Fiscal Inflation with Incomplete Information

By Junjie Guo, Zhao Han, and Abhiprerna Smit*

We quantify fiscal inflation through the lens of incomplete information between funded and unfunded fiscal shocks. Information friction naturally breaks the Ricardian equivalence for deficits to be inflationary. We identify the unfunded shock through a pair of interconnected short-term inflation and debt targets that vary over time. Qualitatively, incomplete information alters the effects of both monetary and fiscal shocks on inflation. Quantitatively, in response to an unfunded shock, the inflation responses are approximately 40%-60% lower compared to the case of full information. Both fiscal stimulus and supply shocks contribute significantly to COVID inflation.

Last updated: October 2, 2025

"*Neither the President-elect, nor I, propose this relief package without an appreciation for the country's debt burden. But right now, with interest rates at historic lows, the smartest thing we can do is act big. I believe the benefits will far outweigh the costs. — Yellen (2021)*"

I. Introduction

The COVID-19 pandemic and the subsequent inflationary episode have sparked renewed debate about the role of fiscal policy and its impact on inflation. The formidable pandemic has caused substantial disruptions to the economy, including supply chain shortages, shifts in preferences toward consumption and labor supply, and the unprecedented fiscal response, among others. Although there is a consensus that all of these shocks can contribute to the increase in prices in theory, there is still much controversy about the decomposition of supply- and demand-driven inflation in practice (see Giannone and Primiceri (2024) and Bernanke and Blanchard (2023)).

An important debate centers on the relative importance of fiscal inflation. The prompt fiscal response to the COVID crisis has been the largest in peacetime. In total, more than $5 trillion in federal tax cuts, spending increases, and stimulus checks have been spent to boost aggregate demand. These measures likely put the economy on a path to recovery, but the effects on inflation are unclear. Are fiscal

* Guo: School of Finance, Central University of Finance and Economics, Beijing, China (email: junjguo@cufe.edu.cn); Han: Department of Economics, William & Mary, Williamsburg, Virginia, United States (email: zhaohan@wm.edu); Smit: Department of Economics, William & Mary, Williamsburg, Virginia, United States (email: asmit@wm.edu). Zhao sincerely thank Eric Leeper for several conversations and email exchanges early on, which motivated the paper.

expansions inflationary? If so, how large? Using similarly estimated medium-scale DSGE models, Bianchi, Faccini and Melosi (2023) finds that most of the COVID inflation is due to fiscal stimulus. In contrast, Smets and Wouters (2024) claim that supply shocks, not fiscal expansion, are the primary drivers of post-pandemic inflation.

Although there is a quantitative debate, the literature has largely settled on the origin of potential fiscal inflation. According to the Fiscal Theory of Price Level (FTPL), as prices need to adjust to ensure that the real value of government debt equals the present value of future surpluses, fiscal policy will have a direct impact on inflation. The early influential work of Leeper (1991) proposes two separate regimes of policy behavior. In the monetary-led regime, the central bank controls inflation by adjusting the nominal interest rate more than one for one in response to inflation deviations from its target (i.e., the Taylor principle), and the fiscal authority ensures that it adjusts primary surpluses (i.e., raising taxes and cutting expenditure) properly to stabilize government debt. In contrast, in the fiscal-led regime, the fiscal authority does not adjust primary surpluses sufficiently. With an accommodating central bank that does not satisfy the Taylor principle, fiscal inflation can arise to reduce the real value of that debt. Such a debt erosion process is central to the FTPL and can only happen in the fiscal-led regime. For the past three decades, the literature on FTPL has focused mainly on identifying fiscal/monetary policy regimes to infer the magnitude of fiscal inflation (Leeper, Traum and Walker, 2017; Bianchi and Melosi, 2017).

The recent literature (Bianchi, Faccini and Melosi, 2023; Smets and Wouters, 2024) has moved away from policy regimes and has taken a more unified approach to model fiscal inflation. In particular, Bianchi, Faccini and Melosi (2023) design an environment with both funded and unfunded fiscal shocks. The funded shock is backed by future primary surpluses and is similar to the policy behavior in the monetary-led regime. However, the unfunded shock is not backed, mimicking the policy behavior in the fiscal-led regime. Consequently, while the former shock satisfies the Ricardian equivalence (Barro, 1974) and is noninflationary, the latter shock can generate fiscal inflation once accommodated by the central bank. The coexistence of both shocks allows researchers to confront a quantitative DSGE model directly with fiscal inflation using standard linear Bayesian estimation techniques.

However, the coexistence of both funded and unfunded fiscal shocks naturally introduces an information friction that has not been explored in the existing literature. Intuitively, since the two shocks rely on distinct fiscal backings in the future, economic agents cannot fully tell whether it is a funded shock, an unfunded shock, or a combination of both shocks when a fiscal change occurs today. This is particularly true for U.S. fiscal policy, as politicians often are unable to clarify the underlying backing of fiscal expansions. To capture this salient feature, we model the friction in the source of fiscal expansion through incomplete information. To connect directly to Bianchi, Faccini and Melosi (2023) and Smets and Wouters

(2024), we work within the rational expectations paradigm.

The modeling of the funded fiscal shock is standard. To model the unfunded shock, we utilize a pair of time-varying short-term inflation and debt targets that are interconnected. Although the interpretation is slightly different, our approach is in full agreement with the original design of Bianchi, Faccini and Melosi (2023). For example, we map an analytical model to the simple endowment economy in Bianchi, Faccini and Melosi (2023) one-to-one. We show that the unfunded fiscal shock is exactly the exogenous shock to the debt target. A negative unfunded shock increases the debt target, allowing the fiscal authority to reduce or delay adjustments of future primary surpluses. Moreover, the unfunded shock also needs to drive the inflation target so that the central bank accommodates the unfunded debt by allowing a debt erosion process and higher inflation. We specify a persistent (i.e., an AR(1)) debt target process. To model the accommodating central bank, Bianchi, Faccini and Melosi (2023) considers a shadow economy in which the only shock is the unfunded fiscal shock. The shadow economy translates to a restriction on the inflation target in our model: Since unfunded debt (i.e., the debt target) is the only state variable in the shadow economy, the inflation target must inherit the persistence of the debt target. However, the central bank can still choose the strength of its accommodation by varying the magnitude of the inflation target.

The assumptions that both short-term targets are hidden and time-varying are reasonable. These targets reflect how tolerable policy makers are to short-term deviations of debt and inflation from their long-term targets. Although the U.S. has never formally adopted a numerical long-term debt target, the debt-to-GDP ratio has been rising steadily well before the COVID-19 pandemic. This trend indicates that the federal government is reluctant to stabilize the high debt burden, at least in the short term (Han, 2021). At the same time, while the Federal Reserve adopts a long-term inflation target of 2%, the central bank does not follow the strict inflation targeting rule in the short run (Ireland, 2007). Historically, the central bank considers a broad range of inflation indicators when setting the federal funds rate, and has adopted a deliberately vague "average inflation target" framework during COVID. Empirically, we find strong evidence supporting the presence of both hidden and time-varying policy targets.

Given the combination of a hidden target and a standard policy shock (either monetary or fiscal), the private sector (i.e. households and firms) faces a linear signal extraction problem. Moreover, since the unfunded shock enters both the debt and inflation targets, there is a subsequent informational interaction of monetary and fiscal policy. We follow the standard practice in the literature on incomplete information rational expectations (IIRE) models (Blanchard, L'Huillier and Lorenzoni, 2013) and let households use the optimal algorithm, the Kalman filter, to solve the signal extraction problem.

We first illustrate the transmission mechanism in a simple endowment economy. Incomplete information leads to an initial underreaction of inflation to the unfunded shock, as economic agents perceive that the shock is partially funded at the beginning. Households gradually figure out the nature of the shock, leading to a hump-shaped impulse response to inflation. Similarly, since households can also believe that a funded shock is partially unfunded, its effect on inflation is nonzero (i.e., Ricardian equivalence breaks down) and can be persistent. Lastly, as households confuse between an exogenous monetary policy shock and a changing inflation target driven by the unfunded shock, a transitory monetary policy shock can also generate persistent impulse responses to inflation.

We then estimate a medium-scale DSGE model fitted to the data to quantify fiscal inflation with incomplete information. The model extends the framework of Bianchi, Faccini and Melosi (2023) by incorporating augmented monetary and fiscal policy rules, including a time-varying debt target. Consistent with our simple model, information friction arises from the agents' inability to perfectly distinguish between funded fiscal and monetary policy shocks versus unfunded fiscal shocks. Under incomplete information, an unfunded fiscal shock generates a smaller immediate impact but more persistent inflation dynamics, as households gradually come to realize that the transfers are not backed by future fiscal adjustments. Additionally, the real interest rate declines less than it would under full information, since the central bank faces the same frictions in decoupling unfunded shocks from funded transfers. An exogenous interest rate cut is also significantly more inflationary under incomplete information. Decomposing the contribution of shocks to inflation shows that the full information model over attribute inflation to unfunded shocks while a combination of unfunded and non-policy shock explain inflation under incomplete information. The information frictions embedded in our model also better capture the observed dynamics of post-pandemic inflation, particularly the gradual rise in inflation following the government's stimulus payments.

Related Literature This paper belongs to the vast literature on monetary-fiscal policy interactions (see Sargent and Wallace (1981), Leeper (1991), Sims (1994), and Woodford (2001)). We propose an informational interaction of monetary and fiscal policy and quantify fiscal inflation through the lens of incomplete information between funded and unfunded shocks. Proposed by Bianchi, Faccini and Melosi (2023), these shocks resemble monetary- or fiscal-led policy regime behavior in the regime-switching literature on FTPL (see Davig, Leeper and Walker (2010) and Bianchi and Melosi (2017)). Smets and Wouters (2024) estimates a medium-scale DSGE model, which allows for a time-invariant partial fiscal backing between funded and unfunded shocks. They find that on average 80% of fiscal shocks are funded. We instead consider a dynamic signal extraction problem such that the degree of partial fiscal backing always depends on the underlying monetary-fiscal policy actions and the household beliefs. Consequently, the degree of fiscal backing in our model is always state-dependent and time-varying.

In addition to incomplete information, other information channels or frictions can also play a significant role in generating fiscal inflation. We share the spirit of Eusepi and Preston (2018), who propose a theory of the fiscal foundations of inflation based on imperfect knowledge and recursive least square learning. Bassetto and Miller (2025) uses rational inattention and shows that when bond holders are more concerned with the possibility of a fiscally led regime, sudden inflation can occur. Angeletos, Lian and Wolf (2024) connects to the FTPL by considering a HANK model with a sufficiently slow fiscal adjustment. Since households are non-Ricardian in HANK models, fiscal deficits drive aggregate demand, and thus inflation. Interestingly, although the two papers take completely different approaches, we both arrive at a quantitatively similar result that fiscal inflation is reduced by about half compared to the full-information FTPL case.

II. A Simple Endowment Economy

We use a simple endowment economy (see Leeper (1991)) to highlight the key information friction. The one-period nominal bond B_t, issued by the government, is sold for Q_t. The gross nominal interest rate R_t is given by the inverse of Q_t, i.e., $R_t = 1/Q_t$. The steady-state gross nominal interest rate is $1/\beta$, where $\beta \in (0, 1)$ is the household's time discount factor. In logarithmic linearized form, the Fisher equation is

$$i_t = \mathbb{E}_t^{HH} \pi_{t+1}, \tag{1}$$

where i_t is the net nominal interest rate and π_t is inflation. The rational expectations operator $\mathbb{E}_t^{HH} = \mathbb{E}_t(\cdot | I_t^{HH})$ is conditional on the household's information set I_t^{HH}, which will be specified below.

Monetary policy follows a simple rule.

$$i_t = \phi_\pi(\pi_t - \pi_t^*), \tag{2}$$

where π_t^* stands for the central bank's short-term inflation target and can be varying over time (see Ireland (2007)).[1] The term $\pi_t - \pi_t^*$ defines the inflation gap. The parameter ϕ_π controls the strength with which the central bank reacts to its inflation gap and satisfies the Taylor principle (that is, $\phi_\pi > 1$). To focus solely on fiscal inflation, we do not introduce an exogenous monetary policy shock at this time. We also leave the task of specifying the inflation target that varies over time after introducing the fiscal block.

The government budget constraint is

$$Q_t B_t + P_t T_t = B_{t-1},$$

where T_t defines the primary surplus and $Q_t B_t / P_t$ defines the real market value

[1] The central bank's long-term inflation target π^* can still be time-invariant, For example, the Federal Reserve adopts a 2% long-term inflation target.

of the debt. Let τ_t and $s_{b,t}$ denote the logarithmic deviations of the two variables from their corresponding steady-state values. The linearized government budget constraint (GBC) is

$$s_{b,t} = \beta^{-1}\left[s_{b,t-1} + i_{t-1} - \pi_t - (1-\beta)\tau_t\right]. \tag{3}$$

Recently, elevated public debt levels have been at the center of fiscal discussions. We consider a fiscal rule that incorporates a hidden time-varying debt target (see also Bianchi and Melosi (2017) and Han (2021)). Let us first consider a log-linearized surplus rule

$$\tau_t = \gamma_\tau(s_{b,t-1} - s^*_{b,t}) + \eta^\tau_t,$$

where $s^*_{b,t}$ is the log deviation of the contemporaneous debt target from its steady-state value.[2] The parameter $\gamma_\tau > 1$ controls the strength with which the government reacts to movements of $s_{b,t-1}$ from its time-varying target $s^*_{b,t}$. The η^τ_t represents an exogenous fiscal shock.

We still need to specify the law of motion for the time-varying debt target $s^*_{b,t}$. To achieve this goal, we draw on recent literature on funded and unfunded fiscal shocks. In particular, Bianchi, Faccini and Melosi (2023) considers the following log-linearized fiscal rule.

$$\tau_t = \gamma_\tau(s_{b,t-1} - s^*_{b,t-1}) + \gamma_b s^*_{b,t-1} + (\varepsilon^U_t + \varepsilon^F_t),$$

with $0 < \gamma_b < 1 < \gamma_\tau$, $\varepsilon^F_t \sim N(0, \sigma^2_F)$, and $\varepsilon^U_t \sim N(0, \sigma^2_U)$. For reasons illustrated below, Bianchi, Faccini and Melosi (2023) calls ε^F_t the "funded" shock, and ε^U_t the "unfunded" fiscal shock. Equating the above two fiscal rules and imposing the restriction that $\eta^\tau_t \equiv \varepsilon^F_t$ give the law of motion for the time-varying debt target

$$s^*_{b,t} = (1 - \gamma_b/\gamma_\tau)s^*_{b,t-1} - \gamma_\tau^{-1}\varepsilon^U_t, \quad \varepsilon^U_t \sim N(0, \sigma^2_U); \tag{4}$$

which is a stationary AR(1) process with persistence $1 - \gamma_b/\gamma_\tau \in (0, 1)$.

The crucial distinction between "funded" and "unfunded" fiscal shocks in the current literature is that while future primary surpluses back the former and therefore are not inflationary (that is, ε^F_t satisfies Ricardian equivalence), the unfunded shock ε^U_t is unbacked by necessary future fiscal adjustments and must be inflationary. In Bianchi, Faccini and Melosi (2023), all economic agents have perfect knowledge of ε^F_t and ε^U_t. Furthermore, the central bank is willing to accommodate all fiscal inflation by adjusting its π^*_t, which can only arise from unfunded shocks ε^U_t.

We now specify the time-varying inflation target, π^*_t. Consistent with Bianchi, Faccini and Melosi (2023), we assume that the unfunded fiscal shock completely

[2]The steady-state surplus-to-output ratio τ^* determines the steady-state real market debt s^*_b that the government can finance in the long run. To see the point, imposing steady-state values in the government budget constraint leads to $s^*_b + \tau^* = s^*_b/\beta$. Consequently, $s^*_b = (\beta\tau^*)/(1-\beta) > 0$.

drives π_t^*,

$$\pi_t^* = \mathcal{P}(L)\varepsilon_t^U. \tag{5}$$

For now, we do not impose any restrictions on the serial correlations of π_t^* and only assume that it is a covariance stationary process, which is equivalent to not imposing any functional forms of $\mathcal{P}(L)$ and only requiring $\sum_{j=0}^{\infty} \mathcal{P}_j^2 < \infty$. Technically, $\mathcal{P}(L)$ is an analytical function.

A. *Making connections to Leeper (1991) and Bianchi, Faccini and Melosi (2023)*

Before introducing incomplete information, it is worth connecting to two papers in the literature which also consider similar endowment economies. Setting

$$\gamma_b = \gamma_\tau, \quad \mathcal{P}(L) = 0 \Rightarrow \textit{Leeper}\ (1991) \tag{6}$$

eliminates the time-varying debt and inflation targets. In Leeper (1991), two separate parameter spaces deliver the existence and uniqueness of a rational expectation equilibrium (REE). The first equilibrium is in the monetary-led regime, where monetary policy responds more than one-to-one to deviations in inflation from its target ($\phi_\pi > 1$), and fiscal authority responds strongly to deviations of debt to keep it on a stable path ($\gamma_\tau > 1$). The fiscal shock is funded in the first regime. The other equilibrium is in the fiscal-led regime, where monetary policy responds less than one to one to inflation ($0 \leq \phi_\pi < 1$), and fiscal authority responds weekly to debt ($0 \leq \gamma_\tau < 1$). The fiscal shock in the second regime is unfunded. Leeper (1991) denotes the monetary-led Active Money-Passive Fiscal (AMPF) and the fiscal-led Passive Money-Active Fiscal (PMAF) regime. Appendix A derives both the AMPF and PMAF solutions. As debt stability is achieved with sufficient fiscal adjustments, a distinct feature of the monetary-led regime is that fiscal policy is Ricardian and inflation is independent of the funded fiscal shocks. In the fiscal-led regime, since fiscal authority responds weakly to debt, inflation must adjust to surplus shocks to stabilize government debt. By design, there is only one type of fiscal shock, funded or unfunded, in each of the regimes.

We share the same surplus and debt target rules as Bianchi, Faccini and Melosi (2023). In its simple model section, Bianchi, Faccini and Melosi (2023) considers the following policy rule in which the monetary authority reacts differently to funded and unfunded shocks

$$i_t = \phi_\pi(\pi_t - \pi_t^F) + \phi_F \pi_t^F. \tag{7}$$

In particular, the additional parameter ϕ_F satisfies $0 \leq \phi_F < 1$, and π_t^F is the inflation that would arise in a shadow economy in which the PMAF policy mix is always in place. The derivations in Appendix A imply

$$\pi_t^F = \frac{\beta - 1}{1 - \phi_F L} \varepsilon_t^U,$$

which is a stationary AR(1) process. It follows setting the time-varying inflation target process as follows

$$\mathcal{P}(L) = \left(1 - \frac{\phi_F}{\phi_\pi}\right) \frac{\beta - 1}{1 - \phi_F L} \Rightarrow \textit{Bianchi, Faccini and Melosi (2023)} \tag{8}$$

yields the simple model in Bianchi, Faccini and Melosi (2023).

Both papers contribute to the Fiscal Theory of Price Level and rely on the PMAF regime to generate fiscal inflation. Furthermore, both works assume a Full Information Rational Expectations (FIRE) environment. However, the immediate implication of the FIRE assumption suggests that the private sector should largely predict the COVID-19 inflation that would arise from large-scale fiscal stimuli. It contradicts the movements of bond yields in 2021, as few market participants anticipated the subsequent surge in inflation.

B. *Introducing incomplete information*

Let $\mathcal{M}$ denote the model structure which includes all the structural parameters and the equilibrium conditions. As in all rational expectations models, we first assume $\mathcal{M}$ is common knowledge for the household. Consequently, our information friction is different from the imperfect information channel considered in learning models (e.g. Eusepi and Preston (2018)).

Full-information models assume that economic agents can observe or learn all shocks (i.e., ε_t^F and ε_t^U) perfectly. As a benchmark, we first define the information set for the FIRE case as

$$I_t^{FI} = \{\varepsilon_{t-k}^F, \varepsilon_{t-k}^U, \mathcal{M} | k \geq 0\}. \tag{9}$$

The superscript "FI" denotes full information. The coexistence of funded and unfunded shocks, along with their vague clarifications from policymakers, naturally introduces incomplete information. We now formally introduce our concept of information friction while preserving the assumption of rational expectations.

Rewrite the two policy rules and define the monetary and fiscal signals $s_{m,t}$ and $s_{f,t}$ as

$$s_{m,t} = \pi_t - i_t/\phi_\pi = \pi_t^* \tag{10}$$

$$s_{f,t} = \tau_t - \gamma_\tau s_{b,t-1} = -\gamma_\tau s_{b,t}^* + \varepsilon_t^F. \tag{11}$$

We assume that households make $\mathbb{E}_t^{HH} \pi_{t+1}$ after observing the entire history of the nominal interest rate $\{i_{t-k} | k \geq 0\}$ and inflation $\{\pi_{t-k} | k \geq 0\}$, they can also observe the entire history of surpluses $\{\tau_{t-k}|k \geq 0\}$ and realized real market debt $\{s_{b,t-k}|k \geq 0\}$. It follows that we can define the incomplete information set as

$$I_t^{II} = \{s_{f,t-k}, s_{m,t-k}, \mathcal{M}|k \geq 0\}, \tag{12}$$

where the superscript "II" stands for incomplete information.

C. An analytical case without any monetary policy shocks

So far, we have not introduced exogenous monetary policy shocks. Although it is certainly a simplification, such a modeling choice can deliver powerful insight when coupled with an appropriate assumption. To see the point, comparing the observables in I_t^{II} and I_t^{FI} implies that we can establish the household's signal extraction problem as

$$\underbrace{\begin{bmatrix} s_{f,t} \\ s_{m,t} \end{bmatrix}}_{\mathbf{s}_t} = \underbrace{\begin{bmatrix} 1 & \frac{1}{1-\rho L} \\ 0 & \mathcal{P}(L) \end{bmatrix}}_{M(L)} \begin{bmatrix} \varepsilon_t^F \\ \varepsilon_t^U \end{bmatrix} \tag{13}$$

where $M(L)$ is a mapping in the lag operator L that links the household signals $\mathbf{s}_t$ to the underlying shocks ε_t^F and ε_t^U. For ease of notation, we define $\rho = 1 - \gamma_b/\gamma_\tau$.

