). They document that, in long-run U.S. data, inflation and fiscal deficits exhibit a positive comovement, but that this relationship weakens substantially after the early 1980s. Their central message is that the low-frequency correlation between inflation and deficits is informative about the monetary–fiscal policy mix, and that the post-1980 flattening can be interpreted as evidence of improved monetary policy credibility. This insight is crucial: if fiscal expansions are perceived as temporary and ultimately reversed, they should have little effect on long-run inflation outcomes.

At the same time, the Kliem et al. (2016) exercise highlights an important empirical limitation. A bivariate low-frequency relationship between inflation and deficits is a reduced-form object that abstracts from the joint determination of inflation with long-term inflation expectations, nominal interest rates, and debt dynamics. Many monetary–fiscal frameworks—whether cast in rational expectations, regime-switching policy, or imperfect-knowledge learning—imply that these variables move together at low frequencies because they are pinned down by a small set of common

long-run forces. From this perspective, theory points to a cointegration (common-trend) structure, rather than a purely bivariate relationship between inflation and deficits.

This observation motivates the empirical strategy adopted here. The theoretical framework provides a useful way to characterize the low-frequency restriction. Under imperfect knowledge, equilibrium dynamics can be represented as

$$Z_t = \underbrace{\mathscr{M}\left(\tilde{\Phi}_t\right)\bar{\omega}_t}_{\text{Trend Component}} + \underbrace{\mathscr{B}\left(\tilde{\Phi}_t\right)Z_{t-1} + \mathscr{C}\left(\tilde{\Phi}_t\right)\varepsilon_t}_{\text{Cyclical Component}},$$

where $\bar{\omega}_t$ collects agents' perceived long-run means while $\tilde{\Phi}_t$ summarizes their beliefs about the relationship between aggregate macroeconomic variables that governs the propagation of shocks. The first term isolates the component relevant for the low-frequency analysis. Under rational expectations around the deterministic steady state, $\bar{\omega}_t = 0$. More generally, rational expectations do not rule out persistent fiscal movements, but impose cross-equation restrictions on their long-run behavior: debt must be fully backed by the corresponding path of future primary surpluses, so that fiscal trends do not generate an independent permanent component in inflation. A conventional trend-cycle decomposition can accommodate stochastic trends, but does not by itself impose these economically motivated restrictions on how fiscal trends are jointly transmitted to inflation and long-run expectations. Under imperfect knowledge, these restrictions need not hold. Because perceived long-run fiscal conditions affect current decisions through expectations about future fiscal backing, persistent fiscal movements can generate low-frequency variation in inflation, nominal interest rates, and long-run inflation expectations when beliefs depart from the Ricardian restriction.

The empirical exercise asks whether this additional cross-variable structure is present in the data without imposing the full learning mechanism. I estimate a multivariate unobserved components model with common stochastic trends, building on Del Negro et al. (2017). I extend their framework to include persistent fiscal components together with survey measures of long-run inflation expectations. In this reduced form setting, the conventional specification in which stochastic trends enter only their corresponding variables provides a natural benchmark. Allowing fiscal trends to load on inflation and long-run inflation expectations provides a direct empirical test of whether persistent fiscal developments are associated with the long-run components of nominal variables in the way the theory suggests.

This exercise deliberately does not identify the underlying subjective law of motion $\tilde{\Phi}_t$. Its purpose is instead to establish whether the low-frequency relationships predicted by the learning mechanism are present in the data with minimal structural assumptions. The structural analysis in the following section then imposes the learning model and uses short and long run survey expectations to discipline $\tilde{\Phi}_t$ to recover the evolution of fiscal beliefs and study how those beliefs interact with macroeconomic outcomes.

Formally, the data are described by

$$\begin{pmatrix} \pi_t \\ \pi^e_{t+10} \\ R^{10}_t \\ s_t \\ b_t \end{pmatrix} = \underbrace{\begin{pmatrix} \lambda_1 & \lambda_2 & \lambda_3 & \lambda_4 \\ \lambda_5 & \lambda_6 & \lambda_7 & \lambda_8 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}}_{\equiv \Lambda} \begin{pmatrix} \omega^\pi_t \\ \omega^R_t \\ \omega^s_t \\ \omega^b_t \end{pmatrix} + e_t,$$

where the loadings matrix $\Lambda(\lambda)$ is restricted and depends on a small number of free parameters. The state vector follows

$$
\begin{aligned}
y_t &= \Lambda \omega_t + e_t && (23)\\
\omega_t &= \omega_{t-1} + u_t && (24)\\
\varepsilon_t &= \Phi(L)\, e_t && (25)
\end{aligned}
$$

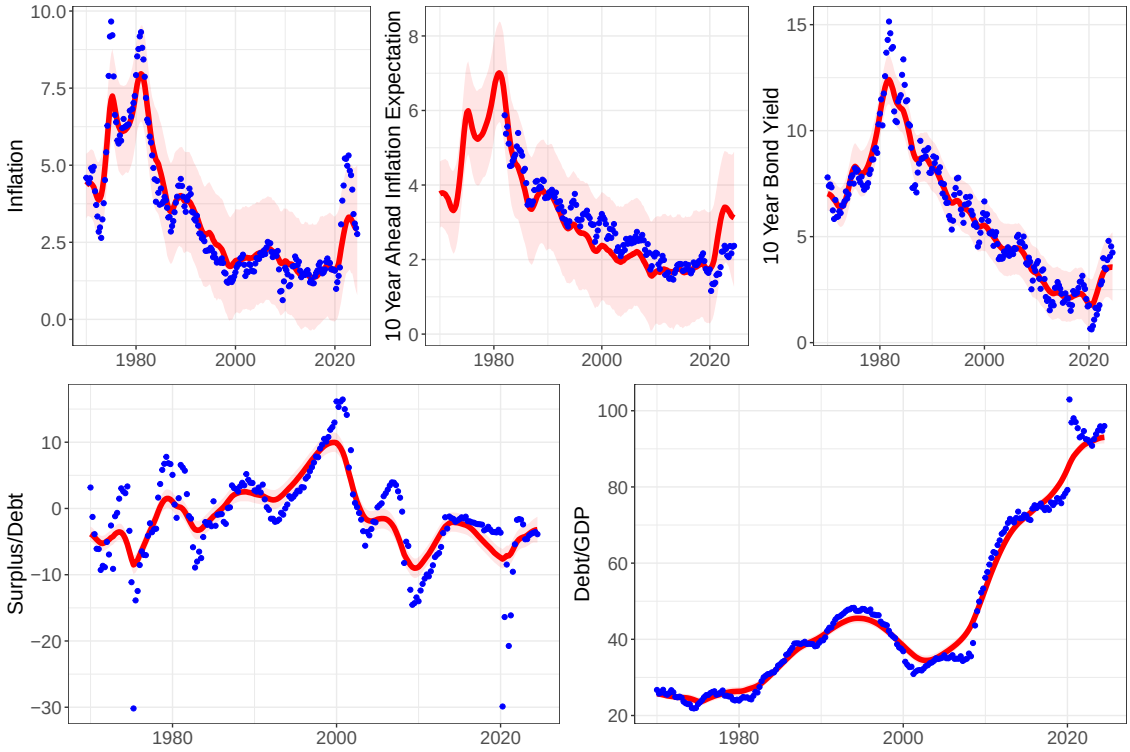
with

$$
\begin{pmatrix} u_t \\ \varepsilon_t \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \Sigma_u & 0 \\ 0 & \Sigma_\varepsilon \end{pmatrix} \right).
$$

I use the 10-year Treasury yield to match the horizon of long-term inflation expectations while avoiding complications associated with the zero lower bound.

