# Inflation Persistence, Noisy Information and the Phillips Curve*

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**Abstract**

Inflation persistence and volatility have fallen since the mid 80s. Using micro-data from US Professional Forecasters on inflation expectations, I show that the gradual increase in public disclosure of US Fed actions and predictions have significantly reduced the anchoring in firm inflation expectations, affecting inflation dynamics. I show that an extended version of the New Keynesian model which relaxes the Full Information Rational Expectations assumption generates the documented fall in persistence. I find that whereas in the benchmark model the disconnection between inflation and the real side of the economy can only be due to a fall in the slope of the Phillips curve, in the noisy information setting it is the result of a change in beliefs. Once the misspecification in the benchmark Phillips curve is corrected, there is no empirical evidence of a change on its slope.

**Keywords:** Inflation persistence, flattening Phillips curve, noisy information.

**JEL Classifications:** E31, E32, E52, E70.

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# 1 Introduction

Economic agents care about prices and inflation when they make decisions. Households care about prices and the real return on their savings. Firms care about aggregate prices and others' pricing decisions when setting their prices. Central Banks ultimately care about stabilizing inflation. Therefore, it is crucial to understand inflation's underlying dynamics. Empirical evidence suggests that the dynamic properties of inflation have not been constant over time. In particular, inflation in the post-war period exhibits a high degree of persistence and volatility up until the mid 1980s, with both falling significantly since then. The fall in inflation persistence observed in the data is not easily understood through the lens of monetary models, which has resulted in the "inflation persistence" puzzle.[1]

I explain the fall in inflation persistence through a decrease in the information frictions that firms face on Central Bank actions. Since the late 1960s, Central Bank public disclosure and transparency has gradually improved, sending clearer signals of their actions and future intentions to the market.[2] Before 1967 the *Federal Open Market Committee* (FOMC) only announced policy decisions once a year in the Annual Report. In 1967, the FOMC decided to release the directive in the Policy Report (PR), 90 days after the decision. In 1976, the PR was enlarged and its delay was reduced to 45 days. Between 1976 and 1993 the information contained in the PR increased, without further changes in the announcement delay.[3] In 1994 the FOMC introduced the immediate release of the PR after a meeting if there had been a decision, coupled with an immediate release of the "tilt" (likelihood regarding possible future action) since 1999. Since January 2000 there is an immediate announcement and press conference after each meeting, regardless of the decision. This paper outlines the mechanism through which the gradual increase in information has reduced the degree of anchoring in firm expectations.[4] Given that expectations are a crucial determinant of macro aggregates like inflation, the gradual de-anchoring in expectation has led to a fall in inflation persistence.[5]

1. Persistence is an important property of a dynamic process since it determines both the memory of any past shock on today's realization, and it increases its volatility. See Fuhrer (2010) for a handbook literature review.

2. See Lindsey (2003) for a comprehensive historical review.

3. In 1977 the *Federal Reserve Reform Act* officially entitled the Fed with 3 objectives: maximum employment, stable prices and moderate long-term interest rates. In 1979, the first macroeconomic forecasts on real GNP and GNP inflation from FOMC members were made available. The "tilt" (predisposition or likelihood regarding possible future action) was introduced in the PR in 1983. Between 1985 and 1991 the Fed introduced the "ranking of policy factors", which after each meeting ranked aggregate macro variables in importance, signaling priorities with regard to possible future adjustments. The minutes, a revised transcript of the discussions during the meeting, started being released together with the PR in 1993, 45 days after the meeting.

4. I define anchoring as the dependance of current variables or expectations on past values.

5. A criticism to the gradual information disclosure argument is that, although actions *themselves* could not be known with certainty until after a year, market participants could observe the changes in interest rates and monetary aggregates induced by the action and could thus infer it, in the spirit of the Grossman

I revisit different theories that produce a structural relation between inflation and other forces in the economy, based on the New Keynesian (NK) environment. I show that, although standard models are successful in explaining the fall in inflation volatility through an increase in the Fed aggressiveness towards excess inflation (see Clarida et al. 2000), they cannot explain the fall in inflation persistence.[6] In the benchmark NK model inflation is proportional to the exogenous driving force, the monetary policy shock, and thus inherits its properties. Hence, in order for the model to explain the fall in inflation persistence documented in the data, it requires a fall in the persistence of monetary policy shocks. I document that monetary policy shocks persistence has not changed over time. Acknowledging that purely forward-looking models cannot generate anchoring or intrinsic persistence, so that exogenous processes drive inflation dynamics, I extend the benchmark and explore backward-looking frameworks. I find that they generate little endogenous persistence, and that empirically-relevant changes are insufficient to generate the significant fall in inflation persistence that I observe in the data.[7]

I extend the textbook NK framework in Galí (2015) and Woodford (2003b) to noisy information following Lucas (1972). Morris and Shin (2002) and Woodford (2003a) are the first to study the economy as a static beauty contest, and Allen et al. (2006), Bacchetta and Van Wincoop (2006), Morris et al. (2006), and Nimark (2008) extend the economy to a dynamic beauty contest. More recently, Angeletos and Huo (2021) and Huo and Takayama (2018) show that noisy information attenuates the General Equilibrium (GE) effects associated with the Keynesian multiplier and the inflation-spending feedback, causing the economy to respond to news about the future *as if* the agents were myopic. I extend the framework

and Stiglitz (1980) paradox. To alleviate this concern, I measure information frictions using data from professional forecasters. The underlying assumption here is that professional forecasters are among the most informed agents in the economy since their job is to make predictions for private companies. Obtaining evidence on significant information friction would therefore invalidate the previous criticism.

6. The structural break around 1985:I in inflation persistence coincides with a structural change in the Fed reaction function. I show that this change in the monetary stance effectively reduces inflation volatility but has no effect on inflation persistence.

7. First I extend the benchmark and incorporate a backward-looking dimension in the supply side (price indexation). I show that the change in the monetary stance now affects inflation intrinsic persistence, although the effect is small. An increase in the elasticity of nominal interest rates to inflation from 1 to 2 is insufficient to produce a significant fall in inflation persistence. I show that the necessary change in the parameter that governs price-indexation is counterfactual: more than full indexation would be required. I then introduce a second backward-looking model, which extends the previous framework to accommodate trend inflation. I follow Ascari and Sbordone (2014), and log-linearize the standard framework around a steady state with positive trend inflation. I show that augmenting the model with trend inflation creates intrinsic persistence in the inflation dynamics through relative price dispersion, a backward-looking variable that has no first-order effects in the benchmark NK model. Most importantly, I show that inflation persistence is increasing in the level of trend inflation. Interestingly, Ascari and Sbordone (2014) obtain an estimate of time-varying trend inflation, and find that the forecasts of 10-years ahead inflation are highly correlated (96%) with their measure, suggesting that agents do not face significant uncertainty about long-term inflation. However, I show that the joint increase in the monetary stance and the decrease in trend inflation are insufficient in order to produce the significant fall in inflation persistence.

in Angeletos and Huo (2021) by merging the two building blocks, the Dynamic IS and NK Philips curves, obtaining closed-form equilibrium dynamics that facilitate the interpretation of our results.

I show that, by relaxing the full information rational expectations (FIRE) assumption, our model generates the documented fall in persistence. Introducing noisy and dispersed information generates heterogeneous beliefs and information sets. Using micro-data on inflation expectations from the Survey of Professional Forecasters (SPF), I show that agents became more informed about inflation after the change in the Federal Reserve disclosure policy in the mid 1980s, which endogenously lowers the intrinsic persistence in inflation dynamics.

In our framework firms only observe their own private conditions and face uncertainty about aggregate output, inflation, nominal rates and the monetary policy shock. Their only source of information is a noisy signal that contains information on the monetary policy shock, from which they inform their forecasts on the aggregate variables. I first show that our departure from the FIRE assumption is consistent with the micro-data evidence on disagreement and belief formation, and generates anchoring or intrinsic inflation persistence without the need of resorting to counterfactual assumptions. Second, I document a structural break in expectation formation that is contemporaneous to the fall in inflation persistence and the change in the monetary stance. I show that around 1985:Q1 agents became more informed about inflation or, in the noisy information model lens, that the signal became more precise, reducing information frictions on inflation. Taken both breaks on the monetary policy stance and the belief formation process together, our noisy information model can explain the fall in inflation persistence.

The previous literature has documented a fall in the sensitivity of inflation and the real side of the economy ("inflation disconnect" puzzle, see Del Negro et al. 2020). In the standard model inflation dynamics are reduced to the NK Phillips curve, which relates current inflation to the current output gap and expected future inflation. Inflation is only related to the real side of the economy through the Phillips curve slope, and the only possible explanation for the lack of dependence of inflation on output in the recent decades is a fall in the slope. The literature has focused extensively on this slope, in the hope of documenting that this relation has weakened and that the inflation process is therefore independent of any change coming from the demand side of the economy, including changes in the policy rate or Central Bank actions. Armed with our noisy information framework, I show that the NK Phillips curve is enlarged with a backward-looking term on lagged inflation, a forward-looking term on expected future output gap, and myopia towards expected future inflation. Once I correct for the misspecification in the NK Phillips curve there is no evidence for a fall in its slope, and the noisy information model explains the fall in inflation sensitivity towards the real side of the economy through changes in beliefs. Furthermore, I show that under a *general* information structure, the Phillips curve is modified such that current inflation is related to current and future output through two different channels: the slope of the Phillips curve and firms' expectation formation process. I show that there is no empirical evidence for a change in the slope once I control for non-standard preferences, using SPF forecasts.

**Roadmap** The paper proceeds as follows. In Section 2 I document the fall in inflation persistence and volatility in the recent decades. Section 3 covers the standard NK framework and different extensions. In Section 4 I document the decrease in information frictions in the recent decades, describe our theoretical framework, and derive the main result. In Section 5 I extend our noisy information framework to households, and explain the inflation disconnect puzzle through noisy information dynamics. Section 6 concludes.

## 2 Inflation Dynamics

In this section I document a fall in inflation persistence and volatility since the mid 1980s.[8] I use the (annualized) quarterly growth in the GDP Deflator as a proxy for aggregate inflation, but the results presented here are robust to alternative inflation measures.[9]

The inflation time series is reported in Figure 1. The sample is divided in two subperiods, pre- and post-1985:Q1, and I report the mean and 2 standard deviation bands by each subperiod. Inflation started its upward trend in the 1960s, continuing in the next decade with two local peaks in the mid 1970s and in the early 1980s. Since then inflation started its downward trend until the early 1990s, and has been roughly at 2% afterwards. Differentiating between the two subperiods, one can see from the previous figure that the level of inflation has fallen from 6% to 2%, and that inflation has become less volatile.