The signal extraction (13) makes it clear that if the mapping $M(L)$ is invertible, then households can perfectly learn the two types of fiscal shocks and $I_t^{II} = I_t^{FI}$. Consequently, the model dynamics becomes FIRE. The Riesz-Fisher Theorem (see Sargent (1987)) establishes a necessary and sufficient condition for the invertibility of the mapping $M(L)$. For invertibility to hold, we must have a determinant of the mapping nonzero (i.e., $\det M(z) = \mathcal{P}(z) \neq 0$ for all $z \in (-1, 1)$.) For example, when $\pi_t^* = \pi_t^F$ follows the stationary AR(1) process (8) as in Bianchi, Faccini and Melosi (2023), there is no incomplete information between funded and unfunded fiscal shocks, even if the household's information set is given by (12).

In other words, to preserve incomplete information, $\mathcal{P}(L)$ must be non-invertible. A non-invertible $\mathcal{P}(L)$ requires at least one root $z \in (-1, 1)$ such that $\mathcal{P}(z) = 0$. For simplicity, we assume that there is only one such root, denoted by λ. Assumption 1 below formalizes the condition.

ASSUMPTION 1: *Assume there is a unique $\lambda \in (-1, 1)$, where $\lambda \neq 0$ such that $\mathcal{P}(z) = 0$. For all $z \in (-1, 1)$ and $z \neq \lambda$, $\mathcal{P}(z) \neq 0$.*

Given Assumption 1 and the signal extraction problem (13), we can solve for the equilibrium inflation process analytically using the frequency domain techniques (see Kasa, Walker and Whiteman (2014) and Han, Ma and Mao (2022)). Appendix B shows that the incomplete-information inflation process follows

$$\pi_t^{II} = \frac{\Pi_{F,0}}{1 - \lambda L} \varepsilon_t^F + \left[\frac{\mathcal{P}(\phi_\pi^{-1}) - \phi_\pi L \mathcal{P}(L)}{1 - \phi_\pi L} + \frac{\Pi_{U,0} - \mathcal{P}(\phi_\pi^{-1})}{1 - \lambda L} \right] \varepsilon_t^U. \tag{14}$$

where $\Pi_{F,0}$ and $\Pi_{U,0}$ are two endogenously determined constants. In contrast, the full-information inflation follows

$$\pi_t^{FI} = \frac{\mathcal{P}(\phi_\pi^{-1}) - \phi_\pi L\mathcal{P}(L)}{1-\phi_\pi L}\varepsilon_t^U. \tag{15}$$

We make several remarks about π_t^{II} and π_t^{FI}. While π_t^{FI} makes it clear that the funded shock ε_t^F satisfies the Ricardian equivalence and is non-inflationary in π_t^{FI}, it introduces an AR(1) term, $\Pi_{F,0}/(1-\lambda L)\varepsilon_t^F$, in π_t^{II}. The persistence of the AR(1) process is given by λ. Under incomplete information, even a transitory, funded fiscal shock can generate persistent inflation. The breakdown of Ricardian equivalence under incomplete information should not come as a surprise, as households cannot perfectly distinguish a funded shock from an unfunded fiscal shock. If the latter can generate some inflation, the former must also be inflationary with incomplete information. Second, compared to π_t^{FI}, which is fully driven by the unfunded shock ε_t^U, the same shock introduces an additional AR(1) term in π_t^{II}, which is given by $\frac{\Pi_{U,0}-\mathcal{P}(\phi_\pi^{-1})}{1-\lambda L}\varepsilon_t^U$. The additional term allows for a more complicated fiscal inflation process.

D. A numerical case with an exogenous monetary policy shock

The analytical result described above relies on a technical assumption (i.e., the non-invertibility of $\mathcal{P}(L)$) to preserve incomplete information. We now argue that information friction can arise naturally if there is an exogenous monetary policy shock e_t. Let the monetary policy rule be

$$i_t = \phi_\pi(\pi_t - \pi_t^*) + e_t, \quad e_t \sim N(0, \sigma_e^2). \tag{16}$$

Households can observe both the histories of i_t and π_t, but cannot separate the exogenous shock e_t from the endogenous inflation target π_t^*. All else being equal, we can establish the household's signal extraction problem between signals and the underlying shocks as

$$\begin{bmatrix} s_{f,t} \\ s_{m,t} \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & \frac{1}{1-\rho L} & 0 \\ 0 & \mathcal{P}(L) & -1/\phi_\pi \end{bmatrix}}_{M_2(L)} \begin{bmatrix} \varepsilon_t^F \\ \varepsilon_t^U \\ e_t \end{bmatrix} \tag{17}$$

Since there are three shocks $\{\varepsilon_t^F, \varepsilon_t^U, e_t\}$ and the private sector can observe only two signals $\{s_{f,t}, s_{m,t}\}$, the above non-square mapping $M_2(L)$ must be non-invertible and can preserve incomplete information.

We are ready to specify the time-varying inflation target process $\pi_t^* = \mathcal{P}(L)\varepsilon_t^U$. Similarly to the quantitative model in Bianchi, Faccini and Melosi (2023), we assume that there is an underlying shadow economy in which unfunded debt (that is, the debt target $s_{b,t}^*$) is the only state variable that can drive π_t^*. It follows that

$$\pi_t^* = \Phi_0 \cdot s_{b,t}^* = \frac{-\left(\Phi_0\gamma_\tau^{-1}\right)}{1-\rho L}\varepsilon_t^U = \frac{-\Phi}{1-\rho L}\varepsilon_t^U, \textit{ where } \Phi = \Phi_0\gamma_\tau^{-1} > 0. \tag{18}$$

It should be noted that the inflation target π_t^* inherits the persistence of $s_{b,t}^*$. The restriction $\Phi > 0$ ensures that when a negative unfunded fiscal shock (that is, $\varepsilon_t^U < 0$), the central bank will increase the short-term inflation target π_t^*. The parameter Φ controls the magnitude of the increase in the inflation target to an unfunded shock, indicating the strength of central bank accommodation to fiscal inflation.

Given the signal extraction problem (17), there is generally no analytical solution. We solve the model following the algorithm in Blanchard, L'Huillier and Lorenzoni (2013). Let $\mathbf{y}_t$ denote the vector of endogenous state variables and $\mathbf{s}_t$ the exogenous state variables. The equilibrium conditions can be written as

$$\mathbf{F}\mathbb{E}_\mathbf{t}^\mathbf{HH}\mathbf{y_{t+1}} + \mathbf{G}\mathbf{y_t} + \mathbf{H}\mathbf{y_{t-1}} + \mathbf{M}\mathbf{s_t} + \mathbf{N}\mathbb{E}_\mathbf{t}^\mathbf{HH}\mathbf{s_{t+1}} = \mathbf{0}, \tag{19}$$

where $\mathbf{F}, \mathbf{G}, \mathbf{H}, \mathbf{M}, \mathbf{N}$ are coefficient matrices. Solving (19) gives a law of motion

$$\mathbf{y_t} = \mathbf{P}\mathbf{y_{t-1}} + \mathbf{Q}\mathbf{s_t} + \mathbf{R}\mathbf{s_{t|t}}. \tag{20}$$

The $\mathbf{s_{t|t}}$ denotes the perceived exogenous state variables of the households, which can be obtained from the Kalman recursion once we establish the household signal extraction problem (17) as a state-space model[3]

For illustration, we fix a set of parameters as a benchmark. The time discount factor β is 0.99, suggesting a quarterly model. Other parameters are as follows.

$$\phi_\pi = 1.5, \quad \Phi = 0.1, \quad \sigma_e = 0.25,$$
$$\gamma_\tau = 2, \quad \gamma_b = 0.1, \quad \sigma_U = 1, \quad \sigma_F = 3;$$

The implied persistence of the time-varying debt target $s_{b,t}^*$ is $\rho = 1-\gamma_b/\gamma_\tau = 0.95$. The parameterization picks $\Phi_0 = \Phi\gamma_\tau = 0.2$, indicating that the central bank increases its inflation target by 0.2% for an additional 1% increase in the debt target. The standard deviations of the monetary and fiscal shocks are chosen to be in line with the existing estimates (see Smets and Wouters (2007) and Leeper, Plante and Traum (2010)).

Figure 1 plots the impulse responses of inflation (quarterly, non-annualized), nominal interest rate, real debt, and lump-sum surpluses to monetary and fiscal shocks (both funded and unfunded). We consider a negative one-standard-deviation shock one at a time to see its inflationary effect. With complete informa-

[3]For technical details of the Kalman recursion, see Hamilton (1994). Guo and Han (2025) uses the same solution algorithm and studies how time-varying fiscal foresight uncertainty impacts government spending multipliers in an incomplete information setting.

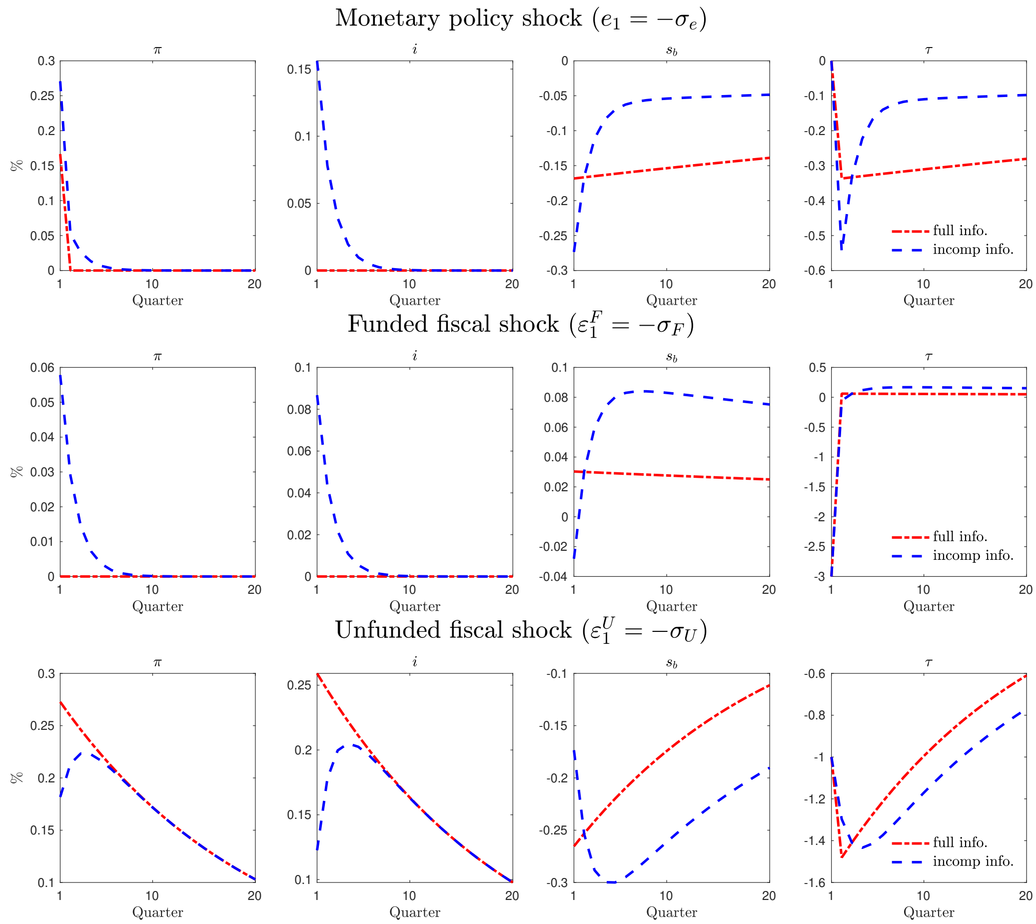

FIGURE 1. IMPULSE RESPONSES OF INFLATION (QUARTERLY, NON-ANNUALIZED), NOMINAL INTEREST RATE, REAL DEBT, AND LUMP-SUM SURPLUSES.

tion, a negative monetary policy shock $e_1 = -\sigma_e$ generates a one-time inflation. Since inflation is transitory and $\mathbb{E}_t^{HH}\pi_{t+1} = 0$, nominal interest rates stay the same. Higher inflation causes the real market value of debt to decrease, leading to negative negative primary surpluses. Due to Ricardian equivalence, the funded fiscal shock $\varepsilon_1^F = -\sigma_F$ generates trivial (that is, identically zero) inflation responses. Only the unfunded fiscal shock $\varepsilon_1^U = -\sigma_U$ can generate persistent inflation with full information.

All shocks can generate non-trivial and persistent inflation in the incomplete information model. This result is intuitive: When a transitory shock (either a monetary policy or a funded fiscal) hits the economy, incomplete information households rationally attribute the movements in their observables $\{s_{m,t}, s_{f,t}\}$to a linear combination of three shocks. The non-zero weight households assign to their *perceived* unfunded fiscal shock is the direct cause of the persistent inflation impulse responses. Consequently, the impulse responses of the nominal interest rate are also persistent to all three types of shocks as it tracks $\mathbb{E}_t^{HH}\pi_{t+1}$ in the Fisherian model.

Similarly, when a persistent unfunded fiscal shock ($\varepsilon_1^U = -\sigma_U$) hits the economy, households rationally believe that some of the observed changes in their signals $\{s_{m,t}, s_{f,t}\}$ are due to funded fiscal and monetary policy shocks. Since both perceived funded fiscal and monetary shocks cannot generate much inflation, the initial impact is small compared to the full-information model. Over time, households gradually determine the intrinsic nature of the underlying shocks, and the impulse responses of inflation and nominal interest rates converge to their full-information counterparts within two years.[4] The two characteristics force inflation and nominal interest rates to display hump-shaped impulse responses to the unfunded fiscal shock. The hump-shaped pattern has become a hallmark of incomplete-information rational expectation models.

Next, we conduct a sensitivity analysis to demonstrate how key parameters are likely to affect inflation dynamics. Figures 2 and 3 plot the impulse responses of inflation when varying the policy parameters $\{\phi_\pi, \Phi, \gamma_\tau, \gamma_b\}$ one at a time. The other parameters are fixed at the benchmark values. As ϕ_π decreases so that the central bank becomes more dovish, a negative policy shock (monetary or fiscal) generates larger inflationary effects. The parameter Φ controls how strongly the central bank accommodates the unfunded fiscal shock ε_t^U by raising its short-term inflation target π_t^*. When $\Phi = 0$ so that the central bank does not accommodate ε_t^U at all, both fiscal shocks ε_t^F and ε_t^U satisfy the Ricardian equivalence and are non-inflationary. As Φ increases from 0 to 1, it greatly amplifies the impulse responses of inflation to unfunded shocks. The persistence of the debt and inflation targets is both $\rho = 1 - \gamma_b/\gamma_\tau$. As γ_τ increases and γ_b decreases, the resulting inflation from the unfunded fiscal shock becomes larger and more persistent.

Figure 4 plots the impulse responses of inflation when varying the shocks' standard deviations $\{\sigma_e, \sigma_F, \sigma_U\}$. These parameters enter the model dynamics multiplicatively only through their corresponding shocks in full-information models. With incomplete information, these standard deviations play an additional role as they enter the signal extraction problem of the household (17) and determine the weights that the household assigns to their perceived shocks. For example, when σ_e and σ_F are relatively small compared to σ_U, households will assign more weight to their perceived unfunded shock when the actual shock is $\varepsilon_1^U = -\sigma_U$, with larger inflationary impulse responses (that is, the third column of Figure 4).

III. A Quantitative Model

We now embed the incomplete information structure into a medium-scale DSGE New Keynesian framework. Following Leeper, Traum and Walker (2017) and

[4]Since the real debt and the lump-sum primary surpluses are themselves very persistent, Figure 1 suggests that the convergence of the impulse responses can be very slow.

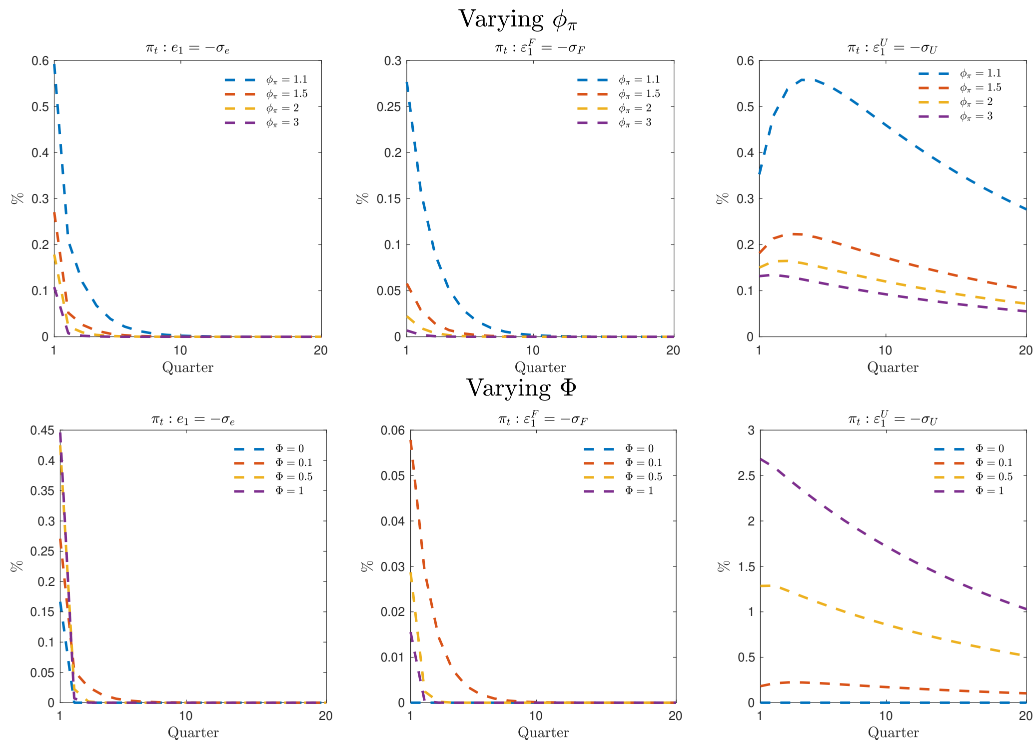

FIGURE 2. IMPULSE RESPONSES OF INFLATION (QUARTERLY, NON-ANNUALIZED) WHEN VARYING MONETARY POLICY PARAMETERS $\{\phi_\pi, \Phi\}$.

Bianchi, Faccini and Melosi (2023), the model includes a large set of real and nominal frictions and a rich fiscal block. These features are included to enhance the model's empirical fit and align with US business cycle dynamics. Since the model structure is standard, we describe here its main ingredients and defer the details and log-linearization to Appendix C.

There are two types of households in the economy: savers and hand-to-mouth consumers. Both households are subject to external habit formation and a discount factor shock. They receive wage income by providing labor to firms and are subject to various taxes. They also receive lump-sum transfers from the government. Savers have access to short- and long-term government bonds and can also accumulate capital, subject to variable capacity utilization and adjustment costs in investment. Hand-to-mouth households consume all of their disposable, after-tax income and do not save. Both Saver (S) and Non-saver (N) households derive utility from consumption of the composite good and disutility from the

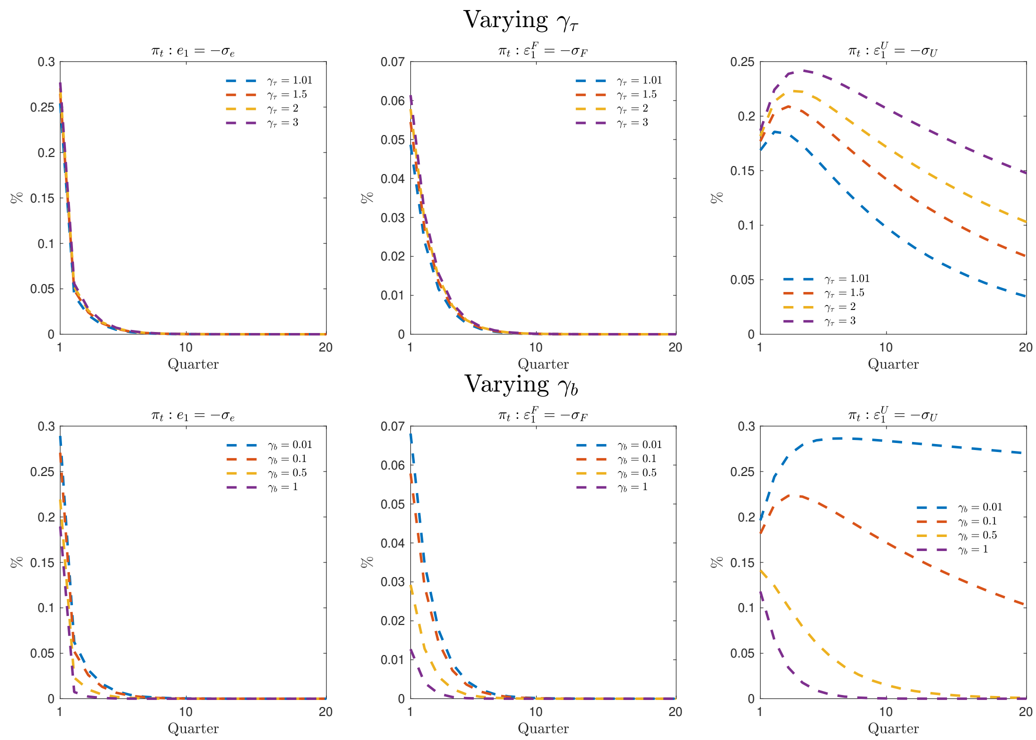

Figure 3. Impulse responses of inflation (quarterly, non-annualized) when varying fiscal policy parameters $\{\gamma_\tau, \gamma_b\}$.

supply of labor services:

$$U_t^i(j) = u_t^d \left(\ln \left(C_t^{*i}(j) - hC_{t-1}^{*i} \right) - \frac{L_t^i(j)^{1+\chi}}{1+\chi} \right), \qquad i \in \{S, N\} \tag{21}$$

where u_t^d is a shock from the discount factor, and $1/\chi$ is the Frisch elasticity of the labor supply.