The cointegration restrictions among inflation, long-run inflation expectations, and long-term nominal yields follow Del Negro et al. (2017) while the additional fiscal trends allow persistent movements in surpluses and debt to load on the long-run components of nominal variables. The loading matrix is time invariant, so the exercise abstracts from the evolution of $\tilde{\Phi}_t$ that is central to the structural learning model. I use conservative priors on the innovation variances of the slow moving components, following Del Negro et al. (2017). The results are robust to allowing greater variation in these trends. Details of the priors, posterior distributions, and Gibbs sampler are reported in Appendix Section §J. Figure 13 compares the observed data with the estimated trend component $\Lambda\omega_t$. The model captures the major low frequency movements in the data. In particular, once fiscal trends are included, the fitted inflation component captures both inflation peaks of the 1970s, which are more difficult to reproduce in the specification without fiscal variables.

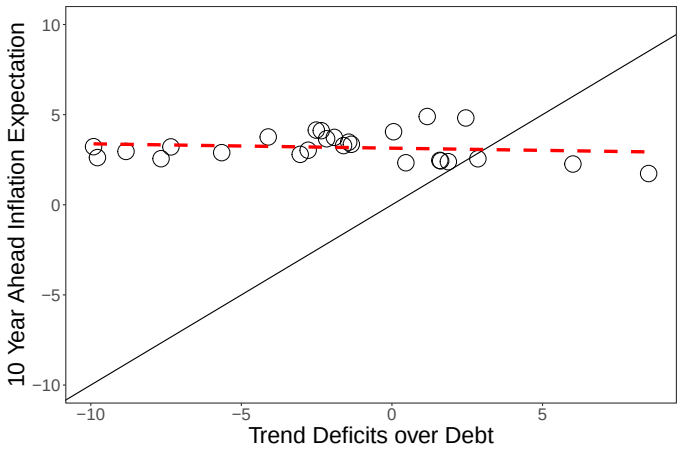
Figure 13: The Model Fits; The Plot of the Data and $\Lambda\omega$



Note: The red solid line represents the median estimate of $\Lambda\omega$ and the shade areas are 90% credible sets. The blue points are the actual data.

To relate the multivariate results to the existing evidence, figure 14 revisits the bivariate relationship emphasized by Kliem et al. (2016). I regress 10 year ahead inflation expectations on the estimated low frequency deficit component over 1984–2009. Consistent with their finding, the fitted relationship is nearly flat. Extending the sample further produces a slightly negative relationship. Thus, the simple bivariate evidence suggests little positive low-frequency association between deficits and long-run inflation expectations after the early 1980s.

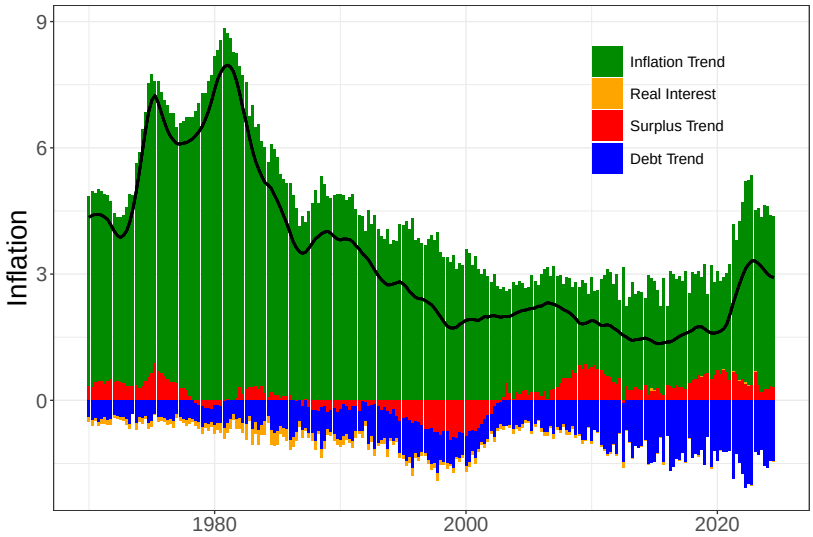
Figure 14: Revisit the Scatter Plot from Kliem et al. (2016)



Note: Each circle represents the first quarter of the year for the readability following Kliem et al. (2016). I use 10 year ahead inflation expectation and estimated trends of deficits over debt as low-frequency measures instead of filtered data. Using the estimated inflation trend ω_t^{π} does not change the result. The red dashed line indicates the fitted line using OLS while the black solid line represents the 45 degree line. As the graph shows it appears to be no relationship between inflation and deficits during these periods, which is consistent with the conclusion in Kliem et al. (2016).

The multivariate decomposition produces a different picture. The bivariate relationship does not condition on the joint low frequency movements in debt, interest rates, and other beliefs that enter the equilibrium mapping. Figure 15 decomposes fitted trend inflation $e_{\pi}'\Lambda\omega_t$ into the contributions associated with each estimated trend. Inflation's own trend accounts for the largest component, but fiscal trends also contribute meaningfully to its low frequency variation. Persistent movements toward larger deficits are associated with higher inflation, whereas the debt trend enters with the opposite sign.

Figure 15: Inflation and the Effect of Trends



Note: The black solid line is the inflation from the fitted value, Λy so that the sum of each bar adds up. Each bar shows the contribution of each trend on the inflation.

The estimated loading pattern is consistent with the fiscal backing mechanism developed in the theoretical model. Persistent movements toward larger deficits are associated with higher inflation and long-run inflation expectations. The debt trend, by contrast, loads negatively on inflation. The negative debt loading has a natural interpretation in the model. When higher debt raises households' expectations of future primary surpluses, it increases the expected present value of the surplus stream and thereby reduces the perceived net wealth associated with government liabilities. Persistent debt therefore need not generate the positive inflation response associated with persistent deficits. The trend-cycle exercise does not identify the underlying evolution of fiscal beliefs directly, but the estimated loading pattern is consistent with the long-run fiscal restrictions implied by the structural model.

