The Fiscal Anchor of Long-term Inflation Expectations

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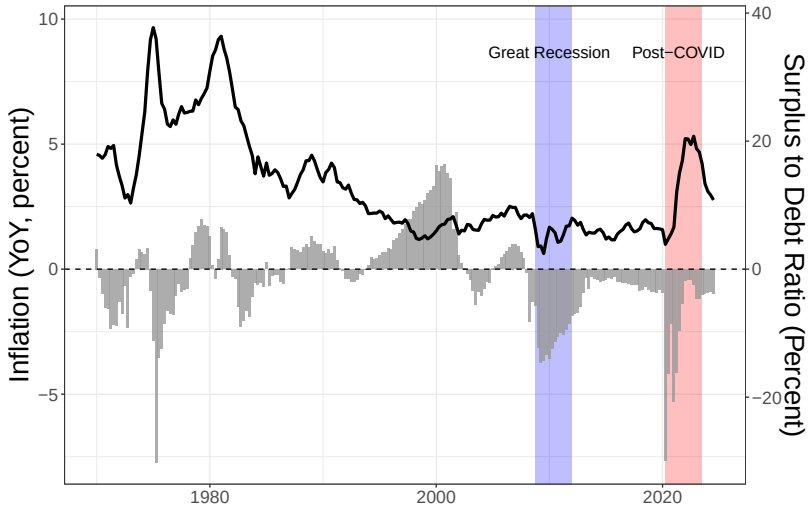
Abstract

I build a New Keynesian model with adaptive learning to study how imperfect knowledge of fiscal policy shapes inflation dynamics. Agents form beliefs about a fiscal rule, and the fiscal anchor is determined by the information they possess about its parameters. When the fiscal coefficients are known and monetary policy satisfies the Taylor principle, fiscal shocks are Ricardian and leave inflation and long-term expectations unchanged. When agents are uncertain about the fiscal rule, fiscal disturbances trigger a learning process that raises inflation and shifts long-horizon expectations—even under monetary dominance. Using U.S. data, I estimate the model and find that the fiscal policy shock, operating through learning about fiscal behavior, accounts for a sizable share of the post-COVID inflation surge.

1 Introduction

The central question of this paper is: under what informational conditions do fiscal expansions generate inflation? Recent U.S. experience presents a striking contrast. Despite historically large deficits in both episodes, the fiscal expansion during the Great Recession coincided with muted inflation, whereas the post-2021 stimulus was followed by a sharp and persistent rise in prices. Why did similarly large increases in public debt produce such different inflation outcomes?

Figure 1: Fiscal Expansion and Subsequent Inflation



Note: Inflation is year-over-year PCE (left axis). The fiscal impulse (right axis) is the surplus to debt ratio, scaled for visual comparison. Shaded regions correspond to the Great Recession (2008–11) and the post-COVID period (2020–23). The figure highlights that the 2008 fiscal expansion was not followed by rising inflation, whereas the 2020–21 fiscal expansions coincided with a significant and sustained increase in inflation.

One key difference lies in fiscal communication. During the Great Recession, policymakers repeatedly emphasized that the surge in deficits was temporary and would be reversed. As President Obama stated, "The massive deficit we've inherited will be temporary. Our plan is not to create more debt, but to put people back to work so we can pay that debt down." This explicit commitment to future consolidation provided guidance about how higher debt would ultimately be stabilized. By contrast, during the COVID crisis, fiscal policy was framed as open-ended emergency support. Press Secretary Jen Psaki described the legislation as "an emergency package… not designed for long-term deficit reduction." The absence of clear signals about future fiscal adjustment in 2020–21 left private agents uncertain about how rising debt would be managed. Cross-country evidence in the post-COVID period similarly points to a stronger link between fiscal expansions and inflation when fiscal backing is unclear (see Barro and Bianchi (2025)). These episodes suggest that fiscal expansions become inflationary not simply because deficits are large, but because expectations about future fiscal adjustment differ.

To formalize this mechanism, I develop a general-equilibrium New Keynesian model with adaptive learning and monetary–fiscal interactions in which fiscal policy follows a systematic rule. I depart from Eusepi and Preston (2018) by allowing households to be imperfectly informed about

the fiscal coefficients. This modification captures the idea that fiscal expectations may be anchored in some periods and unanchored in others. When fiscal parameters are known, fiscal shocks are Ricardian and inflation remains insulated. But when agents are uncertain about the fiscal rule, a fiscal expansion triggers a learning process that alters beliefs about future fiscal adjustment, raising inflation and shifting long-term expectations even when monetary policy satisfies the Taylor principle. In this environment, fiscal expansions become inflationary not because debt is high per se, but because agents are uncertain about whether and how it will ultimately be stabilized. This informational friction is absent in standard rational-expectations models, where the Taylor principle alone suffices to anchor long-run inflation expectations.

This paper is inherently concerned with how central banks anchor long-run inflation expectations and with the informational conditions under which such anchoring is sustained. When households understand the policy regime and correctly anticipate future fiscal adjustment, the economy collapses to a familiar benchmark in the monetary–fiscal literature. In particular, when agents know the functional form of policy rules and their slope coefficients while remaining uncertain about intercept terms, government debt carries no perceived net wealth effect. Higher debt today is expected to be offset by future fiscal adjustment, so Ricardian equivalence holds in the sense of Barro (1974). In this environment, the Taylor principle is sufficient to fully anchor long-run inflation expectations even under adaptive learning: monetary policy uniquely pins down the long-run price level, fiscal shocks are neutral for inflation beyond finite horizons, and the resulting learning equilibrium is E-stable.[1] This benchmark provides a useful point of reference, but it relies critically on agents understanding that fiscal policy systematically adjusts to stabilize government debt, even if some parameters must be learned from the data.

Once this informational assumption is relaxed, the same monetary policy rule is no longer sufficient to deliver Ricardian equivalence or to anchor long-run inflation expectations. When the fact that fiscal policy will ultimately stabilize government debt is outside households' information set, fiscal expansions generate perceived wealth effects, alter consumption–saving decisions, and induce belief updating about future fiscal adjustment. Inflation then responds endogenously to fiscal shocks, and long-run inflation expectations can drift in response to short-run developments even when monetary policy satisfies the Taylor principle. In this environment, anchoring is no longer guaranteed by policy rules alone but becomes an outcome of agents' evolving beliefs about fiscal behavior. Persistent fiscal disturbances can therefore reshape long-run expectations despite the presence of an active monetary policy and a stabilizing fiscal regime in the background.

This informational perspective helps reconcile standard theory with a growing body of empirical evidence showing that long-run inflation expectations are neither perfectly anchored nor invariant to short-run developments. Gürkaynak, Sack and Swanson (2005) document that long-maturity nominal yields respond systematically to macroeconomic and policy news, contradicting the prediction of rational-expectations models in which distant-horizon beliefs are predetermined by the policy regime. More recent evidence such as Coibion, Gorodnichenko and Weber (2021) indicates that this responsiveness extends to fiscal information. Households and professional forecasters revise long-run inflation expectations in response to news about public debt dynamics, fiscal sustainability, and policy narratives, suggesting that expectations are formed using a multivariate information set that includes beliefs about future fiscal adjustment. These patterns are difficult to rationalize in frameworks where fiscal backing is known and fully internalized.

[1] For detailed discussion of E-stability, see Evans and Honkapohja (2001).

The policy relevance of anchoring long-run inflation expectations has become increasingly clear in recent work. Nakamura, Riblier and Steinsson (2025) emphasize that the degree to which distant-horizon expectations remain anchored crucially determines the extent to which central banks can look through inflationary shocks. When long-run expectations are firmly anchored, monetary policy can accommodate transitory disturbances without generating persistent inflation. When they are not, similar shocks require much more aggressive policy responses. From this perspective, anchoring is not merely a background assumption but a key state variable for macroeconomic stabilization. The framework developed in this paper provides a mechanism through which anchoring itself becomes endogenous, emerging from agents' beliefs about fiscal behavior rather than being guaranteed by monetary policy alone.

The breakdown of Ricardian equivalence is at the heart of this paper. In the model, each household observes only its own objectives, constraints, beliefs, and a set of aggregate variables. Households are therefore heterogeneous in their information sets. When they lack sufficient knowledge about the fiscal policy rule, they do not internalize that future primary surpluses will adjust to stabilize outstanding liabilities. In this environment, agents do not enforce the government's intertemporal budget constraint through their expectations, and the price level must adjust to ensure fiscal solvency. This departure from rational expectations echoes a point emphasized by Moll (2025): in heterogeneous-agent settings, it is hard to believe that the aggregate expectation operator contains the information embodied in the full cross-section of household beliefs. By allowing agents to learn and potentially misperceive the fiscal rule, the model captures precisely this tension.

The distinction between monetary and fiscal dominance plays a central role in determining whether fiscal expansions generate inflation. Under monetary dominance, the central bank raises nominal interest rates more than one-to-one in response to inflation, and households internalize that higher current deficits will be offset by future primary surpluses. In this regime, fiscal shocks are "Ricardian": they do not create net wealth for households and inflation remains anchored. Under fiscal dominance, by contrast, future primary surpluses fail to adjust enough to stabilize debt. The government's intertemporal budget constraint must then be satisfied through movements in the price level, making inflation the mechanism that revalues nominal liabilities. This framework, formalized by Leeper (1991) among many others has proven useful for understanding inflationary fiscal episodes. Yet a key limitation is that the regime is assumed to be known and often time assumed to be fixed: households must correctly infer whether fiscal policy will adjust in the future or whether inflation will bear the burden of stabilizing debt.

A related strand of the literature emphasizes that the interaction between monetary and fiscal policy need not be governed by a fixed regime. Seminal contributions by Bianchi and Melosi (2013, 2019, 2017); Bianchi and Ilut (2017); Bianchi, Faccini and Melosi (2023) show that shifts in policy regimes, combined with rational expectations, can account for key features of postwar U.S. inflation dynamics. In these frameworks, agents perfectly infer the prevailing policy regime and form expectations accordingly, so that changes in beliefs about future fiscal adjustment transmit directly to inflation outcomes. This paper shares the view that expectations about fiscal policy are central, but differs in the mechanism through which they evolve. Rather than assuming rational regime inference, I allow households to be imperfectly informed about the fiscal policy rule and to learn about its parameters over time. This distinction is quantitatively important. Under imperfect knowledge, fiscal expansions can raise inflation even when monetary policy satisfies the Taylor principle the entire periods. At the same time, the model does not imply that higher public debt must be interpreted as an inflationary signal for long-run inflation or inflation expectations,

in contrast to the implication of fiscal-dominance regimes under rational expectations, which is thoroughly discussed in Bianchi and Ilut (2017).

Outside the representative-agent benchmark, Ricardian equivalence can break down even under monetary dominance. Heterogeneous-agent New Keynesian (HANK) models allow fiscal policy to redistribute resources across households with different marginal propensities to consume and save, generating nontrivial wealth effects and inflationary responses to fiscal shocks. Recent work by Angeletos, Lian and Wolf (2024) shows that these redistribution channels bring HANK models closer to the logic of the Fiscal Theory of the Price Level, while Hazell and Hobler (2024) estimate that the 2021 U.S. fiscal deficits account for a sizable share of the subsequent inflation. However, these frameworks typically maintain rational expectations and assume that households understand the fiscal policy rule and the future path of adjustment. As a result, long-run inflation expectations remain anchored by construction, even when short-run inflation responds to fiscal disturbances. In this sense, HANK models explain why fiscal policy can affect inflation, but not how fiscal behavior and fiscal uncertainty shape the anchoring of long-run expectations—a question that is central to current monetary policy debates.

In the following section, I present a stripped-down endowment economy, closely following Eusepi and Preston (2018), to isolate the mechanism through which imperfect knowledge of fiscal behavior influences inflation. Households are allowed to be imperfectly informed about the fiscal policy rule and to form beliefs using least-squares learning.When agents possess full knowledge of the fiscal rule up to its coefficients, the model reproduces the Ricardian result emphasized by Eusepi and Preston: fiscal expansions carry no perceived wealth effects, and inflation remains insulated. By contrast, when households are uncertain about the fiscal coefficients and update beliefs through recursive least squares or constant-gain learning as in Milani (2007), fiscal expansions become inflationary. This generalizes Preston (2005)'s insight that limited knowledge induces households to treat part of a fiscal disturbance as permanent through a signal-extraction problem. The study closest to this paper is Eusepi and Preston (2012), though I adopt a different conceptual stance. Whereas they define fiscal expectations as anchored when household beliefs are consistent with the aggregate intertemporal government budget constraint, I define fiscal anchoring as a state in which households possess sufficient information about the fiscal rule itself, so that fiscal shocks are perceived as Ricardian.

This simple model delivers two central predictions. First, as long as agents perceive a positive relationship between debt and future primary surpluses, their long-run beliefs about debt are deflationary: higher long-run debt signals stronger expected fiscal adjustment, exerting downward pressure on current inflation and long-horizon inflation expectations. This result does not rely on Ricardian equivalence holding in the aggregate, but only on this sign restriction in beliefs. Second, when fiscal shocks are persistent, learning induces a positive short-run co-movement between inflation and long-run debt beliefs and can further de-anchor long-term inflation expectations. Together, these dynamics underscore the central role of fiscal information in shaping inflation outcomes and motivate the empirical and structural analyses that follow.

