The Perceived Sources of Unexpected Inflation *

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Abstract

We use high-frequency asset price changes around Consumer Price Index announcements in the US to learn about market perceptions regarding the economy. First, we document three facts. An unexpected increase in the CPI inflation leads to an increase in (a) treasury nominal yields (b) forward breakeven inflation rates. The response of the stock price and the future annual dividends of S&P 500 companies varies over the years, which is key for our identification of demand versus supply shocks. We interpret these facts through the lens of a New Keynesian Model with an inflation announcement to decompose unexpected inflation into demand and supply components. We find that the share of supply in unexpected inflation has increased by 20 percentage points post-covid.

JEL Codes: E31, E40, E44, E50, D80, D84

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1 Introduction

Finance literature has documented huge asset price movements around macroeconomic news releases for many decades. However, how these asset price movements reflect market perceptions of macroeconomic fundamentals, such as demand or supply, has been relatively less explored. In this paper, we interpret these asset price movements through the lens of a New Keynesian model with a macroeconomics news announcement, specifically inflation announcement.

Our model gives us a novel way to understand how unexpected inflation is decomposed into demand or supply components by the market. In our model, the demand shock is represented as a discount factor shock, while the supply shock can be interpreted as a markup shock, a labor supply shock, or a technology shock. Importantly, our focus is on the market's perception of the sources of unexpected inflation, rather than actual or expected inflation. Understanding how the market attributes unexpected inflation into demand and supply components is useful for several reasons.

Firstly, both policymakers and professional forecasters have been repeatedly caught off guard by inflation in recent years[1]. Understanding where we went wrong is important. The model allows us to understand how the market attributes its mistakes, or the unexpected components of inflation into demand and supply. The policymakers can either learn from the market decomposition or can guide the market if required. It will also help in better forecasting of market response to different policies. Secondly, "demand" and "supply" conditions are frequently referenced in FOMC speeches, and the policy responses differ based on the nature of these shocks [2]. Even if we only shed light on the demand and supply shocks related to unexpected inflation, this information could still be valuable for informing policy decisions.

The key intuition for distinguishing between demand and supply shocks is as follows. According to textbook economic theory, when both prices and quantities increase, it typically indicates a demand shift. Conversely, if prices rise while quantities fall, it suggests a supply shift. Similarly, in the case of a positive surprise in inflation, if consumption expectations increase, it implies that a positive demand shock is playing a significant role in the unexpected inflation. On the other hand, if consumption expecta-

[1] *The economy has repeatedly surprised us and all other forecasters* - Jerome Powell, Dec 1, 2023

[2] https://www.federalreserve.gov/newsevents/speech/powell20231109a.htm

tions decrease, it points to a negative supply shock being crucial. We construct a daily measure of consumption expectations and analyze its changes around Consumer Price Index (CPI) inflation announcements (see Figure 12). Consumption expectations rose with a positive surprise in inflation around the announcement before Covid, and fell after Covid, indicating the increasing role of supply shocks in unexpected inflation post Covid. While this graph provides qualitative insights, for a more quantitative analysis, we examine other asset price movements around CPI announcements and develop a model to interpret these movements.

In the first part of the paper, we study high-frequency asset price movements around Consumer Price Index (CPI) announcements in the US. We document several facts. An unexpected increase in CPI inflation leads to an average increase in treasury yields for bonds maturing in 2 years and longer. The forward breakeven inflation rates, as measured by TIPS, also increases on an average. The response of S&P 500 stock price and dividend futures to the surprise could be positive or negative for different years, which is key for our identification of demand or supply shocks.

To interpret the empirical facts, we write a standard New Keynesian model with Calvo pricing and Taylor rule. The new element added to this model is the aggregate inflation announcement. The model mechanism is as follows. Inflation is a combination of the underlying demand and supply shocks. Thus, when the announcement takes place, the aggregate inflation acts as an additional signal of the underlying two shocks. The market participants, have incomplete information about the two shocks, and thus use the inflation signal to update their beliefs about the underlying shocks by Bayes' rule.

By Bayes' rule, the market revises their beliefs more significantly about the shock that has the greatest impact on inflation. For example, if in a model, demand shocks are perfectly accommodated and do not affect inflation much, then a surprise in inflation will not lead to an update in beliefs about demand shocks much. Second, beliefs about those shocks are revised more, for which the household is more uncertain. For example, if there has been an unprecedented fiscal policy, and the market is very uncertain about the demand conditions, then in those circumstances, a positive surprise in inflation will lead to more of an upward revision of the positive demand shock. Analogously, a war in Ukraine starts, and the market is more uncertain about supply chain bottlenecks, then a positive surprise in inflation will lead to them attributing it more to a negative supply shock. The revision of beliefs about the current underlying shocks leads to the revision of beliefs regarding the future states of the economy as well. This is due to the persistence of the underlying shocks. This will further change beliefs about future interest rates and output in the model.

We now try to match the observed asset price movements around CPI announcements to the model. We measure changes in future interest rate expectations around the announcement using treasury yields, and we infer changes in future consumption expectations using a tracking portfolio involving dividends futures.

We construct a sufficient statistic for the share of each shock in unexpected inflation. The sufficient statistic depends on the parameter values of the New Keynesian values and the ratio of the change in consumption expectations divided by the change in interest rate expectations around the announcement. This ratio varies announcement by announcement and the share of demand (supply) in unexpected inflation increases (decreases) with this ratio. Intuitively, with a positive surprise in inflation (price increases), if consumption expectations increases (quantity increases), it is likely more demand driven, and if consumption expectations fall (quantity falls), it is likely more supply driven. Consumption expectations mostly fell with a positive surprise in inflation post covid. We calculate that the share of supply in unexpected inflation increased by 20 percentage points post-covid.

Related Literature. This paper broadly contributes to three strands of literature. There is a rapidly growing literature that studies the sources of the recent inflation surge. Shapiro (2022) uses the underlying category level data of the personal consumption expenditures index (PCE) and similar price quantity comovement identification to decompose inflation into demand and supply components. Bernanke and Blanchard (2023) use a simple dynamic model of prices, wages, and short-run and long-run inflation expectations to estimate the sources of inflation. Gagliardone and Gertler (2023) highlight the role of supply shocks by using a quantitative New Keynesian Model with oil as a complementary good. Rubbo (2023) uses cross-sectional variation in a heterogeneous New Keynesian model to quantify the contribution of demand versus inflation in the recent few years. Comin et al. (2023) and Acharya et al. (2023) highlight the role of supply bottlenecks during this time. Our study contributes to this literature by shifting the focus from actual to perceived sources of inflation, providing a novel perspective on how market participants interpret inflationary pressures. Additional papers that focus on perceived sources of inflation are Cieslak and Pflueger (2023) and Pflueger (2023). They show that different types of shocks should generate different bond-stock correlation through the lens of a New Keynesian Model. We, on the other hand, specifically focus on asset price changes around CPI announcements to get the causal impact of this information on market expectations. Through the lens of a basic New Keynesian model, we extract the change in beliefs about underlying sources of *unexpected* inflation.

There is a vast literature on the reaction of financial markets to macroeconomic news and no attempt is made to do a survey here. McQueen and Roley (1993), Faust et al. (2007), Savor and Wilson (2013), Ai and Bansal (2018), Fisher et al. (2022), Gil de Rubio Cruz et al. (2023) and Bocola et al. (2024) are few of the papers that influenced our thinking. There is also a huge literature on the impact of monetary policy announcements on asset prices starting from Cook and Hahn (1989) and Kuttner (2001). Mertens and Zhang (2023) also does an event study analysis to understand how New Keynesian parameters change around announcement. We contribute to this literature by specifically modelling announcement in a New Keynesian model. We interpret the asset price reaction to announcement results through the model to extract the belief updates in the underlying macro-fundamental shocks.

Finally, some parallels can be drawn with the literature that tries to decompose a monetary policy announcement into monetary versus non-monetary news. Melosi (2017), Nakamura and Steinsson (2018), and Jarociński and Karadi (2020) were particularly relevant. Our paper, instead, decomposed macroeconomic news releases into demand versus supply shock components.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 provides summary statistics and empirical results,. Section 4 writes a model to intepret the empirical results. Section 5 describes the equilibrium. Section 6 talks about the findings of the paper. Section 7 concludes with the next steps.

2 Data

We use the expectations of CPI from Bloomberg and high-frequency changes in asset prices from the Fed, Chicago Mercantile Exchange, Tickdata and Bloomberg.

Bloomberg survey: Bloomberg surveys academics, professionals from banks, finance, etc. regarding their forecast, or more appropriately "backcast", for the past month's CPI. The data is available in their "ECO" function. According to Bloomberg, "surveys listed on the ECO function normally start one to two weeks before a release, and are updated on a constant, real-time basis leading up to that release". Thus, if the CPI for October 2023 is announced on November 14, 2023 at 8:30 AM EST, then the survey opens up around November 1, 2023, and the surveyees are allowed to update their "backcasts" until 8:29 AM EST on November 14, 2023. Thus, any information released until the announcement could be taken into account by the surveyees in forming their "backcasts". The variables included in this dataset are the date and time of announcement, the event that is announced and the announced value (the original source being **Bureau of Labor Services** for that), the survey median, high, low, average and standard deviation of the "backcast", number of people surveyed and some sparse information about previous periods' revisions. We specifically focus on the data from 2004-2022 and the data is at monthly frequency. CPI monthly announcements became scheduled regularly 2004 onwards and 2022 is the end of our sample.

Asset price data: We use the tick-level Treasury futures data (tickers TU, FV and TY) from the Chicago Mercantile Exchange and tickdata.com. We calculate the implied yields using the corresponding duration from Bloomberg [3]. We use data about the daily nominal treasury yields [4] and real treasury yields[5] from the Fed. We collect data on daily dividend futures and stock price of S&P 500 from Bloomberg.

Consumption: We collect monthly nominal aggregate consumption expenditures on non-durables and services from National Income and Product Accounts (NIPA) Table 2.8.5.

[3] using the Bloomberg variable Conventional CTD Forward Risk
[4] https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html
[5] https://www.federalreserve.gov/data/tips-yield-curve-and-inflation-compensation.htm

3 Summary Statistics and Empirical Results

Our goal in this section is to show summary statistics about inflation surprises and document facts about the effect of these inflation surprises of scheduled consumer price index (CPI) announcements on the bond and stock market.

We look at the seasonally adjusted CPI for all urban consumers. We define a surprise in CPI inflation as follows:

$$surprise_t^{CPI} \equiv CPI_t^{ann} - \mathrm{E}[CPI]_t^{Bloomberg} \tag{1}$$

where CPI_t^{ann} is the CPI announced in period t for the past period or month $t-1$ (in percentage form) and $\mathrm{E}[CPI]_t^{Bloomberg}$ is the median expectations of the surveyees of Bloomberg in period t regarding the CPI of the past month $t-1$. The CPI announcement and the survey are for both core goods (excluding food and energy, referred to as CPI Core) and all the goods (referred to as simply CPI) in the basket. We focus on CPI month-on-month (MoM) announcement and surprise because conceptually CPI month-on-month surprise is easier to interpret within a model where each time-period is a month, and inflation news about the month is revealed in the announcement. However, the results are similar for CPI year-on-year (YoY) as well.