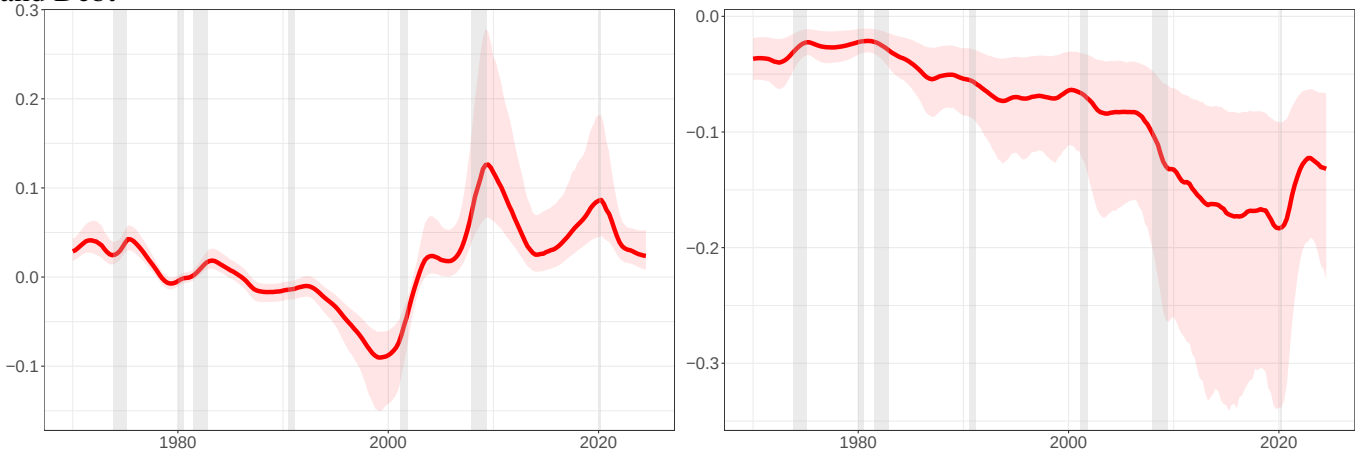
An additional advantage of this more flexible specification is that it can be estimated through the post-ZLB period. I use a long-term nominal yield rather than the short-term policy rate, and the slow moving fiscal components are not required to evolve according to the constant gain learning rule imposed in the structural estimation. The trend-cycle evidence therefore provides a longer sample complement to the structural analysis. The latter is restricted to the pre-ZLB period, where the monetary policy specification remains appropriate and unusually large post-ZLB fiscal forecast errors do not dominate the estimation of the learning dynamics.

Next, I show how much total movements in long-term inflation expectations are explained by the debt trend. More specifically, I present

$$\frac{\lambda_7 \omega_t^s}{|\lambda_5 \omega_t^\pi| + |\lambda_6 \omega_t^R| + |\lambda_7 \omega_t^s| + |\lambda_8 \omega_t^b|} \quad \text{and} \quad \frac{\lambda_8 \omega_t^b}{|\lambda_5 \omega_t^\pi| + |\lambda_6 \omega_t^R| + |\lambda_7 \omega_t^s| + |\lambda_8 \omega_t^b|}$$

As the signs of these objects are as equally important as its magnitude, I keep the signs for the numerators. Hence the y axis can be interpreted as the fraction but with signs, which is bounded between -1 to 1.

Figure 16: The Low-Frequency Relationship between Long-run Inflation Expectation and Surplus and Debt



Note: The red line represents the fraction of long-term inflation expectation explained by the debt trend with 90 percent credible sets. Shaded grey areas show the NBER recession periods.

Figure 16 shows that the debt trend has a non-negligible effect on long-run inflation expectations. Interestingly, the estimated relationship is negative: higher debt is associated with lower

long-run inflation expectations. This is not an obvious result. In models of fiscal dominance, such as those studied by Bianchi and Melosi (2019) higher debt raises the likelihood that fiscal imbalances will eventually be resolved through inflation, implying a positive relationship between debt and long-run inflation expectations when Ricardian equivalence breaks down. The negative relationship documented here instead suggests that agents, on average, associate higher debt with future fiscal adjustment rather than inflationary resolution. At the same time, the effect is not negligible, indicating that these expectations are not perfectly anchored.

One limitation of this empirical approach is that it does not separately identify structural shocks without imposing additional restrictions that are not tightly linked to the theory. As a result, it is difficult to cleanly trace the effects of fiscal policy shocks on inflation and long-run inflation expectations.

To address this issue, I develop a New Keynesian model with imperfect knowledge, building on Eusepi and Preston (2018). I relax the assumption on the subjective beliefs to allow the endogenous revision of long-term expectations following fiscal policy shocks. In the model, private agents do not know the long-run means or the coefficients governing fiscal dynamics and must learn about them by observing macroeconomic outcomes. In this sense, the framework also extends Milani (2007) by incorporating monetary–fiscal interactions into a learning environment.

I Estimation: Trend-Cycle Decomposition with Common Trends

In this section, I show how the estimation of the trend-cycle decomposition works by using simulated data. I draw 20000 samples and discard first 10000 samples. The estimation algorithm is based on the appendix in Del Negro et al. (2017). The model is summarized by the state space model

$$y_t = \Lambda \omega_t + e_t \tag{26}$$
$$\omega_t = \omega_{t-1} + u_t \tag{27}$$

and a VAR

$$\varepsilon_t = \Phi(L)\, e_t \tag{28}$$

with

$$\begin{pmatrix} u_t \\ \varepsilon_t \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \Sigma_u & 0 \\ 0 & \Sigma_\varepsilon \end{pmatrix} \right).$$

I use Gibbs sampling to estimate the model and it consists of the following blocks:

- Step 1.

1. $\lambda | \varphi, \Sigma_\varepsilon, \Sigma_u, y_{1:T}$
2. $\omega_{0:T}, e_{-p+1:T} | \lambda, \varphi, \Sigma_\varepsilon, \Sigma_u, y_{1:T}$

- Step 2.

1. $\varphi, \Sigma_\varepsilon, \Sigma_u | \omega_{0:T}, e_{-p+1:T}, \lambda, y_{1:T}$

I.1 $\lambda|\varphi,\Sigma_\varepsilon,\Sigma_u,y_{1:T}$

By Bayes' rule

$$p(\lambda|\varphi,\Sigma_\varepsilon,\Sigma_u,y_{1:T}) \propto \mathscr{L}(y_{1:T}|\lambda,\varphi,\Sigma_\varepsilon,\Sigma_u)\, p(\lambda),$$

where $\mathscr{L}(y_{1:T}|\lambda,\varphi,\Sigma_\varepsilon,\Sigma_u)$ is the likelihood obtained from the Kalman filter. I use random walk Metropolis-Hastings to estimate λ.

Since y_t and ω_t are jointly normally distributed,

$$\begin{pmatrix} y_t \\ \omega_t \end{pmatrix} \sim \mathscr{N}\left(\begin{pmatrix} \Lambda\omega_{t-1|t-1} \\ \omega_{t-1|t-1} \end{pmatrix}, \begin{pmatrix} \Lambda P_{t|t-1}\Lambda' + \Sigma_\varepsilon & \Lambda P_{t|t-1} \\ \Lambda P_{t|t-1} & P_{t|t-1} \end{pmatrix}\right),$$

with

$$P_{t|t-1} = P_{t-1|t-1} + \Sigma_u$$

The Kalman filter implies that

$$\begin{aligned} \omega_{t|t} &= \omega_{t-1|t-1} + P_{t|t-1}\Lambda'\left(\Lambda P_{t|t-1}\Lambda' + \Sigma_\varepsilon\right)^{-1}\left(y_t - \Lambda\omega_{t-1|t-1}\right) \\ P_{t|t} &= P_{t|t-1} - P_{t|t-1}\Lambda'\left(\Lambda P_{t|t-1}\Lambda' + \Sigma_\varepsilon\right)^{-1}\Lambda P_{t|t-1} \end{aligned}$$

Note that because

$$y_{t|t-1}|\lambda,\varphi,\Sigma_\varepsilon,\Sigma_u \sim \mathscr{N}\left(\Lambda\omega_{t-1|t-1}, \Lambda P_{t|t-1}\Lambda' + \Sigma_\varepsilon\right),$$

the likelihood function becomes

$$\mathscr{L} = -\frac{1}{2}\log 2\pi - \frac{1}{2}\log\left(\det\left(F_{t|t-1}\right)\right) - \frac{1}{2}\left(y_t - y_{t|t-1}\right)' F_{t|t-1}^{-1}\left(y_t - y_{t|t-1}\right),$$

where $F_{t|t-1} \equiv \Lambda P_{t|t-1}\Lambda' + \Sigma_\varepsilon$. Define Λ as