A second contribution of the paper is empirical. A broad class of models with monetary–fiscal interactions including the framework developed here naturally implies a long-run cointegration relationship among inflation, long-term inflation expectations, interest rates, fiscal surpluses, and public debt. This structure arises independently of whether Ricardian equivalence holds and reflects the joint determination of nominal dynamics and fiscal beliefs in the long run. To assess these implications in the data, I extend the trend–cycle decomposition of Del Negro, Giannone,

Giannoni and Tambalotti (2017) by imposing the cointegration structure implied by this class of models.

The estimation reveals that the long-run debt trend contributes negatively to both U.S. inflation and long-term inflation expectations. Rather than acting as an inflationary force, higher projected public debt is interpreted as signaling future fiscal adjustment, which dampens expected demand and exerts downward pressure on inflation. This finding stands in sharp contrast to the predictions of fiscal-dominance regimes under rational expectations, in which increases in unbacked debt must load positively onto long-run inflation and inflation expectations. Instead, the evidence supports the mechanism emphasized in this paper, whereby imperfectly anchored fiscal beliefs break the tight positive link between public debt and long-run inflation outcomes, even though fiscal expansions can still be inflationary. Motivated by this evidence, I then develop a structural model to identify fiscal policy shocks and to quantify their effects on inflation and inflation expectations in environments with imperfectly anchored fiscal beliefs.

2 An Endowment Economy

To build intuition for the main mechanism, I present a simple endowment economy with imperfect knowledge based on Eusepi and Preston (2018). In this environment, a fiscal expansion can become inflationary through its effect on optimal consumption decisions and long-horizon expectations when households are uncertain about the fiscal rule. The mechanism is similar in spirit to Bianchi and Melosi (2013), but distinct in that inflation arises not from regime switching, but from households' incomplete knowledge of fiscal policy.

The exercise also connects to Eusepi and Preston (2012), who formally define a fiscal anchor; I adopt their concept but offer a different interpretation by emphasizing the information that households possess about the fiscal coefficients. This perspective is related to discussion of fiscal expectation anchoring in Leeper (2009) and clarifies what constitutes a fiscal anchor in my setting. When fiscal expectations are anchored in this sense, long-term inflation expectations remain unresponsive to fiscal policy shocks; when they are not, a fiscal expansion triggers belief updating that raises inflation.

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

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

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).

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

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

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

$$\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} c_T(i) = \hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} y_T(i) + \delta \left(b_{t-1}(i) - \pi_t - \hat{E}_t^i \left[\sum_{T=t}^{\infty} \beta^{T-t} \{(1-\beta) s_T(i) - \beta (R_T - \pi_{T+1})\} \right] \right) \tag{4}$$

To get the optimal consumption, iterate the Euler equation forward

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

Substitute this into the (4) to get the optimal consumption in spirit of the permanent income

$$\begin{aligned} c_t(i) &= (1-\beta) \hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} y_T(i) - \frac{\beta}{\sigma} \hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} (R_T - \pi_{T+1}) \\ &+ (1-\beta) \delta \left(b_{t-1}(i) - \pi_t - \hat{E}_t^i \left[\sum_{T=t}^{\infty} \beta^{T-t} \{(1-\beta) s_T(i) - \beta (R_T - \pi_{T+1})\} \right] \right) \end{aligned} \tag{5}$$

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

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

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 both correct functional form and parameters. How much agents know about the policy constitute the degree of "anchoring", which is consistent with the definition in Eusepi and Preston (2010). To isolate the effect of a fiscal policy shock, 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 Aggregate Dynamics

Following Eusepi and Preston (2018), I study a symmetric equilibrium where all households are identical but they do not know this is the case. Because households have identical initial asset holdings, preferences, endowment, taxes, and information sets while facing the same constraints, they make identical state-contingent decisions. 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

$$
\begin{aligned}
c_t &= \underbrace{(1-\beta)\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t} y_T - \frac{\beta}{\sigma}\hat{E}_t \sum_{T=t}^{\infty} \beta^{T-t}\left(R_T - \pi_{T+1}\right)}_{\text{Permanent Income}} \\
&\quad \underbrace{+(1-\beta)\,\delta\left(b_{t-1} - \pi_t - \hat{E}_t\left[\sum_{T=t}^{\infty} \beta^{T-t}\left\{(1-\beta)\,s_T - \beta\left(R_T - \pi_{T+1}\right)\right\}\right]\right)}_{\text{Wealth Effect of Fiscal Policy}} \qquad (6) \\
R_t &= \phi_\pi \pi_t \qquad (7) \\
s_t &= \phi_b b_{t-1} + \varepsilon_t^{FP} \qquad (8) \\
b_t &= \beta^{-1}\left(1-(1-\beta)\,\phi_b\right) b_{t-1} - \left(\beta^{-1} - \phi_\pi\right)\pi_t - \beta^{-1}(1-\beta)\,\varepsilon_t^{FP}. \qquad (9)
\end{aligned}
$$

Following Eusepi and Preston (2018),

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

is defined as the perceived wealth effect.

Under the rational expectation the wealth effect becomes precisely zero. This can be seen from that the representative household's intertemporal budget constraint coincides with the government intertemporal budget constraint after imposing the market clearing condition

$$
\begin{aligned}
b_{t-1} &= \mathbb{E}_t\left[\delta^{-1}\sum_{T=t}^{\infty}\beta^{T-t}\left(c_T - y_T\right) + \pi_t + \sum_{T=t}^{\infty}\beta^{T-t}\left\{(1-\beta)\,s_T - \beta\left(R_T - \pi_{T+1}\right)\right\}\right] \\
&= \pi_t + \mathbb{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{(1-\beta)\,s_T - \beta\left(R_T - \pi_{T+1}\right)\right\}\right]
\end{aligned}
$$

By taking the difference between the two, we see that

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

at the equilibrium. Note that in rational expectation, $\pi_t = 0$ at the equilibrium in the current environment.

2.5 Subjective Beliefs

To close the model, the subjective beliefs need to be specified. This amounts to be pinning down the infinite horizon expectations in (6). I assume that average beliefs can be represented by

$$
\begin{aligned}
\begin{pmatrix} \pi_t \\ R_t \\ s_t \\ b_t \end{pmatrix} &= \bar{\omega}_t + \Phi_t \begin{pmatrix} \pi_{t-1} \\ R_{t-1} \\ s_{t-1} \\ b_{t-1} \end{pmatrix} + e_t \qquad (10) \\
\bar{\omega}_{t+1} &= \bar{\omega}_t + u_{t+1}, \qquad (11)
\end{aligned}
$$

where prior beliefs about transitory shocks and innovations to the low-frequency components satisfy $\Sigma = E[e_t e_t']$ and $E[u_t u_t'] = \bar{g}^2\Sigma$ for some constant $0 < \bar{g} < 1$. $\bar{\omega}_t$ can be interpreted as the long-run uncertainties that agents are facing while Φ_t summarizes more short-run uncertainties. Specifying the subjective beliefs is equivalent to choose how agents do or do not update $\bar{\omega}_t$ and Φ_t. I will study three cases, the rational expectation, the subjective beliefs used in Eusepi and Preston (2018), and the more general subjective belief I will use throughout the paper.[2]I discuss these subjective beliefs specifically focusing on the endogenous connection between fiscal policy shocks, long-term inflation expectations, and inflation.

Following the literature of adaptive learning, I also employ the anticipated utility approach Kreps (1998). Households do not take into account the possibility that they will update their beliefs into account when they form expectations for the optimal decision. This implies that the beliefs summarized by $\bar{\omega}_t$ and Φ_t are state variable, introducing another type of information friction into the model, which derives the aggregate dynamics.

3 Aggregate Dynamics with Different Subjective Beliefs

3.1 Full Information and Rational Expectation

In the full information and rational expectation, households know the true data generating process. This implies $\bar{\omega}_t = 0$ and

$$\Phi_t = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_b \\ 0 & 0 & 0 & \beta^{-1}(1-(1-\beta)\phi_b) \end{pmatrix} \equiv \Phi^*$$

for all t. The optimal consumption decision for the representative household becomes

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

Imposing the market clearing condition $c_t = y_t$ to get

$$\pi_t = -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}(1-\beta\phi_\pi)\mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t}\pi_{T+1}$$

In the second inequality, I use the fact that the household internalizes the Ricardian equivalence so that the last term is precisely 0 as well as that they know the monetary policy rule $R_t = \phi_\pi\pi_t$.

[2]I also use the subjective beliefs in Eusepi et al. (2020). This has an advantage that the model exhibits a simple closed form solution while the general implication is mostly consistent with the general subjective belief case. See appendix for the further discussion.

By quasi-differentiating the equation and use the law of iterated expectation,

$$\begin{aligned}
\pi_t &= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}\mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t}(1-\beta\phi_\pi)\pi_{T+1} \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}(1-\beta\phi_\pi)\mathbb{E}_t\pi_{t+1} + \phi_\pi^{-1}(1-\beta\phi_\pi)\beta^{-1}\mathbb{E}_t\mathbb{E}_{t+1}\sum_{T=t+1}^{\infty}\beta^{T-t}\pi_{T+1} \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}(1-\beta\phi_\pi)\mathbb{E}_t\pi_{t+1} + \beta\mathbb{E}_t\pi_{t+1} \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}\mathbb{E}_t\pi_{t+1}
\end{aligned}$$

Notice two things: This is exactly the aggregate Euler equation after imposing the market clearing condition $c_t = y_t$. To arrive at this result, I need the "aggregate" law of iterated expectation $\mathbb{E}_t\mathbb{E}_{t+1} = \mathbb{E}_t$, indicating that the household must know the data generating process, which is not necessarily true for an arbitrary belief as pointed out by Preston (2005) and Adam and Marcet (2011).

I solve it by the forward integration to obtain the unique and bounded solution.

$$\begin{aligned}
\pi_t &= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}\mathbb{E}_t\pi_{t+1} \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-1}\mathbb{E}_t\left[-\sigma\phi_\pi^{-1} y_{t+1} + \phi_\pi^{-1}\mathbb{E}_{t+1}\pi_{t+2}\right] \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-2}\mathbb{E}_t\mathbb{E}_{t+1}\pi_{t+2} \\
&= -\sigma\phi_\pi^{-1} y_t + \phi_\pi^{-2}\mathbb{E}_t\pi_{t+2} \\
&\vdots \\
&= -\sigma\phi_\pi^{-1} y_t + \lim_{T\to\infty}\phi_\pi^{-T}\mathbb{E}_t\pi_{t+T} \\
&= -\sigma\phi_\pi^{-1} y_t.
\end{aligned}$$

The debt dynamics is backward stable

$$\begin{aligned}
b_t &= b_{t-1} - \pi_t + \beta R_t - (1-\beta)s_t \\
&= \beta^{-1}(1-(1-\beta)\phi_b)b_{t-1} - \left(\beta^{-1}-\phi_\pi\right)\pi_t - \beta^{-1}(1-\beta)\varepsilon_t^{FP} \\
&= \beta^{-1}(1-(1-\beta)\phi_b)b_{t-1} - \sigma\phi_\pi^{-1}\left(\phi_\pi - \beta^{-1}\right)y_t - \beta^{-1}(1-\beta)\varepsilon_t^{FP}
\end{aligned}$$

The long-term inflation expectation is independent of fiscal policy and well-anchored at the target

$$\lim_{T\to\infty}\mathbb{E}_t[\pi_T] = 0$$

3.2 Long-Run Uncertainties and Ricardian Equivalence

Eusepi and Preston (2018) allow the departure of long-term expectations from the rational expectation. The average beliefs can be described as

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

This is a special case of the subjective belief defined above, $\Phi_t = \Phi^*$ for all t while $\bar{\omega}_t \neq 0$ in general. The subjective belief can be represented by

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

Agents use the steady state Kalman filter to update their beliefs

$$\begin{aligned}
\omega^{\pi}_{t+1} &= \omega^{\pi}_t + \bar{g}\left(\pi_t - \omega^{\pi}_t\right) \\
\omega^{s}_{t+1} &= \omega^{s}_t + \bar{g}\left(s_t - \omega^{s}_t - \phi_b b_{t-1}\right) \\
\omega^{b}_{t+1} &= \omega^{b}_t + \bar{g}\left[b_t - \omega^{b}_t - \beta^{-1}\left(1-(1-\beta)\phi_b\right) b_{t-1}\right].
\end{aligned}$$

Here, the critical assumption is that the only uncertainty that agents face is the long-run objective of policy and they cannot disentangle persistent shocks $\bar{\omega}_t$ and transitory shocks e_t. For expositional purpose, I assume that agents form their interest rate expectations by $\omega^R_t = \phi_\pi \omega^{\pi}_t$, which implies that R_t drops out of the state vector Z_t.