Both households receive after-tax nominal income (W_t) and lump sum transfers from the government (Z_t). In addition, households can save by investing in a one-period government bond (B_t), a long-term nominal government bond (B_t^m), invest in physical capital (I_t), and receive dividends from firms (D_t). The budget

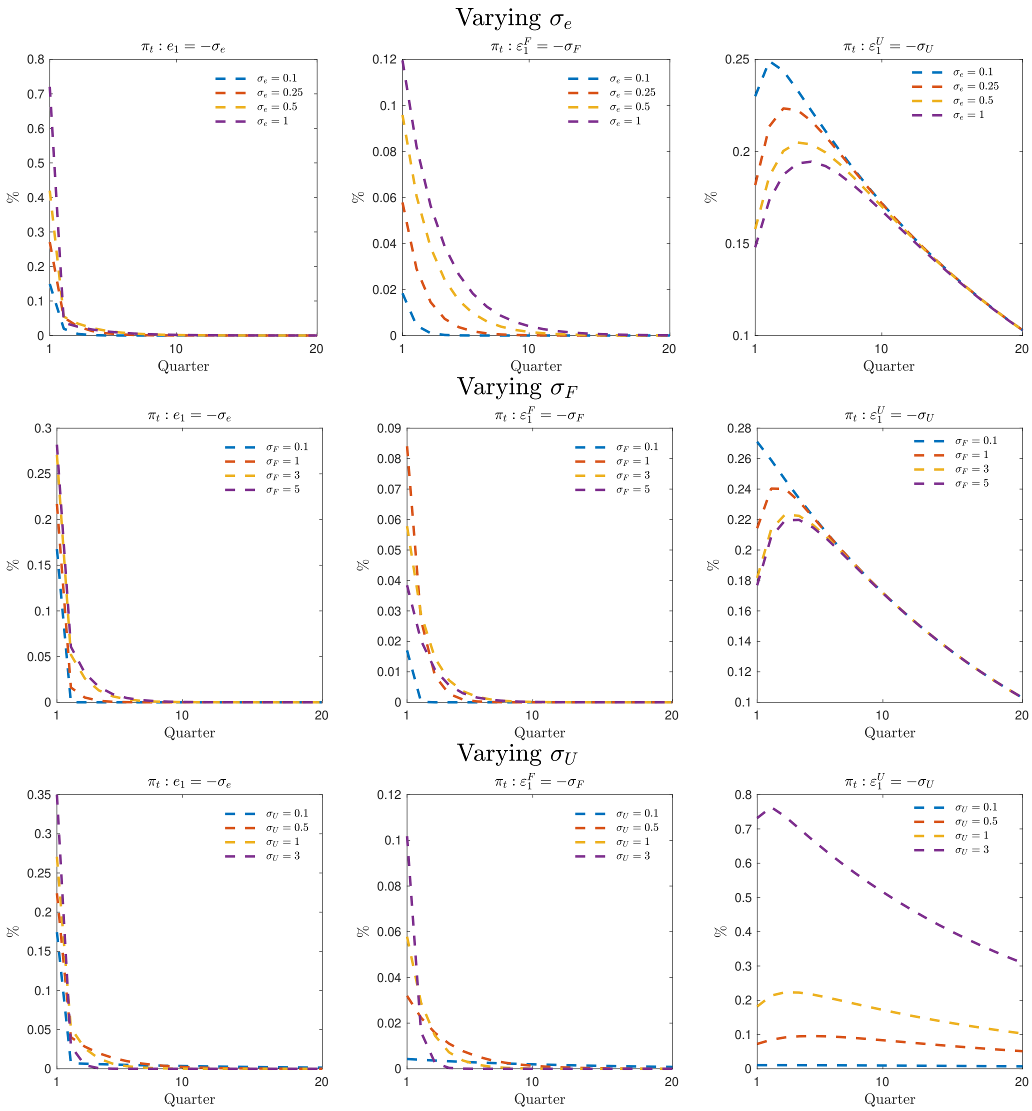

FIGURE 4. IMPULSE RESPONSES OF INFLATION (QUARTERLY, NON-ANNUALIZED) WHEN VARYING $\{\sigma_e, \sigma_F, \sigma_U\}$.

constraint of saver households can be written as:

$$
\begin{aligned}
& P_t \left(1+\tau_{C,t}\right) C_t^S + P_t I_t^S + P_t^m B_t^m + R_{n,t}^{-1} B_t \\
&= \left(1+\rho P_t^m\right) B_{t-1}^m + B_{t-1} + \left(1-\tau_{L,t}\right) \int_0^1 W_t(l) L_t^S dl \\
&\quad + \left(1-\tau_{K,t}\right) R_{K,t} \nu_t \bar{K}_{t-1}^S - \Psi\left(\nu_t\right) \bar{K}_{t-1}^S + P_t Z_t^S + D_t, \qquad (22)
\end{aligned}
$$

where $\tau_{C,t}$ and $\tau_{L,t}$ denote the tax rates on consumption and labor income, respectively. P_t and P_t^m are the prices of one-year and long-term bonds. The arbitrage condition and the law of capital accumulation are described in Appendix C in more detail. The household maximizes the expected utility $\mathbb{E}_0^{HH} \sum_{t=0}^{\infty} \beta^t U_t^S$ subject to the sequence of budget constraints in equation (22) and the law of motion of capital accumulation.

Intermediate goods firms are subject to the Calvo pricing and price indexation. To allow for balanced growth, the labor-augmenting technology A_t follows an exogenous process that is stationary in the growth rate. There is a perfectly competitive sector of final good firms that produce the final consumption good Y_t by combining a unit measure of intermediate differentiated inputs. Intermediate firms produce goods according to the production function:

$$Y_t(i) = K_t(i)^{\alpha} \left(A_t L_t(i)\right)^{1-\alpha} - A_t \Omega, \tag{23}$$

where Ω is a fixed production cost that increases with the rate of technological advancement that increases labor A_t, and $\alpha \in [0,1]$ is the capital share. When setting prices, firms face Calvo-style price rigidity. Wages set by firms are subject to both sticky wages and wage indexation.

The monetary and fiscal policy blocks in our model differ from the canonical DSGE models in two important ways. First, monetary policy follows a generalized Taylor rule

$$\hat{r}_t^n = \rho_r \hat{r}_{t-1}^n + (1-\rho_r)\left[\phi_\pi \left(\hat{\pi}_t - \hat{\pi}_t^*\right) + \phi_y \hat{y}_t\right] + u_t^m, \tag{24}$$

which embeds interest rate inertia and satisfies the Taylor principle (that is, $\phi_\pi > 1$). It also responds to the deviation of the inflation gap $\hat{\pi}_t - \hat{\pi}_t^*$ and the output $\hat{y}_t$. The existence of a persistent (that is, AR (1)) monetary policy shock, u_t^m, prevents households from learning the time-varying inflation target $\hat{\pi}_t^*$ perfectly from the monetary policy rule (24).

Fiscal policy consists of a set of expenditure, transfer, and tax rules. Let $s_{b,t}$ denote the real market debt-to-output ratio. The fiscal authority adjusts government spending $\hat{g}_t$, transfers $\hat{z}_t$, and tax rates on capital income $\hat{\tau}_k$ and labor income $\hat{\tau}_l$ as follows:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\left[\gamma_G\left(\hat{s}_{b,t-1} - \hat{s}_{b,t}^*\right) + \phi_{g,y}\hat{y}_t\right] + \varepsilon_t^g, \tag{25}$$

$$\hat{z}_t^b = \rho_Z \hat{z}_{t-1}^b - (1-\rho_Z)\left[\gamma_Z\left(\hat{s}_{b,t-1} - \hat{s}_{b,t}^*\right) + \phi_{z,y}\hat{y}_t\right] + \varepsilon_t^z, \tag{26}$$

$$\hat{\tau}_{J,t} = \rho_J \hat{\tau}_{J,t-1} + (1-\rho_J)\gamma_J\left[\hat{s}_{b,t-1} - \hat{s}_{b,t}^*\right] + \varepsilon_t^J, \text{ for } J \in \{k,l\}; \tag{27}$$

where γ_G, γ_Z, and $\gamma_J > 0$ are large enough to guarantee that the debt remains on a stable path. We abstract from consumption tax $\hat{\tau}_c$ by fixing its value. As in the Fisherian economy, the time-varying debt target, $s_{b,t}^*$, follows a stationary

AR(1) process:

$$\hat{s}^*_{b,t} = \rho_s \hat{s}^*_{b,t-1} - \varepsilon^U_t, \quad \varepsilon^U_t \sim N(0, \sigma^2_U),$$

with $\rho_s \in (0,1)$ and ε^U_t represents the unfunded fiscal shock. It should be noted that we do not let the tax rates respond to the output $\hat{y}_t$. This model choice follows Leeper, Traum and Walker (2017) and Bianchi, Faccini and Melosi (2023). It does not affect our main results.

Finally, as in the simple model, the unfunded fiscal shock drives the time-varying inflation target $\hat{\pi}^*_t$ as

$$\hat{\pi}^*_t = \rho_s \hat{\pi}^*_{t-1} - \Phi \cdot \varepsilon^U_t \tag{28}$$

with $\Phi > 0$. The parameter Φ controls the strength with which the central bank adjusts its short-term inflation target π^*_t to accommodate unfunded debt $s^*_{b,t}$. All economic agents form rational expectations, subject to incomplete information on monetary and fiscal policy shocks. We do not introduce incomplete information on any other shocks in the economy to focus on fiscal inflation.

A. Empirical Analysis

The model is estimated using Bayesian techniques to match the following 12 observables for the US economy: real per capita GDP growth, real per capita consumption growth, real per-capita investment growth, a measure of the hours gap, the effective federal funds rate, the growth of average weekly earnings, price inflation based on the GDP deflator, the growth of real government transfers, the growth of government expenditure, the government debt-to-GDP ratio, labor tax revenue and capital tax revenue. The data construction is explained in more detail in Appendix F.

Our sample period spans from 1960:Q1 to 2022:Q3. The estimation strategy to deal with the zero lower bound period after the financial crisis relies on two subsamples, the first sample from 1960:Q1 to 2007:Q4 and the second subsample from 2008:Q1 to 2022:Q3. The measurement equations linking observables to model variables are shown in the Appendix F.F1. Following Bianchi, Faccini and Melosi (2023) and Campbell et al. (2012), we discipline the second sample estimation by allowing agents' expectations of future interest rates to be informed by market forecasts. The latter subsample incorporates additional observables using overnight index swaps to measure the forecast of one to ten quarters ahead of the federal funds rate. Each sample is estimated in two steps; first we calculate the likelihood of our model and elicit the mode of posterior distribution. Second, we used MCMC with 50,000 simulations with burn-in 50% to obtain the entire posterior distribution.

The economic agents in the model form rational expectations of inflation, real interest rate, bond price, investment, marginal utility of the household of the savers, capital rental rate, capital tax rate, marginal utility of investment and real wages. We first estimate our model under the assumption that agents have full information about the shocks underlying the economy, which gives us our FIRE estimates.

We introduce incomplete information by assuming that all households, intermediate firms, and final good firms share the same information set, denoted by $\mathcal{I}_t^{HH}$. We assume that the agents can observe the entire history of the nominal interest rate $\{r_{t-k}^n | k \geq 0\}$, inflation $\{\pi_{t-k} | k \geq 0\}$, and output $\{y_{t-k} | k \geq 0\}$. The households can also observe the history of real-market debt $\{s_{b,t-k} | k \geq 0\}$, government spending and transfers $\{g_{t-k}, z_{t-k} | k \geq 0\}$, and the histories of labor and capital tax rates $\{\tau_{k,t-k}, \tau_{l,t-k} | k \geq 0\}$. However, households cannot distinguish between the exogenous shock to fiscal and monetary policy and the shock to time-varying debt and inflation targets.

There are more policy shocks than signals. Thus, incomplete information arises naturally in our model. For example, rewriting the monetary rule (24) as

$$\hat{r}_t^n - \rho_r \hat{r}_{t-1}^n - (1-\rho_r)\left(\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t\right) = \underbrace{-(1-\rho_r)\phi_\pi \pi_t^* + u_t^m}_{s_t^m}$$

indicates that the history of the variables on the right side, s_t^m, is also known to households. Similarly, rewriting the fiscal rules (25) and (26) as

$$\hat{g}_t - \rho_G \hat{g}_{t-1} + (1-\rho_G)\left[\gamma_G \hat{s}_{b,t-1} + \phi_{g,y} \hat{y}_t\right] = \underbrace{(1-\rho_G)\gamma_G \hat{s}_{b,t}^* + \varepsilon_t^g}_{s_t^g}$$
$$\hat{z}_t - \rho_Z \hat{z}_{t-1} + (1-\rho_Z)\left[\gamma_Z \hat{s}_{b,t-1} + \phi_{z,y} \hat{y}_t\right] = \underbrace{(1-\rho_Z)\gamma_Z \hat{s}_{b,t}^* + \varepsilon_t^z}_{s_t^z}$$

suggests that the two right-hand variables, s_t^g and s_t^z, are also in the household information set. Finally, the tax rules (27) can also be rewritten with signals where s_t^J is in the household information set. That is,

$$\hat{\tau}_{J,t} - \rho_J \hat{\tau}_{J,t-1} - (1-\rho_J)\gamma_J \hat{s}_{b,t-1} = \underbrace{-(1-\rho_J)\gamma_J \hat{s}_{b,t}^* + \varepsilon_t^J}_{s_t^J} \quad \forall J \in \{k, l\}$$

We do not introduce incomplete information about any other shocks in the model and assume that they can be observed perfectly by households. These shocks are intended to improve the empirical fit of the medium-scale DSGE model. Formally, we define the incomplete information set $\mathcal{I}_t^{HH}$ as

$$\mathcal{I}_t^{HH} = \{s_{t-k}^m, s_{t-k}^g, s_{t-k}^z, s_{t-k}^k, s_{t-k}^l, \mathcal{M} | k \geq 0\}.$$

The model is then re-estimated with incomplete information. Appendix D establishes the solution of the incomplete information rational expectations (IIRE) model as a state-space representation used in estimation.

B. Calibration and Prior Distributions

The priors for the model parameters are shown in Table 1. We set the prior parameter measuring the response of the short-term inflation target to the unfunded fiscal shock Φ as a Gamma distribution with mean 0.5 and variance 0.2. Our prior imposes the restriction that Φ must be greater than 0. The autocorrelation parameter ρ for all persistent shocks (except cost push) follows a Beta distribution with mean 0.5 and standard deviation 0.1. The AR(1) coefficients in the monetary and fiscal policy rules also follow a beta distribution at the same moments. We follow Bianchi, Faccini and Melosi (2023) and set a very persistent prior for the cost push shock with mean 0.995 and standard deviation 0.001 to allow persistent inflationary effects of the supply shock ex ante. We use an inverse gamma distribution with mean 0.5 and standard deviation 0.2 for the standard deviations of the shocks.

The response of fiscal variables to debt, γ_G, γ_{TK}, γ_{TL}, γ_Z, follows a normal distribution with mean 0.1 and standard deviation 0.1. Our fiscal rule allows government spending and transfers to respond to fluctuations in output. The associated policy parameters are restricted to be positive using the Gamma distribution with mean 0.2 and 0.5, and standard deviation 0.05 and 0.2 for transfers and government spending, respectively. All other prior choices follow Bianchi, Faccini and Melosi (2023) and Leeper, Traum and Walker (2017).

We calibrate the remaining parameters and the steady state in the model to sample averages consistent with Bianchi, Faccini and Melosi (2023). The discount factor β is set at 0.99, the share of capital in the production function α at 0.33, the depreciation rate δ at 2.5%, the substitution elasticity between labor and between intermediate goods at 0.14 and the share of agents from hand to mouth μ at 0.11. The steady state of government expenditure to GDP ratio is set at 0.11, and the steady state of labor, capital, and consumption tax rates are set at 0.186, 0.218, and 0.023, respectively.

IV. Estimation Results

We now present the results of our model estimation under the assumption of Full Information Rational Expectations (FIRE) and Incomplete Information Rational Expectations (IIRE). The posterior medians along with the 90%-credible intervals for all parameters are presented in Table 1. The incomplete information model performs better than the full information model in the estimation under both the first and second samples, measured by the higher log likelihoods.

A. FIRE versus IIRE: Non-policy shocks

Table 1 presents the posterior distribution from the first sample estimation (1960:Q1 to 2007:Q4) for all parameters and shocks in the model, and provides a direct comparison between the estimation results under FIRE and IIRE. Estimates are largely similar for most structural parameters and shock processes,

Parameter		**Prior**		**FIRE**				**IIRE**			
	Type	Mean	Std	Mode	Median	5%	95%	Mode	Median	5%	95%
Debt to GDP s_b	N	2.40	0.05	2.4076	2.400	2.325	2.480	2.3811	2.383	2.304	2.458
SS growth 100γ	N	0.5	0.05	0.4055	0.395	0.337	0.449	0.4796	0.481	0.443	0.516
SS inflation 100Π	N	0.5	0.05	0.4846	0.416	0.373	0.455	0.5088	0.553	0.477	0.603
Inverse Frisch ξ	G	2	0.25	2.4653	2.439	2.381	2.469	2.2567	2.225	2.167	2.325
Non-savers μ	B	0.11	0.01	0.0886	0.091	0.080	0.107	0.0879	0.089	0.076	0.102
Wage Calvo ω_w	B	0.5	0.1	0.7125	0.716	0.684	0.739	0.735	0.732	0.712	0.752
Price Calvo ω_p	B	0.5	0.1	0.7194	0.723	0.693	0.751	0.726	0.731	0.708	0.758
Cap util cost ψ	B	0.5	0.1	0.8575	0.788	0.748	0.832	0.7708	0.745	0.695	0.796
Invest adj cost	N	6	0.5	5.9752	5.754	5.698	5.808	5.0557	5.233	5.153	5.398
Wage index χ_w	B	0.5	0.2	0.0378	0.073	0.051	0.103	0.0436	0.050	0.035	0.087
Price index χ_p	B	0.5	0.2	0.0958	0.130	0.112	0.144	0.0579	0.063	0.055	0.070
Habits θ	B	0.5	0.2	0.9289	0.927	0.920	0.933	0.9149	0.914	0.905	0.922
C/G sub α_G	N	0	0.1	-0.0304	-0.017	-0.057	0.032	-0.0416	-0.026	-0.093	0.082
Taylor rule coeff ϕ_π	N	1.5	0.1	1.7268	1.695	1.614	1.760	1.7005	1.662	1.572	1.749
TR coeff on Y ϕ_y	N	0.5	0.1	0.0118	0.004	0.001	0.011	0.0029	0.001	0.000	0.004
Debt response γ_G	N	0.1	0.1	0.1489	0.159	0.151	0.170	0.1564	0.146	0.138	0.168
Debt response γ_{TK}	N	0.1	0.1	0.2025	0.252	0.209	0.293	0.266	0.297	0.280	0.326
Debt response γ_{TL}	N	0.1	0.1	0.0428	0.036	0.015	0.056	0.0022	0.002	0.000	0.005
Debt response γ_z	N	0.1	0.1	0.0137	0.012	0.010	0.014	0.0068	0.006	0.001	0.009
Output response $\phi_{z,y}$	G	0.2	0.1	0.2198	0.254	0.241	0.268	0.1953	0.210	0.195	0.223
Output response $\phi_{g,y}$	G	0.2	0.1	0.1836	0.195	0.189	0.199	0.1836	0.185	0.171	0.192
Infl. target strength Φ	G	0.5	0.1	0.4207	0.456	0.377	0.489	0.3414	0.251	0.218	0.282
AR(1) Coefficients and Standard Deviations of Shocks											
AR(1) MP-rule ρ_r	B	0.5	0.1	0.7847	0.745	0.711	0.786	0.7295	0.686	0.649	0.723
AR(1) G-rule ρ_g	B	0.5	0.1	0.9906	0.983	0.976	0.988	0.9764	0.978	0.969	0.984
AR(1) Z-rule ρ_z	B	0.5	0.1	0.9093	0.927	0.901	0.949	0.9457	0.957	0.939	0.971
AR(1) TK-rule ρ_{TK}	B	0.5	0.1	0.9263	0.910	0.890	0.926	0.9168	0.914	0.887	0.932
AR(1) TL-rule ρ_{TL}	B	0.5	0.1	0.8577	0.906	0.868	0.943	0.8468	0.860	0.829	0.885
Gov. Spending ρ_g^u	B	0.5	0.05	0.3917	0.414	0.372	0.451	0.4218	0.396	0.343	0.450
Technology ρ_a	B	0.5	0.1	0.3493	0.355	0.331	0.390	0.1221	0.109	0.075	0.138
Preference ρ_b	B	0.5	0.1	0.3586	0.424	0.381	0.487	0.7175	0.705	0.660	0.744
Monetary ρ_m	B	0.5	0.1	0.355	0.443	0.412	0.483	0.4116	0.497	0.403	0.538
Investment ρ_i	B	0.5	0.1	0.8972	0.861	0.835	0.891	0.8935	0.872	0.857	0.893
Risk Prem. ρ_{rp}	B	0.5	0.1	0.9002	0.881	0.863	0.898	0.8503	0.829	0.806	0.850
Cost-push ρ_{cp}	B	0.995	0.001	0.9961	0.996	0.994	0.997	0.9961	0.996	0.995	0.997
Transfer rho_z^u	B	0.5	0.05	0.3709	0.358	0.325	0.385	0.3695	0.357	0.317	0.392
Capital Tax ρ_{tk}^u	B	0.5	0.05	0.3618	0.438	0.389	0.483	0.3776	0.407	0.357	0.460
Labor Tax ρ_{tl}^u	B	0.5	0.05	0.3766	0.310	0.268	0.356	0.3801	0.369	0.297	0.405
Debt-target ρ_s	B	0.5	0.1	0.9638	0.961	0.952	0.972	0.9827	0.986	0.982	0.990
Gov spending σ_g	I	0.5	0.2	2.0465	2.158	2.061	2.246	2.0871	1.951	1.859	2.086
Technology σ_a	I	0.5	0.2	1.3105	1.287	1.168	1.391	1.2115	1.229	1.121	1.328
Preference σ_b	I	0.5	0.2	4.9421	4.984	4.968	4.998	4.994	4.992	4.981	4.999
Monetary σ_m	I	0.5	0.2	0.2471	0.253	0.229	0.275	0.2665	0.269	0.245	0.297
Investment σ_i	I	0.5	0.2	0.6674	0.674	0.633	0.715	0.6635	0.659	0.595	0.726
Wage σ_w	I	0.5	0.2	0.3194	0.315	0.291	0.343	0.3344	0.335	0.308	0.367
Price markup σ_p	I	0.5	0.2	0.1822	0.178	0.154	0.209	0.172	0.171	0.148	0.201
Risk prem. σ_{rp}	I	0.5	0.2	0.4035	0.444	0.413	0.474	0.4806	0.525	0.481	0.581
Cost-push σ_{cp}	I	0.5	0.2	0.1422	0.138	0.118	0.163	0.135	0.132	0.114	0.151
Transfer σ_z	I	0.5	0.2	3.4064	3.331	3.270	3.406	3.4694	3.612	3.559	3.662
Unfunded σ_U	I	0.5	0.2	0.2135	0.196	0.169	0.214	0.1617	0.188	0.160	0.222
Capital tax σ_{tk}	I	0.5	0.2	4.799	4.921	4.865	4.961	4.8327	4.889	4.849	4.912
Labor tax σ_{tl}	I	0.5	0.2	3.0317	3.148	3.032	3.265	3.0225	2.888	2.728	3.032
GDP M.E. σ_y^{ME}	I	0.5	0.2	0.4353	0.447	0.412	0.475	0.4426	0.445	0.411	0.498
Debt/GDP M.E. σ_{sb}^{ME}	I	0.5	0.2	0.322	0.290	0.266	0.313	0.326	0.307	0.273	0.322

Table 1—Parameter Estimates Comparison: FIRE vs. IIRE

Notes: The letters in the column with the heading Prior Type indicate the prior density function: N, G, B, and I stand for Normal, Gamma, Beta, and Inverse-Gamma respectively. The posterior median and confidence intervals are computed using MCMC with 200,000 simulations and 50% burn-in.

including policy response coefficients. We find the central bank to be marginally more aggressive in its response to inflation deviations from its long-term steady state with full information. However, the central bank also adjusts its short-term inflation target in response to an unfunded fiscal shock more aggressively (captured by a higher Φ) under FIRE than under IIRE.