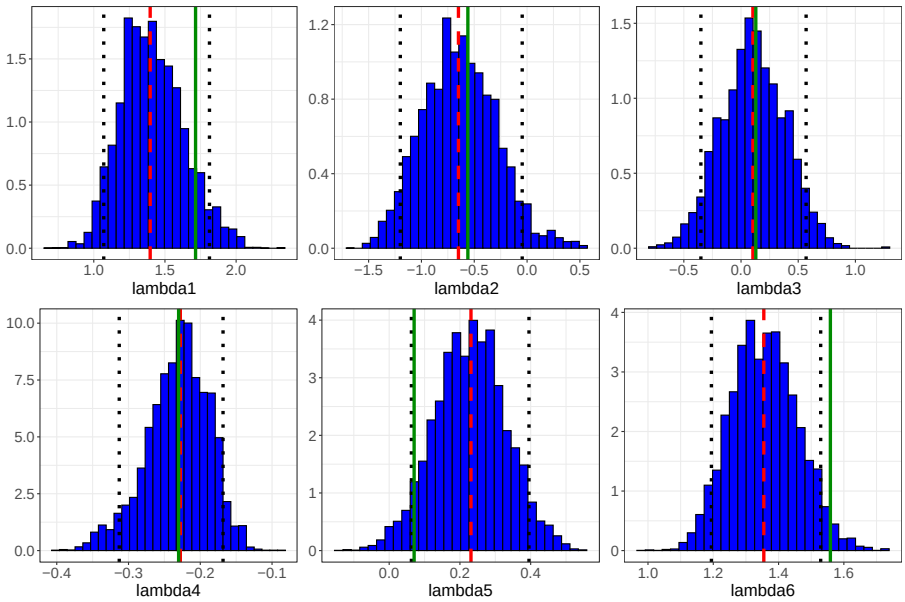
$$\Lambda \equiv \begin{pmatrix} \lambda_1 & \lambda_2 & \lambda_3 & 0 \\ \lambda_4 & \lambda_5 & \lambda_6 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix},$$

then, I have six free parameters to estimate. Define the probability to accept the proposal as

$$\alpha = \frac{\mathscr{L}\left(y_{1:T}|\lambda_{\text{prop}},\varphi,\Sigma_\varepsilon,\Sigma_u\right) p\left(\lambda_{\text{prop}}\right)}{\mathscr{L}\left(y_{1:T}|\lambda^{(d)},\varphi,\Sigma_\varepsilon,\Sigma_u\right) p\left(\lambda^{(d)}\right)}.$$

Here I use independent $\mathscr{N}(0,1)$ as priors for all λs. The following shows results using simulated data.

Figure 17: Simulated Data: Metropolis-Hastings



Note: The green line indicates the true value of the parameter. The red dashed line is the mean of the estimate and black dotted lines represent 90% credible sets.

I.2 $\omega_{0:T}, e_{-p+1:T} | \lambda, \varphi, \Sigma_\varepsilon, \Sigma_u, y_{1:T}$

Following Del Negro et al. (2017), to draw $\omega_{0:T}$ and $e_{-p+1:T}$, I use the simulation smoother proposed by Durbin and Koopman (2002) and implemented by Jarociński (2015). The blue line shows the true state while the red dots represent the median of 5000 draws from the simulation smoother. Once the states are sampled, cyclical components and shocks are identified by

$$\begin{aligned} e_t &= y_t - \Lambda \omega_t \\ \varepsilon_t &= \left(I - \sum_{l=1}^{p} \Phi_l L^l \right) e_t \\ &= e_t - \Phi_1 e_{t-1} - \cdots - \Phi_p e_{t-p}, \end{aligned}$$

where Φs are know. Initial values are assumed to be following diffuse priors

$$\begin{aligned} \omega_0 &\sim \mathcal{N}(0, I) \\ e_{-p+1:0} &\sim \mathcal{N}(0, V(\Phi, \Sigma_\varepsilon)). \end{aligned}$$

Note that the unconditional mean of ω_0 is set to be 0 following Jarociński (2015). The sampling process is the following:

1. Draw ω^+ and y^+, which are unconditional draws from distributions, by means of recursion (26)-(28), where the recursion is initialized by a draw $\omega_0^+ \sim \mathcal{N}(0, I)$.

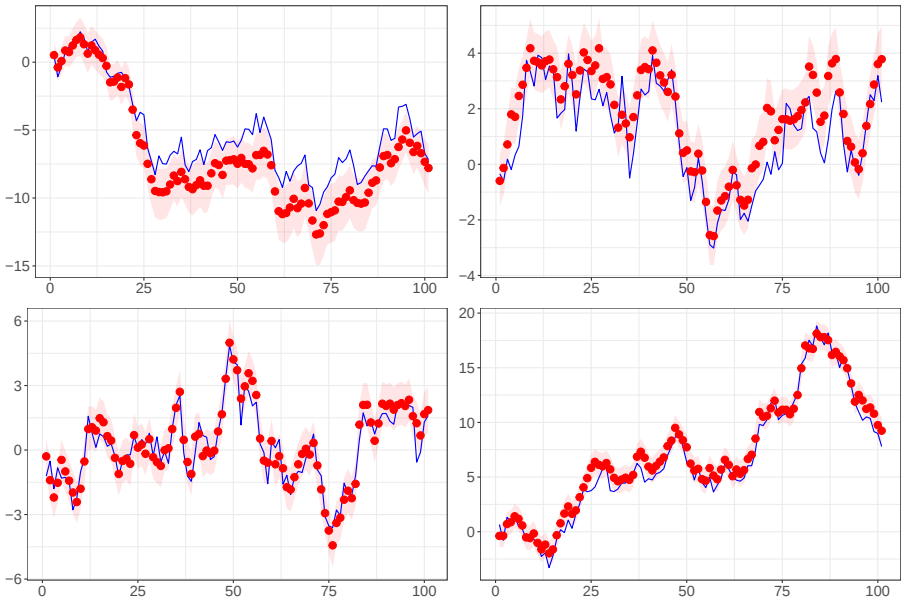
2. Construct the artificial series $y^* = y - y^+$ and compute $\hat{\omega}^* = E(\omega | y^*)$ by putting y^* through the Kalman filter and smoother.

3. Take $\tilde{\omega} = \hat{\omega}^* + \omega^+$. $\tilde{\omega}$ is a draw from the distribution of ω conditional on y. This is done by taking the conditional expectation given y of both sides of (27), substituting for u_t from the smoothed disturbance

$$\begin{aligned} \tilde{\omega}_t &= \hat{\omega}^*_{t-1} + \Sigma_u r_{t-1} + \omega^+_t \\ r_{t-1} &= \Lambda' F^{-1}_{t|t-1} \left(y_t - y^+_t - \Lambda \omega_t \right) + (I - K_t \Lambda) r_t, \end{aligned}$$

where $K_t \equiv P_{t|t-1}\Lambda' \left(\Lambda P_{t|t-1} \Lambda' + \Sigma_\varepsilon \right)^{-1}$ represents the Kalman gain.