Recall that the optimal consumption is characterized by

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

The subjective beliefs imply that

$$\begin{aligned}
b_t &= \omega^{b}_t + \beta^{-1}\left(1-(1-\beta)\phi_b\right) b_{t-1} \\
\Leftrightarrow \beta b_t &= \beta \omega^{b}_t + b_{t-1} - (1-\beta)\phi_b b_{t-1} \\
\Leftrightarrow \phi_b b_{t-1} &= (1-\beta)^{-1} \beta \omega^{b}_t + (1-\beta)^{-1} b_{t-1} - (1-\beta)^{-1} \beta b_t, \qquad (12)
\end{aligned}$$

where I drop the shock as $\hat{E}_t e_T = 0$ for $T > t$. Notice that I use the fact that agents know the debt dynamics up to the drift. Using the expression (12), households believe that fiscal policy rule is

$$\begin{aligned}
s_t &= \omega^{s}_t + \phi_b b_{t-1} \\
&= \omega^{s}_t + (1-\beta)^{-1} \beta \omega^{b}_t + (1-\beta)^{-1} b_{t-1} - (1-\beta)^{-1} \beta b_t
\end{aligned}$$

Again, agents need to know the fiscal policy function up to the drift. Iterate forward to see;

$$\begin{aligned}
s_{t+1} &= \omega^{s}_{t+1} + (1-\beta)^{-1} \beta \omega^{b}_{t+1} + (1-\beta)^{-1} b_t - (1-\beta)^{-1} \beta b_{t+1} \\
\hat{E}_t s_{t+1} &= \omega^{s}_t + (1-\beta)^{-1} \beta \omega^{b}_t + (1-\beta)^{-1} b_t - (1-\beta)^{-1} \beta \omega^{b}_t,
\end{aligned}$$

which implies that

$$\begin{aligned}
\beta \hat{E}_t s_{t+2} &= \beta \omega^{s}_t + (1-\beta)^{-1} \beta^2 \omega^{b}_t + (1-\beta)^{-1} \beta \omega^{b}_t - (1-\beta)^{-1} \beta^2 \omega^{b}_t \\
\beta^2 \hat{E}_t s_{t+3} &= \beta^2 \omega^{s}_t + (1-\beta)^{-1} \beta^3 \omega^{b}_t + (1-\beta)^{-1} \beta^2 \omega^{b}_t - (1-\beta)^{-1} \beta^3 \omega^{b}_t
\end{aligned}$$

Because last terms are cancelling out

$$\begin{aligned}(1-\beta)\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}s_{T+1} &= (1-\beta)\sum_{T=t}^{\infty}\beta^{T-t}\left(\omega_t^s+(1-\beta)^{-1}\beta\omega_t^b\right)+b_t \\ &= \omega_t^s+(1-\beta)^{-1}\beta\omega_t^b+b_t \end{aligned} \tag{13}$$

Note that

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

can be rewritten as

$$b_{t-1}-\pi_t-(1-\beta)s_t-\beta R_t-\beta\hat{E}_t\left[\sum_{T=t}^{\infty}\beta^{T-t}\left\{(1-\beta)s_{T+1}-\left(\beta R_{T+1}-\pi_{T+1}\right)\right\}\right].$$

Combining with the government budget constraint to get

$$\beta b_t-\beta(1-\beta)\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}s_{T+1}+\beta\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)$$

Substitute the expression (13) to get

$$\beta b_t-\beta\left(\omega_t^s+(1-\beta)^{-1}\beta\omega_t^b+b_t\right)+\beta\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right),$$

which reduces to

$$-\left(\beta\omega_t^s+(1-\beta)^{-1}\beta^2\omega_t^b\right)+\frac{\beta}{1-\beta}\left(\beta\phi_\pi-1\right)\omega_t^\pi$$

Combining with the optimal consumption decision rule to get

$$\begin{aligned} c_t &= (1-\beta)y_t-\frac{\beta}{\sigma}\phi_\pi\pi_t-\frac{\beta}{\sigma(1-\beta)}\left(\beta\phi_\pi-1\right)\omega_t^\pi \\ &+ (\beta-1)\delta\left[\left(\beta\omega_t^s+(1-\beta)^{-1}\beta^2\omega_t^b\right)-\frac{\beta}{1-\beta}\left(\beta\phi_\pi-1\right)\omega_t^\pi\right] \end{aligned} \tag{14}$$

Imposing an equilibrium condition $c_t=y_t$ and solving for the inflation to get

$$\pi_t=-\frac{\beta-\phi_\pi^{-1}}{1-\beta}\omega_t^\pi-\sigma\phi_\pi^{-1}y_t+n_{w,t}, \tag{15}$$

where

$$n_{w,t}=\sigma\delta\left(\beta-\phi_\pi^{-1}\right)\omega_t^\pi+\sigma\delta\phi_\pi^{-1}\beta(\beta-1)\left(\omega_t^s+(1-\beta)^{-1}\beta\omega_t^b\right)$$

represents the perceived wealth effect conditional on the subjective beliefs.

The following proposition restates one of findings in Eusepi and Preston (2018).

Proposition 1. *Fiscal policy shocks, ε_t^{FP}, do not lead to any perceived wealth effects and inflation. After an unexpected fiscal policy shock, $\varepsilon_t^{FP}\neq 0$, $\pi_T=n_{w,T}=0$ in every period $T\geq t$. Therefore, there is no revision of long-term inflation expectations following a fiscal policy shock: households are Ricardian.*

Proof. Assume that $\omega_t^{\pi} = \omega_t^s = \omega_t^b = 0$. This is without the loss of generality. Recall that the true data generating process for the fiscal block is

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

From (15), the fiscal policy shock has no contemporaneous impacts on inflation. Therefore $\pi_t = n_{w,t} = 0$. Moreover from the steady state Kalman filter

$$\begin{aligned} \omega_{t+1}^s &= \bar{g}\varepsilon_t^{FP} \\ \omega_{t+1}^b &= -\bar{g}\beta^{-1}(1-\beta)\varepsilon_t^{FP} \end{aligned}$$

Substitute these expressions into the perceived wealth effect to see

$$\begin{aligned} \omega_{t+1}^s + (1-\beta)^{-1}\beta\omega_{t+1}^b &= \bar{g}\varepsilon_t^{FP} - (1-\beta)^{-1}\beta\bar{g}\beta^{-1}(1-\beta)\varepsilon_t^{FP} \\ &= \bar{g}\varepsilon_t^{FP} - \bar{g}\varepsilon_t^{FP} \\ &= 0. \end{aligned}$$

Thus, $\pi_T = n_{w,T} = 0$, $T > t$. □

Knowing the policy regime implies the following. Although households do not know that the drift terms $\bar{\omega}_t$ are identically zero, they understand the structure of fiscal policy: any tax cut today is exactly offset by higher future debt. Because the fiscal regime is known, households also know that increases in debt will not be accommodated by inflation. As a result, fiscal policy shocks do not generate perceived wealth effects, long-run inflation expectations remain unchanged, and inflation does not respond. In this sense, fiscal expectations are fully anchored, and fiscal policy remains Ricardian despite agents' imperfect information about long-run policy objectives. This is a strong result, implying that $\varepsilon_t^{FP} = 0$ can be assumed, for all t to study the inflation dynamics in this economy without loss of generality.

Now the dynamics of this economy is summarized by

$$\begin{aligned} \pi_t &= -\frac{\beta-\phi_\pi^{-1}}{1-\beta}\omega_t^{\pi} - \sigma\phi_\pi^{-1}y_t + \sigma\delta\left(\beta-\phi_\pi^{-1}\right)\omega_t^{\pi} + \sigma\delta\phi_\pi^{-1}(\beta-1)\left(\omega_t^s + (1-\beta)^{-1}\beta\omega_t^b\right) \\ b_t &= \beta^{-1}\left(1-(1-\beta)\phi_b\right)b_{t-1} - \left(\beta^{-1}-\phi_\pi\right)\pi_t, \end{aligned}$$

and updating rules for beliefs. E-stability condition is obtained from the ordinary differential equation (ODE) for beliefs

$$\frac{\partial\omega}{\partial t} = (T-I)\,\omega,$$

where

$$T - I = \begin{pmatrix} \Gamma_1 - 1 & -\sigma\delta\beta\phi_\pi^{-1} \\ -\left(\beta^{-1}-\phi_\pi\right)\Gamma_1 & \left(\beta^{-1}-\phi_\pi\right)\sigma\delta\beta\phi_\pi^{-1} - 1 \end{pmatrix}$$

with

$$\Gamma_1 = \frac{\beta-\phi_\pi^{-1}}{1-\beta} + \sigma\delta\left(\beta-\phi_\pi^{-1}\right).$$

The E-stability requires

$$\frac{\phi_\pi - 1}{\phi_\pi (\beta - 1)} < 0,$$

which coincides with the Taylor principle, $\phi_\pi > 1$.

Proposition 2. *When households know the fiscal policy up to its slope parameters, the Taylor principle is sufficient to ensure the Ricardian equivalence as well as fully anchor the long-run inflation expectations, achieving the expectational stability.*

.

3.3 Policy Regime Uncertainties and the Breakdown of Ricardian Equivalence

In this section, I employ the recursive least squares learning with a constant gain to show that fiscal policy shocks cease to be Ricardian when households are uncertain about the policy regimes.[3]

Given the belief structure, the fiscal anchor of long-term inflation expectations is determined by the information households possess about the fiscal policy rule. When households are uncertain about the fiscal policy rule, a fiscal policy shock triggers the learning process and de-anchor the long run expectations. I, then, study how temporary but persistent fiscal policy shocks that raises both debt and deficits can erode the fiscal anchor and affect long-term inflation expectations and inflation dynamics. (Discuss this is consistent with Cram, Kung and Lustig (2025) learning assumption).

The average subjective belief of households takes the general form:

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

where

$$\tilde{\Phi}_t = \begin{pmatrix} \varphi_{\pi\pi} & \varphi_{\pi R} & \varphi_{\pi s} & \varphi_{\pi b} \\ \varphi_{R\pi} & \varphi_{RR} & \varphi_{Rs} & \varphi_{Rb} \\ \varphi_{s\pi} & \varphi_{sR} & \varphi_{ss} & \varphi_{sb} \\ \varphi_{b\pi} & \varphi_{bR} & \varphi_{bs} & \varphi_{bb} \end{pmatrix}.$$

Given the prior belief of households Φ_1. For exposition, I suppress the time dimension in each estimated parameters. The perceived relationship between surpluses and lagged debt, φ_{sb} indicated by red, determines the correlation between debt and inflation in the long run. Households'

[3] I present another example following the subjective belief used in Eusepi et al. (2020). The subjective belief used here is admittedly restrictive because it is equivalent to assume that households have a dogmatic prior $\Phi = \mathbf{0}$ throughout the time. This has been done for expositional simplicity and I use it later whenever it is convenient.

expectations in period T can be described as

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

Note that when households form expectation, they treat $\bar{\omega}_t$ and $\tilde{\Phi}_t$ as parameters based on the anticipated utility approach, Kreps (1998). The assumption is standard in the learning literature as this effectively circumvent the discussion of $\hat{E}_t \bar{\omega}_T$ and $\hat{E}_t \tilde{\Phi}_T$ for $T > t$ as the law of iterated expectation does not hold in general with subjective beliefs.

By taking the expectation conditional on the information available at period t, the forecasts become

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

I assume the constant gain learning as Milani (2007) to capture the structural changes. Learning about intercepts matters also as households cannot reduce infinite horizon problem due to their lack of knowledge about the model.

The updating rule is described by

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

where $\Psi_t = \begin{pmatrix} \bar{\omega}_t' & vec\left(\tilde{\Phi}_t\right)' \end{pmatrix}'$ and $X_t = \begin{Bmatrix} \mathbf{1} & Z_{t-1} \end{Bmatrix}_0^{t-1}$.

The expectations are determined by

$$\hat{E}_t Z_T = \left(I_4 - \tilde{\Phi}_t\right)^{-1} \left(I_4 - \tilde{\Phi}_t^{T-t+2}\right) \bar{\omega}_t + \tilde{\Phi}_t^{T-t+2} Z_{t-1} \tag{16}$$

with updating of the unknown parameters

$$\Psi_t = \Psi_{t-1} + \bar{g} \Omega_{t-1}^{-1} X_t \left(Z_t - X_t' \Psi_{t-1}\right) \tag{17}$$

$$\Omega_t = \Omega_{t-1} + \bar{g} \left(X_t X_t' - \Omega_{t-1}\right) \tag{18}$$

This system of equations characterize the equilibrium conditions. An important difference from the rational expectation equilibrium is that how expectations are formed (16) must be specified on top of the actual law of motion as households are unaware of it.

Proposition 3. *When fiscal expectations are initially anchored, so that households' beliefs satisfy* $\bar{\omega}_1 = 0$ *and* $\tilde{\Phi}_1 = \Phi^*$*, fiscal policy shocks remain Ricardian, and the conclusions of Proposition 2 apply. When fiscal expectations are unanchored,* $\tilde{\Phi}_1 \neq \Phi^*$*, fiscal policy shocks are no longer Ricardian. A fiscal disturbance* ε_t^{FP} *alters households' beliefs about long-run fiscal adjustment, leading to a shift in long-term inflation expectations* ω_T^{π}*.*

Proof. See the appendix. □

I define the fiscal expectation is anchored when households are endowed with the correct initial beliefs

$$\tilde{\Phi}_t = \Phi^*.$$

This definition is inspired by Eusepi and Preston (2012). While they define the anchored fiscal expectation as the aggregate expectation being consistent with the government intertemporal budget constraint, the definition is relaxed here. Both definitions are sufficient to ensure the Ricardian equivalence.

