Controlling inflation with central bank communication*

Nikolaos Kokonas[†], Michalis Rousakis[‡] and Efthymios Smyrniotis[§]

July 10, 2023

Abstract

What determines the stochastic path of inflation? We study this question in a monetary economy featuring imperfect information and rational expectations. The central bank follows an inflation targeting rule and communicates noisy information about the future state of the economy to market participants through its public forecasts of inflation and output. Agents update their beliefs in a Bayesian way and infer the central bank's noisy signal. Through this mechanism, the central bank's forecasts shape market expectations of economic conditions, imposing additional restrictions on the equilibrium and ultimately determining the stochastic path of inflation. Importantly, in the absence of explicit guidance provided by public forecasts, the central bank loses control over its main target under the inflation targeting policy.

Keywords: determinacy, monetary policy, public information
JEL Classification: E31, E32, E52,

*We thank Niki Anesti, Ricardo Reis, Herakles Polemarchakis, Bassel Tarbush, Kostas Mavromatis, Jose David Garcia Revelo, Paulo Santos Monteiro, Tai-Wei Hu and seminar participants at NIESR, the University of Crete, the University of Southampton, the University of Bath, King's College London, De La Salle University, the RES 2019 conference, and the T2M 2022 conference for helpful comments. The views here are those of the authors, not necessarily those of Bank of America.

[†]University of Bath, n.kokonas@bath.ac.uk.
[‡]Bank of America, michalis.rousakis@bofa.com
[§]University of Bristol, e.smyrniotis@bristol.ac.uk

1 Introduction

The recent global rise in inflation has sparked an interesting debate among academics and policy-makers regarding its causes and the extent of monetary policy tightening needed to control inflation. One explanation of why central banks delayed their reaction to prevent the burst in inflation, was the belief that inflation expectations were firmly anchored and the rise in inflation would be temporary. However, recent data suggests that expectations were not so well-anchored, with a rising share of households expecting inflation to be higher in the future (Reis, 2022).

The paper demonstrates that releases of public information, in the form of central bank forecasts regarding inflation and output, provide information to market participants about the state of the economy that is essential to control the stochastic path of inflation. By treating the determination of the stochastic path of inflation as a signal-extraction problem, we emphasise the significance of central bank communication as an important policy tool to control inflation. Importantly, we show that without additional explicit guidance on the future path of the economy, conventional inflation targeting policies allow agents' expectations about the future state of the economy to arbitrarily influence the equilibrium path of inflation. As a result, the central bank loses control over its main target.

The model relies on three key elements. Firstly, the state of the economy is determined by productivity, which includes a permanent component that follows an AR(1) process and a temporary component that is independently and identically distributed. Secondly, the central bank adopts an expected inflation targeting rule and receives noisy signals about the future movements of the temporary component of productivity. Thirdly, the economy consists of a representative consumer/worker and a representative producer. Consumers learn about current productivity, but they are physically separated from producers during production decisions, leading to fluctuations driven by the producer's expectational error in prices.

In our framework, the determination of the stochastic path inflation can be understood through the stochastic Fisher equation, which connects the real and nominal interest rates with inflation rates across states of the world. Interest rate setting, allowing even for endogenous feedback rules, does not suffice to pin down the distribution of inflation rates across states of the world. Additionally, when combined with the supply equation of the model, it also leaves the distribution of output arbitrary. Indeterminacy in our framework derives from the inability of arbitrage and interest rate setting (linked together through the Fisher equation) to pin down the distribution of inflation rates, and it is not related to the stability of steady state.[1]

[1] In fact, Castillo-Martinez and Reis (2019), in a review of the relevant literature, distinguish between models where

We study linear and stationary equilibria, where the dynamics of inflation and output depend on realised productivity and the heterogenous expectations of economic agents regarding the state of the economy. These expectations are represented by the producer's expectation of productivity due to information asymmetries and the consumer's expectation of the permanent component, which provides the most accurate estimate of future overall economic activity. Accounting for heterogeneous expectational terms in describing aggregate dynamics is appropriate in the context of central bank communication aimed at influencing market expectations of economic conditions. By focusing on linear solutions and making use of standard assumptions on preferences and shock distributions, we can express the agents' optimality conditions in a linear form, which includes second-order terms. We then substitute linear conjectures into these optimality conditions to solve for rational expectations equilibria.

Without public communication, we show that the equilibrium paths of inflation and output are influenced arbitrarily by the consumer's forecast error, defined as the difference between realised productivity and the consumer's expectations regarding the permanent component based on past observations. Arbitrage and interest rate setting does not add sufficient equilibrium restrictions to pin down uniquely the distributions of inflation and output, which are described by their first and second moments. Without explicit announcements that can influence agents' beliefs about economic fundamentals, monetary policy actions implemented through the feedback interest rate rule cannot prevent the emergence of inefficient, endogenous fluctuations.

Central bank communication has the power to shape market expectations regarding the future state of the economy and, combined with interest rate setting, can effectively control the stochastic path of inflation and output. By providing explicit guidance through announcements of the central bank's one-step-ahead forecasts – expected values – of either inflation or output (both lead to the same outcome), agents can deduce the central bank's noisy signal about future temporary changes in productivity. Through Bayesian updating, this additional information imposes additional equilibrium constraints (equations) that uniquely determine the paths of inflation and output. In an extension of the model, we consider more general forms of linear equilibria, which depend on agents' expectations of the state of the economy over finite future horizons. We demonstrate that achieving determinacy of equilibrium requires explicit guidance through central bank announcements that

arbitrage and interest rate pegs do not suffice to pin down the stochastic path of inflation, and models where arbitrage together with feedback rules and, crucially, an "elusive" terminal condition on inflation, suffice to pin down the price level (as in the canonical New Keynesian model). Lubik et al. (2023) showed that the introduction of information asymmetries into a broad class of linear models can generate stable dynamics driven by self-fulfilling beliefs. Our approach, combining arbitrage and feedback interest rate rules but without restricting equilibrium dynamics in a neighbourhood around a steady state, emphasise the role of public information in determining the stochastic path of inflation and the price level.

include longer forecasting horizons, expanding upon the previous argument.

The empirical literature has demonstrated that central banks have additional information about inflation beyond what is known to market participants, and that policy actions can modify market participants' forecasts (Romer and Romer, 2000). Furthermore, Gurkaynak et al. (2005) have shown that the Fed signals not only through its actions, but also through its statements, implying that Fed signals incorporate forward guidance and include information about different shocks, and Nakamura and Steinsson (2018) showed that monetary policy shocks transmit information about fundamentals that affect market expectation of economic conditions, termed as the information effect by Romer and Romer (2000). Our theoretical results – in the spirit of the information effect literature – highlight another channel, where central bank forecasts, through the modification of agents' expectations about the likely path of the economy, determine the stochastic path of inflation and output.[2]

Our findings provide three policy insights. Firstly, employing "simple" communication strategies, such as one-step-ahead forecasts, is sufficient to determine the distributions of inflation and output at equilibrium, without the need for additional information about risk and uncertainty around economic conditions.[3] Secondly, public information has social value in our framework as it prevents the emergence of inefficient fluctuations driven by arbitrary market beliefs, regardless of the precision of the public signals. Finally, certain communication policies are ineffective and fail to restore uniqueness. This occurs when signals only provide noisy information about future shocks to the permanent component process. Policymakers should avoid conveying information to the market about variables that agents can gradually learn by observing past and current realisations of the state of the economy.

1.1 Related Literature

Our paper contributes to the vast and important literature on indeterminacy of monetary equilibria. A non-extensive list of contributions includes Sargent and Wallace (1975), McCallum (1981), Sims (1994), Woodford (1994), Clarida et al. (2000), Cochrane (2011), Hall and Reis (2016), Angeletos and Lian (2021), amongst others. Castillo-Martinez and Reis (2019) provide an insightful review of the literature. It is worth emphasising once more that our indeterminacy results do not derive from

[2]Recent empirical work, see, for example, Jain and Sutherland (2020), argues that central bank projections, especially projections about expected inflation, provide additional information to market participants and manage to modify their forecasts.

[3]However, we should point out that Hansen et al. (2019) show that news on economic uncertainty have large effects on the yield curve, a channel that we abstract from in this paper. Our results point to the fact that communication strategies in levels suffice to pin down second moments of aggregate variables at equilibrium.

the stability of steady state or even the infinity of the horizon. In contrasts, our work relates closely to Nakajima and Polemarchakis (2005), who showed that in finite or infinite horizon stochastic monetary economies, and under "Ricardian" fiscal policy, interest rate or money supply rules cannot pin down the distribution of inflation rates across states of the world. In that context, Adao et al. (2014) and Magill and Quinzii (2014) showed that fixing the term structure of interest rates determines the path of inflation, while McMahon et al. (2018) emphasised the importance of credit easing policies in controlling inflation. We expand this line of research by treating the determination of the stochastic path of inflation as a signal-extraction problem, and show that public communication of noisy information, in the form of central bank's forecasts about the likely future movements of macroeconomic variables, is essential to control the path of inflation. Notably, in our framework, fiscal policy does not impose additional constraints to determine the path of inflation and the price level. Thus, our analysis focuses on the effectiveness of public communication in controlling inflation and the price level.

