Decomposing Monetary Policy Surprises: Shock, Information, and Policy Rule Revision

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Abstract

Two explanations exist for the output and price puzzles arising from the identification of monetary policy shocks with high-frequency monetary surprises: the 'information channel' and the 'Fed response to news' hypothesis. We argue that the information channel better explains these anomalies, aligns more closely with empirical evidence, and relies on fewer assumptions. Using a model of imperfect information incorporating both monetary policy shocks and policy rule deviations, we derive testable implications to distinguish the two hypotheses. Our findings show that policy rule deviations have minimal impact, while information effects drive the observed puzzles, resolving key inconsistencies in the literature.

JEL classification: E32, E52, E58

Keywords: Monetary Policy, high-frequency identification, information effects

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1 Introduction

The analysis of high-frequency market reactions to monetary policy decisions, pioneered by Kuttner (2001) and Gürkaynak et al. (2005a), has provided researchers with instrumental variables (IVs) for identifying policy shocks in reduced-form macroeconomic models, such as vector autoregressions (VARs) and local projections (LPs). This IV approach, first proposed by Gertler and Karadi (2015a) and later adopted as the state-of-the-art methodology, allows for identification without relying on assumptions about the sign or timing of macroeconomic responses. However, the use of monetary policy surprises as IVs to identify structural monetary policy shocks often leads to puzzling results (see Ramey, 2016).

The literature has converged on two key 'puzzling' stylised facts, which escape a simple full information rational expectation framework. First, high-frequency monetary policy surprises often produce unexpected results, such as rising inflation and output following a policy tightening, known as price and output puzzles. Second, these surprises can be predicted by past data, violating the assumption of full-information rational expectations.

Two competing explanations attempt to account for these anomalies: one focusing on imperfect information, the other on deviations from perfect rationality. The 'information channel' explanation for conventional monetary policy shocks, proposed by Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021), assumes that economic agents have imperfect information about the state of the economy. Conversely, the 'Fed response to news' hypothesis of Bauer and Swanson (2023a,b) suggests that agents misestimate the Fed's reaction to inflation due to incorrect parameter assumptions. Both explanations likely capture elements of the truth, but the question remains as to which one better explains the observed data and puzzles.

The information channel argument posits that both the central bank and market participants operate with imperfect information, leading to differences in economic forecasts. These discrepancies cause policy surprises to be partially endogenous. In fact, when market participants are surprised by an interest rate change, they may attribute it to an actual policy shock, or conversely to the central bank's anticipation of higher inflation. These two different types of shocks – i.e. the monetary policy shock and the structural shocks to which the central bank responds – both generate in the market asset price revisions triggered by the policy announcement. The contamination of the high-frequency monetary policy surprises by the endogenous policy response generates price and output puzzles. Furthermore, since agents continuously update their beliefs based on new information, policy surprises exhibit autocorrelation and are somewhat predictable, supporting the idea that imperfect information is a primary driver of these anomalies.

The 'Fed response to news' hypothesis, on the other hand, attributes these puzzles to agents' systematic underestimation of the Fed's inflation response. If market participants consistently use incorrect parameters for the Fed's policy rule – particularly underestimating its responsiveness to inflation – monetary policy surprises will appear to be driven by errors in expectation rather than genuine policy shifts. However, for this explanation to hold, agents must repeatedly make the same mistake due to a stochastic drift in the parameter, or never updating their estimates despite available data, as suggested by Bauer and Swanson (2023a,b). To explain the persistent predictability of forecast revisions, this hypothesis also needs to appeal to the existence of informational rigidities, thus overlapping with the information hypothesis (see discussion in Bauer and Swanson, 2023a).

To a large extent the two hypotheses explain the same facts and hence are generally regarded as two plausible interpretations of the same empirical evidence. This paper tries to move beyond this observation and provides an assessment of the two hypotheses in three steps.

In our first step, in Section 2, we provide an exposition of the hypotheses, focusing on the stylised facts that the two arguments attempt to explain, and provide an argument of parsimony in favour of the information channel argument. In fact, the 'Fed response to news' argument requires assuming that (i) all agents use the same misspecified rule, (ii) the rule is misspecified with one-sided errors in the parameters, and (iii) there are information frictions that determine the observed degree of forecastability of forecast errors. On the other hand, the information channel hypothesis only requires the last assumption – imperfect information – to explain the same facts.

Furthermore, the 'Fed response to news' hypothesis is a U.S.-centric explanation. However, similar monetary policy puzzles have been observed across various central banks, including the ECB, the Bank of Japan, the Bank of England, and the South African Reserve Bank. If markets worldwide consistently underestimated policy responses, it would imply an unlikely global pattern of miscalculation. We conclude that a simple application of Occam's razor, which favours simpler and more powerful theories capable of rationalising a large set of facts with fewer assumptions, would favour the information channel argument.