In the monetary macro literature, inflation is generally assumed to follow an independent autoregressive stochastic process. In such case, the stationary mean depends both on the intercept and on the lagged inflation coefficients. On the other hand, the stationary volatility depends both on the innovation volatility and on the lagged inflation coefficients. Table 1 reports summary statistics on the mean, volatility and first-order autocorrelation by each subsample.[10] In the following we seek to investigate if these differences across subsamples

8. Inflation data is available at a quarterly frequency since 1947:Q1. However, I will stick to the 1968:Q4-2020:Q2 sample since we seek to link the results presented in this section to surveys on expectations, which are available since 1968:Q4.

9. I define the inflation rate at time t, $\pi_t$, as the annualized log growth in the index, $400 \times (\log X_t - X_{t-1})$, where $X_t$ is the GDP Deflator at time $t$.

10. The $k$-th order autocorrelation $\rho_k$ of a stationary variable $\pi_t$ is defined as $\rho_k = \frac{\mathbb{E}(\pi_t \pi_{t-k})}{\mathbb{V}(\pi)}$ where the autocorrelation function is defined as the vector of autocorrelations $\mathcal{A} = [\rho_1, \ldots, \rho_k]$. For example, in the

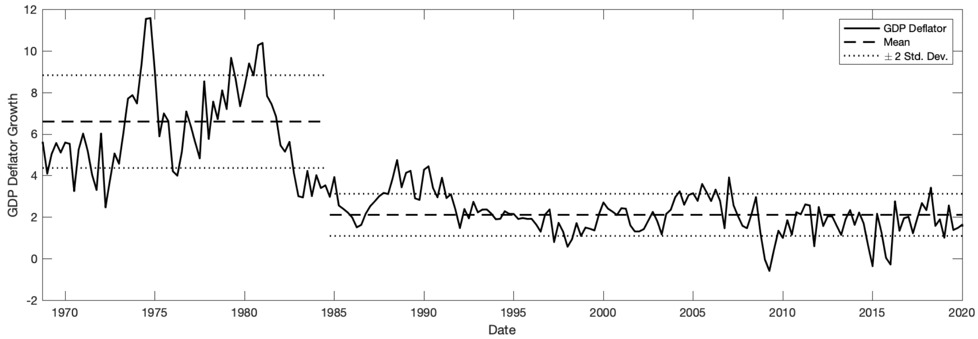



Figure 1: Time series of inflation, with subsample mean and standard deviation.

Table 1: Summary statistics over time.

| | 1968:Q4–2020:Q1 | 1968:Q4–1984:Q4 | 1985:Q1–2020:Q1 |
|---|---|---|---|
| Mean | 3.362 | 6.160 | 2.117 |
| Volatility | 2.400 | 2.234 | 1.016 |
| First-Order Autocorrelation | 0.880 | 0.754 | 0.505 |

are statistically significant.

## 2.1 Persistence and Volatility

**Persistence** Let us consider that inflation follows a simple AR(1) process with a drift. In the previous section we argued that the change in the level documented in Figure 1 can be explained by two key parameters: intercept and persistence. I begin by testing if there is a significant structural break in inflation dynamics around 1985:Q1. We cannot reject the null of a (known) structural break in the whole regression ($p$-value = 0.0001), but the test is inconclusive on whether the intercept or persistence (or both) are the culprits of the structural change in inflation dynamics. In order to disentangle between the two we test for a structural break on intercept and persistence separately. Formally, consider the regression

$$\pi_t = \alpha_\pi + \alpha_{\pi,*}\mathbb{1}_{\{t\geq t^*\}} + \rho_\pi \pi_{t-1} + \rho_{\pi,*}\pi_{t-1}\mathbb{1}_{\{t\geq t^*\}} + e_t \tag{2.1}$$

where $\mathbb{1}_{\{t\geq t^*\}}$ is an indicator variable equal to 1 if the period is within the post-1985 era, and $e_t$ is the error term. The advantage of relying on a specification like (2.1) instead of a cross-sample analysis is that the former allows us to verify if the structural change in the

particular case of an AR(1) process, each $k$-th order of the autocorrelation function becomes the $k$-th power: $\mathcal{A} = [\rho, \rho^2, \dots, \rho^k]$. A time series is considered to be relatively persistent if its autocorrelations decay slowly.

Table 2: Persistence and Volatility

| Panel A: Persistence | (1) | (2) |
|---|---|---|
| $\pi_{t-1}$ | $0.880^{***}$ | $0.785^{***}$ |
| | (0.0466) | (0.0755) |
| $\pi_{t-1} \times \mathbb{1}_{\{t\geq t^*\}}$ | | $-0.287^{**}$ |
| | | (0.144) |
| Constant | $0.400^{**}$ | $1.320^{***}$ |
| | (0.166) | (0.471) |
| Constant$\times\mathbb{1}_{\{t\geq t^*\}}$ | | $-0.263$ |
| | | (0.543) |
| Observations | 206 | 206 |

| Panel B: Innovation Variance | |
|---|---|
| Constant | $2.712^{***}$ |
| | (0.163) |
| Constant$\times\mathbb{1}_{\{t\geq t^*\}}$ | $-1.843^{***}$ |
| | (0.182) |
| Observations | 208 |

HAC robust standard errors in parentheses

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

coefficients is statistically significant. We report our findings in Table 2 Panel A. First, we find that both the intercept and persistence are highly significant (column 1). Second, I find strong evidence for a structural break in persistence, falling from 0.79 in the pre-1985 period to 0.5 afterwards (column 2). On the other hand, I do not find evidence of a structural break in the intercept. Considering these findings, we conclude that the fall in the level in inflation documented in Figure 1 is explained through a change in inflation persistence.

**Volatility** Let us now move to volatility. We documented in Figure 1 that inflation volatility fell by a factor of 2 in the post-1985 period. Using the assumed AR(1) dynamics, we can already verify that the change in inflation persistence explains around 50% of the fall in unconditional volatility, and must be coupled with a fall in the innovation volatility. To further investigate this, in this section I model inflation variance as a GARCH(1,1) process. Let $\varepsilon_t^\pi$ denote the error terms in the regression $\pi_t = \rho_\pi \pi_{t-1} + \varepsilon_t^\pi$. These $\varepsilon_t^\pi$ are split into a stochastic piece $z_t$ and a time-dependent standard deviation $\sigma_{\varepsilon,t}$ characterizing the typical size of the terms so that $\varepsilon_t^\pi = z_t \sigma_{\varepsilon,t}$, where the random variable $z_t$ is a white noise process.

The GARCH(1,1) series $\sigma^2_{\varepsilon,t}$ is modelled as $\sigma^2_{\varepsilon,t} = \alpha + \beta(\varepsilon^{\pi}_{t-1})^2 + \gamma\sigma^2_{\varepsilon,t-1}$. To investigate whether the difference in volatility across sub-periods is significant, I proceed as in our previous structural break analysis. First, I perform a Wald test for a structural break around a known date (1985:Q1), which cannot be rejected ($p-$value$=0.000$) and then estimate the following equation

$$\hat{\sigma}^2_{\varepsilon,t} = \alpha_\sigma + \alpha_{\sigma,*}\mathbb{1}_{\{t\geq t^*\}} + u_t$$

I report our results in Table 2 Panel B. The structural change in the level of the innovation volatility around 1985:I is statistically significant, suggesting a fall from 1.647 to 0.932 and explaining the remaining 50% fall in inflation volatility.

## 2.2 Robustness

I discuss the robustness of the previous findings in this section, and report the results in Appendix B.1. First, I use four alternative measures of inflation: price inflation (CPI), producer inflation (PCE), and their respective core series.[11] All inflation measures exhibit a strong correlation.

Our second robustness dimension entails different persistence analyses. First, we follow Fuhrer (2010) and Pivetta and Reis (2007) and compute rolling-sample estimates of an independent AR(1) process using a 14-year window. The results suggest that there is significant time variation in inflation persistence, which rises in the 1970s (from 0 to around 0.8), stays roughly constant in the 1980s, falls in the 1990s (0.5-0.6) and falls further in the 2000s (0-0.4). Similarly, we study a Time-Varying Parameter (TVP) AR(1) process, where the time-varying persistence coefficient is assumed to follow a random walk. Results are consistent with our main findings, and reported in Appendix B.1.

Our two final robustness checks focus on unit roots. If an autorregressive process contains a unit root, persistence is unquestionably large. First, restricting ourselves to the class of order 1 processes, we find that we cannot reject the null of a unit root in the pre-sample while the null is rejected in the post-sample. These findings support the notion that persistence fell after 1985:Q1. Second, relaxing the order of the autoregressive process, we then study the dominant root of an independent AR($p$) process. Our results show that the dominant root fell in the post-1985 period.

11. Their calculation excludes food and energy prices, which are generally more volatile.

## 2.3 Summary

In this section and in Appendix B.1 I provide empirical evidence on the fall in inflation persistence in the recent decades through a variety of analyses, ranging from cross-sample autocorrelation function, unit root tests, dominant root analysis to structural break tests. I also provide evidence for the fall in inflation volatility in the recent decades. However, all our analyses are based on an ad-hoc formulation of the inflation process, without a grounded theory behind.

In Section 3 I revisit different theories that produce a structural relation between inflation and other forces in the economy, based on the NK environment. I then investigate if such framework can explain the documented fall in inflation persistence and volatility. I show that, although the NK framework is successful in explaining the fall in inflation volatility, a variety of common extensions cannot explain the fall in inflation persistence. I then suggest an extension to the benchmark model, in which the assumption of complete and full information is relaxed, in Section 4.

# 3 Persistence and Volatility in NK Models

In this section I study the determinants of inflation persistence and volatility in a structural macro framework. I show that the empirical findings documented in the previous section present a puzzle in the NK model. I cover a wide range of NK frameworks and show that they cannot explain the fall in inflation persistence in an empirically consistent manner. Regarding volatility, I show that its fall can be explained via a change in the monetary stance in the post-Volcker era.