We plot the time series of CPI MoM and CPI Core MoM surprises from mid 1998 onwards till 2023 in figure 1 to show that there were both negative and positive surprises throughout the sample, largely between -.2% and .2%. However, in the recent few years, surprises shot up as high as .8% as well. It shows that the survey participants did not systematically over or under forecast in particular time periods. To add more validation to forecast capabilities of the surveyors, we plot a scatter plot of the survey median versus the announced value in Figure 2. Clearly, the forecasts predicts the actual values very well.

We now proceed to try and understand the impact of these surprises on various assets. We focus on CPI Core MoM to avoid the volatility driven by food and energy prices. Specifically, we estimate

$$\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMoM} + \epsilon_t \tag{2}$$

Here ΔY_t is the change in the outcome variable of interest (e.g., the yield on a zero-coupon Treasury bond, log price of S&P500 etc.), $surprise_t^{CPICoreMoM}$ is a measure of the surprise in inflation revealed in the CPI announcement, ϵ_t is an error term, and α and β are regression parameters. The parameter of interest is β, which measures the effect of the surprise in inflation on the asset prices.

We first document facts about the response of bond market to a surprise in inflation. We focus on the years 2004-2023 because announcements became regularly scheduled 2004 onwards, and because the TIPS bond market was more illiquid earlier (D'Amico et al., 2018). First, we look at daily changes in nominal yields of zero coupon bonds with maturities from two to ten years (Figure 3). We find that a 1% increase in CPI Core MoM leads to around an average 20 basis point increase in nominal yields two years from now on. The positive effect on nominal yields is significant but muted for longer maturities. We also construct high-frequency changes in nominal yields of treasury bonds using Treasury futures data. The CPI announcement occurs at 8:30 AM, and we look at futures around a 30-minute window between 8:20 AM and 8:50 AM. We have treasury futures data for bonds maturing in 2, 5 and 10 years. As shown in Figure 4, the β coefficients for high-frequency change in nominal yields, and the daily change in nominal yields are very similar, but as expected the 95% confidence interval is tighter for the high-frequency coefficients. Finally, for further robustness, we use the Kim and Wright (2005)) measure of nominal yields that accounts for term premia in the bond pricing (refer to Figure 5). Although the positive effect on yield is more muted, the results are still significant. Finally there is some heterogeneity in the response of nominal yields to a surprise in inflation over the years (see figure 7). In the recent years, a 1% positive surprise in CPI Core MoM leads to a as high as a 70 basis point response in 2 year ahead nominal yields. Also, as expected, during the zero lower bound periods after the Great Recession and at the onset of covid, nominal yields hardly moved in response to a surprise in inflation. In the model, we will interpret this fact as the Fed's Taylor rule at work.

Second, we look at daily changes in forward breakeven inflation rates as implied by TIPS with maturities from two to ten years (Figure 6). We find that a 1% increase in CPI Core MoM leads to an average 15 basis point increase in inflation two years from now on. The positive effect on future inflation is muted for longer maturities. Both these facts are in line with what is documented in the literature for older years, for example as in Faust et al. (2007). The response of future forward breakeven inflation to a surprise in inflation rate also varies over the years (see figure 8). In the model section, we will interpret this fact as high persistence of the underlying shocks.

Now, we study the response of the stock market to a surprise in inflation (refer to figure 9). We find that both S&P 500 and Annual Dividends of S&P 500 as implied by dividend futures could either increase or decrease with a positive surprise in CPI. This is also in line with the literature that suggest that the response of the stock market to macroeconomic news releases in state-dependent (McQueen and Roley, 1993). This response in either direction is going to be key for our identification of demand or supply shocks, as we will show in later sections. Also, table 1 suggests that the impact of CPI surprises on the volatility in the stock market is insignificant.

To summarize, we find that the response of nominal yields and breakeven yields to a positive surprise in inflation is positive, significant and persistent many years ahead. The stock market response varies over the years. In the next section, we write down a model to interpret these empirical findings to help decompose the demand and supply contribution to unexpected inflation.

4 New Keynesian Model with Announcement

The section builds on a basic New Keynesian model as in Gali (2003) chapter 3, and adds an announcement of aggregate inflation to it. We also add dispersed information on the side of the firms when they fix their prices.

In a standard New Keynesian model, firms producing differentiated goods fix their prices and the representative household makes its consumption-savings decisions simultaneously. Another way to describe the model is that the firms fix their prices *first*, say in stage 1, having complete information about how the households are going to behave, and once the prices of the goods are fixed, in say stage 2, the representative household chooses how much of each of the differentiated goods to purchase, and how much to save in a one-period bond see Figure 10. This has the exact same real allocation as in the standard New Keynesian model. Our model timeline will also have these two stages, but we will also add an aggregate inflation announcement in the middle (see Figure 11) .

Fundamentals and information. We have two shocks in our economy: discount factor shock that we call the demand shock z_t^d, and a marginal cost shock, which could be interpreted as a markup, technology or labor supply shock z_t^s. The law of motion of the demand and supply shock z_t^k is given by an AR(1) process:

$$z_t^k = \rho_k z_{t-1}^k + u_t^k \tag{3}$$

where $u_t^k \sim \mathcal{N}(0, \sigma_{k0}^2)$ and $\rho_k \in (0,1)$. The normality assumption is for convenience in solving the model. The AR(1) process is chosen (instead of an i.i.d process for example) to capture the empirical fact that interest rates and inflation many years ahead measured from treasury yields and forward breakeven inflation rates also respond to a surprise in inflation. It is indicative of the idea that the shocks that are causing a surprise in inflation today are expected to persist and affect the future state of the economy as well.

The aggregate fundamentals of the economy in period t are identified by the joint distribution of the shocks $u_t \equiv (u_t^d, u_t^s)$. Firms have dispersed information about shock u_t in stage 1. To elaborate, firms j have dispersed signals about the underlying shocks $k \in (d, s)$

$$x_{jt}^k = z_t^k + u_{jt}^k$$

where $u_{jt}^k \sim \mathcal{N}(0, \sigma_k^2)$. If $\sigma_k^2 \to 0$, then we reach the situation where all firms have perfect information about u_t in stage 1, as is the case in a standard New Keynesian model described in the previous paragraph. We add dispersed information on the side of the firms to allow for the fact that these price-setting firms could have different precision of information regarding demand or supply shocks. The firms fix their prices based on their beliefs about the underlying shocks in order to maximize profits. The household needs to observe u_t as well as the all the prices set by firms only in stage 2 to make its optimal consumption-saving decision. The Fed also sets the interest rate i_t in stage 2. By stage 2, all the agents know the shock realization $u_t \equiv (u_t^d, u_t^s)$ with complete certainty. The timeline with the shocks can be represented as in Figure 11.

Stage 2. Since the household observes the shocks u_t perfectly in stage 2, as in a standard New Keynesian model, its total utility optimization exercise will yield the familiar log-linearized Euler equation (for microfoundations see A.1 or Gali (2003) Chapter 3).

$$c_t = \mathrm{E}_t\left[c_{t+1}\right] - \frac{1}{\gamma}\left(i_t - \mathrm{E}_t\left[\pi_{t+1}\right]\right) + z_t^d \tag{4}$$

z_t^d is the demand shock, and γ is the inverse of intemporal elasticity of consumption. The interest rate is set by the Fed's Taylor rule

$$i_t = \phi_\pi^{Tay}\pi_t + \phi_y^{Tay}(y_t - y_t^n) \tag{5}$$

where $y_t^n \equiv -z_t^s/(\gamma+\psi)$ is the natural level of output. z_t^s is the supply shock, and ψ is the Frisch elasticity of labor supply. ϕ^{Tay} are the Taylor coefficients. We could add a monetary shock to the model, but as long as the firms and households have the same information about the monetary shock, we can show that it will not matter for our purposes. So, we are refraining from including it here. In section 5.4, we will talk more about how monetary policy shocks can be interpreted in our model. The Taylor rule captures well the empirical fact stated in the previous section that nominal yields increase with a positive surprise in inflation.

Stage 1. The firms anticipate the household and Fed behavior in stage 2, and accordingly fix prices in stage 1 to maximise profits. Calvo rule applies, so only $1-\theta$ firms are allowed to change their prices every period.

If firm j is allowed to reset their price, they will choose the optimal price $p_t^*(j)$ that will maximise their present discounted value of current and future profits. Let $\pi_t^*(j) = p_t^*(j) - p_{t-1}$ be called the optimal reset inflation for firm j. In log-linearized form, it is given by

$$\pi_t^*(j) = (1-\beta\theta)E_{jt}\hat{mc}_t + E_{jt}\pi_t + \beta\theta E_{jt}\pi_{t+1}^*(j) \tag{6}$$

where $\hat{mc}_t = (\gamma+\psi)y_t + z_t^s$ and β is the discount factor. So a firm's optimal reset inflation depends on its expected marginal cost, expected current aggregate inflation, and its expected future optimal reset inflation. This is exactly how a firm sets its price in a standard New Keynesian model as in Gali (2003), except now it is firm specific expectations E_{jt} instead of E_t which is supposed to represent same expectations for all firms.

Now, exante at time t, all firms will be identical at $t+1$ because all the shocks are visible to all the firms at the end of the period t. Thus, $\pi^*_{t+1}(j) = p^*_{t+1}(j) - p_t$ is exante expected to be the same for all j and is equal to reset inflation averaged across all the firms π^*_{t+1}. The average reset inflation is given by

$$\pi^*_t = \int_j \pi^*_t(j)dj \tag{7}$$

Since only $(1-\theta)$ fraction of randomly chosen firms can change their prices, the aggregate inflation will be $1-\theta$ times average reset price of all firms i.e.,

$$\pi_t = (1-\theta)\pi^*_t \tag{8}$$

If all firms have perfect information about the shock u_t in stage 1, i.e, $\sigma^2_k \to 0$ for all $k \in (d,s)$ then we get the familiar Phillips curve as in a standard NK model

$$\pi_t = \beta \mathrm{E}_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \hat{mc}_t \tag{9}$$

Stage 1.5: Adding Announcement. At stage 1, the firms fix their prices. So an aggregate measure of inflation exists. However, at this stage, the households have incomplete information about the value of the shock $u_t \equiv (u^d_t, u^s_t)$, and cannot observe the prices set by the firms as well. They can observe both u_t and the prices only in stage 2. In real life, when firms set prices, the households can immediately observe them if they want to. However, all households do not purchase all goods, and thus they are unaware of aggregate inflation but only have incomplete information. Having multiple households with dispersed information about the prices would come at the cost of tractability. Thus, we make the simplifying assumption of a representative household which has incomplete information about the underlying structural shocks in stage 1. Between stage 1 and stage 2, we add another stage, called stage 1.5, where the only activity that takes place is an announcement of aggregate inflation (see Figure 11). The aggregate inflation is an additional source of information regarding the underlying fundamentals u_t and the household accordingly updates its belief regarding them. This has no impact on real allocations in our model, since the real allocations take place in stage 2, when all shocks are fully visible. Thus, the Euler equation, modified Phillips curve and Taylor rule remain unchanged.

Model Equilibrium Solution. As is standard in these type of models, the macro-variables are linear in the underlying shocks.