To compute the inflation dynamics, I rearrange

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

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

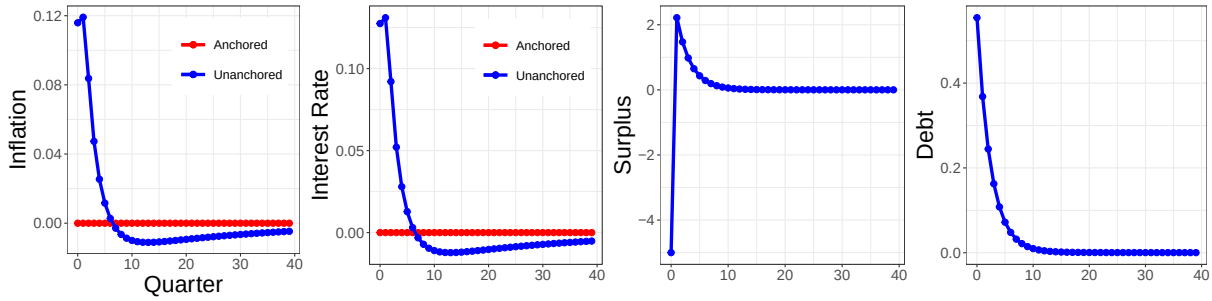
$$\pi_t = \varphi_1 b_{t-1}-\left(1-\beta\right)\varphi_2\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}s_{T+1}-\left(1-\beta\right)\varphi_3\hat{E}_t\sum_{T=t}^{\infty}\beta^{T-t}\left(\beta R_{T+1}-\pi_{T+1}\right)-\varphi_4\varepsilon_t^{FP} \quad (19)$$

3.3.1 Fiscal Anchor and Impulse Responses

I consider a fiscal expansion of 5 percentage points, that is, a fiscal policy shock of $\varepsilon_1^{FP} = -5$. I report impulse response functions to this shock under initial beliefs $\bar{\omega}_1 = 0$ and $\tilde{\Phi}_1 = \mathbf{0}$.[4] In this context, fiscal expectations are said to be unanchored when households do not know the fiscal policy coefficients governing future taxes and surpluses, and therefore treat the fiscal expansion as potentially persistent. By contrast, fiscal expectations are anchored when households correctly understand these fiscal coefficients and anticipate future adjustment consistent with government solvency.

The key contrast between anchored and unanchored fiscal expectations emerges in inflation dynamics and households' consumption–saving decisions. Following the fiscal expansion, inflation rises on impact when fiscal expectations are unanchored because households expect part of the increase in income to be permanent. This perceived permanence reduces aggregate saving and raises current demand. When fiscal expectations are anchored, households anticipate future fiscal consolidation and adjust saving accordingly, which dampens inflationary pressures as shown in Proposition 1.

Figure 2: Dynamics with the Recursive Learning

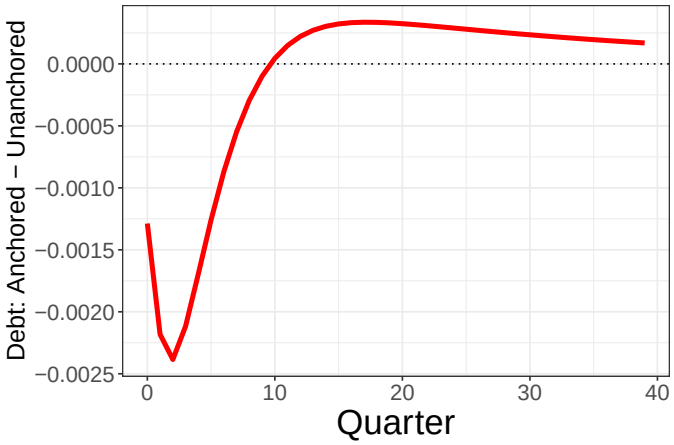


The importance of fiscal expectations is especially transparent in the dynamics of government debt. To isolate this mechanism, I compute the difference in debt dynamics between the unanchored and anchored cases. The resulting difference is negative on impact, indicating lower saving when fiscal expectations are unanchored. This reflects the temporary perception of government debt as net wealth, contrary to Barro (1974), arising from households' uncertainty about future fiscal adjustment.

Over time, as households infer the fiscal coefficients from observed policy behavior and learn that the government runs future surpluses to stabilize debt, fiscal expectations gradually re-anchor. As a result, saving rises relative to the anchored benchmark, and the initial divergence in debt dynamics fades. These dynamics underscore that it is not the size of the fiscal expansion per se, but the degree to which fiscal expectations are anchored, that governs the magnitude and persistence of inflationary effects.

[4]This initial beliefs is consistent with trend-cycle decomposition, which is specified in the appendix.

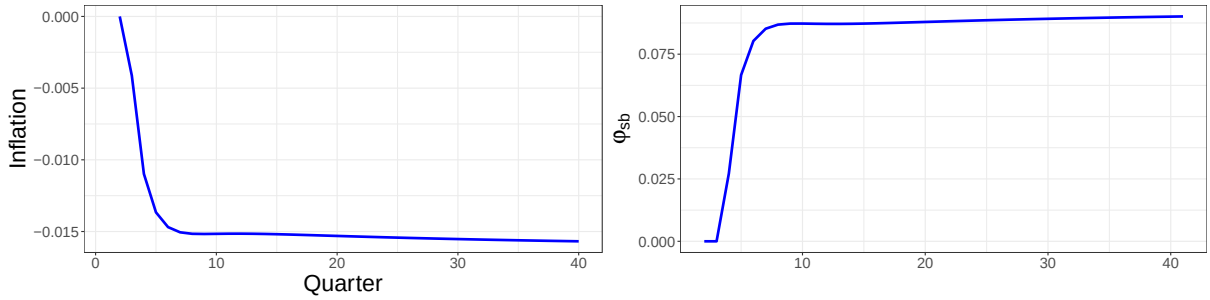
Figure 3: Debt Dynamics: Anchored - Unanchored



3.3.2 The Cointegration and the Persistence of the Shock

This subsection studies how evolving beliefs about long-run public debt affect current inflation, rather than the unconditional relationship between debt and prices.

Figure 4: The Fiscal Anchor of Long-term Inflation Expectations



The left panel illustrates the marginal effect of long-run debt beliefs, ω_t^b, on contemporaneous inflation following a fiscal policy shock. I compute this object by perturbing ω_t^b by one unit and measuring the resulting change in inflation on impact. Formally, this approximates

$$\frac{\partial \pi_t}{\partial \omega_t^b}.$$

When fiscal policy shocks are i.i.d., this marginal effect is negative: higher perceived long-run debt exerts downward pressure on current inflation. The mechanism is belief-driven. Households interpret higher long-run debt as signaling future fiscal adjustment, which lowers expected future disposable income, increases saving, and dampens current inflationary pressures. Importantly, this result does not imply that debt and inflation are negatively related in the long run; it reflects a conditional, contemporaneous response of inflation to beliefs about long-run debt.

This deflationary channel hinges on households' perceived fiscal response, summarized by the estimated coefficient φ_{sb}, shown in the right panel. As long as households believe that higher debt will be met with future adjustment, long-run debt beliefs act as a stabilizing force for inflation.

Remark 1. A persistent fiscal policy shock can erode the fiscal anchor further, leading to the positive association between higher long-term debt beliefs and higher inflation despite the policy regime in place is active money and passive fiscal.

To see this, I introduce the persistence to the fiscal policy shocks, so

$$\varepsilon_t^{FP} = \alpha^{FP}\varepsilon_{t-1}^{FP}.$$

In the baseline simulation, I set $\alpha^{FP} = 0.95$. I show the impulse response function of one percentage point increase in deficit, how additional unit of long-term debt expectation affects the inflation dynamics, and how the fiscal anchoring evolves after the shock.

Figure 5: Dynamics with the Recursive Learning

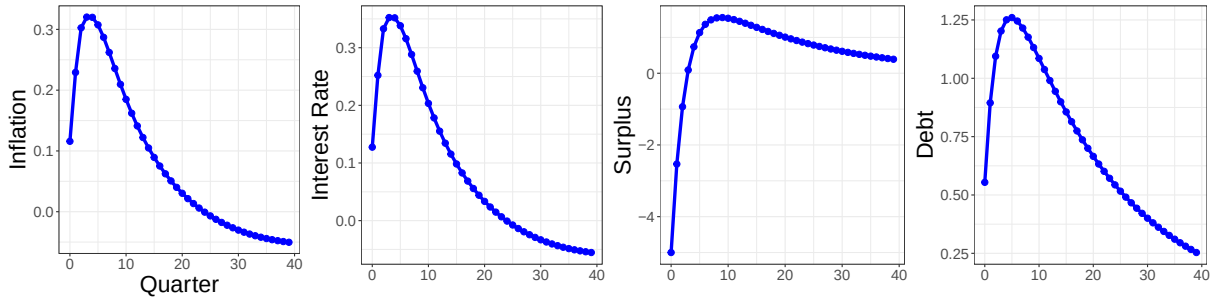
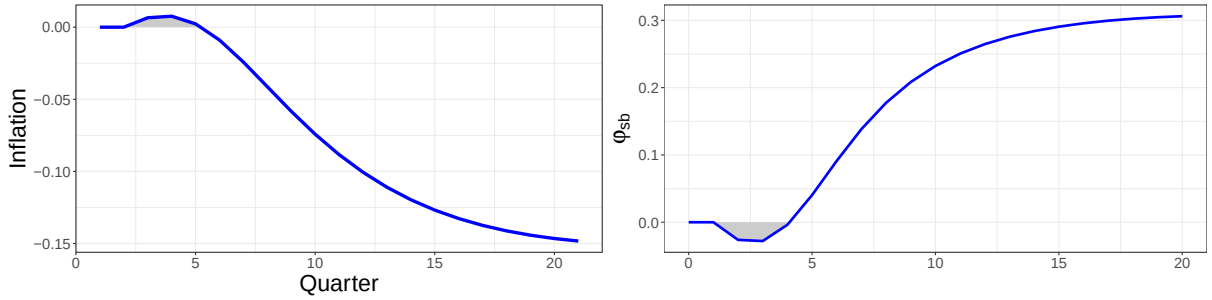


Figure 6: The Fiscal Anchor of Long-term Inflation Expectations



Note: The left figure shows how an additional unit of long-term debt expectation affect the inflation dynamics. The shaded area highlights that the higher long-run debt expectation is associated with the higher inflation. The right figure depicts the evolution of the fiscal anchor. Because the fiscal policy shock is persistent, the fiscal anchor deteriorates initially, which is highlighted in grey.

The shaded area indicates the periods in which higher debt beliefs are associated with the higher realized inflation $\frac{\partial \pi_t}{\partial \omega_t^b} > 0$,which precisely coincide with the period in which households perceive the higher levels of debt result in higher deficits.

3.3.3 De-Anchoring of Long Run Expectations

So far, I have focused on how fiscal policy shocks affect inflation and macroeconomic dynamics at finite horizons. I now shift attention to a distinct but closely related channel: how fiscal shocks

reshape agents' beliefs about the long run. Rather than asking how inflation responds today or tomorrow, I ask how fiscal policy alters households' perceptions of the long-run nominal and fiscal anchor itself.

To see this, I study the dynamics of long-term expectations. More specifically

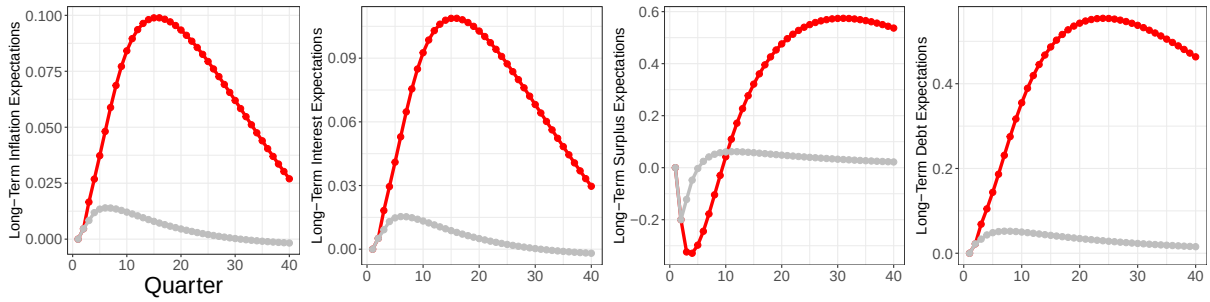
$$\lim_{T\to\infty} \hat{E}_t Z_T = \left(I_4 - \tilde{\Phi}_t\right)^{-1} \bar{\omega}_t.$$

This object captures the evolution of perceived long-run fundamentals. Any deviation of $\lim_{T\to\infty} \hat{E}_t Z_T$ from zero reflects a change in agents' beliefs about the economy's long-run nominal and fiscal environment, rather than a temporary response to cyclical shocks. Under rational expectations, long-run expectations are perfectly anchored. Fiscal shocks, regardless of their size or persistence, do not affect the long-run beliefs. This follows mechanically from the fact that the perceived drift term $\bar{\omega}_t$ is identically zero and the transition matrix is stable.