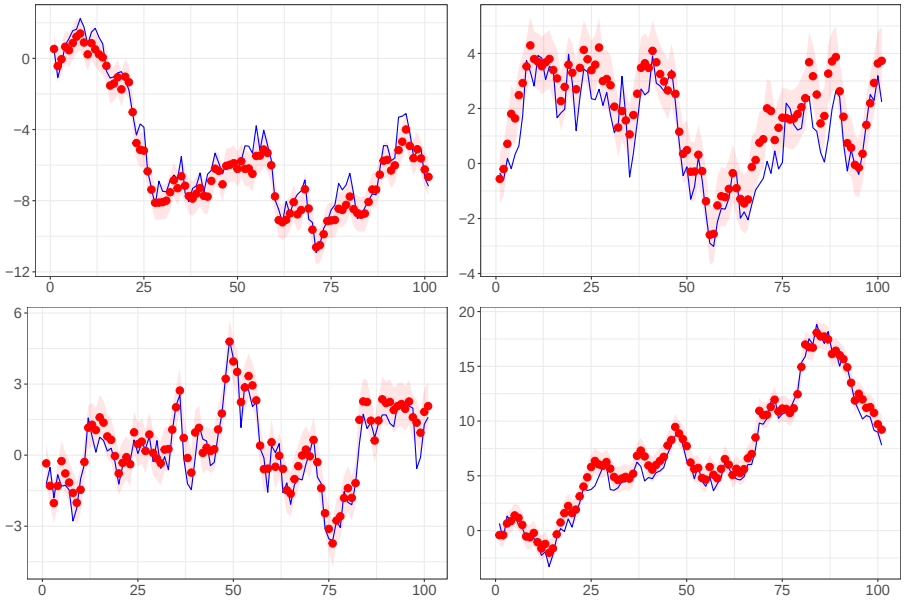
Figure 18: Simulated Data: Simulation Smoother



Note: The blue line indicates the true states. The red dots represent median of 10000 draws from the simulation smoother developed by Durbin and Koopman (2002). The red shaded area shows the 68 percent credible sets.

The first state appears to have downward bias, but it is likely coming from the uncertainty regarding loading terms. As the sanity check, I perform the same Gibbs sampling while providing the correct Λ. The following figure shows the downward bias disappears.

Figure 19: Simulated Data: Simulation Smoother with Correct Λ



Note: The blue line indicates the true states. The red dots represent median of 5000 draws from the simulation smoother above. The red shaded area shows the 68 percent credible sets. The estimation is performed given the correct Λ while the other parts are kept the same.

I.3 $\varphi, \Sigma_\varepsilon, \Sigma_u | \omega_{0:T}, e_{-p+1:T}, \lambda, y_{1:T}$

With the prior distribution for VAR coefficients and variance-covariance matrices being

$$\begin{aligned} p(\varphi|\Sigma_\varepsilon) &= \mathcal{N}(0, \Sigma_\varepsilon \otimes \underline{\Omega})\, 1(\varphi), \\ p(\Sigma_\varepsilon) &= \mathcal{IW}((\kappa_\varepsilon + n + 1)\underline{\Sigma}_\varepsilon, \kappa_\varepsilon) \\ p(\Sigma_u) &= \mathcal{IW}((\kappa_u + q + 1)\underline{\Sigma}_u, \kappa_u), \end{aligned}$$

where $1(\varphi)$ is the indicator function that takes 1 when the VAR is stable and 0 otherwise. the posterior distribution of Σ_u can be simply expressed as

$$p(\Sigma_u|\omega_{0:T}) = \mathcal{IW}\left(\underline{\Sigma}_u + \hat{S}_u, \kappa_u + T\right),$$

where $\hat{S}_u = \sum_{t=1}^{T}(\omega_t - \omega_{t-1})(\omega_t - \omega_{t-1})'$. The posterior distributions of φ and Σ_ε is given by

$$\begin{aligned} p(\Sigma_\varepsilon|e_{0:T}) &= \mathcal{IW}\left(\underline{\Sigma}_\varepsilon + \hat{S}_\varepsilon, \kappa_\varepsilon + T\right) \\ p(\varphi|\Sigma_\varepsilon, e_{0:T}) &= \mathcal{N}\left(vec\left(\hat{\Phi}\right), \Sigma_\varepsilon \otimes \left(\sum_{t=t}^{T} \tilde{x}_t \tilde{x}_t' + \underline{\Omega}^{-1}\right)^{-1}\right), \end{aligned}$$

where $\tilde{x}_t = \begin{pmatrix} e'_{t-1} & \cdots & e'_{t-p} \end{pmatrix}'$ collects the VAR regressors,

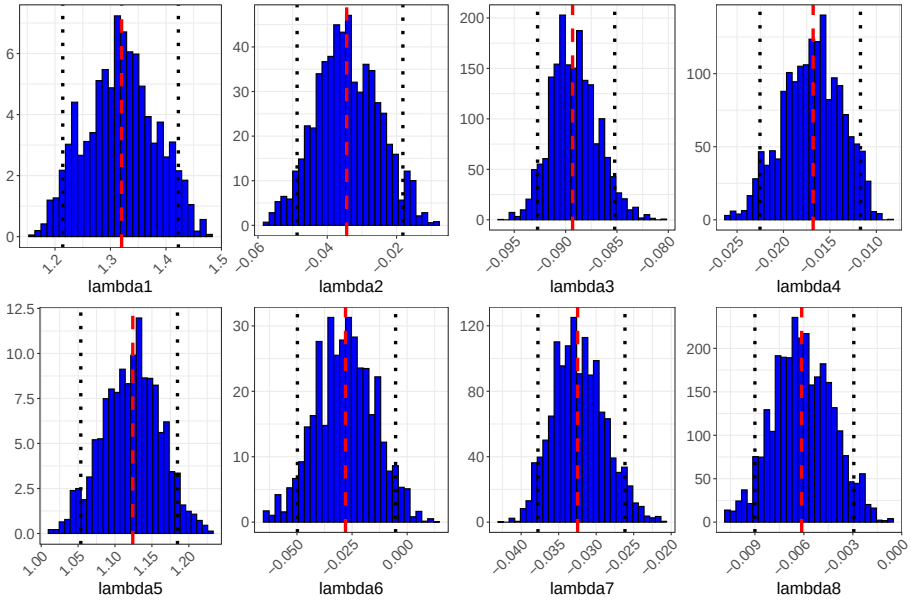
$$\begin{aligned} \hat{\Phi} &= \left(\sum_{t=t}^{T} \tilde{x}_t \tilde{x}'_t + \underline{\Omega}^{-1} \right)^{-1} \left(\sum_{t=t}^{T} \tilde{x}_t e'_t \right) \\ \hat{S}_\varepsilon &= \sum_{t=1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}'_t + \hat{\Phi}' \underline{\Omega}^{-1} \hat{\Phi} \end{aligned}$$

and $\hat{\varepsilon}_t = e_t - \hat{\Phi}' \tilde{x}_t$ are the VAR residuals.

J Estimation of the Common Trend Model

$$\begin{aligned} \lambda_1 &\sim \mathcal{N}(1, 0.5) \\ \lambda_2, \lambda_6 &\sim \mathcal{N}(0, 0.1) \\ \lambda_3, \lambda_7 &\sim \mathcal{N}(0, 0.05) \\ \lambda_4, \lambda_8 &\sim \mathcal{N}(0, 0.01) \\ \lambda_5 &\sim \mathcal{N}(0, 0.5) \end{aligned}$$

Figure 20: Posterior Distribution of Λ



Note: The red line indicate the posterior median and black dashed lines are 90 percent credible sets.