Similar estimated posterior distributions across the two frameworks imply that the impulse responses of macroeconomic variables should be quantitatively similar for all shocks which are not subject to incomplete information. Appendix E presents the impulse responses of six key macro variables, output, inflation, nominal interest rate, real interest rate, expected inflation, and real marginal cost, to all non-policy shocks in the model. Since incomplete information is introduced only for policy shocks, responses to other shocks help reveal effects of differences in the estimated structural parameters. For these non-policy shocks, the effects on macro variables are nearly identical under both the FIRE and IIRE frameworks. However, some differences emerge with the preference shock, which is estimated to be twice as persistent under IIRE, leading to a larger impact on inflation, expected inflation, and the real interest rate compared to FIRE. In contrast, a less persistent risk premium shock produces a smaller inflationary response under IIRE.

B. FIRE versus IIRE: Funded and unfunded fiscal shocks

The main interest of our analysis lies with the behavior of the economy in response to an unfunded fiscal shock under FIRE and IIRE. Figure 5 presents the impulse response for output, inflation, and the real interest rate, under a one-percent expansionary unfunded fiscal shock and funded transfer shock. The magnitude of the responses are percentage deviations from the steady state. Funded and unfunded fiscal shocks are clearly identified in the model, with the funded shock having quantitatively negligible effects on output, inflation, and real interest rate under both FIRE and IIRE. The real interest rate decreases in response to the funded shock, raising both inflation and output on impact.

An expansionary unfunded shock is a quantitatively significant demand shock that persistently raises both output and inflation under the FIRE and IIRE estimations. On impact, output responds similarly to both estimates, reaching the maximum response in about four years. In the long run, output remains above its steady state level, with a modest but persistent difference (0.15%) between the FIRE and IIRE responses after ten years. In contrast, the response to inflation is large and strikingly different between the two information frameworks. On impact, the annualized inflation response is significantly lower under incomplete information than under full information despite similar posterior distributions for all policy parameters under FIRE and IIRE.

The difference in response of inflation lies in how an unfunded shock transmits under full and incomplete information. Under full information, agents can perfectly separate unfunded shocks from other shocks to the economy. Conse-

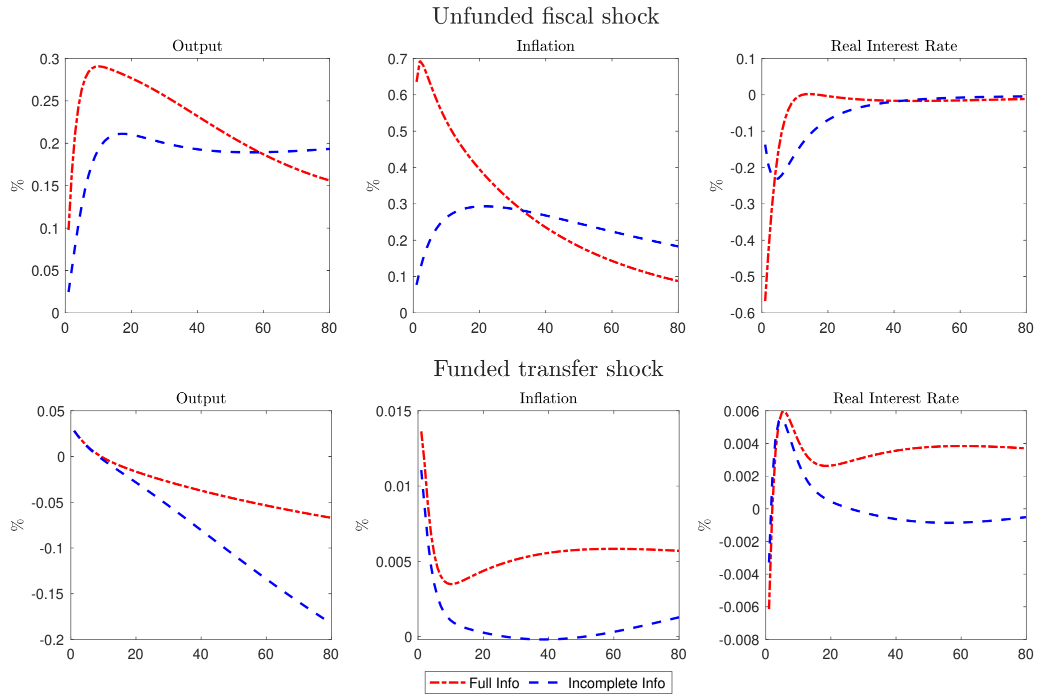

FIGURE 5. IMPULSE RESPONSES TO EXPANSIONARY FUNDED AND UNFUNDED FISCAL SHOCKS

Notes: Impulse response to unfunded fiscal shock (top panel) and funded transfer shock (bottom panel) for output, inflation (annualized), and real interest rate (annualized) under FIRE and IIRE. The size of shocks are fixed at one standard deviation expansionary shock, as estimated in the second sample. The units of response are percentage deviations from steady state.

quently, inflation rises rapidly to pay for the transfers. This increase in inflation is accommodated by monetary policy in the short run, as captured by the large decrease in real interest rate under FIRE. The interest rate increases as the central bank reacts more aggressively to deviations in inflation from their medium run target, with deviations for the real interest rate reverting to 0 in approximately two years. The difference in inflation response narrows as inflation under IIRE reaches a peak of 0.3% in approximately four years. Given the information frictions, agents cannot immediately distinguish between a funded and an unfunded shock attributing some proportion of the observed shock to each type. An hump-shaped response to inflation emerges as agents acquire more information about the nature of the shock. Our information friction also extends to the central bank which cannot distinguish between funded shocks and unfunded shocks affecting its short term inflation target. As a result, the central bank under IIRE is significantly less accommodating, with the real interest rate decreasing much less on impact than FIRE. However, the interest rate remains persistently low for ten additional quarters as the central bank gradually understands the nature of the shock.

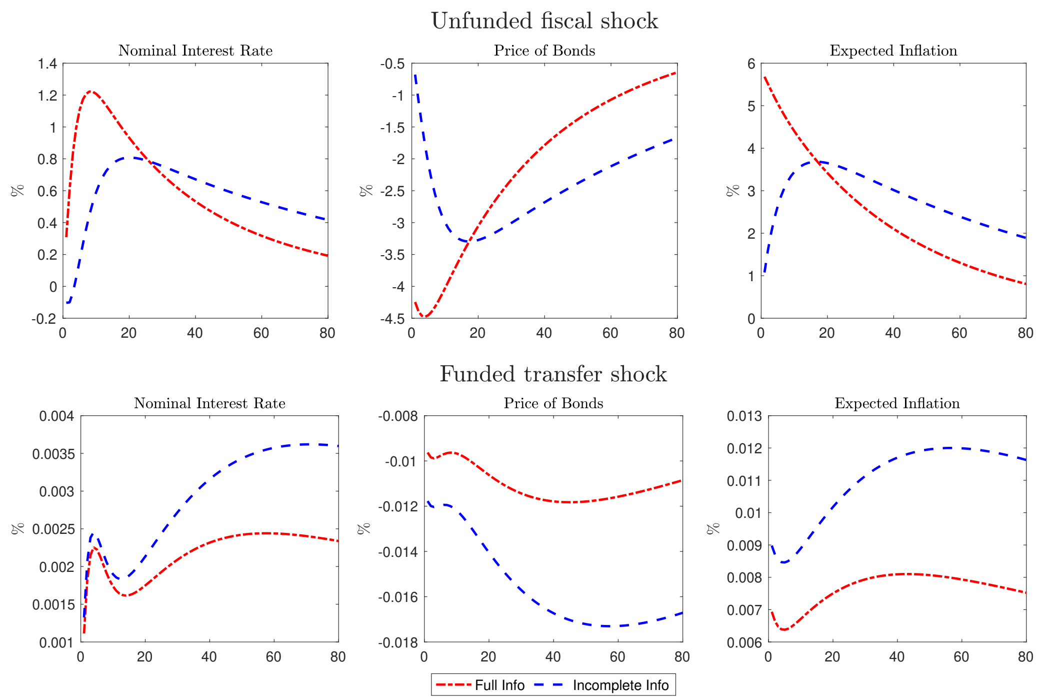

Figure 6. Impulse responses to expansionary funded and unfunded fiscal shocks

Notes: Impulse response to unfunded fiscal shock (top panel) and funded transfer shock (bottom panel) for nominal interest rate (annualized), price of bonds, and expected inflation (annualized) under FIRE and IIRE. The size of shocks are fixed at one standard deviation expansionary shock, as estimated in the second sample. The units of response are percentage deviations from steady state.

Figure 6 presents the impulse response functions for nominal interest rate, expected inflation, and price of bonds to one percent unfunded and funded fiscal shocks. Similarly to Figure 5, the magnitude of the responses of all nominal variables is near 0 for an expansionary funded transfer shock, while the unfunded fiscal shock creates significant effects. Nominal interest rate increases with inflation under both FIRE and IIRE with the persistence of response being higher under IIRE. Combined with higher inflation and interest rate, the decrease in bond prices on impact is nearly four times as significant under FIRE than under IIRE. As the nature of the policy shock becomes clearer under IIRE, bonds prices fall further, quantitatively reaching the same levels as FIRE but only after ten additional quarters. An unfunded shock not only affects current inflation but significantly raises five-year-forward inflation expectations. The expected inflation under FIRE is highest on impact, decaying with time as the real value of transfers decreases. Five-year-forward expected inflation follows the same inverse

U-shaped response as current inflation under information frictions. The transmission mechanism remains the same- as economic agents acquire information about the nature of the shock with a lag, inflation expectations gradually increase for nearly five years after impact before decaying slowly.

C. Historical Decomposition

We now discuss how the drivers of historical inflation differ under incomplete information relative to full information. Figure 7 presents the decomposition of annualized inflation over our sample period under incomplete information (Panel A). The bars indicate the cumulative contributions from three sources: unfunded fiscal shocks (dark blue), other policy shocks (purple), and all other non-policy shocks and steady-state (light blue).The solid line plots annualized inflation. Panel B shows the historical contribution of supply shocks (dark blue) and monetary policy shock (light blue) to inflation.[5]

The decomposition results illustrate how the model attributes observed inflation to unfunded fiscal shocks versus other shocks under incomplete-information rational expectations (IIRE). The unfunded shocks gained prominence in the United States in mid-1960s after tax cuts went into effect in 1964, marking a sharp departure from the government's balanced budget philosophy. A second wave of expansionary policies arrived in the early 1970s, characterized by increased government transfers and a substantial rise in the money supply. The model suggests that unfunded shocks explained about one-third of the roughly 12% inflation observed in the mid-1970s.

The inflation surge in mid-1970s is attributed to all three categories of unfunded transfer, other policy, and non-policy shocks. A closer look from Panel B shows that roughly half of the inflation peak in 1974 is explained by the supply shocks and the remaining by monetary policy shocks, reflecting the monetary expansion in 1970s under then Federal Reserve Chair Arthur Burns (Blinder, 2022; Bianchi, Faccini and Melosi, 2023). This period coincides with the first oil price shocks of the 70s and the model links the rapid inflationary surge primarily to these oil shocks (captured by the supply shocks category). A renewed spike in oil prices drove the second major inflation peak in 1981, which the IIRE model also links primarily to supply shocks. Overall, the IIRE model underscores the role of multiple drivers, both policy and non-policy, in the high inflation of the 1970s and 1980s. While supply shocks also play an important role in BFM's model, their model finds no role for monetary expansions in inflation dynamics of the 1970s.

[5]The category "Non-policy Shocks" include technology, wage markup, cost-push, price markup shock, investment shock, preference shock and risk premium shock, along with the steady state. The category "Other Policy Shocks" include all policy shocks except the unfunded shock- funded fiscal transfers, funded government expenditure, shock to labor tax revenue, shock to capital tax revenue, and the monetary policy shock. "Supply shocks" include persistent cost push shock, transitory price markup shock, transitory wage markup shock, and technology shock.

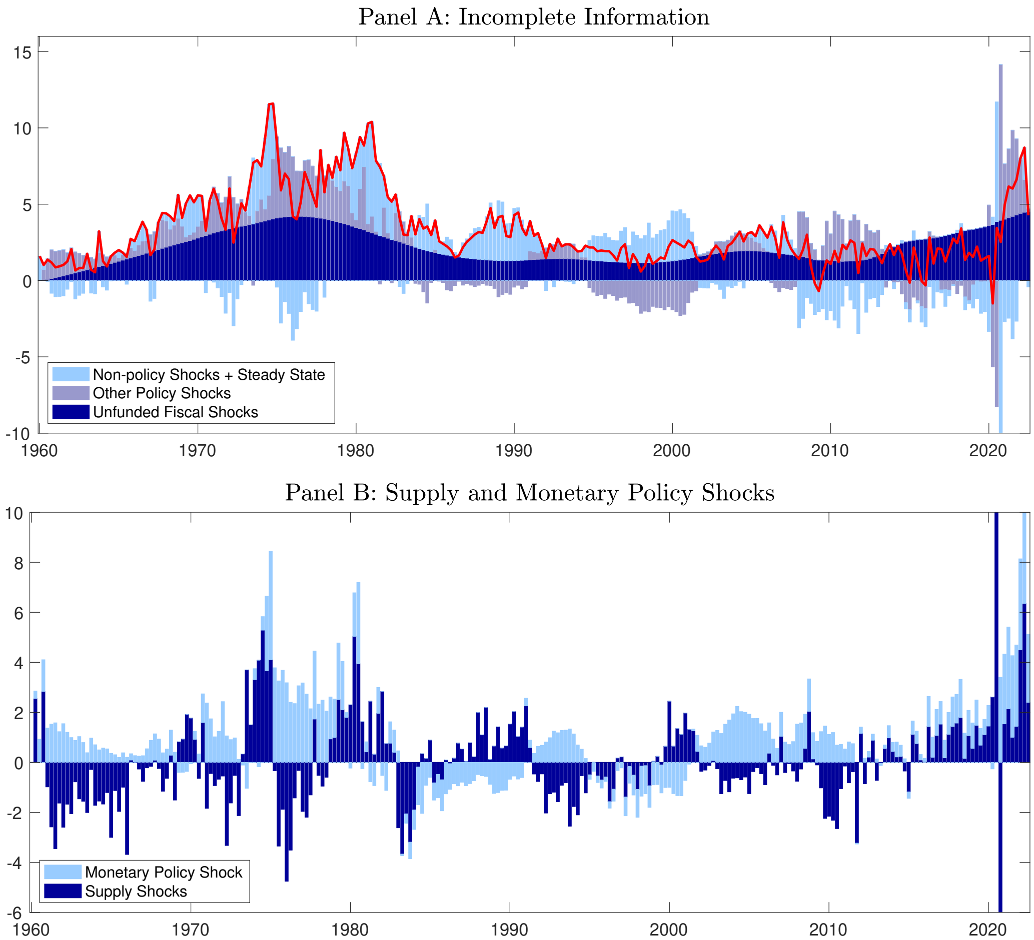

FIGURE 7. HISTORICAL DECOMPOSITION OF INFLATION UNDER INCOMPLETE INFORMATION

Notes: Figure shows the historical decomposition of inflation under Incomplete Information over our sample period from 1960:Q1 to 2022:Q3. The solid red line is the annualized inflation as measured by growth in GDP deflator. Panel A: Dark blue bars are the contribution of unfunded fiscal shocks, purple bars are the contribution of all other policy shocks, and light blue bars are the contribution of all other shocks and steady-state. Panel B: Dark blue bars are the contribution of supply shocks which include cost push shock, price-markup shock, technology shock, and wage markup shock, and light blue bars are the contribution of monetary policy shock. Shocks are estimated using estimated mode for sample 1 until 2007:Q4, and estimated modes from sample 2 starting 2008:Q1.

The unfunded tax cuts of the 1970s and early 1980s continued to influence inflation, although volatility during this period was increasingly driven by supply shocks and other policy and non-policy shocks. The final major oil price shock of the 20th century struck in the late 1980s and early 1990s, pushing inflation to a peak of about 5%. The IIRE model captures this episode as a supply shock, attributing the bulk of the inflation to this factor. Inflation remained subdued through the rest of the 1990s and early 2000s, rising again in the early to mid-2000s. The tax cuts of the 2000s are reflected in the persistent positive contribution of unfunded transfers during this period. Panel B shows that monetary expansion was also a key contributor towards inflation in mid 2000s. Following the financial crisis, unfunded fiscal shocks emerged as the primary counterforce to deflationary pressures from supply shocks, a dynamic captured by both ours and BFM's model. Notably, our model also highlights the contribution of expansionary monetary policy in countering deflationary shocks.

Panel A and B of Figure 7 show that like the 70s, a combination of unfunded shocks, monetary policy shocks, and supply shocks contributed to the sharp increase in inflation post-pandemic. Under IIRE, the contribution of unfunded shock to inflation increases steadily following the disbursement of first round of stimulus payments under the CARES act. The IIRE model also captures the inflationary impact of supply chain disruptions and semiconductor shortages that raised production costs for many consumer goods during the pandemic. This dynamic is captured by the sharp increase in contribution of supply shock post-pandemic with the peak in 2022:Q2.[6]

The existing literature remains divided on the key drivers of post-pandemic inflation. In BFM, the increase in inflation is attributed entirely to unfunded fiscal shocks, while non-policy shocks are found to exert an offsetting, deflationary influence. By contrast, Smets and Wouters (2024) argue that supply shocks were the primary contributors to pandemic-era inflation, with unfunded transfers playing no inflationary role. Our results suggest that while the persistence of inflation was driven by unfunded fiscal shocks, the sharp rise and subsequent decline in inflation between late 2021 and mid-2022 is explained by supply shocks. Our model shows that information frictions are key to reconciling the findings in Bianchi, Faccini and Melosi (2023) and Smets and Wouters (2024).

D. *Monetary-Fiscal Interaction under Information Frictions*

An important feature of our model is the interaction between monetary and fiscal policy in the presence of information frictions. The central bank accommodates unfunded fiscal shocks by adjusting its short-term inflation target, but it does not accommodate funded fiscal shocks. Under imperfect information (IIRE), economic agents cannot perfectly distinguish between funded and unfunded shocks. As a result, an expansionary monetary policy shock can signal an increase in the central bank's short term inflation target, leading to higher and more persistent inflation response compared to the full-information (FIRE) case.

Figure 8 shows the impulse response of output, inflation, and interest rate to a one-percent expansionary monetary policy shock. Inflation and output increase, while real interest rate fall under both FIRE and IIRE. However, under IIRE

[6]The semiconductor or "chip" shortage during the pandemic sharply increased used car prices in the U.S. with the largest contribution to CPI in early and mid-2022. Our model captures this increase and subsequent decline in prices under the category "supply shocks".