Lemma 1. *The equilibrium levels of aggregate output, inflation and interest rates can be given by a linear combination of the structural shocks (ignoring constants)*

$$c_t = \boldsymbol{a_c} \cdot \boldsymbol{z_t} \tag{10}$$

$$\pi_t = \boldsymbol{a_\pi} \cdot \boldsymbol{z_t} \tag{11}$$

$$i_t = \boldsymbol{a_i} \cdot \boldsymbol{z_t} \tag{12}$$

where $\boldsymbol{a_c} \equiv (a_c^d, a_c^s)'$, $\boldsymbol{a_\pi} \equiv (a_\pi^d, a_\pi^s)'$ *and* $\boldsymbol{a_i} \equiv (a_i^d, a_i^s)'$ *can be calculated in terms of model parameters.* $\boldsymbol{z_t}$ *is the vector of shocks,* $\boldsymbol{z_t} \equiv (z_t^d, z_t^s)'$

Proof. See Appendix A.1.

Furthermore, as expected in a standard New Keynesian model, a positive demand shock i.e., $z_t^d > 0$ leads to an increase in consumption, inflation and nominal interest rate $a_c^d > 0, a_\pi^d > 0, a_i^d > 0$ and a negative supply shock i.e., $z_t^s > 0$ leads to an decrease in consumption and an increase in inflation and nominal interest rate $a_c^s < 0, a_\pi^s > 0, a_i^s > 0$.

4.1 Announcement and Revision of Beliefs

At the end of stage 1 (before the announcement of aggregate price in stage 1.5), the household's prior about the underlying demand and supply shock z_t^k is given by

$$\mu_{ht}^k \equiv \mathbb{E}_{ht}^{ba} z_t^k$$

$$\sigma_h^{2k} \equiv \mathbb{V}_{ht}^{ba} z_t^k$$

Where $\mathbb{E}_{ht}^{ba}$ and $\mathbb{V}_{ht}^{ba}$ refers to expectations and variance of household (h) beliefs before announcement (ba) at time period t respectively. We are not taking a stance on what the value of μ_{ht}^k and σ_h^{2k} are. If the household receives no extra information or signals regarding the underlying shocks in stage 1, then their prior before announcement would simply be based on the underlying law of motion (3), i.e. $\mu_{ht}^k = \rho_k z_{t-1}^k$ and $\sigma_h^{2k} = \sigma_{k0}^2$. If the household receives additional signals in stage 1, then μ_{ht}^k and σ_h^{2k} would change accordingly. Also, no time subscript is given for the variance of household prior since it is assumed to be the same in every period (or sub-periods that we will focus on in the data).

From (11), since inflation is a linear combination of the underlying shocks in equilibrium, the household's prior belief about mean and variance of aggregate inflation price at the end of stage 1 before announcement is given by

$$\mu_{ht}^\pi \equiv \mathbb{E}_{ht}^{ba} \pi_t = a_\pi^d \mu_{ht}^d + a_\pi^s \mu_{ht}^s$$

and the variance is given by

$$\sigma_h^{2\pi} \equiv \mathbb{V}_{ht}^{ba} \pi_t = a_\pi^{2d} \sigma_h^{2d} + a_\pi^{2s} \sigma_h^{2s}$$

Also, the covariance of household prior between the shock and inflation is given by

$$cov_h^{\pi,k} \equiv cov_h(\pi, z_t^k) = a_\pi^k \sigma_h^{2k}$$

Now we focus on what happens to household's beliefs after the inflation announcement when they follow Bayes' rule.

Proposition 1. *The household's change in belief about shock k after π_t is announced (as say $\bar{\pi}_t$) is given by*

$$\underbrace{\mathrm{E}_{ht}\left[z_t^k | \pi_t = \bar{\pi}_t\right] - \mathrm{E}_{ht}^{ba}\left[z_t^k\right]}_{\Delta^{ann} E_{ht} z_t^k} = \frac{cov_h^{\pi,k}}{\sigma_h^{2\pi}}(\bar{\pi}_t - \mu_{ht}^\pi) = \frac{a_\pi^k \sigma_h^{2k}}{\sigma_h^{2\pi}} \underbrace{(\bar{\pi}_t - \mu_{ht}^\pi)}_{surprise_{ht}^\pi} \tag{13}$$

Proof of Proposition 1. We know that

$$\begin{pmatrix} z_t^k \\ \\ \pi_t \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} \mu_{ht}^k \\ \\ \mu_{ht}^\pi \end{pmatrix}, \begin{pmatrix} \sigma_h^{2k} & cov_h^{\pi,k} \\ \\ cov_h^{\pi,k} & \sigma_h^{2\pi} \end{pmatrix}\right)$$

Then, by property of bivariate normal distribution, the conditional distribution of shock z_t^k given π_t is announced as $\bar{\pi}_t$ is given by

$$z_t^k \mid (\pi_t = \bar{\pi}_t) \sim \mathcal{N}\left(\mu_{ht}^k + \frac{cov_h^{\pi,k}}{\sigma_h^{2k}}\left(\bar{\pi}_t - \mu_{ht}^\pi\right), \left(1 - (\frac{cov_h^{\pi,k}}{\sigma_h^\pi \sigma_h^k})^2\right)\sigma_h^{2k}\right).$$

Thus,

$$\mathrm{E}_{ht}(z_t^k \mid (\pi_t = \bar{\pi}_t)) - \mathrm{E}_{ht} z_t^k = \frac{cov_h^{\pi,k}}{\sigma_h^{2k}}\left(\bar{\pi}_t - \mu_{ht}^\pi\right)$$

where $\mathrm{E}_{ht}\left[z_t^k\right] = \mu_{ht}^k$. Hence proved.

Equation 13 is quite intuitive. It is reminiscent of an OLS regression of z_t^k on π_t where the OLS coefficient is $\frac{cov_h^{\pi,k}}{\sigma_h^{2\pi}}$. Intuitively, the agents make the *best linear prediction* of z_t^k given $\pi_t = \bar{\pi}_t$. Otherwise as well, the equation makes intuitive sense. The higher the surprise in the aggregate inflation, the higher the revision in belief of underlying fundamental shocks, i.e., all updates in expectations about the structural shocks are directly proportional to the surprise in inflation. Second, the more the weight of a particular shock in the equilibrium inflation, i.e., higher the value of a_π^k, higher is the revision of belief about shock k. This essentially means that if a particular shock does not impact inflation much, then the inflation announcement will not lead to much revision of that shock. Finally, if households receive less precise signals about the shock k, i.e., a high variance σ_h^{2k}, then they update more their beliefs about that shock. For example, Covid and the Ukraine war created more uncertainty regarding supply chains, leading to poorer information about supply related shocks. In that case, if a higher than expected inflation is realized, then the household is going to revise its belief more about the supply shock since it was more uncertain about it. Similarly, an unprecedented fiscal policy will create more uncertainty about demand conditions, leading to more revision of demand shocks in case of a surprise in inflation. Thus, the revision of the underlying shocks will depend on how uncertain we are about the underlying shocks.

The idea is that firms have perfect information about underlying shocks in stage 1 while setting prices. Thus, the announced inflation is an additional signal of the underlying shocks for the households, and they try to infer the value of the underlying shocks better. Note that if the firms have dispersed information about the underlying shocks, then the quality of information that the individual firms receive for each of the shocks is taken into account by the household in its belief update process. For example, If the information that firms receive for demand is more dispersed and thus less informative, it will weaken the coefficient a_π^d and thus the covariance between inflation and the demand shock. Thus, in that case, the household will infer less about demand shocks from the inflation announcement.

The next section tries to explain how the revision of beliefs can be inferred from the data.

5 Matching the Model to the Data

In this section, we match the model to the data to infer how the market decomposed unexpected inflation into demand and supply components over the years.

5.1 Constructing observables that map to the model

The revision of beliefs of each of the underlying shocks are unobservable in the data. However, we can extract these beliefs by observing asset price movements around announcements.

By 12 and 10, since consumption and nominal interest rate are linear combinations of the underlying shocks, the revision of beliefs about them around announcement after π_t is announced as say $\bar{\pi}_t$ can be given by

$$E_{ht}\left[i_t|\pi_t = \bar{\pi}_t\right] - E_{ht}^{ba}\left[i_t\right] = \Sigma_k \underbrace{a_i^k}_{\text{weight of } k \text{ in } i} \underbrace{\frac{a_\pi^k \sigma_h^{2k}}{\sigma_h^{2\pi}}}_{\text{revision of shock } k} \underbrace{(\bar{\pi}_t - \mu_{ht}^\pi)}_{surprise_{ht}^\pi} \tag{14}$$

The left hand side are changes in expectations of nominal interest rates, and can be inferred from the changes in treasury yields around CPI announcements (assuming risk-neutrality in these asset prices). The surprise in inflation can be inferred from the Bloomberg surprise in CPI as defined in 1. The green coefficient is the weight of shock k in interest rate i times the update in belief of shock k as in proposition 1, summed over the two shocks of demand and supply. As shown in Lemma 1, $a_i^k, a_\pi^k > 0$ for all k, i.e.

interest rates and inflation increases with positive demand shock and negative supply, the green coefficient must be positive. $a_\pi^k > 0$ implies that when there is a positive surprise in inflation, both the positive demand shock and the negative supply shock are positively revised. The green coefficient can simply be matched to the OLS regression coefficient when changes in nominal yields are regressed on the surprise in CPI. As verified by the 7, the response is positive as predicted by the model, with the exception of the zero lower bound period.

The changes in output expectations are given by

$$E_{ht}[c_t|\pi_t = \bar{\pi}_t] - E_{ht}^{ba}[y_t] = \Sigma_k \underbrace{a_c^k}_{\text{weight of } k \text{ in } c} \underbrace{\frac{a_\pi^k \sigma_h^{2k}}{\sigma_h^{2\pi}}}_{\text{revision of shock } k} \underbrace{(\bar{\pi}_t - \mu_{ht}^\pi)}_{surprise_{ht}^\pi} \tag{15}$$

The left hand side measure changes in consumption expectations around announcement. It is hard to find a direct counterpart to consumption expectations in the assets market. We measure consumption expectations by constructing a tracking portfolio (Lamont, 2001) using dividend futures of S&P 500. It is a well known fact that dividends are procyclical. Also theoretically, the finance literature has assumed that aggregate real dividends are proportional to aggregate consumption, i.e., $c_t = \kappa d_t$ in many models (Campbell, 2003). Some papers like Campbell et al. (2020), Cieslak and Pflueger (2023), Jarociński and Karadi (2020) and Pflueger (2023) use the stock price change of S&P 500 as a measure of consumption expectations. The implicit assumption, however, is that stocks are a levered claim on *consumption* following Abel (1990). Dividend futures of S&P 500, on the other hand, are a relevant measure of consumption expectations as it refers to the cashflow component of these stocks and is not contaminated by yield curve changes (Nagel and Xu, 2024).

We measure actual monthly nominal consumption growth of non-durables and services using data from NIPA. We measure monthly growth in expectations of total nominal dividend payouts of S&P 500 companies at the end of the year, i.e. in December, from dividends futures. One caveat is that dividend futures are only available November 2015 onwards and we use the data until December 2023 . At the monthly level, we regress nominal consumption growth on the growth in expectations of nominal dividends end of the year controlling for 2 yr, 5 yr, and 10 yr breakeven inflation rates (as measured from TIPS). Thus we control for inflation, to interpret the relationship between the two variables to be real instead of nominal. We find a highly significant regression coefficient of 0.25 and an R-squared of 30%. Thus, if there is a 1% month-over-month growth in expectations of real dividends at the end of the year, it leads to a 0.26% growth in actual real consumption month over month. This coefficient is quite robust to controlling for a wide number of variables like nominal yields, breakeven inflation rates and dividend futures for later years (see Table 2). Thus $\kappa = 0.26$ is assumed.