In the benchmark NK model, in which agents form rational expectations using complete information, the demand (output gap) and supply side (inflation) dynamics are modeled as two forward-looking stochastic equations, commonly referred to as the Dynamic IS (DIS) and New Keynesian Phillips (NKPC) curves.[12] Nominal interest rates are set by the Central Bank following a reaction function that takes the form of a standard Taylor rule. The Central Bank reacts to excess inflation and output gap and controls an exogenous component, $v_t$, which follows an independent AR(1) process which innovations are treated as serially uncorrelated monetary policy shocks.

$$\tilde{y}_t = -\frac{1}{\sigma}\left(i_t - \mathbb{E}_t\pi_{t+1}\right) + \mathbb{E}_t\tilde{y}_{t+1} \tag{3.1}$$

$$\pi_t = \kappa\tilde{y}_t + \beta\mathbb{E}_t\pi_{t+1} \tag{3.2}$$

12. The model derivation is relegated to Online Appendix D.

$$i_t = \phi_\pi \pi_t + \phi_y \tilde{y}_t + v_t \tag{3.3}$$

$$v_t = \rho_v v_{t-1} + \varepsilon_t^v, \qquad \varepsilon_t^v \sim \mathcal{N}(0, \sigma_\varepsilon^2) \tag{3.4}$$

Inserting the Taylor rule (3.3)-(3.4) into the DIS curve (3.1), one can write the model as a system of two first-order stochastic difference equations that can be solved analytically. In particular, inflation dynamics satisfy

$$\pi_t = -\psi_\pi v_t = \rho_v \pi_{t-1} - \psi_\pi \varepsilon_t^v \tag{3.5}$$

where $\psi_\pi$ satisfies,

$$\psi_\pi = \frac{\kappa}{(1-\rho_v\beta)[\sigma(1-\rho_v)+\phi_y]+\kappa(\phi_\pi-\rho_v)} \tag{3.6}$$

and output gap dynamics are given by $\tilde{y}_t = -\psi_y v_t = \rho_v \tilde{y}_{t-1} - \psi_y \varepsilon_t^v$. Notice that inflation is proportional to the exogenous shock. As a result inflation will inherit its dynamic properties from the exogenous driving force.[13] A final implication is that inflation is only *extrinsically* persistent: its persistence is determined by the $v_t$ AR(1) process' persistence.

In order to explain the fall in inflation persistence and volatility I discuss each causal explanation separately. First, I explore whether there has been a change in the structural shocks affecting the economy. I show that these exogenous forces' dynamics have been remarkably stable since the beginning of the sample. Second, I investigate if a change in the monetary stance around 1985:Q1, for which Clarida et al. (2000) and Lubik and Schorfheide (2004) provide empirical evidence, could have affected inflation dynamics. I show that the change in the monetary stance can indeed explain the fall in volatility but has null or modest effects on persistence. Finally, I explore if changes in intrinsic persistence, generated via backward-looking assumptions on the firm side, have a sizeable effect on persistence. As in the previous case, I show that these have only marginal effects.

## 3.1 Structural Shocks

I documented in Section 2 that inflation persistence and volatility fell in the recent decades. The NK model suggests that such fall is inherited from a fall in the persistence of the monetary policy shock process. I now seek to find evidence on the time-varying properties of such persistence.

13. One can also notice that the benchmark model predicts that output gap and inflation are equally persistent, and their dynamics will only differ due to the differential monetary policy shock impact effect, captured by $\psi_y$ and $\psi_\pi$. Another implication is that the Pearson correlation coefficient between output gap and inflation is equal to 1, an aspect rejected in the data.

**Persistence** The challenge that the econometrician faces is that she does not have an empirical proxy for $v_t$. The monetary policy shocks estimated by the literature are not serially correlated, and are therefore a better picture of the monetary policy shock $\varepsilon_t^v$.[14,15] However, one can use the model properties and rewrite the Taylor rule (3.3) using the AR(1) properties of (3.4), as

$$i_t = \rho_v i_{t-1} + (\phi_\pi \pi_t + \phi_y y_t) - \rho_v (\phi_\pi \pi_{t-1} + \phi_y y_{t-1}) + \varepsilon_t^v \tag{3.7}$$

where the error term is the monetary policy shock.[16] Hence, an estimate of the first-order autoregressive coefficient in (3.7) identifies the monetary policy shock process persistence.[17] I present here the structural break analysis and leave for Appendix B.2.1 the robustness analysis. I test for a potential tructural break in the persistence of the nominal interest rate process, described by (3.7), around 1985:Q1. I do this in two different ways. First, I use an unrestricted GMM and estimate

$$i_t = \alpha_i + \alpha_{i,*} \mathbb{1}_{\{t \geq t^*\}} + \rho_i i_{t-1} + \rho_{i,*} i_{t-1} \mathbb{1}_{\{t \geq t^*\}} + \boldsymbol{\gamma} \boldsymbol{X}_t + u_t$$

where $\boldsymbol{X}_t$ is a set of control variables that includes current and lagged output gap and inflation.[18] I report our results in the first two columns of Table 3 Panel A. There is no evidence for a decrease in nominal interest rate persistence (and thus, monetary shock process persistence) over time. Notice however that monetary shock persistence plays a dual role in (3.7), since it also affects lagged output and inflation. As a robustness check, I estimate the structural break version of (3.7) using a restricted-coefficient GMM, reported in the last two columns in Table 3 Panel A. Our findings are similar.

This set of results is inconsistent with the NK model, since the model suggests that the empirically documented fall in inflation persistence can only be explained by an *identical* fall in nominal interest rates persistence.

14. In fact, the process $v_t$ is a model device engineered to produce inertia yet still allowing us to obtain a closed-form solution. If inertia is directly introduced in the nominal interest rate equation, I would not be able to obtain the closed-form solution (3.5) since the system would also feature a backward-looking term whose coefficients would depend on the roots of a quadratic polynomial.

15. For example, Romer and Romer (2004) use the cumulative sum of their estimated monetary policy shocks to derive the IRFs.

16. Using the lag operator, I can write the monetary policy shock process (3.4) as $v_t = (1 - \rho_v L)^{-1} \varepsilon_t^v$. Introducing this last expression into (3.3), multiplying by $(1 - \rho_v L)$ and rearranging terms, I obtain (3.7).

17. Our measure of the nominal rate will be the effective Fed Funds rate (EFFR), calculated as a volume-weighted median of overnight federal funds transactions, and is available at daily frequency. I use the quarterly frequency series.

18. The instrument set includes four lags of the Effective Fed Funds rate, GDP Deflator, CBO Output Gap, labor share, Commodity Price Inflation, Real M2 Growth and the spread between the long-term bond rate and the three-month Treasury Bill rate.

Table 3: Regression table

| *Panel A* | (1) Unrestricted GMM | (2) Restricted GMM |
|---|---|---|
| $i_{t-1}$ | $0.939^{***}$ | $0.931^{***}$ |
| | (0.0448) | (0.0365) |
| $i_{t-1} \times \mathbb{1}_{\{t \geq t^*\}}$ | $-0.00261$ | $-0.0537$ |
| | (0.0591) | (0.0632) |
| Constant | 0.305 | $0.851^{**}$ |
| | (0.473) | (0.373) |
| Constant$\times \mathbb{1}_{\{t \geq t^*\}}$ | $-0.123$ | $-0.813$ |
| | (0.436) | (0.559) |
| Observations | 203 | 203 |
| *Panel B* | Romer & Romer | |
| | Pre 1985 | Post 1985 |
| Standard deviation | 0.286 | 0.0923 |

HAC robust standard errors in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Volatility** In order to discuss inflation volatility, let us first state the model-implied measure of inflation volatility. Inflation dynamics are described by (3.5) and inflation volatility is given by

$$\sigma_\pi = \psi_\pi \frac{\sigma_\varepsilon}{\sqrt{1-\rho_v^2}} \tag{3.8}$$

We assume momentarily that structural model parameters, summarized by $\psi_\pi$, are constant across samples.[19] In this case, the inflation volatility fall could only be explained from a fall in the volatility of the innovation $\sigma_\varepsilon$. To further investigate the fall in the volatility of exogenous monetary shocks, I calculate the standard deviation of Romer and Romer (2004) monetary policy shocks in the two periods. I report the standard deviation findings in Table 3 Panel B. I find that the volatility is greatly reduced in the post-1985 period.

**Additional Structural shocks** In the model studied above I only considered monetary policy shocks, but it could be the case that other relevant shocks have lost persistence in the recent decades and could thus explain the fall in inflation persistence. I additionally consider demand (technology) and supply (cost-push) shocks. In this case inflation dynamics follow

$$\pi_t = \psi_{\pi v} v_t + \psi_{\pi a} a_t + \psi_{\pi u} u_t \tag{3.9}$$

19. We will return to this in the next subsection, when we study potential changes in the monetary stance.

Table 4: Summary

| *Panel A* | Model | | Data | |
|---|---|---|---|---|
| Persistence | Pre 1985 | Post 1985 | Pre 1985 | Post 1985 |
| Monetary | 0.94 | 0.94 | 0.79 | 0.50 |
| Add technology & cost-push | 0.94* | 0.95* | 0.77* | 0.51* |
| *Panel B* | | | | |
| Technology shocks | Pre 1985 | Post 1985 | | |
| First-order autocorrelation | 0.934 | 0.980 | | |
| Standard deviation | 0.0422 | 0.0948 | | |
| *Panel C* | | | | |
| Cost-push shocks | Pre 1985 | Post 1985 | | |
| First-order autocorrelation | 0.933 | 0.913 | | |
| Standard deviation | 0.0401 | 0.0308 | | |

*An asterisk denotes persistence measured as the first-order autocorrelation. Data refers to Table 2 (row 1) and Figure A.2 (row 2).

where $a_t$ is the technology shock, $u_t$ is the cost-push shock, $\psi_{\pi x}$ for $x \in \{v, a, u\}$ are scalars that depend on model parameters, defined in Online Appendix C, and shock processes follow respective AR(1) processes $x_t = \rho_x x_{t-1} + \varepsilon_t^x$. Using different measures of technology shocks from Fernald (2014), Francis et al. (2014), and Justiniano et al. (2011) and cost-push shocks from Nekarda and Ramey (2010), I show in Online Appendix C that there is no empirical evidence for a fall in their persistence, which rules out this explanation.

## 3.2 Monetary Stance

We now consider exogenous changes in the reaction function of the monetary authority. Let us first consider the benchmark framework, with inflation dynamics described by (3.5). We already argued that changes in the policy rule do not affect inflation persistence. Let us focus on volatility then. Recall that model-implied inflation volatility is given by (3.8). We now focus on the determinants of $\psi_\pi$. In particular, we study the inflation coefficient in the Taylor rule. Clarida et al. (2000) and Lubik and Schorfheide (2004) document an increase from around 1 to 2 in the post-Volcker period, which we corroborate in Appendix B.3. Using a standard calibration of the NK model, presented in Table OA.8, we find that $\psi_\pi$ falls by a factor of 4 in the post-sample, which squares well with our findings in Table 2 Panel B.