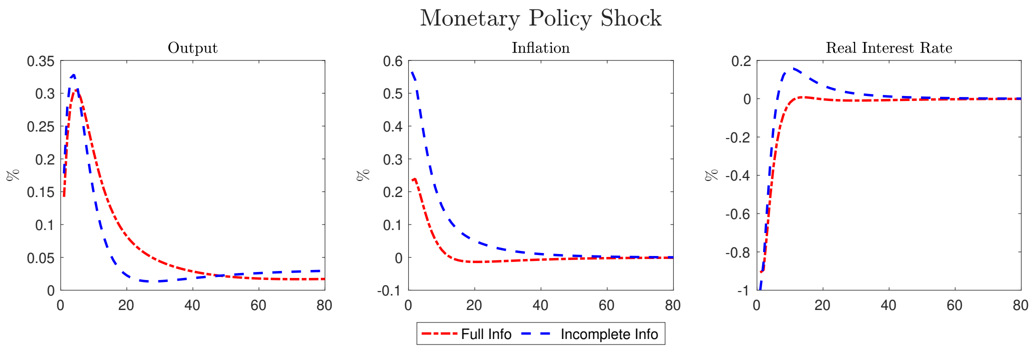

FIGURE 8. IMPULSE RESPONSES OF OUTPUT, INFLATION, AND REAL INTEREST RATE TO A ONE-PERCENT EXPANSIONARY MONETARY POLICY SHOCK

Notes: Impulse response to a one percent funded monetary policy shock for three variables: output, inflation, and real interest rate, under full information and incomplete information estimation. The size of shocks are fixed at one standard deviation expansionary shock, as estimated in the second sample. The units are percentage deviations from steady-state.

the effects on inflation are notably stronger. Annualized inflation increases by nearly 0.6 percentage points on impact and remains persistently elevated. By contrast, under FIRE the inflationary response is more muted, with inflation rising by only 0.25 percentage points on impact. However, the output responses are very similar across the two regimes as information frictions primarily shape the inflation dynamics through the central bank's short-term inflation target.

Panel B of Figure 7 extends the decomposition exercise in Section IV.C to highlight the contribution of monetary policy shocks (light blue bars) towards inflation during the pandemic under incomplete information. While much focus has been placed on stimulus payments during COVID in supporting consumer demand, the recovery from COVID was also supported by highly expansionary monetary policy. The Federal Reserve lowered the effective federal funds rate from 1.5% to near 0 between January and April 2020. Reduction in the already low interest rates were insufficient stimulus for the economy which prompted the Fed to pursue large quantitative easing measures purchasing nearly $4.2 trillion of US treasury and mortgage-backed securities between February 2020 and March 2022.

While unfunded shocks continue to contribute to elevated post-pandemic inflation, the IIRE model also emphasizes the role of monetary–fiscal coordination in driving inflation to its peak. Between 2021 and 2022, the IIRE model attributes roughly the same fraction of inflation to both unfunded fiscal shocks and expansionary monetary policy measures. This aligns with our earlier finding that information frictions amplify the inflationary impact of monetary expansions.

E. Tax multipliers: Funded versus unfunded

Figure 9 reports the impulse responses of output, inflation, and the debt-to-GDP ratio to a one–standard deviation expansionary capital or labor tax shock (i.e., a tax cut) under incomplete information. For comparison, we also present results for unfunded fiscal shocks. Funded capital and labor tax cuts generate a sizable and persistent increase in output but have only negligible effects on inflation compared to the effects under the unfunded shock. Since both tax cuts are financed, the real debt-to-GDP ratio rises steadily, stabilizing about 0.7 percentage points above its steady state. By contrast, output increases persistently and real interest rate declines lowering the borrowing cost (Figure 5), resulting in a decrease in debt to GDP ratio in response to an expansionary unfunded fiscal shock.

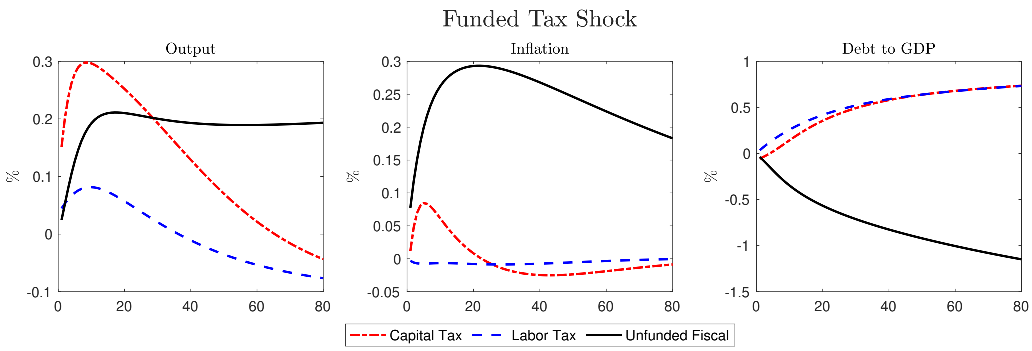

FIGURE 9. IMPULSE RESPONSES TO EXPANSIONARY FUNDED LABOR TAX, CAPITAL TAX, AND UNFUNDED FISCAL SHOCK

Notes: Impulse response to a standard deviation funded labor tax, capital tax, and unfunded fiscal shock for three variables: output, inflation, and debt to GDP ratio, under incomplete information estimation. The size of shocks are fixed at one standard deviation expansionary shock, as estimated in the second sample. The units are percentage deviations from steady-state.

To capture the dynamics of output over time in response to capital and labor tax shock, we compute the present value multipliers following Leeper, Traum and Walker (2011).[7] Capital tax shocks generate an output multiplier of -0.43 on impact, a present value multiplier larger than -1 after twelve quarters, and a maximum multiplier of -1.6 after 68 quarters. Our findings are consistent with the empirical fiscal multiplier literature which shows that capital tax cuts are highly stimulative in the long run (Romer and Romer, 2010). The multipliers for labor tax shock is modest in contrast with multiplier of -0.14 on impact and a

[7]Present value multipliers are computed as the ratio of the present value of changes in output to the present value of changes in capital or labor taxes: $E_t \frac{\sum_{j=0}^{k}(\Pi_{i=0}^{j} R_{t+i}^{-1})\Delta Y_{t+j}}{\sum_{j=0}^{k}(\Pi_{i=0}^{j} R_{t+i}^{-1})\Delta T_{t+j}}$.

maximum multiplier of -0.39 reached after 30 quarters. While the information frictions in our model amplify the output response, we do not find any significant inflation effects due to the funded tax shocks.

V. Conclusion

This paper presents a novel informational interaction of monetary and fiscal policy within the larger class of DSGE models to generate fiscal inflation with an active monetary policy which satisfies the Taylor principle. We achieve this through the lens of incomplete information between funded and unfunded fiscal shocks. We augment monetary and fiscal policy rules with a pair of interconnected inflation and debt targets that vary over time. The unfunded fiscal shock drives the two hidden short-term targets, altering both policy implications.

Fiscal inflation arises from incomplete information where economic agents cannot immediately distinguish funded fiscal shock and monetary policy shock from unfunded fiscal shocks, which are inherently inflationary as they must be paid through erosion of real value of debt gradually. In our simple model, even funded transfer shocks are inflationary as information frictions break Ricardian equivalence. Moreover, an exogenous one-time interest rate cut can generate persistent inflation, as households can only identify the nature of policy shocks over time.

We incorporate our adjusted policy rules and information friction in a New Keynesian framework and estimate our model using macroeconomic data. Incomplete information affects both the transmission mechanism and the parameter estimates. Compared to full information, inflation arising from unfunded shocks under incomplete information is lower but more persistent.

Historical decomposition of inflation under incomplete information shows that unfunded shocks significantly contributed to inflation during 1970s and countered deflationary pressures from supply shocks after the 2008 financial crisis. Following the COVID pandemic, a consistent increase in unfunded fiscal transfers and expenditure contribute positively to rising inflation. However, our model also highlights the contribution of supply shocks and expansionary monetary policy shock towards the rapid increase and subsequent decline of inflation between 2021 and 2023.

REFERENCES

Angeletos, George-Marios, Chen Lian, and Christian K. Wolf. 2024. "Deficits and Inflation: HANK Meets FTPL." *NBER Working Ppaer*, , (33102).

Barro, Robert J. 1974. "Are Government Bonds Net Wealth?" *Journal of Political Economy*, 82(6): 1095–1117.

Bassetto, Marco, and David S Miller. 2025. "A monetary-fiscal theory of sudden inflations." *The Quarterly Journal of Economics.*

Bernanke, Ben, and Olivier Blanchard. 2023. *What caused the US pandemic-era inflation?* Vol. 86, PIIE, Peterson Institute for International Economics.

Bianchi, Francesco, and Leonardo Melosi. 2017. "Escaping the Great Recession." *American Economic Review*, 107(4): 1030–58.

Bianchi, Francesco, Renato Faccini, and Leonardo Melosi. 2023. "A Fiscal Theory of Persistent Inflation*." *The Quarterly Journal of Economics*, 138(4): 2127–2179.

Blanchard, Olivier J., Jean-Paul L'Huillier, and Guido Lorenzoni. 2013. "News, Noise, and Fluctuations: An Empirical Exploration." *American Economic Review*, 103(7): 3045–70.

Blinder, Alan S. 2022. *A Monetary and Fiscal History of the United States, 1961-2021.* Princeton University Press.

Campbell, Jeffrey R, Charles L Evans, Jonas DM Fisher, and Justiniano. 2012. "Macroeconomic effects of federal reserve forward guidance." *Brookings papers on economic activity*, 1–80.

Davig, Troy, Eric M. Leeper, and Todd B. Walker. 2010. "'Unfunded Liabilities' and Uncertain Fiscal Financing." *Journal of Monetary Economics*, 57(5): 600–619.

Eusepi, Stefano, and Bruce Preston. 2018. "Fiscal Foundations of Inflation: Imperfect Knowledge." *American Economic Review*, 108(9): 2551–89.

Giannone, Domenico, and Giorgio Primiceri. 2024. "The drivers of post-pandemic inflation."

Guo, Junjie, and Zhao Han. 2025. "Time-varying government spending foresight." *Journal of Economic Dynamics and Control*, 173: 105067.

Hamilton, James D. 1994. *Time Series Analysis.* Princeton:Princeton university press.

Han, Zhao. 2021. "Low-frequency fiscal uncertainty." *Journal of Monetary Economics*, 117.

Han, Zhao, Xiaohan Ma, and Ruoyun Mao. 2022. "The role of dispersed information in inflation and inflation expectations." *Review of Economic Dynamics.*

Ireland, Peter N. 2007. "Changes in the Federal Reserve's inflation target: Causes and consequences." *Journal of Money, credit and Banking*, 39(8): 1851–1882.

Kasa, Kenneth, Todd B. Walker, and Charles H. Whiteman. 2014. "Heterogeneous Beliefs and Tests of Present Value Models." *The Review of Economic Studies*, 81(3): 1137–1163.

Leeper, Eric M. 1991. "Equilibria Under 'Active' and 'Passive' Monetary and Fiscal Policies." *Journal of Monetary Economics*, 27(1): 129–147.

Leeper, Eric M., Michael Plante, and Nora Traum. 2010. "Dynamics of Fiscal Financing in the United States." *Journal of Econometrics*, 156(2): 304–321.

Leeper, Eric M., Nora Traum, and Todd B. Walker. 2011. "Clearing up the Fiscal Multiplier Morass." Indiana University Working Paper.

Leeper, Eric M., Nora Traum, and Todd B. Walker. 2017. "Clearing Up the Fiscal Multiplier Morass." *American Economic Review*, 107(8): 2409–54.

Romer, Christina D., and David H. Romer. 2010. "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks." *American Economic Review*, 100(3): 763–801.

Rozanov, Yu. A. 1967. *Stationary Random Processes.* San Francisco:Holden-Day.

Sargent, Thomas J. 1987. *Dynamic Macroeconomic Theory.* Cambridge, MA:Harvard University Press.

Sargent, Thomas J., and Neil Wallace. 1981. "Some Unpleasant Monetarist Arithmetic." *Federal Reserve Bank of Minneapolis Quarterly Review*, 5(Fall): 1–17.

Sims, Christopher A. 1994. "A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy." *Economic Theory*, 4(3): 381–399.

Smets, F., and R. Wouters. 2024. "DP19791 Fiscal Backing, Inflation and US Business Cycles." *CEPR Discussion Paper*, , (19791).

Smets, Frank, and Raf Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review*, 97(3): 586–606.

Woodford, Michael. 2001. "Fiscal Requirements for Price Stability." *Journal of Money, Credit, and Banking*, 33(3): 669–728.

Yellen, Janet. 2021. "Opening Statement of Dr. Janet Yellen Before the Senate Finance Committee."

APPENDIX

Recovering AMPF and PMAF dynamics in Leeper (1991)

This section recovers the classic *Active Monetary-Passive Fiscal* (AMPF) and *Passive Monetary-Active Fiscal* (PMAF) inflation dynamics of the simple model in Leeper (1991). The only shock in the economy is the fiscal shock η_t^τ. The equilibrium conditions are

(A1) Fisher equation: $i_t = \mathbb{E}_t^{HH}\pi_{t+1}$

(A2) Monetary policy: $i_t = \phi_\pi \pi_t$

(A3) Gov. budget constraint: $s_{b,t} = \beta^{-1}\left[s_{b,t-1} + i_{t-1} - \pi_t - (1-\beta)\tau_t\right]$

(A4) Fiscal policy: $\tau_t = \gamma_\tau s_{b,t-1} + \eta_t^\tau$

Denote the inflation dynamics $\pi_t = \Pi(L)\eta_t^\tau = \sum_{j=0}^{\infty}\Pi_j\eta_t^\tau$. We utilize frequency domain techniques (see Kasa, Walker and Whiteman (2014)) to derive the functional form of $\Pi^{FI}(L)$. Combining the Fisher equation (A1) and the Taylor rule (A2) and applying the Wiener-Kolmogorov formula lead to

$$L^{-1}\left[\Pi(L) - \Pi_0\right] = \phi_\pi \Pi(L).$$

Rearranging the terms yields the following results

$$\Pi(L) = \frac{\Pi_0}{1-\phi_\pi L}. \tag{A5}$$

If $\phi_\pi > 1$ (i.e. active monetary policy), the above equation defines a stationary inflation process if and only if $\Pi_0 = 0$. It follows $\Pi(L) = 0$ and $\pi_t = 0$ under active monetary policy. Combining the government budget constraint (A3) and the fiscal rule (A4) and plugging in $i_t = 0, \pi_t = 0$ yield

$$s_{b,t} = \beta^{-1}\left[1-(1-\beta)\gamma_\tau\right]s_{b,t-1} - \beta^{-1}\left[(1-\beta)\right]\eta_t^\tau. \tag{A6}$$

If $0 < \beta^{-1}\left[1-(1-\beta)\gamma_\tau\right] < 1$, or equivalently, $\gamma_\tau > 1$ (that is, passive fiscal policy), then $s_{b,t}$ defined by (A6) is always a stationary process. We summarize the AMPF inflation and debt dynamics as

(A7)

$$\textbf{AMPF:}\quad \pi_t = 0, \quad s_{b,t} = -\frac{\beta^{-1}(1-\beta)}{1-\beta^{-1}\left[1-(1-\beta)\gamma_\tau\right]L}\eta_t^\tau, \text{ when } \phi_\pi > 1, \gamma_\tau > 1.$$

If $0 < \phi_\pi < 1$ (i.e., passive monetary policy), then equation (A5) always defines a stationary AR(1) inflation process, where Π_0 is a free parameter. Since $i_t =$

$\phi_\pi \Pi_0/(1-\phi_\pi L)\varepsilon_t, \pi_t = \Pi_0/(1-\phi_\pi L)\varepsilon_t$, it follows that

$$i_{t-1} - \pi_t = \frac{\Pi_0 \phi_\pi L}{1-\phi_\pi L}\eta_t^\tau - \frac{\Pi_0}{1-\phi_\pi L}\eta_t^\tau = -\Pi_0 \eta_t^\tau.$$

Combining the government budget constraint (A3) and the fiscal rule (A4) and plugging in $i_{t-1} - \pi_t = \Pi_0 \eta_t^\tau$ yield

$$s_{b,t} = \beta^{-1}\left[1-(1-\beta)\gamma_\tau\right] s_{b,t-1} - \beta^{-1}\left[\Pi_0 + (1-\beta)\right]\eta_t^\tau. \tag{A8}$$

If $0 < \gamma_\tau < 1$ so that $\beta^{-1}\left[1-(1-\beta)\gamma_\tau\right] > 1$ (that is, active fiscal policy), we can rewrite equation (A8) using the lag operator L as

$$\left(1 - \beta^{-1}\left[1-(1-\beta)\gamma_\tau\right] L\right) s_{b,t} = -\beta^{-1}\left[\Pi_0 + (1-\beta)\right]\eta_t^\tau \tag{A9}$$

Evaluating the above equation at $L = z_1 = \beta\left[1-(1-\beta)\gamma_\tau\right]^{-1}$ pins down

$$\Pi_0 = -(1-\beta),$$

leading to PMAF inflation and debt dynamics as

$$\textbf{PMAF:} \quad \pi_t = \frac{\beta - 1}{1-\phi_\pi L}\eta_t^\tau, \quad s_{b,t} = 0, \text{ when } 0 < \phi_\pi < 1, 0 < \gamma_\tau < 1. \tag{A10}$$

Deriving the analytical inflation process

The mapping between the household's observables and the underlying shocks is

$$\begin{bmatrix} f_t^* \\ \pi_t^* \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & \frac{1}{1-\rho L} \\ 0 & \mathcal{P}(L) \end{bmatrix}}_{M(L)} \begin{bmatrix} \varepsilon_t^F \\ \varepsilon_t^U \end{bmatrix} \tag{B1}$$

We have assumed that $z = \lambda$ is the only root of $\mathcal{P}(z)$ inside of $z \in (-1, 1)$. Following Rozanov (1967)'s terminology, the existence of such a root implies the representation (B1) is non-fundamental to the household, and a fundamental representation needs to be derived before forming households' expectations. A fundamental representation consists of a fundamental mapping, denoted by $M^*(L)$, and its associated fundamental innovations. To derive $M^*(L)$, the principal is to utilize the Blaschke factor matrix to flip the root of $\mathcal{P}(z)$ from $|z| < 1$ to $|z| > 1$. Let $\mathcal{B}_\lambda(L)$ be

$$\mathcal{B}_\lambda(L) = \begin{bmatrix} 1 & 0 \\ 0 & \frac{1-\lambda L}{\lambda - L} \end{bmatrix} \tag{B2}$$

The fundamental mapping $M^*(L)$ is given by

$$M^*(L) = M(L)\mathcal{W}_\lambda \mathcal{B}_\lambda(L), \tag{B3}$$

where $\mathcal{W}_\lambda$ is an orthonormal matrix given by

$$\mathcal{W}_\lambda = \begin{bmatrix} B_1 & A_1 \\ B_2 & A_2 \end{bmatrix} = \frac{1}{\sqrt{\sigma_U^2 + (1-\rho\lambda)^2\sigma_F^2}} \begin{bmatrix} \sigma_F(1-\rho\lambda) & -\sigma_U \\ \sigma_U & \sigma_F(1-\rho\lambda) \end{bmatrix}.$$

Given $M^*(L)$, the associated fundamental innovations are

$$\begin{bmatrix} \tilde{\varepsilon}_t^F \\ \tilde{\varepsilon}_t^U \end{bmatrix} = \mathcal{B}_\lambda(L^{-1})\mathcal{W}_\lambda' \begin{bmatrix} \varepsilon_t^F \\ \varepsilon_t^U \end{bmatrix} \tag{B4}$$

Calculating $\mathcal{B}_\lambda(L)$ and $\mathcal{W}_\lambda$ gives

$$M^*(L) = M(L) \begin{bmatrix} B_1 & A_1 \frac{1-\lambda L}{\lambda - L} \\ B_2 & A_2 \frac{1-\lambda L}{\lambda - L} \end{bmatrix}, \tag{B5}$$

$$\begin{bmatrix} \tilde{\varepsilon}_t^F \\ \tilde{\varepsilon}_t^U \end{bmatrix} = \begin{bmatrix} B_1 & B_2 \\ A_1 \frac{\lambda - L}{1-\lambda L} & A_2 \frac{\lambda - L}{1-\lambda L} \end{bmatrix} \begin{bmatrix} \varepsilon_t^F \\ \varepsilon_t^U \end{bmatrix} \tag{B6}$$

Combining the Fisher equation and the monetary policy rule gives a

$$\pi_t - \pi_t^* = \phi_\pi^{-1} \mathbb{E}_t^{HH} \pi_{t+1} \tag{B7}$$

Under FIRE, it can be shown that the inflation process π_t^{FI} is given by a Hansen-Sargent formula

$$\pi_t^{FI} = \frac{\mathcal{P}(\phi_\pi^{-1}) - \phi_\pi L \mathcal{P}(L)}{1 - \phi_\pi L} \varepsilon_t^U. \tag{B8}$$

Denote the incomplete information inflation process

$$\pi_t^{II} = \Pi_F(L)\varepsilon_t^F + \Pi_U(L)\varepsilon_t^U. \tag{B9}$$

We now utilize the fundamental representation to derive $\mathbb{E}_t^{HH}\pi_{t+1}$. It follows that

$$\begin{aligned}
\mathbb{E}_t^{HH}\pi_{t+1} &= L^{-1}\left[\Pi_F(L)B_1 + \Pi_U(L)B_2 - (\Pi_F(0)B_1 + \Pi_U(0)B_2)\right]\tilde{\varepsilon}_t^F \\
&\quad + L^{-1}\left[\frac{1-\lambda L}{\lambda - L}\left(\Pi_F(L)A_1 + \Pi_U(L)A_2\right) - \frac{1}{\lambda}\left(\Pi_F(0)A_1 + \Pi_U(0)A_2\right)\right]\tilde{\varepsilon}_t^U \\
&= L^{-1}\left[\Pi_F(L) - \Pi_F(0)\right]\varepsilon_t^F + L^{-1}\left[\Pi_U(L) - \Pi_U(0)\right]\varepsilon_t^U \\
&\quad + \frac{1-\lambda^2}{\lambda(1-\lambda L)}\left[\Pi_F(0)A_1 + \Pi_U(0)A_2\right]\left(A_1\varepsilon_t^F + A_2\varepsilon_t^U\right)
\end{aligned}$$

Plugging the above $\mathbb{E}_t^{HH}\pi_{t+1}$ into (B7) and matching the coefficients in front of ε_t^F lead to

$$L\Pi_F(L) = \phi_\pi^{-1}\left[\Pi_F(L) - \Pi_F(0)\right] + \phi_\pi^{-1}\frac{1-\lambda^2}{\lambda(1-\lambda L)}\left[\Pi_F(0)A_1 + \Pi_U(0)A_2\right]A_1 L$$

Imposing $L = \phi_\pi^{-1}$ on both sides gives the first restriction

$$\phi_\pi \Pi_F(0) = \frac{1-\lambda^2}{\lambda(1-\lambda\phi_\pi^{-1})}\left[\Pi_F(0)A_1 + \Pi_U(0)A_2\right]A_1. \tag{B10}$$

It follows that

$$\Pi_F(L) = \frac{\Pi_F(0)}{1-\lambda}.$$

Similarly, matching the coefficients in front of ε_t^U in(B7) yields

$$L\Pi_U(L) - L\mathcal{P}(L) = \phi_\pi^{-1}\left[\Pi_U(L) - \Pi_U(0)\right] + \phi_\pi^{-1}\frac{1-\lambda^2}{\lambda(1-\lambda L)}\left[\Pi_F(0)A_1 + \Pi_U(0)A_2\right]A_2 L$$

Imposing $L = \phi_\pi^{-1}$ on both sides leads to the second restriction

$$\phi_\pi\left[\Pi_U(0) - \mathcal{P}(\phi_\pi^{-1})\right] = \frac{1-\lambda^2}{\lambda(1-\lambda\phi_\pi^{-1})}\left[\Pi_F(0)A_1 + \Pi_U(0)A_2\right]A_2 \tag{B11}$$

It follows that

$$\Pi_U(L) = \frac{\mathcal{P}(\phi_\pi^{-1}) - \phi_\pi L\mathcal{P}(L)}{1-\phi_\pi L} + \left[\Pi_U(0) - \mathcal{P}(\phi_\pi^{-1})\right]\frac{1}{1-\lambda L}.$$

Finally, it should be noted that $\Pi_F(0)$ and $\Pi_U(0)$ are not free parameters. Instead, they are the unique solution to the linear system (B10)-(B11).

