A Monetary-Fiscal Theory of Sudden Inflations*

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Abstract This paper posits an information channel as an explanation for sudden inflations. Households saving via nominal government bonds face a choice whether to acquire costly information about future government surpluses. They trade off the cost of acquiring information about the surpluses that back bond repayment against the benefit of a more informed saving decision. Through the information channel, small changes in the economic environment can trigger large responses in consumers' behavior and prices. This setting explains why there can be long stretches of time during which government surpluses have large movements with little inflation response; yet, at some point, something snaps, and a sudden inflation takes off that is strongly responsive to incoming fiscal news.

JEL classification: E31, E51, E52, E63

Keywords: Sudden Inflation, Price Level Determination, Monetary Fiscal Interaction, Fiscal Theory of the Price Level

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1 Introduction

Countries can sustain variable government surpluses and large amounts of debt over long periods without an obvious connection between these quantities and inflation. Then at some point they become connected, as in the examples from Burnside et al. (2001), leading to a sudden inflation. We explain why surpluses, debt, and inflation appear disconnected and how they suddenly become connected using an information channel. The price of nominal government bonds is normally insensitive to information about the future government surpluses that back the bonds because it is difficult for households to research and understand information about those surpluses. Variable surpluses and high debt are sustainable until repayment risk drives households to worry enough that they acquire costly information about future surpluses, making the price of nominal bonds informationally sensitive, and potentially setting off a sudden inflation.

The switch from informationally insensitive to informationally sensitive nominal bonds helps answer why, as shown in Bassetto and Butters (2010), large deficits in industrialized countries do not necessarily lead to inflation, and yet Barro and Bianchi (2023) uncover a tighter connection in the recent post-COVID period. In the long run, buying a nominal government bond is an investment in the government. The bond's nominal payoff will be the face value of the bond; the bond's real payoff will be determined by the government's future real surplus. If the government's fiscal capacity is high enough, the price level could be driven by considerations other than fiscal policy, such as monetary policy targets. Assuming that the country pursues low and stable inflation, the bond holder will receive a stable repayment in real terms; we call this the "M" regime. However, there are instances in which the size of the surplus is constrained – due to a Laffer limit on tax revenue or, more likely, political constraints on austerity. In this case, the real payoff of the nominal bond will have to adjust to fiscal shocks. Barring explicit default, this adjustment takes place through inflation; we call this the "F" regime.

An example of this assumed long-run relationship is captured by Figure 1,

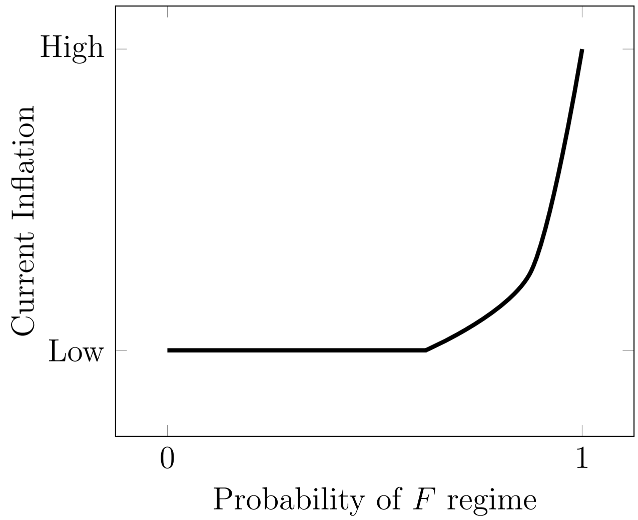

Figure 1: Relationship between current inflation and fiscal news indicating the F regime will hold in the future

a simplified illustration of the numerical version that we develop in Section 3.1. When buying government bonds, debt holders anticipate the possibility that the economy may be in either regime, and form expectations accordingly. As long as they perceive the probability of the M regime to be high, they expect the future price level to be unresponsive to fiscal news, as in the flat portion of Figure 1. When signals about fiscal imbalances indicate a greater likelihood of the F regime, as when we get closer to the critical threshold/kink in Figure 1, the concern over higher future inflation spills over into current inflation as well. Bad news about current and future deficits has an immediate impact on current prices.

When bad news triggers information acquisition, the sudden nature of the emergence of fiscal inflation is magnified, and the model helps explain why higher inflation is correlated with greater inflation volatility, as described empirically in Borio et al. (2023). Similar to the results found in Bianchi and Ilut (2017), when debt is informationally sensitive, inflation is likely to be high and respond to fiscal news. The M regime is likely to hold in times of ample fiscal capacity and the reverse is true for the F regime. Second, the underlying asymmetry of the feedthrough, or lack thereof, explains why there is greater potential for sudden fiscal inflations rather than deflations. Assuming, as in the example of Roosevelt leaving the gold standard described in Jacobson et al. (2019), that the government will not raise extra tax revenue to fund extra real returns, debt will not become informationally sensitive due to the impossibility of an increased real return.

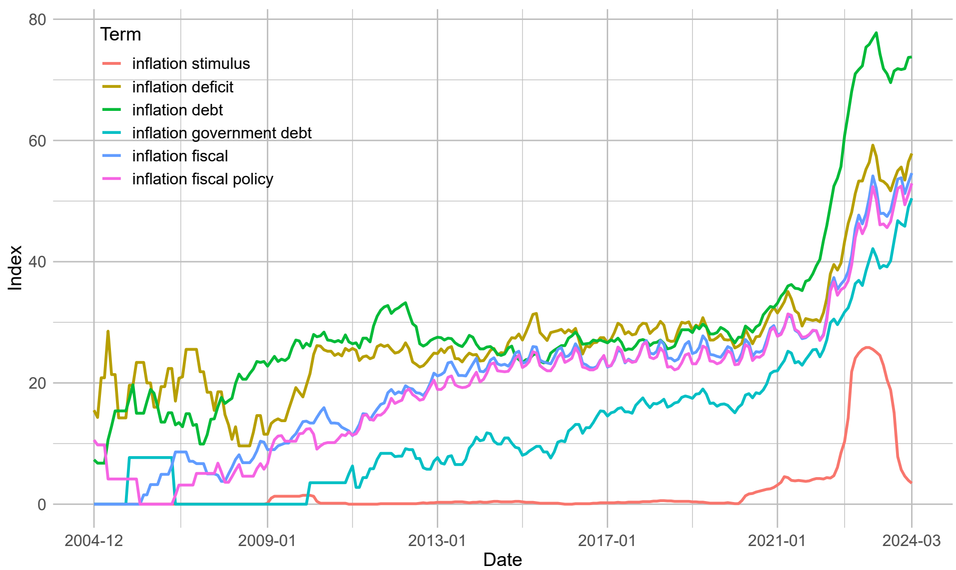

Figure 2: Google searches of terms related to inflation and fiscal policy (12-month MA, month of highest activity normalized to 100)

Figure 2 shows how Google searches that include inflation and various fiscal terms have trended over time, and is a backdrop for the evidence in Barro and Bianchi (2023) that fiscal concerns have accounted for the recent evolution of inflation in advanced economies.

Given the prominent role of endogenous information acquisition, our model needs to account for the way prices aggregate and reveal information, as in the vast literature that follows Grossman and Stiglitz (1980). Within macroeconomics, similar insights have been developed by the literature on rational inattention pioneered by Sims (2003) and reviewed in Maćkowiak et al. (2022). Our environment builds on a simplified version of Maćkowiak and Wiederholt

(2015), in which price-setting producers interact with shoppers who choose quantities to purchase, giving us tractability and allowing us to derive sharp analytical implications even though the long-run price level arising from the underlying fiscal theory exhibits an option-like payoff. We show that this payoff/right skewness of the long-run inflation distribution seen in Figure 1 generates a complementarity in the choice of agents to acquire information, leading to simple pure-strategy equilibria. There may be other additional factors in play that determine the substitutability or complementarity of the information choice. For example, if collective desire for information leads mass media to pay closer attention to the relationship between government finances and inflation, the cost of acquiring information may be decreasing in the attention that others devote to the question. The robust feature is that endogenous attention acts as a force that magnifies the asymmetric response of inflation to deficit news.

We discuss how our paper is connected to various strands of literature in Section 2. Section 3 presents a simple competitive model where information is exogenous in order to make clear how the sensitivity of inflation depends on future fiscal news. Using this model, we show what this implies for the value of acquiring extra information for a single agent who has access to a costly signal; specifically, such an agent would find it worthwhile to learn more about prospective deficits when incoming (free) news is bad. We then enrich the model to properly study endogenous information acquisition in general equilibrium in Section 4. The insight that information is valuable when incoming news is bad is still valid, and the strategic complementarity that we uncover in the decision to acquire information leads to a region of multiple equilibria and the possibility of discontinuous jumps in inflation in response to small changes in fiscal news. Section 5 discusses several extensions.

2 Literature Review

Our paper builds on the literature on the Fiscal Theory of the Price Level (FTPL), which was inspired by the closely related Sargent and Wallace (1981).

The papers of Leeper (1991), Sims (1994), Woodford (1994), and Cochrane (2005) view the ultimate determinant of the price level to be the balance between the primary surpluses of the government and the value of its nominal debt. Bassetto (2002) provides a richer description of the theoretical underpinnings of the FTPL. We feature a feedback from monetary policy to debt as in Sims (2011).

An early challenge for the FTPL is contained in Canzoneri et al. (2001), who establish that the empirical relationship between deficits and inflation in the United States from 1951 through 1995 seems inconsistent with the FTPL. Cochrane (2022a,b) emphasizes that we should expect fiscal policy to sometimes respond to news of incoming fiscal shocks, dampening the price response, otherwise the government would never be able to raise real resources from increasing its debt stock. Our paper provides an explanation for why deficits and inflation are usually not linked in advanced economies, and how they may become linked in episodes such as the COVID aftermath. Examining the post-COVID period, Barro and Bianchi (2023) show that the magnitude of government stimulus during the COVID pandemic accounted for substantial differences in inflation across countries.

Our work is related to more applied studies of regime-switching models of monetary-fiscal policy, such as Davig and Leeper (2007), Chung et al. (2007), and Bianchi and Melosi (2014, 2019) and in a related international context Maćkowiak (2007). In these papers, the seeming lack of a response of fiscal policy to increasing amounts of debt serves as evidence that fiscal policy has entered into a new regime. We differ in the fact that, in our paper, economic agents within the model are not endowed with knowledge of the regime, but they can spend resources to learn about it. Bianchi and Melosi (2017) find evidence that beliefs of the possibility of a fiscally-led regime increased during the Great Recession. Bianchi and Melosi (2022) update their estimates to include the pandemic recession in an attempt to explain the sustained high inflation experienced in 2022.

Valuing government debt in a world of high debt where interest rates may be lower than growth (commonly known as $r < g$) is an active area of research.

Jiang et al. (2023) investigate how government debt and surpluses should be valued from a finance perspective. Inspired by Blanchard (2019), Mehrotra and Sergeyev (2021) and Reis (2021) examine the effects $r < g$ would have on fiscal space and fiscal limits. This paper emphasizes the difficulty in valuing government debt and surpluses, as the variety of this research indicates, while allowing agents to become more informed if they devote the resources to doing so. In this, our paper is complementary to the research agenda developed in Holmstrom (2015), Gorton (2017) and Caballero and Farhi (2017) that views safe assets as special and necessary for their ability to provide savings and insurance, and Holmstrom's (2017) insight that full knowledge of the safe assets' backing destroys the symmetric ignorance that enables trade and leads to lower welfare through inability to insure.

A separate branch of research investigating valuing debt in Bassetto and Cui (2018), Berentsen and Waller (2018), Williamson (2018), Brunnermeier et al. (2020), and the related Andolfatto (2010) explores the complications arising from the liquidity premium of government debt in relation to the FTPL. For simplicity we abstract from the liquidity role of government debt, focusing only on the role of endogenous information acquisition in generating jumps in the behavior of inflation. The economic forces that we highlight would be magnified by adding a liquidity role that is disrupted when deficits generate uncertainty in the eventual real payoff of debt.

In our setup, inflation acts as partial default on government debt, and in that way our paper is also related to the vast literature on sovereign default started by Eaton and Gersovitz (1981) and Calvo (1988). Our emphasis on endogenous information and its relationship with monetary-fiscal policy is what sets us apart. Bassetto and Galli (2019) develop a model of sovereign debt with heterogeneously informed agents, but the information structure there is taken as exogenous. We view regime F and hence the possibility of a sudden inflation as a low-probability event. Through considering the impact of rare events, we are connected to the literature on rare disasters pioneered by Barro (2006). For a review of this literature, see Barro and Ursúa (2012). In our model "rarity" is not in a dynamic sense, but it is interpreted across states of nature.