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

De-anchoring is therefore ruled out by construction in the rational-expectations benchmark. With learning, fiscal shocks affect beliefs not only through current realizations, but through how agents update their perceived long-run drift $\bar{\omega}_t$ and policy parameters $\tilde{\Phi}_t$. Even purely transitory fiscal shocks can therefore generate non-zero long-run expectations if they are interpreted as informative about long-run policy regimes.

Figure 7: Long-Term Expectations $\lim_{T\to\infty} \hat{E}_t Z_T$



Note: The grey line represents the impulse response functions of long-term expectations when the fiscal shock is i.i.d., while the red line represents the impulse response functions when the fiscal shock is persistent. The magnitude and the persistence of the shock is specified above.

Remark 2. When households lack sufficient knowledge about the fiscal policy rule, fiscal policy shocks can de-anchor long-term inflation expectations through the learning process. More persistent shocks lead to larger and more persistent movements in long-run beliefs.

Importantly, while higher perceived long-run debt is typically associated with lower inflation and lower long-term inflation expectations, reflecting expectations of future fiscal adjustment, the unconditional comovement between debt and inflation in the long-run remains positive. Fiscal expansions simultaneously raise inflation and public debt on impact, masking the underlying belief-based mechanism in unconditional correlations.

Figure 7 illustrates these dynamics by comparing impulse responses to i.i.d. and persistent fiscal policy shocks. These results motivate the empirical analysis that follows, which investigates whether long-run inflation expectations and public debt share common stochastic trends consistent with the belief-updating mechanism emphasized here.

4 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. Instead of treating the low-frequency component of deficits as an exogenous regressor, I estimate a multivariate common-trend model in which inflation, long-term inflation expectations, long-term nominal interest rates, deficits, and debt are jointly driven by a restricted set of stochastic trends. This approach delivers two key advantages. First, it explicitly incorporates survey-based measures of long-term inflation expectations, which play a central role in modern theories of expectation formation and are empirically disciplined by evidence that forecasters use multivariate information sets when forming long-horizon beliefs. Second, it allows persistent fiscal forces to operate through both deficits and debt, rather than attributing low-frequency inflation movements to deficits alone, providing

a coherent decomposition of inflation and long-run expectations into economically interpretable permanent components.

A broad class of learning-based monetary–fiscal models implies that inflation, long-term inflation expectations, nominal interest rates, and persistent fiscal variables are jointly determined at low frequencies because private agents update their long-run beliefs using multivariate information. In these environments, beliefs about trend inflation, long-run real rates, and fiscal sustainability evolve together, so persistent fiscal movements—such as deficits or debt—affect both realized inflation and long-horizon inflation expectations through the same underlying belief dynamics. Importantly, this implication does not depend on the precise form of learning or expectation formation, but follows from the fact that agents condition on long-run components rather than high-frequency fluctuations.

This theoretical restriction is supported by empirical evidence on expectation formation. Crump et al. (2023) show that professional forecasters form long-term inflation expectations using multivariate forecasting models that incorporate information from interest rates and macroeconomic fundamentals, rather than univariate extrapolation from inflation alone. Similarly, Coibion et al. (2021) document that households revise long-term inflation expectations when provided with information about future fiscal conditions. Together, these findings support modeling long-run inflation expectations as the outcome of a joint assessment of monetary and fiscal fundamentals, motivating the multivariate common-trend structure used below.

To make this intuition concrete, consider a simplified example derived from the theoretical framework in which households employ a trend–cycle decomposition to learn about long-run inflation. In this environment, current inflation can be written as a function of slow-moving beliefs about inflation, interest rates, and fiscal policy:

$$\pi_t = \underbrace{\varphi_3 \omega_t^{\pi} - \varphi_3 \beta\, \omega_t^{R} - \varphi_2 \omega_t^{s}}_{\text{Common Trends}} + \varphi_1 b_{t-1} - \varphi_4 \varepsilon_t^{FP}.$$

Households update their perceived inflation trend according to

$$\omega_{t+1}^{\pi} = \omega_t^{\pi} + \bar{g}\,(\pi_t - \omega_t^{\pi}),$$

which implies

$$\omega_{t+1}^{\pi} = \underbrace{(1 - \bar{g} + \bar{g}\varphi_3)\,\omega_t^{\pi} - \bar{g}\varphi_3\beta\,\omega_t^{R} - \bar{g}\varphi_2\omega_t^{s}}_{\text{Common Trends}} + \bar{g}\varphi_1 b_{t-1} - \bar{g}\varphi_4\varepsilon_t^{FP} \tag{20}$$

The purpose of this example is not to estimate a specific learning rule, but to highlight a general implication: both inflation and long-term inflation expectations depend on the same underlying persistent components. This delivers a natural cointegration structure among inflation, long-term expectations, interest rates, and fiscal variables, regardless of the precise form of belief updating.

Guided by this theoretical restriction, I estimate a multivariate unobserved-components model with common stochastic trends, building on Del Negro et al. (2017). Relative to their framework, which focuses on disentangling trend inflation and long-run real rates, I extend the state vector to include persistent fiscal components and incorporate survey-based measures of long-term inflation expectations. This extension allows fiscal policy to influence inflation and expectations through the same permanent components that agents learn about in the theoretical model.

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

$$y_t = \Lambda \omega_t + e_t \tag{21}$$
$$\omega_t = \omega_{t-1} + u_t \tag{22}$$
$$\varepsilon_t = \Phi(L)\, e_t \tag{23}$$

with

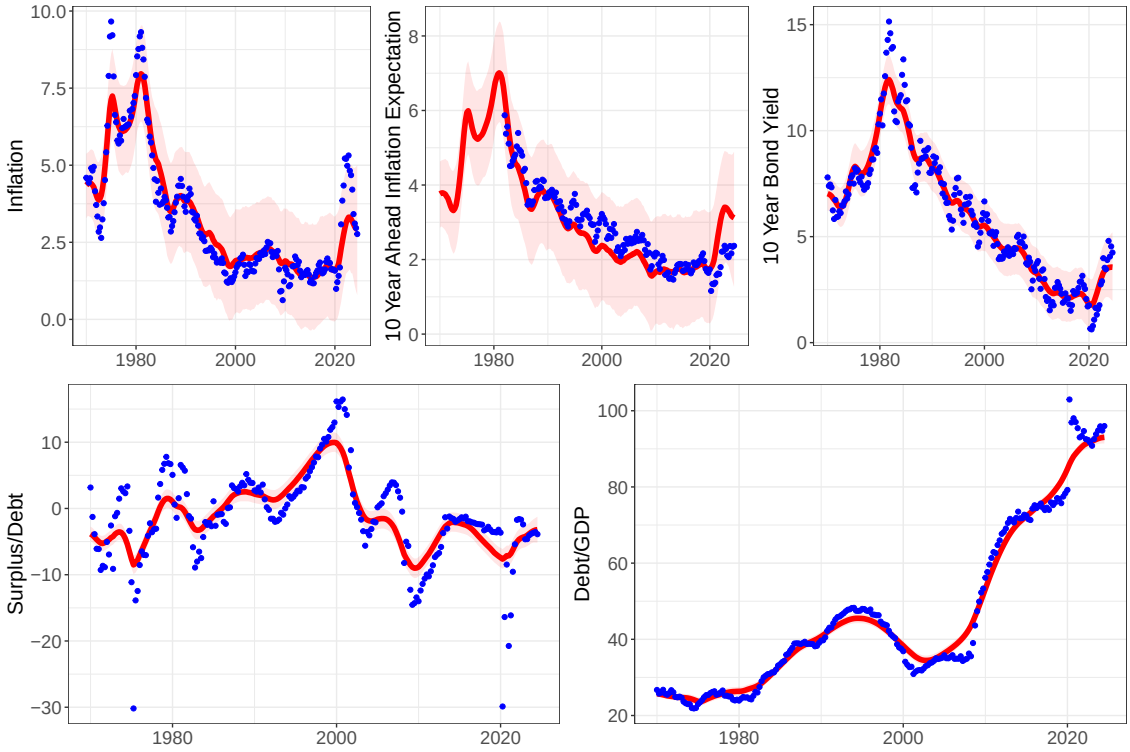
$$\begin{pmatrix} u_t \\ \varepsilon_t \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \Sigma_u & 0 \\ 0 & \Sigma_\varepsilon \end{pmatrix} \right).$$

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.

In this framework, the cointegration between inflation and long-term inflation expectations is directly motivated by the learning model, while the cointegration involving long-term nominal yields follows Del Negro et al. (2017) and captures the Fisher relationship in the long run. The inclusion of fiscal trends allows the data to discipline the strength and sign of fiscal influences on long-run inflation expectations in a way that is consistent with both theory and observed belief formation.

The details on prior distributions, posterior distributions, and the Gibbs sampling are relegated to the appendix. The treatment of the prior distribution for Σ_u is consistent with Del Negro et al. (2017), meaning I place a very conservative priors on the evolution of the slow-moving components of inflation and long-term inflation expectations. Using the relatively more loose prior would not change the implications of the model.

Figure 8: 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.

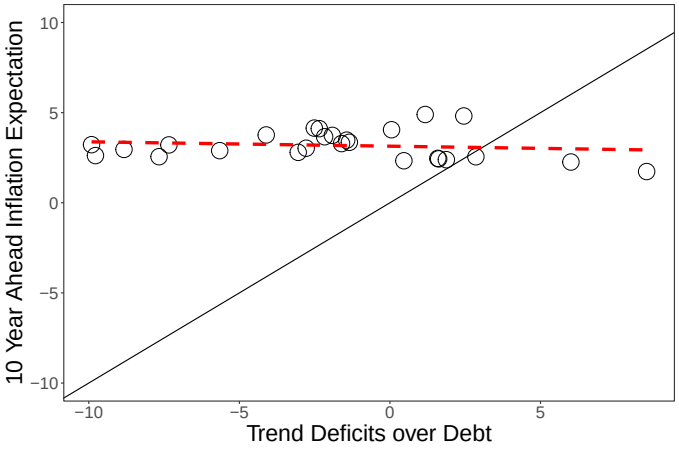
Figure 8 shows the actual data represented by blue dots, and the model fit $\Lambda\omega$ represented by the red line with 90 percent credible sets highlighted by light red shades. It is worth mentioning that once fiscal variables are taken into account, the model can capture two peaks in inflation during 1970s compared to the model without fiscal variables. See the online appendix in Del Negro et al. (2017) for example.

This exercise is closely related to Kliem et al. (2016), who find nearly zero relationship between inflation and public deficits in low-frequency after 1980. I revisit their scatter plot using 10 year ahead inflation expectation and estimated deficits trend instead of using the filtered data. The red dashed line represents the slope produced by the ordinary least squares (OLS)

$$\pi^e_{t+10} = \text{const} + b \times (-\omega^s_t) + \text{error}.$$

To make the results compatible, I only use the data from 1984 to 2009.

Figure 9: 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 trend inflation ω_t^{π} does not change the result. The red dashed line indicates the fitted line using the ordinary least squares while the black solid line represents the 45 degree line. As the graph shows it appears to be no relationship between inflation and surplus during these periods that is consistent with the conclusion in Kliem et al. (2016).

The scatter plot appears to confirm their conclusion that the low-frequency relationship between inflation and deficits disappears after 1980 as indicated by the almost flat fitted line, which they attribute to better monetary policy. Moreover, once I include the entire samples the fitted line becomes slightly negative: The higher deficits are associated with lower inflation, suggesting the similar puzzle as Jørgensen and Ravn (2022). The theoretical model shows the exercise can suffer from a potential endogeneity problem when agents are learning. Recall the Kalman updating equation for inflation (20). Recovering the slope coefficient associated with the low-frequency component of deficits by running OLS can result in a bias whose sign can be positive or negative.

$$\omega_{t+1}^{\pi} = \bar{g}\varphi_2\left(-\omega_t^s\right) + \underbrace{\left(1-\bar{g}+\bar{g}\varphi_3\right)\omega_t^{\pi} - \bar{g}\varphi_3\beta\,\omega_t^{R} + \bar{g}\varphi_1 b_{t-1} - \bar{g}\varphi_4\varepsilon_t^{FP}}_{\equiv \text{error}}$$

This bias can come from the correlation between long-term expectation for deficits and other beliefs or between long-term expectation for deficits and lagged debt.[5]

Hazell and Hobler (2024) point out a similar issue and use the high frequency identification to gauge the effect of deficits on inflation while I use the common trend model guided by theory including the debt to GDP to address this issue.