Let us now consider extensions of the benchmark model that could explain the fall in inflation persistence. We begin by considering a hypothetical change in monetary policy, conducted via the Taylor rule (3.3)-(3.4). The previous literature has considered the possibility of the Fed conducting a passive monetary policy before 1985, which in the lens of the theory would lead to multiplicity of equilibria. For example, Clarida et al. (2000) document that the inflation coefficient in the Taylor rule was well below one, not satisfying the Taylor principle. Lubik and Schorfheide (2004) estimate a NK model under determinacy and indeterminacy, and argue that monetary policy after 1982 is consistent with determinacy, whereas the pre-Volcker policy is not. I study if this change in the monetary stance could have affected inflation persistence. I find that inflation dynamics are less persistent in the indeterminacy region when measured using the IRF to a monetary policy shock. If we instead consider the response to a sunspot shock, inflation dynamics are more persistent. However, the change in persistence is minimal: 0.97 in the pre-1985 (indeterminacy) period and 0.94 afterwards.

The second extension that I inspect is optimal monetary policy under discretion. I show that an increase in $\phi_\pi$ can be micro-founded through a change in the monetary stance in which the central bank follows a Taylor rule in the pre-1985 period, while it follows optimal monetary policy under discretion in the post-1985 period. In such case, inflation dynamics follow (3.9) in the pre-1985 period, and $\pi_t = \rho_u \pi_{t-1} + \psi_d \varepsilon_t^u$ in the post-1985 period, where $\psi_d$ is a positive scalar that depends on deep parameters and inflation persistence is inherited from the cost-push shock. Compared to the pre-1985 dynamics, described by (3.9), there is no significant change in inflation persistence: in the pre-period, model persistence is around 0.95,[20] while in the post-period persistence is around 0.96.[21] Therefore, such change in the policy stance would have generated an *increase* in inflation persistence, which rules out this explanation.

Consider the benchmark NK model with optimal monetary policy under commitment. Under commitment, the monetary authority can credibly control households' and firms' expectations. In this framework, inflation dynamics are given by $\pi_t = \rho_c \pi_{t-1} + \psi_c \Delta u_t$, where $\rho_c$ and $\psi_c$ are positive scalars that depend on deep parameters, $\Delta u_t \equiv u_t - u_{t-1}$ is the exogenous cost-push shock process, with $\rho_c$ governing inflation intrinsic persistence. Using a standard parameterization I find that $\rho_c = 0.310$, which suggests that this framework, although it produces an excessive fall in inflation persistence, could explain its fall. Its main drawback is that its *implied* Taylor rule in the post-1985 period would require an increase in $\phi_\pi$ from 1 to 6.5, as I show in Online Appendix C, which is inconsistent with the documented evidence in table 3 Panel A. On top of this, it suggests that the output gap intrinsic persistence fall is *exactly* the same than that of persistence. I show in Online Appendix C.1.1 that output gap persistence has been remarkably constant over time, which rules out this explanation.

20. Measured by the first-order autocorrelation of (3.9).

21. The estimated persistence of cost-push shocks, $\rho_u$, is constant throughout both periods, as I document in Table OA.12.

Table 5: Summary

| Persistence | Model Pre 1985 | Model Post 1985 | Data Pre 1985 | Data Post 1985 |
|---|---|---|---|---|
| Indeterminacy | 0.97 | 0.94 | 0.79 | 0.50 |
| Discretion | 0.94* | 0.96 | 0.77* | 0.51* |
| Commitment | 0.94* | 0.31 | 0.83 | 0.61 |

*An asterisk denotes persistence measured as the first-order autocorrelation.
Data refers to Table 2 (row 1) and Figure A.2 (row 2) and Table OA.15 (row 3).

### 3.3 Intrinsic Persistence

The main reason for the failure in explaining the change in the dynamics in the benchmark NK model is that the endogenous outcome variables, output gap and inflation, are proportional to the monetary policy shock process and thus inherit its dynamics. This is a result of having a pure forward-looking model, which direct consequence is that endogenous variables are not intrinsically persistent, and its persistence is simply inherited from the exogenous driving force and unaffected by changes in the monetary stance. I therefore enlarge the standard NK model to accommodate a backward-looking dimension in the following discussed extensions, including a lagged term in the system of equations.

I consider a backward-looking inflation framework, "micro-founded" through price indexation. In this framework, a restricted firm resets its price (partially) indexed to past inflation, which generates anchoring in aggregate inflation dynamics. In such framework, inflation dynamics are given by $\pi_t = \rho_\omega \pi_{t-1} + \psi_\omega v_t$. In this framework inflation intrinsic persistence is increasing in the degree of price indexation $\omega$, as I show in Online Appendix C. A fall in the degree of indexation could explain the fall in inflation persistence. However, the parameterization of such parameter is not a clear one. Price indexation implies that every price is changed every period, and therefore one could not identify the Calvo restricted firms in the data and estimate $\omega$. As a result, the parameter is usually estimated using aggregate data and trying to match the anchoring of the inflation dynamics, and its estimate will therefore depend on the additional model equations. Christiano et al. (2005) assume $\omega = 1$. Smets and Wouters (2007) estimate a value of $\omega = 0.21$ trying to match aggregate anchoring in inflation dynamics. It is hard to justify a particular micro estimate for $\omega$, since it is unobservable in the micro data.[22] A counterfactual prediction in this framework is that all prices are changed in every period, in contradiction with the empirical findings in Bils and Klenow (2004) and Nakamura and Steinsson (2008). As a result, one cannot credibly claim that $\omega$ is the causant of the fall in inflation persistence, since it needs to be identified from the macro aggregate

22. One would need to identify the firms that were not hit by the Calvo fairy in a given period, yet they change their price.

Table 6: Summary

| | Model | | Data | |
|---|---|---|---|---|
| Persistence | Pre 1985 | Post 1985 | Pre 1985 | Post 1985 |
| Price indexation | 0.60 | 0.55 | 0.81 | 0.48 |
| Trend inflation | 0.11 | 0.09 | 0.81 | 0.48 |
| Price indexation & trend inflation | 0.63 | 0.57 | 0.81 | 0.48 |

Data refers to Table OA.17.

data, which makes unfeasible to identify $\omega$ and the true inflation persistence separately.

Our last extension is to include trend inflation, for which the literature has documented a fall from 4% in the 1947-1985 period to 2% afterwards (see e.g., Ascari and Sbordone 2014; Stock and Watson 2007). Differently from the standard environment, I log-linearize the model equations around a steady state with positive trend inflation, which I assume constant within eras. Augmenting the model with trend inflation creates intrinsic persistence in the inflation dynamics through relative price dispersion, which is a backward-looking variable that has no first-order effects in the benchmark NK model. Inflation dynamics are now given by $\pi_t = \rho_{\bar{\pi}}\pi_{t-1} + \psi_{\bar{\pi}} v_t + \xi_t$, where first-order intrinsic persistence is given by $\rho_{\bar{\pi}}$, which is increasing in the level of trend inflation, and $\xi_t$ is an MA($\infty$) process. I therefore investigate if the documented fall in trend inflation, coupled with the already discussed change in the monetary stance, can explain the fall in inflation persistence. Although in the correct direction, I find that the fall in trend inflation and the increase in the Taylor rule coefficients produce a small decrease in intrinsic persistence, from 0.11 to 0.09.

# 4 Noisy Information

I have introduced a variety of New Keynesian models, and shown that none of them is able to produce a significant fall in inflation persistence as a result of a structural break. In this section I study a contemporaneous change in beliefs and expectation formation around the same date in which inflation persistence is reported to break.

As I discussed in the introduction, Fed's actions have become more transparent over time. On the one hand, the delay between the action and the announcement to the public has been shortened from around a year to a few minutes. On the other hand, the amount of information contained in the PR, and other documents released to the public, has substantially increased. [23] In this section I show that this gradual increase in information has reduced the degree of anchoring in firm expectations. Given that expectations are a crucial determinant

23. I provide a more detailed historical analysis of the Fed gradual increase in transparency in Online Appendix H.

of inflation, the gradual de-anchoring in expectation has led to a de-anchoring in inflation.

## 4.1 Noisy Information New Keynesian Model

In order to relate the previous empirical findings on inflation persistence to information frictions, I construct a noisy information New Keynesian model based on the work by Huo and Takayama (2018) and Angeletos and Huo (2021).[24] Throughout this subsection I will assume that households and monetary authority have access to full information, while firms face information frictions.[25] Firms do not observe aggregate macro variables like inflation, output or interest rates. Instead, they observe a noisy signal that provides information on the monetary policy shock. With this piece of information, firms form expectations on inflation, aggregate output and interest rates. Therefore, their actions are based on the (limited) information that they have received.

Apart from the information frictions, which I describe formally below, firms are subject to the standard Calvo-lottery price friction, which allows us to write the price-setting problem as a forward-looking one, and compete in a monopolistic economy. The price-setting decision of a firm $i$ can be described (in log-linear terms with respect to a zero inflation steady state) as

$$\pi_{it} = \kappa\theta\mathbb{E}_{it}\tilde{y}_t + (1-\theta)\mathbb{E}_{it}\pi_t + \beta\theta\mathbb{E}_{it}\pi_{i,t+1}, \quad \text{with } \pi_t = \int \pi_{it}\, dj \tag{4.1}$$

which is written in terms of individual inflation setting $\pi_{it} = (1-\theta)(p_{it} - p_{t-1})$, where $\mathbb{E}_{it}(\cdot)$ denotes firm $i$'s expectation conditional on *its* information set at time $t$. It is important to note that in order to derive condition (4.1) I have not specified an information structure yet.[26] Therefore, the price-setting condition (4.1) should be interpreted as a *general* individual-level Phillips curve.[27]

I assume that information is incomplete and dispersed. Each firm $i$ observes a noisy signal $x_{it}$ that contains information on the monetary shock $v_t$, and takes the standard functional

24. The derivation of the model is relegated to Online Appendix D.

25. I relax the FI assumption in Online Appendix C.3.2.

26. In order to derive condition (4.1) I have assumed that firms know the aggregate price level at time $t-1$, but does not extract information form it. Vives and Yang (2016) motivate this through bounded rationality and inattention, while Angeletos and Huo (2021) argue that inflation contains little statistical information about real variables. Huo and Pedroni (2021) allow for endogenous information, but such choice complicates dynamics and the concept of persistence becomes less clear.

27. In the FIRE NK model agents observe perfectly inflation and output, and face a symmetric Nash equilibrium game, and thus every firm acts as a representative agent firm. In such case, the individual Phillips curve (4.1) can be aggregated to the well-known New Keynesian Phillips curve (3.2).

form of "outcome plus noise". Formally, signal $x_{it}$ is described as

$$x_{it} = v_t + u_{it}, \qquad \text{with } u_{it} \sim \mathcal{N}(0, \sigma_u^2) \tag{4.2}$$

where signals are agent-specific. This implies that each agent's information set is different, and therefore generates heterogeneous information sets across the population of firms.