Our paper also relates to the important literature on the social value of public information. The seminal work of Morris and Shin (2002, 2005) argued that the welfare effects of increased public information is ambiguous in environments featuring strategic complementarities between agents' actions; while Woodford (2005) and Svensson (2006) provided a critical assessment of the anti-transparency result in Morris and Shin (2002).[4] Our approach abstracts from strategic interactions and the resulting externality that arises when individuals are trying to second-guess the actions of others.[5] Public information in our model is beneficial as it changes market expectations about economic fundamentals, adding additional equilibrium restrictions that determine the paths of inflation and output, and effectively preventing the emergence of inefficient fluctuations driven by beliefs. However, our framework remains silent regarding how precise public signals should be; as argued by the literature, this would require careful consideration of agents' interactions.[6]

Bassetto (2019) studies a game of cheap talk between a central bank and an agent in a Barro-Gordon framework, sidestepping the issue of inflation determinacy, and finds that information transmission is possible at equilibrium. We abstract from the intricacies arising from cheap talk,

[4] Angeletos and Pavan (2004), Hellwig (2005), and Cornand and Heinemann (2008) extended the Morris and Shin set up in various directions and showed that more public information increases welfare, while Angeletos and Pavan (2007) analysed the social value of public information in a general class of economies featuring a coordination motive due to strategic complementarities or substitutes, externalities, and heterogenous information.

[5] For the same reason, our paper differs from the literature that incorporates strategic interactions and imperfect common knowledge into monetary models (see Woodford, 2001; Hellwig, 2005; Adam, 2007; Lorenzoni, 2010, among others).

[6] There exist also literature that studies the social value of information in economies with incomplete asset markets. In that context, public information reduces the possibilities of sharing risk and hence, it may be welfare impairing (Gottardi and Rahi, 2014). Our representative agent framework allows us to abstract from the risk sharing channel.

without questioning the credibility of the central bank to reveal its information truthfully, and instead, show the importance of the value of public information in controlling inflation and output.

Lastly, in the tradition of Phelps (1970) and Lucas (1972), the model features lags in informational adjustment between the representative consumer and producer, in turn, giving rise to a Philips curve relationship, and allowing the emergence of suboptimal belief-driven fluctuations in the absence of explicit guidance by the central bank.[7]

The rest of the paper is organised as follows. Section 2 presents the model. Section 3 characterises equilibrium without the release of public information, and section 4 allows for releases of public information from the central bank. Section 5 allows for more general forms of linear equilibria, and section 6 concludes.

2 Model

2.1 Set-up

Time is discrete and infinite with each period denoted by $t = 0, 1, ...$ The economy is populated by a representative consumer/worker, a representative firm and the central bank. The household supplies labor to the firm, trades one-period nominal bonds in zero net supply and consumes a single non-storable good. Consumer preferences are represented by the utility function

$$E\left[\sum_{t=0}^{\infty}\beta^t\left(\log\left(C_t\right)-\frac{N_t^{1+\zeta}}{1+\zeta}\right)\right], \tag{1}$$

where C_t denotes consumption and N_t denotes labor supply at period t. The parameter $\zeta > 0$ is the inverse of Frisch elasticity of labor supply and $\beta \in (0, 1)$ is the discount factor. The consumer faces a sequence of budget constraints:

$$P_tC_t + Q_tB_{t+1} = B_t + W_tN_t + \Psi_t,\ t = 0, 1, ... \tag{2}$$

where P_t denotes commodity prices, B_{t+1} denotes holdings of nominal bonds purchased at period t and maturing at $t + 1$, Q_t denotes the nominal bond price, W_t denotes the nominal wage and Ψ_t denotes the firm's nominal profits. The firm's technology and profits are given respectively by:

$$Y_t = A_tN_t \tag{3}$$

[7] See also Mankiw and Reis (2002), Reis (2006), Lorenzoni (2009, 2010), La'O and Angeletos (2011), among others, for alternative models where lags in informational adjustment give rise to nominal rigidities.

$$\Psi_t = P_t Y_t - W_t N_t, \tag{4}$$

where Y_t is aggregate output and A_t denotes productivity. The Central bank targets expected inflation and sets the nominal bond price according to the following rule:

$$Q_t = E_t\big[\Pi_{t+1}\big]^{-\phi}, \tag{5}$$

where $\phi > 0$, $\Pi_t \equiv P_t/P_{t-1}$ is the rate of inflation between $t-1$ and t, and E denotes the expectation operator with respect to the consumer's information set (see details below).

2.2 Shocks and Signals

Let $a_t = \log(A_t)$ and define similarly any lowercase variable henceforth. Aggregate productivity consists of a permanent component, x_t, and a temporary component, ϵ_t:

$$a_t = \log(A_t) = x_t + \epsilon_t \quad \text{with} \quad \epsilon_t \sim N(0, \sigma_\epsilon^2).$$

The household observes a_t but not its decomposition. The permanent component of aggregate productivity follows an AR(1) process:

$$x_t = \rho x_{t-1} + e_t \quad \text{with} \quad e_t \sim N(0, \sigma_e^2), \quad \rho \in (0, 1].$$

At each date t, the central bank receives noisy signals about the temporary component of productivity next period:

$$s_t = \epsilon_{t+1} + u_{t+1} \quad \text{with} \quad u_{t+1} \sim N(0, \sigma_u^2).$$

The noise term, u_t, and shocks, e_t, ϵ_t, are mutually independent and serially uncorrelated.

2.3 Timing and information

Each period is divided in two stages: labor decisions are made in stage 1, while consumption/savings decisions are made in stage 2. All payments materialise in stage 2 and are perfectly enforceable.

In stage 1, the consumer learns a_t and the central bank receives a noisy signal s_t that communicates to all agents. At the same time, the consumer/worker decides on her labour supply and production takes place. We assume that the producer and the consumer are physically separated at the time production takes place, and the representative producer, taking prices as given, forms expectations about a_t (and as a consequence of P_t) to maximise expected profits (as we discussed in detail below).[8]

In stage 2, the Central Bank sets the nominal interest rate (which is the inverse of the bond price Q) according to the targeting rule (5), and commodity and bonds markets open. The consumer decides on her consumption/saving decisions at the given prices. With production pre-determined from stage 1, the good's price adjust to clear the good's market and the bonds market clears residually. All agents learn a_t, but the permanent component, x_t, remains unobserved.

Let the information of agent i, with $i \in \{p, c\}$ denoting respectively the producer and consumer, be denoted by $I^i_{t,s}$ with $s \in \{1, 2\}$ denoting the stage within a given period t. Throughout the analysis, we characterise equilibrium under the case of no public communication and the case where the central bank releases public signals s_t at evert date.

The information sets of agents in the absence of public signals are given by

$$I^c_t = \{a_0, a_1, ..., a_{t-1}, a_t\}\,,\ I^p_{t,1} = \{a_0, a_1, ..., a_{t-1}\}\,,\ I^c_t = I^p_{t,2} \tag{6}$$

and in the presence of public signals are given by

$$I^c_t = \{a_0, a_1, .., a_{t-1}, a_t, s_{-1}, s_0, s_1, .., s_t\}\,,\ I^p_{t,1}\,\{a_0, a_1, .., a_{t-1}, s_{-1}, s_0, s_1, .., s_t\}\,,\ I^c_t = I^p_{t,2}; \tag{7}$$

and following our convention regarding the arrival of noisy information, we assume that the central bank is endowed with a noisy signal s_{-1} at date zero. All agents information sets at $(t, 2)$ are common since producers learn current productivity at stage 2. As a result, the central bank targets expected inflation in (5) using the agents' common information set at stage $(t, 2)$. However, when we construct endogenous signals below, in the form of central bank forecasts about the likely movements of future macroeconomic variables, we use the least informed agent's information set in our construction, namely, the producer's information set at $(t, 1)$. This is done to ensure that central bank announcements do not undo the producer's informational restrictions and allow the producer to learn productivity at the time of the production decisions.

With slight abuse of notation we denote the expectation of agent $i \in \{p, c\}$ at date t and stage s, conditional on their information set $I^i_{t,s}$, with $E^i_{t,s}[.] \equiv E^i_{t,s}[.|I^i_{t,s}]$. As we explain in detail below, we focus on linear equilibria where the stochastic paths of inflation and output depend on agents' expectation about the permanent component of productivity, x, and on the current productivity, a.

[8]The producer can not infer a_t upon observing the nominal wage due to linearity in production that requires the equilibrium wage to be independent of the amount of labor. Alternatively, we could assume decreasing returns in production and introduce idiosyncratic shocks to labour supply to get a similar result.

In turn, agents use past and current realisations of observables to update their information about x recursively through the use of the Kalman filter. Specifically, the consumer's estimate about x_t is given by

$$E_t^c[x_t] = E_{t-1}^c[x_t] + \mu\left(a_t - a_{t|t-1}\right),$$

where μ is a constant that depends on the variance parameters and $a - a_{t|t-1}$ is the gain in information upon observing a_t, with prior mean given by $a_{t|t-1} \equiv E_{t-1}^c[a_t] = E_{t-1}^c[x_t] + \kappa s_{t-1}$, where κ depends on variance parameters as well.[9] The producer does not observe the current realisation of a at $(t,1)$, and as a consequence, their estimate about x_t is given by

$$E_{t,1}^p[x_t] = E_{t-1}^c[x_t],$$

which coincides with the consumer's estimate of x_t at the end of $t-1$. Furthermore, upon observing public signals at each date, the consumer and the producer update beliefs about aggregate productivity, a, as follows:

$$E_t^c[a_{t+1}] = \rho E_t^c[x_t] + \kappa s_t, \tag{8}$$

$$E_{t,1}^p[a_{t+\tau}] = \rho^\tau E_t^p[x_t] + \kappa s_{t+\tau-1}, \quad \tau = 0, 1. \tag{9}$$

2.4 Equilibrium and Optimality Conditions

A rational expectations equilibrium under the interest rate rule (5) is given by a collection of prices, $\{P_t, W_t, Q_t\}_{t=0}^\infty$, and allocations, $\{C_t, B_t, N_t, Y_t\}_{t=0}^\infty$, such that agents' decisions are optimal, at the stated prices, and markets clear, $Y_t = C_t$, $B_t = 0$, $\forall t$, with initial condition $B_0 = 0$.