3 Inflation and Fiscal Regimes with Exogenous Information

We start our analysis from a minimalistic competitive model where all information arises exogenously. Figure 3 presents an overview of the timing of the model. Our economy lasts three periods. The first period acts as a baseline, in which the price level is determined based on prior information alone; in the second period agents respond to incoming information; and the final period is "the long run," when all uncertainty is resolved and government debt is repaid according to the inflation and surplus regime that prevails.

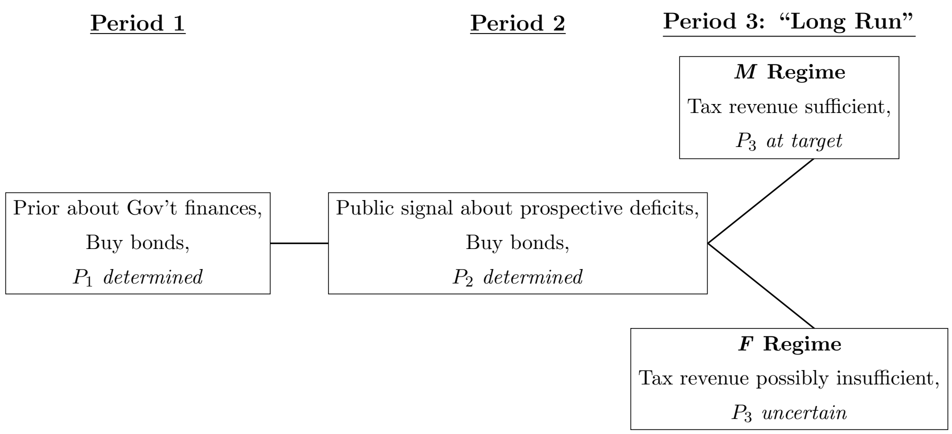

Figure 3: Outline of the Model's Timeline

The economy is populated by a continuum of identical households. Each household i has preferences given by

$$\sum_{t=1}^{3} \beta^t E\left[u(c_{it}) - L_{it}\right], \tag{1}$$

where c_{it} is consumption in period t and L_{it} is the labor supplied, with one unit of labor producing one unit of the good.

The government inherits an amount B_0 of nominal debt, held by the households, due at the beginning of period 1. To repay the debt, the government has access to lump-sum taxes in each period t, denoted by T_t in real terms. Nominal debt is the only asset in the economy. There is no government spending in periods 1 and 2. The assumption that $G_1 = G_2 = 0$ is without loss of generality if government spending is deterministic in those periods; we discuss the consequences of uncertain deficits in period 2 in Section 5. Lump-sum taxes are set in periods 1 and 2 so as to keep debt constant in nominal terms until period 3. As with spending, in the absence of uncertainty, this taxation assumption is without loss of generality. The government has an exogenous and uncertain real spending requirement G_3 in period 3. There is a price level target P_3^* in the third period that the government attempts to achieve.

In period 3, the government is in one of two regimes: "price targeter," (M), or "fiscally-led," (F). In the M regime, real government taxes respond one for one to government spending and are given by $G_3 + B_2/P_3^*$, leaving a primary surplus of B_2/P_3^* to be distributed to bond holders. We call the M regime price targeting because, as we prove below, the primary surplus implies that the equilibrium price level will be P_3^*, independent of the realization of G_3. In the F regime, taxes are not able to respond to spending and are set at an exogenous real amount $\bar{T}$, possibly because they are at an upper bound determined by unmodeled political constraints. We assume that $\bar{T}$ is known, but the quasilinear structure of our preferences implies that prices and private consumption are determined by deficits alone, hence it does not matter whether the shock hits only spending, as we assume, or both spending and taxes.

In general we expect that the incoming information about the regime and future spending conditional on the F regime are correlated: if $\bar{T}$ is interpreted as being driven by political constraints on taxation, those constraints are more likely to bind when spending needs are high. In our numerical example in Section 3.1, we make the extreme assumption that the realization of G_3 by itself determines the fiscal regime. The more flexible specification that we adopt here allows us to conceptually disentangle the sensitivity of inflation to spending news from the convexity of inflation to spending news. While in practice the two are closely related when the fiscal regime and future spending are correlated, our Proposition 3 is about the former.

Finally, the government sets "monetary policy" in the form of a fixed nominal interest rate i at which debt can be rolled over from period 1 to period 2 and from period 2 to period 3. We normalize $1 + i = 1/\beta$, so that the price level would be constant in the absence of uncertainty. The addition of an endogenous interest rate response would strengthen our results if interest rates respond to inflation positively, as in a Taylor rule, and we allow for government debt to increase with the interest rate, as in Loyo (1999) and Sims (2011).

In the first period, households have a prior on the future government. This prior contains information about the regime (M vs. F) and prospective spending G_3. We denote by π_1 the prior that the government will be in regime F in period 3. At the beginning of period 2, public signals about the probability of the F regime and about G_3 conditional on being in the F regime are revealed. π_2 is the posterior of the F regime conditional on time-2 information. In period 3, the fiscal regime $\{M, F\}$ and government spending G_3 are realized.

Each household takes as given government policy and the aggregate price level. Define $b_{i,t-1}$ as the bonds held by household i at the beginning of period t, when they mature. The household budget constraint in period t is

$$b_{i,t-1} + P_t L_{it} = \frac{b_{it}}{1+i} + P_t(C_{it} + T_t). \tag{2}$$

In (2), $b_{i0} = B_0$, the exogenously given initial debt, and $b_{i3} = 0$: no debt is rolled over in the final period.

The necessary and sufficient first-order conditions of the household problem yield the intratemporal optimality relation

$$u'(c_{it}) = 1, \quad t = 1, 2, 3, \tag{3}$$

the Euler equation

$$u'(c_{it}) = \beta(1+i)E_t\left[u'(c_{i,t+1})\frac{P_t}{P_{t+1}}\right], \quad t = 1, 2, \tag{4}$$

and the budget constraints (2).

We are thus ready to define a competitive equilibrium:

Definition 1 A competitive equilibrium is an allocation $\{C_t, L_t, B_t\}_{t=1,2,3}$, nominal prices $\{P_t\}_{t=1,2,3}$, fiscal policy $\{T_t, B_t\}_{t=1,2,3}$ and fixed monetary policy i such that:

- All time-t variables are measurable with respect to the information available at t: that is, period 1 variables only depend on the prior, period 2 variables depend also on the posterior based on the public signal, and period 3 variables depend on the entire history including the final realizations of the spending and monetary-fiscal regime (M or F).

- Given prices and government policy, $\{C_t, L_t, B_t\}_{t=1,2,3}$ solve household i's optimization problem, that is, equations (2), (3), and (4) hold, with $b_{i3} = 0$.

- The government budget equation holds in each period, and taxes obey the fiscal rules that we set out:

$$\frac{B_t}{1+i} = B_{t-1} + P_t(G_t - T_t), \quad t = 1, 2, 3, \tag{5}$$

with $B_3 = 0$,

$$P_t T_t = \frac{iB_{t-1}}{1+i}, \quad t = 1, 2, \tag{6}$$

$$T_3 = G_3 + \frac{B_2}{P_3^*}, \quad \text{in regime } M, \tag{7}$$

and

$$T_3 = \bar{T}, \quad \text{in regime } F. \tag{8}$$

- Markets clear:

$$C_t + G_t = L_t, \quad t = 1, 2, 3. \tag{9}$$

This economy has a unique competitive equilibrium, as we now show. First, equation (3) implies that $C_t = (u')^{-1}(1)$. Equation (9) implies then that $L_t = C_t + G_t$. In the terminal period, households optimally choose not to roll over any government debt (and they are of course also prevented from leaving a short position in government debt after the final period). Taxes and government debt are given by equations (6), (7), and (8). Let $E_t(.)$ represent the expectation conditional on the freely available information at time t (which is the only information that we have introduced so far), and let $\bar{G}_3 := E_2(G_3|F)$ be expected period-3 government spending in regime F. Substituting the fiscal rules and aggregate variables into the household budget constraint, we obtain that the equilibrium price level in period 3 must be given by

$$P_3 = \begin{cases} P_3^* & \text{in regime } M, \\ \frac{B_2}{\bar{T} - G_3} & \text{in regime } F. \end{cases} \tag{10}$$

Prices in periods 1 and 2 can be obtained (working backward) from the household Euler equation (4):

$$\frac{1}{P_2} = \pi_2 \frac{\bar{T} - \bar{G}_3}{B_2} + (1 - \pi_2) \frac{1}{P_3^*} \tag{11}$$

and

$$\frac{1}{P_1} = E_1 \left(\frac{1}{P_2} \right). \tag{12}$$

In a finite-horizon model such as ours, the terminal price is necessarily determined by the resources available to repay government debt. In regime M, these resources adjust so as to ensure that the price level is P_3^*, but in regime F, which we interpret as a regime of fiscal distress, the resources are fixed and the price level is forced to adjust in response to government spending. Consistent with the notion that regime F corresponds to tight government finances, we assume that, at least in expected value as of time 2, taxes in regime F are lower than in regime M:

Assumption 2 $\bar{T} < \bar{G}_3 + \frac{B_2}{P_3^*}$.

We could write Assumption 2 equivalently in terms of the exogenous B_0, since $B_2 = B_0$. Together, Assumption 2 and Equation (11) imply that the sensitivity of the *second period* price level to incoming fiscal news is higher when the probability of the regime of fiscal stress is higher. Formally:

Proposition 3 *In equilibrium,*

$$\frac{\partial^2 P_2}{\partial \pi_2 \partial \bar{G}_3} > 0. \tag{13}$$

Proof. See Appendix A ■

Since the first period price level P_1 is determined by prior information alone, the properties that we proved for the second period price level P_2 carry over immediately to inflation $\pi_2 = P_2/P_1$ between periods 1 and 2: incoming news about fiscal spending has little effect on inflation when the probability that the government is against a fiscal limit is low, but inflation will respond more and more as the chance of being in a regime in which taxes are unable to catch up to spending increases.

3.1 Numerical Example

In order to illustrate the option-like payoff of nominal government debt and equivalently the right-skewed distribution of inflation, we compute a specific parametric example. While a thorough quantitative assessment of our analysis is beyond the scope of our paper, we choose parameter values that deliver reasonable quantitative predictions.

We set the nominal interest rate to $\beta(1 + i) = 1.02$ so that inflation from one period to the next would be 2% if the economy were in regime M with probability 1.

We assume that G_3 is governed by an underlying truncated normal random variable. The exact truncation point is irrelevant under our parameter choices, as the probability of hitting it is trifling, but we do need to ensure that the terminal primary surplus is non-negative, so as to avoid negative prices. We assume that the fiscal regime is entirely determined by the realization of the shock G_3. Specifically, taxes adjust one-to-one with the realization of spending up to an upper bound $\bar{T}$, and remain constant at $\bar{T}$ for any higher level of spending. Given our functional-form assumptions, this implies that the posterior distribution of G_3 is a sufficient statistic to describe the freely available information.

$$T_3 = \begin{cases} G_3 + \frac{B_2}{P_3^*} & \text{for } G_3 < \bar{T} \text{ (regime } M\text{)}, \\ \bar{T} & \text{for } G_3 \geq \bar{T} \text{ (regime } F\text{)}. \end{cases}$$

We normalize the target price level P_3^* and the unconditional mean of spending to 1 and use the standard deviation σ of G_3 and the tax threshold $\bar{T}$ to achieve a 10% probability that the price level in period 3 is 2% above its target, and a 5% probability that it is 6% above its target.

In period 2, households receive a (public) normally distributed signal of G_3. We choose the precision of the signal to be $\sigma_s = .057$. We pick this parameter value in anticipation of Section 4.4 where the precision of the public signal will help determine the benefit of costly endogenous private information acquisition.

Figure 4 plots the price level in the long run (period 3), as a function of the realization of government spending G_3. The range of the plot corresponds to the mean $\pm$ 4 standard deviations. This captures our notion that government debt has an option-like payoff, in which fiscal and monetary policy will act to prevent deflationary forces, but may be hamstrung by fiscal constraints when faced with upside pressure on prices.

