Changing Perceptions and Post-Pandemic Monetary Policy*

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Abstract

We document that the Fed's perceived monetary policy response to inflation shifted materially over the post-pandemic period. In forward-looking policy rules estimated from surveys of macroeconomic forecasters, the inflation coefficient rose significantly after liftoff from the zero lower bound in March 2022. Consistent with a shift in the perceived policy response, event studies show that interest rates became significantly more sensitive to inflation data surprises following liftoff. The increase in the perceived inflation response likely aided the transmission of monetary policy to the real economy and improved the Fed's inflation-unemployment tradeoff. The timing of this shift and additional evidence from surveys and financial markets suggest that forecasters and markets were highly uncertain about the monetary policy rule prior to liftoff and learned about it from the Fed's rate hikes.

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1 Introduction

The aftermath of the Covid-19 pandemic has presented serious challenges for monetary policy. The Federal Reserve responded to the ensuing inflation surge with the fastest increase in the federal funds rate in 40 years. The effectiveness of any such policy response depends crucially on the public's understanding of the monetary policy framework and strategy.[1] To understand this episode and the effectiveness of the Fed's tightening, it is therefore important to address the following question: How did public perceptions of the Federal Reserve's response to inflation evolve over the post-pandemic inflation episode?

In this paper, we address this question using both surveys of professional forecasters and financial market data. We use the methodology we developed in Bauer, Pflueger and Sunderam (2024) to estimate the perceived monetary policy rule from the individual forecaster responses in the Blue Chip Financial Forecasts (BCFF). By relating policy rate forecasts to output gap and inflation forecasts, we obtain a forward-looking estimate of how the Federal Reserve is expected to react to incoming economic data. We can estimate this relationship in each monthly panel of survey forecasts, which allows us to detect changes in the perceived rule over the course of the monetary policy cycle.

The main result from this survey-based analysis is that the perceived inflation response coefficient was close to zero for many years but then increased substantially and rapidly during the Fed's monetary tightening. It reached a level around one in 2023, in line with the Taylor principle. During periods when inflation is low and stable, the inflation coefficient in any estimated policy rule may well be low regardless of whether the central bank is credibly committed to price stability (Clarida, Gali and Gertler, 2000). However, episodes of high inflation reveal whether a central bank is indeed committed to fighting inflation, and whether this commitment is perceived as credible. The significant increase in the Fed's perceived responsiveness to high inflation confirms that this is indeed the case: Monetary policy perceptions are consistent with the Fed's strong commitment to price stability.

Bond markets provide a second source of evidence on perceptions about a central bank's responsiveness to inflation. When investors anticipate a stronger policy response to inflation, then interest rates should move more in response to news about inflation. For example, if an inflation print comes in higher than the consensus expected prior to the data release, a higher perceived inflation coefficient should lead to larger upward revisions of investor forecasts of future policy rates, and thus to a stronger interest rate response.[2]

[1] See, for example, Cukierman and Meltzer (1986), Erceg and Levin (2003), Orphanides and Williams (2004), Blinder et al. (2008), Eusepi and Preston (2010), and Cogley, Matthes and Sbordone (2015).

[2] Hamilton, Pruitt and Borger (2011), Swanson and Williams (2014) and Elenev et al. (2024) also studied the role of monetary policy for the sensitivity of financial markets to macroeconomic announcements.

To test this idea, we estimate event-study regressions of interest rate changes on core CPI surprises, calculated as the released core CPI inflation minus consensus expectations before the announcement. The rate changes are taken over narrow windows around the inflation data releases, so that the regressions arguably identify the causal effects of inflation news on interest rates. We find that Treasury yields as well as money market futures rates became significantly more responsive to inflation news after the Fed's liftoff from the zero lower bound (ZLB) in March 2022. For example, a core CPI surprise led to essentially no change in the two-year yield over the period from January 2014 to March 2022, despite the fact that there were several large core CPI surprises in 2021. But core CPI surprise of 10 basis points (bps) led to a statistically highly significant 9.6 bps increase in the two-year yield over the post-liftoff period from April 2022 through May 2024, indicating a roughly one-for-one yield response to news about inflation. Our finding of a flat relationship between bond yield changes and inflation news surprises pre-March 2022 is not a mechanical result of the ZLB, as we find that the sensitivity of the 10-year Treasury bond yield to inflation also significantly increased after liftoff. This evidence from inflation surprises corroborates our survey-based evidence of a substantial increase in the perceived inflation coefficient using a completely different methodology in different data.

Our finding of a substantial increase in the perceived monetary policy response to inflation is relevant for policy for at least two reasons. First, the perceived reaction function shapes the key asset prices that transmit monetary policy to the real economy. As argued by Woodford (2005), markets can "do the central bank's work for it" provided that market participants understand how policy will react to changes in the economic outlook. In this case, expected future short rates, long-term rates, and broader financial conditions became more responsive to macroeconomic news.[3] Second, perceptions about the policy response to inflation can matter for the inflation-unemployment tradeoff faced by a central bank. We show that a stronger perceived inflation response can help lower inflation at a given output gap in a simple New Keynesian model with separate actual and perceived monetary policy rules.[4] Given its importance for monetary transmission and monetary tradeoffs, the shift towards a strong perceived inflation response may help explain why the recent disinflation had low output and unemployment costs, particularly compared to the Volcker disinflation of the 1980s.

[3]More generally, the perceived monetary policy rule is priced in bonds and stocks and matters for risk and term premia (Piazzesi, 2005; Song, 2017; Bianchi, Lettau and Ludvigson, 2022; Bianchi, Ludvigson and Ma, 2022; Drechsler, Savov and Schnabl, 2018; Campbell, Pflueger and Viceira, 2020).

[4]Earlier work in monetary economics has linked the "sacrifice ratio," the economic cost of a disinflation, to expectations, central bank credibility, and perceptions about the monetary policy framework (Ball, 1995; Erceg and Levin, 2003; Goodfriend and King, 2005; Orphanides and Williams, 2005).

The timing of the shift in policy perceptions we document is noteworthy and somewhat puzzling. Our evidence suggests that it only happened after liftoff in March 2022, and some estimates suggest it came well after that point in time. For example, the inflation coefficient in our simple perceived policy rule only increases in early 2023. This is puzzling because one might have expected the perceived policy rule to start changing in 2021, when markets and forecasters were repeatedly surprised by large, positive inflation announcements and the public likely expected the Fed to respond to the inflation surge. We consider three potential explanations for the relatively late change in perceptions.

The first possibility is that the public thought inflation was transitory and would come down even in the absence of a monetary policy response. To assess the relevance of this explanation, we examine heterogeneity across forecasters. While our survey data shows that the average forecaster believed inflation would be quite transitory, there was substantial heterogeneity. In December 2021, 25% of forecasters believed CPI would average 3% or higher over the next four quarters and 10% believed it would average over 3.75%. We find little evidence that forecasters who expected higher inflation anticipated a different policy response than the average forecaster prior to liftoff in March 2022. Prior to liftoff, even forecasters who thought inflation was likely to persist believed that the Fed's response to inflation would be limited.

The second possibility is that the public may have believed the FOMC was following a well-known but nonlinear or state-dependent monetary policy rule. For example, average inflation targeting (AIT) may call for the Fed to remain "behind the curve" after undershooting its inflation target for an extended period of time.[5] This type of mechanism could generate a substantial increase in the perceived monetary policy inflation coefficient with a lag after an inflationary episode.[6] To study this hypothesis, we examine the sensitivity of yields of different maturities to inflation surprises. Even if the FOMC followed a deliberate and well-communicated strategy of remaining "behind the curve" for some time, long-term interest rates should still be sensitive to inflation surprises early on. But we find little evidence for such interest rate sensitivity. Prior to March 2022, long-horizon Eurodollar futures rates were only slightly more responsive to inflation surprises than short-maturity rates. Furthermore, the sensitivity of long-maturity rates to inflation surprises was small even during the significant inflation surprises of 2021, and only rose following liftoff. This evidence is inconsistent with the view that markets expected the Fed to respond strongly

[5] See for example Williams (2021) for a discussion of the policy implications of the theory of average inflation targeting and Jia and Wu (2022) for a theory of average inflation targeting in the presence of supply shocks.

[6] Similar predictions would hold if markets believed that the Fed was wrong in its assessment of inflation and would eventually come around to a more persistent view of inflation (Caballero and Simsek, 2022).

to inflation but simply with a lag, until previous inflation shortfalls had been made up. Instead, it suggests that even in late 2021 and right up until liftoff in 2022, markets expected a moderate Fed policy response to inflation, and only updated their beliefs after observing liftoff and major rate increases.

We also examine survey data from Europe. We find a similar pickup in the perceived monetary policy inflation coefficient for the ECB. If anything, the increase in the perceived inflation coefficient was somewhat later and less pronounced in Europe than in the U.S. Since the ECB did not have an AIT framework in place, this comparison between the Fed and the ECB therefore further suggests that complex monetary policy rules cannot explain our results.

The third possibility is based on the notion that knowledge about the Fed's policy rule is incomplete. Under this plausible assumption, forecasters and markets take cues from FOMC interest rate decisions and update their beliefs about its systematic inflation coefficient from observed rate hikes. The idea that the monetary policy rule is partly unknown and even experts update their perceptions about the rule from policy actions is consistent with our findings in Bauer, Pflueger and Sunderam (2024) over a much longer sample period, as well as with evidence in Cieslak (2018), Schmeling, Schrimpf and Steffensen (2022), Bauer and Swanson (2023*a*), Bauer and Swanson (2023*b*). It appears that the data are most consistent with this third explanation for the delayed shift in perceptions. Uncertainty about future interest rates and the Fed's policy response was elevated during this entire episode, as evident from option-based interest rate uncertainty. Monetary policy surprises—the reactions of interest rates to monetary policy announcements—were small in magnitude in 2021, but large and volatile with the onset of rate hikes in 2022. If the policy rule were fully understood before policy actions, then such large monetary policy surprises would have been unlikely. A rough back-of-the-envelope calculation suggests that learning from policy actions likely played a quantitatively significant role in the shift in public perceptions towards a stronger policy response to inflation we document.

Taken together, our results suggest that the recent pivot in monetary policy seems to have been broadly successful. Evidence from surveys of professional forecasters and financial markets show that public perceptions shifted towards a strong systematic inflation response during the Fed's recent hiking cycle, and within standard models this shift would have helped generate a larger disinflation for a given decline in output. However, our results also indicate that substantial rate hikes were apparently necessary for perceptions to shift, and that the public did not fully understand the Fed's strategy and policy rule prior to liftoff.

We highlight three policy implications of our findings. First, policy makers may want to track the perceived monetary policy rule via the survey- and market-based methodologies shown to be useful in this paper. Second, policy rate actions contribute to, and may even be necessary for, the effectiveness of communication, particularly when uncertainty about the monetary policy framework is high. As our evidence shows, a timely policy rate response to inflation matters not only for influencing immediate financial conditions, but also for signaling that policy makers are serious about responding to future inflation news. Third, innovations that allow for clearer communication of the intended monetary policy rule may be helpful. For instance, the Summary of Economic Projections could link macroeconomic and policy rate forecasts, allowing the public to more easily learn about the Fed's reaction function.

Our paper is related to other recent work that has studied the linkages of monetary policy and financial markets in the post-pandemic period. Cieslak, McMahon and Pang (2024) also document an increased sensitivity of Treasury yields to core CPI news since liftoff in March 2022, consider the role of term premium estimates in this context, and overall provide a detailed, critical analysis of the Fed's policy response to the recent inflation surge. Arnaut and Bauer (2024) show that broader financial conditions have become more responsive to inflation news over this period. Bocola et al. (2024) show that the correlation of daily changes in nominal Treasury yields with inflation compensation over the 2020–2022 period was significantly lower than in the pre-pandemic period, which is consistent with our finding of low interest rate sensitivity to inflation news before liftoff. Haddad, Moreira and Muir (2023, 2024) argue that unconventional monetary policy announcements convey information about asset purchase rules, as revealed by options and term premia. Pflueger (2023) analyzes the comovement of nominal yields, breakeven inflation, and stock returns within a quantitative New Keynesian asset pricing model, and her evidence is also consistent with a low inflation coefficient in 2021 and into 2022, and a late switch in financial market perceptions of the monetary policy framework.

The remainder of the paper is organized as follows: Section 2 presents our main empirical results, including estimates of the perceived monetary policy rule and event-study evidence of interest rate sensitivity to inflation news, and discusses the economic relevance of the shift in perceptions. Section 3 investigates the drivers of changes in the perceived inflation response and evaluates the three possible explanations for the late timing. Section 4 explores policy implications, and Section 5 concludes.

2 Policy perceptions during the recent inflation episode

In this section, we show that the perceived response of monetary policy to inflation increased significantly after liftoff in March 2022, based on data both from surveys of professional forecasters and financial markets. We then discuss why this shift policy perceptions is economically significant for the monetary transmission mechanism.

2.1 Perceived monetary policy rule from survey data

We apply our methodology from Bauer, Pflueger and Sunderam (2024) to estimate the perceived monetary policy rule through the recent inflation experience and liftoff. The data is from Blue Chip Financial Forecasts (BCFF), a monthly survey of professional forecasters, and we include survey waves up to and including April 2024. The BCFF survey asks participants for forecasts of interest rates, including the federal funds rate, as well as their *assumptions* about output growth and inflation underlying their rate forecasts, effectively asking forecasters for their perceived relationship between macroeconomic variables and interest rates. Forecasts are for quarterly horizons from the current quarter out to five quarters ahead. See the Appendix A for further information about the data and summary statistics.

We estimate the relationship between forecasts for the federal funds rate, inflation, and the output gap using panel regressions according to a standard Taylor-type monetary policy rule (Taylor, 1993, 1999). In contrast to the standard macroeconomics literature, which typically obtains backward-looking estimates of the Fed's policy rule using macroeconomic time series (Kim and Nelson, 2006; Boivin, 2006; Orphanides, 2003; Cogley and Sargent, 2005; Clarida, Gali and Gertler, 1999; Rudebusch, 2002), our estimates from BCFF forecasts should be interpreted as forward-looking. We estimate

$$E_t^{(j)} i_{t+h} = a_t^{(j)} + \hat{\beta}_t E_t^{(j)} \pi_{t+h} + \hat{\gamma}_t E_t^{(j)} x_{t+h} + e_{th}^{(j)} \tag{1}$$

for each survey month (t), where horizon (h) and forecaster (j) are the two panel dimensions. Here the expectations operator $E_t^{(j)}$ denotes the forecast of forecaster j in survey wave t, i_t is the federal funds rate, π_t is year-over-year inflation in the consumer price index (CPI), and x_t is the output gap, derived from real GDP growth forecasts as described in Appendix A. We include forecaster fixed effects $a_t^{(j)}$ to absorb forecaster beliefs about long-run inflation and the long-run real interest rate, which may be correlated with inflation and output gap forecasts. Since we estimate a separate panel regression in each monthly survey, we can allow all parameters to vary over time in a completely unrestricted manner.

The coefficients $\hat{\beta}_t$ and $\hat{\gamma}_t$ in (1) capture the *perceived* policy responses to inflation and the output gap, respectively. These perceived response coefficients may well differ from the true response coefficients in the Fed's policy rule, β_t and γ_t, which would require long samples of macroeconomic data to estimate and we treat as unobserved. In addition to the simple rule above, we also estimate a perceived inertial rule, which allows for interest-rate smoothing by including forecasts of the policy rate one quarter earlier, $E_t^{(j)} i_{t+h-3}$, as an additional regressor. The estimates from the inertial rule should be interpreted as the perceived short-run monetary policy response, which can cumulate over time with monetary policy persistence. The estimates from the baseline rule should be interpreted as the perceived medium-run response over the forecast horizon.