The demand side behaves as in the standard framework, since households are unaffected by the information friction. Output gap dynamics are still described by the DIS curve (3.1), and nominal interest rates are set by the Central Bank following (3.3)-(3.4). An equilibrium must therefore satisfy the individual-level optimal pricing policy functions (4.1), the aggregate DIS curve (3.1), the Taylor rule (3.3), and rational expectation formation should be consistent with the exogenous monetary shock process (3.4) and the signal process (4.2). The following proposition outlines inflation and output gap dynamics.

**Proposition 1.** *Under noisy information, output gap and inflation dynamics are given by*

$$\tilde{y}_t = -\frac{\vartheta(\phi_\pi - \vartheta)}{\sigma(1-\vartheta) + \phi_y}\pi_{t-1} - \psi_y \chi(\vartheta) v_t \tag{4.3}$$

$$\pi_t = \vartheta \pi_{t-1} - \psi_\pi \chi(\vartheta) \left(1 - \frac{\vartheta}{\rho_v}\right) v_t \tag{4.4}$$

*where* $\chi(\vartheta) = \left(1 - \frac{\frac{\kappa\sigma\vartheta(\phi_\pi - \vartheta)}{\sigma(1-\vartheta)+\phi_y}}{(1-\rho_v\beta)[\sigma(1-\rho)+\phi_y]+\kappa(\phi_\pi-\rho)+\frac{\kappa\sigma\vartheta(\phi_\pi-\vartheta)}{\sigma(1-\vartheta)+\phi_y}}\right) \in (0,1)$, *and* $\vartheta$ *is the reciprocal of the largest root of the cubic polynomial*

$$\mathcal{P}(z) = (\beta\theta - z)(z - \rho^{-1})(z - \rho) - \frac{\sigma_\varepsilon^2}{\rho_v \sigma_u^2} z\theta \left[\beta - z\left(1 + \frac{\kappa(\phi_\pi - \vartheta)}{\sigma(1-\vartheta) + \phi_y}\right)\right]$$

*Proof.* See Appendix A □

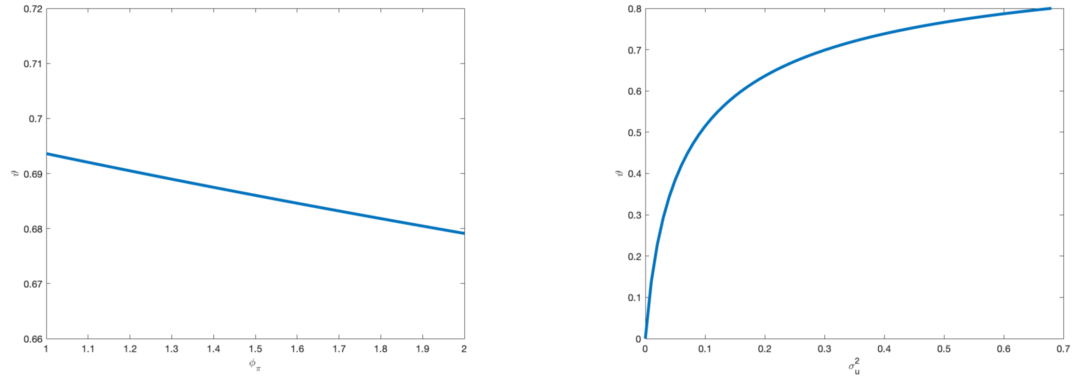
In the noisy information framework inflation is intrinsically persistent and its persistence is governed by the new information-related parameter $\vartheta$, as opposed to the benchmark framework in which it is only extrinsically persistent. Since out ultimate goal is to understand the break in inflation persistence documented in Section 2, the following proposition exposes the determinants of $\vartheta$ and provides analytical comparative statics.

**Proposition 2.** *The relevant information frictions parameter* $\vartheta$

*(i) is bounded between 0 and* $\rho_v$

*(ii) is decreasing in* $\phi_\pi$

*(iii) is increasing in* $\sigma_u$




(a) Relation $\vartheta$ and $\phi_\pi$

(b) Relation $\vartheta$ and $\sigma_u$

Figure 2: Comparative statics.

*(iv) in the limit of no information frictions ($\sigma_u \to 0$), $\vartheta \to 0$.*

*Proof.* See Appendix A. □

Inflation persistence and information frictions are both governed by $\vartheta$. The above proposition is key to understand the time-varying properties of inflation persistence. First, part ($i$) establishes that $\vartheta$ is between 0 and $\rho_v$, and is therefore stationary as long as the exogenous monetary process (3.4) is stationary ($\rho_v < 1$). Part ($ii$) states that inflation intrinsic persistence is decreasing in the Taylor rule coefficient for inflation. In this framework, information frictions become more important as strategic complementarities arise. Stabilising inflation via interest rates reduces strategic complementarities between firms, reducing persistence for a given level of information frictions. However, the change in the monetary stance has very little effect on inflation persistence (see Figure 2a). Part ($iii$) states that inflation persistence is increasing in the degree of information frictions, formalized via the noise of the signal innovation. A decrease in information frictions as the one documented in Section 4.2 would de-anchor individual inflation expectations, which would in turn de-anchor inflation dynamics. Importantly, as opposed to the previous case, information frictions will have the required quantitative bite, as shown in Figure 2b. This key result, coupled with the next one introduced in Proposition 4, will explain the overall fall in inflation persistence. Last, ($iv$) when information frictions tend to 0, $\sigma_u \to 0$ and $\vartheta \to 0$ and inflation dynamics converge to the FIRE benchmark (3.5).

In the next section I relate our theoretical findings on inflation persistence to empirical evidence on information frictions, and their fall in the recent decades.

## 4.2 Empirical Evidence on Information Frictions

**Empirics** Using expectations data from the Survey of Professional Forecasters (SPF), I study whether there is a significant change on different measures of information frictions around 1985:Q1.[28] I conduct a robustness check by either studying the impulse response of ex-post inflation forecast errors to ex-ante monetary policy shocks, the cross-sectional volatility of inflation forecasts over time, or using alternative datasets like the Livingston Survey in Appendix B.4.

Following Coibion and Gorodnichenko (2015), I regress the forecast error, computed as the difference between the realized variable at $t+1$ and the expectation at time $t$ of that variable at $t+1$, $error_t \equiv \pi_{t+3,t} - \overline{\mathbb{E}}_t \pi_{t+3,t}$ where $\pi_{t+3,t}$ denotes the GDP deflator (percentage) change between period $t-1$ and period $t+3$ and $\overline{\mathbb{E}}_t \pi_{t+3,t}$ is the cross-sectional mean of forecasts at time $t$, on the forecast revision, the change in the forecast of a given variable at a given point in time between periods $t$ and $t-1$, $revision_t \equiv \overline{\mathbb{E}}_t \pi_{t+3,t} - \overline{\mathbb{E}}_{t-1} \pi_{t+3,t}$,

$$error_t = \alpha_{CG} + \beta_{CG}\, revision_t + u_t \tag{4.5}$$

Under the FIRE assumption, $\beta_{CG}$ should be zero. Each agent's individual forecast is identical to each other agents' forecast. As a result, the average expectation operator in (4.5) could be interpreted as a representative agent forecast, and we would be effectively regressing the forecast error of the representative agent on its forecast revision. Under RE, the forecast revision should not consistently predict the forecast error. Otherwise, the agent would incorporate this information into his information set. Therefore, a positive estimate of $\beta_{CG}$ in the above regression suggests that the FIRE assumption is violated.[29]

Our results, reported in the first column in Table 7, suggest a strong violation of the FIRE assumption: the measure of information frictions, $\beta_{CG}$, is significantly different from zero. This will generate intrinsic persistence in inflation dynamics without the need to extend the model to habit formation, price indexation or trend inflation but this is not enough to

28. The American Statistical Association and the National Bureau of Economic Research started the survey in 1968:Q4, which has been conducted by the Federal Reserve Bank of Philadelphia since 1990:Q1. Every three months, professional forecasters are surveyed on their forecasts on economic variables like output, inflation or interest rates. These forecasters work at Wall Street financial firms, commercial banks, consulting firms, university research centers and other private sector companies.

29. In our model we maintain the RE assumption, and assume that agents face information frictions, generating heterogenous beliefs (information sets) across households. Bordalo et al. (2018) and Broer and Kohlhas (2019) find evidence for a violation of the rational expectations assumption by regressing (4.5) at the individual level, finding evidence for agent over-confidence when forecasting inflation. Notice that, even if I assume information frictions, the above regression at the individual level should report a $\beta_{CG}$ estimate of zero, because at the individual level the forecast revision should not consistently predict the forecast error. I do not assume a departure from rational expectations because, as Angeletos et al. (2020b) show, over-confidence would have no effect on aggregate dynamics and would therefore not affect inflation persistence.

Table 7: Regression table

| | (1) CG Regression | (2) Break |
|---|---|---|
| Revision | 1.230*** | 1.504*** |
| | (0.250) | (0.315) |
| Revision Change | | −1.146*** |
| | | (0.376) |
| Constant | −0.0875 | −0.135* |
| | (0.0696) | (0.0687) |
| Observations | 197 | 197 |

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

explain the *change* in inflation persistence over time. Since expectation formation affects inflation intrinsic persistence, a structural break in expectation formation could potentially explain the fall in inflation persistence. I test for a structural break in belief formation around 1985:Q1 by estimating the following structural-break version of (4.5),

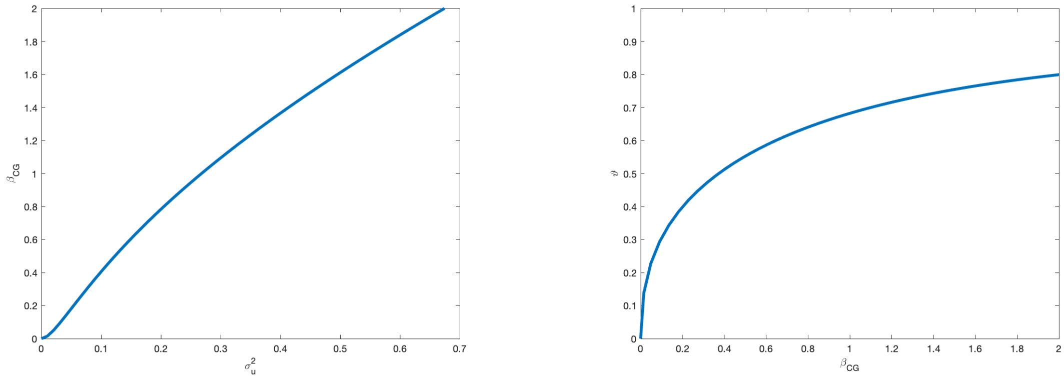
$$error_t = \alpha_{CG} + \left(\beta_{CG} + \beta_{CG*}\mathbb{1}_{\{t \geq t^*\}}\right) revision_t + u_t \tag{4.6}$$

A significant estimate of $\beta_{CG*}$ suggests a break in information frictions. Our results in the second column in Table 7 suggest that there is a structural break around 1985:Q1. Our estimate $\hat{\beta}_{CG*} < 0$ suggests that agents became *more* more informed about inflation, with individual forecasts relying less on priors and more on news. Or, in the dispersed-information model lens, that the signal noise became more precise, reducing information frictions after the change in the Fed transparency policy. These results are consistent with alternative measures of information frictions, discussed in Appendix B.4.