Figure 5 plots second period inflation as a function of the incoming information, which is summarized by the posterior mean of government spending. If we define the signal to be s_t, the posterior mean is related to the incoming signal by

$$E_2(G_3) = \frac{\alpha_1 E_1(G_3) + \alpha_2 s_t}{\alpha_1 + \alpha_2},$$

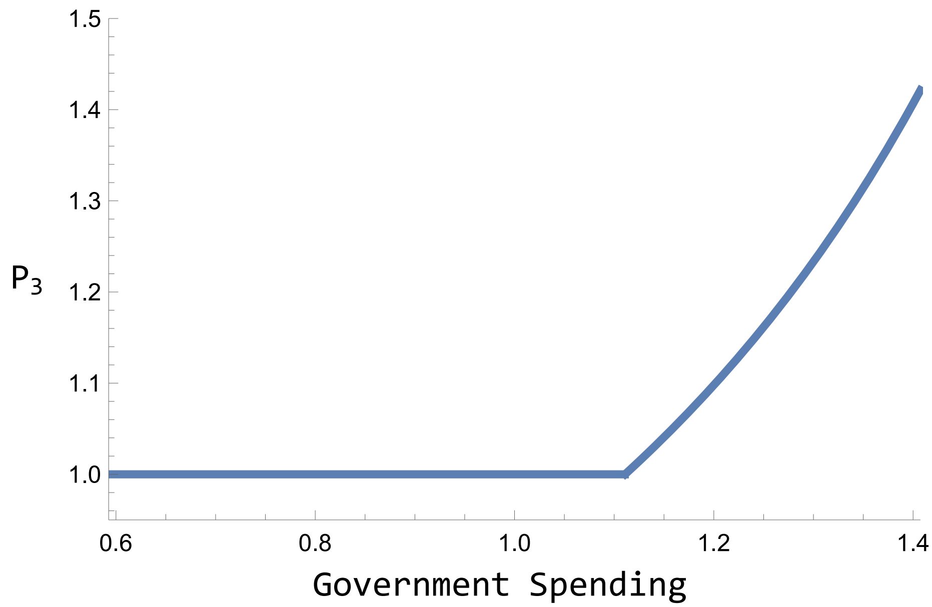

Figure 4: "Long-run" relationship between prices and government spending

with $\alpha_1 = 1/\sigma^2$ and $\alpha_2 = 1/\sigma_s^2$.

When the public signal in period 2 indicates that the M regime is almost certain to prevail in period 3, inflation is about 1.3%, below the 2% level that would prevail if regime M were known to prevail as of period 1 as well.[1] As expected, second period inflation is insensitive to fiscal news over much of the range. However, as the signal reveals a greater likelihood of the F regime prevailing (equivalently, government spending above the limit $\bar{T}$), inflation in the second period starts responding more and more to the incoming signal. For sufficiently negative fiscal news, when regime F is almost certain to prevail, inflation responds to the signal in period 2 as strongly as it would in period 3 to the actual realization of spending. More precisely, it is inverse inflation that responds in the same way, since in our model inverse inflation is linear

[1]This undershoot coming from good news on the fiscal front could of course be undone if the central bank set a correspondingly higher interest rate as of period 1, which would cause a parallel increase in inflation in both good states and bad. Whether the central bank is willing to take this risk, or has the information advantage necessary, as in Bauer and Swanson (2021), to be confident in doing so is beyond the scope of this paper.

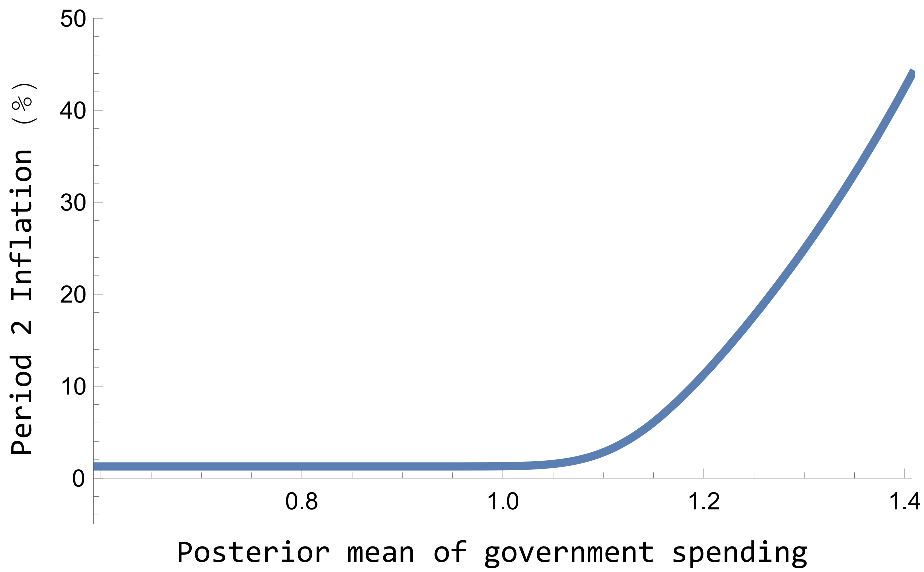

Figure 5: Period-2 inflation under exogenous information.

in the spending shock as of period 3 and in its expected value as of period 2 conditional on regime F.

In this competitive model, we could ask the following question: suppose that we endow a single agent in the economy with the ability to learn in period 2 the realization of the fiscal regime and of future spending, at a utility cost K. When would the agent choose to acquire the information? This information is valuable if there is sufficient uncertainty about P_3, which happens for a sufficiently high probability of being in the F regime and/or enough uncertainty about future spending in that regime.

Consider again the numerical example of the previous section. In order to evaluate the optimal information choice, we need to specify some more parameters. We pick $\beta = 0.99$, $u(c) = \log c$, and $K = 0.0171429$, which is the same utility cost that we target in our full-fledged model of endogenous information below. With these choices, it is optimal for a single agent to acquire information when $E_2(G_3) > 1.017$.

This computation highlights that, when information is a choice, the economy is likely to behave very differently once sufficiently negative information about deficits materializes. It is not however a satisfactory representation of the problem, because each household does not act in isolation. In a competitive equilibrium, a household observes the current price level when making its decisions. How should a household act if others are acquiring the information? What information is revealed by prices? What are the options to learn from the actions of others?

In order to properly address the questions above, we need to enrich the model and make explicit who is setting prices and who is choosing quantities, and when. This is what we do next.

4 Inflation and Fiscal Regimes with Endogenous Information

In this section, we provide an expanded model in order to fully explore the complications surrounding endogenous information acquisition that the model in Section 3 simplified. Our model is designed so that, when information is exogenous, it yields exactly the same equilibrium conditions as in Section 3 except for a constant monopoly markup that affects the marginal utility of consumption in all periods and all states uniformly. When information acquisition is endogenous, the model highlights the role upside inflation risk plays in the decision to become informed and yields pure strategy equilibria that illustrate how information acquisition amplifies the link between fiscal news and inflation highlighted in the previous model's Proposition 3.

We modify the model in Section 3 by assuming that each household i is composed of a continuum of identical producers, indexed by $j \in [0, 1]$, and a single shopper. This structure follows Maćkowiak and Wiederholt (2015), but simplifies their setup by allowing workers to own their own firm. By separating consumers and producers, we separate the consumer problem of choosing quantity demanded given prices from the producer problem of setting prices. Each producer is atomistic with respect to both the household and the aggregate economy, hence takes as given the marginal utility of consumption of the household to which the producer belongs and the aggregate price level. The separation of producers and shoppers and the two-dimensional continuum (a continuum of producers in each household) simplifies the information structure of the model and allows us to cleanly highlight the source of complementarities, at the cost of additional notation.

Household i has preferences given by (1) over consumption and labor aggregates. c_{it} is a Dixit-Stiglitz aggregator of the differentiated varieties produced by each producer of each household. Let $c_{kjt,i}$ be consumption in period t by household i of the good produced by producer j of household k. We have

$$c_{it} = \left(\int_0^1 \int_0^1 c_{kjt,i}^{\frac{\theta-1}{\theta}} dj dk \right)^{\frac{\theta}{\theta-1}}, \tag{14}$$

with $\theta > 1$. We retain the linearity assumption on the disutility of labor, so L_{it} is simply the integral of the labor supply of each producer, denoted ℓ_{it}:

$$L_{it} = \int_0^1 \ell_{it} di.$$

The government has the same spending requirements as in Section 3, but this is now in terms of the consumption aggregate. Given the realization of the spending shock G_3, the government minimizes the cost of attaining this level.

In each period, nature moves first, then the government, the producers, and finally the shoppers. Specifically:

1. Shocks are realized. In period 1 there are no shocks; in period 2, (public) signals about the future are revealed; and in period 3 all uncertainty is resolved.

2. Interest rates and taxes are set by the government according to the rules described in Section 3.

3. In period 2, producers do not know the aggregate price level when setting their own price. However, they have an option to pay a utility cost K and learn additional information about the future. To keep algebra

simple, we assume that upon paying K they learn perfectly the future realizations of $\{M, F\}$ and G_3, but all of our results would apply if paying K allowed them to acquire a (common) signal that is more precise than the freely available signal, but not perfectly revealing.

4. After observing prices, the shopper chooses the quantities of different varieties to buy, allocating the residual to bond purchases. Labor supply adjusts so as to meet demand.

We start our analysis by describing the equilibria that arise when the decision to acquire extra information is exogenous, showing the parallels with the simpler model in Section 3: in Section 4.1 we assume that no one acquires information, and in Section 4.2 we assume that everyone acquires it. In these equilibria, information is symmetric across all agents in the economy, and we can rely on the familiar notion of a (monopolistically) competitive equilibrium. The determination of equilibrium prices is a simple application of the FTPL and household Euler equations, yielding expressions (10), (11), and (12).

We then move on to the endogenous information case where there is a choice about whether or not to acquire information. Section 4.3 shows how the exogenous equilibrium where no one acquires information and the exogenous equilibrium where everyone acquires information are spliced together under endogenous information. Due to the complementary nature of information, this splicing leaves a region of multiple equilibria. The end result is an economy that may have a limited inflation response to fiscal news over a range of signals until suddenly the response of inflation to fiscal news, and inflation itself, jumps. Section 4.4 illustrates the model with a numerical example.

4.1 Equilibrium with No Information Acquisition

In this subsection, we assume that no producer acquires extra information beyond the freely available signal, such as would be the case if $K \to \infty$. We also use this as a building block in studying equilibria with endogenous information acquisition, since the same quantities and prices prevail in that case in regions where producers find it optimal not to acquire the information.

Each household takes as given government policy and the prices charged by all other households, as well as *aggregate* consumption by other households in each period that we denote by C_t. As usual, we break up each household i's optimization problem into two steps:

(i) Given consumption of the composite good c_{it} in each period, we determine the allocation across varieties that minimizes the cost of attaining c_{it};

(ii) Given prices, government policy, the cost of attaining c_{it} computed in the first step, and the demand function by other households for each variety, we determine the optimal allocation $\{\{\ell_{ijt}\}_{j\in[0,1]}, c_{it}, b_{it}\}_{t=1,2,3}$.

In the first step, the household solves

$$\min_{\{c_{kjt,i}\}_{j,k\in[0,1]}} \int_0^1 \int_0^1 p_{kjt} c_{kjt,i} dj dk,$$

subject to (14). The optimal solution yields the demand function

$$\frac{c_{kjt,i}}{c_{it}} = \left(\frac{p_{kjt}}{P_t}\right)^{-\theta}, \tag{15}$$

with the price index defined by

$$P_t := \left(\int_0^1 \int_0^1 p_{kjt}^{1-\theta} dj dk\right)^{\frac{1}{1-\theta}}. \tag{16}$$

The corresponding cost for the household of attaining c_{it} is $P_t c_{it}$. In period 3, the government solves a similar problem, setting its demand to

$$\frac{G_{kj3}}{G_3} = \left(\frac{p_{kjt}}{P_t}\right)^{-\theta}, \tag{17}$$

with G_3 exogenous.

We can aggregate the household demand functions (15) and obtain

$$\frac{C_{kjt}}{C_t} = \left(\frac{p_{kjt}}{P_t}\right)^{-\theta}, \tag{18}$$

where C_{kjt} is aggregate consumption of the good supplied by producer j of household k in period t.