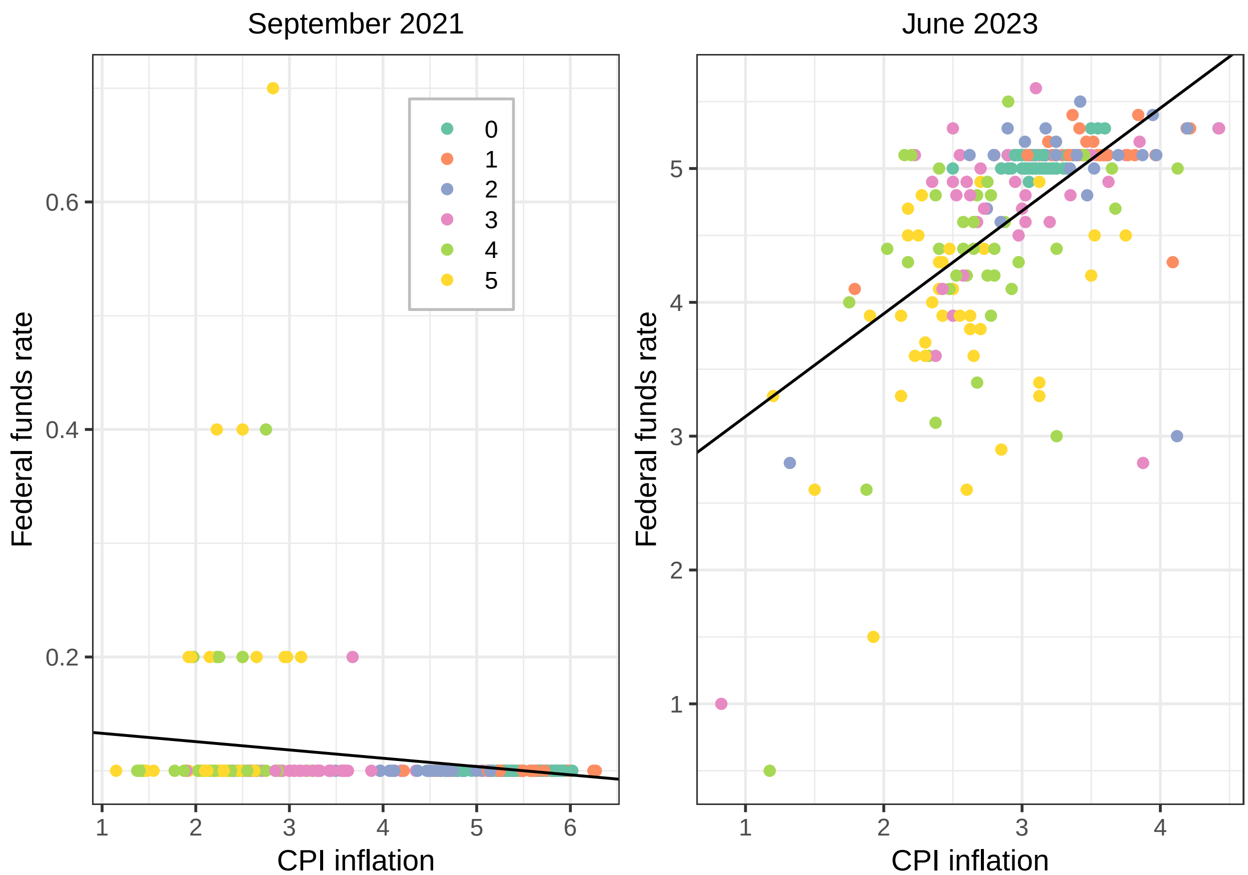
In Bauer, Pflueger and Sunderam (2024) we described four sufficient assumptions for the panel regression (1) to recover the perceived monetary policy rule. First, forecasters must disagree about future output and inflation. Second, their forecasts for future output and inflation must be uncorrelated with their forecasts of future monetary policy shocks. Third, the regression (1) must capture the correct specification of the policy rule, including homogeneous beliefs about its parameters. Finally, expectations about the rule parameters must be constant over the forecast horizon. Our earlier work showed that these assumptions are likely to be satisfied in practice, at least to a first approximation. We also showed that results are robust to relaxing some assumptions, for instance allowing heterogeneous beliefs about the policy rule and alternative specifications controlling for financial conditions.

In our context, the second assumption is substantive, but violations should, if anything, work against our main result. Strictly speaking, the exogeneity assumption requires that forecasters do not take into account the impact of perceived monetary policy shocks on inflation. However, our main finding is unlikely to be driven by violations of this assumption for three reasons. First, the direction of any potential endogeneity should be such that forecasters who perceive a positive policy rate shock should forecast lower inflation, thereby leading to a negative bias in the relationship between inflation and policy rate forecasts. Second, we are primarily interested in *changes* in $\hat{\beta}_t$ over the post-Covid period. If anything, the bias is likely to have become more negative as the perceived volatility of monetary policy shocks rose around liftoff. Hence, both the level and the increase in $\hat{\beta}_t$ may be understated if endogeneity is present. Third, our evidence from financial markets in Section 2.2 does not require this assumption and corroborates our results.

Figure 1 illustrates our main finding in the raw BCFF survey data. The left panel shows a flat relationship between forecasts of the federal funds rate on the y-axis and forecasts of CPI inflation on the x-axis in the September 2021 survey wave. Different forecast horizons are depicted in different colors. We see that there was significant variation in inflation forecasts both across and within forecast horizons in September 2021. However, this variation is uncorrelated with forecasts of the funds rate. As a result, our estimation methodology recovers a perceived monetary policy inflation coefficient, $\hat{\beta}_t$, that is close to zero in September 2021.

The picture looks markedly different in June 2023, shown in the right panel, where

Figure 1: Forecasts in September 2021 and June 2023



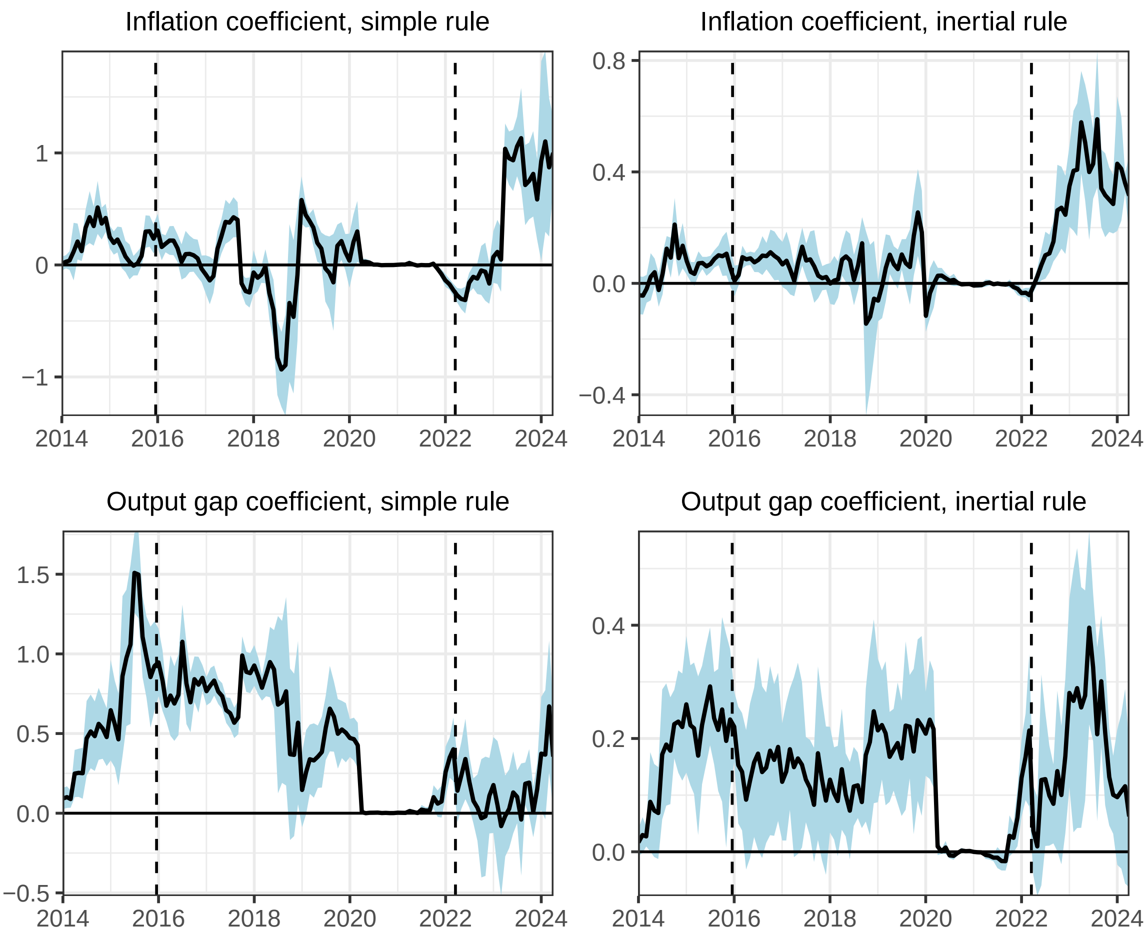
Scatter plots of federal funds rate forecasts against CPI forecasts in the Blue Chip Financial Forecast surveys from September 2021 and June 2023. Different colors correspond to different forecast horizons between zero and five quarters.

the upward-sloping relationship between CPI inflation forecasts and policy rate forecasts is unmistakable. At this time, there was again substantial disagreement about inflation forecasts, both across forecasters and across forecast horizons. However, different from two years prior, forecasts for the federal funds rate were tightly linked to inflation forecasts. Correspondingly, for the June 2023 survey wave, we estimate a perceived monetary policy inflation coefficient, $\hat{\beta}_t$, close to one.

Figure 2 plots the estimated inflation and output gap coefficients, $\hat{\beta}_t$ and $\hat{\gamma}_t$, for all survey waves between January 2014 and April 2024.[7] The left panels show the perceived coefficients from the simple rule, and the right panels show the perceived coefficients from the inertial rule. Vertical dashed lines indicate the two dates when the Fed lifted its policy rate off the

[7]Note that the values for September 2021 and June 2023 do not exactly match Figure 1 because Figure 2 is based on a multivariate regression with forecaster fixed effects, while Figure 1 gives the univariate relationship without fixed effects.

Figure 2: Forward-looking policy rules



Coefficients in forward-looking/perceived monetary policy rules, estimated from month-by-month panel regressions on Blue Chip Financial Forecast surveys from January 2014 to April 2024. Blue-shaded areas are 95% confidence intervals based on standard errors with two-way clustering (by forecasters and horizon). Vertical lines show liftoff dates December 2015 and March 2022.

ZLB, December 16, 2015 and March 16, 2022. The figure shows that during the pre-pandemic period $\hat{\beta}_t$ fluctuated close to zero, while $\hat{\gamma}_t$ was generally positive and ranged between 0.5 and 1.0 for the simple rule.[8] In Bauer, Pflueger and Sunderam (2024), we estimated the perceived monetary policy rule for a longer sample starting in January 1985 but ending earlier in May 2023. In that analysis we found a time-varying, generally positive perceived output gap coefficient, and we analyzed in detail its variation over the monetary policy cycle

[8]The briefly negative perceived inflation coefficient in 2018 reflected transitory fluctuations in inflation due to high oil prices, since BCFF collects headline CPI forecasts. Appendix Figure B.1 shows that the perceived inflation coefficient remains positive throughout the sample using core CPI inflation forecasts from the Survey of Professional Forecasters (SPF). Unfortunately, SPF forecasts are not available monthly but only quarterly, limiting their usefulness in estimating changing perceptions around specific events.

and in response to policy actions. That analysis did not focus on the perceived inflation coefficient, which was generally low and close to zero for most of that sample period, similar to the shorter pre-pandemic period shown in Figure 2.

The time variation in the perceived monetary policy rule over the recent period illustrates the forward-looking nature of our estimates. In particular, the onset of the ZLB period during the pandemic is clearly visible in the estimated perceived monetary policy coefficients, which both drop to essentially zero in March 2020. This result contrasts with our findings for the first ZLB in Bauer, Pflueger and Sunderam (2024), where we found that the perceived output gap coefficient remained positive until 2011.[9] The rapid drop in the estimated perceived monetary policy parameters reflects well-understood forward guidance in 2020 and contrasts with the first ZLB period which began with much less explicit forward guidance from the Fed.

Our main result is clearly visible in Figure 2, which shows a substantial shift in perceptions in the post-liftoff period, 2022–2024. The top-left panel shows that the inflation coefficient in the perceived simple rule rose from zero to around one, consistent with the Taylor principle that the Fed should raise interest rates at least one-for-one with inflation. The rise in $\hat{\beta}_t$ stands out from the pre-pandemic period and speaks to the exceptional changes in both the macroeconomic environment and monetary policy strategy—true and perceived—during this recent period.

The estimates for the inertial rule in the right panels of Figure 2 show broadly similar patterns to the estimates for the simple rule. The magnitudes for the inertial rule are different because the inertial rule captures the perceived short-term responses to inflation and the output gap.[10] One notable difference between the two top panels is that the inertial $\hat{\beta}_t$ on the right turns positive and gradually increases immediately after liftoff in March 2022, while the simple-rule $\hat{\beta}_t$ on the left hovers near zero until early 2023, when it suddenly jumps to levels near one. This difference suggests that perceived monetary policy inertia may have played a role in the delayed rise of the inflation coefficient in the simple rule. The inertial rule also shows a clearer positive perceived output gap coefficient immediately after liftoff. Overall, panel regressions of forward-looking policy rules using monthly waves of professional macroeconomic forecasts show a substantial increase in the perceived monetary policy inflation coefficient after liftoff in 2022, whether we estimate a perceived monetary policy rule with or without policy inertia.

[9] See also Swanson and Williams (2014) for evidence that the first ZLB was initially believed to be short-lived.

[10] The estimated perceived inertia coefficient averages 0.8 over our sample period.

2.2 Perceived monetary policy rule in financial markets

We next estimate the sensitivity of interest rates to inflation news in event study regressions, and again find a substantial increase in the perceived response of monetary policy to inflation using completely separate approaches and data. This approach is motivated by the idea that the yield curve response in narrow windows around data releases mainly reflects market expectations about the Fed's response to this news. The magnitude of the response therefore reveals how strongly investors expect Fed policy to react to new inflation data. In other words, such event studies estimate the "market-perceived monetary policy rule" (Hamilton, Pruitt and Borger, 2011).

We investigate the relationship between inflation news and interest rates using event-study regressions

$$\Delta y_t = \alpha + \theta\, s_t + \varepsilon_t, \tag{2}$$

where s_t is the core CPI surprise, the difference between monthly core CPI inflation and the average Bloomberg forecast immediately prior to the release and Δy_t is the daily yield change on the day of the inflation release. The intuition described above suggests that the sensitivity coefficient θ is closely related to the perceived monetary policy response to inflation, $\hat{\beta}_t$. This intuition can be formalized in a model of monetary policy perceptions. In Bauer, Pflueger and Sunderam (2024) we confirmed the predictions of such a model for the time-varying monetary policy output gap coefficient, using event study regressions around non-farm payroll news and a broader macro news index following Swanson and Williams (2014). Here we instead focus on inflation news releases, which have received renewed attention during recent years, to directly compare estimates of the Fed's perceived inflation response from survey forecasts with estimates from financial markets.

Table 1 reports the sensitivity of different interest rates to core CPI surprises over the pre- and post-liftoff periods. We study the responses of two-year, and ten-year Treasury yields, and money market futures rates for expirations of 4, 8, 12 and 16 quarters. We use a January 2014 start date to match our survey data analysis.[11] Core CPI releases are monthly, giving 97 observations for the pre-liftoff period and 26 observations post-liftoff. The two-year yield is often used as a summary of the current monetary policy stance and immediate forward guidance, while the 10-year Treasury yield response reflects longer-term monetary policy expectations, term premia, and potentially even unconventional monetary policy (Swanson and Williams, 2014). Money market future rates provide a more granular view of policy rate expectations at specific horizons. Of course, all interest rates may also

[11] Constant-maturity market yields are from the Fed's H.15 release, obtained via FRED. We use data for Eurodollar futures until December 2021 and SOFR futures starting in January 2022.