The Medium-scale DSGE Model Environment

C1. *Households*

There are two types of households in the economy, and their measures sum up to one. Among these households, a fraction of μ are hand-to-mouth consumers, and the remaining $1-\mu$ are savers.

Savers

Savers, each indexed by j, derive utility from the consumption of a composite good $C_t^{*S}(j)$, which comprises private consumption $C_t^S(j)$ and government consumption G_t such that $C_t^{*S}(j) = C_t^S(j) + \alpha_G G_t$. The parameter α_G governs the substitutability between private and government consumption. When α_G is negative (positive), these goods are complements (substitutes). External consumption habits imply that the utility is derived relative to the previous period value of aggregate saver consumption of the composite good hC^{*S}_{t-1}, where $h \in [0,1]$ is the habit parameter. Saver households also derive disutility from the supply of differentiated labor services from all their members, indexed by l, $L^S_t(j) = \int_0^1 L^S_t(j,l)dl$. The period utility function is given by

$$U^S_t(j) = u^d_t \left(\ln \left(C^{*S}_t(j) - hC^{*S}_{t-1} \right) - \frac{L^S_t(j)^{1+\chi}}{1+\chi} \right), \tag{C1}$$

where u^d_t is a discount factor shock, and $1/\chi$ is the Frisch elasticity of the labor supply.

Savers accumulate wealth in the form of physical capital $\bar{K}^S_t$. The law of motion for physical capital is given by

$$\bar{K}^S_t(j) = (1-\delta)\bar{K}^S_{t-1}(j) + u^i_t \left[1 - s\left(\frac{I^S_t(j)}{I^S_{t-1}(j)} \right) \right] I^S_t(j), \tag{C2}$$

where δ is the depreciation rate, u^i_t is a shock to the marginal efficiency of investment and s denotes an investment adjustment cost function that satisfies the properties $s\left(e^{\varkappa}\right) = s'\left(e^{\varkappa}\right) = 0$ and $s''\left(e^{\varkappa}\right) > 0$, where $\varkappa$ is a drift parameter capturing the logarithm of the growth rate of technology in steady state.

Households derive income from renting effective capital $K^S_t(j)$ to intermediate firms. Effective capital is related to physical capital according to the following law of motion,

$$K^S_t(j) = \nu_t(j)\bar{K}^S_{t-1}, \tag{C3}$$

where $\nu_t(j)$ is the capital utilization rate. In steady state, the utilization rate $\nu(j)$ is 1. The cost of utilizing one unit of physical capital is given by the function $\Psi\left(\nu_t(j)\right)$ that satisfies the following properties: $\Psi(1) = 0$ and $\frac{\Psi''(1)}{\Psi'(1)} = \frac{\psi}{1-\psi}$, where $\psi \in [0,1)$. We denote the gross capital rental rate as $R_{K,t}$ and the capital rental income tax rate as $\tau_{K,t}$.

The household can also save by purchasing one-period government bonds in zero net supply and a more general portfolio of long-term government bonds in non-zero net supply. The one-period bonds promising a nominal payoff B_t at time $t+1$ can be purchased at the present discounted value $R^{-1}_{n,t}B_t$, where $R_{n,t}$ is the gross nominal interest rate set by the central bank. The long-term bond B^m_t mimics a portfolio of bonds with average maturity m and duration $(1-\beta\rho)^{-1}$, where $\rho \in [0,1]$ is a constant decay rate. This bond can be purchased at a price

P_t^m, determined by the arbitrage condition

$$R_{n,t} = \mathbb{E}_t^{HH}[(1+\ P_{t+1}^m)\,/P_t^m]\, e^{-u_t^{rp}},$$

where the wedge u_t^{rp} can be interpreted as a risk premium shock.

In each period, households receive nominal labor income after tax, after-tax revenues from renting capital to firms, lump sum transfers from the government (Z_t^S), and dividends from firms (D_t). Households spend to consume and invest in physical capital and bonds. Omitting the index j to simplify the notation, we can write the nominal budget constraint for the saver household as

$$\begin{aligned} & P_t\,(1+\tau_{C,t})\,C_t^S + P_t I_t^S + P_t^m B_t^m + R_{n,t}^{-1} B_t \\ &= (1+\rho P_t^m)\,B_{t-1}^m + B_{t-1} + (1-\tau_{L,t})\int_0^1 W_t(l) L_t^S dl \\ &\quad + (1-\tau_{K,t})\,R_{K,t}\nu_t \bar{K}_{t-1}^S - \Psi(\nu_t)\,\bar{K}_{t-1}^S + P_t Z_t^S + D_t, \end{aligned} \tag{C4}$$

where $W_t(l)$ denotes the wage rate faced by all household members, and $\tau_{C,t}$ and $\tau_{L,t}$ denote the tax rates on consumption and labor income, respectively. The household maximizes the expected utility $\mathbb{E}_0^{HH}\sum_{t=0}^{\infty}\beta^t U_t^S$ subject to the sequence of budget constraints in equation (C4) and the law of motion of capital accumulation (C2).

For ease of notation, we drop the index j in the following. The first-order optimality conditions (FOCs) concerning consumption, labor supply, one-period bond, investment, capital, and capital utilization are

$$(\partial C_t^{*S}) \quad \Lambda_t^S = u_t^d (C_t^{*S} - hC_{t-1}^{*S})^{-1} \tag{C5}$$

$$(\partial L_t^S) \quad L_t^{S,\chi} = \Lambda_t^S (1-\tau_{L,t}) \frac{W_t^h}{P_t} \tag{C6}$$

$$(\partial B_t) \quad \Lambda_t^S = \beta R_{nt} \mathbb{E}_t^{HH}\left[\frac{\Lambda_{t+1}^S}{\pi_{t+1}}\right] \tag{C7}$$

$$\begin{aligned} (\partial I_t) \quad 1 = {} & Q_t^k \mu_t \left[1 - s\left(\frac{I_t}{I_{t-1}}\right) - s'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] \\ & + \beta \mathbb{E}_t^{HH}\left\{\frac{\Xi_{t+1}^K}{\Lambda_t^S}\left[Q_{t+1} u_{t+1}^i s'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]\right\} \end{aligned} \tag{C8}$$

$$(\partial \bar{K}_t)\ Q_t = \beta \mathbb{E}_t^{HH}\left\{\frac{\Xi_{t+1}^K}{\Lambda_t^S}\left[((1-\tau_{K,t}) r_{K,t}\nu_{t+1} - \Psi(\nu_{t+1})) + Q_{t+1}(1-\delta)\right]\right\} \tag{C9}$$

$$(\partial \nu_t) \quad (1-\tau_{K,t}) r_{K,t} = \Psi'(\nu_t) \tag{C10}$$

where Λ_t^S and Ξ_{t+1}^K are the Lagrange multipliers associated with the budget and capital accumulation constraints, respectively, and $Q_t = \frac{\Xi_t^K}{\Lambda_t^S}$ is the Tobin's Q and equals one in the absence of adjustment costs.

Hand-to-Mouth Households

In every period, hand-to-mouth households derive disposable, after-tax income from labor supply and government transfers and consume all of them. They provide differentiated labor services and set their wage equal to the average wage that is optimally chosen by savers, as described below. Hand-to-mouth households face the same tax rates on consumption and labor income as savers. The specification of period-by-period utility for hand-to-mouth households is the same as that of savers, that is,

$$U_t^N(j) = u_t^d \left(\ln \left(C_t^{*N}(j) - hC_{t-1}^{*N} \right) - \frac{L_t^N(j)^{1+\chi}}{1+\chi}) \right). \tag{C11}$$

Their budget constraint is

$$(1+\tau_{C,t})\, P_t C_t^N = (1-\tau_{L,t}) \int_0^1 W_t(l) L_t^N(l) dl + P_t Z_t^N, \tag{C12}$$

where the superscript N indicates the variables for hand-to-mouth households.

Hand-to-mouth households maximize the discounted utility $\mathbb{E}_0^{HH} \sum_{t=0}^{\infty} \beta^t U_t^N$ subject to the budget constraint (C12). The F.O.Cs are

$$(\partial(C_t^{*N})) \quad \Lambda_t^N = u_t^d (C_t^{*N} - hC_{t-1}^{*S})^{-1}, \tag{C13}$$

$$(\partial L_t^N) \quad L_t^{S,\chi} = \Lambda_t^N (1-\tau_{L,t}) \frac{W_t}{P_t}. \tag{C14}$$

C2. Firms

Final good producers

There is a perfectly competitive sector of final good firms that produces the homogeneous good Y_t in time t by combining a unit measure of intermediate differentiated inputs using aggregation technology

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{1}{1+\eta_t^p + u_t^p}} di \right)^{1+\eta_t^p + u_t^p}, \tag{C15}$$

where η_t^p is the *i.i.d.* price mark-up shock. The variable u_t^p is a cost push shock and is assumed to follow a near-unit-root process. The highly persistent cost-push shock captures other external forces, such as international trade, that can generate low-frequency movements of inflation. Profit maximization yields the demand function for intermediate goods as

$$Y_t(i) = Y_t \Big(\frac{P_t(i)}{P_t}\Big)^{-\frac{1+\eta_t^p+u_t^p}{\eta_t^p+u_t^p}}, \tag{C16}$$

where $P_t(i)$ is the price of the differentiated good i and P_t is the price of the final good.

Intermediate good producers

There is a unit measure of intermediate firms that produce goods according to the production function

$$Y_t(i) = K_t(i)^{\alpha} \left(A_t L_t(i)\right)^{1-\alpha} - A_t \Omega, \tag{C17}$$

where Ω is a fixed cost of production that grows with the rate of labor-augmenting technological progress A_t, and $\alpha \in [0,1]$ is the capital share. The labor-augmenting technological progress, A_t, follows an exogenous process that is stationary in its growth rate. Specifically, we assume that $a_t = \ln\left(A_t/A_{t-1}\right) - \varkappa = u_t^a$. Intermediate firms rent capital and labor from perfectly competitive capital and labor markets, respectively. As described in the following, L_t is a bundle of all the differentiated labor services supplied in the economy, aggregated into a homogeneous input by a labor agency. Intermediate firms' cost minimization implies the same nominal marginal cost for all firms

$$MC_t = (1-\alpha)^{\alpha-1} \alpha^{-\alpha} \left(R_{K,t}\right)^{\alpha} W_t^{1-\alpha} A_t^{-1+\alpha}. \tag{C18}$$

Intermediate producers reset prices in the spirit of the Calvo pricing. At time t, a firm i can optimally reset its price with probability ω_p. Otherwise, it adjusts the price with partial indexation to the previous period's inflation rate according to the rule

$$P_t(i) = \left(\Pi_{t-1}\right)^{\xi_p} \left(\Pi\right)^{1-\xi_p} P_{t-1}(i), \tag{C19}$$

where $\xi_p \in [0,1]$ is a parameter, $\Pi_{t-1} = P_{t-1}/P_{t-2}$, and Π denotes the aggregate rate of inflation at steady state. Intermediate producers that are allowed to reset their price maximizes the expected discounted stream of nominal profits,

(C20)

$$\max \mathbb{E}_t^{Firm} \sum_{s=0}^{\infty} (\beta\omega_p)^s \frac{\Lambda_{t+s}^S}{\Lambda_t^S} \left[\left(\prod_{k=1}^{s} \Pi_{t+k-1}^{\xi^p} \Pi^{1-\xi^p} \right) P_t(i) Y_{t+s}(i) - MC_{t+s} Y_{t+s}(i) \right],$$

subject to the demand function (C16), with Λ_t^S denoting the marginal utility of the savers.

The FOC is given by

(C21)
$$\max \mathbb{E}_t^{Firm} \sum_{s=0}^{\infty} (\beta\omega_p)^s \frac{\Lambda_{t+s}^S}{\Lambda_t^S} Y_{t+s}(i) \left[\frac{-1}{\eta_t^p + u_t^p} X_{t,s}^P P_t(i) + \frac{1+\eta_t^p + u_t^p}{\eta_t^p + u_t^p} MC_{t+s} \right] = 0,$$

where

$$X_{t,s}^P = \begin{cases} 1 & \text{for } s = 0 \\ \left(\prod_{k=1}^{s} \Pi_{t+k-1}^{\xi^p} \Pi^{1-\xi^p}\right) & \text{for } s = 1, \ldots, \infty \end{cases} \tag{C22}$$

C3. Wage Settings

Both savers and hand-to-mouth households supply a unit measure of differentiated labor service indexed by l. In each period, a saver household has probability ω_w to optimally re-adjust the wage rate that applies to all of its workers, $W_t(l)$. If the wage cannot be re-optimized, it will be increased at the geometric average of the steady-state rate of inflation Π and of last period inflation Π_{t-1}, according to the rule

$$W_t(l) = W_{t-1}(l) \left(\Pi_{t-1} e^{\varkappa}\right)^{\xi_w} \left(\Pi e^{\xi}\right)^{1-\xi_w}, \tag{C23}$$

where $\xi_w \in [0,1]$ captures the degree of nominal wage indexation. All households, including both savers and non-savers, sell their labor service to a representative, competitive agency that transforms it into an aggregate labor input, according to the technology

$$L_t = \left(\int_0^1 L_t(l)^{\frac{1}{1+\eta_t^w}} dl\right)^{1+\eta_t^w}, \tag{C24}$$

where η_t^w is an *i.i.d.* exogenous wage mark-up shock. The agency rents labor type $L_t(l)$ at a price $W_t(l)$ and sells a homogeneous labor input to the intermediate producers at a price W_t. The static profit maximization problem yields the labor demand function

$$L_t(l) = L_t \left(W_t(l)/W_t\right)^{-(1+\eta_t^w)/\eta_t^w}. \tag{C25}$$

Labor unions use this marginal rate of substitution as the cost of labor services in their negotiations with labor packers. The markup above the marginal disutility is distributed to the households. For those that can adjust, the problem is to choose a wage $W_t(l)$ that maximizes the discounted total wage income in the future subject to (C23) and (C25),

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \omega_w^s \beta^s \frac{\Lambda_{t+s}^S P_t}{\Lambda_t^S P_{t+s}} \left[W_{t+s}(l) - W_{t+s}^h\right] L_{t+s}(l). \tag{C26}$$

The FOC becomes

$$\mathbb{E}_t \sum_{s=0}^{\infty} \omega_w^s \beta^s \frac{\Lambda_{t+s}^S P_t}{\Lambda_t^S P_{t+s}} L_{t+s}(l) \left[\left(X_{t,s}^W W_t(l) - W_{t+s}^h\right)\left(-\frac{1+\eta_{w,t+s}}{\eta_{w,t+s}}\right) - X_{t,s}^W W_t(l)\right] = 0, \tag{C27}$$

where

$$X_{t,s}^W = \begin{cases} 1 & \text{for } s = 0 \\ \left(\prod_{k=1}^{s} \Pi_{t+k-1}^{\xi^w} \Pi^{1-\xi^w}\right) & \text{for } s = 1, \ldots, \infty \end{cases} \tag{C28}$$

C4. Monetary and Fiscal Policy

We have assumed that the government supplies one-period bonds in zero net supply, and both types of households receive the same amount of transfers. It follows that the government's nominal budget constraint is

$$P_t^m B_t^m + \tau_{K,t} R_{K,t} K_t + \tau_{L,t} W_t L_t + \tau_{C,t} P_t C_t = (1 + \rho P_t^m) B_{t-1}^m + P_t G_t + P_t Z_t, \tag{C29}$$

where C_t and Z_t denote aggregate consumption and total transfers, respectively. Their expressions are the following

$$C_t = \mu C_t^N + (1-\mu) C_t^S, \tag{C30}$$

$$Z_t = \int_0^1 Z_t(j) dj. \tag{C31}$$

The budget constraint (C29) implies that the fiscal authority finances government expenditures, transfers, and the rollover of expiring long-term debt by issuing new long-term debt obligations as well as by raising labor, capital, and consumption taxes.

The aggregate resource constraint is given by

$$Y_t = C_t + I_t + G_t + \Psi_t(\nu_t)\bar{K}_{t-1}. \tag{C32}$$

We rescale the variables entering the fiscal rules as $g_t = G_t/A_t$ and $z_t = Z_t/A_t$. For each variable $x_t, \widehat{x}_t$ denotes the percentage deviation from its balanced-growth steady state.

Let $s_{b,t} = (P_t^m B_t^m)/(P_t Y_t)$ denote the real market debt-to-GDP ratio. The fiscal authority adjusts government spending $\hat{g}_t$, transfers $\hat{z}_t$, and tax rates on capital income, labor income, and consumption $\hat{\tau}_J$, $J \in \{k, l, c\}$ as follows:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\left[\gamma_G\left(\hat{s}_{b,t-1} - \hat{s}^*_{b,t}\right) + \phi_{g,y}\hat{y}_t\right] + \varepsilon^g_t, \tag{C33}$$

$$\hat{z}^b_t = \rho_Z \hat{z}^b_{t-1} - (1-\rho_Z)\left[\gamma_Z\left(\hat{s}_{b,t-1} - \hat{s}^*_{b,t}\right) + \phi_{z,y}\hat{y}_t\right] + \varepsilon^z_t, \tag{C34}$$

$$\hat{\tau}_{J,t} = \rho_J \hat{\tau}_{J,t-1} + (1-\rho_J)\gamma_J\left[\hat{s}_{b,t-1} - \hat{s}^*_{b,t}\right] + u^J_t, \text{ for } J \in \{k, l\}; \tag{C35}$$

$$\hat{\tau}_{c,t} = \rho_c \hat{\tau}_{c,t-1}; \tag{C36}$$

where γ_G, γ_Z, and $\gamma_J > 0$ are large enough to guarantee that the debt remains on a stable path. The time-varying debt target, $s^*_{b,t}$, follows a stationary AR(1) process

$$\hat{s}^*_{b,t} = \rho_s \hat{s}^*_{b,t-1} - \varepsilon^U_t, \quad \varepsilon^U_t \sim N(0, \sigma^2_U),$$

with $\rho_s \in (0,1)$. ε^U_t is the unfunded fiscal shock that increases the government's debt target.

Finally, the central bank follows the Taylor rule and adjusts the short-term interest rate R^n_t in response to inflation deviations and the output gap. The linearized monetary policy rule is the following:

$$\hat{r}^n_t = \rho_r \hat{r}^n_{t-1} + (1-\rho_r)[\phi_\pi(\hat{\pi}_t - \hat{\pi}^*_t) + \phi_y \hat{y}_t] + u^m_t \tag{C37}$$

where u^m_t is the monetary policy shock and $\phi_\pi > 1$ satisfies the Taylor principle. We introduce a time-varying inflation target which follows a stationary AR(1) process, that is

$$\hat{\pi}^*_t = \rho_s \hat{\pi}^*_{t-1} - \Phi\epsilon^U_t, \quad \Phi > 0$$

C5. Specifying Shocks and Introducing Incomplete Information

Throughout the paper, we use the notation u^x_t to denote a persistent shock and η^x_t to denote a transitory shock. For each $x \in \{d, i, rp, p, a, g, z, m\}$, we specify a stationary AR(1) process for the persistent shock u^x_t as

$$u^x_t = \rho_x u^x_{t-1} + \varepsilon^x_t, \quad \varepsilon^x_t \sim N(0, \sigma^2_x)$$

with $\rho_x \in (0,1)$. We let the transitory shock $\eta^p_t \sim N(0, \sigma^2_{\eta,p})$ and $\epsilon^U_t \sim N(0, \sigma^2_U)$ follow an *i.i.d.* process.