In the rest of this section, we describe in detail each agents' optimal decision problem. The consumer maximises expected, discounted utility (1), subject to the sequence of flow budget constraints (2), and the usual natural debt limit on borrowing. Optimality conditions are

$$N_t^\zeta = \frac{W_t}{P_t C_t} \tag{10}$$

$$Q_t = \beta E_t^c\left[\frac{1}{\Pi_{t+1}}\frac{C_t}{C_{t+1}}\right], \tag{11}$$

where (10) is the intratemporal optimality condition that equates the real wage in terms of consumption units to the marginal disutility of labor, and (11) is the standard Euler equation.

Given that the producer does not observe a_t at the time production decisions take place (although

[9] See Appendix A for detailed derivations.

they might receive a noisy, public signal about productivity), they maximise expected profits, $E^p_{t,1}[\lambda_t \Psi_t]$, evaluated using the consumer's/owner's marginal utility of wealth, $\lambda_t = (P_t C_t)^{-1}$, as the appropriate discount rate.[10] The optimality condition reduces to

$$W_t = \frac{E^p_{t,1}[\lambda_t P_t A_t]}{E^p_{t,1}[\lambda_t]}. \tag{12}$$

Due to linearity in technology, the firm accommodates any labour supplied at the given wage as long as expected profits are zero (realised profits are typically not zero since the real wage is not equal to productivity). Optimality conditions (10) and (12) are consistent with a wedge between the marginal product of labour and the marginal rate of substitution between consumption and leisure.[11]

3 Linear equilibria

The assumption of separable, isoelastic preferences and Gaussian shocks allows us to derive linear rational expectations equilibria in closed form. We postulate linear rules for the paths of inflation and output as function of shocks, and then substitute our linear conjectures into the agent's optimality conditions to solve for rational expectations equilibria. Importantly, we show that in a linear equilibrium the agents optimality conditions can be written in a linear form.[12]

Firstly, we discuss all our key results in the benchmark environment of symmetric information, where classical dichotomy applies and monetary policy has no real effects; and subsequently, we proceed to characterise the case of asymmetric information, where communication allows the central bank to stabilise the economy from inefficient, endogenous fluctuations.

3.1 Symmetric information

Under the symmetric information benchmark, all agents in the economy observe current productivity a_t at each date t; however, no agent observes the permanent component of productivity, x_t. Due to informational symmetry, we drop the superscripts from agents' expectations. In particular, under

[10] Observe that the consumer/owner Lagrange multiplier reveals perfectly a_t. However, as we discussed above, we assume that the consumer and the producer are separated at the time production decisions take place, which allow us to abstract from the "Lucas-Phelps" islands framework and consider only one "island" in its place. Furthermore, by maximising the firm's profits evaluated with the consumer's Lagrange multiplier, the producer operates the firm in the way the consumer/owner would want her to (Magill and Quinzii, 1996).

[11] An alternative interpretation of (12) is that nominal wages at the beginning of every date t are preset and equal to an expected value of productivity, thus, informational frictions give rise to nominal wage rigidities.

[12] Our computational methodology is similar to Lorenzoni (2010), albeit in an environment that abstracts from strategic interactions and dispersed information across many islands.

the symmetric benchmark, the real wage is equal to productivity, that is, in logs, $w_t - p_t = a_t$, and combining with market clearing, $y_t = c_t$, technology, $y_t = a_t + n_t$, and intratemporal optimality, $\zeta n_t = w_t - p_t - c_t$, all expressed in logs, yields

$$n_t = 0, \; y_t = a_t, \tag{13}$$

where the equilibrium labor supply is constant and independent of productivity due to offsetting income and substitution effect (as a result of log-utility in consumption), and output is determined by the exogenous process that governs aggregate productivity.

We focus on linear, stationary rational expectations equilibria of the following form:

$$\pi_t = \xi_0 + \xi_1 a_{t-1} + \xi_2 a_t + \xi_3 E_t[x_t], \; t = 0, 1, .. \tag{14}$$

where a_{-1} is given at date zero. In turn, realised inflation at date t is a function of past and current realisations of aggregate activity, a_{t-1} and a_t, and of agents' expectations about the permanent component of productivity, $E_t[x_t]$, which, in turn, give the best estimate about aggregate activity next period. Augmenting linear conjectures with agents' expectations about future productivity is appropriate in the context of central bank communication, which aims to affect market expectations and, as we show, determine the stochastic path of inflation. The coefficients $\{\xi_0, \xi_1, \xi_2, \xi_3\}$ are to be determined.

In a linear equilibrium, we show that combining the interest rate rule (5) and agents' Euler equation (11), together with market clearing, yields

$$E_t[a_{t+1}] - a_t = (\phi - 1) E_t[\pi_{t+1}] + \kappa_c, \tag{15}$$

where κ_c includes second-order terms, and as we show in Appendix B, it is a quadratic function of coefficients $\{\xi_2, \xi_3\}$. Equilibrium condition (15) represents the stochastic Fisher equation that fully characterises equilibrium under the symmetric benchmark.[13]

Taking expectations of π_{t+1} as of date t, and assuming that there is no transmission of public information, yields

$$E_t[\pi_{t+1}] = \xi_0 + \xi_1 a_t + (\xi_2 + \xi_3) E_t[x_{t+1}], \tag{16}$$

where $E_t[E_{t+1}[x_{t+1}]] = E_t[x_{t+1}]$ and, importantly, $E_t[a_{t+1}] = E_t[x_{t+1}]$ without the release of noisy

[13] Note that we are not using first-order local approximations around a steady state to characterise equilibria, but rather transform the non-linear optimality conditions into a linear form, exploiting the assumptions made on preferences and the distribution of shocks, and the focus on linear solutions for inflation.

public signals. The key observation is that as of date t, the one-step-period ahead forecast of aggregate productivity coincides with the one-step-ahead forecast of its permanent component, i.e., $E_t[a_{t+1}] = E_t[x_{t+1}]$. Substituting (16) into (15) and matching coefficients yields

$$\xi_0 = -\frac{\kappa_c}{\phi - 1}, \quad \xi_1 = -\frac{1}{\phi - 1} \quad \text{and} \quad \xi_2 + \xi_3 = \frac{1}{\phi - 1}, \tag{17}$$

which shows that the equilibrium system introduces three independent restrictions to pin down four unknowns (coefficients). In turn, substituting (17) into (14), taking into account that $E_t[x_t] = (1 - \mu)E_{t-1}[x_t] + \mu a_t$, yields

$$\pi_t = -\frac{\kappa_c (\xi_3)}{\phi - 1} + \frac{1}{\phi - 1}(a_t - a_{t-1}) + \xi_3(1 - \mu)(E_{t-1}[x_t] - a_t). \tag{18}$$

It follows that the distribution of inflation, including first and second moments, depends arbitrarily on ξ_3, as the latter coefficient affects arbitrarily realised inflation at each date t through the intercept term, ξ_0, and the agents' forecast error about a_t. At each date t, the agents' forecast error about future productivity affects arbitrarily the future realisations of inflation.

Notice that indeterminacy is purely nominal, since consumption and output are determined by the exogenous process that drives aggregate activity. Regardless, this example is enough to hint our key result. Noisy public signal releases about the temporary component of aggregate activity, ϵ, regardless of the signal precision (as long as it is bounded away from zero), transmit new information to market participants and add additional equilibrium restrictions, since $E_t[a_{t+1}] = E_t[x_{t+1}] + \kappa s_t \neq E_t[x_{t+1}]$, so that (16) modifies to

$$E_t[\pi_{t+1}] = \xi_0 + \xi_1 a_t + \xi_2 E_t[a_{t+1}] + \xi_3 E_t[x_{t+1}], \tag{19}$$

and matching coefficients once gain requires that $\xi_3 = 0$. To understand this, we match the coefficient of $E_t[x_{t+1}]$ in the right-hand side of (15) – once we substitute (19) into the Fisher equation –, which is given by ξ_3, with its coefficient in the left-hand side which is equal to zero, since the left-hand side depends only on $E_t[a_{t+1}]$, hence, we obtain $\xi_3 = 0$. As a result, the agents' expectations of the permanent component of aggregate productivity become irrelevant and do not affect realised inflation.

However, if the central bank's signals were to communicate only noisy information about shocks to the permanent component, e, then $E_t[a_{t+1}] = E_t[x_{t+1}]$ would still hold true, and the stochastic path of inflation would still depend arbitrarily on ξ_3, as (18) shows. In fact, the policy of transmitting public signals about shocks to the permanent, forecastable component of aggregate productivity is ineffective and cannot determine the distribution of inflation.

Central bank communication in our environment imposes additional equilibrium restrictions beyond the equilibrium restrictions already imposed by conventional monetary policy, allowing to control the stochastic path of inflation. The same result, as we show later on, can be achieved when the central bank communicates its one-step-ahead forecasts of inflation or output and agents are able to infer the central bank's noisy signal.