The remainder of the household problem consists of maximizing (1) with respect to $\{\{\ell_{ijt}, p_{ijt}\}_{j\in[0,1]}, c_{it}, B_{it}\}_{i\in[0,1],t=1,2,3}$ subject to ℓ_{ijt} meeting the demand functions (17) and (18), taking C_t as given, and subject to the budget constraints (2).

We are thus ready to define an equilibrium:

Definition 4 When no extra information can be acquired, a monopolistically competitive equilibrium is an allocation $\{c_{kjt,i}, C_{kjt}, c_{it}, C_t, \ell_{ijt}, b_{it}, G_{kjt}\}_{i,j,k\in[0,1],t=1,2,3}$, a price system $\{p_{ijt}, P_t\}_{i,j\in[0,1],t=1,2,3}$, fiscal policy $\{T_t, B_t\}_{t=1,2,3}$ and an exogenous interest rate i such that:

- All time-t variables are measurable with respect to the information available at t.

- Consumption of individual varieties by each household and the government satisfy the individual static household cost minimization problem, that is, equations (15), (17), and (18) hold.

- Given aggregate consumption and prices $\{C_t, P_t\}_{t=1,2,3}$, and given government policy and the demand functions (17), and (18), $\{c_{kjt,i}, c_{it}, \ell_{ijt}, p_{ijt}, b_{it}\}_{j,k\in[0,1],t=1,2,3}$ solve household i's optimization problem.

- The government budget equation holds in each period, and taxes obey the fiscal rules that we set out, that is, equations (5), (6), (7), and (8) hold.

- Aggregates are consistent with individual choices, that is, (14) and (16) hold, as well as

$$C_{kjt} = \int_0^1 c_{kjt,i} di, \quad k, j \in [0,1], t = 1, 2, 3, \tag{19}$$

and

$$C_t = \int_0^1 c_{it} di, \quad t = 1, 2, 3. \tag{20}$$

- Markets clear:

$$C_{kjt} + G_{kjt} = \ell_{kjt}, \quad k, j \in [0,1], t = 1, 2, 3, \tag{21}$$

and

$$B_t = \int_0^1 b_{it} di, \quad t = 1, 2, 3. \tag{22}$$

In period 1, we directly impose $b_{i0} = B_0, i \in [0,1]$ as the initial condition.

Proposition 5 *There exists a unique equilibrium, in which all varieties share the same prices and quantities; prices, taxes, and government bonds are the same as in the competitive equilibrium of Section 3, and consumption is given by*

$$C_t = (u')^{-1} \left(\frac{\theta}{\theta - 1} \right), \quad t = 1, 2, 3. \tag{23}$$

Proof. Straightforward substitution proves that the allocation, prices and policy in the statement of the theorem meet the definition of an equilibrium. To prove uniqueness, note that, after using equations (17), (18), and (21) to substitute for ℓ_{ijt}, the household problem features a strictly concave objective function and a convex constraint set, hence its solution is unique.

Under monopolistic competition, a household is a monopolist for the varieties that it produces so it takes into account the market-clearing condition (21) at the optimization stage, when the aggregates C_t, G_t, and P_t are taken as given. Since all households share the same initial conditions, they must make the same choices. Furthermore, the objective function is symmetric in the production of all varieties, therefore charging the same price for each variety is optimal; equations (17) and (18) imply then that the demand for each variety is the same as well.

Having established that the consumption, prices, and production of each variety by each household are the same, equation (3) implies that equation (23) must hold, which uniquely determines consumption. Equations (17) and (18) uniquely determine production and government spending. Since all households choose the same amount of bonds, equations (5) and (6) imply that bonds must satisfy equations (7) and (8). Finally, equations (4), (7), and (8) imply that good prices must be given by the solution to equations (10), (11), and (12). ■

Since prices are determined by the same equations as in the competitive equilibrium model of Section 3, Proposition 3 continues to apply when no information acquisition takes place.

4.2 Equilibrium with Information Acquisition

We next consider the opposite case, in which all producers in period 2 acquire perfect information, as would endogenously happen if $K = 0$. Producers acquire this information by paying K, and shoppers learn from prices. The equilibrium that we study here has the feature that the price charged by producers fully reveals the acquired information to the shoppers. There are no equilibria in which all producers choose to acquire extra information and this information is not revealed through prices. This property of prices arises because the problem of the producers has a unique solution, so that all producers necessarily charge the same price in equilibrium; furthermore, conditional on this observation, different expectations about P_3 necessarily imply different choices for P_2.

This equilibrium is a special case of the equilibrium of Subsection 4.1, where the posterior information on the regime and G_3 is degenerate. We obtain $P_2 = P_3 = P_3^*$ when regime M is known to prevail and $P_2 = P_3 = B_2/(\hat{T} - G_3)$ when F is known to prevail. Period 2 prices are either completely unresponsive to fiscal news (regime M), or maximally responsive (regime F). These prices fully reveal the regime and the realization of G_3 in regime F, ensuring that shoppers will be fully informed even without acquiring the underlying information directly. A small exception occurs if there is a positive probability that $P_2 = P_3^*$ in regime F. In this case, shoppers would not know whether $P_2 = P_3^*$ as a consequence of being in regime M or because of the specific realization of G_3 in regime F. Nonetheless, they would have full information about the future price level $P_3 = P_3^*$, which is all they need to implement the optimal intertemporal choice according to the Euler equation.

Our results readily generalize to less-extreme assumptions about the precision of period 2 information. Even if the extra information that agents acquire is not perfect, the posterior probability of the F regime π_2 would be on average closer to reflecting the future state. Inflation would on average respond more to fiscal news when regime F is likely to be realized than when regime M is likely to be realized.

We can similarly characterize the equilibrium that prevails if producers follow a simple rule choosing to acquire information whenever the freely available signal is 'bad' enough. Assume producers acquire information whenever the freely available signal (denoted by a generic vector s) takes values in some set S. The equilibrium will once again satisfy the same equations as in Section 4.1, but now expectations as of period 2 are based on full information when the signal belongs to the set S and strictly on the publicly available information otherwise.

4.3 Endogenous Information Acquisition

We now endogenize the choice of information acquisition, and establish conditions that characterize the ranges over which no information acquisition, full information acquisition, or both are equilibria. We consider pure-strategy equilibria in the main text. Our analysis highlights a strategic complementarity in the producers' choice that makes it more valuable for producers to acquire information when all of them do rather than when nobody does. In Appendix B we detail mixed-strategy computations within our numerical example; we find that for plausible values of the intertemporal elasticity of substitution the complementarity extends to all of the range of mixed strategies, showing that, when they exist, mixed-strategy equilibria are knife-edge.

We look at the incentives of a single producer to deviate from the actions taken by the rest of the producers. In studying these incentives, we identify features of our model that lead to complementarities in the choice of acquiring information and hence pure-strategy equilibria. First we look at the situation of a producer who chooses not to acquire information when all other producers acquire information, then at the situation of a producer who chooses to acquire information when all other producers don't acquire information.

The producer problem is simplified by the model's structure: producers are infinitesimal both with respect to the aggregate economy and with respect to their household. Furthermore, we assume that shoppers do not learn from the choices of a measure zero set of producers. Together, these assumptions imply that producers take the equilibrium allocation of all goods except their own as given. It would be straightforward to provide microfoundations for ignoring measure zero sets of producers by introducing idiosyncratic productivity shocks, which can be accommodated within our framework without complicating the proofs, but would require further burdensome notation.

When is Information Acquisition An Equilibrium?

We study the conditions under which there exists an equilibrium in which all producers acquire information. Consider the problem of a producer when all other producers choose to acquire information. In this case, shoppers are able to learn the information and thus infer the future regime and spending by the producers' prices, and the economy is in the equilibrium of Section 4.2. Suppose producer ij unilaterally chooses not to acquire information, thereby saving K. We analyze the expected revenue and profit for the deviating producer.

Producer ij knows that other producers have acquired information, so that $P_2 = P_3$ according to the equilibrium of Section 4.2, but has to set her price without knowing the aggregate price level. Conditional on P_2, the revenues accruing to producer ij from setting a price p_{ij2} are

$$p_{ij2}C_2\left(\frac{p_{ij2}}{P_2}\right)^{-\theta}. \tag{24}$$

In the competitive equilibrium, the household's marginal utility of consumption is $\theta/(\theta-1)$ and the period-3 price is $P_3 = P_2$. Furthermore, aggregate consumption is $C_2 = (u')^{-1}(\theta/\theta - 1)$. Substituting this information into (24), the revenue evaluated in utility terms is

$$\frac{\theta}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left(\frac{p_{ij2}}{P_2}\right)^{1-\theta}. \tag{25}$$

It is worth noting that the timing of consumption by the household's shopper does not matter in this case. Whether each individual producer chooses to acquire or not to acquire information, she knows that the shopper would act optimally based on full information and the envelope condition implies indifference at the margin. By the Euler equation, the marginal utility of the extra revenues is given by equation (25) in either case.

The labor cost incurred by producer ij when setting a price p_{ij2} and when the aggregate price level is P_2 in utility terms is

$$C_2\left(\frac{p_{ij2}}{P_2}\right)^{-\theta}. \tag{26}$$

Producer ij chooses her optimal price by maximizing *expected* revenues minus costs, which yields

$$p_{ij2} = \frac{E_2\left[P_3^{\theta}\right]}{E_2\left[P_3^{\theta-1}\right]}, \tag{27}$$

where we used the fact that $P_2 = P_3$. Publicly available information is insufficient to know P_2 when other producers acquire information (otherwise the other producers wouldn't have acquired information). In the degenerate case of no uncertainty, we obtain $p_{ij2} = P_2$. In this case, information has no value, and the "uninformed" producer chooses the same monopolistically competitive equilibrium price as all others.

The expected profits earned by the uninformed producer ij setting price p_{ij2} according to equation (27) are given by

$$\Pi_{\text{noinfo}} := u'^{-1}\left(\frac{\theta}{\theta-1}\right)\frac{1}{\theta-1}\left[E_2\left(P_3^{\theta}\right)\right]^{1-\theta}\left[E_2\left(P_3^{\theta-1}\right)\right]^{\theta}. \tag{28}$$

Producer ij compares the profits in equation (28) with those earned if she acquired information, which are given by

$$\Pi_{\text{eq}} := u'^{-1}\left(\frac{\theta}{\theta-1}\right)\frac{1}{\theta-1}. \tag{29}$$

Π_{eq} and Π_{noinfo} differ by the factor $\left[E_2\left(P_3^{\theta}\right)\right]^{1-\theta}\left[E_2\left(P_3^{\theta-1}\right)\right]^{\theta}$, which is less than 1 by Jensen's inequality. To see this, note that

$$\left[E_2\left(P_3^{\theta}\right)\right]^{1-\theta}\left[E_2\left(P_3^{\theta-1}\right)\right]^{\theta} = \left[\left[E_2\left(P_3^{\theta}\right)\right]^{\frac{1-\theta}{\theta}} E_2\left(\left(P_3^{\theta}\right)^{\frac{\theta-1}{\theta}}\right)\right]^{\theta}, \tag{30}$$

and

$$\left[E_2\left(P_3^{\theta}\right)\right]^{\frac{\theta-1}{\theta}} > E_2\left(\left(P_3^{\theta}\right)^{\frac{\theta-1}{\theta}}\right) \tag{31}$$

since $f(x) = x^{\frac{\theta-1}{\theta}}$ is concave.

Full information acquisition is therefore part of an equilibrium for all ranges of the signal for which $\Pi_{\text{eq}} - \Pi_{\text{noinfo}} > K$. This condition holds provided there is enough uncertainty about the future price level P_3 as determined by the expectation terms in equation (28). The incentive to acquire information is particularly sensitive to *upward tail risk* on inflation. Mathematically, both expectations in equation (28) involve positive powers of the future price level, and one of them involves a power that is above 1. Intuitively, the most costly scenario for an uninformed producer facing informed competition is to pick a price that is too low and be forced to produce large quantities at a loss in real terms. The opposite situation, in which the uninformed producer charges too high a price, is less costly, since in this case production is low and profits are bounded below by zero.

When is No Information Acquisition An Equilibrium?

We now consider the case in which no producers acquire information. In this case, the aggregate economy is in the monopolistically competitive equilibrium of Section 4.1. An individual producer can pay the cost K and learn the future price level P_3. As before, we look at the expected revenue and profit of the deviating producer.