We construct a measure of change in expectations of real dividends 2 years ahead around the announcements. We focus on 2 years ahead because the earliest measure of breakeven inflation using TIPS is 2 years ahead. Another reason is that we want to focus on more medium-term dynamics than short-term dynamics which could be driven by a lot of other factors. We construct the real dividend measure as follows. Expectations of nominal dividends two years ahead are assumed to be given by the average of nominal dividend futures that is settled in December of (a) the next year and (b) the year after that. So for example, if CPI announcement occurs in May 2020, dividends futures that are settled in December 2021, and December 2022 are looked at, and their average is taken as the two year ahead (from the announcement date) expectations of nominal dividends. We subtract these expectations with 2 times the 2 year ahead annual breakeven inflation rate as measured from TIPS, to get daily expectations of real dividends two years ahead. We, thus, study changes in daily expectations of real dividends two years ahead around announcements. By the regression analysis in the previous paragraph, the daily changes in real consumption expectations 2 years ahead around CPI announcements would be 0.26 times changes in daily expectations of real dividends two years ahead. Thus, the left hand side part of equation 15 can now be measured using asset prices.

In the right hand side, the green term can either be positive or negative since $a_c^d > 0, a_c^s < 0$, i.e., consumption increases with a positive demand shock but decreases with a negative supply shock. As shown in figure 9, the stock market response can go in either direction. Figure 12 shows that the response of mostly positive before covid, and became negative post covid, highlighting the increasing role of supply shocks post covid.

5.2 Findings

Throughout this section, some of the parameters of the model will be kept fixed. These are the discount rate β, the inverse of the intertemporal elasticity of consumption γ, the curvature of the disutility of supplying labour, the parameters in the Taylor-type rule ϕ and the persistence of the structural shock ρ. These will be set as $\{\theta, \beta, \gamma, \varphi, \phi_\pi, \phi_y, \rho_d, \rho_s\} = \{0.9, 0.995, 1, 1, 1.5, 0.5, 0.9, 0.9\}$. The parameterisation of the discount factor β at 0.995 reflects that a period in the model should be interpreted as being one month, to match with the frequency of announcements. The Calvo parameter θ should thus be interpreted as the fraction of firms that do not change prices in a given month and it will be set to $\theta = 0.9$ which implies an average price duration of 10 months. The choice of the exogenous persistence parameter for labour supply shock $\rho_s = 0.9$ roughly reflects the persistence of various measures of marginal cost (for instance the labour share in GDP) and is also used in Nimark (2008) where each time-period is also a month. We set the same value for persistence of demand shock ρ_d. Finally, The precision ratio of the signals of the shocks received by firms given by (f_d, f_s) is set to $(0.8, 1)$. $f_s = 1$ means firms know the supply shock with certainty, whereas $f_d < 1$ shows that they have dispersed information about the demand shock and do not know it with certainty. $f_d < f_s$ is to capture the fact that the price-setting firms have more precise information about the supply conditions rather than demand conditions. It does not matter for the qualitative results and only their relative values matter for quantitative results.

With these parameters, we can recover $\boldsymbol{a_c}, \boldsymbol{a_\pi}, \boldsymbol{a_i}$ in 10, 11 and 12. We define the market-perceived share of demand in unexpected inflation as:

$$\begin{aligned}\text{Share}_{dd} &= \frac{a_\pi^{2d}\sigma_h^{2d}}{a_\pi^{2d}\sigma_h^{2d} + a_\pi^{2s}\sigma_h^{2s}} \\ &= \frac{a_\pi^{2d} V_d}{a_\pi^{2d} V_d + a_\pi^{2s} V_s}\end{aligned} \tag{16}$$

where $V_k = \sigma_h^{2k} / \sigma_h^{2\pi}$ for $k \in (d, s)$ is used for normalization. Now, V_d, V_s can be recovered from 14 and 15 (where the revision of each shock is multiplied by ρ_k^{24} to adjust for 2 year ahead asset prices) and the $\boldsymbol{a}$ is given by the calibration of the New Keynesian model parameters. After the matching exercise and some further algebra (see A.2), we can show that

$$\text{Share}_{dd} = \frac{\frac{a_\pi^d}{\rho_d^{24}}(a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})}{\frac{a_\pi^d}{\rho_d^{24}}(a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}}) + \frac{a_\pi^s}{\rho_s^{24}}(-a_c^d + a_i^d \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})} \tag{17}$$

where $\frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}}$ is the change in 2 year ahead consumption expectations around CPI announcement divided by the change in 2 year ahead interest rate expectations around announcement. ρ_d^{24} and ρ_s^{24} occurs because the model is at monthly frequency, hence the auto-correlation coefficient is raised to the power 24 to account for two year ahead expectations. Thus, we have a sufficient statistic for the share of demand in unexpected inflation that only depends on $\boldsymbol{a}$, ρ and the *ratio* of change in consumption expectations around announcement divided by the change in interest rate expectations around announcement $\frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}}$. It is also independent of the level of surprise. To understand why, suppose the change in observed asset prices representing interest rates Δi_{2yr}^{obs} and consumption Δc_{2yr}^{obs} doubles, then by 14 and 15, V_d and V_s would also double, but the share of demand in unexpected inflation Share_{dd} would be multiplied by 2 in both numerator and denominator, thus remaining unchanged. Thus, share of demand only depends on the ratio and it depends *positively*, i.e, more positive the change in the consumption change to interest rate change ratio, higher the share of demand in unexpected inflation. This is intuitive, because a positive demand shock leads to a positive suprise in inflation and increases consumption expectations, while a negative supply shock leads to a positive surprise in inflation but decreases consumption expectations.

We do a rolling regression of Δc_{2yr}^{obs} on Δi_{2yr}^{obs} with a window size of 24 observations (or 2 years) over the years and construct the share of demand shock (see Figure 13). We do a rolling regression to smooth out the noise in the financial markets. From 2016-2019, the share of demand in unexpected inflation was around 80% whereas it was around 60% post covid. Thus, the share of supply increased by 20 percentage points post covid. This is not surprising if we looking at the response of consumption expectations to a surprise in inflation over the years (see Figure 12). Consumption expectations increased with a positive surprise in inflation before covid, while the response turned negative around 2021 onwards, indicative of the increasing role of supply shocks.

5.3 Sensitivity of the Share in Unexpected Inflation to Parameter Values

In Figure 13, we explore how sensitive the share of demand in unexpected inflation is to different parameter values. The share curve largely maintains its shape for different parameter values of the relative information precision of the signal of the firms (f_d, f_s), the Taylor coefficients ($\phi_y^{Tay}, \phi_\pi^{Tay}$). the inverse of the intertemporal elasticity of substitution of income (γ) and the Frisch elasticity of labor supply (ψ). Thus, our key result that the share of unexpected demand in inflation falls by 20 percentage points post covid doesn't change much. The shape does vary slightly with the autocorrelation coefficients ρ_d, ρ_s, but this is because they not only affect the **a**, i.e., the weight of each of the underlying shock to macro variables of interest rate, inflation and output, but also have a direct effect (see equation A.2). This is because how much the two year ahead interest rate or consumption expectations should move directly depends on the persistence of the underlying shocks. However, the share of demand shock in unexpected inflation definitely fell post-covid.

5.4 Role of Monetary Policy in this model

The interpretation of monetary policy in this model depends on the information set of the firms vis-à-vis the household. If firms and household have the same level of information about the monetary shock, that is, the error term in the Taylor rule, then there will be no belief update by the household about the monetary shock when the inflation announcement occurs. This could happen when there are only public signals about the monetary shock, and no private information. FOMC announcements could be such an example of public signals where the communication is from the central banks to all the agents in the economy. Thus, for the purposes of our question, this would be equivalent to assuming there is no error term in the Taylor rule, which is what we do.

If firms have private information about the monetary policy shocks beyond what the household knows, then household will also update their belief about monetary shocks from the inflation announcement. In such a model, an expansionary monetary shock will act very similar to a positive demand shock. Thus demand shocks will absorb the role of a monetary policy shock in such a situation. If firms have incorrect information about the monetary policy rule, then the model becomes trickier to solve. An example could be that the Taylor coefficients are time-varying or asymmetric, and firms have incorrect perceptions about them. Supply shocks might absorb some role of monetary policy in those situations.

6 Next Steps

We use a standard New Keynesian model with announcement to interpret asset price movements around CPI announcements. We find that the share of supply in unexpected inflation has increased by 20 percentage points post-covid. We want to incorporate the role of optimal monetary policy in the future.

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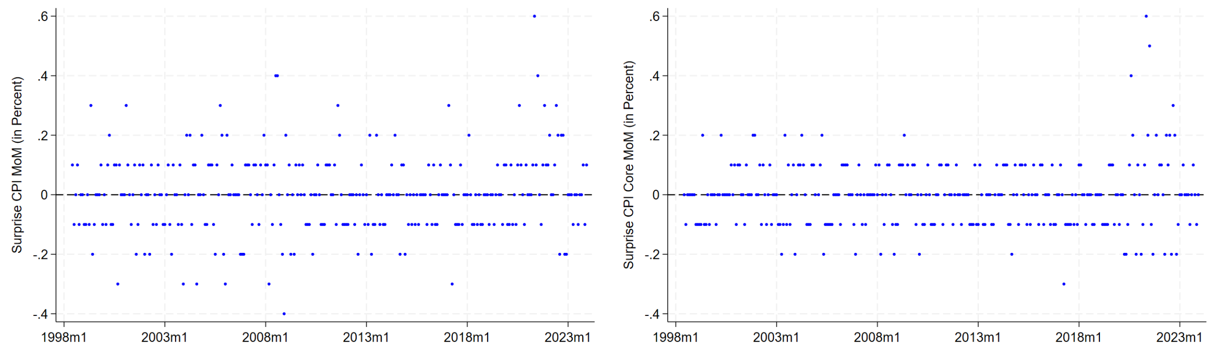
7 Figures

Figure 1: **Time Series of CPI Surprises**

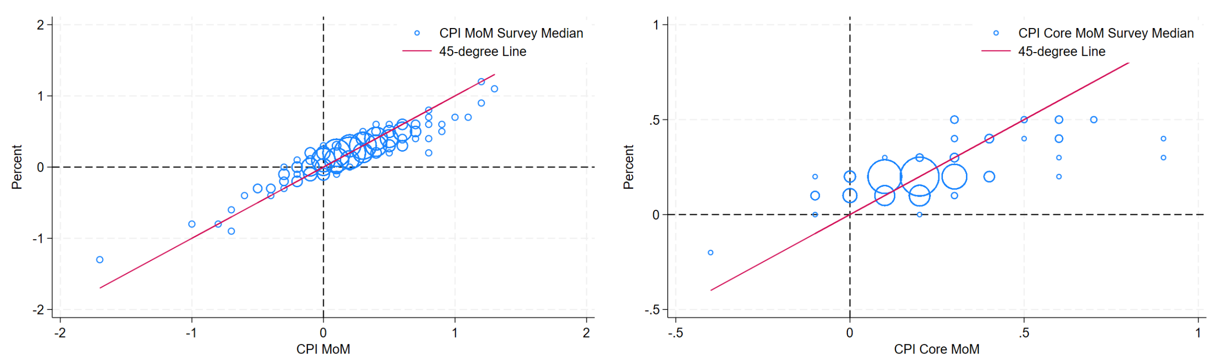
(a) CPI MoM (b) CPI Core MoM



This figure plots the time series of $surprise_t^{CPI}$ which is the difference of the CPI actual or announced value in each month and the CPI Bloomberg Survey Median (in percent) from 1998m6 to 2023m12.