Table 1: Sensitivity of interest rates to inflation news

	Treasuries		Money Market Futures			
	2y	10y	4q	8q	12q	16q
Panel A: Pre-liftoff, 2014:01 to 2022:03						
Coefficient	0.06	0.11***	0.08*	0.14**	0.13**	0.13**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Observations	97	97	93	93	93	93
R^2	0.02	0.06	0.03	0.07	0.06	0.06
Panel B: post-liftoff, 2022:04 to 2024:05						
Coefficient	0.96***	0.57***	1.22***	1.11***	0.82***	0.59***
	(0.21)	(0.21)	(0.25)	(0.28)	(0.23)	(0.21)
Observations	26	26	26	26	26	26
R^2	0.48	0.27	0.50	0.43	0.35	0.26

Event-study regressions of daily changes in interest rates on core CPI surprises, the difference between the released monthly core CPI inflation rate and the average Bloomberg forecast immediately before the data release. Treasury yields are constant-maturity rates from the Fed's H.15 release. Money market futures are Eurodollar futures until December 2021 and SOFR futures starting in January 2022. Regression intercept is included but not reported. White robust standard errors are reported in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

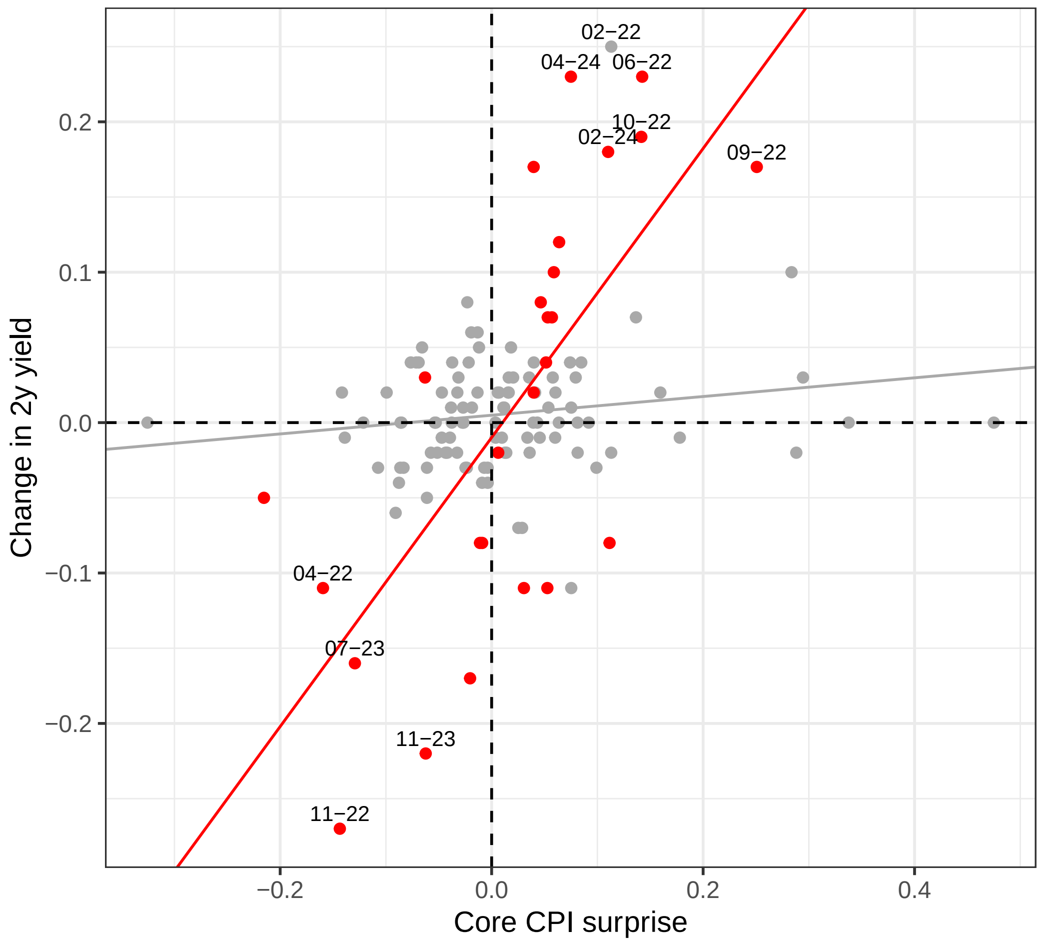
reflect changes in term premia, though term premia should matter primarily for long-term yields, and should, if anything, bias upwards the pre-liftoff sensitivity of long-term yields (Cieslak, McMahon and Pang, 2024).

The top panel of Table 1 shows that the sensitivity of interest rates to inflation surprises was very low prior to liftoff.[12] The sensitivity over this period is only about 0.1, meaning that a 10 basis point surprise in the core CPI release leads to a 1 basis point increase in interest rates. The statistical significance for the pre-liftoff period is also low, with the coefficient for the two-year yield not significantly different from zero at the 10-percent level. In contrast, the bottom panel shows that after liftoff, short-term interest rates were about ten times more sensitive to inflation surprises than pre-liftoff. The post-liftoff sensitivities for short-term interest rates were around or even greater than one. The sensitivity of longer-term yields to inflation surprises also increased substantially from the pre-liftoff period to about 0.6 post-liftoff. All coefficients are statistically significant at the one percent level, despite the much smaller sample size of only 26 observations.[13]

[12] The last observation in this sample is the February 2022 CPI release, which was made public on March 10, 2022, a week before the FOMC announcement of liftoff on March 16, 2022.

[13] Kroner (2024) studies the incorporation of inflation surprises into inflation expectations using similar high-frequency regressions and argues that attention to inflation news releases has increased during the recent high-inflation period from May 2021 onwards. To see how the incorporation of inflation surprises into inflation expectations matters, note that in equation (2), the coefficient θ reflects both the perceived

Figure 3: Changes in two-year Treasury yield and core CPI surprises



Changes in two-year Treasury yield and core CPI surprises, defined as the difference between released core CPI inflation and consensus expectations. Gray: pre-liftoff sample, January 2014 to March 2022. Red: post-liftoff sample, April 2022 to May 2024. Ten most influential observations in the full-sample (2014-2024) regression are labeled.

Figure 3 plots the raw data to help better understand the increased interest rate sensitivity to inflation news post-liftoff. It depicts a scatter plot of daily changes in the two-year yield on the y-axis against core CPI surprises on the x-axis, with each dot corresponding to a release date. The gray dots correspond to the pre-liftoff observations, and the gray fitted line corresponds to the regression in the first column of the top panel of Table 1. A striking

policy rule coefficient, $\hat{\beta}$, and the change in inflation expectations given the news $\Delta E[\pi_t|s_t]$. Two pieces of evidence suggest that changes in the perceived policy rule coefficient $\hat{\beta}$ played an important role in the rising post-liftoff sensitivity of yields documented in Table 1. First, the sensitivity of inflation swap rates to inflation surprises rose substantially earlier than the sensitivity of interest rates, as we confirm in Appendix Figure B.2. Markets believed there would be little Fed response to inflation even after they ceased to believe that inflation would be transitory. Second, our survey-based estimates in Section 2 measure expectations directly and are hence not sensitive to how inflation expectations are formed.

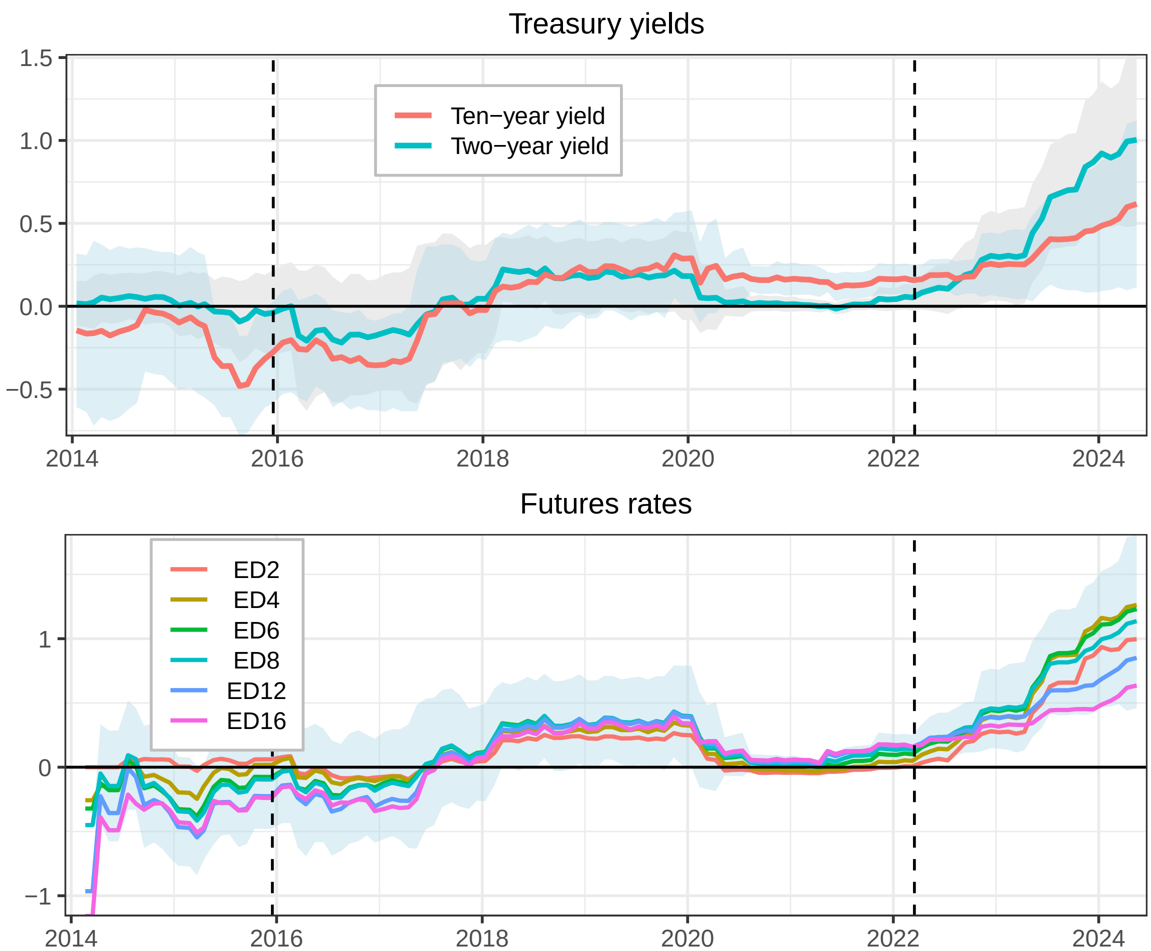
example of the lack of rate sensitivity over this period is the CPI release on May 12, 2021. Reported month-over-month core CPI inflation was 47.5 basis points above the consensus expectation, the largest surprise in our entire sample. The two-year yield, however, did not respond at all and remained unchanged on this day, evidently due to the (ex-post incorrect) perception that the Fed's policy rate would not respond to higher inflation over the subsequent two years. Several other large inflation surprises in 2021 also led to essentially no yield response. This shows that the low sensitivity of yields to inflation surprises before liftoff was not just due to the absence of meaningful surprises.

The red dots in Figure 3 highlight the observations after liftoff, and the corresponding regression line illustrates that core CPI surprises led to an almost one-for-one response in the two-year yield. The ten most influential observations for the full-sample (2014-2024) regression are labeled, and it is notable that most of these observations occurred well after liftoff, in the second half of 2022 or later. Though on average inflation was moderating from its peak after mid-2022, the inflation releases since then still contained both positive and negative surprises, many of which were quite large in magnitude. The strong sensitivity of yields after liftoff appears roughly symmetric for positive and negative inflation surprises, supporting the specification of a simple linear regression and a linear perceived policy rule.

A concern might arise that the low pre-liftoff sensitivity and the substantial increase thereafter are a mechanical result of the ZLB constraint on nominal interest rates during 2020-2021. However, we know from Swanson and Williams (2014) that for a significant portion of the 2008–2015 ZLB episode, short-term rates were stuck near zero and unresponsive, but yields on bonds with maturities of two years and longer were unconstrained by the ZLB and remained sensitive to macroeconomic news. It therefore seems unlikely that the low sensitivity of longer-term rates in the top panel of Table 1 is simply mechanical.

To further investigate the timing of the shift documented above, and to better assess the role of the ZLB, we estimate a time-varying sensitivity of interest rates to inflation surprises using rolling regressions. The window length is 24 months, and we report estimates for windows ending in January 2014 up to May 2024. Figure 4 shows that the sensitivity of Treasury yields (top) and for money market futures (bottom) increased substantially after liftoff and through 2023 and 2024, mirroring our results from BCFF survey data in Figure 2. Again, similarly to the perceived monetary policy rule from surveys, Figure 4 shows that the ZLB had a visible impact on the two-year yield and futures rate sensitivities, which collapsed to zero in March 2020. The rate sensitivities then increased towards the end of the sample to levels far above those previously seen between the two ZLB episodes. For example, the highest sensitivity of the two-year yield before 2022 is around 0.25 in 2018-2019. In contrast, in 2023 this sensitivity starts to exceed 0.5 and reaches one at the end of the sample. We

Figure 4: Sensitivity of interest rates to inflation news



Coefficient in rolling regressions of changes in Treasury yields (top panel) or federal funds rate future (bottom panel) on core CPI news, the difference between released core CPI inflation and consensus expectations. Rolling windows use 24 monthly releases. Sample period: January 2012 to May 2024. Blue-shaded areas are 95% confidence intervals based on robust (White) standard errors.

also see that the sensitivity of the ten-year yield barely dropped during period 2020–2021, and then rose to unprecedented levels in 2023 and 2024.

The main takeaway from these results is that the market-perceived monetary policy response to inflation increased substantially after the liftoff from the ZLB in March 2022, and the magnitude of the response was stronger than at any time earlier in the sample, on or off the ZLB. The increase in the market-perceived inflation response closely mirrors the rise in the survey-based perceived response, $\hat{\beta}_t$, documented in Section 2.1, leading to consistent results across the two approaches.

2.3 Economic significance of changes in perceived rule

A long line of research in monetary economics has argued that perceptions about monetary policy are crucially important for the effectiveness of monetary policy. The following discussion highlights two channels through which a strong perceived inflation response coefficient—as documented above for the period after liftoff from the ZLB in 2022—is helpful for monetary policy transmission.

The first channel is based on the insight that monetary transmission depends on expectations of future policy, because they determine borrowing rates and asset prices in the economy. When the monetary policy reaction function to macroeconomic data is well-understood, then markets to some extent can "do the central bank's work for it" (Woodford, 2005). Specifically, a strong perceived monetary policy inflation coefficient ensures that long- and short-term interest rates respond to inflation news, with the implication that financial conditions tighten with higher inflation prints and loosen with lower inflation prints, long before any actual changes in the policy rate. Compared with a situation where the market first has to wait for an explicit response from the FOMC, an earlier response in financial conditions is beneficial because it works somewhat akin to an "automatic stabilizer" and helps shorten the lags that usually characterize the effects of monetary policy.