The producer's revenues and costs are still described by equations (24) and (26), but now P_2 is given by equation (11), with the expectation taken with respect to the exogenous public information only (and P_2 will not be equal to P_3 in general). Unlike the previous case, in which P_2 revealed all information, both public and privately acquired, to the shopper, a producer who chooses to deviate here acquires extra information not available to anybody else, and in particular not available to the shopper.

Based on this superior information, the allocation of consumption across periods dictated by the shopper's Euler equation is suboptimal, and the envelope condition fails. As a consequence, it matters when the shopper consumes the extra resources provided by the increased profit from the deviating producer. There are two assumptions that would be consistent with the model as described so far:

- The shopper only finds out about the extra resources in period 3, and adjusts consumption at that stage. This is the assumption that we adopt.
- The shopper finds out about the extra resources in period 2, and allocates them across both periods 2 and 3 so as to preserve the Euler equation (4).

We will assume the shopper consumes the extra resources in period 3. This assumption is conservative with respect to the emergence of strategic complementarities and regions of multiple equilibria. In this context, information is valuable because it lets the producer know in advance the real value of extra resources carried into period 3. The more resources that are consumed in period 3, the more valuable acquiring information will be, shrinking the region in which no information acquisition is optimal (together with the no information region's overlap with the region in which multiple equilibria emerge).

To gain further intuition, suppose that the shopper consumed all of the extra resources in period 2. In this case, acquiring extra information would be worthless for the producer, since the real value of the extra resources can be computed from the marginal utility of consumption in period 2 and the price level in period 2. Both of these quantities would be independent of the extra information when no other producer becomes informed and thus known to all producers even without acquiring additional information. Under such an extreme assumption, an equilibrium with no information acquisition would exist for any value of the free signal.

When shoppers spend the extra resources in period 3, the revenues of the producer converted to utility terms are given by

$$\frac{\frac{\theta}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)}{P_3}\left(\frac{p_{ij2}}{P_2}\right)^{-\theta} \tag{32}$$

which is derived by repeating the same steps that lead to Equation (28), but assuming that P_2 is known by the producer. Equilibrium consumption and its marginal utility are the same in the equilibria with or without information acquisition, so the corresponding terms in equations (25) and (32) remain the same. Also, equation (32) embeds the interest rate $\beta(1+i)=1$, although the same results could be derived in the more general case.

An informed producer maximizes the difference between (32) and (26), which is achieved by setting $p_{ij2}=P_3$. The profits (in utility terms) accruing to the producer are

$$(u')^{-1}\left(\frac{\theta}{\theta-1}\right)\frac{1}{\theta-1}\left(\frac{P_3}{P_2}\right)^{-\theta}.$$

In equilibrium, P_2 is known as of time 2 without acquiring information since no other producer chooses to acquire information before setting their price. Prior to receiving the extra information, the expected profits of acquiring information when no other producer does are thus given by

$$\begin{aligned}\Pi_{\text{fullinfo}} &:= (u')^{-1}\left(\frac{\theta}{\theta-1}\right)\frac{1}{\theta-1}P_2^{\theta}E_2(P_3^{-\theta})\\ &= (u')^{-1}\left(\frac{\theta}{\theta-1}\right)\frac{1}{\theta-1}\left[E_2(P_3^{-1})\right]^{-\theta}E_2(P_3^{-\theta}),\end{aligned} \tag{33}$$

where the last equality follows from equation (11).

Repeating the same steps, the profits of uninformed producers in this equilibrium are given by equation (29). No information acquisition can be part of an equilibrium for all ranges of the free public signal such that $\Pi_{\text{fullinfo}} - \Pi_{\text{eq}} < K$. Jensen's inequality implies that this happens when uncertainty about the future price level is sufficiently low. The decision to acquire information when nobody else does is particularly sensitive to *downside inflation risk*. Mathematically, this occurs because the expectations in equation (33) involve negative powers of the price level. Intuitively, the most favorable scenario for an informed seller facing uninformed competition is to find out that the future price will be low, so she can set a low price, undercut the competition and reap the rewards of a high volume of sales while maintaining the appropriate profit margin. In the reverse case, the best an informed producer can do is to charge a higher price than competitors and produce little, with limited profits.

Characterizing the sensitivity of inflation to fiscal news

While mathematically we have not ruled out significant downside inflation risk, our economic application is predicated on the idea that this risk is limited. For example, as described in Jacobson et al. (2019), deflation caused by a rise in the price of gold would have required austere fiscal policy in order to raise the surplus necessary to repay government debt. Faced with the required austerity, Roosevelt chose to leave the gold standard rather than deflate. The asymmetry that justifies our exercise lies in the fact that the government is more likely to implement the target price P_3^* when fiscal resources are plentiful, and a higher price level will tend to prevail when the fiscally constrained regime F applies, leaving the door open to greater upside inflation risk.

It is thus likely that the threshold for the information cost above which an equilibrium with information acquisition exists is *lower* than the threshold for the information cost above which an equilibrium with no information acquisition exists. This ordering happens in the quantitative example explored in section 4.4. In this case, with a fixed information cost, we have three regions indexed by the probability of the F regime π_2: at low π_2 there is a region in which only the equilibrium with no information acquisition is possible, an intermediate region where multiple equilibria coexist, and at high π_2 a region in which only the equilibrium with full information acquisition survives.

In the region of multiple equilibria, the model could jump back and forth between equilibria. However, a selection criterion would make such erratic behavior unlikely. While we do not include any such criteria in the model, two obvious candidates are announcements by the fiscal or monetary authority. In a negative sense, since a country may be in the region of multiple equilibria but inflation remains tranquil, even small announcements by the fiscal or monetary authority could have the effect of pushing a country into a sudden inflation. Conversely, if a country is in the region of multiple equilibria but inflation is high, announcements by the fiscal or monetary authority could have the effect of quelling an incipient sudden inflation.

In the exogenous equilibrium of Section 4.1, inflation *gradually* responds more to incoming fiscal news as the probability that taxes will not respond to government spending increases. This gradual increase is present even under endogenous information, but the endogenous choice may add a further discrete jump:

- When the probability of regime F is sufficiently low, the only pure-strategy equilibrium is one in which it is not profitable to spend resources to learn more about government finances. As a consequence, changes in π_2 in this region have a small effect on the price level.

- As π_2 increases, we enter the region of multiple equilibria. In this region, sensitivity, and inflation, can jump for no reason at all. If, at some point within this region, the full information acquisition equilibrium is sustained, a jump in the sensitivity of the price level to inflation occurs, and the price level starts closely tracking incoming fiscal news. Eventually, as we move to the next region, the no information acquisition equilibrium falls away, supporting the prediction that at some point inflation starts tracking incoming fiscal news more closely.

- As π_2 increases further, only the equilibrium with full information acquisition survives. In this case, regime F is sufficiently likely that producers find it optimal to pay the cost and learn about government finances. Thus, no matter what occurs in the region with multiple equilibria, eventually a jump in the responsiveness of inflation to fiscal news occurs.

Extrapolating our results to an economy where this uncertainty is revealed over time, we can explain why inflation does not respond to bad fiscal news for a long time, and yet at some point inflation discretely snaps and starts reacting. The region with multiple equilibria adds an additional fear: even an observer with full knowledge of the economy cannot know exactly the tipping point when bad fiscal news will lead to increased inflation responsiveness.

4.4 Numerical Example with Endogenous Information Acquisition

To better illustrate the message of our paper, we return to the specific parametric example of Section 3.1. All parameters are the same as before. We have one new parameter, θ, which we set to 3.5 so that the producer mark-up is 40%.

We choose the precision of the freely available signal and the information cost such that endogenous information acquisition is triggered with probability approximately 1/8. The results are not particularly sensitive to the exact combination of precision and cost that yield this probability. To compute this probability, we also need to take a stance on which equilibrium will be played in the (small) region of multiple equilibria; we assume that in this region agents remain uninformed, which is the Pareto-dominant equilibrium. This gives us values of $\sigma_s = .057$ for the standard deviation of the signal conditional on G_3 and a cost of information equal to 0.6% of equilibrium profits evaluated in leisure terms. Since utility is assumed to be linear in leisure, by expressing the cost of information in this way, we do not need to specify the utility function for consumption.

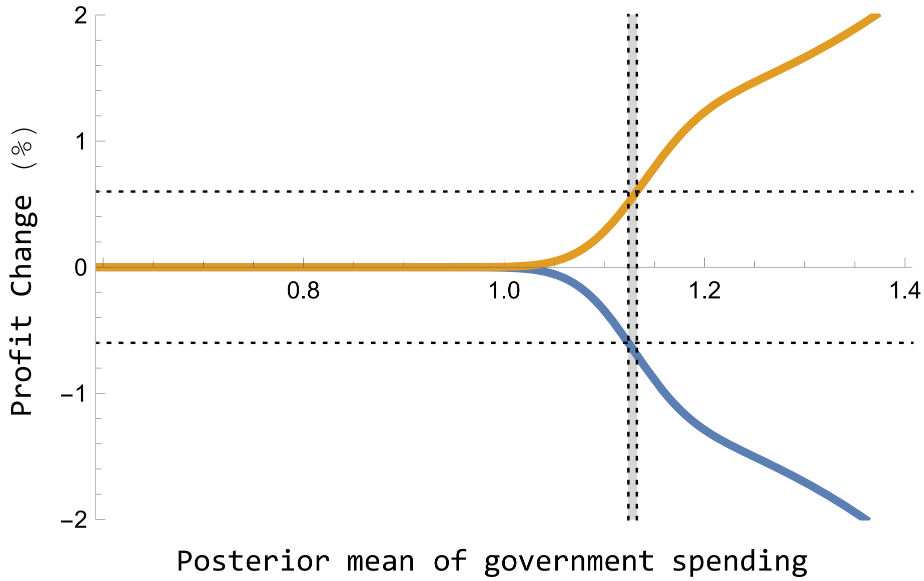

Figure 6: Profit change for the deviating producer to acquire information or not, when all other producers choose the other option. Orange line: Increase in profits from acquiring information if all other producers do not acquire information. Blue line: Decrease in profits from not acquiring information if all other producers acquire information. Horizontal dashed lines: Cost of acquiring information. Vertical dashed lines: Levels of posterior mean government spending where cost or benefit of deviating cross the cost of acquiring information, separating the regions of possible equilibria. Grey area: region of multiple equilibria, where either equilibrium is possible, depending on the expectations of the agents in the economy.

Figure 6 plots the cost as a fraction of equilibrium profits for the producer not to acquire extra information when all other producers do, and the benefit of acquiring the information when nobody else does. The two measures look very similar in absolute value, but they are not exactly symmetric (hence the region of multiple equilibria). The two horizontal lines correspond to the information cost K that we set to 0.006, and the two vertical lines denote the critical thresholds at which the cost and the benefit cross this value.

The grey area between the two lines is the region where multiple equilibria are possible. To the left of the grey area, the only equilibrium features no information acquisition: the probability that the government will be constrained by its fiscal capacity is negligible and the change in profits arising from the acquisition of information is too small for producers to choose to acquire it, regardless of what others are doing. To the right of the grey area, fiscal sustainability is a sufficient concern that all producers will find it optimal to become informed in equilibrium. In the grey area, both equilibria are possible, depending on expectations about the actions of others. The region of multiple equilibria is small, having a probability of about 1.5%. We can show that the region will be of limited size more generally: letting σ_{P_3} be the standard deviation of P_3 conditional on information freely available at time 2, the distance between the two critical thresholds is $O(\sigma_{P_3}^3)$ as $\sigma_{P_3} \to 0$.

Figure 7 displays inflation as a function of incoming fiscal news, with the region of multiple equilibria shaded in grey once again. To the left of the grey area, inflation behaves exactly as in Figure 5, since no agent acquires extra information, and the price level only responds to publicly available information. To the right of the grey area, agents are fully informed in equilibrium, so inflation is no longer responding to the second period signal, but to the fully anticipated realization of fiscal variables that will prevail in period 3. The horizontal lines correspond to three possible realizations of the spending shock G_3. These lines are drawn for a value of the spending shock G_3 equal to the posterior mean at the upper threshold of the region of multiple equilibria, and for the same plus or minus one posterior standard deviation. Thus they represent the central range of what we would expect to happen. In the grey area, the equilibrium can either be described by the solid line of no information or by the dotted lines, depending on the coordination of agents' beliefs about the information actions of others.