3.2 Asymmetric information

Let us proceed to characterise equilibrium when the producer does not observe aggregate productivity at the time production decisions take place. In that case, equilibrium of this economy is fully characterised by two equilibrium blocks, the Fisher equation, as in the symmetric benchmark, and a Philips curve relationship (PC), arising due to informational frictions. In terms of notation, we assume $E^p_{t,1}[\cdot] \equiv E^p_t[\cdot]$ for the remainder of the analysis.

We focus on linear rational expectations equilibria of the following form:

$$\pi_t \;=\; \xi_0 \,+\, \xi_1 a_{t-1} \,+\, \xi_2 E^c_{t-1}[x_{t-1}] \,+\, \xi_3 E^p_{t-1}[a_{t-1}] \,+\, \xi_4 a_t \,+\, \xi_5 E^c_t[x_t],\;\; t = 0, 1, ... \tag{20}$$

$$y_t \;=\; \theta_0 \,+\, \theta_1 a_t \,+\, \theta_2 E^p_t[a_t] \,+\, \theta_3 E^c_t[x_t],\;\; t = 0, 1, ..., \tag{21}$$

where $a_{-1}, E^c_{-1}[x_{-1}], E^p_{-1}[a_{-1}]$ are given at date zero. Inflation dynamics in (20) are augmented by two additional terms (highlighted in red) compared to (14), and (21) represents output dynamics. We postpone discussing the form of the linear rules in the case of asymmetric information until we introduce the Phillips curve.

Combining intratemporal optimality – expression (10) –, market clearing, technology, and the producer's optimality condition – expression (12) –, yields

$$(1+\zeta)y_t \;=\; E^p_t[a_t] + E^p_t[\pi_t] - \pi_t + \zeta a_t \,+\, \kappa_y, \tag{22}$$

which represents the PC relationship in the economy with informational frictions, and shows that aggregate fluctuations are driven by the producer's expectational error in prices, $E^p_t[\pi_t] - \pi_t$, as a result of informational frictions when production takes place.

The equilibrium under asymmetric information is fully characterised by the Fisher equation (FE) and the Phillips curve (PC):

$$(1+\zeta)y_t \;=\; E^p_t[a_t] + E^p_t[\pi_t] - \pi_t + \zeta a_t \,+\, \kappa_y, \tag{PC}$$

$$E_t[y_{t+1}] - y_t = (\phi - 1)E_t[\pi_{t+1}] + \kappa_c, \tag{FE}$$

where κ_c, κ_y are quadratic functions of coefficients $\{\theta_1, \theta_3, \xi_4, \xi_5\}$ (see Appendix B).

We proceed to the discussion of the linear rules (20),(21). Output dynamics are a function of current realisation of productivity, a, the producer's estimate of current productivity, $E_t^p[a_t]$, as it is immediate from (PC), and also of the consumer's estimate of the current long-run component, $E_t^c[x_t]$, since the producer's expectational error in prices, $E_t^p[\pi_t] - \pi_t$, is a function of the latter estimates. Finally, it follows from (FE) that expected inflation depends on current output, y_t, and thus, to construct an equilibrium we need to augment the dynamics of inflation in (20) with the lagged terms $E_{t-1}^c[x_{t-1}]$ and $E_{t-1}^p[a_{t-1}]$. To compute equilibrium, we substitute (20)-(21) into (PC) and (FE), and match coefficients.

More formally, we get the following result.

Proposition 1 *Without public communication, the stochastic path of inflation and output at equilibrium are given by*

$$\pi_t = -\frac{\kappa_c(\xi_5) - \frac{\kappa_y(\xi_5)}{1+\zeta}}{\phi - 1} + \frac{1}{\phi-1}\left(a_t - y_{t-1}(\xi_5)\right) + \xi_5(1-\mu)\left(E_{t-1}^c[x_t] - a_t\right), \ t = 0, 1, .., \tag{23}$$

$$(1+\zeta)y_t = \kappa_y(\xi_5) + a_t\left(\zeta - \frac{1}{\phi-1}\right) + E_t^p[a_t]\frac{\phi}{\phi-1} - \xi_5(1-\mu)\left(E_{t-1}^c[x_t] - a_t\right), \ t = 0, 1, .. \tag{24}$$

and ξ_5 cannot be determined by the equilibrium system.

Proof. In Appendix B, we solve for rational expectations equilibria and express coefficients of linear rules (20),(21) as functions of primitive and policy parameters, but also ξ_5. Specifically, we obtain

$$\theta_0 = \frac{\kappa_y(\xi_5)}{1+\zeta}, \ \theta_1 = \frac{\zeta - \frac{1}{\phi-1} + \xi_5}{1+\zeta}, \ \theta_2 = \frac{\phi}{(\phi-1)(1+\zeta)}, \ \theta_3 = -\frac{\xi_5}{1+\zeta}, \tag{25}$$

and

$$\xi_0 = -\frac{\kappa_c(\xi_5)}{\phi - 1}, \ \xi_1 = -\frac{\theta_1}{\phi-1}, \ \xi_2 = -\frac{\theta_3}{\phi-1}, \ \xi_3 = -\frac{\theta_2}{\phi-1}, \ \xi_4 + \xi_5 = \frac{1}{\phi-1}. \tag{26}$$

Substituting (25) into (21), and taking into account that $E_t^c[x_t] = (1-\mu)E_{t-1}^c[x_t] + \mu a_t$, yields (24). Next, substituting (26) into (20), and adding and subtracting $\theta_0/(\phi-1)$ to the right-hand side of

(20), yields

$$\pi_t = -\frac{\kappa_c - \frac{\kappa_y}{1+\zeta}}{\phi-1} - \frac{1}{\phi-1} \underbrace{\left(\theta_0 + \theta_1 a_{t-1} + \theta_2 E^p_{t-1}[a_{t-1}] + \theta_3 E^c_{t-1}[x_{t-1}]\right)}_{\equiv y_{t-1}} + \left(\frac{1}{\phi-1} - \xi_6\right) a_t + \xi_6 E^c_t[x_t]. \tag{27}$$

The term in the underbrace is equal to y_{t-1} – simply iterate the linear rule (21) one period in the past – and taking into account that $E^c_t[x_t] = (1-\mu)E^c_{t-1}[x_t] + \mu a_t$, yields (23). ■

The structure of the inflation dynamics derived in Proposition 1 are similar with the corresponding dynamics under the symmetric benchmark, expression (18), with the exception here that realised inflation is a function of past aggregate output realisations, that, in turn, depend arbitrarily on ξ_5. The inability of conventional policy to control the distribution of inflation and output enables agents to coordinate their actions on the realisation of extrinsic signals, that might induce inefficient volatility in aggregate variables.

The logic behind multiplicity is similar to what we discussed in the symmetric benchmark, with one important qualification, that the PC relationship does not provide the necessary equilibrium restrictions to pin down the stochastic path of inflation and output. To understand this, let us consider the matching of coefficients between the expectational price error (right-hand side of PC) with the output linear rule (left-hand side of PC). The expectational price error of the producer depends on current productivity, a, the producer's expectation of productivity, $E^p_t[a_t]$, the consumer's expectation about the permanent component, $E^c_t[x_t]$, and also, the producer's expectation about the consumer's expectation about the permanent component, $E^p_t\left[E^c_t[x_t]\right]$, which, in turn, is equal to the producer's expectation about productivity, $E^p_t\left[E^x_t[x_t]\right] = E^c_{t-1}[x_t] + \mu E^p_t\left[a_t - a_{t|t-1}\right] = E^c_{t-1}[x_t] = E^p_t[a_t]$. When we match coefficients, we end up with the same number of equilibrium restrictions as the number of coefficients in (21). As a result, the overall equilibrium system, which includes the FE and PC blocks, is left with one coefficient that cannot be determined. The key point is that the producer's second-order belief, $E^p_t\left[E^c_t[x_t]\right]$, is pinned down by $E^p_t[a_t]$ and thus, its coefficient can be matched with the coefficient attached to the producer's expectation of productivity in the left-hand side of PC. As we show next, this condition fails in the presence of public information, adding the equilibrium restrictions needed to pin down the equilibrium uniquely.

4 Public information

Suppose the central bank releases noisy, public signals to market participants about the future temporary component of aggregate productivity, $s_t = \epsilon_{t+1} + u_{t+1}$, at every date t. This suffices to pin down the distribution of inflation and output.

More formally, we obtain the following result.

Proposition 2 *If the central bank releases noisy signals s_t to market participants at every date t, then the stochastic path of inflation and output at equilibrium are given by*

$$\pi_t = -\frac{\kappa_c - \frac{\kappa_y}{1+\zeta}}{\phi - 1} + \frac{1}{\phi - 1}(a_t - y_{t-1}), \; t = 0, 1, .. \tag{28}$$

$$(1+\zeta) y_t = \kappa_y + a_t \left(\zeta - \frac{1}{\phi - 1}\right) + E_t^p[a_t]\frac{\phi}{\phi - 1}, \; t = 0, 1, .., \tag{29}$$

where κ_c, κ_y are functions of policy and primitive parameters.