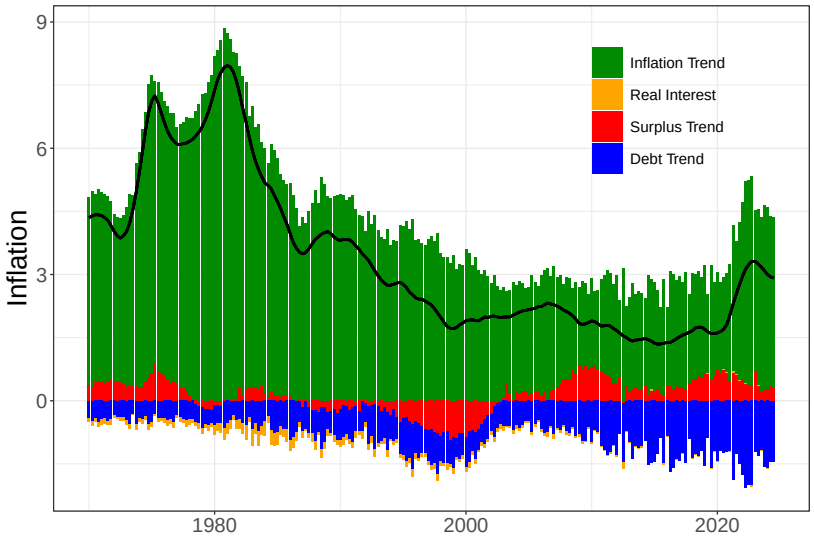
Figure 10 decomposes the actual inflation, the black line, into four low-frequency components. It is natural to observe that the majority is attributed to its own trend, which I refer as inflation trend.[6] The next biggest portion is attributed to the debt trend. Under the assumption that the loadings are time invariant, the lager debt trend is always deflationary, which is consistent with

[5]Because beliefs are state variables, the correlation between ω_t^s and the current fiscal policy shock is 0.

[6]The reason whyI use this terminology is to avoid the confusion with the trend inflation, which is often used in the literature. As is apparent in the co-integration structure I assume, this is not necessarily the same object as the trend inflation in the usual sense.

the prediction of the theory presented above. This is due to the strong fiscal anchor. As private agents expect surplus must rise in the long run to pay off the higher expected debt, they reduce their contemporaneous consumptions, bringing down the inflation today. The surplus trend has the expected impact on inflation: When the surplus trend is higher, it brings down the inflation while t raises the inflation when it turns to the deficits.

Figure 10: Inflation and the Effect of Trends



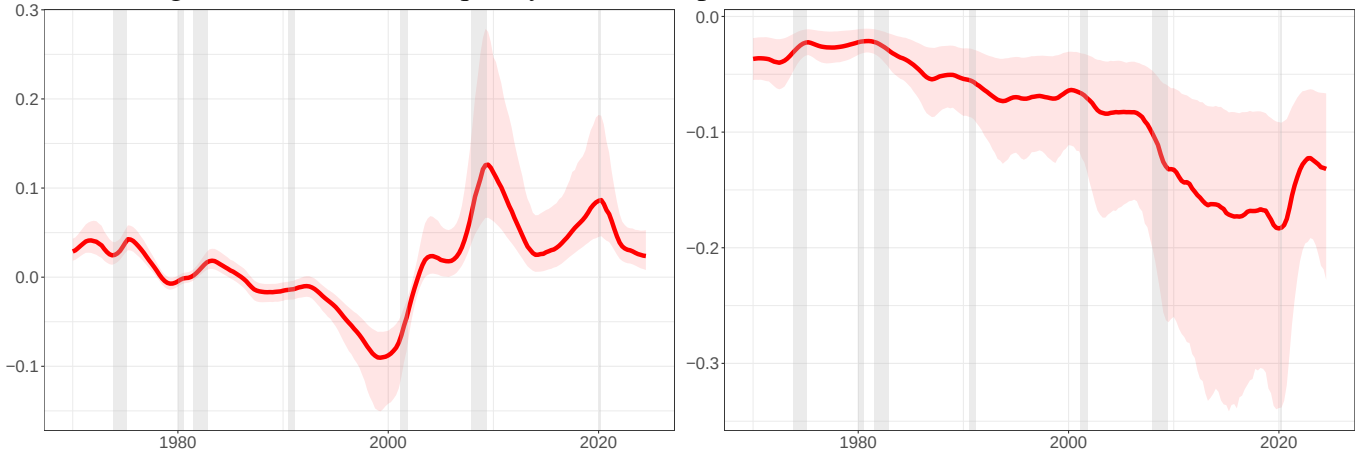
Note: The black solid line is the inflation from the fitted value, Λy so that the sum of each bar adds up. Each bar shows the contribution of each trend on the inflation.

Next, I show how movements in long-term inflation expectations are explained by the deficits and debt trend respectively. 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 11: The Low-Frequency Relationship between Inflation and Deficits



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

Figure 11 shows that debt and deficits trend affect the long-term inflation expectation by non-negligible amount. There are several things to mention. While the effect of deficits trend is tightly estimated and close to zero up until around 1990, it starts accounting for higher fraction of long-term inflation expectations especially during the Great Financial Crisis (GFC). It also becomes more volatile especially during the recessions indicated by the grey shaded area. The similar point can be made for the debt trend: the median effect on the long-term inflation expectations is always negative and becomes much more uncertain during the GFC. These estimates seem to be consistent with the implications from Eusepi and Preston (2012) that fiscal policy uncertainty becomes more important for forming long-term expectations when monetary policy expectations are well anchored.

One shortcoming of this empirical strategy is that structural shocks are not identified without imposing additional restrictions that are not necessarily motivated by the theory, which makes it difficult to study the effect of fiscal policy shocks on inflation, long-term inflation expectations and the fiscal anchor.

To address this issue, I build the New Keynesian model with imperfect knowledge based 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. Private agents do not know *both* the long-run means and coefficients and have to learn observing the macro variables. In this sense, the model is also an extension of Milani (2007) incorporating monetary-fiscal interactions.

5 A Medium-Scale New Keynesian Model: Preliminary

I present a New Keynesian model based on Eusepi and Preston (2018) and Eusepi et al. (2020) extended to admit more general subjective beliefs. The purpose of the structural model is to identify the fiscal policy shocks and quantify the cumulative effects on inflation dynamics through the learning mechanism.

Firms

A continuum of monopolistically competitive firms $\omega \in [0,1]$ each produce differentiated goods, $Y_t(\omega)$, using the linear production function in labor, $N_t(\omega)$,

$$Y_t(\omega) = A_t\left[Z_t N_t(\omega)\right],$$

where Z_t, labor-augmenting technical progress, evolves deterministically as $Z_t = \gamma Z_{t-1}$, with $\gamma > 1$, and A_t denotes a stationary technology process. Each firm faces a demand curve

$$Y_t(\omega) = \left(\frac{P_t(\omega)}{P_t}\right)^{-\theta_{p,t}^{\omega}} Y_t$$

where $\theta_{p,t}^{\omega} > 1$, the elasticity of substitution across differentiated goods, is a stationary exogenous process. A fraction of firms $0 < \alpha_p < 1$ cannot optimally choose their price. The remaining fraction of firms choose a price $P_t(\omega)$ to maximize the expected discounted value of profits

$$\hat{E}_t^{\omega} \sum_{T=t}^{\infty} \alpha_p^{T-t} Q_{t,T} \Pi_T(\omega)$$

where the stochastic discount factor, $Q_{t,T} = \beta^{T-t}\lambda_T/\lambda_t$, values future profits

$$\Pi_T(\omega) = Y_T(\omega)\left(\frac{P_t(\omega)}{P_T} - \frac{W_T}{A_T P_T Z_T}\right).$$

for λ_t the marginal value of household wealth. (Note that $N_T(\omega) = \frac{Y_T(\omega)}{A_T Z_T}$,which implies $W_T N_T(\omega) = Y_T(\omega)\frac{W_T}{A_T Z_T}$.) The optimal price depends on subjective expectations, $\hat{E}_t^{\omega}$, about the future path of equilibrium inflation and real wages net of productivity trend $\{W_T/(P_T Z_T), P_T/P_{T-1}\}_{T=t}^{\infty}$ and the exogenous stochastic process $\left\{A_T, \theta_{p,T}^{\omega}\right\}_{T=t}^{\infty}$.

Households

A continuum of households $i \in [0,1]$ maximize intertemporal utility

$$\hat{E}_t^i \sum_{T=t}^{\infty} \zeta_T^i \beta^{T-t}\left[\frac{\left(C_T(i)/Z_T\right)^{1-\sigma}}{1-\sigma} - \frac{N_T(i)^{1+\chi^{-1}}}{1+\chi^{-1}}\right]$$

with $\sigma, \chi > 0$. Preferences are subject to household specific discount rate shock, ζ_t^i. The household's flow budget constraint is

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

where R_t is the gross one period nominal interest rate. $B_t(i)$ represents one period nominal government debt and Π_t is the profits, S_t will be the government surpluses net of transfers, or primary surpluses set by a fiscal policy rule. Household's optimal consumption and portfolio choice must also satisfy the No-Ponzi condition

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

Government Policy

The central bank implements monetary policy using the interest rate rule

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

where $\phi_\pi, \phi_x \geq 0$, R is the steady state gross nominal interest rate, and X_t represents the output gap defined as the ratio of output to the level of output that would prevail under flexible prices under rational expectations. Interest rate policy exhibits inertia and responds to deviations of inflation and output from steady state levels. I focus on the zero inflation steady state. $m_t = \sigma_m \varepsilon_t^{MP}$ represents a mean zero i.i.d. monetary shock.

The flow government budget constraint is

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

The government levies lump sum taxes net of transfer using the rule

$$S_t = \bar{s} + \rho_s (S_t - \bar{s}) + (1 - \rho_s) \phi_b (B_{t-1} - b) + \bar{s}_t,$$

where $\bar{s}$ is the normalized steady state level of surpluses. $\bar{s}_t = \rho_s \bar{s}_{t-1} + \sigma_{\bar{s}} \varepsilon_t^{FP}$ represents mean zero fiscal policy shock.

Subjective Beliefs

The subjective beliefs and forecasting are the same as the endowment economy. The model includes all variables that households and firms need to forecast to make consumption, saving, and pricing decisions. Following the learning literature, assume agents have perfect knowledge of the stationary exogenous shocks. This implies that the perceived drifts are zero and parameters are consistent with the model in every periods. Using a constant gain, (17) and (18) updates the beliefs about endogenous variables.

Conditional on beliefs, I solve for optimal decisions under the anticipated utility approach following Eusepi and Preston (2018).

6 Conclusion

This paper studies when and why fiscal expansions become inflationary by extending the learning framework of Eusepi and Preston (2018) to an environment in which private agents are imperfectly informed about fiscal policy. When households and firms must infer fiscal behavior from observed outcomes, fiscal policy shocks are no longer Ricardian. Instead, a fiscal expansion can trigger a learning process about the government's long-run budgetary stance, with macroeconomic effects that depend on agents' estimates of fiscal coefficients and on the perceived persistence of the shock.

I then provide empirical evidence that is consistent with this mechanism using U.S. data. A trend–cycle decomposition reveals that upward shifts in long-run debt beliefs are associated with lower contemporaneous inflation and lower long-term inflation expectations. Rather than operating

as an inflationary force, higher projected public debt appears to signal future fiscal adjustment, dampening expected demand and exerting downward pressure on inflation. Motivated by this evidence, I develop a structural New Keynesian model with imperfect information about fiscal policy to identify fiscal policy shocks and to quantify how much they contribute to the evolution of inflation and long-term inflation expectations through this learning channel.

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A Analytical Results with Shifting Endpoints Model

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 $\omega_{t+1} \equiv \hat{E}_t(\bar{\omega}_{t+1}|\pi_t, R_t, s_t, b_t, \omega_t)$ to at the end of the period using the steady-state Kalman filter

$$\begin{aligned}
\omega^{\pi}_{t+1} &= \omega^{\pi}_t + \bar{g}(\pi_t - \omega^{\pi}_t) && (24)\\
\omega^{R}_{t+1} &= \omega^{R}_t + \bar{g}\left(R_t - \omega^{R}_t\right) && (25)\\
\omega^{s}_{t+1} &= \omega^{s}_t + \bar{g}(s_t - \omega^{s}_t) && (26)\\
\omega^{b}_{t+1} &= \omega^{b}_t + \bar{g}\left(b_t - \omega^{b}_t\right) && (27)
\end{aligned}$$

Substitute policy rules into equation (5) as actual law of motions and aggregate over households to get

$$c_t = (1-\beta)y_t - \frac{\beta}{\sigma}\phi_\pi\pi_t - \beta(1-\beta)\delta b_t - \frac{\beta}{\sigma(1-\beta)}\left(\beta\omega^R_t - \omega^\pi_t\right) - (1-\beta)\delta\left(\beta\omega^s_t + \frac{\beta}{1-\beta}\omega^\pi_t - \frac{\beta^2}{1-\beta}\omega^R_t\right)$$

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

$$\begin{aligned}
\pi_t &= -\sigma\phi_\pi^{-1}y_t - \frac{1}{\phi_\pi(1-\beta)}\left(\beta\omega^R_t - \omega^\pi_t\right) + \frac{\sigma\delta(1-\beta)}{\phi_\pi}\left\{b_t - \omega^s_t + \frac{1}{1-\beta}\left(\beta\omega^R_t - \omega^\pi_t\right)\right\} && (28)\\
R_t &= \phi_\pi\pi_t && (29)\\
s_t &= \phi_b b_{t-1} + \varepsilon^{FP}_t && (30)\\
b_t &= \beta^{-1}(1-(1-\beta)\phi_b)b_{t-1} - \left(\beta^{-1} - \phi_\pi\right)\pi_t - \beta^{-1}(1-\beta)\varepsilon^{FP}_t, && (31)
\end{aligned}$$

and the Kalman filter specified by equation (24)-equation (27) 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 (28) and equation (31) to express the inflation dynamics as a function of state variables and exogenous shocks:

$$\pi_t = \varphi_1 b_{t-1} - \varphi_2\omega^s_t - \varphi_3\left(\beta\omega^R_t - \omega^\pi_t\right) - \varphi_4\varepsilon^{FP}_t,$$

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 (28)-equation (31) into the updating rule to get

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

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 can be wrong according to Eusepi and Preston (2012); need to prove again.)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.