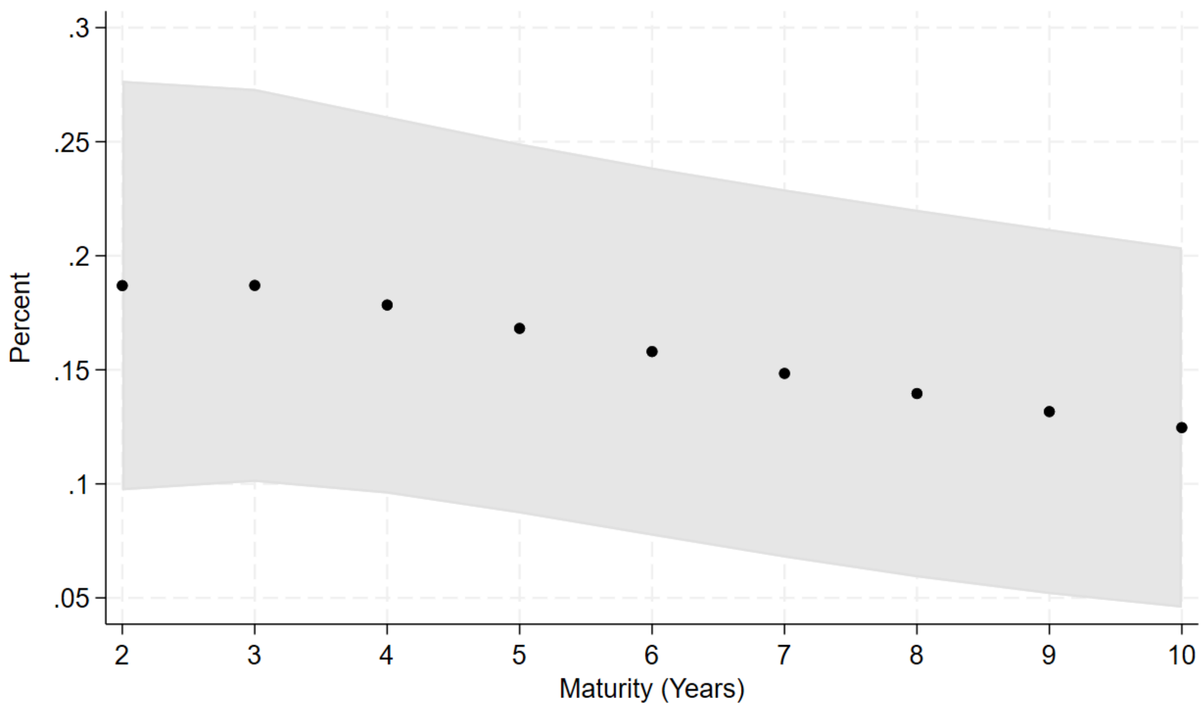
Figure 2: **Actual CPI MoM versus Survey Median**

(a) CPI MoM (b) CPI Core MoM



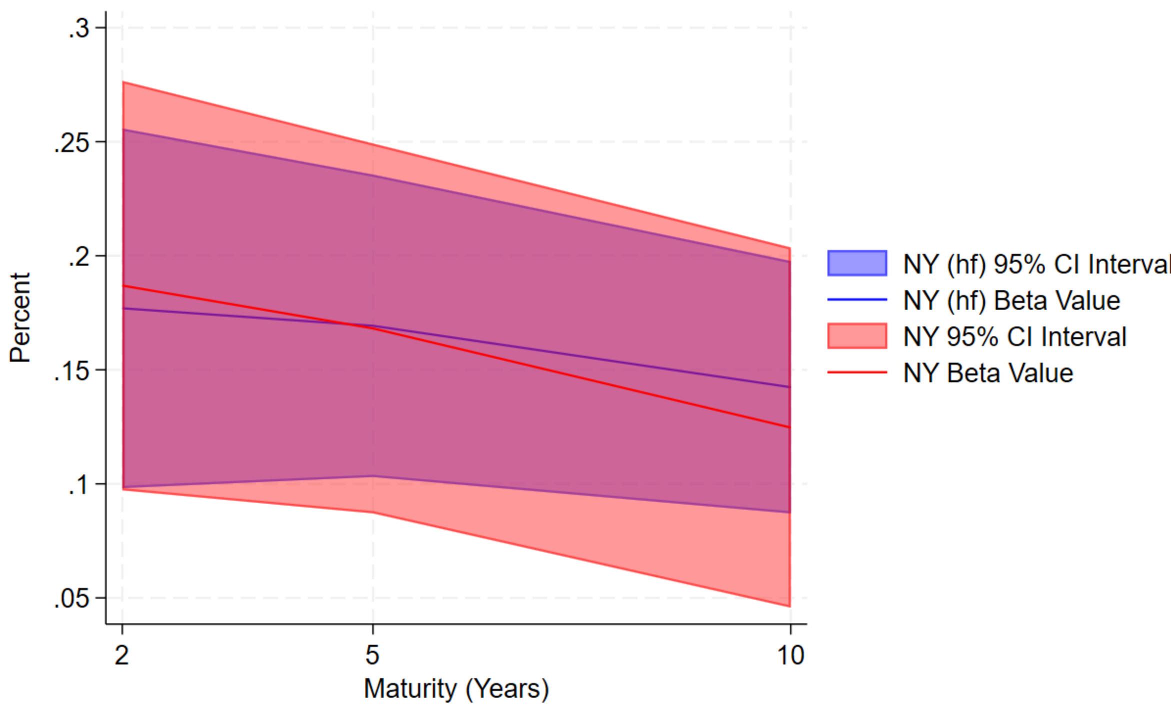
This figure plots a scatter plot of the CPI actual or announced value in the x axis and the CPI Bloomberg Survey Median on the y axis from 1998m6 to 2023m12. The red line is a 45 degree line.

Figure 3: Nominal Yields



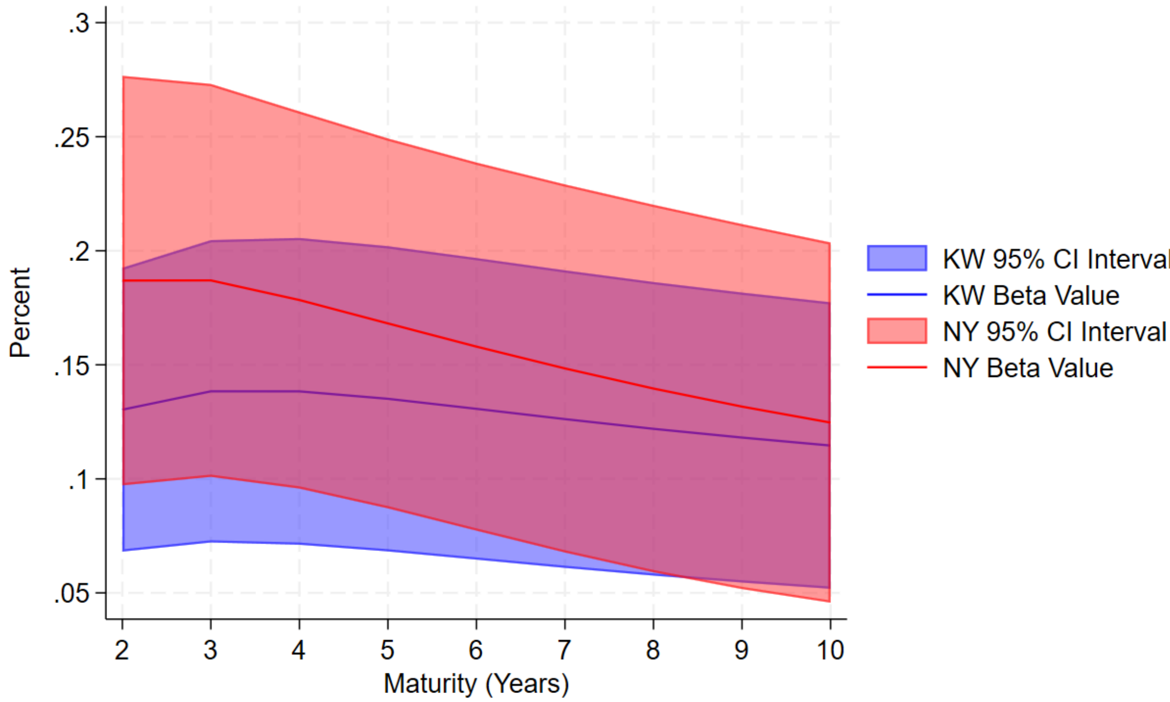
This figure plots the β coefficients (black dots) and their 95% confidence intervals (shaded grey region) for the regression 2 $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where Δy_t is the daily change in the Treasury nominal yields (in percent) of different maturities and the x axis is the maturity of the Treasury bond in years. t refers to the CPI announcement date. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text. The time period is from 2004m1-2023m12.

Figure 4: Nominal Yields (high frequency)



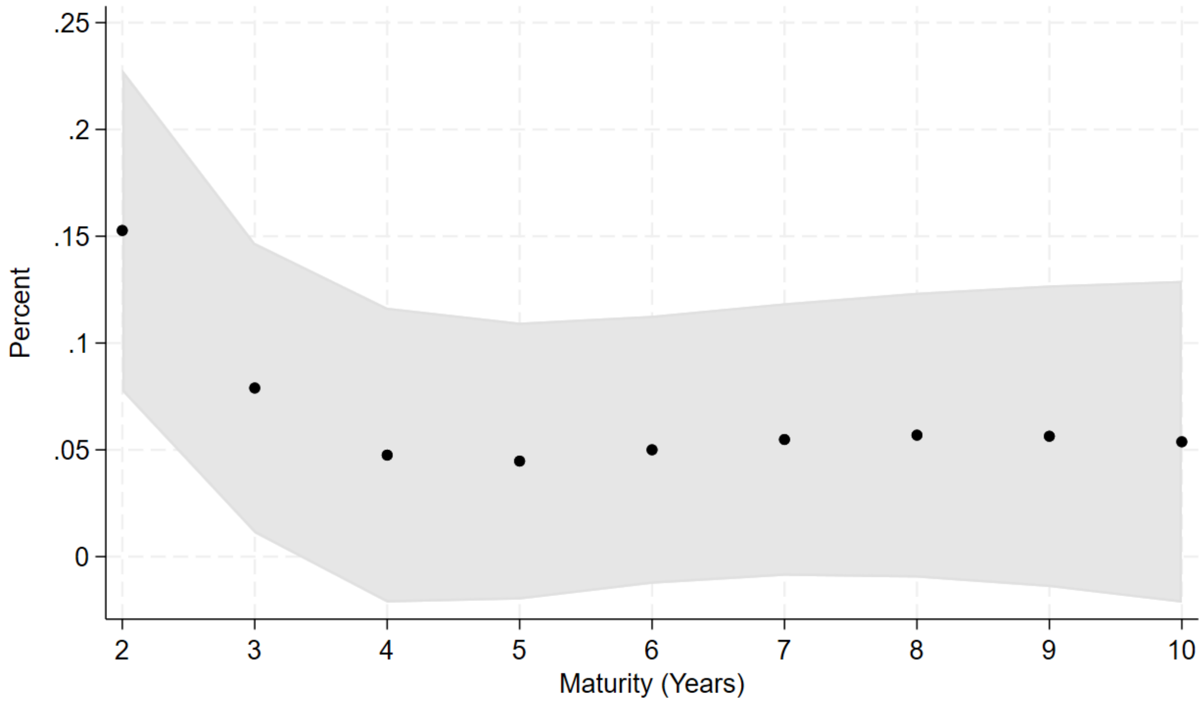
This figure plots the β coefficients (line) and their 95% confidence intervals (shaded region) for the regression 2 $\Delta y_t = \alpha + \beta \times surprise_t^{CPI} + \epsilon_t$ where x axis is the maturity of the Treasury bond in years. The red and blue color refers to when Δy_t is the daily and the high-frequency change in Treasury nominal yields (in percent) respectively. t refers to the CPI announcement date. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text. The time period is from 2004m1-2023m12.