The quantitative importance of this channel over the most recent disinflationary episode becomes evident from a simple back-of-the-envelope calculation. Let's assume the perceived inflation coefficient equals 0.75 – the estimated value for the simple rule from the October 2023 survey wave. Then a string of good inflation news lowering 12-month core PCE from 4.80% (July 2023) to 3.93% (October 2023) should lower interest rates by $0.75 \times (4.80\% - 3.93\%) = 65$ bps. The two-year Treasury yield did indeed fall by 80 bps from 5.03% on September 29, 2023 to 4.23% on December 29, 2023. The ten-year yield also exhibited a decline of similar magnitude over this period, falling by 71 bps to 3.88%.[14] Financial market commentary attributed the fall in longer-term interest rates during the last quarter of 2023 to precisely this channel.[15]

Second, perceptions of a strong interest rate response to inflation can improve the output-inflation tradeoff for monetary policy in standard New Keynesian models, similar to the well-known effects of a commitment to price stability. A classic result of this nature is discussed in Clarida, Gali and Gertler (1999), which however assumes a constant monetary policy rule, complete information, and rational expectations. Once the assumption about identical actual and perceived monetary policy rules is relaxed, it becomes clear that the improved

[14] In this calculation, core PCE inflation is lagged by two months to account for publication lag.

[15] See, for example, "Cooling Inflation Likely Ends Fed Rate Hikes: Mild October prices report unleashes stock and bond rallies", Wall Street Journal, November 14, 2023.

inflation-output tradeoff depends critically on *perceptions* about the future policy response (see Appendix C for details). The key result from this model is that a stronger perceived response to inflation improves the inflation-output tradeoff for the central bank. Intuitively, a strong perceived anti-inflationary monetary policy rule reduces the response of *expected* inflation to a positive cost-push shock, thereby containing the rise in actual inflation through price-setters' equilibrium response. In particular, a positive cost-push shock is predicted to lead to less inflation for any given decline in the output gap if agents in the economy trust that the central bank will counteract inflationary cost-push shocks going forward. Further, in this framework, if agents perceive a strongly anti-inflationary policy rule going forward, then the central bank can achieve lower volatilities for *both* inflation and the output gap. Qualitatively, the improved outcomes from a high perceived $\hat{\beta}_t$ are similar to the benefits of commitment over discretion with regard to the optimal monetary policy of a central bank (Kydland and Prescott, 1977; Taylor, 1993; Clarida, Gali and Gertler, 1999).

Because the model is highly stylized, this analysis should not be taken to imply that the Fed can repeatedly benefit from manipulating perceptions about monetary policy without following through with policy rate actions. As discussed in Section 4, our findings suggest that policy rate hikes in the face of inflation play a crucial role in communicating commitment to a strong inflation response. Implications for the inflation-output tradeoff also rely on some specific modeling assumptions of the standard framework, such as forward-looking and rational (conditional on the monetary policy rule) inflation expectations.[16] While a more thorough theoretical analysis of expectations formation in the New Keynesian model is beyond the scope of this paper, we view this simple modeling exercise as highlighting the value of a clear commitment to a monetary policy strategy of fighting inflation when it arises.

Overall, a strong perceived inflation response supports the transmission of monetary policy actions to long-term rates and asset prices and ultimately the macroeconomic impact. Moreover, it likely helps improve the inflation-output tradeoff faced by the central bank. Given these benefits, we now examine the mechanisms likely contributing to the rise in the perceived monetary policy inflation coefficient during the recent tightening cycle.

3 Timing and mechanism

In this section, we provide empirical evidence on the potential mechanisms driving the rise in the perceived response of monetary policy to inflation and its timing. While the rise in the perceived monetary policy inflation coefficient was significant and likely contributed to

[16] Empirically, Phillips curves are often found to be backward-looking (Fuhrer, 1997) and macroeconomic expectations to exhibit over- or under-reaction (Angeletos, Huo and Sastry, 2021).

the overall success of the tightening cycle, it also occurred somewhat late. One might have thought that the large positive inflation surprises of 2021 should have led to a change in the perceived monetary policy rule. Since BCFF forecasts and bond yields are forward-looking, our methodology is well-suited to detect a change in the perceived monetary policy rule even when the current policy rate is still at the ZLB. However, the evidence in Section 2 shows that the perceived Fed responsiveness to inflation increased substantially only *after* liftoff from the ZLB in March 2022. Why did the perceived monetary policy inflation response not rise earlier?

We consider three possible explanations: i) the increase in inflation was initially perceived as transitory; ii) forecasters understood that the FOMC was following a history-dependent or non-linear monetary policy rule, such as a well-communicated intent to allow inflation to overshoot for a limited period of time; iii) forecasters learned about the rule from monetary policy actions. Understanding these mechanisms matters because each is linked to different policy strategies. While all three explanations likely played some role in the recent episode, the additional evidence in this section, together with the late timing of the rise in $\hat{\beta}$, favors the third one: forecasters and markets learned about the Fed's inflation response from the Fed's interest rate changes, and this "learning from actions" channel was quantitatively important.

3.1 Transitory inflation expectations

The first possible explanation for the late rise in the perceived response of monetary policy to inflation is that the public may have perceived inflation to be transitory throughout 2021. Under this view, inflation would subside even in the absence of a monetary policy response and there was no need for the Fed to raise the federal funds rate. This view was shared by the Fed and many private forecasters through late 2021. In his Jackson Hole speech on August 27, 2021 Chairman Powell emphasized the incomplete labor market recovery and "the absence so far of broad-based inflation pressures" justifying continued low policy rates.

To better understand the relevance of beliefs about perceived inflation persistence, we split our sample of professional forecasters according to their mid-2021 inflation expectations into "team transitory" and "team permanent".[17] While the Fed and many forecasters believed that the run-up in inflation was transitory and not broad-based until late in 2021, there was a vigorous debate between policy-makers and commentators that broadly fell into two groups denoted by these terms.[18] If professionals believed that the Fed would not re-

[17]In late 2021, much of the discussion centered around "team transitory" vs. "team permanent". We adopt this popular terminology, recognizing that it seems unlikely that anyone viewed inflation as truly permanent.

[18]For example, Joel Naroff from Naroff Economics is quoted in the September 2021 BCFF survey as follows:

spond to transitory fluctuations in inflation but would respond to more long-lived inflation fluctuations, we would expect that forecasters on team permanent should have predicted an earlier and more vigorous liftoff from the zero lower bound, as well as a higher perceived monetary policy inflation coefficient.

To examine this hypothesis, we exploit the heterogeneity in medium-term inflation expectations across BCFF forecasters and classify forecasters based on their 4-quarter expectations for CPI inflation in July 2021. We define team transitory as all forecasters with 4-quarter CPI inflation forecasts in July 2021 below the median; team permanent consists of all forecasters with above-median four-quarter inflation forecasts. For each group, Figure 5 plots their average 4-quarter forecasts for inflation and the federal funds from July 2021 onwards. Consistent with the public discussion at the time, there were meaningful differences in inflation forecasts between the two groups throughout 2021 and 2022. Nonetheless, the two groups had very similar forecasts for the federal funds rate throughout the tightening cycle. This finding is also visible in the raw data from the September 2021 wave depicted in the left panel of Figure 1, which shows that most forecasters agreed that there would be no liftoff for the next 5 quarters, even those with very high forecasts for CPI.

If forecasters understood that the Fed would not respond to transitory inflation, but it would to persistent inflation, then we would expect team transitory to anticipate lower policy rates for longer than team permanent. However, we find that both groups of forecasters predicted essentially the same path for the federal funds rate prior to liftoff.[19] Overall, this evidence from individual forecasters suggests that the belief that inflation was transitory cannot fully explain why the Fed's perceived responsiveness to inflation only rose after liftoff.

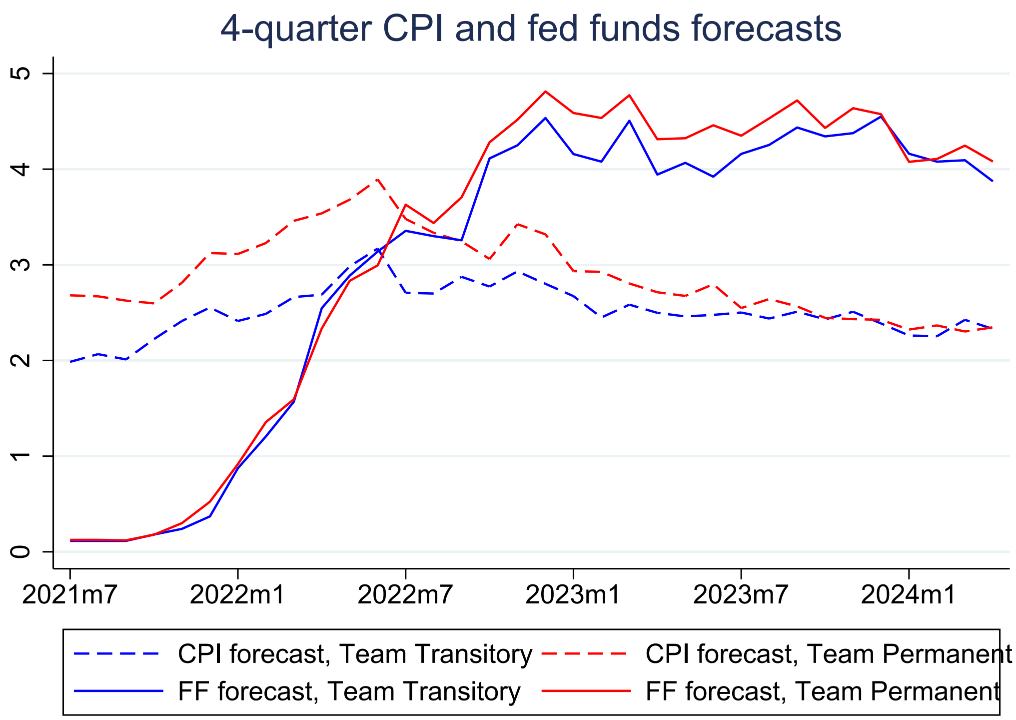
3.2 History-dependent or non-linear monetary policy rule

A second possible explanation for the late rise in the perceived inflation coefficient $\hat{\beta}$ is that forecasters believed the FOMC was intentionally allowing for a temporary inflation overshoot. With a well-understood history-dependent or nonlinear monetary policy rule, forecasters might plausibly expect the Fed to show little response to the initial inflation run-up in 2021 in the short-run, while still anticipating a stronger inflation response in the longer-run. This is not just a theoretical possibility, but exactly the idea behind average inflation targeting (AIT), which the Federal Reserve embraced in its newly revised strategic policy framework in 2020. The Fed's revised policy framework is one of many possible make-up strategies, all

"He [Chairman Powell] has been making the argument that the factors driving the surge in inflation were transitory for a while now, but his defense today was as strong as it gets. I almost believe him. Almost."

[19] Appendix Figures B.4 and B.5 provide additional consistent evidence by estimating the perceived monetary policy rules separately for both groups of forecasters.

Figure 5: Survey forecasts for inflation optimists and pessimists



Four-quarter forecasts for federal funds rate the CPI inflation from Blue Chip Financial Forecasts. Forecasters are split into inflation optimists, who have below-median four-quarter CPI forecasts in July 2021, and inflation pessimists, who have above-median forecasts. Sample period: July 2021 to April 2024.

of which "fundamentally work through the same mechanism of delivering interest rates that are 'lower for longer' following a negative shock" (Williams, 2021). Another example is the policy proposed by Reifschneider and Williams (2000), which would keep interest rates at zero until the cumulative missed monetary policy stimulus due to the zero lower bound has been recovered. Such "lower for longer" strategies and an explicit intention to "overshoot" on inflation would seem consistent with the delayed pickup in the perceived monetary policy inflation coefficient.

The explanation based on a history-dependent or non-linear rule, however, has distinct testable predictions for how long- and short-term interest rates should respond to inflation surprises, that are not borne out in the data. In particular, while this hypothesis can explain why short-term interest rates did not respond to inflation surprises in 2021, it also predicts that longer-term rates should have already started responding to inflation surprises in 2021. However, Figure 4 shows no quantitatively meaningful increase in the responses of either the ten-year Treasury yield (top panel) or longer-term Eurodollar rates (bottom panel) to CPI news surprises until well after liftoff in March 2022. This evidence suggests that even long-term policy expectations did not respond to the inflation surge in 2021, casting doubt on the importance of a perceived "lower for longer" strategy.[20]

International evidence is also helpful for evaluating this second explanation. Like the Fed, the European Central Bank revised its strategic framework in light of the ZLB experience, but it did not formally adopt average inflation targeting or another type of make-up strategy.[21] Given the differences in the monetary policy frameworks, we consider perceptions about the ECB's monetary policy response to the recent global inflation surge. Figure 6 presents the results of applying our methodology for estimating policy perceptions to the ECB's Survey of Professional Forecasters (ECB SPF).[22] Like the Fed's perceived response, the ECB's perceived response was close to zero throughout 2021 and only started to rise after liftoff from the ZLB, which for the ECB happened in July 2022. Appendix Figure B.3 shows that bond market responses to inflation surprises in Europe also look broadly similar to the responses we document for the U.S. in Section 2.2. The similarity between the two central banks thus further suggests that AIT or a broader make-up strategy were not the main driver for the late shift in the perceived monetary policy rule in the United States.

3.3 Learning from monetary policy actions

The third possibility is that policy perceptions may have shifted late because high uncertainty about the Fed's reaction function in 2021 and 2022 required concrete policy actions—liftoff and substantial rate hikes—to signal that monetary policy would respond strongly to inflation. The shift in the public's understanding of the Fed's systematic inflation responses occurred clearly after liftoff (see Figures 2 and 4), suggesting that learning from observed rate hikes played an important role. Here we provide additional evidence from high-frequency monetary policy surprises around FOMC announcements and option-based interest rate uncertainty that further supports this mechanism.

If the public's knowledge of the monetary policy rule is incomplete, monetary policy actions provide valuable information about the policy rule followed by a central bank. A simple model, following Bauer and Swanson (2023*a*,*b*), formalizes this idea.[23] The central

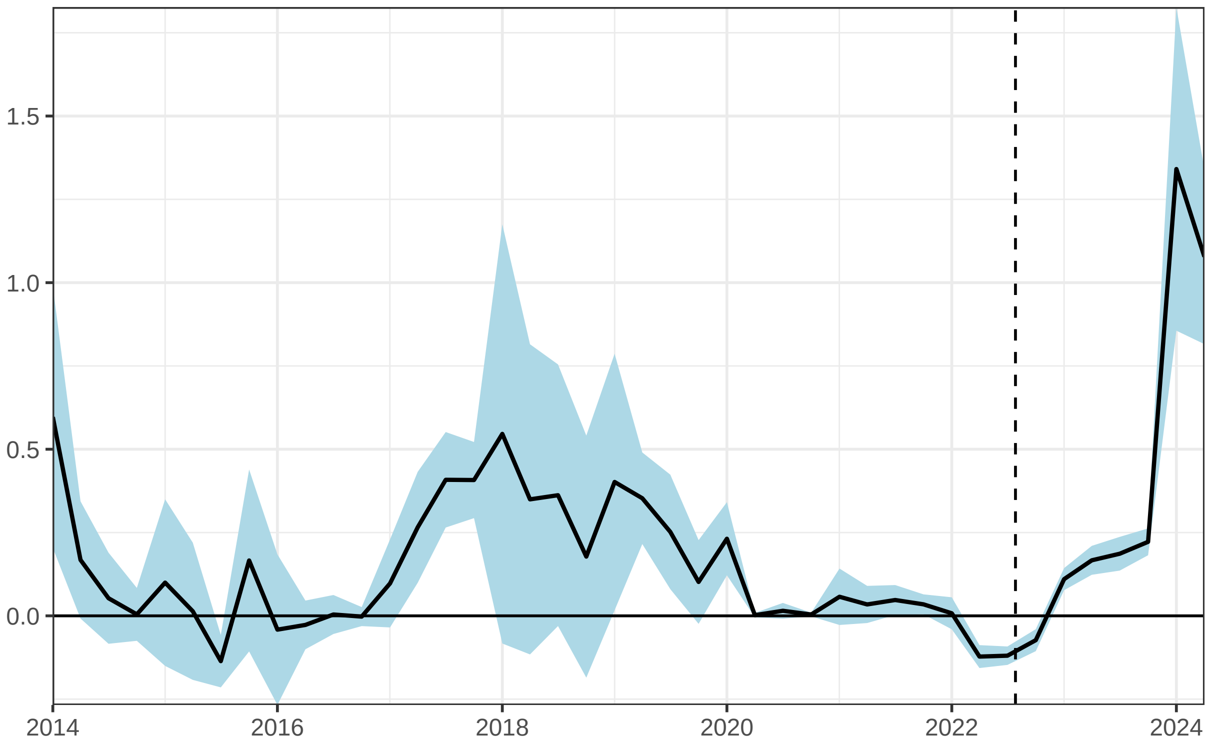
[20] Cieslak, McMahon and Pang (2024) also find a very small increase in the yield sensitivity to inflation news over the period from January 2021 through February 2022. Furthermore, they attribute most of the sensitivity of yields pre-liftoff to bond risk premia, not the expected path of short-term interest rates.