We now introduce incomplete information by assuming all households, intermediate firms, and final good firms share the same information set, denoted by $\mathcal{I}^{HH}_t$. We assume agents can observe the entire histories of nominal interest rate $\{r_{t-k}|k \geq 0\}$ and inflation $\{\pi_{t-k}|k \geq 0\}$. The households can also observe history of surpluses $\{\tau_{t-k}|k \geq 0\}$, the realized real market debt $\{s_{b,t-k}|k \geq 0\}$, and the histories of labor, capital, and consumption tax rates $\{\tau_{J,t-k}|k \geq 0\}$. However, households cannot distinguish between the exogenous shock to fiscal and monetary policy and the shock to time-varying debt and inflation targets.

There are now four shocks to fiscal and monetary policy rules, but only three signals and incomplete information arise naturally in the model. The monetary policy rule (C37) and the fiscal rules (C33) and (C34) indicate that policy variables can also serve as signals to households. For instance, rewriting the monetary rule (C37) as

$$\hat{r}_t^n - \rho_r \hat{r}_{t-1}^n - (1-\rho_r)\left(\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t\right) = \underbrace{-(1-\rho_r)\phi_\pi \pi_t^* + u_t^m}_{s_t^m}$$

indicates the history of the right side variables, s_t^m, is also known to households. Similarly, rewriting the fiscal rules (C33) and (C34) as

$$\hat{g}_t - \rho_G \hat{g}_{t-1} + (1-\rho_G)\left[\gamma_G \hat{s}_{b,t-1} + \phi_{g,y}\hat{y}_t\right] = \underbrace{(1-\rho_G)\gamma_G \hat{s}_{b,t}^* + \varepsilon_t^g}_{s_t^g}$$

$$\hat{z}_t - \rho_Z \hat{z}_{t-1} + (1-\rho_Z)\left[\gamma_Z \hat{s}_{b,t-1} + \phi_{z,y}\hat{y}_t\right] = \underbrace{(1-\rho_Z)\gamma_Z \hat{s}_{b,t}^* + \varepsilon_t^z}_{s_t^z}$$

suggests that the two right side variables, s_t^g and s_t^z, are also in the household's information set. Additionally, agents cannot distinguish between shocks to time-varying debt targets and shocks to the tax rules. Finally, the tax rules (C35) can also be rewritten with signals where s_t^J are in the household's information set. We do not include shock to consumption tax rate in our estimation.

$$\hat{\tau}_{J,t} - \rho_J \hat{\tau}_{J,t-1} - (1-\rho_J)\gamma_J \hat{s}_{b,t-1} = \underbrace{-(1-\rho_J)\gamma_J \hat{s}_{b,t}^* + \varepsilon_t^j}_{s_t^J} \quad \forall J \in \{k,l\}$$

We do not introduce incomplete information to any other shocks in the model and assume that they can be observed perfectly by households. These shocks are intended to improve the empirical fit of the medium-scale DSGE model. Formally, we define the incomplete information set $\mathcal{I}_t^{HH}$ as

$$\mathcal{I}_t^{HH} = \{s_{t-k}^m, s_{t-k}^g, s_{t-k}^z, s_{t-k}^k, s_{t-k}^l \mathcal{M} | k \geq 0\}.$$

C6. Deriving the log-linearized equilibrium conditions

To make the model stationary, we de-trend the non-stationary variables, accounting for the unit root in the labor-augmenting technology process. We define the following variables: $y_t = \frac{Y_t}{A_t}, c_t^* = \frac{C_t^{*S}}{A_t}, c_t^S = \frac{C_t^S}{A_t}, c_t^N = \frac{C_t^N}{A_t}, k_t = \frac{K_t}{A_t}, g_t = \frac{G_t}{A_t}, z_t = \frac{Z_t}{A_t}, b_t = \frac{P_t^m B_t^m}{P_t A_t}, s_{b,t} = \frac{P_t^m B_t^m}{P_t Y_t}, w_t = \frac{W_t}{P_t A_t}$, and $\lambda_t^S = \Lambda_t^S A_t$. In what follows, $e^{\varkappa}$ denotes the steady-state growth of the technology process. That is, $e^a = e^{\varkappa}$.

Production function:

$$\hat{y}_t = \frac{y+\Omega}{y}\left[\alpha \hat{k}_t + (1-\alpha)\hat{L}_t\right]. \tag{C38}$$

Capital-labor ratio:

$$\hat{r}_{K,t} - \hat{w}_t = \hat{L}_t - \hat{k}_t. \tag{C39}$$

Marginal cost:

$$\hat{m}_t = \alpha \hat{r}_{K,t} + (1-\alpha)\hat{w}_t. \tag{C40}$$

Phillips curve:

$$\hat{\pi}_t = \frac{\beta}{1+\xi_p\beta}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\xi_p}{1+\xi_p\beta}\hat{\pi}_{t-1} + \kappa_p\hat{m}_t + \kappa_p\hat{tp}_t, \tag{C41}$$

where $\kappa_p = [(1-\beta\omega_p)(1-\omega_p)] / [\omega_p(1+\beta\xi_p)]$.

Saver household's FOC for consumption:

$$\hat{\lambda}^S_t = \hat{u}^d_t - \frac{h}{e^z-h}\hat{u}^a_t - \frac{e^z}{e^z-h}\hat{c}^{*S}_t + \frac{h}{e^z-h}\hat{c}^{*S}_{t-1} - \frac{\tau^C}{1+\tau^C}\hat{\tau}^C_t \tag{C42}$$

Cost-Push shock Process:

$$\hat{tp}_t = \hat{u}^p_t + \hat{\eta}^p_t \tag{C43}$$

Public/private consumption in utility:

$$\hat{c}^*_t = \frac{c^S}{c^S+\alpha_G g}\hat{c}^S_t + \frac{\alpha_G g}{c^S+\alpha_G g}\hat{g}_t \tag{C44}$$

Euler equation:

$$\hat{\lambda}^S_t = \hat{r}_{n,t} + \mathbb{E}_t\hat{\lambda}^S_{t+1} - \mathbb{E}_t\hat{\pi}_{t+1} - \mathbb{E}_t\hat{u}^a_{t+1} + \hat{u}^{rp}_t \tag{C45}$$

The maturity structure of debt is

$$\hat{r}_{n,t} + \hat{P}^m_t = \frac{P_m}{1+P_m}\mathbb{E}_t\hat{P}^m_{t+1} - \hat{u}^{rp}_t \tag{C46}$$

where $P_m = \frac{\rho}{R_n-\rho}$.

Saver household's FOC for capacity utilization:

$$\hat{r}_{K,t} - \frac{\tau_K}{1-\tau_K}\hat{r}_{K,t} = \frac{\psi}{1-\psi}\hat{v}_t. \tag{C47}$$

Saver household's FOC for capital:

(C48)
$$\hat{q}_t = \mathbb{E}_t\hat{\pi}_{t+1} - \hat{r}_{n,t} + \beta e^{-\varkappa}(1-\tau_K)r_K\mathbb{E}_t\hat{r}_{K,t+1} - \beta e^{-\varkappa}\tau_K r_K\mathbb{E}_t\hat{\tau}_{K,t+1} + \beta e^{-\varkappa}(1-\delta)\mathbb{E}_t\hat{q}_{t+1} - \hat{u}_t^{rp}$$

Saver household's FOC for investment:

$$\hat{i}_t = \frac{1}{(1+\beta)se^{2\varkappa}}\hat{q}_t + \hat{u}_t^i + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{i}_{t+1} - \frac{1}{1+\beta}\hat{u}_t^a + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{u}_{t+1}^a + \frac{1}{1+\beta}\hat{i}_{t-1} \tag{C49}$$

Effective capital:

$$\hat{k}_t = \hat{v}_t + \hat{\bar{k}}_{t-1} - \hat{u}_t^a. \tag{C50}$$

Law of motion for capital:

$$\hat{\bar{k}}_t = (1-\delta)e^{-\varkappa}\left(\hat{\bar{k}}_{t-1} - \hat{u}_t^a\right) + \left[1-(1-\delta)e^{-\varkappa}\right]\left[(1+\beta)se^{2\varkappa}\hat{u}_t^i + \hat{i}_t\right]. \tag{C51}$$

Hand-to-mouth household's budget constraint:

$$\tau_C C_N\hat{\tau}_{C,t} + (1+\tau_C)C_N\hat{C}_t^N = (1-\tau_L)wL\left(\hat{w}_t + \hat{L}_t\right) - \tau_L wL\hat{\tau}_{L,t} + z\hat{z}_t. \tag{C52}$$

Wage equation:

(C53)
$$\hat{w}_t = \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{w}_{t+1} - \kappa_w\left[\hat{w}_t - \chi\hat{L}_t - \hat{d}_t + \lambda_t^S - \frac{\tau_L}{1-\tau_L}\hat{\tau}_{L,t}\right] + \frac{\chi_w}{1+\beta}\hat{\pi}_{t-1}$$
$$-\frac{1+\beta\chi_w}{1+\beta}\hat{\pi}_t + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\chi_w}{1+\beta}\hat{u}_{t-1}^a - \frac{1+\beta\chi_w-\rho_a\beta}{1+\beta}\hat{u}_t^a + \kappa_w\eta_t^w$$

where $\kappa_w \equiv \left[(1-\beta\omega_w)(1-\omega_w)\right] / \left[(1+\beta)\omega_w\left(1+\frac{(1+n^w)\xi}{\eta^w}\right)\right]$.

Aggregate households' consumption:

$$c\hat{c}_t = c^S(1-\mu)\hat{c}_t^S + c^N\mu\hat{c}_t^N. \tag{C54}$$

Aggregate resource constraint:

$$y\hat{y}_t = c\hat{c}_t + i\hat{i}_t + g\hat{g}_t + \psi'(1)k\hat{k}_t. \tag{C55}$$

Government budget constraint:

(C56)
$$\frac{b}{y}\hat{b}_t + \tau_K r_K \frac{k}{y}\left[\hat{\tau}_{K,t} + \hat{r}_{K,t} + \hat{k}_t\right] + \tau_L w \frac{L}{y}\left[\hat{\tau}_{L,t} + \hat{w}_t + \hat{L}_t\right] + \tau_C \frac{C}{y}\left(\hat{\tau}_{C,t} + \hat{c}_t\right)$$
$$= \frac{1}{\beta}\frac{b}{y}\left[\hat{b}_{t-1} - \hat{\pi}_t - \hat{P}^m_{t-1} - \hat{u}^a_t\right] + \frac{b}{y}\frac{\rho}{ye^{\varkappa}}\hat{P}^m_t + \frac{g}{y}\hat{g}_t + \frac{z}{y}\hat{z}_t,$$

where we define $b_t = \frac{P^m_t B_t}{P_t A_t}$ so that $s_{b,t} = \frac{P^m_t B_t}{P_t Y_t} = \frac{b_t}{y_t}$. It follows that

$$s_{b,t} = \hat{b}_t - \hat{y}_t. \quad \text{(C57)}$$

Fiscal rules:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\left[\gamma_G(\hat{s}_{b,t-1} - \hat{s}^*_{b,t}) + \phi_{g,y}\hat{y}_t\right] + \hat{u}^g_t \quad \text{(C58)}$$
$$\hat{z}_t = \rho_Z \hat{z}_{t-1} - (1-\rho_Z)\left[\gamma_Z(\hat{s}_{b,t-1} - \hat{s}^*_{b,t}) + \phi_{z,y}\hat{y}_t\right] + \hat{u}^z_t \quad \text{(C59)}$$
$$\hat{\tau}_{L,t} = \rho_L \hat{\tau}_{L,t-1} + (1-\rho_L)\gamma_L[\hat{s}_{b,t-1} - \hat{s}^*_{b,t}] + \hat{u}^l_t \quad \text{(C60)}$$
$$\hat{\tau}_{K,t} = \rho_K \hat{\tau}_{K,t-1} + (1-\rho_K)\gamma_K[\hat{s}_{b,t-1} - \hat{s}^*_{b,t}] + \hat{u}^k_t \quad \text{(C61)}$$

where the time-varying debt target follows an AR(1) process

$$s^*_{b,t} = \rho_b s^*_{b,t-1} - \epsilon^U_t \quad \text{(C62)}$$

Monetary Rule:

$$\hat{r}_{n,t} = \rho_r \hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi(\hat{\pi}_t - \hat{\pi}^*_t) - \phi_y \hat{y}_t\right] + u^m_t \quad \text{(C63)}$$

Time-varying inflation target:

$$\hat{\pi}^*_t = \phi_F \hat{\pi}^*_{t-1} - \Phi\epsilon^U_t \quad \text{(C64)}$$

State-space representation for estimation

This section establishes the incomplete information model solution as a state-space representation used in the estimation. We follow the notation and algorithm of Blanchard, L'Huillier and Lorenzoni (2013) closely. The signal extraction problem is defined by a pair of equations

$$\mathbf{x_t} = \mathbf{A}\mathbf{x_{t-1}} + \mathbf{B}\nu_\mathbf{t}, \tag{D1}$$

$$\mathbf{s_t} = \mathbf{C}\mathbf{x_t} + \mathbf{D}\nu_\mathbf{t}, \tag{D2}$$

where ν_t is an n_ν-dimensional vector of mutually independent *i.i.d.* shocks. The dimensions of exogenous variables $\mathbf{x_t}$ and signals $\mathbf{s_t}$ are n_x and n_s. Let $\mathbf{y_t}$ denote a vector of endogenous state variables of size n_y. The economic model can be described in terms of the stochastic difference equation

$$\mathbf{F}\mathbb{E}_\mathbf{t}[\mathbf{y_{t+1}}] + \mathbf{G}\mathbf{y_t} + \mathbf{H}\mathbf{y_{t-1}} + \mathbf{M}\mathbf{s_t} + \mathbf{N}\mathbb{E}_\mathbf{t}[\mathbf{s_{t+1}}] = \mathbf{0}, \tag{D3}$$

where $\mathbb{E}_t(\cdot)$ is the rational expectations operator under incomplete information and $\mathbf{F}, \mathbf{G}, \mathbf{H}, \mathbf{M}, \mathbf{N}$ are matrices of parameters. The solution of the model can be described as

$$\mathbf{y_t} = \mathbf{P}\mathbf{y_{t-1}} + \mathbf{Q}\mathbf{s_t} + \mathbf{R}\mathbf{x_{t|t}}, \tag{D4}$$

where the matrices $\mathbf{P}, \mathbf{Q}, \mathbf{R}$ can be found by solving the three matrix equations

$$\mathbf{F}\mathbf{P}^\mathbf{2} + \mathbf{G}\mathbf{P} + \mathbf{H} = \mathbf{0}, \quad (\mathbf{F}\mathbf{P} + \mathbf{G})\mathbf{Q} + \mathbf{M} = \mathbf{0},$$
$$(\mathbf{F}\mathbf{P} + \mathbf{G})\mathbf{R} + [\mathbf{F}(\mathbf{Q}\mathbf{C} + \mathbf{R}) + \mathbf{N}\mathbf{C}]\,\mathbf{A} = \mathbf{0}.$$

We know from the Kalman recursion that the law of motion of $\mathbf{x_{t|t}}$ can be written as

$$\mathbf{x_{t|t}} = \mathbf{KCA}\mathbf{x_{t-1}} + (\mathbf{I} - \mathbf{KC})\mathbf{A}\mathbf{x_{t-1|t-1}} + \mathbf{K}(\mathbf{CB} + \mathbf{D})\nu_\mathbf{t},$$

where $\mathbf{K}$ is the Kalman gain matrix of size $n_x \times n_s$. It follows that we can write the model solution $\mathbf{y}_t$ as

$$\mathbf{y_t} = \mathbf{P}\mathbf{y_{t-1}} + (\mathbf{Q} + \mathbf{RK})\mathbf{CA}\mathbf{x_{t-1}} + \mathbf{R}(\mathbf{I} - \mathbf{KC})\mathbf{A}\mathbf{x_{t-1|t-1}} + (\mathbf{Q} + \mathbf{RK})(\mathbf{CB} + \mathbf{D})\nu_\mathbf{t}$$

Define the extended state variables as $\left[\mathbf{y_t}, \mathbf{x_t}, \mathbf{x_{t|t}}\right]'$. The state-space representation of the incomplete information model solution can be written as

$$\begin{bmatrix} \mathbf{y_t} \\ \mathbf{x_t} \\ \mathbf{x_{t|t}} \end{bmatrix} = \begin{bmatrix} \mathbf{P} & (\mathbf{Q} + \mathbf{RK})\mathbf{CA} & \mathbf{R}(\mathbf{I} - \mathbf{KC})\mathbf{A} \\ \mathbf{0} & \mathbf{A} & \mathbf{0} \\ \mathbf{0} & \mathbf{KCA} & (\mathbf{I} - \mathbf{KC})\mathbf{A} \end{bmatrix} \begin{bmatrix} \mathbf{y_{t-1}} \\ \mathbf{x_{t-1}} \\ \mathbf{x_{t-1|t-1}} \end{bmatrix} + \begin{bmatrix} (\mathbf{Q} + \mathbf{RK})(\mathbf{CB} + \mathbf{D}) \\ \mathbf{B} \\ \mathbf{K}(\mathbf{CB} + \mathbf{D}) \end{bmatrix} \nu_\mathbf{t}.$$

Impulse Response for all other shocks

This section presents the impulse response for the remaining shocks in the model. Each figure presents the IRFs for six variables- output, inflation, nominal interest rate, real interest rate, expected inflation, and real marginal cost, under full information and incomplete information. Figure E1 shows the impulse response for funded fiscal shock. A decrease in fiscal spending decreases production and causes deflation. The presence of hand-to-mouth agents in our model allows us to have inflation effects from funded fiscal spending under both FIRE and incomplete information (IIRE).

We also present results for tax shocks in our fiscal block, i.e. an expansionary labor-tax shock and capital-tax shock. A one-standard-deviation negative (expansionary) labor tax shock is deflationary and reduces expected inflation under both FIRE and incomplete information (Figure E2). Cut in capital tax rate expands output and increases inflation, both of which effects are more prominent under IIRE. Output increases due to the fall in real marginal cost, which expands investment. As the shock is funded, the debt-to-GDP ratio expands to pay for labor and capital tax cuts.

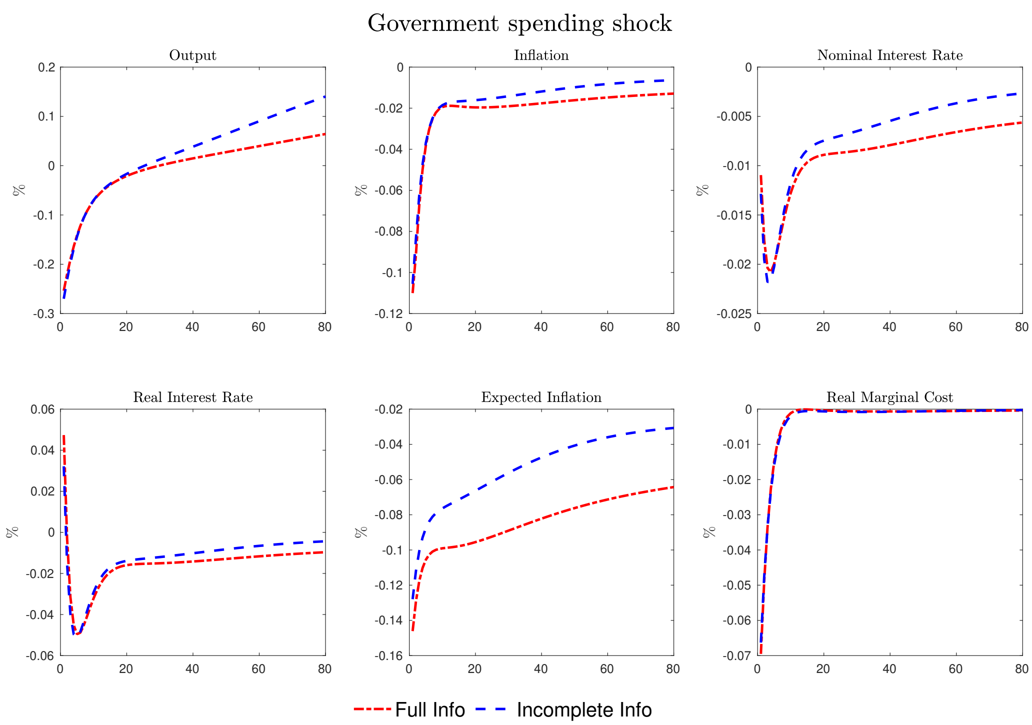

Figure E1. Impulse responses to a one standard deviation government spending shock

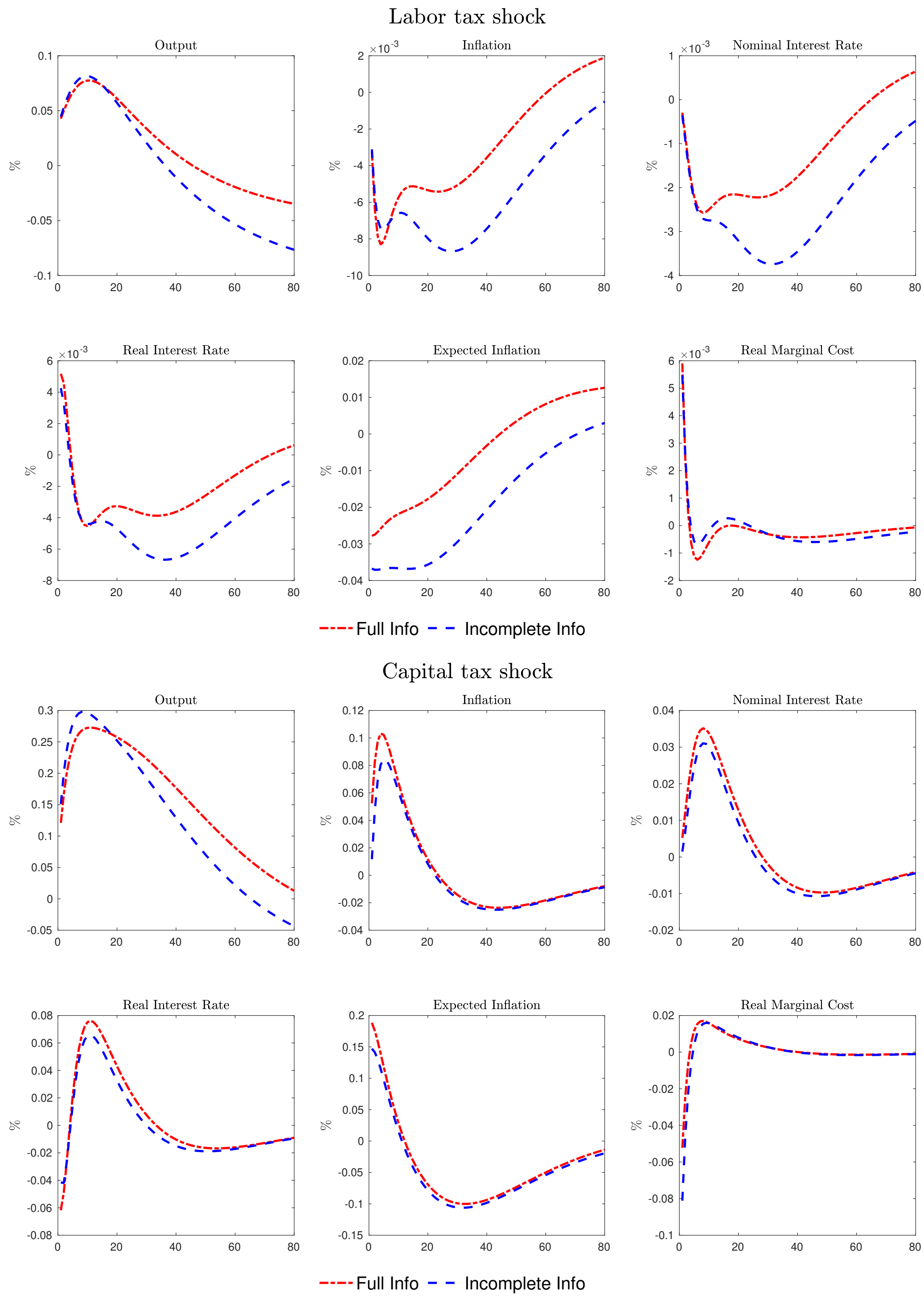

Figure E2. Impulse responses to a one standard deviation labor and capital tax shock

We do not introduce incomplete information with respect to any other shocks in our model. The response of macro variables to a one standard deviation risk premium shock (E3), technology shock, investment-specific technology shock (Figure E4), preference shock, wage mark-up shock (Figure E5), cost push shock, and price mark-up shock (E6) are largely similar under FIRE and IIRE.