Proof. In Appendix B, we show that releases of noisy signals pins down a unique rational expectations equilibrium, where $\xi_2 = \xi_5 = \theta_3 = 0$ (coefficients that multiply the consumer's expectation of x), and substituting into (25),(26), we pin down the remaining coefficients as function of policy and primitive parameters. In turn, substituting the coefficients into the linear rules (20),(21), yields (28),(29). ■

As we hinted earlier, public information causes the producer's first- and second-order beliefs to decouple, $E_t^p\left[E_t^x[x_t]\right] = E_{t-1}^c[x_t] + \mu E_t^p\left[a_t - a_{t|t-1}\right] = E_{t-1}^c[x_t] \neq E_t^p[a_t] = E_{t-1}^c[x_t] + \kappa s_{t-1}$. The coefficient ξ_5 multiplies the second-order belief on the right-hand side of PC. However, the coefficient on the left-hand side is multiplied by zero, since the output conjecture is not influenced by second-order beliefs, indicating that $\xi_5 = 0$. Subsequently, taking into consideration the decoupling between the one-step-ahead forecasts between aggregate productivity and its permanent component, $E_t^c[a_{t+1}] \neq E_t^c[x_{t+1}]$, as discussed in the symmetric benchmark, we complete the characterisation by showing that all other coefficients that multiply the consumer's expectation about the permanent component are zero, and the unique equilibrium is characterised by (28),(29).

The following result demonstrates that by using carefully constructed endogenous signals in the form of one-step-ahead forecasts of inflation and output, agents can infer the central bank's signal s_t at each date. By updating their expectations accordingly we can attain the equilibrium characterised in Proposition 2. This is an implementation result using communication strategies commonly employed by policymakers to convey information about the fundamental of the economy to market participants. To construct the central bank's forecasts, we take expectations of (28),(29), which is the equilibrium we want to implement, as of $t-1$, based on information available to the least informed agent, in particular, the producer's information at stage 1 of period $t-1$. This ensures that announcements do not eliminate the informational frictions faced by the producer at the time production takes place. Consequently, agents can accurately infer s_t upon observing the central bank's one-step-ahead forecasts because of linearity of the equilibrium.

Proposition 3 *The equilibrium (28)-(29) can be implemented with central bank announcements of its one-step-ahead forecast of inflation,*

$$E^p_{t-1}[\pi_t] \;=\; \Delta^\pi_{t-1} \,+\, \frac{\kappa}{\phi-1} s_{t-1}, \tag{30}$$

or announcements of its one-step-ahead forecast of aggregate output,

$$E^p_{t-1}[y_t] \;=\; \Delta^y_{t-1} \,+\, \kappa s_{t-1}, \tag{31}$$

where $\Delta^\pi_{t-1}, \Delta^y_{t-1}$ are functions of predetermined variables at $t-1$.

Proof. We derive first $E^p_{t-1}[\pi_t]$. Defining the central bank's expectations as above, and taking expectation of (28) as of date $t-1$, yields

$$E^p_{t-1}[\pi_t] \;=\; -\frac{\kappa_c - \frac{\kappa_y}{1+\zeta}}{\phi-1} \,+\, \frac{1}{\phi-1}\left(E^p_{t-1}[a_t] - E^p_{t-1}[y_{t-1}]\right). \tag{32}$$

The expectation of a_t as of $t-1$ is given by

$$E^p_{t-1}[a_t] \;=\; E^p_{t-1}[x_t] + \kappa s_{t-1} \;=\; \rho E^p_{t-1}[x_{t-1}] \,+\, \kappa s_{t-1} \;=\; \rho E^c_{t-2}[x_{t-1}] \,+\, \kappa s_{t-1}, \tag{33}$$

which is a linear function of s_{t-1} and another predetermined term at $t-1$. Next, computing $E^p_{t-1}[y_{t-1}]$, yields

$$E^p_{t-1}[y_{t-1}] \;=\; \tfrac{\kappa_y}{1+\zeta} \,+\, E^c_{t-2}[x_{t-1}] + \kappa s_{t-2}, \tag{34}$$

where we have used the fact that $E^p_{t-1}[a_{t-1}] = E^p_{t-1}[x_{t-1}] + \kappa s_{t-2} = E^c_{t-2}[x_{t-1}] + \kappa s_{t-2}$. It follows that $E^p_{t-1}[y_{t-1}]$ is a functions of predetermined variables as of $t-1$. Combining (32)-(34), yields (30), with

$$\Delta^\pi_{t-1} = -\frac{\kappa_c - \frac{\kappa_y}{1+\zeta}}{\phi-1} \,-\, \tfrac{1}{\phi-1} E^p_{t-1}[y_{t-1}] + \tfrac{1}{\phi-1}\rho E^c_{t-2}[x_{t-1}].$$

Finally, we derive $E^p_{t-1}[y_t]$. Taking expectations of (29) as of $t-1$, we obtain

$$(1+\zeta)E^p_{t-1}[y_t] \;=\; \kappa_y \,+\, E^p_{t-1}[a_t]\left(\zeta - \frac{1}{\phi-1}\right) \,+\, E^p_{t-1}\left[E^p_t[a_t]\right]\frac{\phi}{\phi-1}, \tag{35}$$

and using the fact that

$$
\begin{aligned}
E_{t-1}^{p}\left[E_t^p[a_t]\right] = E_{t-1}^{p}\left[E_t^p[x_t] + \kappa s_{t-1}\right] = E_{t-1}^{p}\left[E_{t-1}^{c}[x_t]\right] + \kappa s_{t-1} = \rho E_{t-2}^{c}[x_{t-1}] + \kappa s_{t-1}, \\
E_{t-1}^{p}[a_t] \;=\; E_{t-1}^{p}[x_t] \;+\; \kappa s_{t-1} \;=\; \rho E_{t-1}^{p}[x_{t-1}] \;+\; \kappa s_{t-1} \;=\; \rho E_{t-2}^{c}[x_{t-1}] + \kappa s_{t-1},
\end{aligned} \tag{36}
$$

we obtain (31), with

$$\Delta_{t-1}^{y} = \tfrac{\kappa_y}{1+\zeta} \;+\; \rho E_{t-2}^{c}[x_{t-1}].$$

■

5 Longer forecasting horizons

To simplify exposition, but without loss of generality, we present this extension in the symmetric information benchmark. Consider a generalisation of the linear rule (14), as follows:

$$\pi_t \;=\; \xi_0 \;+\; \xi_1 a_{t-1} \;+\; \xi_2 a_t \;+\; \xi_3 E_t[x_t] \;+\; \sum_{i=1}^{T} \omega_i E_t[a_{t+i}],\;\; t = 0, 1, ...,$$

with new terms highlighted in red and $T < \infty$. To simplify matters, we focus on $T = 1$. Without releases of noisy signals, we obtain $E_t[a_{t+1}] = E_t[x_{t+1}] = \rho E_t[x_t]$, and the generalised linear rule reduces to (14) in the main text, but with ξ_3 replaced by $\tilde{\xi}_3 \equiv \xi_3 \;+\; \rho\omega_1$, and the stochastic path of inflation depends arbitrarily on $\tilde{\xi}_3$, through the same channel discussed in the main text.

Suppose the central bank releases noisy signals $s_t = \epsilon_{t+1} + u_{t+1}$, at every date t. Taking expectations of π_{t+1} as of date t, we obtain

$$E_t[\pi_{t+1}] \;=\; \xi_0 \;+\; \xi_1 a_t \;+\; \xi_2 E_t[a_{t+1}] \;+\; \tilde{\xi}_3 E_t[x_{t+1}],$$

where we have used that $E_t[a_{t+1}] \neq E_t[x_{t+1}]$, given the release of s_t at date t, and also $E_t[a_{t+2}] = \rho E_t[x_{t+1}]$, since $E_t[s_{t+1}] = 0$. Matching coefficients yields $\tilde{\xi}_3 = 0$, leaving its composition arbitrary, and the remaining coefficients are given by $\xi_0 = -\kappa_c(\omega_1)/(\phi - 1), \xi_1 = -1/(\phi - 1), \xi_2 = 1/(\phi - 1)$. The stochastic path of inflation reduces to

$$\pi_t \;=\; -\frac{\kappa_c\,(\omega_1)}{\phi - 1} \;+\; \frac{1}{\phi - 1}\,(a_t \;-\; a_{t-1}) \;+\; \omega_1 \kappa s_t,$$

and the distribution of inflation depends arbitrarily on the coefficient ω_1.

Compare the previous result with a communication strategy where the central bank releases two independent noisy signals at every date t: one about realisations of ϵ_{t+1} and another about ϵ_{t+2}. Taking expectations of π_{t+1} as of date t, we obtain

$$E_t[\pi_{t+1}] = \xi_0 + \xi_1 a_t + \xi_2 E_t[a_{t+1}] + \xi_3 E_t[x_{t+1}] + \omega_1 E_t[a_{t+2}],$$

where $E_t[a_{t+1}] \neq E_t[x_{t+1}]$ and $E_t[a_{t+2}] \neq \rho E_t[x_{t+1}]$, and importantly, the latter decoupling of expectations follows from the fact that agents receive, as of date t, noisy signals about temporary shocks two periods ahead. Matching coefficients yields $\xi_3 = \omega_1 = 0$ and the distribution of inflation is determined uniquely. The argument generalises to $T > 1$.

6 Conclusion

This paper considers a monetary economy with imperfect information and rational expectations and shows that conventional monetary policy, implemented through endogenous feedback rules, cannot control the stochastic path of inflation. Our indeterminacy result does not derive from the stability of steady state, but instead, is a consequence of the inability of the stochastic Fisher equation and interest rate setting to control the stochastic path of inflation. Public communication of noisy information, either directly or through the central bank's one-step-ahead forecasts of inflation and output, changes agents' expectations about the future state of the economy. This, in turn, introduces additional restrictions to the equilibrium that help determine the path of inflation and output. Our results underscore the importance of central bank forecasts as an additional policy tool for policymakers to achieve their primary objective of maintaining price stability.