Figure 5: Nominal Yields (accounting for risk premia)



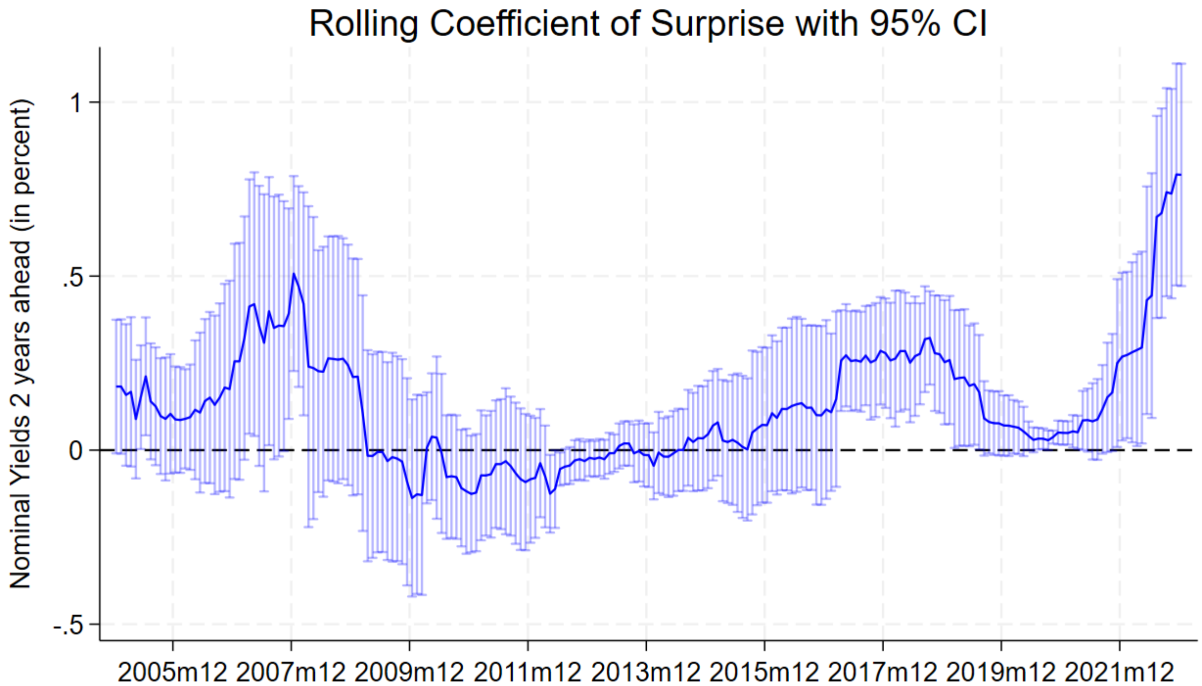
This figure plots the β coefficients (line) and their 95% confidence intervals (shaded region) for the regression 2 $\Delta y_t = \alpha + \beta \times surprise_t^{CPI} + \epsilon_t$ where x axis is the maturity of the Treasury bond in years. The red color refers to when Δy_t is the daily change in Treasury nominal yields (in percent). The blue color refers to when Δy_t is the Kim and Wright (cite) measure of change in Treasury nominal yields (in percent) that accounts for term premia. t refers to the CPI announcement date. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text. The time period is from 2004m1-2023m12.

Figure 6: Forward Breakeven Inflation



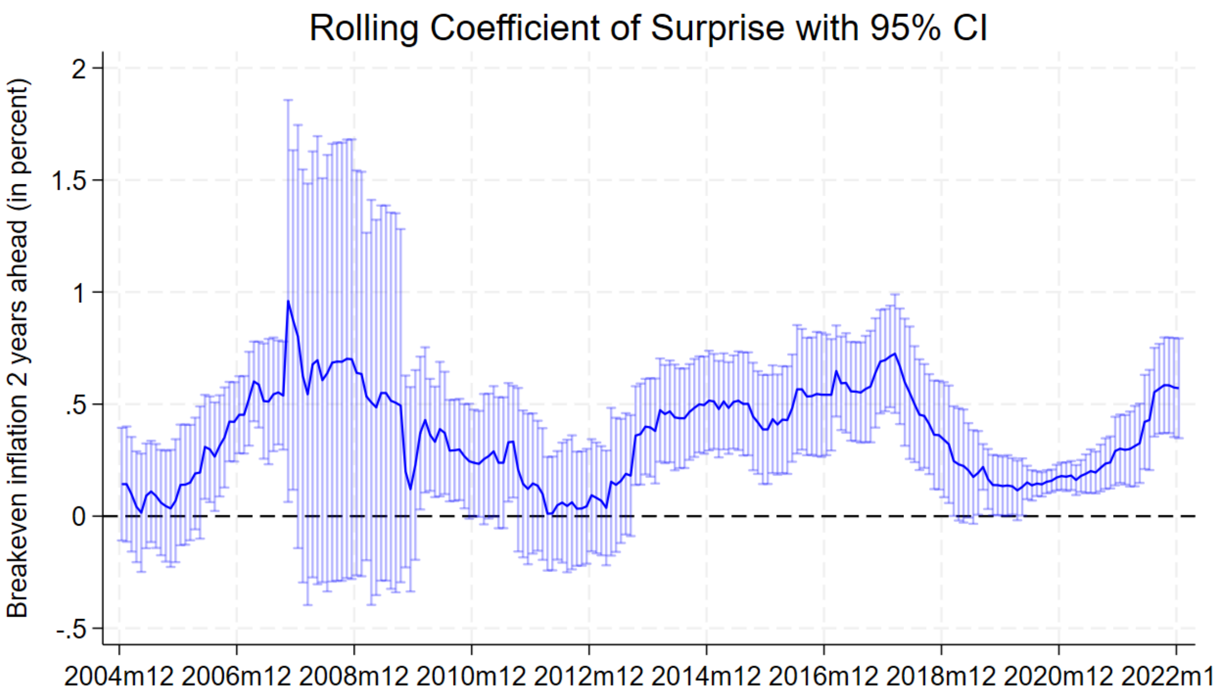
This figure plots the β coefficients (black dots) and their 95% confidence intervals (shaded grey region) for the regression 2 $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where Δy_t is the daily change in the forward breakeven inflation (in percent) of different maturities and the x axis is the maturity of the Treasury bond in years. t refers to the CPI announcement date. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text. The time period is from 2004m1-2023m12.

Figure 7: Response of nominal yield expectations to surprise in CPI over the years



This figure plots the rolling β coefficients (blue line) and their 95% confidence intervals (blue bars) for the regression 2 $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where Δy_t is the daily change in the two year ahead nominal yields (in percent) and t refers to the CPI announcement date. The x axis is the month of the announcement. The window size is 24 observations i.e. $\pm$ 1 year around the month of observation in the x axis. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text.

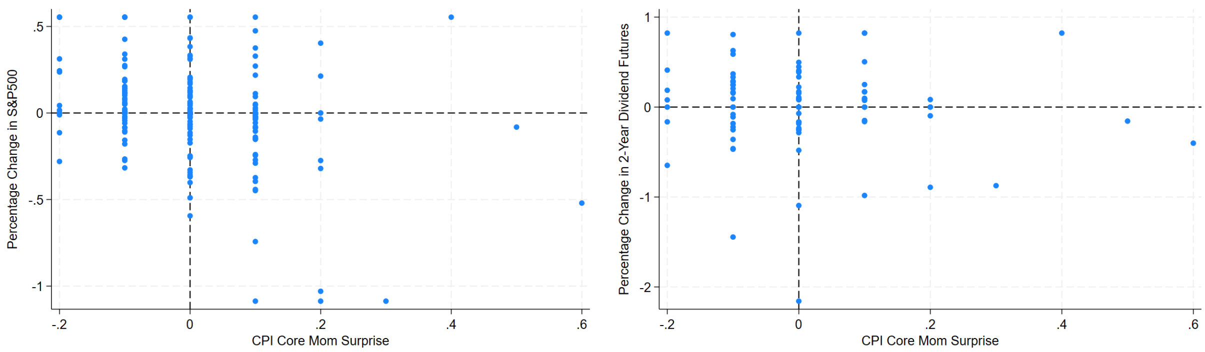
Figure 8: Response of breakeven inflation to surprise in CPI over the years



This figure plots the rolling β coefficients (blue line) and their 95% confidence intervals (blue bars) for the regression 2 $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where Δy_t is the daily change in the two year ahead breakeven inflation (in percent) and t refers to the CPI announcement date. The x axis is the month of the announcement. The window size is 24 observations i.e. $\pm$ 1 year around the month of observation in the x axis. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text.

Figure 9: **Stock Market vs CPI Surprises**

(a) S&P500 (b) Dividends



This figure plots a scatter plot of the CPI Core Mom Surprise on the x axis as defined by 1 in the text. The y axis plots (a) the percentage change in price (open-close) of S&P 500 and (b) the daily percentage change in price of Dividend futures of S&P500 expiring in 2 years. The percentage change in price is winsorized at 5% from the top and 1% from the bottom. The CPI announcement dates around which the Surprise and daily percentage change in price is calculated is from 2004m1-2023m12 for S&P500 and from 2015m11-2023m12 for dividend futures.

Table 1: Volatility Index

	(1)	(2)
CPI Core MoM Surprise	-0.15	0.45
	(0.34)	(1.59)
Observations	236	236
R^2	0.001	0.001

Results from estimating $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where column (1) refers to the case where Δy_t is the open price at date t minus the close price at date $t-1$ of the CBOE Volatility Index or VIX and column (2) refers to the case where Δy_t is the close price at date t minus the close price at date $t-1$ of VIX. t refers to the CPI announcement date. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text.