K Medium Scale New Keynesian Model Derivations

Households

Household i's optimization problem is

$$\max_{C_T(i),h_T^i} \hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left[\frac{C_T(i)^{1-\sigma}}{1-\sigma} - h_T^i \right]$$

subject to

$$\begin{aligned} C_t(i) + \frac{B_t(i)}{R_t P_t} &\leq \pi_t^{-1} \frac{B_{t-1}(i)}{P_{t-1}} + \frac{W_t}{P_t} h_t^i + \Pi_t - S_t \\ \lim_{T\to\infty} \hat{E}_t^i \left(\prod_{s=0}^{T-t} R_{t+s} \pi_{t+s}^{-1} \right) \frac{B_T(i)}{P_T} &\geq 0. \end{aligned}$$

The first order condition is

$$\begin{aligned} C_t(i)^{-\sigma} &= \lambda_t^i \\ \lambda_t^i &= \beta \hat{E}_t^i \left[R_t \pi_{t+1}^{-1} \lambda_{t+1}^i \right] \\ \frac{W_t}{P_t} \lambda_t^i &= 1 \end{aligned}$$

Household i's Euler equation is

$$C_t(i)^{-\sigma} = \beta \hat{E}_t^i \left[R_t \pi_{t+1}^{-1} C_{t+1}(i)^{-\sigma} \right].$$

Log-linearizing around the zero inflation steady state to get

$$\begin{aligned} \bar{C}^{-1} e^{-\sigma \hat{c}_t(i)} &= \beta \hat{E}_t^i \left[\bar{R} e^{R_t} \bar{\pi}^{-1} e^{-\pi_{t+1}} \bar{C}^{-1} e^{-\sigma \hat{c}_{t+1}(i)} \right] \\ \hat{c}_t(i) &= \hat{E}_t^i \hat{c}_{t+1}(i) - \frac{1}{\sigma} \left(R_t - \hat{E}_t^i \pi_{t+1} \right). \end{aligned} \tag{29}$$

The second equation uses the fact that

$$\begin{aligned} e^x &\approx 1 + x \\ \beta \bar{R} \bar{\pi}^{-1} &= 1 \end{aligned}$$

The household budget constraint can be linearized as

$$\begin{aligned} \bar{C}\left(1 + \hat{c}_t(i)\right) + \beta \bar{b} \left(1 + \hat{b}_t(i) - R_t\right) &= \bar{b} \left(1 + \hat{b}_{t-1}(i) - \pi_t\right) + \bar{Y} \hat{Y}_t(i) - \bar{s} \hat{s}_t. \\ \delta^{-1} \hat{c}_t(i) + \beta \hat{b}_t(i) - \beta R_t &= \hat{b}_{t-1}(i) - \pi_t + \delta^{-1} \hat{Y}_t(i) - (1-\beta) \hat{s}_t, \end{aligned} \tag{30}$$

where $\delta = \frac{\bar{b}}{\bar{Y}}$ represents the steady state indebtedness and $\bar{C} = \bar{Y}$. In the steady state, $\bar{s} = (1-\beta)\bar{b}$ holds from the government budget constraint. To get the log-linearization, I use the fact that

$$\begin{aligned} \hat{x}_t &\equiv \log\left(\frac{X_t}{\bar{X}} \right) \\ X_t &\approx \bar{X}\left(1 + \hat{x}_t\right). \end{aligned}$$

Note that

$$\begin{aligned}\log X_t &\approx \log \bar{X} + \frac{1}{\bar{X}}(X_t - \bar{X}) \\ X_t &\approx \bar{X}(1+\hat{x}_t).\end{aligned}$$

Because the surplus process can be negative, it is linearized using the level instead. Combining the Euler equation and linearized budget constraint and aggregating over households to obtain

$$\begin{aligned}\hat{c}_t &= (1-\beta)\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t}\hat{Y}_T - \frac{\beta}{\sigma}\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t}(R_T - \pi_{T+1}) \\ &+ (1-\beta)\delta\left(\hat{b}_{t-1} - \pi_t - \hat{E}_t^i\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)\hat{s}_T - \beta(R_T - \pi_{T+1})\}\right]\right).\end{aligned}$$

Imposing the equilibrium condition $\hat{c}_t = \hat{y}_t$, this can be expressed in terms of the output gap

$$\begin{aligned}\hat{x}_t &= (1-\beta)\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t}\hat{x}_{T+1} - \frac{\beta}{\sigma}\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t}(R_T - \pi_{T+1} - \hat{r}_T^n) + \\ &+ \beta^{-1}(1-\beta)\delta\left(\hat{b}_{t-1} - \pi_t - \hat{E}_t^i\left[\sum_{T=t}^{\infty}\beta^{T-t}\{(1-\beta)\hat{s}_T - \beta(R_T - \pi_{T+1})\}\right]\right)\end{aligned}$$

Firms

Firms maximize their expected future profits defined as

$$\max_{p^*} \hat{E}_t^j \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T}\Pi_T^j(j).$$

Defining the real marginal cost as

$$mc_t = \frac{W_t}{A_t P_t},$$

this can be rewritten as

$$\max_{p^*} \hat{E}_t^j \sum_{T=t}^{\infty} (\alpha\beta)^{T-t}\left(\frac{p^*}{P_T} - mc_T\right)\left(\frac{p^*}{P_T}\right)^{-\theta_T}.$$

The first order condition with respect to p^* yields

$$\hat{E}_t^j \sum_{T=t}^{\infty} (\alpha\beta)^{T-t}\left(\frac{p^*}{P_T} - \frac{\theta_T}{\theta_T - 1}mc_T\right)\left(\frac{p^*}{P_T}\right)^{-\theta_T} = 0.$$

Let

$$\hat{p}_t \equiv d\log\frac{p_t^*}{P_t}$$

be the reset price relative to the current aggregate price level. This implies

$$d\log\frac{p_t^*}{P_T} = d\log\frac{p_t^*}{P_t} + d\log\frac{P_t}{P_T}.$$

Since

$$d\log\frac{P_t}{P_T} = -\sum_{k=t+1}^{T}\pi_k,$$

I have

$$\widehat{\left(\frac{p_t^*}{P_T}\right)} = \hat{p}_t - \sum_{k=t+1}^{T}\pi_k.$$

Therefore the log-linearization of the first order condition becomes

$$\hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\hat{p}_t - \sum_{k=t+1}^{T}\pi_k - \left(\widehat{mc}_T - \frac{1}{\bar{\theta}-1}\hat{\theta}_T\right)\right] = 0,$$

which in turn becomes

$$\begin{aligned}\hat{p}_t &= (1-\alpha\beta)\,\hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\left(\widehat{mc}_T - \frac{1}{\bar{\theta}-1}\hat{\theta}_T\right) + \sum_{k=t+1}^{T}\pi_k\right]\\ &= \hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[(1-\alpha\beta)\left(\widehat{mc}_T - \frac{1}{\bar{\theta}-1}\hat{\theta}_T\right) + \alpha\beta\pi_{T+1}\right].\end{aligned}$$