Appendix

A Kalman filter

Consider first the case without public announcements. Let the consumer's prior at date t about x and a be given by:

$$x_t|I^c_{t-1} \sim \mathcal{N}\left(x_{t|t-1}, \sigma^2_{x|t-1}\right) \tag{A.1}$$

$$a_t|I^c_{t-1} \sim \mathcal{N}\left(x_{t|t-1}, \sigma^2_{x|t-1} + \sigma^2_{\epsilon}\right), \tag{A.2}$$

where $x_{t|t-1} := E[x_t|I^c_{t-1}]$ and $\sigma^2_{x|t-1} := Var[x_t|I^c_{t-1}]$. Upon observing a_t, the consumer's updated beliefs about x_t are given by:

$$x_t|I^c_t \sim \mathcal{N}\left(x_{t|t-1} + \mu_t\left(a_t - a_{t|t-1}\right), \quad \left(\frac{1}{\sigma_{x,t-1}} + \frac{1}{\sigma_{\epsilon}}\right)^{-1}\right) \quad \text{where} \quad \mu_t = \frac{\frac{1}{\sigma^2_{\epsilon}}}{\frac{1}{\sigma^2_{x|t-1}} + \frac{1}{\sigma^2_{\epsilon}}}. \tag{A.3}$$

Their expectation about x_{t+1} are given by:

$$x_{t+1}|I^c_t \sim \mathcal{N}\left(\rho x_{t|t}, \sigma^2_{x|t}\right), \tag{A.4}$$

where

$$\sigma^2_{x|t} = \left(\frac{1}{\sigma^2_{x|t-1}} + \frac{1}{\sigma^2_{\epsilon}}\right)^{-1} + \sigma^2_{e}. \tag{A.5}$$

Let σ^2_x denote the solution (fixed point) of the Riccati equation $(A.5)$. We assume that at period 0, the agents' learning problem is at their steady state $x_0 \sim \mathcal{N}\left(x_{0|-1}, \sigma^2_x\right)$. The Kalman gain will be also time invariant:

$$\mu = \frac{\frac{1}{\sigma^2_{\epsilon}}}{\frac{1}{\sigma^2_x} + \frac{1}{\sigma^2_{\epsilon}}}. \tag{A.6}$$

Moreover, the posterior distribution of $a_{t+\tau}$, $\tau \geq 1$, is given by

$$a_{t+\tau}|I^c_t \sim \mathcal{N}\left(\rho^{\tau} x_{t|t}, \sigma^2_x + \sigma^2_{\epsilon}\right), \tag{A.7}$$

with $x_{t|t} = (1-\mu)x_{t|t-1} + \mu a_t$.

The producer does not observe a at $(t, 1)$, and their expectation about the permanent component coincide with the expectation of the consumer about x at the end of $t-1$, $E_t^p[x_t] = E_{t-1}^c[x_t] = x_{t|t-1}$. However, they learn realised productivity at $(t, 2)$, and their beliefs are then given by the posterior distribution in $(A.3)$.

Next, we proceed to characterise the agents' learning problem when the central bank releases noisy signals about the temporary component next period at every date. Let the consumer's prior at date t about x and a be given by:

$$x_t | I_{t-1}^c \sim \mathcal{N}\left(x_{t|t-1}, \sigma^2_{x|t-1}\right), \tag{A.8}$$

$$a_t | I_{t-1}^c \sim \mathcal{N}\left(x_{t|t-1} + \kappa s_{t-1}, \sigma^2_{x|t-1} + \left(\frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right) \tag{A.9}$$

where

$$\kappa = \frac{\frac{1}{\sigma_u^2}}{\frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon^2}} \tag{A.10}$$

denotes the precision of the signal s_t that agents receive at $t-1$ about the temporary component of productivity at t.

Upon observing a_t, the consumer's updated beliefs about x_t are given by:

$$x_t | I_t^c \sim \mathcal{N}\left(x_{t|t-1} + \mu_t\left(a_t - a_{t|t-1}\right), \quad \left(\frac{1}{\sigma_{x,t-1}} + \frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon}\right)^{-1}\right) \quad \text{where} \quad \mu_t = \frac{\frac{1}{\sigma_\epsilon^2} + \frac{1}{\sigma_u^2}}{\frac{1}{\sigma^2_{x|t-1}} + \frac{1}{\sigma_\epsilon^2} + \frac{1}{\sigma_u^2}}. \tag{A.11}$$

Following similar steps as shown above, the posterior distribution of x_{t+1} is given by

$$x_{t+1} | I_t^c \sim \mathcal{N}\left(\rho x_{t|t}, \sigma^2_{x|t}\right), \tag{A.12}$$

with

$$\sigma^2_{x|t} = \left(\frac{1}{\sigma_{x,t-1}} + \frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon}\right)^{-1} + \sigma_e^2 \tag{A.13}$$

and, as before, σ_x^2 denote the solution (fixed point) of the Riccati equation $(A.13)$.

The posterior distributions for the consumer are given by

$$a_{t+1}|I_t^c \sim \mathcal{N}\left(\rho x_{t|t} + \kappa s_t, \sigma_x^2 + \left(\frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{A.14}$$

$$a_{t+\tau}|I_t^c \sim \mathcal{N}\left(\rho^\tau x_{t|t}, \sigma_x^2 + \sigma_\epsilon^2\right) \quad \tau \geq 2; \tag{A.15}$$

and the relevant posteriors for the producer are given by

$$a_t|I_{t,1}^i \sim \mathcal{N}\left(x_{t|t-1} + \kappa s_{t-1}, \sigma_x^2 + \left(\frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{A.16}$$

$$a_{t+1}|I_{t,1}^i \sim \mathcal{N}\left(\rho x_{t|t-1} + \kappa s_t, \sigma_x^2 + \left(\frac{1}{\sigma_u^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right). \tag{A.17}$$

B Linear equilibria

B.1 Symmetric benchmark

Define $x_t \equiv \log(X_t)$ and, as in the main text, assume no public announcements. We focus on linear equilibria of the following form:

$$\pi_t \;=\; \xi_0 \;+\; \xi_1 a_{t-1} \;+\; \xi_2 a_t \;+\; \xi_3 E_t[x_t],\;\; t = 0, 1, .. \tag{B.1}$$

The interest rate rule (5) can be written as

$$e^{q_t} \;=\; \{E_t\left[e^{\pi_{t+1}}\right]\}^{-\phi} \;=\; e^{-\phi\left(E_t[\pi_{t+1}] + \frac{1}{2}Var_t[\pi_{t+1}]\right)}, \tag{B.2}$$

where the last equality follows from the fact that π_{t+1} is normally distributed (hence $e^{\pi_{t+1}}$ is log-normally distributed).

Next, we express the Euler equation (11) as:

$$e^{q_t} \;=\; e^{\log\beta} E_t\left[e^{-\,\pi_{t+1}\,+\,a_t\,-\,a_{t+1}}\right] \;=\; e^{\log\beta + a_t + E_t[-(\pi_{t+1} + a_{t+1})] + \frac{1}{2}Var_t[\pi_{t+1} + a_{t+1}]}, \tag{B.3}$$

where we have used the equilibrium condition $y_t \;=\; c_t \;=\; a_t$, and the fact that $\pi_{t+1} + a_{t+1}$ is normally distributed (hence $e^{\pi_{t+1} + a_{t+1}}$ is log-normally distributed).

Combining (B.2),(B.3) to eliminate q_t, yields

$$E_t[a_{t+1}] - a_t = (\phi - 1)E_t[\pi_{t+1}] + \kappa_c, \tag{B.4}$$

with

$$\kappa_c = \log\beta + \frac{1}{2}(1+\xi_2+\xi_3\mu)^2\left(\sigma_x^2+\sigma_\epsilon^2\right) + \frac{\phi}{2}(\xi_2+\xi_3\mu)^2\left(\sigma_x^2+\sigma_\epsilon^2\right). \tag{B.5}$$

Finally, substituting (B.1) into (B.4) and matching coefficients, yields

$$\xi_0 = -\frac{1}{\phi-1}\kappa_c, \tag{B.6}$$

$$\xi_1 = -\frac{1}{\phi-1}, \tag{B.7}$$

$$\xi_2+\xi_3 = \frac{1}{\phi-1}. \tag{B.8}$$

B.2 Asymmetric information

We focus on linear equilibria of the following form:

$$\pi_t = \xi_0 + \xi_1 a_{t-1} + \xi_2 E^c_{t-1}[x_{t-1}] + \xi_3 E^p_{t-1}[a_{t-1}] + \xi_4 a_t + \xi_5 E^c_t[x_t],\ t = 0, 1, ... \tag{B.9}$$

$$y_t = \theta_0 + \theta_1 a_t + \theta_2 E^p_t[a_t] + \theta_3 E^c_t[x_t],\ t = 0, 1, ... \tag{B.10}$$

B.2.1 No public information

Let us start with the labor optimality condition. Substituting (12) into (10), taking into account that $\lambda_t = (P_t C_t)^{-1}$, and multiplying and dividing the right-hand side of (10) by P_{t-1}, yields

$$N_t^\zeta = \frac{1}{\Pi_t C_t}\frac{E^p_t\left[\frac{A_t}{C_t}\right]}{E^p_t\left[\frac{1}{\Pi_t C_t}\right]}. \tag{B.11}$$

In turn, taking into account that, in turn, technology and market clearing in logs can written as $y_t = n_t + a_t$ and $c_t = y_t$, (B.11) can be written as follows:

$$e^{(1+\zeta)y_t - \zeta a_t + \pi_t} = \frac{E^p_t\left[e^{a_t - y_t}\right]}{E^p_t\left[e^{-\pi_t - y_t}\right]}. \tag{B.12}$$