**Theory** Propositions 1 and 2 stated that inflation becomes less persistent when we relax information frictions. In the next pair of propositions I relate the previous empirical findings on expectations to model-implied inflation persistence.

**Proposition 3.** *The theoretical counterpart of the coefficient $\beta_{CG}$ in (4.5) is given by*

$$\beta_{\mathcal{CG}} = \frac{\lambda^2\{(1-\lambda^2)\vartheta^2(1-\rho_v\vartheta) + [\rho_v(\vartheta-\lambda) - \vartheta\lambda(1-\rho_v\lambda)](1-\vartheta\lambda)\}}{(\rho_v-\lambda)(\vartheta-\lambda)(1-\vartheta\lambda)} \tag{4.7}$$




(a) Relation $\beta_{CG}$ and $\sigma_u$ (b) Relation $\vartheta$ and $\beta_{CG}$

Figure 3: Comparative statics.

*where $\lambda$ is the inside root of the following quadratic polynomial*

$$\mathcal{Q}(z) = (z - \rho_v^{-1})(z - \rho_v) - \frac{\sigma_\varepsilon^2}{\rho_v \sigma_u^2} z$$

*Proof.* See Appendix A. □

Proposition 3 introduces the model-implied $\beta_{CG}$ coefficient, $\beta_{\mathcal{CG}}$, which depends on the monetary policy shock persistence $\rho_v$ and on the information-related parameters $\vartheta$ and $\lambda$, where $\lambda$ depends in turn on the persistence parameter and on the signal-to-noise ratio. I now provide the key result on the determinants of $\beta_{\mathcal{CG}}$.

**Proposition 4.** *The theoretical counterpart of the coefficient $\beta_{CG}$, $\beta_{\mathcal{CG}}(\lambda, \vartheta, \rho_v)$, is increasing in $\sigma_u$.*

*Proof.* See Appendix A. □

In our noisy information framework $\beta_{\mathcal{CG}}$ is strictly positive and increases with the degree of information frictions. I show this graphically in Figure 3a. This generates underreaction at the aggregate level, and produces hump-shaped IRF dynamics. Finally, the most important result is that $\beta_{\mathcal{CG}}$ and $\vartheta$, the theoretical counterparts of Coibion and Gorodnichenko (2015) underreaction estimate $\beta_{CG}$ and inflation persistence, are closely related as I show in Figure 3b.

Propositions 3 and 4 map the theoretical information friction, $\sigma_u$, with the Coibion and Gorodnichenko (2015) estimate. Our empirical results support a fall in information frictions in the recent decades. In the model lens, this would imply an exogenous fall in $\sigma_u$, which would then reduce inflation intrinsic persistence $\vartheta$, as I observe in the data. We now study whether the quantitative bite of this change in beliefs can trigger the large fall in intrinsic

Table 8: Model Parameters

| Parameter | Description | Value | Source/Target |
|---|---|---|---|
| $\sigma^2_{u,\text{pre}}$ | Signal innovation variance pre-1985 | 0.445 | $\beta_{CG,\text{pre}}$ in Table 7 |
| $\sigma^2_{u,\text{post}}$ | Signal innovation variance post-1985 | 0.095 | $\beta_{CG,\text{post}}$ in Table 7 |

persistence that I document. For our quantitative analysis I use a standard parameterization in the literature.[30]

Notice that the dynamics generated by noisy information model (4.4) resemble to those generated by the ad-hoc backward-looking models presented in Section 3.3. However, differently from those ad-hoc frameworks, in the noisy information framework intrinsic persistence is the result of the micro-founded anchoring in expectations. Extending the model to accommodate noisy information introduces anchoring *through* expectations, for which I have empirical evidence, rather than the more ad-hoc consumption external habits or price indexation assumptions, for which we have little or no evidence.[31]

**Anchoring in Expectations** Our key results rely on the anchoring in individual expectations. The following proposition exposes the relative anchoring in the individual Phillips curves (4.1).

**Proposition 5.** *Firm i's nowcast of the monetary policy shock process is*

$$\mathbb{E}_{it}v_t = \mathbb{E}_{i,t-1}v_t + G(x_{it} - \mathbb{E}_{i,t-1}v_t) \tag{4.8}$$

*where the Kalman gain is given by* $G(\rho, \sigma_\varepsilon, \sigma_u) = 1 - \frac{\lambda}{\rho_v}$. *Firm i's expectations of current aggregate output and individual future inflation as*

$$\mathbb{E}_{it}\pi_t = \mathbb{E}_{i,t-1}\pi_t + G_1(x_{it} - \mathbb{E}_{i,t-1}v_t)$$
$$\mathbb{E}_{it}\pi_{i,t+1} = \mathbb{E}_{i,t-1}\pi_{i,t+1} + G_2(x_{it} - \mathbb{E}_{i,t-1}v_t)$$

*where* $G_k(\beta, \sigma, \theta, \kappa, \phi_\pi, \phi_y, \rho, \sigma_\varepsilon, \sigma_u)$ *for* $k = \{1, 2\}$, *satisfying* $G_1 < G_2 < G$.

*Proof.* See Appendix A. □

30. All parameters are set to the values reported in Table OA.8. The first six parameters are set to the standard textbook values. The next four parameters are set to their estimated values. Finally, I calibrate $\sigma_u$ to match the empirical evidence on $\beta_{CG}$ in Table 7.

31. Havranek et al. (2017) present a meta-analysis of the different estimates of habits in the macro literature and the available micro-estimates. In general, macro models take $h = 0.75$, whereas micro-estimates suggest a value around $\hat{h} = 0.4$. On the other hand, the price-indexation model suggests that every price is changed every period, which is inconsistent with micro-data estimates provided by Nakamura and Steinsson (2008).

Table 9: Regression table

| | (1) OLS | (2) Newey-West |
|---|---|---|
| $\pi_{t-1}$ | $0.814^{***}$ | $0.814^{***}$ |
| | (0.0481) | (0.0483) |
| $\pi_{t-1} \times \mathbb{1}_{\{t \geq t^*\}}$ | $-0.323^{***}$ | $-0.323^{***}$ |
| | (0.0807) | (0.0804) |
| Constant | $1.088^{***}$ | $1.088^{***}$ |
| | (0.263) | (0.247) |
| Observations | 207 | 207 |

Standard errors in parentheses

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Condition (4.8) states that expectations will only be updated by a factor of $G \in (0, 1)$. In this case firm $i$ is predicting a purely exogenous variable, and does not need to infer others' actions.[32] When forecasting an exogenous variable, agents only need to rely on their private information since others' beliefs and actions do not determine the exogenous variable. As a result, the Kalman gain only depends on the exogenous shock persistence and the signal-to-noise ratio.

This is not the case when agents forecast an endogenous variable, which depends on each other beliefs and actions, giving rise to a beauty contest game with higher-order beliefs. Since the degree of anchoring in expectations is higher at each belief order, this leads to larger anchoring in expectations of endogenous aggregates, summarized by $G_1 < G_2 < G$.

## 4.3 Persistence and Volatility

**Persistence** I repeat the empirical analysis of the inflation dynamics over time in the light of the implied model dynamics. In section 2 I test for changes in inflation dynamics assuming that inflation follows an exogenous AR(1) without considering that the error term could be serially correlated as the NI model suggests. I repeat our structural break analysis, and report our estimates in Table 9. In the second column I report the estimated coefficients using Newey-West standard errors that control for the AR(1) structure of the error term. Again, our results suggest that inflation fell from 0.814 to 0.491 in the recent decades.

In the noisy information framework inflation intrinsic persistence is governed by $\vartheta$. Propositions 1-4 establish a direct relation between $\vartheta$ and $\beta_{CG}$, our empirical measure of infor-

32. In the benchmark model $\lambda = 0$ and the best prediction of the current monetary policy shock is the signal itself, $\mathbb{E}_{it} v_t = x_{it}$, which has zero noise.

Table 10: Persistence and Volatility

| | Pre 1985 | Post 1985 ($\phi_\pi = 1$) | Post 1985 |
|---|---|---|---|
| Persistence | 0.739 | 0.486 | 0.444 |
| Volatility | 0.459 | 0.808 | 0.235 |

mation frictions. Figure 3b shows graphically the monotonically increasing relation between $\vartheta$ and $\beta_{CG}$, holding $\phi_\pi$ constant. Since I model the post-1985 period as the change in two parameters, $\phi_\pi$ and $\beta_{\mathcal{M}}$, I study one change at a time. In the initial pre-1985 period, with $\phi_\pi = 1$ and $\beta_{\mathcal{M}} = 1.50$, the model-implied inflation persistence is $\vartheta = 0.739$. If I hold $\phi_\pi$ constant and instead calibrate information frictions to match the post-1985 period $\beta_{\mathcal{M}} = 0.39$, I obtain $\vartheta = 0.486$. Finally, if I allow for an increase in $\phi_\pi$ to 2, the model-implied intrinsic persistence falls to $\vartheta = 0.444$. Comparing our model results with our empirical analysis in Table 9, I find that the NI framework produces persistence dynamics that lie within the 95% confidence interval.[33] Noisy information produces such fall in a micro-consistent manner, compared to the standard ad-hoc NK models studied in Section 3.