Comparing this figure with the case of exogenous information in Figure 5,

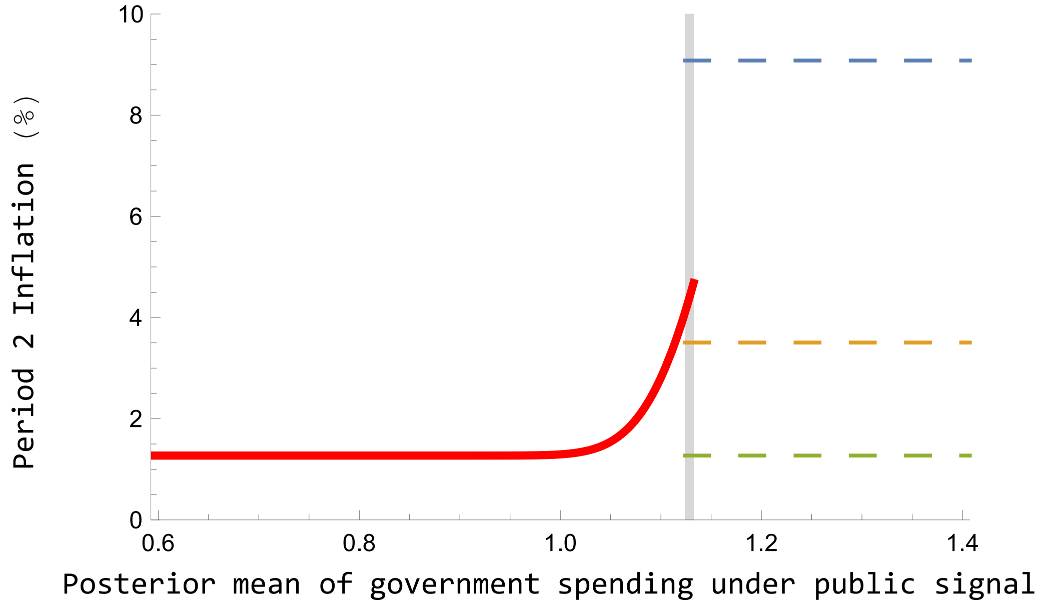

Figure 7: Period-2 inflation under endogenous information. Solid line: inflation in the region where no endogenous information acquisition takes place. Dashed lines: inflation when endogenous acquisition takes place, for different realizations of the spending process. Grey area: region of multiple equilibria, where either option is possible, depending on the expectations of the agents in the economy.

endogenous information gives rise to "inflation scares," a critical tipping point at which economic agents start paying close attention to incoming fiscal news and react to the news. Once this threshold is reached, a discrete jump in inflation will occur. Since agents process available information efficiently, this jump cannot be one-sided: if the endogenously acquired information turns out to be benign, the inflation scare will abate. However, when the bad signal is confirmed by the information agents acquire, a discrete upward jump in inflation takes place. Since the price level in period 3 is bounded below, inflation will feature frequent downward movements bringing the price level back toward its target (the green and orange dashed lines), and less frequent, but larger upward jumps (the blue dashed line). At the critical threshold, the probability that the information reveals that spending is sufficiently low that

P_3^* can be attained is 1/3, so a significant fraction of downward jumps (the orange dashed line) do not get back all the way to the inflation that would prevail if the regime M had been expected to prevail (the flat part of the solid red line).

5 Extensions

5.1 Multiple Deficit Shocks

So far, we have exclusively considered uncertainty about primary surpluses in the final period, where all the action in the interim period comes from fiscal news about the final period. It is straightforward to add an additional fiscal shock to the model that occurs in the interim period. Specifically, we can add a shock to taxes and/or spending in period 2 to the model that affects the amount of debt B_2 that the government inherits at the beginning of period 3.

What really matters for our results is the evolution of the present value of primary surpluses that back the debt. If we retain (for simplicity) the same interest rate peg as in the main model, but allow for more general shocks to taxes and spending in period 2 and 3, in an equilibrium with no information acquisition we would still obtain

$$\frac{B_1}{P_2} = T_2 - G_2 + \beta E_2(T_3 - G_3), \tag{34}$$

where the expectation here is taken across the future realizations of T_3 and G_3, and across the possible fiscal regimes in the terminal period. We use the linearity of utility with respect to leisure to keep the equation simple. Otherwise, equilibrium consumption would vary across periods and the marginal utility of consumption would appear in the expression. This would not change the logic of our argument.

The key assumption that makes our model work is that bad fiscal news is associated with both lower present values of the surpluses (almost by definition) and more uncertainty about their realized value. To the extent that a bad realization of $T_2 - G_2$ pushes the government close to a fiscal limit where future inflation is more uncertain, our analysis of both exogenous and endogenous-information equilibria continues to apply. The equivalence between period-2 and period-3 deficits is related to Ricardian equivalence, as discussed in Barro (1974).

5.2 More than Three Periods

Our analysis can also be extended to a longer time horizon. This extension allows us to study how an event that triggers information acquisition affects the economy in its aftermath. To this end, we extend the model of Section 4 by adding one period: specifically, to keep the notation as similar as possible, we keep periods 2 and 3 as they are but start the economy in period 0 rather than period 1. In period 0, there is a prior on government spending and regime, and some information about future spending (and deficits) is revealed in period 1. Producers have an additional option to acquire costly information in period 1.

We retain the assumption that the costly signal in period 2 is perfectly revealing, whereas the differently-costly signal that can be acquired in period 1 has precision $\tau_c < \infty$, for otherwise there would be nothing left to learn in period 2. Fuller details of the equilibrium derivation for this case are in Appendix C.

When producers choose to acquire information in period 1, two countervailing forces are in play for period 2. Having acquired better information than would-be publicly available in period 1, producers value less the additional information that they may acquire in period 2. Counter to that, if the information acquired in period 1 confirms the suspicion that the government is likely to be hamstrung in its ability to raise sufficient revenue to keep prices under control, the value of information about future deficits is correspondingly increased. In general, whether information acquisition in period 1 makes information acquisition in period 2 more or less likely depends on parameter values, but we can reach some conclusions by observing that when period-1 news is more negative about fiscal solvency, the second effect, increasing the value of further information, is stronger.

Since such negative news leads to higher inflation, a switch to a persistent regime of information acquisition (and thus volatile inflation) is more likely, the higher is the realization of inflation in period 1. This positive correlation between inflation and inflation volatility is empirically seen in Borio et al. (2023) and Bianchi and Ilut (2017). The adverse scenario resembles the account of the 1970s appearing in Bianchi and Melosi (2017, 2019, 2022) and Bianchi et al. (2023), where a change in the monetary/fiscal regime triggers sustained inflation volatility. While in their work agents freely learn that the regime has changed, in ours the shift to a different regime emerges endogenously as a consequence of the information choices of the private sector. Our model does not contain elements that would generate positive correlation of inflation *levels* across periods 1 and 2. To obtain such a correlation, we would need to either introduce nominal frictions, as in the works cited above, or long-term debt, as in Cochrane (2001).

Our model predicts that the economy is subject "inflation scares", episodes in which bad fiscal news triggers information acquisition, but the subsequent information is revealed to be benign, so that inflation stays low and there is a low probability of further endogenous information acquisition (and low information volatility) in the near future.

The multiple-period model can also address episodes when inflations ends abruptly, as described in Sargent (1983). If information acquisition occurs in period 1 and adverse fiscal news is revealed, inflation will occur. However, a prominent policy change in period 2 (a good realization of the public signal, in the model's language) may stabilize inflation. This course of action supports a lower price level and it reduces the variance of prices by inducing agents not to engage in further costly information acquisition. This public signal can come from either fiscal or monetary authorities, but more often from the way the two coordinate. In the account of Bianchi et al. (2023), the Volcker disinflation of the early 1980s might be such an episode.

We illustrate the forces in the model by extending the numerical example of Section 4.4. We retain the same parameter values as the 3-period model, except for the following:

- We cut in half the precision of the free signals (now received in periods 1 and 2), so that the agents acquire the same amount of free information by the end of period 2;
- We also cut in half the cost of information acquisition in each period;
- We assume that the precision of the costly signal in period 1 is 5 times as large as that of the free signal, while retaining the assumption that the costly signal in period 2 is perfectly informative;
- We assume the discount factor $\beta = 0.96$. (β does not affect the results that we report for the 3-period numerical example.)

We also need to take a stance on the following two issues:

- Since there is a region of multiple equilibria, we need to select the equilibrium that will be played. We assume that agents remain uninformed as long as this is a possible equilibrium, in both periods. Our results are not sensitive to this assumption, since the region of multiple equilibria is small.
- As before, we retain the assumption that a single deviating producer who acquires information while everybody else does not is too small to convey any information to the rest of the economy, including her own household. As before, we assume that the household receives the extra revenues at the end of the period in which they are earned. For period 2, as before, this implies that all extra revenues are spent in period 3. For revenues accruing in period 1, we assume that the household divides the extra expenditure across periods 2 and 3 so as to preserve the Euler equation. Since in equilibrium consumption is constant, this implies that $1/(1+\beta)$ of the revenues are spent in period 2 at the price P_2, and the remaining revenues are carried to period 3 and spent then.

With this parameterization, the probability that agents acquire information in period 2 is 3.5% if signals induced them to choose not to acquire information in period 1, but jumps to 30% if bad news induced them to pay the cost to acquire information in period 1 and learn more about prospective deficits. Information acquisition in period 1 is triggered in a region in which sustained attention to incoming fiscal data is warranted, so that the value of continued learning dominates over the effect of already acquired better information. At the same time, whether further information will be acquired depends in large part on what the costly information reveals, which in turn determines period-1 inflation after information acquisition.

We can thus plot the probability of information acquisition in period 2 as a function of the inflation in period 1, conditional on the free signal in period 1 being in the region that triggers information acquisition in period 1. This probability is displayed in Figure 8 and illustrates how experiencing high inflation in period 1 is associated with moving to a regime of continual information acquisition.

5.3 Liquidity

Holmstrom (2015), Gorton (2017) and Caballero and Farhi (2017) show models in which safe assets play a special role in providing liquidity services for the financial intermediation sector. In their story, the high cost to acquire private information about safe assets' underlying value is important in generating this special role by eliminating concerns over asymmetric information. The liquidity services lead to a premium on safe assets that translates into higher prices (and lower returns) for the assets. In our model, government bonds are nominally risk free, but their *real* return becomes riskier and riskier as the prospects of fiscal limits loom. Endogenous learning of the form presented in this paper threatens to disrupt the liquidity premium when the fiscal risk becomes sufficiently acute. Papers such as Bassetto and Cui (2018) and Brunnermeier et al. (2020) highlight the possibility that the liquidity role of government bonds serves to fortify government surpluses when using the FTPL

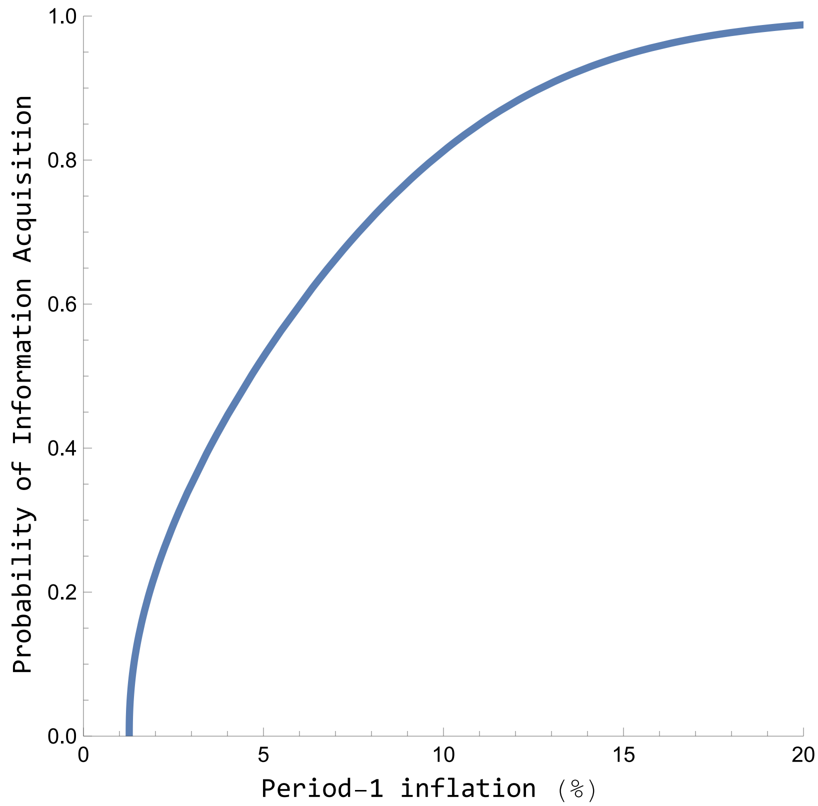

Figure 8: Probability of further information acquisition in period 2 as a function of period-1 inflation, conditional on the free signal in period 1 triggering information acquisition in that period.

to analyze the price level. Thus, learning about future surpluses would offer an additional avenue by which jumps in inflation could occur by hampering liquidity, eliminating any liquidity premium, and causing spikes in the real interest rate.