The following result will be useful in the analysis that follows:

$$E_t^p\left[E_t^x[x_t]\right] \;=\; x_{t|t-1} \;+\; \mu \underbrace{E_t^p\left[a_t - a_{t|t-1}\right]}_{=0} \;=\; E_t^p[a_t]. \tag{B.13}$$

Conditional on the producer's information set at $(t,1)$, the exponent of the numerator in the right-hand side of (B.12) is normally distributed with mean

$$E_t^p[a_t - y_t] = -\theta_0 \;+\; (1-\theta_1-\theta_2-\theta_3)E_t^p[a_t] \tag{B.14}$$

and variance

$$Var_t^p[a_t - y_t] = (1-\theta_1-\mu\theta_3)^2\left(\sigma_x^2+\sigma_\epsilon^2\right), \tag{B.15}$$

where σ_x^2 solves the Riccati equation (A.5). Similarly, the exponent of the denominator is normally distributed with mean

$$E_t^p\left[-(\pi_t+y_t)\right] \;=\; \Delta \;-\left\{\theta_1+\theta_2+\theta_3+\xi_4+\xi_5\right\}E_t^p[a_t], \tag{B.16}$$

where $\Delta = -\left\{\theta_0+\xi_0+\xi_1 a_{t-1}+\xi_2 E_{t-1}^c(x_{t-1})+\xi_3 E_{t-1}^p(a_{t-1})\right\}$ and variance

$$Var_t^p[\pi_t+y_t] = (\xi_4+\xi_5\mu+\theta_1+\mu\theta_3)^2\left(\sigma_x^2+\sigma_\epsilon^2\right). \tag{B.17}$$

In turn, (B.12) reduces to

$$e^{(1+\zeta)y_t-\zeta a_t+\pi_t} \;=\; \frac{E_t^p\left[e^{a_t-y_t}\right]}{E_t^p\left[e^{-\pi_t-y_t}\right]} \;=\; e^{E_t^p[a_t-y_t]+E_t^p[\pi_t+y_t]+\frac{1}{2}Var_t^p[a_t-y_t]-\frac{1}{2}Var_t^p[\pi_t+y_t]}, \tag{B.18}$$

which, in turn, can be equivalently written as follows:

$$(1+\zeta)y_t \;=\; E_t^p[a_t]+\zeta a_t+E_t^p[\pi_t]-\pi_t+\kappa_y, \tag{B.19}$$

with

$$\kappa_y = \frac{1}{2}(1-\theta_1-\mu\theta_3)^2\left(\sigma_x^2+\sigma_\epsilon^2\right)-\frac{1}{2}(\xi_4+\xi_5\mu+\theta_1+\mu\theta_3)^2\left(\sigma_x^2+\sigma_\epsilon^2\right). \tag{B.20}$$

Substituting conjectures (B.9)-(B.10) into (B.19), and matching coefficients, yields

$$(1+\zeta)\theta_1 \;-\; \zeta \;+\; \xi_4 \;=0, \tag{B.21}$$

$$(1+\zeta)\theta_3 \; + \; \xi_5 \; = \; 0, \tag{B.22}$$

$$(1+\zeta)\theta_2 \; = \; 1 \; + \; \xi_4 \; + \; \xi_5, \tag{B.23}$$

$$(1+\zeta)\theta_0 \; = \; \kappa_y. \tag{B.24}$$

Next, following similar steps as in the symmetric benchmark case, the Euler equation can be written as

$$E_t^c[y_{t+1}] \; - \; y_t \; = \; (\phi - 1)E_t^c[\pi_{t+1}] \; + \kappa_c, \tag{B.25}$$

with

$$\kappa_c = \log\beta + \frac{\phi}{2}(\xi_4 + \xi_5\mu)^2(\sigma_x^2 + \sigma_\epsilon^2) + \frac{1}{2}(\theta_1 + \theta_3\mu + \xi_4 + \xi_5\mu)^2(\sigma_x^2 + \sigma_\epsilon^2). \tag{B.26}$$

The one-step-ahead forecasts of inflation and output are given by

$$E_t^c[\pi_{t+1}] \; = \; \xi_0 \; + \xi_1 a_t \; + \; \xi_2 E_t^c[x_t] \; + \; \xi_3 E_t^p[a_t] \; + \; (\xi_4 + \xi_5)E_t^c[x_{t+1}], \tag{B.27}$$

$$E_t^c[y_{t+1}] \; = \; \theta_0 \; + \; (\theta_1 \; + \; \theta_2 \; + \; \theta_3)\, E_t^c[x_{t+1}], \tag{B.28}$$

where we have used that $E_t^c[a_{t+1}] = E_t^c\left[E_{t+1}^c[x_{t+1}]\right] = E_t^c[x_{t+1}]$ and $E_t^c[a_{t+1}] = E_t^c\left[E_{t+1}^c[x_{t+1}]\right] = E_t^c\left[E_{t+1}^p[a_{t+1}]\right] = E_t^c[x_{t+1}]$. In turn, substituting the previous one-step-ahead forecasts into (B.25) and matching coefficients, yields

$$(\phi - 1)\xi_1 \; = \; -\theta_1, \tag{B.29}$$

$$(\phi - 1)\xi_3 \; = \; -\theta_2, \tag{B.30}$$

$$(\phi - 1)\xi_2 \; = \; -\theta_3, \tag{B.31}$$

$$(\phi - 1)(\xi_4 + \xi_5) \; = \; (\theta_1 \; + \; \theta_2 \; + \; \theta_3), \tag{B.32}$$

$$(\phi - 1)\xi_0 \; = \; -\kappa_c. \tag{B.33}$$

Combining (B.21)-(B.23) and (B.29)-(B.32), yields

$$\theta_1 \; = \; \frac{1}{1+\zeta}\left(\zeta - \frac{1}{\phi - 1} + \xi_5\right) \tag{B.34}$$

$$\theta_2 \; = \; \frac{\phi}{\phi - 1}(1+\zeta)^{-1}, \tag{B.35}$$

$$\theta_3 \; = \; -\frac{\xi_5}{1+\zeta}, \tag{B.36}$$

$$\xi_1 \; = \; -\frac{1}{(\phi - 1)(1+\zeta)}\left(\zeta - \frac{1}{\phi - 1} + \xi_5\right), \tag{B.37}$$

$$\xi_2 = \frac{\xi_5}{(\phi-1)(1+\zeta)}, \tag{B.38}$$

$$\xi_3 = -\frac{\phi}{(\phi-1)^2}(1+\zeta)^{-1}, \tag{B.39}$$

$$\xi_4 = \frac{1}{\phi-1} - \xi_5, \tag{B.40}$$

and the coefficient ξ_5 cannot be determined by the equilibrium system.

B.2.2 Public information

Suppose the central bank releases noisy information about the temporary component next period at every date. The expected values in the right-hand side of (B.12) reduce to

$$E_t^p\left[a_t - y_t\right] = -\theta_0 + (1-\theta_1-\theta_2)E_t^p[a_t] + \theta_3 E_t^p\left[E_t^c[x_t]\right], \tag{B.41}$$

$$E_t^p\left[-(\pi_t + y_t)\right] = \Delta - (\theta_1+\theta_2+\xi_4)\,E_t^p[a_t] - (\theta_3+\xi_5)E_t^p\left[E_t^c[x_t]\right], \tag{B.42}$$

where $\Delta = -\left\{\theta_0 + \xi_0 + \xi_1 a_{t-1} + \xi_2 E_{t-1}^c(x_{t-1}) + \xi_3 E_{t-1}^p(a_{t-1})\right\}$ and

$$E_t^p\left[E_t^c[x_t]\right] = x_{t|t-1} + E_t^p\left[\mu(a_t - a_{t|t-1})\right] = x_{t|t-1} \neq E_t^p[a_t] = x_{t|t-1} + \kappa s_{t-1}.$$

The relevant variances are given by

$$Var_t^p\left[a_t - y_t\right] = (1-\theta_1-\mu\theta_3)^2\left(\sigma_x^2 + \left(\frac{1}{\sigma_x^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{B.43}$$

$$Var_t^p\left[-(\pi_t + y_t)\right] = (\theta_1+\mu\theta_3)^2\left(\sigma_x^2 + \left(\frac{1}{\sigma_x^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{B.44}$$

and as a result, the constant term κ_y in (B.19) is equal to

$$\kappa_y = \frac{1}{2}(1-\theta_1-\mu\theta_3)^2\left(\sigma_x^2 + \left(\frac{1}{\sigma_x^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right) - \frac{1}{2}(\theta_1+\mu\theta_3)^2\left(\sigma_x^2 + \left(\frac{1}{\sigma_x^2} + \frac{1}{\sigma_\epsilon^2}\right)^{-1}\right). \tag{B.45}$$