The last equation holds because

$$(1-\alpha\beta)\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\sum_{k=t+1}^{T}\pi_k = (1-\alpha\beta)\frac{\alpha\beta}{1-\alpha\beta}\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\pi_{T+1}.$$

Under Calvo pricing, the price index satisfies

$$P_t = \left[\alpha P_{t-1}^{1-\theta_t} + (1-\alpha)\left(p_t^*\right)^{1-\theta_t}\right]^{\frac{1}{1-\theta_t}}.$$

Log-linearizing around zero inflation steady state gives

$$\pi_t = \frac{1-\alpha}{\alpha}\hat{p}_t.$$

Multiply the optimal reset-price by $(1-\alpha)/\alpha$:

$$\pi_t = \frac{1-\alpha}{\alpha}\hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[(1-\alpha\beta)\left(\widehat{mc}_T - \frac{1}{\bar{\theta}-1}\hat{\theta}_T\right) + \alpha\beta\pi_{T+1}\right].$$

Aggregate over firms and define the average beliefs by $\hat{E}_t \equiv \int_0^1 \hat{E}_t^j dj$,

$$\pi_t = \hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\kappa\left(\widehat{mc}_T - \frac{1}{\bar{\theta}-1}\hat{\theta}_T\right) + (1-\alpha)\beta\pi_{T+1}\right].$$

Because

$$\widehat{mc}_t = \hat{Y}_t - \hat{a}_t$$

and

$$\begin{aligned}\hat{Y}_t^n &= \hat{a}_t,\\ \widehat{mc}_t &= \hat{x}_t.\end{aligned}$$

Replacing the above relationship to get the NKPC

$$\hat{\pi}_t = \kappa\hat{x}_t + \hat{E}_t^j\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\left[\kappa\alpha\beta\hat{x}_{T+1} + (1-\alpha)\beta\pi_{T+1}\right] - \frac{\kappa}{\bar{\theta}-1}\hat{\theta}_t.$$

L The State-Space Representation

- The endogenous variables are summarized by the vector

$$Z_t \equiv \begin{pmatrix} \hat{x}_t \\ \pi_t \\ R_t \\ \hat{s}_t \\ \hat{b}_t \\ r_t^n \end{pmatrix}.$$

Then the equilibrium condition can be expressed compactly

$$A_0 Z_t = A_x \left[F_0\left(\beta, \tilde{\Phi}_t\right) \bar{\omega}_t + F_1\left(\beta, \tilde{\Phi}_t\right) Z_t \right] + A_\pi \left[F_0\left(\alpha\beta, \tilde{\Phi}_t\right) \bar{\omega}_t + F_1\left(\alpha\beta, \tilde{\Phi}_t\right) Z_t \right] + A_2 Z_{t-1} + A_3 \varepsilon_t,$$

where

$$A_0 = \begin{pmatrix} 1 & \beta^{-1}(1-\beta)\delta & \frac{\beta}{\sigma}-(1-\beta)\delta & \beta^{-1}(1-\beta)^2\delta & 0 & -\frac{\beta}{\sigma} \\ -\kappa & 1 & 0 & 0 & 0 & 0 \\ -(1-\rho_i)\phi_x & -(1-\rho_i)\phi_\pi & 1 & 0 & 0 & 0 \\ -(1-\rho_s)\phi_y & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & -\beta & 1-\beta & \beta & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$A_2 = \begin{pmatrix} 0 & 0 & 0 & 0 & \beta^{-1}(1-\beta)\delta & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \rho_i & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_s & (1-\rho_s)\phi_b & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho_r \end{pmatrix}$$

$$A_3 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\kappa}{\bar{\theta}-1} \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

$$A_x = \begin{pmatrix} 1-\beta & \frac{\beta}{\sigma}-(1-\beta)\delta & -\beta\left[\frac{\beta}{\sigma}-(1-\beta)\delta\right] & -(1-\beta)^2\delta & 0 & \frac{\beta^2}{\sigma} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$A_\pi = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ \kappa\alpha\beta & (1-\alpha)\beta & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

and

$$F_0\left(\beta_s,\tilde{\Phi}_t\right) = \left(I_6-\tilde{\Phi}_t\right)^{-1}\left[(1-\beta_s)^{-1}I_6-\tilde{\Phi}_t\left(1-\beta_s\tilde{\Phi}_t\right)^{-1}\right] \qquad F_1\left(\beta_s,\tilde{\Phi}_t\right) = \tilde{\Phi}_t\left(1-\beta_s\tilde{\Phi}_t\right)^{-1}.$$

Solving for Z_t yields

$$\begin{aligned} Z_t &= \left(A_0-\sum_s A_s F_1\left(\beta_s,\tilde{\Phi}_t\right)\right)^{-1}\left(\sum_s A_s F_0\left(\beta_s,\tilde{\Phi}_t\right)\right)\bar{\omega}_t \\ &+ \left(A_0-\sum_s A_s F_1\left(\beta_s,\tilde{\Phi}_t\right)\right)^{-1} A_2 Z_{t-1} + \left(A_0-\sum_s A_s F_1\left(\beta_s,\tilde{\Phi}_t\right)\right)^{-1} A_3\varepsilon_t \end{aligned} \quad (31)$$

L.1 The Observation Equation

The observation equation is

$$\mu_t(\Theta) + H_t(\Theta) Z_t + o_t,$$

where

$$Y_t = \begin{bmatrix} \text{Output Gap}(t) \\ \text{CPI Inflation}(t) \\ \text{3-Month Tbill}(t) \\ \text{Surplus/Debt}(t) \\ \text{Debt/GDP}(t) \\ E_t^{SPF,1Q-ahead}\text{CPI Inflation} \\ E_t^{SPF,1Q-ahead}\text{3-Month Tbill} \\ E_t^{SPF,10years}\text{CPI Inflation} \\ E_t^{SPF,10years}\text{3-Month Tbill} \end{bmatrix} = \mu + \begin{bmatrix} \hat{x}_t \\ \pi_t \\ R_t \\ \frac{s}{b}\hat{s}_t - \frac{s}{b}\hat{b}_t \\ \frac{b}{y}\hat{b} \\ \hat{E}_t\pi_{t+1} \\ \hat{E}_t R_{t+1} \\ \hat{E}_t^{LR,\pi} \\ \hat{E}_t^{LR,R} \end{bmatrix}$$

and

$$\mu = \begin{bmatrix} 0 \\ \pi \\ \pi + r \\ \frac{s}{b} \\ \frac{b}{y} \\ \pi \\ \pi + r \\ \pi \\ \pi + r \end{bmatrix}$$

Long-run expectations are defined as

$$\hat{E}_t^{LR} Z \equiv \frac{1}{40} \sum_{h=1}^{40} \hat{E}_t Z_{t+h} = \frac{1}{40} \sum_{h=1}^{40} \left[\sum_{j=0}^{h-1} \tilde{\Phi}_t^j \bar{\omega}_t + \tilde{\Phi}_t^h Z_t \right].$$

Then

$$\begin{aligned} \hat{E}_t\pi_{t+1} &= e_\pi' \hat{E}_t Z_{t+1}, \\ \hat{E}_t R_{t+1} &= e_R' \hat{E}_t Z_{t+1}, \\ \hat{E}_t^{LR,\pi} &= e_\pi' \hat{E}_t^{LR} Z, \\ \hat{E}_t^{LR,R} &= e_R' \hat{E}_t^{LR} Z. \end{aligned}$$