The following figure shows the impulse responses to 1 percent fiscal expansions, $\varepsilon^{FP} = -1$, to the economy. As illustrated by the first figure, the economy is no longer Ricardian because households do not know the economic structure. This magnitude of the effect is proportional to the average indebtedness of the economy δ and inversely proportional to ϕ_π, how aggressive a central bank is towards the inflation.

Figure 12: Equilibrium Dynamics in Response to a Fiscal Policy Shock

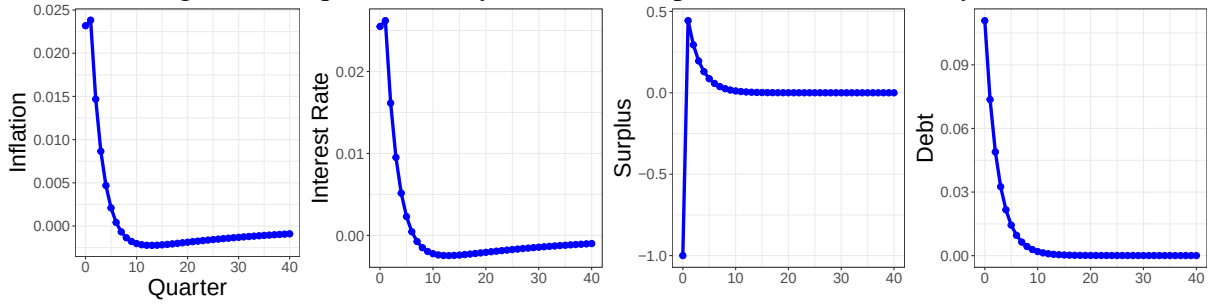
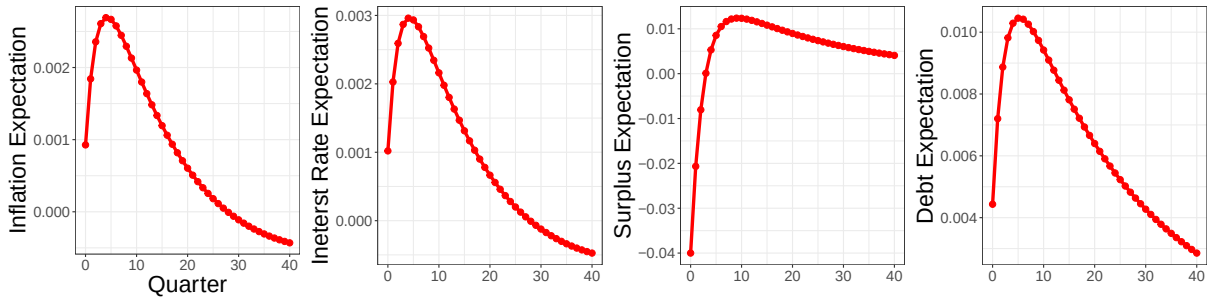
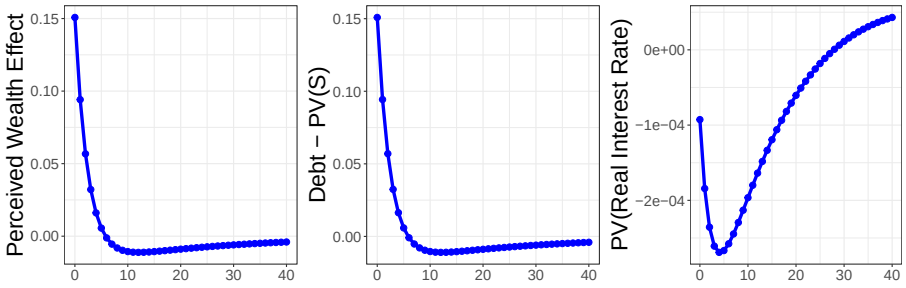


Figure 13: Expectation Dynamics in Response to a Fiscal Policy Shock



On the one hand, b_t represents the evolution of perceived wealth effects households feel by holding more bonds. On the other hand, ω_t^s is the counteracting effect that households expect for future tax obligation. When households form rational expectations and fiscal authority stabilizes the debt, these effects cancel each other out and the perceived wealth effect is precisely zero. This is because households correctly anticipate the tax increase that equals to the exact amount needed to retire the debt on the margin in the present value. I decompose the perceived wealth effect into the difference between the debt and the present value of expected surplus $b_t - \omega_t^s$ and the movement in the expected real interest rate $\frac{1}{1-\beta}\left(\beta\omega_t^R - \omega_t^\pi\right)$. As the model features the flexible price economy, the latter tends to be small. $b_t - \omega_t^s$ captures how hoseholds perceive the government debt as the net wealth in the sense of Barro (1974). The graph shows that households believe that the government debt is the net (positive) wealth in first several periods following the fiscal expansion, and then revise it to be the net (negative) wealth after observing consecutive tax increases.

Figure 14: The Evolution of the Perceived Wealth Effect



The perceived wealth effect shares the similar mechanism to generate inflation as the fiscal theory of the price level (FTPL). In the passive money and active fiscal regime, it is rational to expect that the future surpluses do not increase to stabilize the debt. When households only have imperfect knowledge about the future fiscal policy, they perceived government bonds as net wealth in the short-run while feel the negative wealth effects afterward if the underlying economy is Ricardian.

B An Endowment Economy with Monetary Policy Shocks

I add a monetary policy shock into the model so that

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

and

$$\pi_t = \frac{\sigma\delta(1-\beta)}{\phi_\pi} b_t - \frac{\sigma\delta(1-\beta)}{\phi_\pi}\omega_t^s - \frac{1-\sigma\delta(1-\beta)}{\phi_\pi(1-\beta)}\left(\beta\omega_t^R - \omega_t^\pi\right) - \frac{1}{\phi_\pi}\varepsilon_t^{MP}.$$

I, then, consider a monetary policy shock so that

$$\frac{1}{\xi}\varepsilon_t^{MP} + \frac{\sigma\delta(1-\beta)^2}{\beta\xi}\varepsilon_t^{FP} = 0,$$

thus, $\pi_t = 0$ when shocks realize.

Figure 15: Equilibrium Dynamics in Response to a Composite Shock

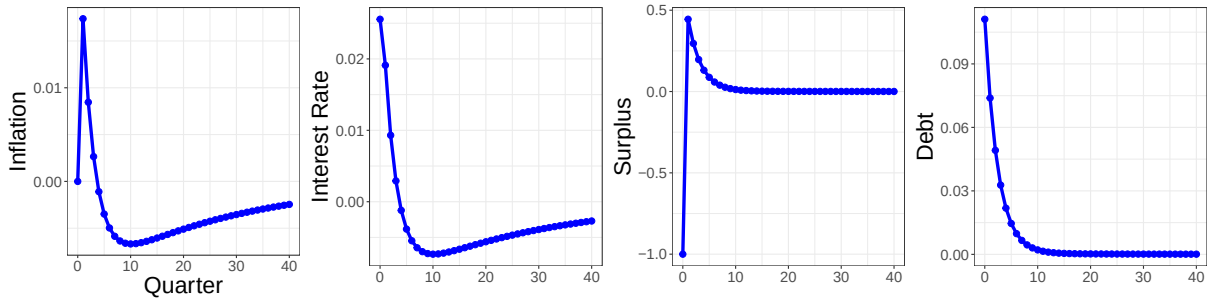
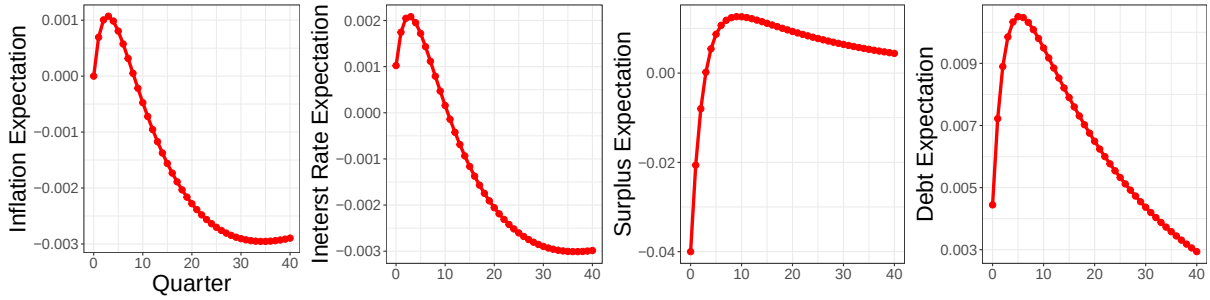


Figure 16: Expectation Dynamics in Response to a Composite Shock



C Expectational Stability of the Model

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

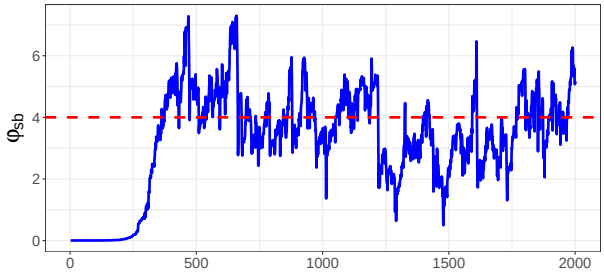
$$\hat{E}_t Z_{T+1} = \left(I_4 - \tilde{\Phi}_t\right)^{-1} \left(I_4 - \tilde{\Phi}_t^{T-t+1}\right) \bar{\omega}_t + \tilde{\Phi}_t^{T-t+1} Z_t.$$

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 (6) - (9) 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.

Figure 17: Expectational Stability and the Convergence of the Fiscal Anchor

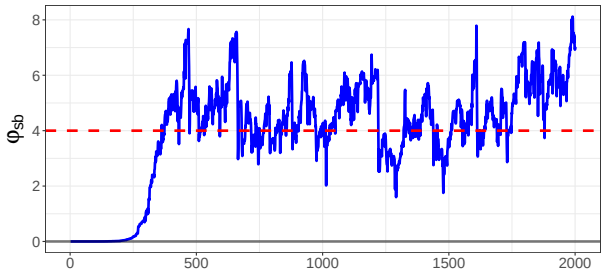


The figure indicates that the fiscal anchor indeed converges around the true value, which is indicated by the red horizontal line.

C.1 The Role of Heteroskedasticity

We can see that the heteroskedasticity of fiscal policy shocks matters to a great deal even in the endowment economy model. In the baseline simulation, I set the standard deviation to 0.01 while I simulate the convergence with 0.02 standard deviation below.

Figure 18: Expectational Stability and the Convergence of the Fiscal Anchor



D 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

$$y_t = \Lambda \omega_t + e_t \tag{32}$$
$$\omega_t = \omega_{t-1} + u_t \tag{33}$$

and a VAR

$$\varepsilon_t = \Phi(L)\, e_t \tag{34}$$

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

D.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

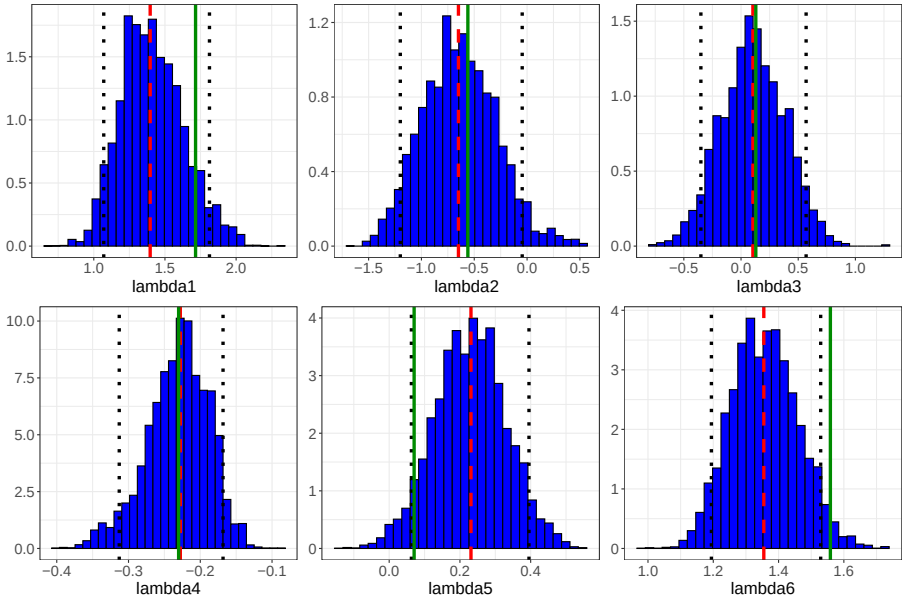
$$\Lambda \equiv \begin{pmatrix} \lambda_1 & \lambda_2 & \lambda_3 & 0 \\ \lambda_4 & \lambda_5 & \lambda_6 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix},$$

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 19: 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.