As before, substituting (B.9)-(B.10) into (B.19) and matching coefficients, yields

$$(1+\zeta)\theta_1 - \zeta + \xi_4 = 0, \tag{B.46}$$

$$(1+\zeta)\theta_2 = 1 + \xi_4, \tag{B.47}$$

$$(1+\zeta)\theta_3 + \xi_5 = 0, \tag{B.48}$$

$$\xi_5 \;=\; 0, \tag{B.49}$$

$$(1+\zeta)\theta_0 \;=\; \kappa_y. \tag{B.50}$$

Next, we turn to the Fisher equation. The one-step-ahead forecasts are given by

$$E_t^c\left[\pi_{t+1}\right] \;=\; \xi_0 \;+\; \xi_1 a_t \;+\; \xi_2 E_t^c[x_t] \;+\; \xi_3 E_t^p[a_t] \;+\; \xi_4 E_t^c[a_{t+1}] \;+\; \xi_5 E_t^c[x_{t+1}], \tag{B.51}$$

$$E_t^c\left[y_{t+1}\right] \;=\; \theta_0 \;+\; (\theta_1+\theta_2)E_t^c[a_{t+1}] \;+\; \theta_3 E_t^c[x_{t+1}], \tag{B.52}$$

where we have used the following results

$$E_t^c\left[E_{t+1}^c[x_{t+1}]\right] \;=\; x_{t+1|t} \;+\; E_t^c\left[\mu(a_{t+1}-a_{t+1|t})\right] \;=\; E_t^c[x_{t+1}], \tag{B.53}$$

$$E_t^c\left[E_{t+1}^p[a_{t+1}]\right] \;=\; x_{t+1|t} \;+\; \kappa s_t \;=\; E_t^c[a_{t+1}], \tag{B.54}$$

$$E_t^c[a_{t+1}] \;=\; x_{t+1|t} \;+\; \kappa s_t \;\neq\; E_t^c[x_{t+1}]. \tag{B.55}$$

The relevant variances are given by

$$Var_t^c\left[\pi_{t+1}\right] \;=\; (\xi_4+\mu\xi_5)^2\left(\sigma_x^2 \;+\; \left(\frac{1}{\sigma_x^2}+\frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{B.56}$$

$$Var_t^c\left[\pi_{t+1}+y_{t+1}\right] \;=\; (\xi_4+\mu\xi_5+\theta_1+\mu\theta_3)^2\left(\sigma_x^2 \;+\; \left(\frac{1}{\sigma_x^2}+\frac{1}{\sigma_\epsilon^2}\right)^{-1}\right), \tag{B.57}$$

and as a result, the constant term κ_c is equal to

$$\kappa_c = \log\beta + \frac{\phi}{2}(\xi_4+\mu\xi_5)^2\left(\sigma_x^2 \;+\; \left(\frac{1}{\sigma_x^2}+\frac{1}{\sigma_\epsilon^2}\right)^{-1}\right) + \frac{1}{2}(\xi_4+\mu\xi_5+\theta_1+\mu\theta_3)^2\left(\sigma_x^2 \;+\; \left(\frac{1}{\sigma_x^2}+\frac{1}{\sigma_\epsilon^2}\right)^{-1}\right). \tag{B.58}$$

Substituting (B.10),(B.51),(B.52),(B.56),(B.57) into (B.25) and matching coefficients, yields

$$(\phi-1)\xi_1 \;=\; -\theta_1, \tag{B.59}$$

$$(\phi-1)\xi_3 \;=\; -\theta_2, \tag{B.60}$$

$$(\phi-1)\xi_2 \;=\; -\theta_3, \tag{B.61}$$

$$(\phi-1)\xi_4 \;=\; \theta_1 \;+\; \theta_2, \tag{B.62}$$

$$(\phi-1)\xi_5 \;=\; \theta_3, \tag{B.63}$$

$$(\phi-1)\xi_0 \;=\; \kappa_c. \tag{B.64}$$

Combining (B.46)-(B.48) and (B.59)-(B.63), yields

$$\theta_1 = \frac{\zeta}{1+\zeta} - \frac{1}{(\phi-1)(1+\zeta)}, \tag{B.65}$$

$$\theta_2 = \frac{1}{1+\zeta}\frac{\phi}{\phi-1}, \tag{B.66}$$

$$\theta_3 = 0, \tag{B.67}$$

$$\xi_1 = -\frac{\theta_1}{(\phi-1)}, \tag{B.68}$$

$$\xi_2 = 0, \tag{B.69}$$

$$\xi_3 = -\frac{\theta_2}{\phi-1}, \tag{B.70}$$

$$\xi_4 = \frac{1}{\phi-1}, \tag{B.71}$$

$$\xi_5 = 0. \tag{B.72}$$

References

Adam, K. (2007, March). Optimal monetary policy with imperfect common knowledge. *Journal of Monetary Economics 54*(2), 267–301.

Adao, B., I. Correia, and P. Teles (2014). Short and long interest rate targets. *Journal of Monetary Economics 66*, 95–107.

Angeletos, G.-M. and C. Lian (2021, June). Determinacy without the Taylor Principle. NBER Working Papers 28881, National Bureau of Economic Research, Inc.

Angeletos, G.-M. and A. Pavan (2004, May). Transparency of information and coordination in economies with investment complementarities. *American Economic Review 94*(2).

Angeletos, G.-M. and A. Pavan (2007). Efficient use of information and social value of information. *Econometrica 75*(4), 1103–1142.

Bassetto, M. (2019). Forward guidance: Communication, commitment, or both? *Journal of Monetary Economics 108*, 69–86.

Castillo-Martinez, L. and R. Reis (2019). How do central banks control inflation? a guide for the perplexed. *LSE manuscript*.

Clarida, R., J. Gali, and M. Gertler (2000). Monetary policy rules and macroeconomic stability: Evidence and some theory. *The Quarterly Journal of Economics 115*(1), 147–180.

Cochrane, J. H. (2011). Determinacy and identification with taylor rules. *Journal of Political Economy 119*(3), 565–615.

Cornand, C. and F. Heinemann (2008). Optimal degree of public information dissemination. *The Economic Journal 118*(528), 718–742.

Gottardi, P. and R. Rahi (2014). Value of information in competitive economies with incomplete markets. *International Economic Review 55*(1), 57–81.

Gurkaynak, R. S., B. Sack, and E. Swanson (2005, May). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking 1*(1).

Hall, R. E. and R. Reis (2016, October). Achieving Price Stability by Manipulating the Central Bank's Payment on Reserves. CEPR Discussion Papers 11578, C.E.P.R. Discussion Papers.

Hansen, S., M. McMahon, and M. Tong (2019). The long-run information effect of central bank communication. *Journal of Monetary Economics*.

Hellwig, C. (2005). Heterogeneous information and the welfare effects of public information disclosures.

Jain, M. and C. S. Sutherland (2020, October). How Do Central Bank Projections and Forward Guidance Influence Private-Sector Forecasts? *International Journal of Central Banking 16*(5), 179–218.

La'O, J. and G.-M. Angeletos (2011). Dispersed Information over the Business Cycle: Optimal Fiscal and Monetary Policy. Technical report.

Lorenzoni, G. (2009, December). A Theory of Demand Shocks. *American Economic Review 99*(5), 2050–2084.

Lorenzoni, G. (2010, 01). Optimal Monetary Policy with Uncertain Fundamentals and Dispersed Information*. *The Review of Economic Studies 77*(1), 305–338.

Lubik, T. A., C. Matthes, and E. Mertens (2023). Indeterminacy and imperfect information. *Review of Economic Dynamics 49*, 37–57.

Lucas, R. J. (1972, April). Expectations and the neutrality of money. *Journal of Economic Theory 4*(2), 103–124.

Magill, M. and M. Quinzii (1996). *Theory of Incomplete Markets*. MIT Press.

Magill, M. and M. Quinzii (2014). Term structure and forward guidance as instruments of monetary policy. *Economic Theory 56*(1), 1–32.

Mankiw, N. G. and R. Reis (2002). Sticky Information versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve. *The Quarterly Journal of Economics 117*(4), 1295–1328.

McCallum, B. T. (1981). Price level determinacy with an interest rate policy rule and rational expectations. *Journal of Monetary Economics 8*(3), 319–329.

McMahon, M., M. U. Peiris, and H. Polemarchakis (2018). Perils of unconventional monetary policy. *Journal of Economic Dynamics and Control 93*(C), 92–114.

Morris, S. and H. S. Shin (2002, December). Social value of public information. *American Economic Review 92*(5), 1521–1534.

Morris, S. and H. S. Shin (2005). Central bank transparency and the signal value of prices. *Brookings Papers on Economic Activity 2005*(2), 1–43.

Nakajima, T. and H. Polemarchakis (2005). Money and prices under uncertainty. *The Review of Economic Studies 72*(1), 223–246.

Nakamura, E. and J. Steinsson (2018). High-Frequency Identification of Monetary Non-Neutrality: The Information Effect*. *The Quarterly Journal of Economics 133*(3), 1283–1330.

Phelps, E. S. (1970). Microeconomic foundations of employment and inflation theory.

Reis, R. (2006). Inattentive Producers. *Review of Economic Studies 73*(3), 793–821.

Reis, R. (2022, June). The Burst of High Inflation in 2021-22: How and Why Did We Get Here? Discussion Papers 2209, Centre for Macroeconomics (CFM).

Romer, C. D. and D. H. Romer (2000, June). Federal reserve information and the behavior of interest rates. *American Economic Review 90*(3), 429–457.

Sargent, T. J. and N. Wallace (1975). "rational" expectations, the optimal monetary instrument, and the optimal money supply rule. *Journal of Political Economy 83*(2), 241–254.

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

Svensson, L. E. O. (2006, March). Social value of public information: Comment: Morris and shin (2002) is actually pro-transparency, not con. *American Economic Review 96*(1), 448–452.

Woodford, M. (1994). Monetary policy and price level determinacy in a cash-in-advance economy. *Economic Theory 4*(3), 345–380.

Woodford, M. (2001, December). Imperfect Common Knowledge and the Effects of Monetary Policy. NBER Working Papers 8673, National Bureau of Economic Research, Inc.

Woodford, M. (2005, December). Central Bank Communication and Policy Effectiveness. Nber working papers, National Bureau of Economic Research, Inc.