M Eliminating All the Fiscal Uncertainties

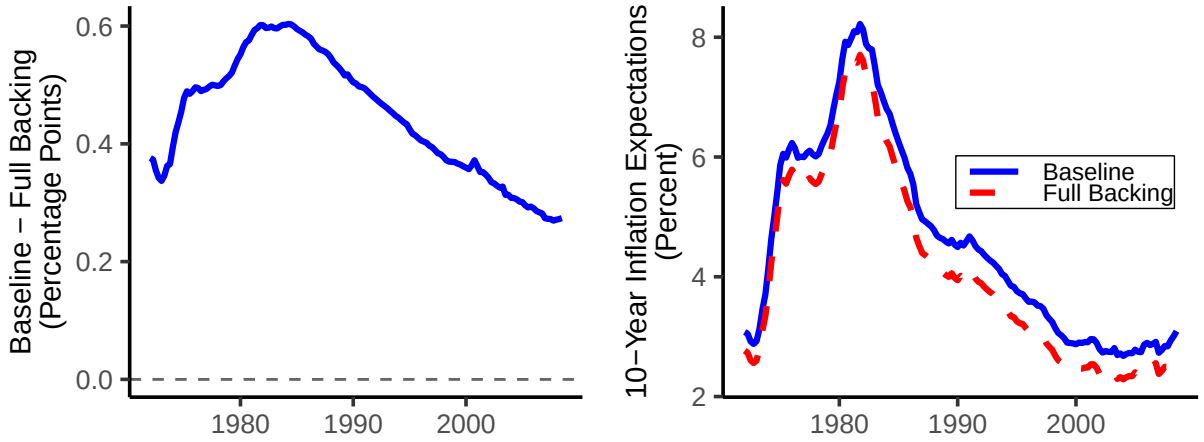
The previous section documents historical variation in perceived fiscal backing and its effects on the transmission of fiscal policy. I next quantify the cumulative implications of these belief dynamics for inflation and long-run inflation expectations. To do so, I construct a historical counterfactual without fiscal uncertainties. Starting from the estimated model, I replay the historical sequence of

structural innovations while imposing the full-backing restrictions on households' perceived fiscal dynamics. This amounts to imposing

$$\omega_s = \omega_b = 0 \quad \text{and} \quad \tilde{\Phi}_t = \Phi^{RE}.$$

The counterfactual holds fixed the shocks hitting the economy and changes only how agents perceive the fiscal consequences of those shocks. Comparing this path with the baseline historical replay isolates the contribution of departures from perceived full backing.

Figure 21: Counterfactual Inflation and Long-run Inflation Expectations



Note: The figure compares the estimated baseline model with a counterfactual economy in which households face no uncertainty about fiscal dynamics. In the counterfactual, households correctly understand the propagation of government debt and primary surpluses and their implications for future fiscal adjustment, eliminating the perceived fiscal wealth channel. The left panel reports the difference in inflation between the baseline and the counterfactual, measured in percentage points. The right panel plots model implied 10-year inflation expectations under the baseline (solid blue line) and the counterfactual without fiscal uncertainty (dashed red line). All other sources of uncertainty remain present.

Figure 21 reports the results. The left panel plots the difference in inflation between the baseline and the full backing counterfactual. Departures from full backing generate a persistent inflation wedge over much of the sample. The wedge is particularly pronounced during the Great Inflation, reaching over 0.3 percentage points at its peak. The effect is not concentrated around the impact of individual fiscal disturbances. Instead, the inflation gap evolves gradually and remains elevated for extended periods, consistent with the slow moving nature of the underlying fiscal beliefs.

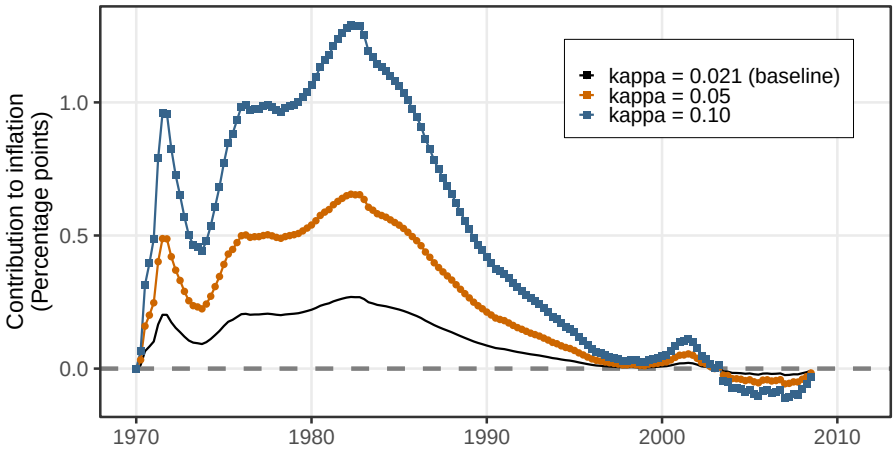
The right panel shows the corresponding implications for long-run inflation expectations. The black lines report baseline and counterfactual inflation expectations over the next 10 years corresponding to the survey of professional forecasters, while the red line, measured against the right axis, reports their difference. Restoring perceived full backing produces a persistent decline in long-run inflation expectations, with a maximum effect of 0.3 percentage point. The counterfactual does not eliminate the movements in long-run expectations: both paths continue to respond to the same historical shocks and to the other belief dynamics in the model. Instead, full backing removes a persistent fiscal component of those movements. The result suggests that fiscal beliefs need not be the dominant source of short-run inflation fluctuations to matter quantitatively for the long-run nominal anchor.

N Wealth Effects to Inflation

To assess the quantitative importance of perceived fiscal wealth effects, I isolate the additional contribution to inflation arising from insufficient perceived backing. When households perceive government liabilities to be insufficiently backed by future primary surpluses, these liabilities become perceived net wealth, stimulating consumption demand. In a New Keynesian economy, the extent to which this additional demand translates into inflation depends on the slope of the Phillips curve, κ.

Figure 22 illustrates this mechanism by evaluating the inflation contribution of fiscal uncertainty under alternative values of κ. At the baseline value of $\kappa = 0.021$, the inflationary contribution peaks at approximately 0.25 percentage point during the early 1980s. Increasing κ to 0.05 raises the peak to roughly 0.6 percentage point, while κ raises it above 1 percentage point. The contribution is approximately proportional to κ, indicating that greater price flexibility amplifies the inflationary consequences of a given perceived fiscal wealth effect.

Figure 22: The Demand Contributions to Inflation



Note: The figure reports the contribution of fiscal uncertainty to inflation, computed as the difference between baseline inflation and inflation in a counterfactual that eliminates fiscal uncertainty, under alternative Phillips curve slopes, κ. Both economies are evaluated using the same historical shocks and estimated beliefs. The baseline value is $\kappa = 0.021$, with alternative values of 0.05 and 0.10.

These results highlight that fiscal beliefs matter for the transmission of fiscal disturbances, but their quantitative importance depends on both the history of realized shocks and the structural parameters governing transmission. The impulse response analysis shows how past macroeconomic disturbances shape perceived fiscal backing and thereby alter the effects of subsequent fiscal shocks. This exercise emphasizes a complementary dimension: even for a given historical path of fiscal beliefs, the inflationary consequences of perceived wealth effects depend on the slope of the Phillips curve, highlighting that the mechanism proposed here is inherently demand driven.