D.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

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

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 (32)-(34), where the recursion is initialized by a draw $\omega_0^+ \sim \mathcal{N}(0, I)$.

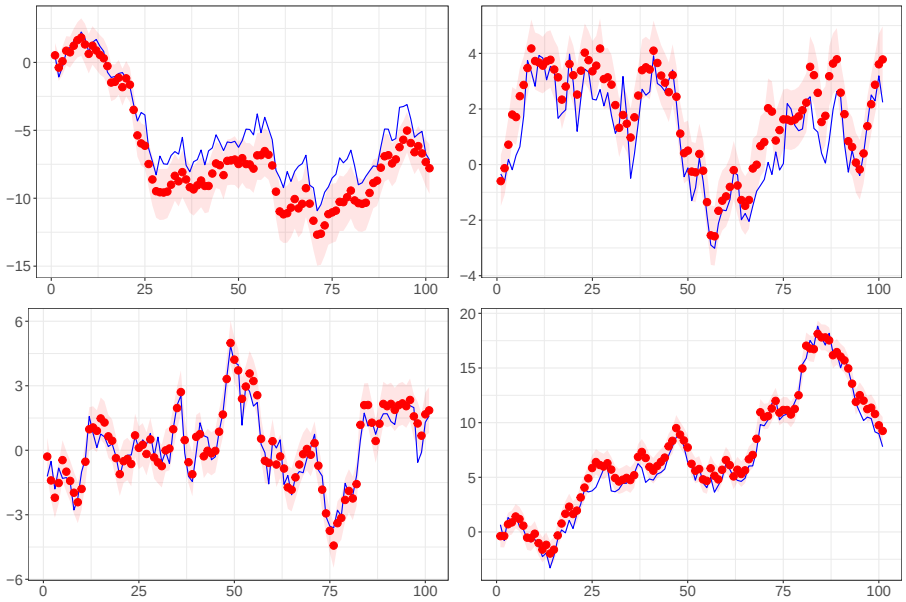
2. Construct the artificial series $y^* = y - y^+$ and compute $\hat{\omega}^* = E(\omega|y^*)$ by putting y^* through the Kalman filter and smoother.

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 (33), 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.

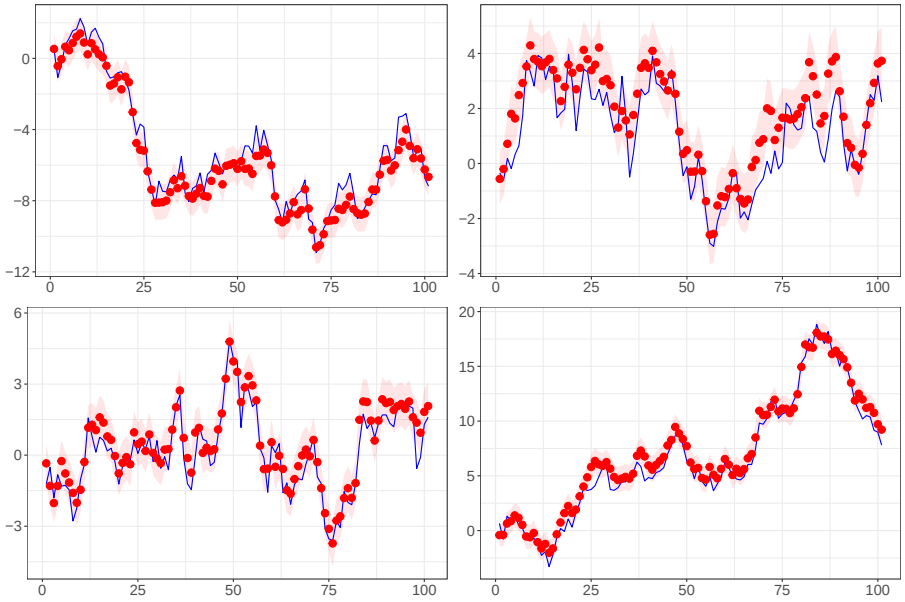
Figure 20: Simulated Data: Simulation Smoother



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 21: 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.

D.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,

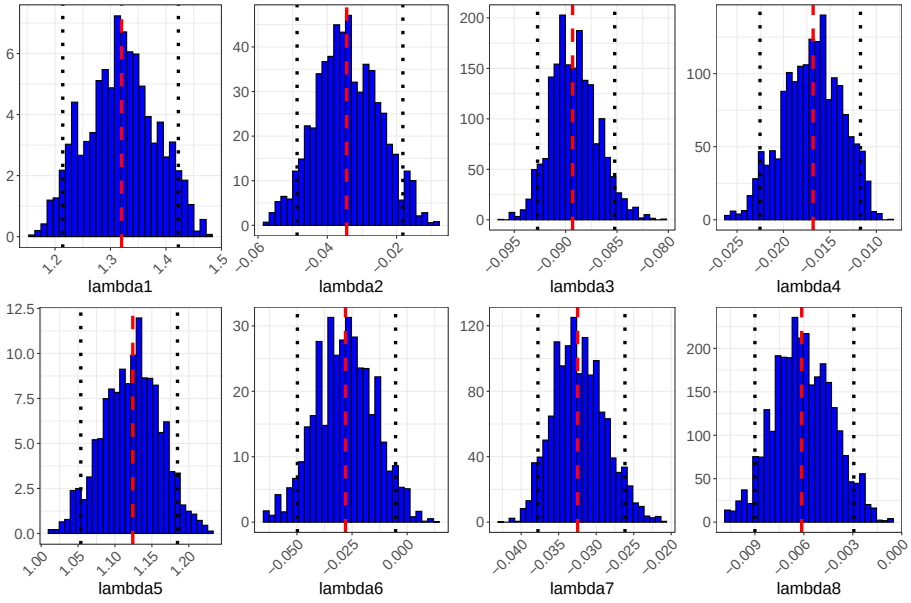
$$\begin{aligned} \hat{\Phi} &= \left(\sum_{t=t}^{T} \tilde{x}_t \tilde{x}'_t + \underline{\Omega}^{-1} \right)^{-1} \left(\sum_{t=t}^{T} \tilde{x}_t e'_t \right) \\ \hat{S}_\varepsilon &= \sum_{t=1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}'_t + \hat{\Phi}' \underline{\Omega}^{-1} \hat{\Phi} \end{aligned}$$

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

E 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 22: Posterior Distribution of Λ



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

F Proof of Proposition 3

The data generating process in this setting can be described as

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

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

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

Assume that

$$\tilde{\Phi}_1 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_b \\ 0 & 0 & 0 & \beta^{-1}(1-(1-\beta)\phi_b) \end{pmatrix}.$$

Then

$$\left(A_0 - F_1\left(\beta, \tilde{\Phi}_1\right)\right)^{-1} A_3 = \begin{pmatrix} 0 & 0 & 0 & \frac{(1-\beta)\varphi_2 - \beta\varphi_4}{\beta + \varphi_2(\beta\phi_\pi - 1)} \\ 0 & 0 & 0 & \phi_\pi \frac{(1-\beta)\varphi_2 - \beta\varphi_4}{\beta + \varphi_2(\beta\phi_\pi - 1)} \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -\frac{(1-\beta) + (\beta\phi_\pi - 1)\varphi_4}{\beta + \varphi_2(\beta\phi_\pi - 1)} \end{pmatrix}.$$

By definitions of φ_2 and φ_4,

$$\frac{(1-\beta)\varphi_2 - \beta\varphi_4}{\beta + \varphi_2(\beta\phi_\pi - 1)} = 0$$

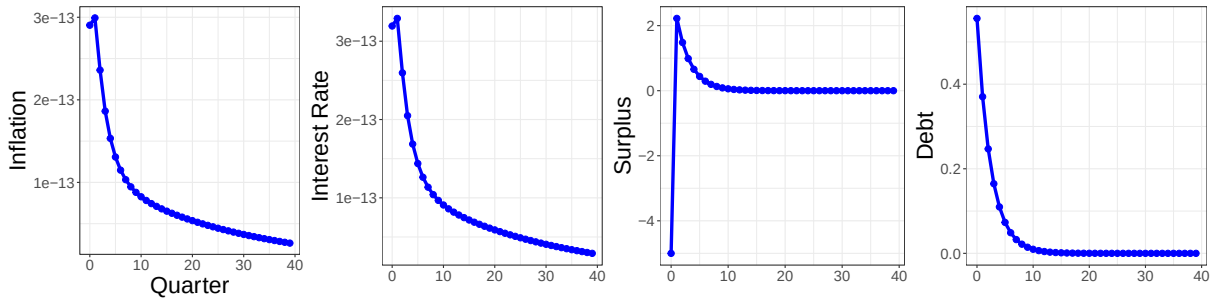
preserving the Ricardian equivalence at the impact. Because the fiscal policy shock does not trigger the learning process for inflation,

$$\pi_t = 0 \quad \text{and} \quad \omega^{\pi}_{t+1} = 0,$$

preserving the Ricardian equivalence $t > 1$ as well.

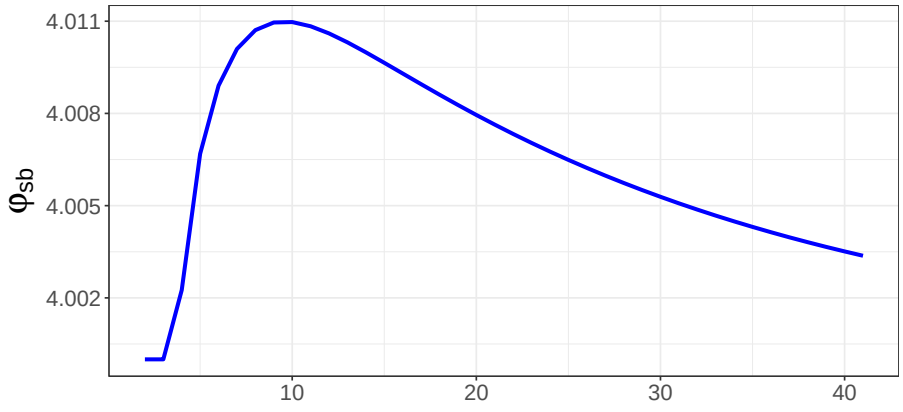
The impulse response function of the fiscal policy shock will be

Figure 23: IRF: General Learning When Fiscal Expectations Are Anchored



Following figures depict how higher long-run debt belief affect inflation on the margin and how the estimate of φ_{sb} evolves over time.

Figure 24: The Estimates of φ_{sb}

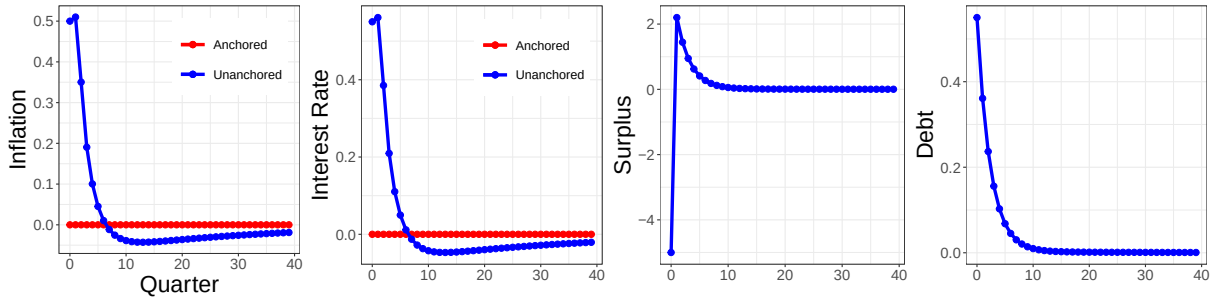


Next, I consider the case when underlying policy regime is not necessarily aligned with households' initial subjective beliefs. Specifically, I consider when households suspect it is fiscal dominance. The initial beliefs are then summarized by

$$\tilde{\Phi}_1 = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & \hat{\phi}_\pi \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \hat{\phi}_\pi \end{pmatrix},$$

with $0 \leq \phi_\pi < 1$ and $\hat{\phi}_b = 0$.

Figure 25: IRF: General Learning When Households Doubt Fiscal Dominance



G E-Stability under General Learning

The true data generating process is described by

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

The stability under learning depends on the interaction between agents' model $\left(\tilde{\Phi}_t\right)$ and the true model $\left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_1 F_0\left(\beta, \tilde{\Phi}_t\right)$ and $\left(A_0 - A_1 F_1\left(\beta, \tilde{\Phi}_t\right)\right)^{-1} A_2$. The two models coincide only at the rational expectations equilibrium.