[21] The ECB's monetary policy strategy statement indicates that the Governing Council may tolerate a "transitory period in which inflation is moderately above target" but does not refer to past policy misses or make-up considerations.

[22] The ECB SPF survey is conducted quarterly and asks professional forecasters for forecasts of policy rates, inflation, and unemployment across multiple horizons. While the frequency and forecast horizons are somewhat different from the U.S. estimates in Figure 2, Figure 6 for the Eurozone is constructed in a way as similar to the U.S. as possible.

[23] In Bauer, Pflueger and Sunderam (2024) we showed that a somewhat richer version of this model with

Figure 6: ECB's perceived response to inflation



Inflation coefficient in forward-looking monetary policy rule, estimated from quarter-by-quarter panel regressions on the ECB's Survey of Professional Forecasters from January 2014 to April 2024. Blue-shaded areas are 95% confidence intervals based on standard errors with two-way clustering (by forecasters and horizon). Vertical lines show liftoff dates December 2015 and March 2022.

assumption is that the inflation coefficient in the policy rule, β_t, is time-varying and not known by the public:

$$i_t = \beta_t (\pi_t - \pi^*) + u_t,$$

where the monetary policy shock u_t is Gaussian white noise with volatility σ_u, and β_t follows a random walk process,

$$\beta_{t+1} = \beta_t + \xi_{t+1}.$$

For simplicity, we assume that the inflation target π^* is constant and commonly known, and that inflation follows the exogenous AR(1) process

$$\pi_t - \pi^* = \phi (\pi_{t-1} - \pi^*) + v_t,$$

belief heterogeneity across forecasters tied together our central empirical findings. In particular, the model demonstrated that we can estimate the perceived monetary policy rule from panels of survey data. It also showed that policy perceptions would update in a state-contingent manner following monetary policy surprises, consistent with what we found in the data.

with Gaussian white noise innovation v_t. Beliefs about the inflation coefficient are characterized by the prior mean $\hat{\beta}_t = E(\beta_t | \mathcal{Y}_{t-1})$ and variance $\sigma_t^2 = Var(\beta_t | \mathcal{Y}_{t-1})$, where the information set $\mathcal{Y}_{t-1}$ includes observed policy rates and inflation up to period $t-1$.

The key implication of this incomplete information setting is that *monetary policy surprises* are driven not only by policy shocks u_t but also by misperceptions about the monetary policy rule:

$$mps_t \equiv i_t - E(i_t | \mathcal{Y}_{t-1}, x_t) = \left(\beta_t - \hat{\beta}_t\right)(\pi_t - \pi^*) + u_t. \tag{3}$$

Equation (3) demonstrates that, for example, a hawkish policy surprise ($mps_t > 0$) can arise either from a contractionary monetary policy shock ($u_t > 0$) or because the Fed responds to high inflation more strongly than the public anticipated ($\beta > \hat{\beta}$ and $\pi_t > \pi^*$).

Agents learn from observed monetary policy surprises about the unknown rule. In the special case where policy shocks are absent ($u_t = 0$), the policy rule can be learned perfectly from observed surprises. In this case, equation (3) implies $\hat{\beta}_{t+1} = \beta_t = \hat{\beta}_t + mps_t/(\pi_t - \pi^*)$. More generally, with uncertainty about u_t, application of the Kalman filter shows that rational forecasters scale down their updating according to the signal-to-noise ratio ω_t:

$$\hat{\beta}_{t+1} - \hat{\beta}_t \;=\; \omega_t \frac{mps_t}{\pi_t - \pi^*}, \quad \omega_t = \frac{\sigma_t^2 (\pi_t - \pi^*)^2}{\sigma_t^2 (\pi_t - \pi^*)^2 + \sigma_u^2}. \tag{4}$$

During times of high inflation ($\pi_t > \pi^*$) a hawkish surprise ($mps_t > 0$) should lead to an upward revision in the perceived inflation response coefficient ($\hat{\beta}_{t+1} > \hat{\beta}_t$). The strength of the updating depends on policy uncertainty: Perceptions update more strongly in response to observed surprises when uncertainty about the monetary policy rule is high, as the signal-to-noise ratio ω_t increases with the prior variance σ_t^2.

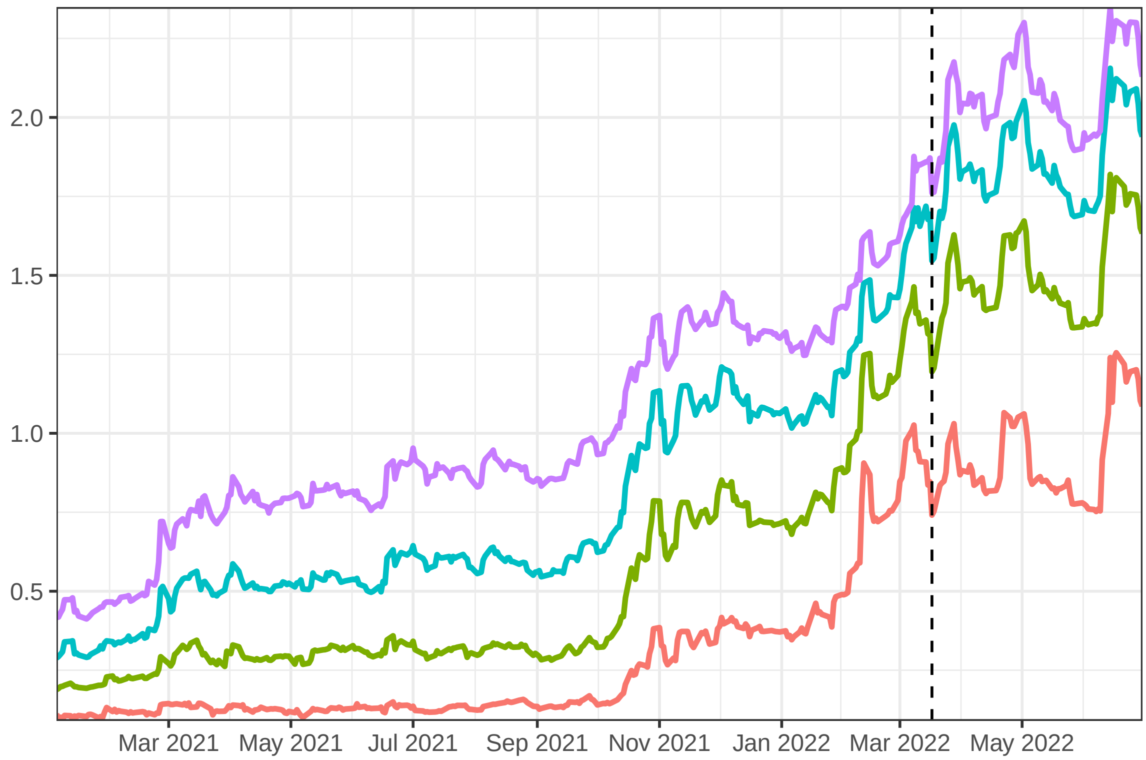
To provide empirical evidence for this kind of updating, one would ideally follow the approach of our earlier work (Bauer, Pflueger and Sunderam, 2024, Section 3), directly relating changes in the perceived policy rule coefficient to monetary policy surprises. Since the recent bout of inflation has been too short for this type of analysis, however, we provide three pieces of complementary evidence.

First, we note that anecdotal evidence suggests that observed rate hikes caused significant increases in $\hat{\beta}_t$. Around liftoff, contemporaneous market commentary interpreted the pace and magnitude of early rate hikes as strong signals of the Fed's disinflationary commitment.[24]

Second, we provide empirical evidence for two necessary conditions for learning from

[24]For example, the Wall Street Journal cited Gary Pollack of Deutsche Bank as saying "The Fed sent a strong signal to the market that it has the commitment and willpower to cool inflationary pressures" (Wall Street Journal, March 17, 2022). Similarly, the Wall Street Journal reported in July 2022 that "U.S. interest-rate expectations are volatile partly because the Fed made a surprising shift in June", referring to the fact that the 75 bps rate hike in June 2022 had surprised markets.

Figure 7: Option-based interest rate uncertainty



Option-based uncertainty about future short rates, measured as risk-neutral conditional standard deviations of short-term rates in 6, 12, 18 and 24 months using Eurodollar futures and options, following Bauer, Lakdawala and Mueller (2022). Line with lowest (highest) uncertainty corresponds to shortest (longest) horizon. Vertical line shows liftoff date March 17, 2022. Sample period: January 4, 2021 to December 30, 2022.

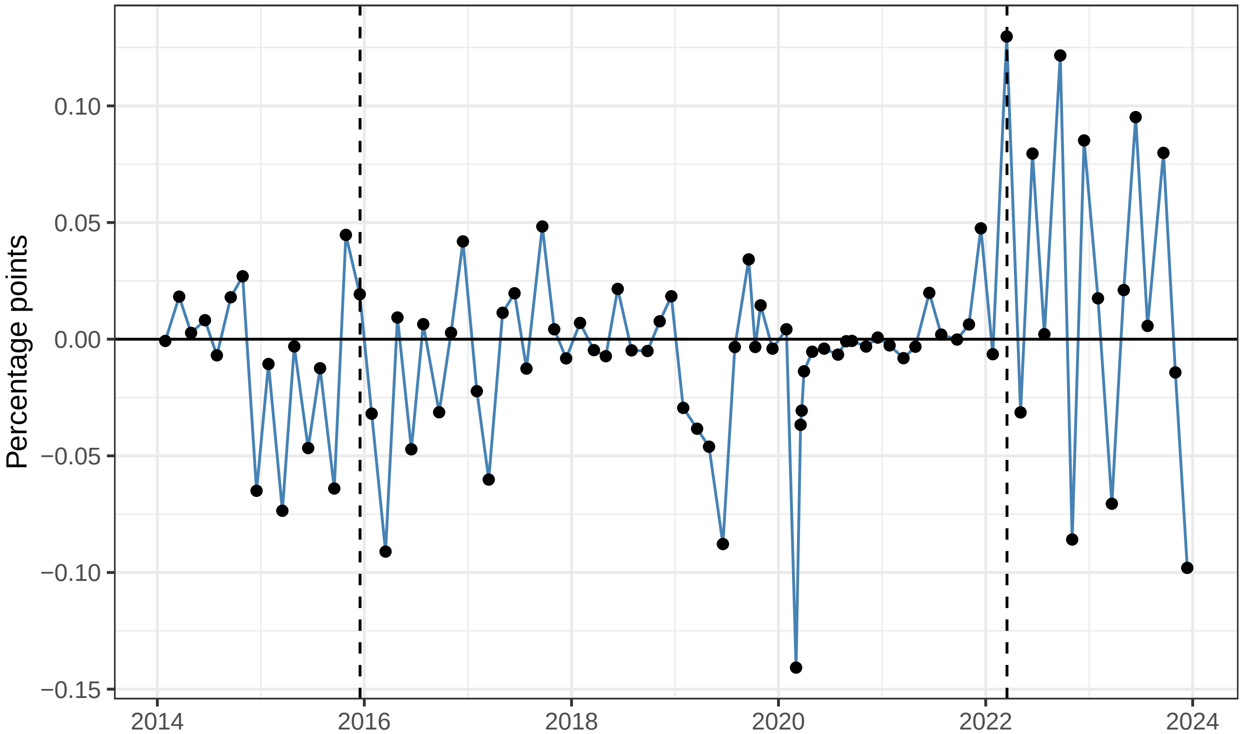
policy actions to drive perceptions of the monetary policy rule. As shown in equation (4), significant updates to the perceived inflation coefficient $\hat{\beta}$ require both high uncertainty about the Fed's policy responses, σ_t^2, and large monetary policy surprises, mps_t.

Figure 7 provides evidence from options markets suggesting high uncertainty about the Fed's policy response in 2021 and 2022. It plots the option-based uncertainty measure for future short term interest rates from Bauer, Lakdawala and Mueller (2022), extended to December 2022. Uncertainty across all reported horizons, from six to 24 months, increased substantially before liftoff, starting in October 2021. A caveat of this time series evidence is that changes in interest rate uncertainty can arise from shifts in either macroeconomic uncertainty or policy uncertainty. However, some of the largest increases in short-rate uncertainty over the pre-liftoff period followed FOMC communications, including speeches by Governors and Bank Presidents.[25] This suggests that policy uncertainty likely contributed

[25]For example, the biggest pre-liftoff increase in uncertainty was on February 10, 2022. Markets reacted to new inflation data, but the biggest market response came "after remarks from [Fed President Bullard]

meaningfully to the increased rate uncertainty shown in Figure 7.

Figure 8: Monetary policy surprises



Monetary policy surprises, calculated as the first principal component of 30-minute changes around FOMC announcements in money market futures rates covering the subsequent four quarters. Vertical lines indicate liftoff dates December 16, 2015 and March 16, 2022. Sample period: January 2014 to December 2023.

Figure 8 then shows that there were large monetary policy surprises after liftoff. It plots high-frequency surprises for FOMC announcements from January 2014 to December 2023, calculated as the first principal component of 30-minute changes in money market futures rates covering the first four quarters after each announcement, following Bauer and Swanson (2023*a*).[26] The magnitude of the surprises increased significantly starting with the March 16, 2022 FOMC announcement that marked liftoff from the ZLB, notably exceeding the magnitude of earlier surprises. As equation (3) suggests, such large monetary policy surprises are likely due, at least in part, to misperceptions and uncertainty about the policy

who signaled the central bank may move more drastically to curtail inflation. The data and comments injected fresh uncertainty..." (Wall Street Journal, February 10, 2022). Further substantial increases in rate uncertainty followed the speeches of Governors Waller and Quarles on October 19 and 20, 2021, and the FOMC meeting ending on January 26, 2022.

[26] Different from Bauer and Swanson (2023*a*), we scale the loadings so that they sum up to one, meaning that the surprises are weighted averages of high-frequency changes in futures rates. We also transition from Eurodollar futures to SOFR futures in January 2023; see Acosta, Brennan and Jacobson (2024) for details on Eurodollar vs. SOFR futures in this context.

rule. If market participants had known the Fed's monetary policy strategy prior to liftoff, then surprises post-liftoff likely would have been smaller.