**Volatility** Using inflation dynamics (4.4) I can write inflation volatility as

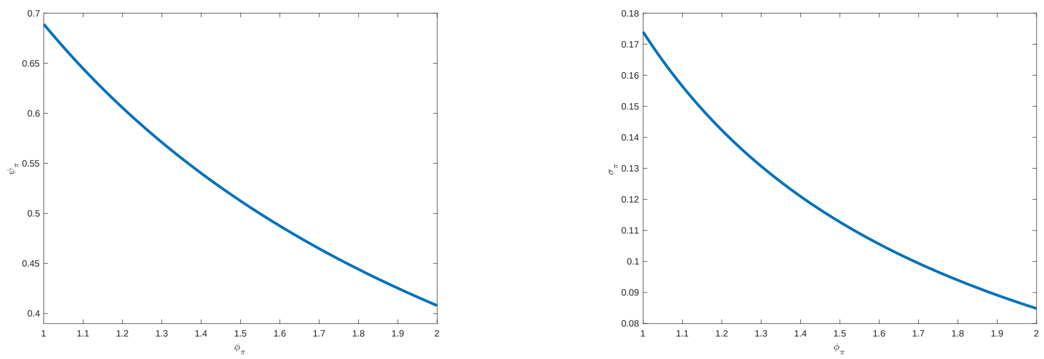
$$\sigma_\pi = \psi_\pi \chi(\vartheta) \left(1 - \frac{\vartheta}{\rho_v}\right) \frac{1}{\sqrt{1 - \vartheta^2}}$$

One can show that a reduction in information frictions, which produces a decrease in $\vartheta$ by Proposition 2, leads to an *increase* in inflation volatility. The rationale for this result is simple: a lessening in information frictions unanchores individual forecasts, which leads to more volatile forecasts and actions, increasing inflation volatility. Therefore, the change in belief formation cannot explain the fall in inflation volatility *on its own*. It is here where the documented increase in the monetary authority response to excess inflation matters the most. One can show that

$$\frac{\partial \sigma_\pi}{\partial \phi_\pi} = \frac{\partial \sigma_\pi}{\partial \vartheta} \frac{\partial \vartheta}{\partial \phi_\pi} + \frac{\partial \sigma_\pi}{\partial \psi_\pi} \frac{\partial \psi_\pi}{\partial \phi_\pi} < 0$$

Since volatility decreases with information frictions, $\partial \sigma_\pi / \partial \vartheta < 0$. By Proposition 2, the second term is also negative. The third term is positive (see condition (3.6)), and the fourth term is negative since $\psi_\pi$ (3.6) is decreasing in $\phi_\pi$. In net, an increase in $\phi_\pi$ leads to a reduction in volatility, as shown in Figure 4b, because the effect of $\phi_\pi$ on $\vartheta$ is small, as shown graphically in Figure 2a, and the effect of $\phi_\pi$ on $\psi_\pi$ is large, as shown in Figure 4a.

33. The change in $\phi_\pi$ is not quantitatively important for inflation persistence, but will be key to match the fall in inflation volatility.




(a) $\psi_\pi$ and $\phi_\pi$. (b) Volatility and $\phi_\pi$.

Figure 4: Comparative statics.

Quantitatively, I proceed by parts as in the previous section. In the initial pre-1985 period, with $\phi_\pi = 1$ and $\beta_{\mathcal{M}} = 1.50$, the model-implied inflation volatility is $\sigma_\pi = 0.459$. If I hold $\phi_\pi$ constant and instead calibrate information frictions to match the post-1985 period $\beta_{\mathcal{M}} = 0.39$, I obtain that volatility increases to $\sigma_\pi = 0.808$. Finally, if I allow for an increase in $\phi_\pi$ to 2, the model-implied volatility falls to $\sigma_\pi = 0.235$. Comparing our model results with our summary statistics in Table 1, I find that the NI framework produces a volatility fall of 50%, in line with our empirical findings.

# 5 The "Inflation Disconnect" Puzzle and the Flattening of the Phillips Curve

The monetary literature has documented the fall in the sensitivity of inflation with respect to other (real) variables and shocks (see Del Negro et al. 2020). The most well-known (structural) inflation equation is the New Keynesian Phillips curve (3.2) which relates current inflation to the current output gap and expected future inflation. Notice that, in this framework, inflation is *only* related to output *through* the Phillips curve slope $\kappa$. Therefore, the only possible explanation for the lack of dependence of inflation on output is the fall in $\kappa$. The literature has focused extensively on the slope of the Phillips curve with respect to output gap, in the hope of showing that this relation has somehow flattened and that inflation is independent of any other variable. The empirical evidence is mixed. As I show below, the mainstream finding that the slope of the Phillips curve has fallen in the recent period is simply the result of a misspecified Phillips curve equation (3.2).

In the next subsections I will first explain the fall in inflation sensitivity through changes in expectations, and then I will show empirically that there is no evidence for a fall in $\kappa$ once we control for non-standard expectations.

## 5.1 Inflation Disconnect via Expectations

In the next of the text I argue that, once we consider a micro-founded Phillips curve that takes into account noisy information, there is no evidence of a change in the Phillips curve slope.

I begin by estimating the standard Phillips curves (3.2) and test for a structural break in the output gap slope. I report our results in Table 11. In column 1 I obtain a negative coefficient in the NK slope, which has been a common puzzle in the empirical NK literature and has led authors to search for alternative proxies for economic slack (see Gali and Gertler 1999). I find (column 2) that the slope break is significant at the 5% level, suggesting a flattening in the Phillips curve, which the literature has extensively interpreted as an explanation of the inflation disconnect puzzle.

I then simulate the model dynamics (4.3) and (4.4) under the two pre- and post-1985 regimes,[34] and estimate the NK Phillips curve (3.2) by standard GMM methods using as instruments the 4-quarter lag of output and inflation. On the one hand, I find that $\hat{\kappa} < 0$ in the pre-1985 period (Table 11, column 1), which is large but qualitatively aligns with my empirical findings. On the other hand, I find that this coefficient is no longer significant in the post-sample period (column 2). That is, model-generated data suggests an *as if* fall in the standard NK Phillips curve slope. We argue below that this change in the sensitivity of inflation towards output can be micro-founded as a change in belief formation.

Let us first recall inflation dynamics in the standard model. In the benchmark NK model the Phillips curve is given by (3.2), the DIS curve is given by (3.1), the Taylor rule is given by (3.3) and the monetary policy shock process is given by (3.4). Inserting the Taylor rule (3.3) into the DIS curve (3.1), one can write the model as a system of two first-order stochastic difference equations with reduced-form dynamics $\boldsymbol{x}_t = \boldsymbol{\delta}\mathbb{E}_t\boldsymbol{x}_{t+1} + \boldsymbol{\varphi}v_t$. Angeletos and Huo (2021) show that, using the NI dynamics (4.3)-(4.4), we can reverse engineer an *as if* system

34. I simulate the model for 10,000 periods, remove the first 1,000 and take a random sample that is of the same size as my data sample.

Table 11: Regression table

| $\pi_t = \kappa\tilde{y}_t + \beta\pi_{t+1} + u_t$ | Data | | Simulated data | |
|---|---|---|---|---|
| | Full Sample | Break | Pre 1985 | Post 1985 |
| $\tilde{y}_t$ | $-0.0261$ | $-0.114^{**}$ | $-0.692^{***}$ | $-0.667$ |
| | (0.0236) | (0.0452) | (0.166) | (0.474) |
| $\pi_{t+1}$ | $0.991^{***}$ | $0.996^{***}$ | $1.164^{***}$ | $0.845^{***}$ |
| | (0.0175) | (0.0171) | (0.0338) | (0.141) |
| $\tilde{y}_t \times \mathbb{1}_{\{t\geq t^*\}}$ | | $0.122^{**}$ | | |
| | | (0.0566) | | |
| Observations | 203 | 203 | 203 | 203 |

Newey West (lag 1) standard errors in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

dynamics that mimic the dynamics of our NI model, such that the following ad-hoc system of equations

$$\boldsymbol{x}_t = \boldsymbol{\omega}_b \boldsymbol{x}_{t-1} + \boldsymbol{\omega}_f \boldsymbol{\delta}\mathbb{E}_t \boldsymbol{x}_{t+1} + \boldsymbol{\varphi} v_t \tag{5.1}$$

satisfies the model dynamics for some arbitrary pair of $2 \times 2$ matrices $(\boldsymbol{\omega}_b, \boldsymbol{\omega}_f)$. The next proposition states that, under certain pair $(\boldsymbol{\omega}_b, \boldsymbol{\omega}_f)$, the ad-hoc economy produces the same dynamics that our noisy information framework

**Proposition 6.** *The ad-hoc hybrid dynamics* (5.1) *produces identical dynamics to the noisy information model for certain matrices. The as if DIS and Phillips curve dynamics are described by*

$$\tilde{y}_t = \frac{\omega_{y\pi}}{\sigma}\pi_{t-1} - \frac{1}{\sigma}\mathbb{E}_t r_t + \frac{\delta_{yy}}{\sigma}\mathbb{E}_t\tilde{y}_{t+1} + \frac{\delta_{y\pi} - 1}{\sigma}\mathbb{E}_t\pi_{t+1} \tag{5.2}$$

$$\pi_t = \omega_{\pi\pi}\pi_{t-1} + \kappa\tilde{y}_t + \delta_{\pi y}\mathbb{E}_t\tilde{y}_{t+1} + \delta_{\pi\pi}\beta\mathbb{E}_t\pi_{t+1} \tag{5.3}$$

*where* $(\omega_{y\pi}, \omega_{yy}, \omega_{\pi y}, \omega_{\pi\pi}, \delta_{y\pi}, \delta_{yy}, \delta_{\pi y}, \delta_{\pi\pi})$ *depend on the* $(\boldsymbol{\omega}_b, \boldsymbol{\omega}_f)$ *pair.*

*Proof.* See Appendix A. □

Different weights in $\boldsymbol{\omega}_f$ are consistent with NI dynamics, although dynamics are unique. Intuitively, agents' actions can be anchored/myopic with respect to aggregate output or inflation. Hence, in order to study the dynamics in the Phillips curve, the theorist is left with two degrees of freedom, since the restrictions imposed on $\boldsymbol{\omega}_f$ result in two equations and four unknowns. To discipline the unknown weights, I assume that agents are only myopic

Table 12: Regression table

| | (1) Full Sample | (2) Break Output | (3) Break Inflation |
|---|---|---|---|
| $\tilde{y}_t$ | 0.192** | 0.273* | 0.265** |
| | (0.0941) | (0.142) | (0.112) |
| $\pi_{t+1}$ | 0.677*** | 0.646*** | 0.499*** |
| | (0.0740) | (0.0876) | (0.104) |
| $\pi_{t-1}$ | 0.309*** | 0.340*** | 0.481*** |
| | (0.0743) | (0.0873) | (0.102) |
| $\tilde{y}_{t+1}$ | −0.221** | −0.307** | −0.272** |
| | (0.104) | (0.142) | (0.120) |
| $\tilde{y}_t \times \mathbb{1}_{\{t \geq t^*\}}$ | | −0.183 | |
| | | (0.198) | |
| $\tilde{y}_{t+1} \times \mathbb{1}_{\{t \geq t^*\}}$ | | 0.191 | |
| | | (0.196) | |
| $\pi_{t-1} \times \mathbb{1}_{\{t \geq t^*\}}$ | | | −0.366* |
| | | | (0.200) |
| $\pi_{t+1} \times \mathbb{1}_{\{t \geq t^*\}}$ | | | 0.406* |
| | | | (0.209) |
| Observations | 203 | 203 | 203 |

Standard errors in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

vis-a-vis their own variable.[35]

**Assumption 1.** *The myopia matrix $\boldsymbol{\omega}_f$ is diagonal.*

I obtain the NI Phillips curve coefficients under both sub-periods. As in section 4.1, we keep all parameters unchanged across subsamples except for the inflation response in the Taylor rule and the degree of information frictions. In the initial pre-1985 period, with $\phi_\pi = 1$ and $\beta_{\mathcal{CG},\text{pre}} = 1.50$, the model produces considerable anchoring, which lines up with the strong inflation persistence during that period, and output gap expectations are irrelevant for inflation dynamics.