6 Conclusion

It is well known that monetary and fiscal policy are intertwined, yet the connection between deficits, debt, and inflation does not stand out when we look, as in Bassetto and Butters (2010), at the experience of industrialized economies after World War II. The United States and many other countries responded to the 2008 financial crisis by running unprecedented peacetime deficits, yet inflation remained subdued throughout the developed (and even most of the developing) world. This has led many economists and policymakers to take a benign view of the even bigger deficits, and even higher debt levels, that followed the COVID pandemic; inflation ensued, however, and Barro and Bianchi (2023) document a connection between deficits and inflation across countries for this latest episode.

In this paper, we argue that there are reasons to expect the connection between deficits and inflation to be subdued, only to resurface suddenly. We identify the endogenous attention that households and firms pay to prospective deficits and their link to monetary policy as an amplifying mechanism that leads to sudden inflation scares. In analogy with Holmstrom (2015) and Gorton's (2017) description of safe assets, we view households as usually poorly informed about the future surpluses that back government bonds; they buy and hold bonds without knowing the government's long-run ability to raise surpluses because they believe the bonds will be repaid, and it's too costly to learn more.

However, when enough bad fiscal news comes in, the risk that the link between inflation and debt may appear leads the private sector to pay greater attention to prospective fiscal policy. When fiscal authorities are revealed to be hamstrung, the idyllic times come to the end, and inflation and debt become linked. We also document the possibility of regions of multiple equilibria, such that pinpointing the exact tipping point may be difficult; in this case, prominent government announcements may act as focal points for regime changes. One such example may be the deficit-financed "mini-budget" announced by Truss's government in the United Kingdom in September 2022. But the warning is more general: even a seemingly small signal can push the private sector over the threshold to pay attention and lead to a sudden inflation, if they are already near the threshold.

Our work has taken fiscal policy as given. An interesting avenue of further research is to link the attention choices of the private sector to the response of fiscal authorities. Returning to the United Kingdom example, the abrupt depreciation of the British pound and the large increase in long-term rates on U.K. bonds that followed the September announcement led to the fall of Truss's government, and to the formation of a government that more than reversed most of the announced measures. This endogenous response offers an additional reason for the private sector to be complacent about deficits in ordinary times: they would expect that, once signals of a confidence crisis emerge, the government would rein in fiscal profligacy and restore calm. Only when the probability is sufficiently high that this sort of austerity may be politically or economically impossible would a confidence crisis emerge with sustained inflation.

Similarly, we have purposely simplified the role of monetary policy. As modeled, a Taylor rule-based monetary policy would strengthen our results, as interest rates would rise with debt-induced inflation. But monetary policy consists of much more than solely interest rates. Expectations of future monetary regimes could provoke or prevent sudden inflations, similar to the fiscal foresight mechanism discussed here. By providing its own public signal of the future regime, the central bank could play a role in coordinating expectations, as it may have done during the Volcker period.

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A Proof of Proposition 3

Define $z_2 : 1/P_2$. From equation (11), we have

$$\frac{\partial z_2}{\partial \bar{G}_3} = -\frac{\pi_2}{B_2} < 0,$$

$$\frac{\partial z_2}{\partial \pi_2} = \frac{\bar{T} - \bar{G}_3}{B_2} - \frac{1}{P_3^*} < 0,$$

where the second inequality follows from Assumption 2, and

$$\frac{\partial^2 z_2}{\partial \pi_2 \partial \bar{G}_3} = -\frac{1}{B_2} < 0.$$

It follows that

$$\frac{\partial P_2}{\partial \pi_2} = -P_2^2 \frac{\partial z_2}{\partial \pi_2} > 0$$

and

$$\frac{\partial^2 P_2}{\partial \pi_2 \partial \bar{G}_3} = 2P_2^3 \frac{\partial z_2}{\partial \bar{G}_3} \frac{\partial z_2}{\partial \pi_2} - P_2^2 \frac{\partial^2 z_2}{\partial \pi_2 \partial \bar{G}_3} > 0.$$

B Mixed-Strategy Equilibria

To study whether mixed-strategy equilibria, in which producers choose to become informed with a probability $\psi \in (0, 1)$, are possible we start by studying the pricing problem for a producer who has chosen to acquire information. In an equilibrium, this producer can correctly anticipate the prices P_2 and P_3. Furthermore, since information is symmetric (and full) again in the final period, consumption in period 3 is still given by $(u')^{-1}(\theta/(\theta-1))$. Hence the marginal utility of an extra dollar acquired in period 2 and spent in period 3 is $\frac{\theta}{(\theta-1)P_3}$, as was the case for pure strategies.

First, consider the problem of a producer who chooses to acquire information when a fraction $\psi > 0$ of producers are becoming informed. Let P_2^I be the price that such a producer chooses. Her problem is

$$\max_{P_2^I} P_2^I C_2 \left(\frac{P_2^I}{P_2}\right)^{-\theta} \frac{\theta}{\theta-1}\frac{1}{P_3^*} - C_2 \left(\frac{P_2^I}{P_2}\right)^{-\theta},$$

which yields

$$P_2^I = P_3 \tag{35}$$

as the optimal solution, independent of the aggregate price index P_2 in the second period.

The price index prevailing in period 2 aggregates the price choice of informed and uninformed producers (P_2^{UI}):

$$P_2 = \left[\psi \left(P_2^I\right)^{1-\theta} + (1-\psi)\left(P_2^{UI}\right)^{1-\theta}\right]\frac{1}{1-\theta}. \tag{36}$$

As long as a positive fraction of producers acquire information ($\psi > 0$), the price P_2 moves monotonically with the information of the informed producers. In an equilibrium, shoppers have correct beliefs about ψ, so they can infer what the future period-3 price will be and choose their quantity to consume accordingly. Taking into account that $u'(C_3) = \theta/(\theta-1)$, their Euler equation implies then

$$u'(C_2) = \frac{\theta}{\theta-1}\frac{P_2}{P_3}. \tag{37}$$

We next consider the optimal pricing choice of uninformed producers:

$$\max_{P_2^{UI}} E_2 \left[P_2^{UI} C_2 \left(\frac{P_2^I}{P_2} \right)^{-\theta} \frac{\theta}{\theta - 1} \frac{1}{P_3^*} - C_2 \left(\frac{P_2^{UI}}{P_2} \right)^{-\theta} \right],$$

which yields

$$P_2^{UI} = \frac{E_2 \left(C_2 P_2^{\theta} \right)}{E_2 \left(C_2 P_2^{\theta} P_3^{-1} \right)}. \tag{38}$$

Equations (35)-(38) can be jointly solved for P_2^{UI} as a function of freely available information in period 2, and (P_2^I, P_2, C_2) as functions of the (perfect) information acquired through the costly signal. We can then compute expected profits for the uninformed producer:

$$\frac{1}{\theta - 1} E_2 \left(C_2 P_2^{\theta} \right)^{1-\theta} E_2 \left(C_2 P_2^{\theta} P_3^{-1} \right)^{\theta}; \tag{39}$$

and the expected profits of an informed producer, conditional on the information available before paying the cost and acquiring the costly signal:

$$\frac{1}{\theta - 1} E_2 \left(C_2 P_2^{\theta} P_3^{-\theta} \right). \tag{40}$$

While profit equations (39) and (40) do not directly involve ψ the fraction of informed producers, the endogenous variables contained in them do depend on it, since ψ appears in equation (36) which is used to solve for the allocation C_2 and period-2 prices. A mixed-strategy equilibrium requires the difference between the (expected) profits of the informed and the uninformed producers to exactly compensate for the cost of acquiring information.

In order to solve for the allocation numerically, we need a functional form for the utility of consumption. We use a CRRA utility function, with a coefficient of 1 in the baseline, and we experiment with various other values. For the other parameters, we use the same parameter values as in our main numerical example of Section 4, but we also experiment with perturbing those values.

Throughout all of our numerical searches, we find that the value of expected profits accruing to informed producers increases relative to those of uninformed producers as ψ increases, except at high levels of the intertemporal elasticity of substitution. This indicates that the strategic complementarity that arises when comparing only across pure strategies exists even when we consider mixed strategies. As a consequence, when a mixed-strategy equilibrium with probability of information acquisition $\psi \in (0, 1)$ exists, it is unstable, in the following sense:

- If we perturb beliefs of the producers by any arbitrarily small amount ϵ downwards, so that they believe that other producers acquire information with probability $\psi - \epsilon$, their best response is not to acquire information ($\psi = 0$).
- If we perturb beliefs upwards to $\psi + \epsilon$, their best response is to acquire information ($\psi = 1$).

As is standard in games of strategic complementarity, we disregard these equilibria.

When the utility is close to linear (for values of the intertemporal elasticity of substitution higher than 3), shoppers respond strongly to movements in expected real rates caused by inflation. In this case, the value of information becomes decreasing in ψ for $\psi \in (0, 1]$ over the relevant range of values for the posterior $E_2 G_3$. The region of multiple pure-strategy equilibria persists, but the uninformed equilibrium becomes fragile in this region. When a small amount of producers acquire information, this triggers perfect learning by shoppers that respond strongly, and it becomes dominant to acquire information.

Our main conclusions continue to apply to this environment. However, in this case, at levels of the posterior for government spending below those that generate multiple pure-strategy equilibria, a new region of multiple equilibria emerges, with one (no longer fragile) equilibrium featuring no information acquisition and one stable mixed-strategy equilibrium. We thus still obtain discontinuous jumps in inflation as a function of the free signal about fiscal solvency.

As a final remark, the emergence of two stable equilibria with no unstable equilibrium in the middle might look surprising, but this is due to the discontinuity of the best response function at $\psi = 0$. When $\psi = 0$, shoppers do not learn the costly signal, but with any $\psi > 0$ they do, altering the producer's problem. At the cost of further complicating the model, we could introduce some noise trading so as to make the price not fully revealing and smooth the discontinuity. As long as the noise trading is sufficiently small, this would only add a third unstable equilibrium.

C Details of the Derivation of An Equilibrium in the 4-period Economy

We now add another period to the economy. It is convenient to make the new period 0. In this way, periods 2 and 3 (and the notation thereof) remain largely unchanged. The computations for period 2 are the same as before, except that we have to perform them twice: in one case, producers have acquired information in period 1, and in the other case they have not. The relevant state for their decision is still the posterior for public spending conditional on the information that they have before acquiring the period-2 costly signal. The difference between the two cases is only the precision of the information that producers have at this stage, hence their posteriors will be different. The resulting thresholds for information acquisition in period 2 will be *higher* when information was acquired in period 1 than if it was not.

We retain the simplifying assumption that the costly signal in period 2 is perfectly informative. In period 1, the costly signal has some precision τ_c. The new signal cannot be perfect, otherwise period 2 would be degenerate after acquisition of information in period 1. We assume that the free signal has the same precision τ_s in both periods (this could be easily relaxed).

We now study the decision to acquire information in period 1.

C.1 Computation of region where everybody becoming informed is an equilibrium

We start from the case in which everybody else chooses to acquire information and a single producer contemplates a deviation. This is the simpler case because the price P_1 reveals the information everyone else acquired, with two implications:

- Consumers know the information when making their decisions about quantities. As a consequence, the envelope condition holds and we can simplify the algebra by just pretending that extra revenues are consumed in period 1.
- A producer who chooses not to acquire the costly signal in period 1 learns about it at the end of the period through the aggregate price, and is therefore on equal footing with all other producers in period 2. Hence, the possible deviation entails costs and benefits in period 1 only.