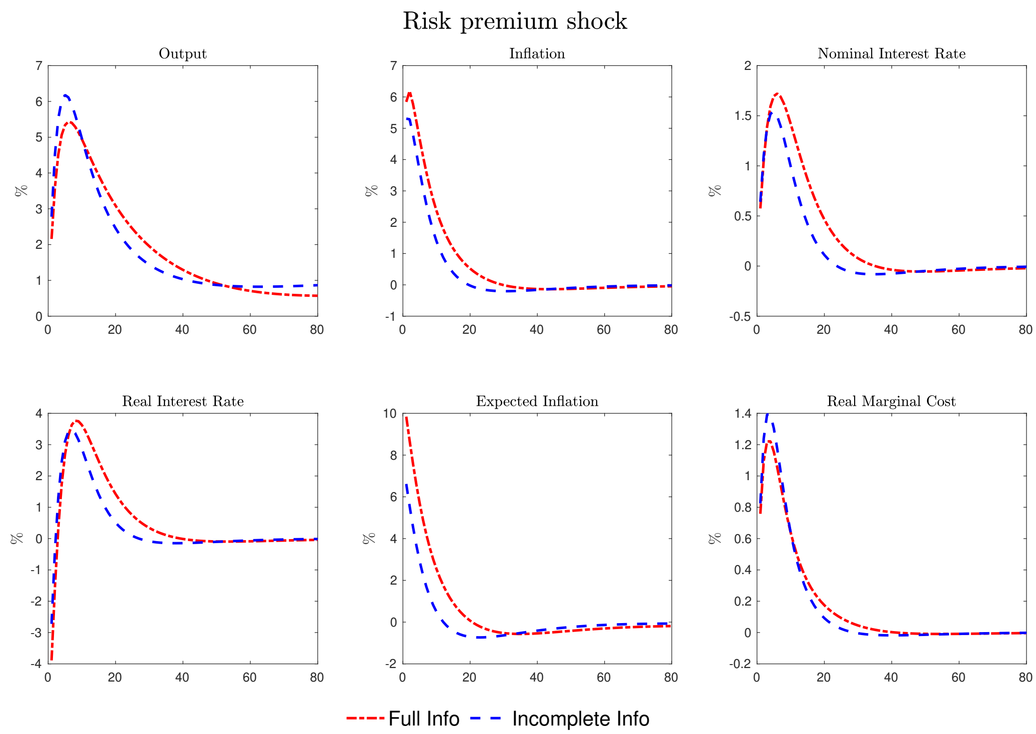

Figure E3. Impulse responses to a one standard deviation risk premium and wage markup shock

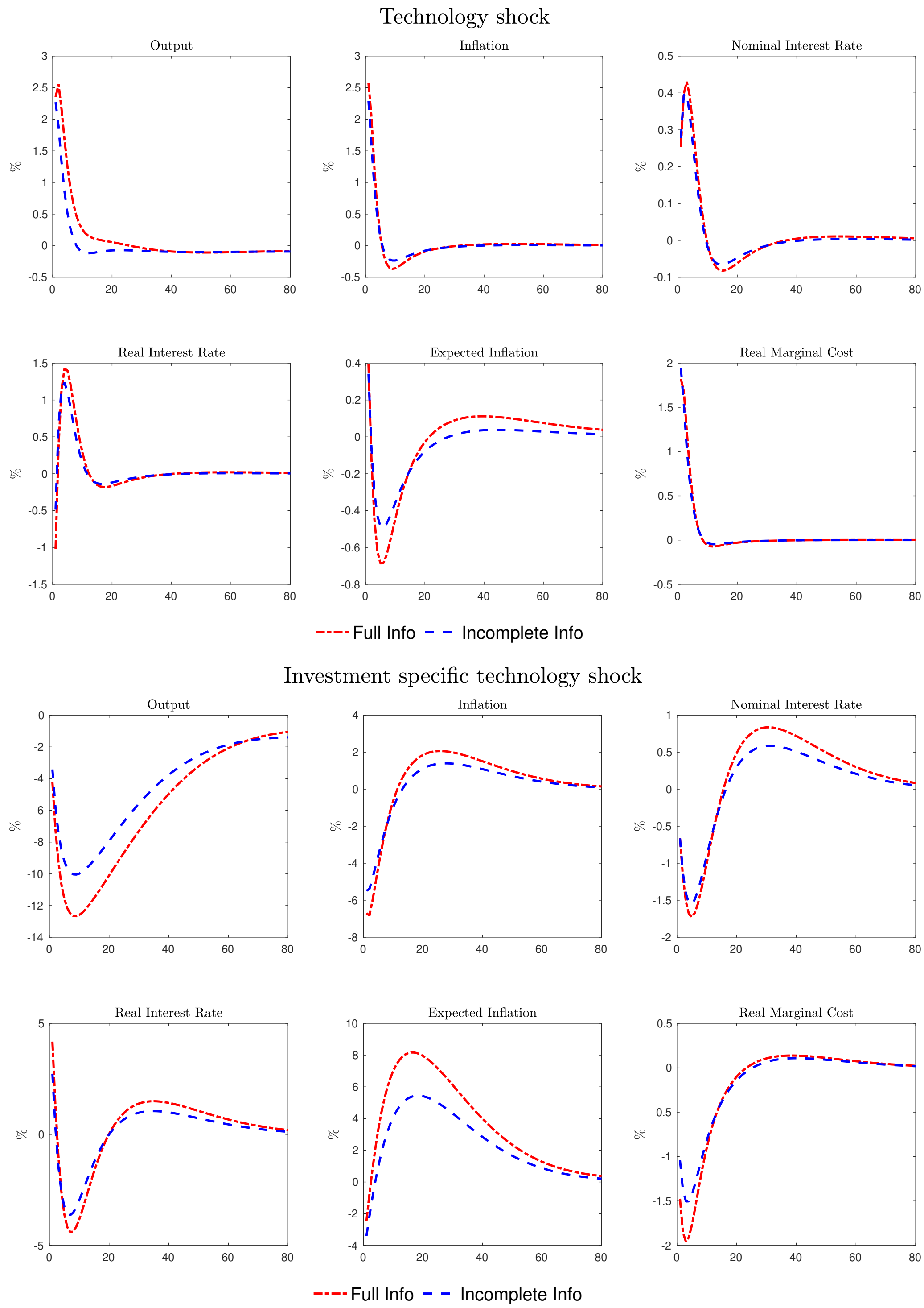

Figure E4. Impulse responses to a one standard deviation technology and investment specific technology shock

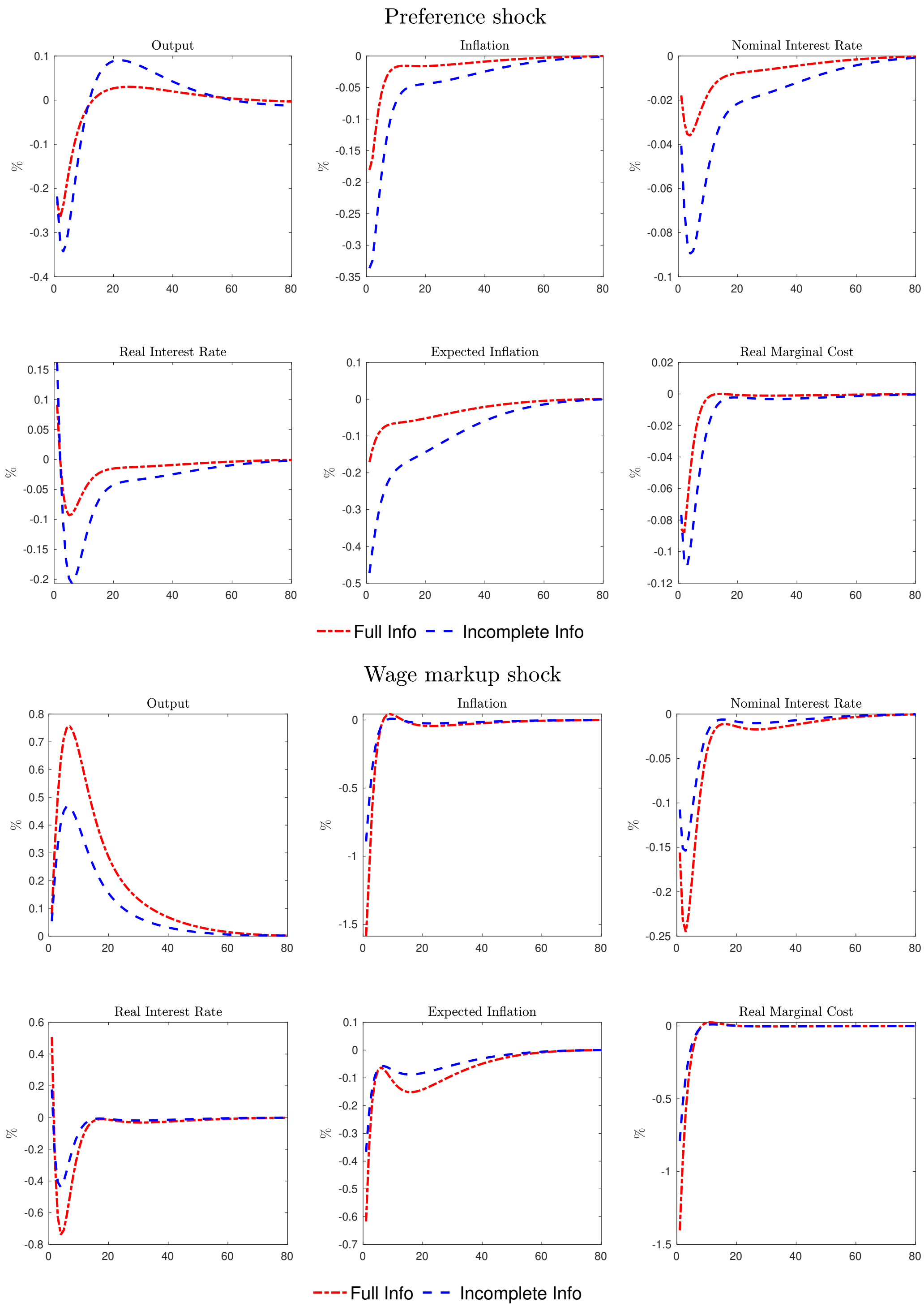

FIGURE E5. IMPULSE RESPONSES TO A ONE STANDARD DEVIATION PREFERENCE AND WAGE MARKUP SHOCK SHOCK

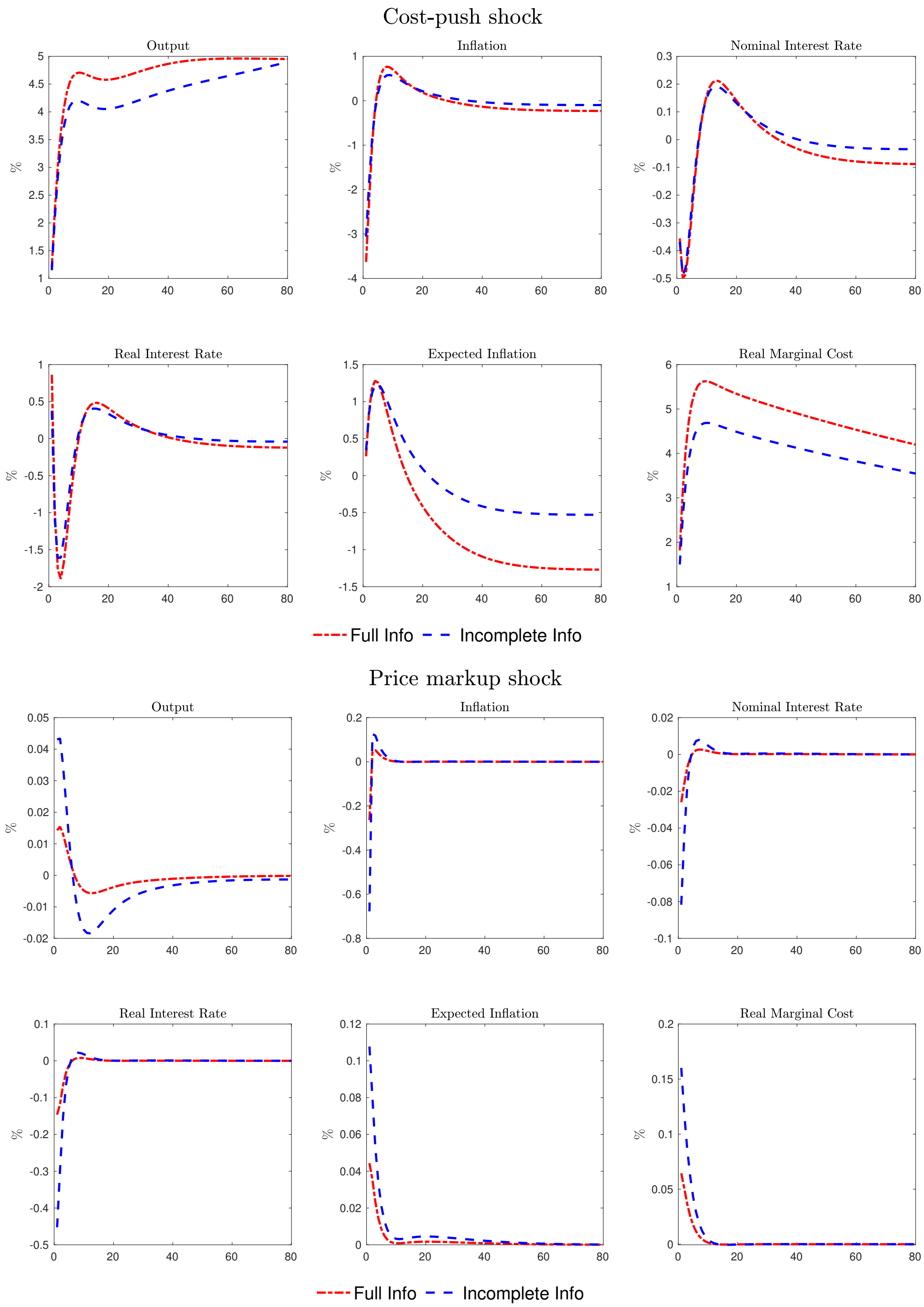

FIGURE E6. IMPULSE RESPONSES TO A ONE STANDARD DEVIATION COST PUSH AND PRICE MARKUP SHOCK

Data Construction

GDP, Consumption, and Investment: All national accounting variables are obtained from National Income and Product Account (NIPA) tables and converted to real values by dividing with the respective price indices with base year 2012:Q3. Consumption is the sum of personal expenditure in non-durable goods and services. Investment is the sub of gross private domestic investment and personal consumption expenditure in durable goods. We scale the real variables with population and convert into growth rates using the formula in Section F.F1.

Hours worked and the average weekly earning: We follow Bianchi, Faccini and Melosi (2023) in constructing the hours gap. We use average weekly hours of all non-farm workers, convert it to per capita using the population index (base year 2012:Q3) and take a difference of hours per capita from its trend which is computed as a fourth degree polynomial. Average weekly wages are constructed by dividing wage and salary accrual with average hours of non-farm workers. Wages are then converted to index with base year 2012:Q3, divided by GDP deflator, and converted to growth rates.

Interest rate and inflation: Interest rates are measured as the effective federal funds rate, inflation is computed as growth rate of GDP deflator index (BY 2012:Q3), and inflation expectations is measured using the 5-year breakeven inflation rate. In our second sample estimation, we also incorporate interest rate expectations measured by overnight index swaps for one to ten quarters ahead federal funds rate.

Government expenditure and transfers: We construct the government expenditure variable as a sum of gross government consumption expenditure and gross government investment expenditure. The nominal variables are converted to real value by dividing with the government expenditure implicit price deflators. To construct an index of government transfers we add together government social benefits, current transfer payments (incl. grants-in-aid to state and local government) and divide by GDP deflator. All real quantities are converted to growth rate after being normalized by the population index.

Revenue from labor and capital tax: Data to calculate revenue from labor and capital tax are obtained from NIPA tables. Following Leeper, Plante and Traum (2010) we first calculate the personal tax rate as:

$$\tau_p = \frac{IT}{WS + PRI/2 + CI}$$

where IT is the personal current tax revenues (Table 3.2, line 3), WS is the wage and salary accrual (Table 1.12, line 3), PRI is the proprietors's income (Table

1.12, line 9), and CI is the capital income defined as the sum of rental income (Table 1.12, line 12), corporate profits (Table 1.12, line 13), interest income (Table 1.12, line 18), and $PRI/2$. Using the personal income tax rate, the labor and capital tax revenue is calculated as:

$$T_L = \tau^p(WS + PRI/2) + CSI$$

$$T_K = \tau^p CI + CT$$

where CSI are contributions to government social insurance (NIPA Table 3.2, line 10) and CT are taxes on corporate income (Table 3.2, line 8).

F1. Observables

All nominal series are converted to real values using GDP deflator indexed to 100 in 2012:Q3 and normalized using civilian non-institutional population (obtained from BLS) indexed to 100 in 2012:Q1 such that:

$$x = ln\left(\frac{x}{\text{Popindex}}\right) \times 100$$

where x is the GDP, consumption, investment, average weekly earnings, government transfers, government consumption and investment expenditure, labor tax revenue, and capital tax revenue. All above series are then converted to growth rates.

The measurement equations are then defined as

$$X_t = C + HY_t + K\Xi_t$$

where Ξ is the vector of measurement errors. The observables are related to the model variables through the following equations:

$$\begin{bmatrix} \text{dlOutput}_t \\ \text{dlCons}_t \\ \text{dlInv}_t \\ \text{dlWage}_t \\ \text{dlGovSpend}_t \\ \text{dlTransfers}_t \\ \text{lGovDebt}_t \\ \text{lHours}_t \\ \text{lInflation}_t \\ \text{lFedFunds}_t \\ \text{dlLaborTaxRevenue}_t \\ \text{dlCapitalTaxRevenue}_t \end{bmatrix} = \begin{bmatrix} 100e^{\gamma} \\ 100e^{\gamma} \\ 100e^{\gamma} \\ 100e^{\gamma} \\ 100e^{\gamma} \\ 100e^{\gamma} \\ \log(s_b) \times 100 \\ 0 \\ \pi^* \\ \log(R_s) \times 100 \\ 100e^{\gamma} \\ 100e^{\gamma} \end{bmatrix} + \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} + \hat{u}_t^a \\ \hat{c}_t - \hat{c}_{t-1} + \hat{u}_t^a \\ \hat{i}_t - \hat{i}_{t-1} + \hat{u}_t^a \\ \hat{w}_t - \hat{w}_{t-1} + \hat{u}_t^a \\ \hat{g}_t - \hat{g}_{t-1} + \hat{u}_t^a \\ \hat{z}_t - \hat{z}_{t-1} + \hat{u}_t^a \\ \hat{b}_t \\ \hat{L}_t \\ \hat{\pi}_t \\ \hat{R}_t \\ \hat{T}_t^L - \hat{T}_{t-1}^L + \hat{u}_t^a \\ \hat{T}_t^K - \hat{T}_{t-1}^K + \hat{u}_t^a \end{bmatrix}$$