Table 2: Numerical illustration of learning mechanism

			Implied $\hat{\beta}_{t+1} - \hat{\beta}_{2022:01}$			
	Monetary Policy Surprise		BCFF 4-Quarter CPI		SEP Core PCE	
Date	mps_t	Cumulative	$\omega_t = 1$	$\omega_t = 0.5$	$\omega_t = 1$	$\omega_t = 0.5$
16-Mar-22	0.130	0.123	0.12	0.06	0.09	0.04
15-Jun-22	0.080	0.171	0.15	0.07	0.11	0.06
21-Sep-22	0.122	0.295	0.26	0.13	0.18	0.09
2-Nov-22	-0.086	0.209	0.19	0.09	0.14	0.07
14-Dec-22	0.085	0.295	0.27	0.13	0.18	0.09
22-Mar-23	-0.071	0.242	0.20	0.10	0.12	0.06
14-Jun-23	0.095	0.358	0.38	0.19	0.21	0.10
20-Sep-23	**0.080**	**0.443**	**0.54**	**0.27**	**0.28**	**0.14**
13-Dec-23	-0.098	0.331	0.26	0.13	0.16	0.08

This table shows FOMC announcements between January 2022 and December 2023 when monetary policy surprises exceeded 7 basis points in absolute value. The column "Cumulative" reports the sum of monetary policy surprises from January 2022 up to the indicated announcement (including smaller ones not listed here). The next two columns compute the implied cumulative change in the perceived monetary policy coefficient from equation (4) using the empirical monetary policy surprise and the latest BCFF 4-quarter CPI inflation forecast for different scenarios of the signal-to-noise ratio ω_t. The last two columns report the analogous calculation using the simple average of the current-year and next-year core PCE forecast (midpoint of central tendency) from the latest Summary of Economic Projections. The September 2023 meeting in bold shows the peak effect on the perceived monetary policy inflation coefficient.

Third, we conduct a simple back-of-the-envelope calculation to assess the potential quantitative importance of learning from observed policy actions. Table 2 reports monetary policy surprises and plausible learning updates based on equation (4) under various parameter assumptions. The first column reports each monetary policy surprise that exceeded 7 bps in absolute value. The second column reports the cumulative monetary policy surprise (including smaller ones not listed here). The third column shows the implied cumulative change in the perceived monetary policy inflation coefficient, using the BCFF 4-quarter inflation forecast for π_t and assuming a signal-to-noise ratio of $\omega_t = 1$, i.e. maximal uncertainty about the policy rule. For example, the FOMC meeting on March 16, 2022 featured a monetary policy surprise of 13 bps and BCFF 4-quarter inflation forecast of 3.03%, implying an inflation gap of $3.03\% - 2\% = 1.03\%$ and an update in the perceived inflation coefficient of $\hat{\beta}_{16-Mar-22} - \hat{\beta}_{1-Jan-22} = 1 \times 0.13/1.03 = 0.12$ (up to rounding).

The peak implied perceived monetary policy inflation coefficient due to learning occurred in September 2023 at a substantial 0.54 and is highlighted in bold. For comparison, the empirical estimate of $\hat{\beta}_t$ from the inertial rule in the top-right panel of Figure 2 increased from roughly zero in January 2022 to 0.32 in the October 2023 survey, and the simple-rule estimate of $\hat{\beta}_t$ in the top-left panel of Figure 2 increased by roughly 0.89 over the same time period. Of course, the third column in Table 2 should be regarded as an upper bound for the relevance of the learning channel, as the uncertainty about the monetary policy rule was high during this period but perhaps did not drive the entire variation in monetary policy surprises on FOMC dates.

The remaining columns of Table 2 show that the magnitude of the learning update for $\hat{\beta}_t$ remains substantial using different values of the signal-to-noise ratio and different inflation measures. If we set $\omega_t = 0.5$, consistent with the estimates we obtained in Bauer, Pflueger and Sunderam (2024) for empirical updating about the output coefficient in the perceived policy rule over a much longer sample, the implied peak increase in $\hat{\beta}_t$ is still 0.27. The last two columns of Table 2 show that if we use the latest core PCE forecast available from the Fed's Summary of Economic Projections, the implied magnitudes are smaller, though still substantial compared to the increase in our empirical estimates of $\hat{\beta}_t$. Taken together, these calculations suggest that signals from the Fed's policy actions likely played a quantitatively significant role in shifting public perceptions towards a stronger policy response to inflation.

Overall, the timing of the observed shifts in $\hat{\beta}_t$, as well as financial market evidence based on high-frequency monetary policy surprises and option-based interest rate uncertainty, are consistent with the view that uncertainty about the Fed's reaction function was high in 2021 and 2022. This initial lack of clarity about the policy response to inflation likely made it particularly beneficial for the Fed to act decisively, in the form of significant and sustained rate hikes, to convince the markets and the public of its strong response to inflation and commitment to price stability.

4 Policy Implications

The analysis in this paper implies several broader lessons for policy. Both survey- and market-based measures of the perceived response of monetary policy to inflation rose significantly during the recent tightening cycle. Such shifts tend to improve the inflation-output tradeoff in standard models of monetary policy, and may have contributed to the relatively smooth disinflation during the recent hiking cycle. The rise in the perceived inflation coefficient also appears to have linked medium- and long-term interest rates more closely to inflation news, accelerating the transmission of monetary policy through financial markets.

Going forward, how can the Federal Reserve and other central banks around the world monitor and guide policy perceptions to enhance the effectiveness of monetary policy? First, our results suggest that central banks may find it beneficial to track the perceived rule using tools such as those proposed in this paper: the perceived rule measured from linked interest rate and macroeconomic forecasts and the market-perceived rule estimated from macroeconomic news announcements.

Second, our evidence on the mechanism behind the recent shift in perceptions suggests that central bank actions help shape public perceptions about the monetary policy rule. Said differently, actions and words are important complements in the conduct of monetary policy. Our findings imply that when uncertainty about the monetary policy rule is high, as options data suggests was the case in 2021, policy actions can play a quantitatively meaningful role in conveying information about the monetary policy rule. Financial markets and the broader public are likely to perceive a higher responsiveness of monetary policy to inflation if they observe rate hikes following high inflation, and if subsequent easings follow inflation developments. Monetary policy perceptions tend to change in response to unanticipated policy actions, such as policy rate surprises; fully anticipated actions are unlikely to change beliefs. The signaling power of policy rate changes implies that there is an added benefit for central banks to hike early and consistently in response to high inflation, and makes it particularly important to condition subsequent easings on improving inflation data.

Finally, central banks can provide information about their reaction function using various communication tools, and in this way shift policy perceptions and potentially improve the effectiveness of monetary policy. Data sets like the BCFF, which link forecasts for the policy rate, inflation, and the real economy, contain useful information about the perceived monetary policy rule. The FOMC produces a very similar set of forecasts for its Summary of Economic Projections (SEP). However, the individual projections underlying the SEP, in which forecasts for the federal funds rate are linked to those for macroeconomic variables, are released only with a five-year lag. Publishing the individual (anonymized) projections in real time would allow public observers and researchers to obtain timely estimates of the Fed's monetary policy rule by applying our methodology.[27] In other words, by "connecting the dots" of the SEP—publishing the individual projections for macroeconomic variables linked to those for the federal funds rate—the FOMC could provide valuable information about its policy strategy and reaction function.

[27] A different but related possibility would be to publish projected interest rates conditional on different macroeconomic scenarios (Bernanke, 2024), though this would represent a more significant deviation from the Fed's current communication framework.

5 Conclusion

This paper estimates changing perceptions of the Fed's monetary policy rule around the inflation surge of 2021 and the tightening cycle of 2022–2023. It shows that the perceived monetary policy response to inflation increased substantially over this period. The shift is visible both in surveys of professional forecasters and in the changing bond market sensitivity to inflation surprises. It likely mattered for monetary policy transmission by amplifying bond yield responses to inflation news and would have been important for containing the rise in inflation expectations within a standard model of monetary policy.

We also find that the increase in the perceived response to inflation occurred later than the actual rise in inflation and only after liftoff from the ZLB. Our evidence suggests that this late shift in perceptions was not due primarily to the fact that inflation was believed to be transitory, or an anticipated temporary inflation overshooting, as one might expect under a strategy of average inflation targeting. Rather, the delayed shift appears to be due, at least in part, to the high uncertainty about the Fed's policy strategy and reaction function before liftoff. Forceful policy actions—in the form of large rate hikes that repeatedly took markets by surprise—were necessary to shift the public's perceptions. We conclude from our calculations that learning about the policy rule from the Fed's rate hikes likely played a quantitatively significant role in shifting policy perceptions towards a strong inflation response

These findings have implications for how policy can build and improve on its recent successes in fighting inflation. Our research suggests that central banks may want to monitor perceptions about the monetary policy rule through survey and market based data, as demonstrated in this paper. For the Federal Reserve, "connecting the dots" of the SEP may be a simple but effective tool to provide information about its reaction function to the public. Finally, raising policy rates promptly in response to realized inflation, and following a highly data-dependent policy rate path thereafter, may have the additional benefit of credibly conveying a strong systematic inflation response.

References

Acosta, Miguel, Connor M. Brennan, and Margaret M. Jacobson. 2024. "Constructing high-frequency monetary policy surprises from SOFR futures." Federal Reserve Board of Governors FEDS Working Paper 2024-023.

Angeletos, George-Marios, Zhen Huo, and Karthik A Sastry. 2021. "Imperfect macroeconomic expectations: Evidence and theory." *NBER Macroeconomics Annual*, 35(1): 1–86.

Arnaut, Zoë, and Michael Bauer. 2024. "Monetary policy and financial conditions." *FRBSF Economic Letter*, 2024: 07.

Ball, Laurence. 1995. "Disinflation with imperfect credibility." *Journal of Monetary economics*, 35(1): 5–23.

Bauer, Michael D., Aeimit Lakdawala, and Philippe Mueller. 2022. "Market-Based Monetary Policy Uncertainty." *The Economic Journal*, 132(644): 1290–1308.

Bauer, Michael D., and Eric T. Swanson. 2023*a*. "An Alternative Explanation for the 'Fed Information Effect'." *American Economic Review*, 113(3): 664–700.

Bauer, Michael D., and Eric T. Swanson. 2023*b*. "A Reassessment of Monetary Policy Surprises and High-Frequency Identification." *NBER Macroeconomics Annual*, 37(1): 87–155.

Bauer, Michael D, Carolin E Pflueger, and Adi Sunderam. 2024. "Perceptions about Monetary Policy." forthcoming in *Quarterly Journal of Economics*.

Bernanke, Ben. 2024. "Forecasting for monetary policy making and communication at the Bank of England: A review, April 12, 2024." https://www.bankofengland.co.uk/independent-evaluation-office/forecasting-for-monetary-policy-making-and-communication-at-the-bank-of-england-a-review/forecasting-for-monetary-policy-making-and-communication-at-the-bank-of-england-a-review.

Bianchi, Francesco, Martin Lettau, and Sydney C Ludvigson. 2022. "Monetary policy and asset valuation." *The Journal of Finance*, 77(2): 967–1017.

Bianchi, Francesco, Sydney C. Ludvigson, and Sai Ma. 2022. "Monetary-Based Asset Pricing: A Mixed-Frequency Structural Approach." Working Paper 30072, National Bureau of Economic Research.

Blinder, Alan S., Michael Ehrmann, Marcel Fratzscher, Jakob De Haan, and David-Jan Jansen. 2008. "Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence." *Journal of Economic Literature*, 46(4): 910–945.

Bocola, Luigi, Alessandro Dovis, Kasper Jørgensen, and Rishabh Kirpalani. 2024. "Bond market views of the Fed." National Bureau of Economic Research working paper 32620.

Boivin, Jean. 2006. "Has US Monetary Policy Changed? Evidence from Drifting Coefficients and Real-Time Data." *Journal of Money, Credit and Banking*, 38(5): 1149–1173.

Caballero, Ricardo J, and Alp Simsek. 2022. "A Monetary Policy Asset Pricing Model." National Bureau of Economic Research Working Paper wp30132.

Campbell, John Y., Carolin Pflueger, and Luis M. Viceira. 2020. "Macroeconomic drivers of bond and equity risks." *Journal of Political Economy*, 128(8): 3148–3185.

Cieslak, Anna. 2018. "Short-Rate Expectations and Unexpected Returns in Treasury Bonds." *Review of Financial Studies*, 31(9): 3265–3306.

Cieslak, Anna, Michael McMahon, and Hao Pang. 2024. "Did I make myself clear? The Fed and the market in the post-2020 framework period." Working Paper.

Clarida, Richard, Jordi Gali, and Mark Gertler. 1999. "The science of monetary policy: A New Keynesian perspective." *Journal of Economic Literature*, 37(4): 1661–1707.

Clarida, Richard, Jordi Gali, and Mark Gertler. 2000. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." *Quarterly Journal of Economics*, 115(1): 147–180.

Cogley, Timothy, and Thomas J. Sargent. 2005. "Drifts and volatilities: Monetary policies and outcomes in the post WWII US." *Review of Economic Dynamics*, 8(2): 262–302.

Cogley, Timothy, Christian Matthes, and Argia M Sbordone. 2015. "Optimized Taylor rules for disinflation when agents are learning." *Journal of Monetary Economics*, 72: 131–147.

Cukierman, Alex, and Allan H Meltzer. 1986. "A theory of ambiguity, credibility, and inflation under discretion and asymmetric information." *Econometrica*, 1099–1128.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2018. "A Model of Monetary Policy and Risk premia." *Journal of Finance*, 73(1): 317–373.

Elenev, Vadim, Tzuo-Hann Law, Dongho Song, and Amir Yaron. 2024. "Fearing the Fed: How Wall Street Reads Main Street." *Journal of Financial Economics*, 153: 103790.

Erceg, Christopher J., and Andrew T. Levin. 2003. "Imperfect Credibility and Inflation Persistence." *Journal of Monetary Economics*, 50(4): 915–944.

Eusepi, Stefano, and Bruce Preston. 2010. "Central Bank Communication and Expectations Stabilization." *American Economic Journal: Macroeconomics*, 2(3): 235–71.

Fuhrer, J.C. 1997. "Inflation/output variance trade-offs and optimal monetary policy." *Journal of Money, Credit, and Banking*, 29(2): 214–234.

Goodfriend, Marvin, and Robert G King. 2005. "The incredible Volcker disinflation." *Journal of Monetary Economics*, 52(5): 981–1015.

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2023. "Whatever it takes? The impact of conditional policy promises." National Bureau of Economic Research working paper wp31259.

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2024. "Asset purchase rules: How QE transformed the bond market." Working paper, UCLA, Rochester, and USC.

Hamilton, James D., Seth Pruitt, and Scott Borger. 2011. "Estimating the market-perceived monetary policy rule." *American Economic Journal: Macroeconomics*, 3(3): 1–28.

Jia, Chengcheng, and Jing Cynthia Wu. 2022. "Average Inflation Targeting: Time Inconsistency and Intentional Ambiguity." National Bureau of Economic Research Working Paper 29673.

Kim, Chang-Jin, and Charles R. Nelson. 2006. "Estimation of a forward-looking monetary policy rule: A time-varying parameter model using ex post data." *Journal of Monetary Economics*, 53(8): 1949–1966.

Kroner, Niklas. 2024. "Inflation and Attention: Evidence from the Market Reaction to Macro Announcements." Working Paper.

Kydland, Finn, and Edward Prescott. 1977. "Rules Rather Than Discretion." *Journal of Political Economy*, 85(3): 473–492.

Orphanides, Athanasios. 2003. "Historical monetary policy analysis and the Taylor rule." *Journal of Monetary Economics*, 50(5): 983–1022.

Orphanides, Athanasios, and John C Williams. 2005. "Inflation scares and forecast-based monetary policy." *Review of Economic Dynamics*, 8(2): 498–527.

Orphanides, Athanasios, and John Williams. 2004. "Imperfect Knowledge, Inflation Expectations, and Monetary Policy." In *The inflation-targeting debate*. 201–246. University of Chicago Press.

Pflueger, Carolin. 2023. "Back to the 1980s or not? The drivers of inflation and real risks in Treasury bonds." Working Paper 30921, National Bureau of Economic Research.

Piazzesi, Monika. 2005. "Bond Yields and the Federal Reserve." *Journal of Political Economy*, 113(2): 311–344.

Reifschneider, David, and John Williams. 2000. "Three Lessons for Monetary Policy in a Low-Inflation Era." *Journal of Money, Credit and Banking*, 32(4): 936–966.