The revenues accruing to a single uninformed producer are given by

$$p_{ij1} C_1 \left(\frac{p_{ij1}}{P_1}\right)^{-\theta}$$

Imposing that in equilibrium $C_1 = u'^{-1}\left(\frac{\theta}{\theta-1}\right)$, the revenues in utility terms for the household become

$$\frac{\theta}{\theta-1} u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left(\frac{p_{ij1}}{P_1}\right)^{-\theta}\frac{p_{ij1}}{P_1}.$$

The labor cost is

$$u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left(\frac{p_{ij1}}{P_1}\right)^{-\theta}.$$

The optimal choice is given by

$$p_{ij1} = E_1[P_1^{\theta}]/E_1[P_1^{\theta-1}]$$

and the resulting profits are

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)(E_1P_1^{\theta})^{1-\theta}(E_1P_1^{\theta-1})^{\theta}. \tag{41}$$

The household Euler equation and optimality by the measure 1 of informed producers implies

$$\frac{1}{P_1}=\hat{E}_1\left(\frac{1}{P_2}\right)=\hat{E}_1\left(\frac{1}{P_3}\right), \tag{42}$$

where $\hat{E}_1$ is the expectation conditional on receiving both the free and the costly signal in period 1, and the last equality follows from the law of iterated expectations, which applies no matter what information choices will be made in period 2. We thus obtain the expected profit for the producer who chooses to be uninformed by substituting (42) into (41). Note that the $\hat{E}_1$ information is summarized by the posterior mean $\hat{\mu}_1$ for G_3. We thus express P_1 as a function of $\hat{\mu}_1$, using equation (42), and then substitute the resulting expression in (41). This requires us to know the distribution of $\hat{\mu}_1$ conditional on μ_1, which is the posterior mean based on the free information alone. We have

$$\hat{\mu}_1=\frac{\tau\mu+\tau_s s_1+\tau_c s_1^c}{\tau+\tau_s+\tau_c}=\frac{(\tau+\tau_s)\mu_1+\tau_c s_1^c}{\tau+\tau_s+\tau_c}=\frac{(\tau+\tau_s)\mu_1+\tau_c(G_3+\epsilon_1^c)}{\tau+\tau_s+\tau_c},$$

where μ is the prior mean and ϵ_1^c is the error in the signal s_1^c. We will follow similar notation for the errors of other signals. We also have $E_1G_3=\mu_1$ and $E_1\epsilon_1^c=0$, which implies $E_1(\hat{\mu}_1)=\mu_1$. Furthermore, $\mathrm{Var}_1(G_3)=(\tau+\tau_s)^{-1}$ and $\mathrm{Var}_1(\epsilon_1^c)=1/\tau_c$, with the two random variables uncorrelated. Therefore $\hat{\mu}_1$ is conditionally normally distributed with mean μ_1 and variance

$$\frac{\tau_c^2}{(\tau+\tau_s+\tau_c)^2}\left[\frac{1}{\tau+\tau_s}+\frac{1}{\tau_c}\right]=\frac{\tau_c}{(\tau+\tau_s+\tau_c)(\tau+\tau_s)}.$$

Armed with this, we can (numerically) evaluate the expression in (41). Everybody becoming informed is an equilibrium in the region in which

$$(E_1P_1^{\theta})^{1-\theta}(E_1P_1^{\theta-1})^{\theta}<1-k.$$

C.2 Computation of region where nobody becoming informed is an equilibrium

Unlike the previous section, a unilateral deviation now carries consequences in both periods. As usual, we assume that a single producer is atomistic and her individual choices do not reveal information to the others.

We need to compute the benefit of acquiring information in period 1 separately for the choices of acquiring information in period 1 and period 2.

Benefits accruing in period 1. A producer who acquires extra information is better informed than the shopper, so the envelope condition will not hold for her and it matters when the shopper consumes the extra revenues. In line with what we assumed for period 2 in Section 4, we assume that no extra revenues are consumed in period 1, but rather they are carried over to the future and consumed in periods 2 and 3 so as to keep marginal utility constant across periods. This choice means that $\frac{1}{1+\beta}$ will be spent in period 2 and $\frac{\beta}{1+\beta}$ will be carried over in period 3 so as to spend an extra $\frac{1}{1+\beta}$ in that period as well.

The informed producer problem becomes

$$\max_{p_{ij1}} u'^{-1}\left(\frac{\theta}{\theta-1}\right) P_1^{\theta}\left[\frac{\theta}{\theta-1}p_{ij1}^{1-\theta}\hat{E}_1\left(\frac{1}{(1+\beta)P_2}+\frac{\beta}{(1+\beta)P_3}\right)-p_{ij1}^{-\theta}\right].$$

Notice that P_1 is in the information set in this case, so it can be taken out of the expectation. The optimal price is

$$p_{ij1}=\left[\hat{E}_1\left(\frac{\bar{\pi}}{(1+\beta)P_2}+\frac{\beta\bar{\pi}^2}{(1+\beta)P_3}\right)\right]^{-1}$$

and the resulting profits are

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right) P_1^{\theta}\left[\hat{E}_1\left(\frac{1}{(1+\beta)P_2}+\frac{\beta}{(1+\beta)P_3}\right)\right]^{\theta}. \tag{43}$$

We break the expectations in equation (43) into parts. First, we examine $\hat{E}_1(1/P_3)$. P_3 is a function of G_3, so this expectation is driven by the distribution of G_3 conditional on the $\hat{E}_1$ information.[2] This expectation is a normal distribution with mean $\hat{\mu}_1$ and precision $\tau + \tau_s + \tau_s^c$. Next, P_2 is a function of the freely available information in period 2 if others do not acquire information in period 2 or it is equal to P_3 otherwise. To compute this expectation, we need the joint distribution of the posterior μ_2 and G_3 conditional on the $\hat{E}_1$ information, where μ_2 is the expectation of G_3 conditional on freely available signals as of period 2.[3]

We have

$$\mu_2 = \frac{\tau\mu + \tau_s(s_1 + s_2)}{\tau + 2\tau_s} = \frac{(\tau + \tau_s)\mu_1 + \tau_s s_2}{\tau + 2\tau_s} = \frac{(\tau + \tau_s)\mu_1 + \tau_s(G_3 + \epsilon_2)}{\tau + 2\tau_s}.$$

μ_1 is in the $\hat{E}_1$ information set. We then have

$$\hat{E}_1\mu_2 = \frac{(\tau + \tau_s)\mu_1 + \tau_s\hat{\mu}_1}{\tau + 2\tau_s}$$

and

$$\widehat{\mathrm{Var}}_1\mu_2 = \frac{\tau_s(\tau + 2\tau_s + \tau_c)}{(\tau + 2\tau_s)^2(\tau + \tau_s + \tau_c)}$$

and finally

$$\widehat{\mathrm{Cov}}_1(\mu_2, G_3) = \frac{\tau_s}{(\tau + 2\tau_s)(\tau + \tau_s + \tau_c)}.$$

To compute the expectation, we need to select which equilibrium will prevail in period 2 in the region of multiple equilibria. We choose the equilibrium in which producers remain uninformed as long as possible, which is the Pareto-dominant equilibrium. Letting $\bar{\mu}_2$ be the threshold at which producers choose to become informed, P_2 is thus a function of μ_2 if $\mu_2 < \bar{\mu}_2$, and is otherwise equal to P_3. The expected profits from information acquisition accruing in

[2]With some abuse of language, we use "$\hat{E}_1$ " information to mean the information filtration available to agents that compute $\hat{E}_1$.

[3]Here and thoughout these notes we take advantage of the fact that all relevant distributions are normal and all second moments are independent of the realization of the signals, so the entire distribution is characterized by the conditional means as functions of the relevant information and of the conditional second moments that are not functions of the realizations of the signals.

period 1 are

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)P_1^{\theta}E_1\left\{\left[\hat{E}_1\left(\frac{1}{(1+\beta)P_2}+\frac{\beta}{(1+\beta)P_3}\right)\right]^{\theta}\right\}. \tag{44}$$

Benefits accruing in period 2. Next, we compute the benefit that the agent acquiring information unilaterally in period 1 accrues in period 2. There are two regions. First, consider the region in which other agents acquire information in period 2. Except for the different information set (corresponding to a different conditional variance of G_3), this computation is identical to the one performed by an agent who chooses whether to acquire information in period 2 when all other agents are acquiring it. The extra profits compared to the other agents are given by

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)\max\left\{0, K+\hat{E}_2\left[P_3^{\theta}\right]^{1-\theta}\left[\hat{E}_2 P_3^{\theta-1}\right]^{\theta}-1\right\}, \tag{45}$$

where $\hat{E}_2$ denotes the expectation conditional on the freely available signals in periods 1 and 2 and on the costly signal in period 1.

The first piece of Equation (45) applies when the agent chooses to acquire information again in period 2, in which case she makes the same profits as everybody else; in the second piece, the agent chooses not to acquire information in period 2, thereby remaining less well informed than everybody else, but saving the cost of information K in period 2. This region above applies whenever μ_2 exceeds the information threshold $\bar{\mu}_2$ in the case in which (almost) no agent became informed in period 1. Below this region, other agents do not pay information costs in period 2. If the agent who acquired information in period 1 does not acquire information in period 2, her problem is

$$\max_{p_{ij2}} u'^{-1}\left(\frac{\theta}{\theta-1}\right)P_2^{\theta}\left[\frac{\theta}{\theta-1}p_{ij2}^{1-\theta}\hat{E}_2\left(\frac{1}{P_3}\right)-p_{ij2}^{-\theta}\right],$$

which is solved by

$$p_{ij2}=\left[\hat{E}_2\left(\frac{1}{P_3}\right)\right]^{-1}$$

yielding expected profits

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)P_2^{\theta}\left[\hat{E}_2\left(\frac{1}{P_3}\right)\right]^{\theta}.$$

If the producer chooses to acquire information, the problem is the same as before, except that now she has perfect information about G_3, so she chooses $p_{ij2} = P_3$ and makes profits

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left(\frac{P_2}{P_3}\right)^{\theta}.$$

In computing the extra profits, it is important to note that in this case the expected profits that others are reaping conditional on the information that the producer who acquired information in period 1 has are not

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right),$$

but rather

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left[\theta P_2\hat{E}_2(P_3^{-1})-1\right].$$

Putting all of this together, when others choose not to acquire information in period 2 (after not acquiring it in period 1), the extra profits accruing to an agent who acquired information in period 1 are (in expected terms conditional on the information available prior to acquiring costly information in period 2)

$$\frac{1}{\theta-1}u'^{-1}\left(\frac{\theta}{\theta-1}\right)\left[\theta\left(1-P_2\hat{E}_2\left(P_3^{-1}\right)\right)-1+\max\left\{P_2^{\theta}\hat{E}_2(P_3^{-\theta})-K,P_2^{\theta}\left(\hat{E}_2(P_3^{-1})\right)^{\theta}\right\}\right]. \tag{46}$$

The final step to compute the threshold $\bar{\mu}_1$ above which it is optimal for the agent to unilaterally deviate and acquire information in period 1 even when others do not is to compute the expected value of the extra profits in period 2 conditional on the freely available information in period 1. Analyzing equations (45) and (46), this last step requires the join distribution of $\hat{\mu}_2 = \hat{E}_2(G_3)$ and $\mu_2 = E_2(G_3)$ conditional on μ_1.

We have

$$\hat{\mu}_2 = \frac{(\tau + \tau_s)\mu_1 + (\tau_s + \tau_c)G_3 + \tau_s\epsilon_2 + \tau_c\epsilon_c}{\tau + 2\tau_s + \tau_c}.$$

This implies

$$E_1(\hat{\mu}_2) = \mu_1$$

and

$$\mathrm{Var}_1(\hat{\mu}_2) = (\tau + 2\tau_s + \tau_c)^{-2}\left[(\tau_s + \tau_c)^2\mathrm{Var}_1(G_3) + \tau_s + \tau_c\right].$$

Similarly,

$$\mu_2 = \frac{(\tau + \tau_s)\mu_1 + \tau_s G_3 + \tau_s\epsilon_2}{\tau + 2\tau_s},$$

$$E_1(\mu_2) = \mu_1$$

and

$$\mathrm{Var}_1(\mu_2) = (\tau + 2\tau_s)^{-2}\left[\tau_s^2\mathrm{Var}_1(G_3) + \tau_s\right].$$

Finally,

$$\mathrm{Cov}_1(\mu_2, \hat{\mu}_2) = \frac{1}{(\tau + 2\tau_s)(\tau + 2\tau_s + \tau_c)}\left[\tau_s(\tau_s + \tau_c)\mathrm{Var}_1(G_3) + \tau_s\right].$$