Figure 10: Timeline of standard New Keynesian Model

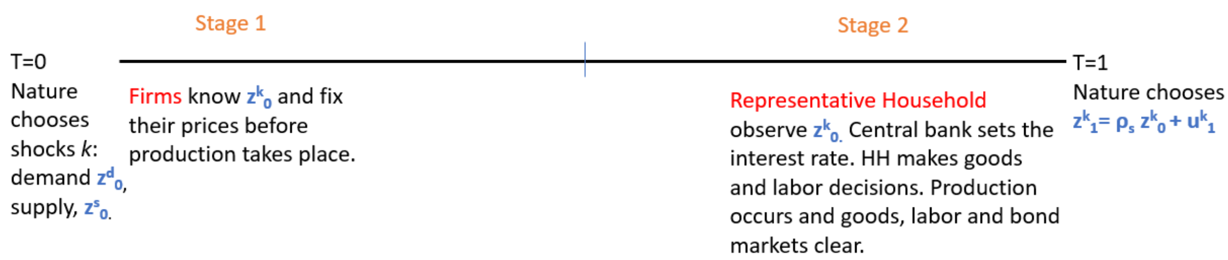


Figure 11: Timeline of standard New Keynesian Model with inflation announcement

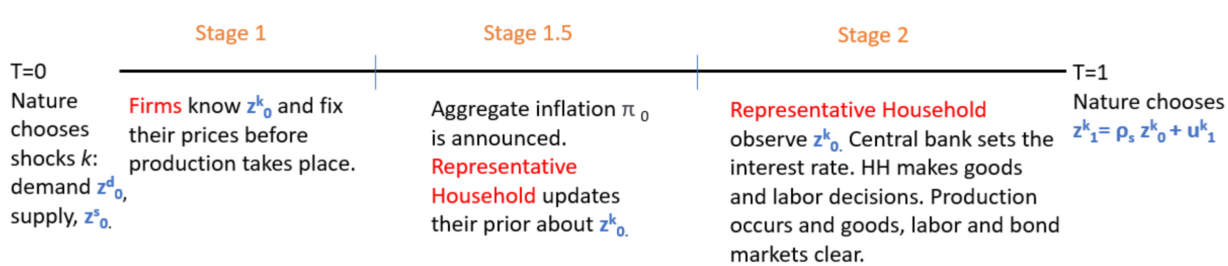
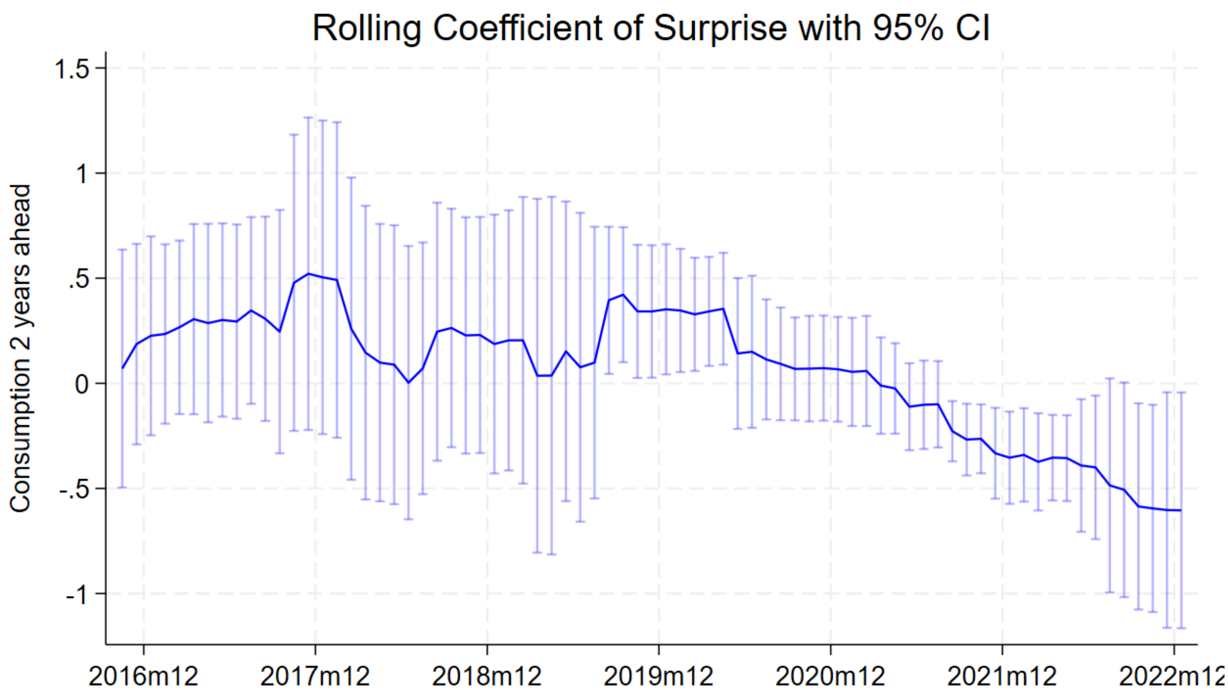


Figure 12: Response of consumption expectations to surprise in CPI over the years



This figure plots the rolling β coefficients (blue line) and their 95% confidence intervals (blue bars) for the regression 2 $\Delta Y_t = \alpha + \beta \times surprise_t^{CPICoreMom} + \epsilon_t$ where Δy_t is the percentage change in 2 year ahead real consumption expectations around the CPI announcement and t refers to the CPI announcement date. The x axis is the month of the announcement. The window size is 24 observations i.e. $\pm$ 1 year around the month of observation in the x axis. $surprise_t^{CPICoreMoM}$ is defined as in 1 in the text.

Table 2: Tracking Portfolio for Consumption

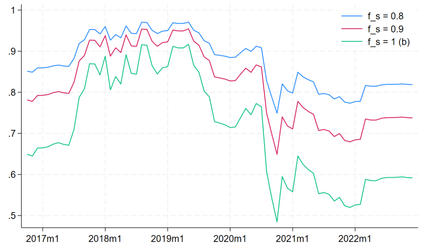
	(1)
Dividend (same year)	0.26***
	(0.10)
Dividend (one year ahead)	-0.06
	(0.09)
Dividend (two years ahead)	-0.06
	(0.11)
Dividend (three years ahead)	0.02
	(0.13)
Dividend (four years ahead)	0.06
	(0.07)
Breakeven inflation (two years ahead)	-0.28
	(0.27)
Breakeven inflation (five years ahead)	1.42
	(0.92)
Breakeven inflation (ten years ahead)	-0.93
	(0.84)
Nominal Yields (two years ahead)	0.46**
	(0.22)
Nominal Yields (five years ahead)	-1.07*
	(0.55)
Nominal Yields (ten years ahead)	0.50
	(0.37)
Constant	0.18
	(0.30)
Observations	89
R^2	0.413

Results from estimating $\text{Cons}_t = \alpha + \beta \times \text{Div}_t + \delta X_t + \epsilon_t$ where $Cons$ refers to the nominal consumption growth of non durables and services at month t from November 2015 till December 2023, trimmed top and bottom at 5%. The regressors are Div_t which is the month t expectations of total nominal dividends implied by the end of the year dividend futures of S&P 500 companies. The controls X_t include dividend futures for one year to four years ahead, and two year, five year and ten year ahead treasury nominal yields and breakeven inflation rates averaged in month t.

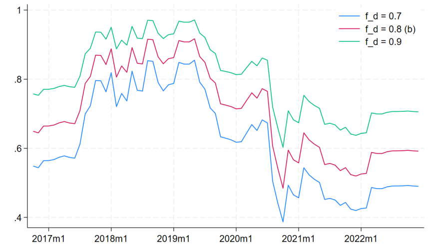
Figure 13: Share of demand shock in variance of inflation over the years

This figure plots the share of demand shock in variance of inflation over the years that is calculated by the method described in the section 5.2.

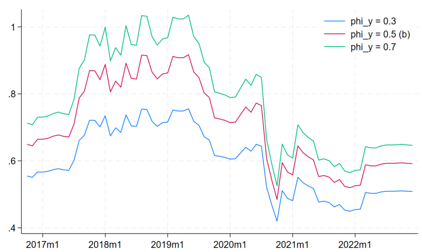
Figure 14: Sensitivity of share of demand in unexpected inflation to different parameter values



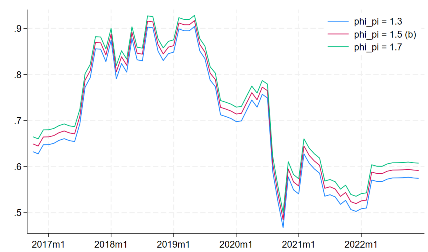
(a) f_s



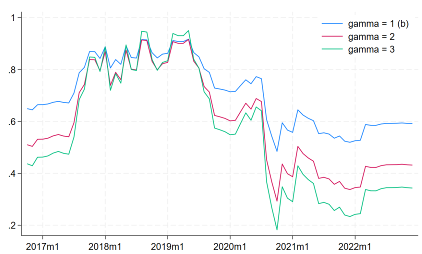
(b) f_d



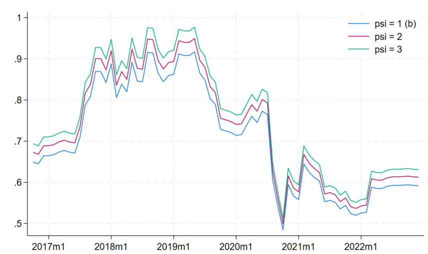
(e) ϕ_y^{Tay}



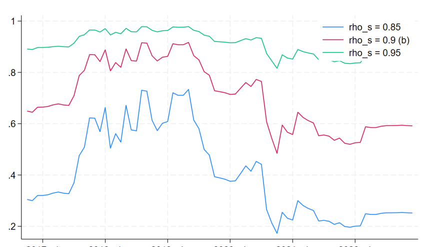
(f) ϕ_π^{Tay}



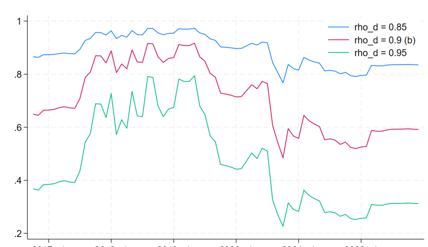
(g) γ



(h) ψ



(c) ρ_s



(d) ρ_d

Each subplot in this figure plots the share of demand shock in the variance of inflation over the years that is calculated by the method described in the section 5.2 but by varying different values of a particular parameter. The bracket (b) in the legend refers to the baseline parameter value chosen.

A APPENDIX

A.1 Proof of Lemma 1 with dispersed information

From Stage 2, the Euler Equation is given by

$$y_t = E_t y_{t+1} - \frac{i_t - E_t \pi_{t+1}}{\gamma} + z_t^d \tag{18}$$

From Stage 2, the Taylor Rule is given by:

$$i_t = \phi_\pi^{Tay} \pi_t + \phi_y^{Tay} (y_t - y_t^n) \tag{19}$$

where $y_t^n = -z_t^s / (\gamma + \psi)$,

In a dispersed information setting, firms j have dispersed signals about the underlying shocks $k \in (dd, ss)$

$$x_{jt}^k = z_t^k + u_{jt}^k$$

where $u_{jt}^k \sim \mathcal{N}(0, \sigma_k^2)$

If firm j is allowed to reset their price, they will choose the optimal price $p_t^*(j)$ that will maximise their profit. Let $\pi_t^*(j) = p_t^*(j) - p_{t-1}$ be called the optimal reset inflation for firm j and is given by

$$\pi_t^*(j) = (1 - \beta\theta) E_{jt} \hat{mc}_t + E_{jt} \pi_t + \beta\theta E_{jt} \pi_{t+1}^*(j) \tag{20}$$

where $\hat{mc}_t = (\gamma + \psi) y_t + z_t^s$. This is exactly how a firm sets its price in a New Keynesian model in Gali (2003), except now it is firm specific expectations E_{jt} instead of E_t.