Rudebusch, Glenn D. 2002. "Term structure evidence on interest rate smoothing and monetary policy inertia." *Journal of monetary economics*, 49(6): 1161–1187.

Schmeling, Maik, Andreas Schrimpf, and Sigurd A.M. Steffensen. 2022. "Monetary policy expectation errors." *Journal of Financial Economics*, 146(3): 841–858.

Song, Dongho. 2017. "Bond Market Exposures to Macroeconomic and Monetary Policy Risks." *Review of Financial Studies*, 30(8): 2761–2817.

Swanson, Eric T., and John C. Williams. 2014. "Measuring the effect of the zero lower bound on medium-and longer-term interest rates." *American Economic Review*, 104(10): 3154–85.

Taylor, John B. 1993. "Discretion Versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy*, 39: 195–214.

Taylor, John B. 1999. "A historical analysis of monetary policy rules." In *Monetary Policy Rules*. 319–348. University of Chicago Press.

Williams, John C. 2021. "The Theory of Average Inflation Targeting." Remarks at Bank of Israel/CEPR Conference on "Inflation: Dynamics, Expectations, and Targeting".

Woodford, Michael. 2005. "Central Bank Communication and Policy Effectiveness." Federal Reserve Bank of Kansas City.

Appendix

A BCFF Survey Data

In the Blue Chip Financial Forecasts (BCFF) survey, about 30–50 professional forecasters are queried each month about their forecasts for interest rates, other financial market variables, and their macroeconomic "assumptions" underlying their financial forecasts. Participants are queried near the end of the month preceding the release of the survey. Specifically, the deadline for the survey responses is the 26th of the previous month, with the exception of December, when the deadline is the 21st. The BCFF contains quarterly forecasts. For the federal funds rate, the forecast target is the quarterly average of the daily effective funds rate, in annualized percent, as reported in the Federal Reserve's H.15 statistical release. The macroeconomic forecasts for output growth and inflation are reported as quarter-over-quarter forecasts in annualized percent.

We calculate year-over-year inflation forecasts as follows: For forecasts with horizons of three to five quarters, we simply calculate annual inflation forecasts from the quarterly forecasts for the four longest horizons. For forecasts with horizons of less than three quarters, we combine the forecasts with actual, observed CPI inflation over recent quarters.

We derive output gap forecasts from real GDP growth forecasts from 1992 onwards and from real GNP growth forecasts before. Conceptually, the calculation is straightforward: Using the current level of real output and the quarterly growth forecasts, we calculate the forecasted future level of real output, which we then combine with CBO projections of potential output to calculate implied output gap forecasts. In practice, the calculations are slightly involved, since careful account needs to be taken of the timing of the surveys and the available real-time GDP data and potential output projections. First, we need real-time GDP for the quarter before the survey. We obtain real-time data vintages for GDP from ALFRED, and use the most recently observed vintage before the deadline of each survey. Second, we calculate forecasts for the *level* of real GDP, denoted as $E_t^{(j)} Y_{t+h}$ using the level in the quarter before the survey and the growth rate forecasts. Third, we obtain real-time vintages for the CBO's projections of future potential GDP, also from ALFRED, and again use the most recent vintage that was available to survey participants at the time.[28] Fourth and finally, output gap forecasts are calculated as the deviation of the GDP forecasts from the potential GDP projections in percentage points:

$$E_t^{(j)} x_{t+h} = 100 \frac{E_t^{(j)} Y_{t+h} - E_t Y_{t+h}^*}{E_t^{(j)} Y_{t+h}^*},$$

where x_t is the output gap and Y_t^* is potential GDP in the quarter ending in t.

In Table A.1 we report summary statistics for our survey data. Across surveys, horizons,

[28] In some cases, we use vintages of real GDP or potential GDP released shortly after the survey deadline. We do this either to obtain real GDP in the quarter immediately before the survey (in case this was released after the deadline), or to obtain consistent units for actual and potential real GDP (in case the dollar base year changed for the actual GDP but not for the potential GDP numbers). Furthermore, since the real-time vintages start in 1991, we use the earliest vintages for the surveys before that time.

Table A.1: Summary statistics for survey forecasts

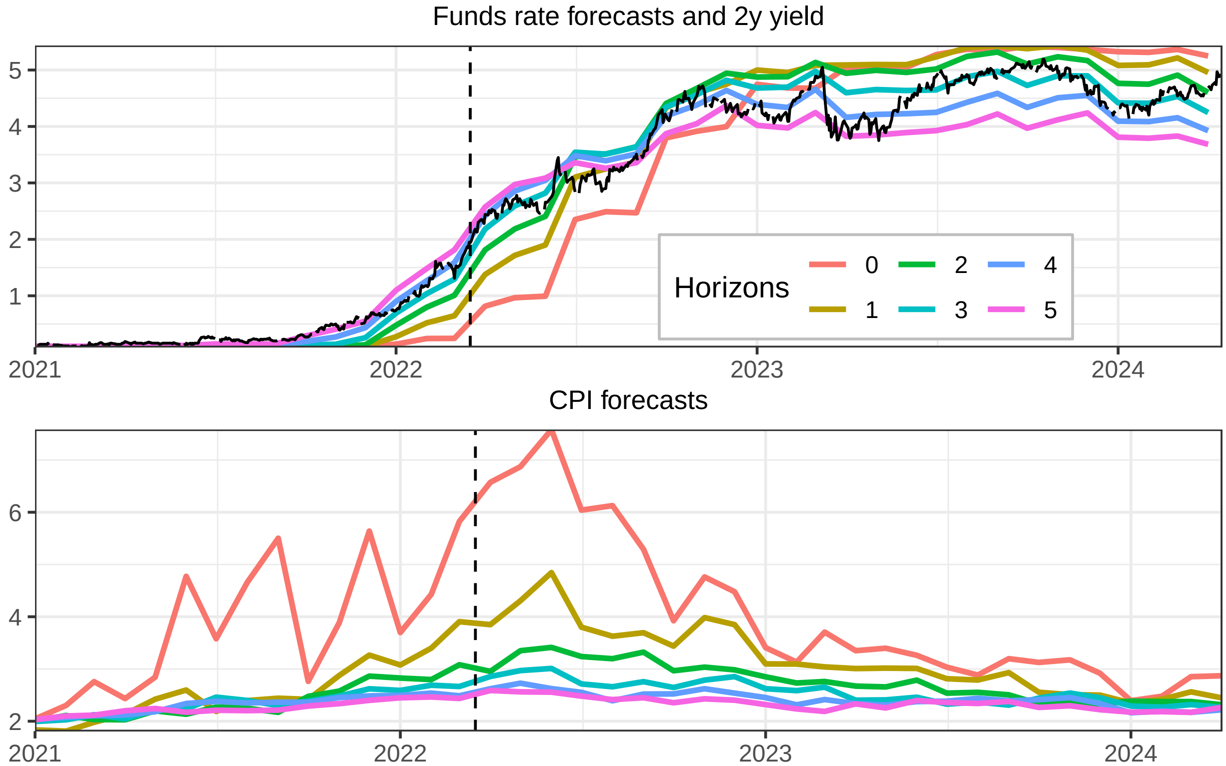
	N	Mean	Standard Deviations			
				Within		
			Overall	Month	Month-ID	Month-Horizon
Fed funds rate	31,572	1.6	1.5	0.38	0.32	0.22
CPI inflation	30,647	2.4	1.3	0.67	0.60	0.36
Output growth	31,161	2.5	2.8	1.23	1.07	0.82
Output gap	31,157	-1.0	1.9	0.67	0.48	0.49

Summary statistics for individual survey forecasts in the Blue Chip Financial Forecasts from January 2014 to April 2024. Horizons are from current quarter to five quarters ahead. Number of forecasters in each survey is between 33 and 49. Interest rate forecasts are in percentage points. CPI inflation forecasts are for four-quarter inflation, calculated from the reported quarterly inflation rates and, for short horizons, past realized inflation, in percent. Output growth forecasts are for quarterly real GDP growth in annualized percent. Output gap forecasts are calculated from growth forecasts, real-time output, and CBO potential output projections as described in the text, in percent. The within-month standard deviation reports the average of the standard deviation of forecasts conditional on month t. The within-month-id standard deviation is the average standard deviation within each month-forecaster (t, j) cell. The within-month-horizon standard deviation is the average standard deviation within each month-horizon (t, h) cell.

and forecasters, there are about 120,000 individual forecasts. Output gap forecasts are negative on average, in line with the fact that both real-time and revised estimates of the output gap were negative for the majority of our sample period. Forecasted CPI inflation averages around 2.7% and the average fed funds rate forecast equals 3.5%, in line with realized inflation and interest rates over our sample. All variables exhibit substantial within-month variation. This within-month variation reflects variation across both forecasters and forecast horizons.

Figure A.1 shows the evolution of consensus forecasts—the arithmetic mean of the individual forecasts—for the federal funds rate and CPI inflation. The date on the horizontal axis refers to the date of the survey, and the lines correspond to the different forecast horizons.

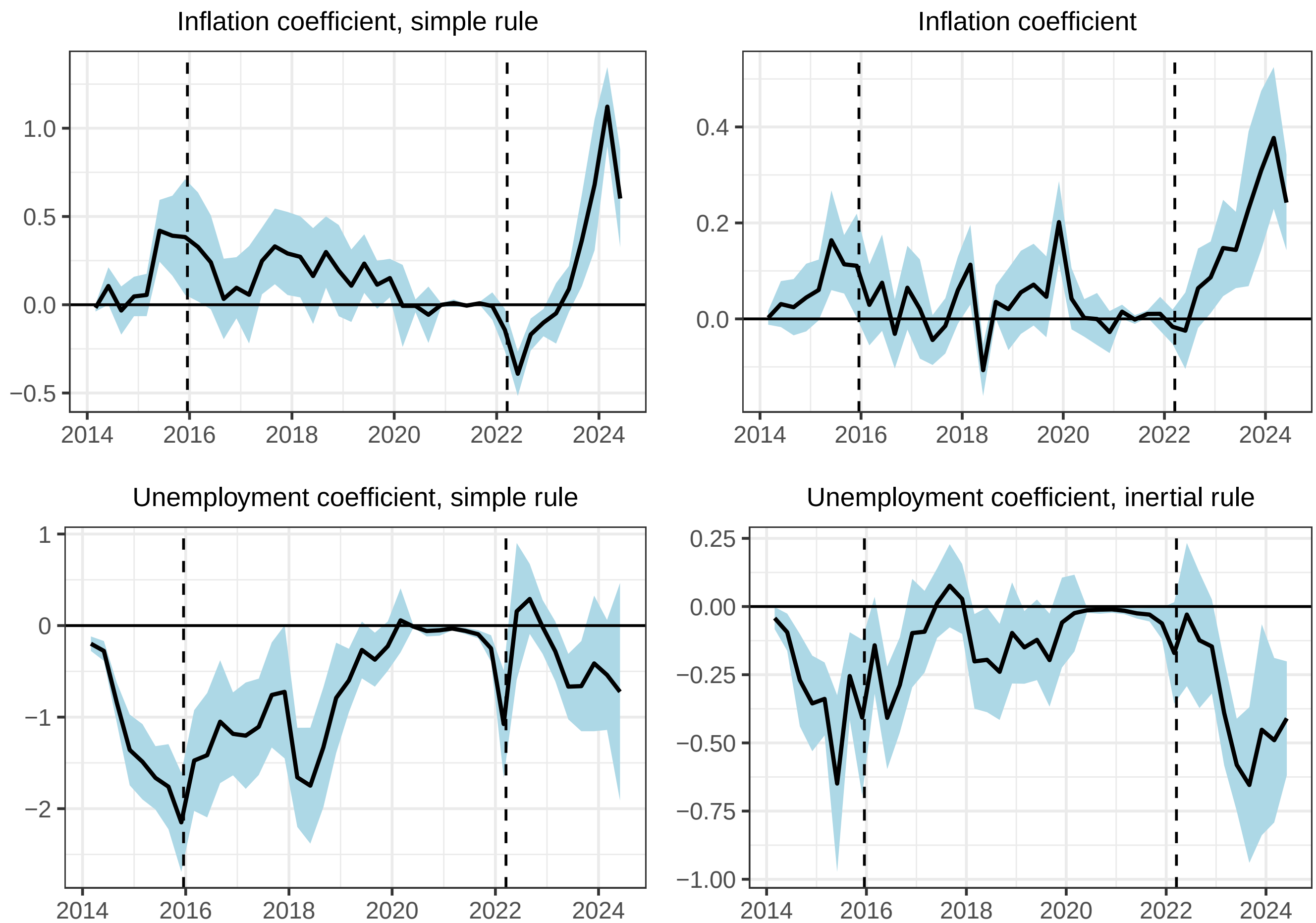
Figure A.1: Consensus forecasts: Federal funds rate and CPI inflation



Top panel: Forecaster average for federal funds rate forecasts from Blue Chip Financial Forecasts, current quarter to five quarters ahead, with (daily) two-year Treasury yield. Bottom panel: Forecaster average for one-quarter CPI inflation rate (annualized, %). Vertical line shows liftoff date, March 16, 2022. Sample period: January 2021 to April 2024.