Let us now consider the post sample. If I set $\phi_\pi = 2$ and recalibrate information frictions to match $\beta_{\mathcal{CG},\text{post}} = 0.39$, I obtain that the Phillips curve has become *more* forward-looking, since the relative importance of lagged (expected) inflation has decreased (increased). Importantly, the future output gaps coefficient becomes negative, which reduces the importance

35. In the benchmark NK model with no information frictions I have $\omega_{b,11} = \omega_{b,12} = \omega_{b,21} = \omega_{b,22} = \omega_{f,12} = \omega_{f,21} = 0$ and $\omega_{f,11} = \omega_{f,22} = 1$. As a result, $\omega_{\pi y} = \omega_{\pi\pi} = \delta_{\pi y} = 0$, $\delta_{\pi\pi} = 1$ and the Phillips curve is reduced to (3.2).

Table 13: NI Phillips Curve

| | Pre 1985 | Post 1985 |
|---|---|---|
| $\omega_{\pi\pi}$ | 0.562 | 0.399 |
| $\delta_{\pi y}$ | 0.000 | -0.114 |
| $\delta_{\pi\pi}$ | 0.405 | 0.633 |

of real variables for inflation dynamics. To see this more clearly, suppose that an econometrician estimates a hybrid Phillips curve as in Galí and Gertler (1999). Assuming, as is common in the literature, that the demand side follows an independent AR(1) process with persistence $\rho_y$, we can write the sensitivity to the demand side as $(\kappa + \delta_{\pi y}\rho_y)\tilde{y}_t$. Given our model parameterization, $\kappa = 0.172$, and that output is highly persistent in the data, the econometrician would naively find that the slope $\kappa$ has fallen, whereas the disconnect really occurred via expectations.

To confirm this, I estimate the NI Phillips curve (5.3) and test for a structural break in the output gap slope. I report my results in Table 12. I find that all coefficients in the noisy information NK Phillips curve are significant (column 1), suggesting that extending the original NK Phillips curve to lagged inflation and forward output gap expectations captures well the Phillips curve dynamics. I find no evidence for a structural break in the NK slope (i.e., no evidence of flattening in the Phillips curve), reported in the second column. In the light of our NI estimates, I take the "NK flattening puzzle" as a result of misspecification in the standard Phillips curve. I find a structural break in lagged and forward inflation: in the recent decades the Phillips curve has become *more* forward-looking. This last result aligns well with the documented drop in information frictions and the mechanism suggested in the NI framework.

## 5.2 Controlling for Non-standard Expectations

In order to obtain our results on inflation persistence we have assumed a particular information structure, noisy and dispersed information. In this section we take a step back and instead take an agnostic stance on expectation formation. Starting from the individual Phillips curves (4.1), iterating forward and aggregating across firms we obtain the aggregate Phillips curve

$$\pi_t = \kappa\theta \sum_{k=0}^{\infty} (\beta\theta)^k \overline{\mathbb{E}}_t^f \tilde{y}_{t+k} + (1-\theta) \sum_{k=0}^{\infty} (\beta\theta)^k \overline{\mathbb{E}}_t^f \pi_{t+k} \tag{5.4}$$

where $\overline{\mathbb{E}}_t^f(\cdot) = \int_0^1 \mathbb{E}_{it}(\cdot)di$ denotes the cross-sectional mean (firm) forecast at time $t$.

Inflation is now related to current *and future* output through two different channels: the slope of the Phillips curve, $\kappa$, and firms' expectation formation process. In order to test for a potential structural break in the slope *controlling for* non-standard expectations, I regress the *general* Phillips curve (5.4) (truncated at $k = 4$), for which I do not assume a particular information structure, using real GDP and GDP Deflator growth forecast data from the SPF,

$$\pi_t = \alpha + \beta_1 \overline{\mathbb{E}}_t^f \tilde{y}_t + ... + \beta_5 \overline{\mathbb{E}}_t^f \tilde{y}_{t+4} + \gamma_1 \overline{\mathbb{E}}_t^f \pi_t + ... + \gamma_5 \overline{\mathbb{E}}_t^f \pi_{t+4} + \eta_t \tag{5.5}$$

where $\eta_t$ denotes a truncation error. Equation (5.5) can be estimated with OLS, since the SPF survey takes place in the middle of each quarter, before the inflation statistic is reported.[36] I report our results in Table A.10. In the first column we find the estimated coefficients in regression (5.5). Focusing on the first output term, I find that $\hat{\beta}_1 = \kappa\theta \approx 0.13$, which coincides with our model-predicted value of $\kappa$. In column 2 I report the structural break version of regression (5.5). We find only weak evidence for a break in the 3-quarter-ahead inflation forecast, and no evidence of a change at other horizons, which supports the notion that the change in inflation dynamics is not coming from an increase in $\kappa$.

An equation like (5.5) is also useful to test for the null of the Law of Iterated Expectations (LIE) assumption. In order to derive the standard Phillips curve the literature assumes a weaker version of FIRE, the LIE. According to the LIE current expectations of 1-quarter-ahead inflation is a sufficient statistic for forecasts of macroeconomic variables at $t+1$, $t+2$,... As a result, all other variables should not be statistically significant. We find that, on top of the 1-quarter inflation forecast, nowcasts and 4-quarter forecasts of output and inflation are significant, which suggests that the LIE does not hold (for the *average* firm) and gives rise to higher-order beliefs.

Alternatively, and since we are not interested in the discount factor nor the Calvo pricing frictions, we do not attempt to estimate them. Instead, we set them to the standard quarterly values $(\beta, \theta) = (0.99, 0.75)$, and regress

$$\pi_t = \alpha_1 + \alpha_2 \tilde{y}_t^e + \alpha_3 \pi_t^e + \eta_t \tag{5.6}$$

where $\tilde{y}_t^e = \theta \sum_{k=0}^{4} (\beta\theta)^k \overline{\mathbb{E}}_t^f \tilde{y}_{t+k}$ and $\pi_t^e = \sum_{k=0}^{4} (\beta\theta)^k \overline{\mathbb{E}}_t^f \pi_{t+k}$ denote the truncated sums of expected real GDP and inflation. We estimate the regression via OLS. We also report our estimates using standard GMM methods by instrumenting for expectations with 4-quarter lagged annual inflation and real GDP growth expectations in Table 14. I report in column 1 the OLS coefficients. I find that $\kappa$ is smaller than in our framework, and similar to the

36. We do not use standard GMM methods since the structural break version of (5.5) would require at least 30 instrumental variables.

Table 14: Regression table

| | OLS | | GMM | |
|---|---|---|---|---|
| $\tilde{y}_t^e$ | 0.0426 | 0.00353 | 0.144$^{*}$ | 0.100 |
| | (0.0279) | (0.0294) | (0.0817) | (0.0782) |
| $\pi_t^e$ | 0.365$^{***}$ | 0.357$^{***}$ | 0.336$^{***}$ | 0.298$^{***}$ |
| | (0.0136) | (0.0163) | (0.0148) | (0.0281) |
| $\tilde{y}_t^e \times \mathbb{1}_{\{t \geq t^*\}}$ | | 0.0967$^{**}$ | | 0.00851 |
| | | (0.0383) | | (0.0841) |
| $\pi_t^e \times \mathbb{1}_{\{t \geq t^*\}}$ | | $-0.125^{***}$ | | $-0.120^{***}$ |
| | | (0.0226) | | (0.0377) |
| Constant | $-0.155^{***}$ | $-0.0123$ | $-0.233^{*}$ | 0.0729 |
| | (0.0522) | (0.0764) | (0.121) | (0.182) |
| Observations | 199 | 199 | 199 | 199 |

HAC robust standard errors in parentheses

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

value found by Hazell et al. (2020). In column 2 we regress its structural break version. This is the only specification that suggests a structural break on the slope, and is on the opposite direction of what the literature suggests. In the last two columns we report our GMM estimates. We find an estimate of $\kappa$ that aligns well with our model prediction, and we find no evidence of a structural break in the NKPC slope.[37]

# 6 Conclusion

In this paper I document a fall in inflation persistence and volatility since the mid 1980s. State-of-the-art monetary models can explain the volatility fall, but face significant challenges in explaining the contemporaneous fall of persistence. I show that, by extending the benchmark NK in a micro-consistent manner relaxing the FIRE assumption, our model generates the documented fall in persistence. Using micro-data on inflation expectations from the Survey of Professional Forecasters (SPF), I show that agents became more informed about inflation after the change in the Federal Reserve disclosure policy, which endogenously lowers the intrinsic persistence in inflation dynamics.

I revisit different theories that produce a structural relation between inflation and other forces in the economy, based on the NK environment. I show that, although standard models are successful in explaining the fall in inflation volatility, a variety of NK models cannot ex-

37. We repeat the analysis using the Livingston Survey on Appendix B, and find similar results.

plain the fall in inflation persistence. I document that the structural break around 1985:Q1 in inflation persistence coincides with a structural change in the Fed reaction function, in which the monetary authority increased its aggressiveness towards excess inflation. This change in the monetary stance reduces inflation volatility but has no effect on inflation persistence. Since the model is purely forward-looking, inflation exhibits no intrinsic persistence, and its dynamic properties are now inherited from monetary policy shocks. However, I document that monetary policy shocks persistence has not changed over time. Acknowledging that purely forward-looking models cannot generate anchoring or intrinsic persistence I extend the benchmark model to incorporate a backward-looking dimension. I show that the change in the monetary stance now affects inflation intrinsic persistence. The effect, however, is small.

I then show that our (noisy and dispersed information) departure from the FIRE assumption is consistent with the micro-data evidence on belief formation, and generates anchoring or intrinsic inflation persistence. Using SPF data, I document a structural break in expectation formation that is contemporaneous to the fall in inflation persistence and the change in the monetary stance, resulting in agents being more informed about inflation.

I discuss the consequences of noisy information on the "inflation disconnect puzzle" and the lack of flattening of the Phillips curve. In the noisy information model inflation is related to the demand side through two different channels: the slope of the Phillips curve and firms' expectation formation process. Our model explains the fall in inflation sensitivity towards the demand side of the economy via changes in expectations, without resorting to changes in the slope. Finally, taking an agnostic stance on expectations, I show that there is no empirical evidence for a change in the Phillips curve slope once we control for non-standard expectations.

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