Now, exante at t, all firms will be identical at $t+1$ because all the shocks are visible to all the firms at the end of the period t. Thus, $\pi_{t+1}^*(j) = p_{t+1}^*(j) - p_t$ and is exante expected to be the same for all j and is equal to reset inflation averaged across all the firms π_{t+1}^*. The average reset inflation is given by

$$\pi_t^* = \int_j \pi_t^*(j) dj \tag{21}$$

Since only $(1-\theta)$ fraction of randomly chosen firms can choose their price, the aggregate inflation will be $1-\theta$ times average reset price of all firms i.e.,

$$\pi_t = (1-\theta)\pi_t^* \tag{22}$$

Let us assume (ignoring constants)

$$y_t = a_y^d z_t^d + a_y^s z_t^s$$

$$\pi_t = a_\pi^d z_t^d + a_\pi^s z_t^s$$

Rewriting 20, we get

$$\pi_t^*(j) = (1-\beta\theta)E_{jt}\{(\gamma+\psi)y_t + z_t^s\} + E_{jt}\pi_t + \beta\theta E_{jt}\pi_{t+1}^*$$

Integrating over j we get

$$\pi_t^* = (1-\beta\theta)\int_j E_{jt}\{(\gamma+\psi)y_t + z_t^s\}dj + \int_j E_{jt}\pi_t dj + \beta\theta\int_j E_{jt}\pi_{t+1}^* dj$$

Substituting 22

$$\pi_t/(1-\theta) = (1-\beta\theta)\int_j \{E_{jt}(\gamma+\psi)y_t + z_t^s\}dj + \int_j E_{jt}pi_t dj + \beta\theta/(1-\theta)\int_j E_{jt}\pi_{t+1}dj$$

$$\frac{a_\pi^d z_t^d + a_\pi^s z_t^s}{(1-\theta)} = (1-\beta\theta)\int_j E_{jt}\{(\gamma+\psi)(a_y^d z_t^d + a_y^s z_t^s) + z_t^s\}dj + \int_j E_{jt}a_\pi^d z_t^d + a_\pi^s z_t^s dj + \beta\theta/(1-\theta)\int_j E_{jt}a_\pi^d z_{t+1}^d + a_\pi^s z_{t+1}^s dj$$

$$\frac{a_\pi^d z_t^d + a_\pi^s z_t^s}{(1-\theta)} = \int_j E_{jt}z_t^d dj \times [(1-\beta\theta)(\gamma+\psi)a_y^d + a_\pi^d + \beta\theta/(1-\theta)\rho_d a_\pi^d] \tag{23}$$

$$+\int_j E_{jt}z_t^s dj \times [(1-\beta\theta)\{(\gamma+\psi)a_y^s + 1\} + a_\pi^s + \beta\theta/(1-\theta)\rho_s a_\pi^s] \tag{24}$$

Now, $\int_j E_{jt}z_t^k dj = \int_j f_k x_{jt}^k dj + (1-f_k)\rho_k z_{t-1}^k = f_k z_t^k + const$ by Bayes' rule where $f_k = \frac{\sigma_k^{-2}}{\sigma_k^{-2}+\sigma_{k0}^{-2}}$ is the weight given to the private signal received by the firm and $1-f_k$ is the weight given to the public information $\rho_k z^k_{t-1}$ inferred from the law of motion of the underlying shocks k. If there was no dispersed information, and the firms knew the shock k perfectly, i.e, the case of perfect information, then $f_k = 1$.

Ignoring constants

$$\frac{a^d_\pi z^d_t + a^s_\pi z^s_t}{(1-\theta)} = f_d z^d_t \times [(1-\beta\theta)(\gamma+\psi)a^d_y + a^d_\pi + \beta\theta/(1-\theta)\rho_d a^d_\pi] \tag{25}$$

$$+ f_s z^s_t \times [(1-\beta\theta)\{(\gamma+\psi)a^s_y + 1\} + a^s_\pi + \beta\theta/(1-\theta)\rho_s a^s_\pi] \tag{26}$$

Comparing coefficients of the shocks

$$\frac{a^d_\pi}{(1-\theta)} = f_d * [(1-\beta\theta)(\gamma+\psi)a^d_y + a^d_\pi + \beta\theta/(1-\theta)\rho_d a^d_\pi]$$

$$\frac{a^s_\pi}{(1-\theta)} = f_s * [(1-\beta\theta)\{(\gamma+\psi)a^s_y + 1\} + a^s_\pi + \beta\theta/(1-\theta)\rho_s a^s_\pi]$$

Let

$$A_k = \frac{1}{1-\theta} - f_k(1 + \frac{\beta\theta\rho_k}{(1-\theta)}) \tag{27}$$

$$B_k = f_k \times [(1-\beta\theta)(\gamma+\psi) \tag{28}$$

Then two crucial equations

$$A_d a^d_\pi = B_d a^d_y \tag{29}$$

$$A_s a^s_\pi = B_s a^s_y + B_s/(\gamma+\psi) \tag{30}$$

From Euler and Taylor we get

$$y_t = E_t y_{t+1} - \frac{\phi^{Tay}_\pi \pi_t + \phi^{Tay}_y (y_t + z^s_t/(\gamma+\psi)) - E_t\pi_{t+1}}{\gamma} + z^d_t$$

$$C_k = 1 - \rho_k + \frac{\phi^{Tay}_y}{\gamma} \tag{31}$$

$$D_k = -\frac{\phi_\pi^{Tay} - \rho_k}{\gamma} \tag{32}$$

Then next two crucial equations

$$C_d a_d^y = D_d a_d^\pi + 1 \tag{33}$$

$$C_s a_s^y = D_s a_s^\pi - \frac{\phi_y^{Tay}}{(\gamma+\psi)\gamma} \tag{34}$$

From 29,

$$a_\pi^d = A_d^{-1} B_d a_y^d$$

substituting in 33 we get

Final 1,2

$$a_d^y = [C_d - D_d A_d^{-1} B_d]^{-1}$$

$$a_d^\pi = A_d^{-1} B_d [C_d - D_d A_d^{-1} B_d]^{-1}$$

From 34 and 30

$$C_s a_s^y = D_s A_s^{-1}(B_s a_y^s + B_s/(\gamma+\psi)) - \frac{\phi_y^{Tay}}{(\gamma+\psi)\gamma}$$

Final 3,4

$$a_s^y = [C_s - D_s A_s^{-1} B_s]^{-1}\{\frac{D_s A_s^{-1} B_s}{\gamma+\psi} - \frac{\phi_y^{Tay}}{(\gamma+\psi)\gamma}\}$$

$$a_\pi^s = A_s^{-1} B_s a_y^s + \frac{A_s^{-1} B_s}{\gamma+\psi}$$

Now, let $K_k = [C_k - D_k A_k^{-1} B_k]^{-1}$. After some algebra,

$$a_i^d = (\phi_\pi^{Tay} A_d^{-1} B_d + \phi_y^{Tay}) K_d \tag{35}$$

$$a_r^d = ((\phi_\pi^{Tay} - \rho_d) A_d^{-1} B_d + \phi_y^{Tay}) K_d \tag{36}$$

$$a_i^s = (\phi_\pi^{Tay} A_s^{-1} B_s + \phi_y^{Tay}) K_s \frac{1-\rho_s}{\gamma+\psi} \tag{37}$$

$$a_r^s = ((\phi_\pi^{Tay} - \rho_s) A_s^{-1} B_s + \phi_y^{Tay}) K_s \frac{1-\rho_s}{\gamma + \psi} \tag{38}$$

Thus Lemma 1 is proved.

A.2 Share of demand in unexpected inflation

Let $V_k = \sigma_h^{2k} / \sigma_h^{2\pi}$ for $k \in (d, s)$. In the data we look at 2 year ahead nominal yields or interest rates, and since the model is at monthly frequency, 14,we get

$$\frac{\Delta i_{2yr}^{obs}}{surprise} = \rho_d^{24} a_i^d a_\pi^d V_d + \rho_s^{24} a_i^s a_\pi^s V_s$$

Similarly, by 15, 2 year ahead consumption expectations are given by

$$\frac{\Delta c_{2yr}^{obs}}{surprise} = \rho_d^{24} a_c^d a_\pi^d V_d + \rho_s^{24} a_c^s a_\pi^s V_s$$

Solving linear system of 2 equations and 2 variables we get:

$$\rho_d^{24} a_\pi^d V_d = \frac{\frac{\Delta i_{2yr}^{obs}}{surprise} a_c^s - \frac{\Delta c_{2yr}^{obs}}{surprise} a_i^s}{a_i^d a_c^s - a_c^d a_i^s}$$

and

$$\rho_s^{24} a_\pi^s V_s = \frac{-\frac{\Delta i_{2yr}^{obs}}{surprise} a_c^d + \frac{\Delta c_{2yr}^{obs}}{surprise} a_i^d}{a_i^d a_c^s - a_c^d a_i^s}$$

$$\begin{aligned}
\text{Share}_{dd} &= \frac{a_\pi^{2d} \sigma_h^{2d}}{a_\pi^{2d} \sigma_h^{2d} + a_\pi^{2s} \sigma_h^{2s}} \\
&= \frac{a_\pi^{2d} V_d}{a_\pi^{2d} V_d + a_\pi^{2s} V_s} \\
&= \frac{a_\pi^d / \rho_d^{24} \frac{\frac{\Delta i_{2yr}^{obs}}{surprise} a_c^s - \frac{\Delta c_{2yr}^{obs}}{surprise} a_i^s}{a_i^d a_c^s - a_c^d a_i^s}}{a_\pi^d / \rho_d^{24} \frac{\frac{\Delta i_{2yr}^{obs}}{surprise} a_c^s - \frac{\Delta c_{2yr}^{obs}}{surprise} a_i^s}{a_i^d a_c^s - a_c^d a_i^s} + a_\pi^s / \rho_s^{24} \frac{\frac{-\Delta i_{2yr}^{obs}}{surprise} a_c^d + \frac{\Delta c_{2yr}^{obs}}{surprise} a_i^d}{a_i^d a_c^s - a_c^d a_i^s}} \\
&= \frac{\frac{a_\pi^d}{\rho_d^{24}} (a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})}{\frac{a_\pi^d}{\rho_d^{24}} (a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}}) + \frac{a_\pi^s}{\rho_s^{24}} (-a_c^d + a_i^d \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})}
\end{aligned}$$

Thus, share of demand in unexpected inflation depends only on calibrated a ρ and $\Delta c_{2yr}^{obs}/\Delta i_{2yr}^{obs}$.

=

$$\text{Share}_{dd} = \frac{\frac{a_\pi^d}{\rho_d^{24}}(a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})}{\frac{a_\pi^d}{\rho_d^{24}}(a_c^s - a_i^s \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}}) + \frac{a_\pi^s}{\rho_s^{24}}(-a_c^d + a_i^d \frac{\Delta c_{2yr}^{obs}}{\Delta i_{2yr}^{obs}})}$$

Share of dd increases with $\Delta c_{2yr}^{obs}/\Delta i_{2yr}^{obs}$. The derivative of Share_{dd} with respect to $\Delta c_{2yr}^{obs}/\Delta i_{2yr}^{obs}$ is greater than zero given we know that $a_i^d, a_i^s, a_\pi^d, a_\pi^s, a_c^d, \rho_d, \rho_s > 0$ and $a_c^s < 0$.