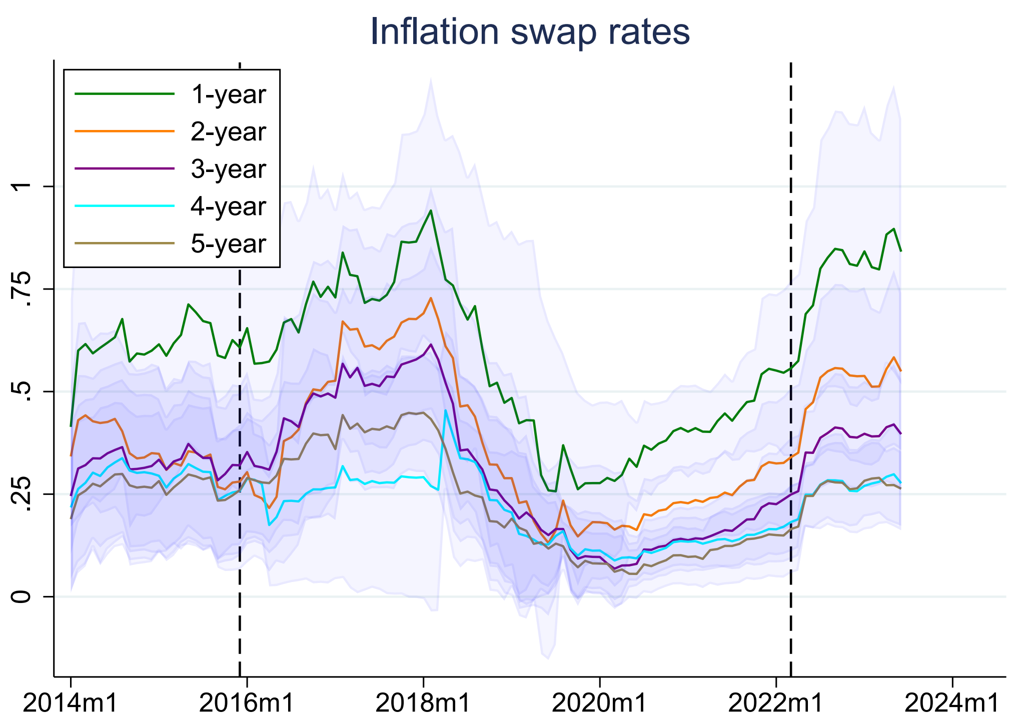
B Additional Results

Figure B.1: Forward-looking policy rules from Survey of Professional Forecasters



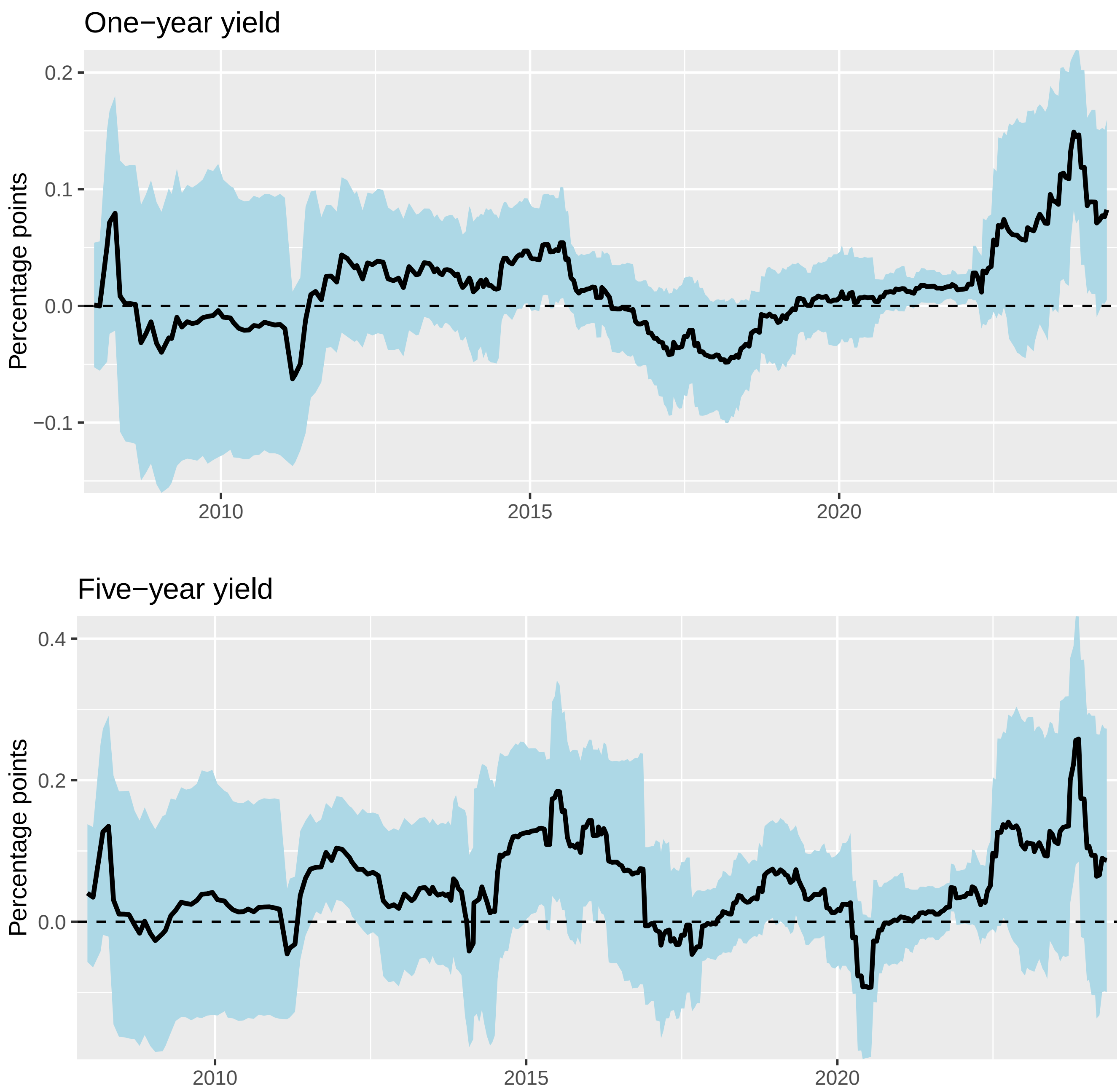
Coefficients in forward-looking/perceived monetary policy rules, estimated from quarterly panel regressions on Survey of Professional Forecasters from 2014:Q1 to 2014:Q2. Inflation forecasts are for core CPI inflation. Blue-shaded areas are 95% confidence intervals based on standard errors with two-way clustering (by forecasters and horizon).

Figure B.2: Sensitivity of inflation swap rates to inflation news



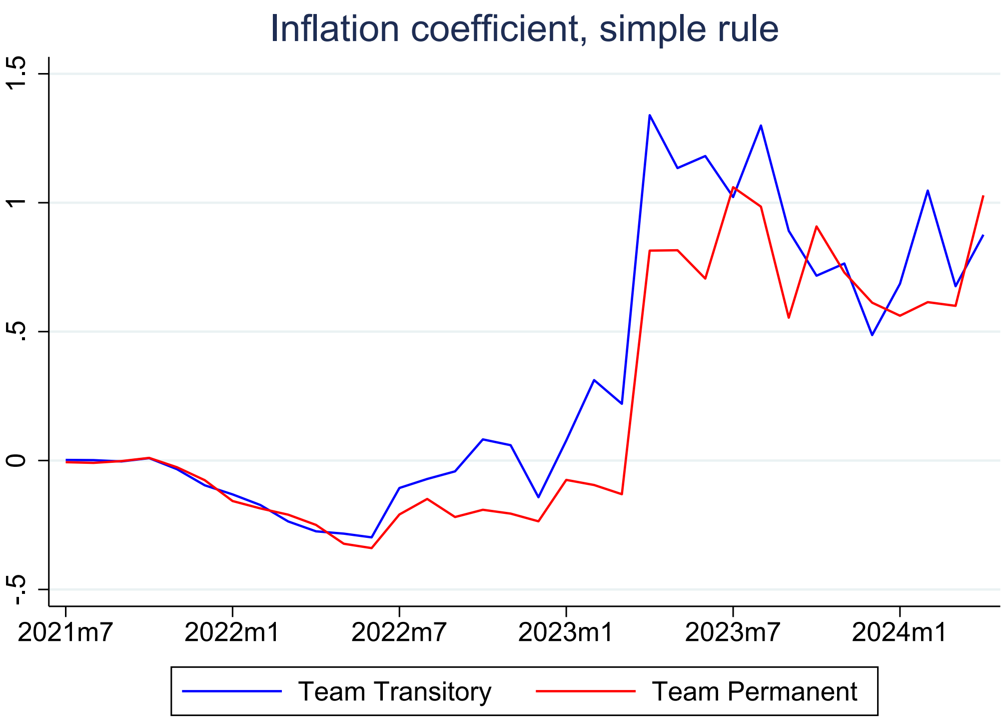
Coefficient in rolling regressions of changes in inflation swap rates on core CPI news, the difference between released core CPI inflation and consensus expectations. Rolling windows use 24 monthly releases. Sample period: January 2012 to May 2024. Blue-shaded areas are 95% confidence intervals based on robust (White) standard errors.

Figure B.3: Sensitivity of European yields to inflation news



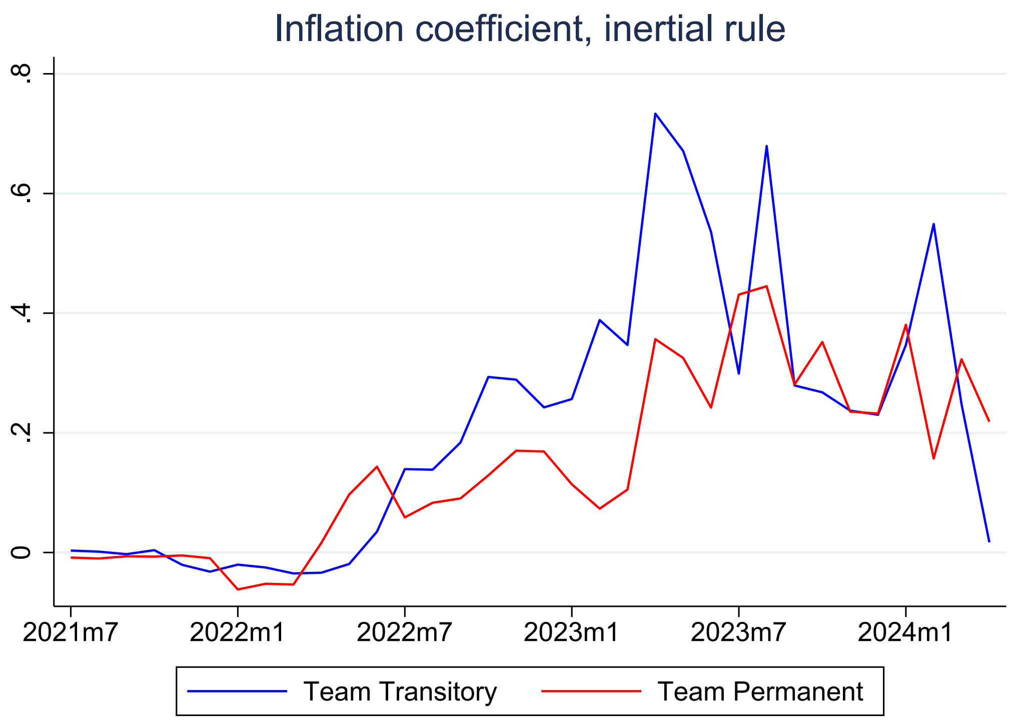
Coefficient in rolling regressions of changes in European yields on core CPI news, that is, the difference between released core CPI inflation and consensus expectations. Rolling windows use 24 monthly releases. Sample period: January 2003 to April 2024. Blue-shaded areas are 95% confidence intervals based on robust (White) standard errors.

Figure B.4: Estimated inflation coefficients for inflation optimists and pessimists: simple rule



Coefficients in forward-looking/perceived simple monetary policy rules, estimated from month-by-month panel regressions on Blue Chip Financial Forecast surveys from July 2021 to April 2024. Forecasters are split into inflation optimists, who have below-median four-quarter CPI forecasts in July 2021, and inflation pessimists, who have above-median forecasts.

Figure B.5: Estimated inflation coefficients for inflation optimists and pessimists: inertial rule



Coefficients in forward-looking/perceived inertial monetary policy rules, estimated from month-by-month panel regressions on Blue Chip Financial Forecast surveys from July 2021 to April 2024. Forecasters are split into inflation optimists, who have below-median four-quarter CPI forecasts in July 2021, and inflation pessimists, who have above-median forecasts.

C New Keynesian Model

We start with the setup of Clarida, Gali and Gertler (1999). The demand side of the economy is given by the Euler equation with no shocks

$$x_t = -\phi \left[i_t - E_t \pi_{t+1} \right] + E_t x_{t+1}, \tag{C.1}$$

where x_t is the log output gap, i_t is the nominal policy rate from time t to $t+1$, π_{t+1} is inflation from time t to $t+1$, and the parameter ϕ is the elasticity of intertemporal substitution. Inflation obeys a forward-looking Phillips curve with serially-correlated cost-push supply shocks

$$\pi_t = \lambda x_t + \delta E_t \pi_{t+1} + u_t, \; u_t = \psi u_{t-1} + \hat{u}_t, \tag{C.2}$$

where $\hat{u}_t$ is iid, the parameter λ is the slope of the Phillips curve, and δ is the discount factor. We follow Clarida, Gali and Gertler (1999) in assuming that the central bank follows a rule whereby it contracts the output gap by $-\omega u_t$ in response to a cost-push shock u_t. This can be achieved by setting the nominal policy rate i_t according to the Euler equation (C.1). Note that in this framework, demand shocks can be perfectly offset by the central bank, and the assumed rule nests the optimal rule under discretion.

Different from Clarida, Gali and Gertler (1999), we assume that the actual and perceived rules can be different with

$$x_t = -\omega u_t, \; E_t x_{t+\tau} = -\hat{\omega} E_t u_{t+\tau}, \; \tau \geq 1. \tag{C.3}$$

The case with $\omega = \hat{\omega}$ is the familiar rational expectations case with a constant monetary policy rule and nests Clarida, Gali and Gertler (1999).

Substituting into the Phillips curve

$$\pi_t = \lambda x_t + \delta E_t \pi_{t+1} + u_t, \tag{C.4}$$

$$= -\lambda \omega u_t + u_t + E_t \sum_{\tau=1}^{\infty} \delta^\tau \left(-\lambda \hat{\omega} u_{t+\tau} + u_{t+\tau} \right), \tag{C.5}$$

$$= \lambda x_t + \left(1 + \frac{\delta \psi (1 - \lambda \hat{\omega})}{1 - \delta \psi} \right) u_t \tag{C.6}$$

Hence, a cost-push shock has a smaller impact on inflation when the perceived monetary policy coefficient $\hat{\omega}$ is higher, holding fixed the impact on the current output gap.

Assuming that $\hat{\omega}$ is given and constant, we next solve for inflation and the output gap for the optimal actual monetary policy coefficient ω. The central bank's objective function is assumed to be quadratic in inflation and the output gap, with a discount factor δ and output gap weight α

$$min \left[\alpha x_t^2 + \pi_t^2 \right] + E_t \sum_{\tau=1}^{\infty} \delta^\tau \left[\alpha x_{t+\tau} + \pi_{t+\tau}^2 \right] \tag{C.7}$$

Taking the first-order condition with respect to x_t gives

$$x_t = -\frac{\lambda}{\alpha}\pi_t. \tag{C.8}$$

Substituting into relation (C.6) gives

$$\pi_t = \frac{\alpha}{\alpha+\lambda^2}\left(1+\frac{\delta\psi(1-\lambda\hat{\omega})}{1-\delta\psi}\right)u_t, \tag{C.9}$$

$$x_t = -\frac{\lambda}{\alpha+\lambda^2}\left(1+\frac{\delta\psi(1-\lambda\hat{\omega})}{1-\delta\psi}\right)u_t. \tag{C.10}$$

These expressions show that a central bank that is perceived to more actively counteract cost-push shocks in the future (higher $\hat{\omega}$) achieves lower volatilities for inflation and the output gap today. Hence, the inflation-output tradeoff today is improved if perceptions of the future anti-inflationary monetary policy response are high.

To formally see that a higher perceived policy coefficient $\hat{\omega}$ corresponds to a higher perceived interest rate sensitivity to inflation, first solve for $E_t\pi_{t+1}$ in terms of $\hat{\omega}$ and E_tu_{t+1}. From period $t+1$ onwards, the central bank is expected to follow a policy rule with constant coefficient $\hat{\omega}$, so $E_t\pi_{t+1}$ satisfies (C.6) with ω set equal to $\hat{\omega}$:

$$E_t\pi_{t+1} = -\lambda\hat{\omega}E_tu_{t+1} + \left(1+\frac{\delta\psi(1-\lambda\hat{\omega})}{1-\delta\psi}\right)E_tu_{t+1}, \tag{C.11}$$

$$= \left(\frac{1-\lambda\hat{\omega}}{1-\delta\psi}\right)E_tu_{t+1} \tag{C.12}$$

The expected $t+1$ policy rate from iterating the Euler equation (C.1) one period forward

$$E_ti_{t+1} = -\frac{E_tx_{t+1}-E_tx_{t+2}}{\phi} + E_t\pi_{t+2}, \tag{C.13}$$

$$= \hat{\omega}\psi\frac{1-\psi}{\phi}u_t + \left(\frac{1-\lambda\hat{\omega}}{1-\delta\psi}\right)\psi^2u_t, \tag{C.14}$$

$$= \underbrace{\left(\frac{(1-\psi)(1-\delta\psi)}{\phi}\frac{\hat{\omega}}{1-\lambda\hat{\omega}}+\psi\right)}_{\hat{\beta}}E_t\pi_{t+1}. \tag{C.15}$$

The relationship for $i_{t+\tau}$ and $\pi_{t+\tau}$ for $\tau > 1$ is analogous. Because $\frac{\hat{\omega}}{1-\lambda\hat{\omega}}$ is a strictly increasing function of $\hat{\omega}$, it follows that a higher perceived willingness to contract future output in response to a cost-pus shock, $\hat{\omega}$, corresponds to a higher perceived policy rate sensitivity to inflation, $\hat{\beta}$.