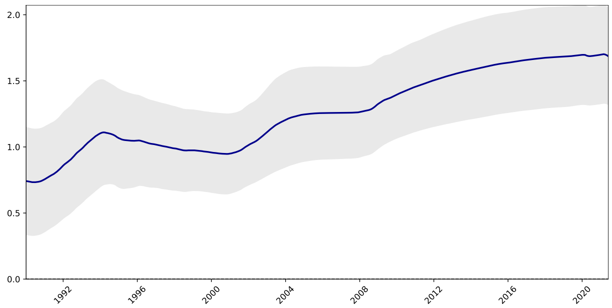
In the second step, in Section 3, we provide an appraisal of both the logical consistency of the arguments and the robustness of the broad empirical evidence available. Our reassessment of the evidence casts doubt on the claims of the 'Fed response to news' hypothesis.

In order: (i) the Fed has an information advantage over individual forecasters; (ii) forecasters update their forecasts after the central bank's announcements, as shown by the survey conducted by Bauer and Swanson (2023a), and in line with the empirical evidence in the literature on information effects; (iii) there is no drift in the coefficients of the policy rule (see Figure 1), as also shown in Bauer et al. (2024);[1] (iv) market participants are not constantly wrong in their forecasts of the policy rate; (v) there is substantial disagreement in the market on the policy rate paths, to the extent that it would force biased forecasters out of the market. We also point to some logical inconsistencies in the argument and a misinterpretation of the information hypothesis.

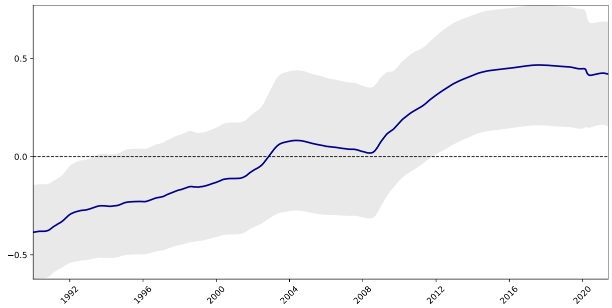
In the last step, we provide a falsification approach by deriving testable model-based predictions to disentangle the empirical implications of the two hypotheses. In Section 4,

[1] The recursive estimates show how the Fed's response has evolved over time, with later periods indicating a more hawkish Fed. The rolling estimates do not confirm this result, as the coefficient for both the output gap and inflation tends to decline at the onset of the Great Financial Crisis. We thank Riccardo Degasperi for pointing this fact out to us.

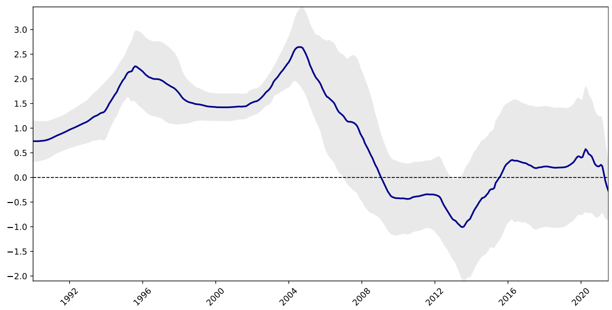
Figure 1: Recursive and rolling estimates of monetary policy rule



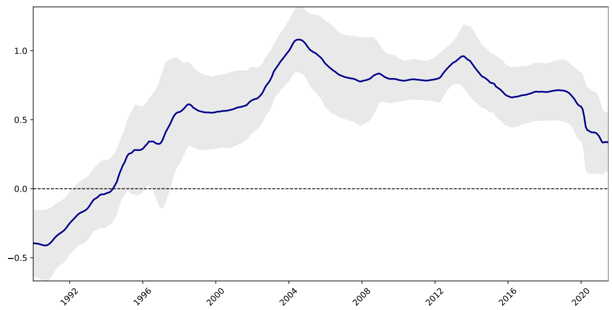
(a) Expanding window inflation coefficient



(b) Expanding window output gap coefficient



(c) Rolling window inflation coefficient



(d) Rolling window output gap coefficient

Notes: The figure presents estimates of the monetary policy rule coefficients from recursive and rolling regressions. The first row shows estimates from an expanding window regression with exponential down-weighting of older observations (as in Bauer and Swanson, 2023b), while the second row presents results from a rolling-window estimation of 164 month each window. The first column represents the response to inflation, while the second column shows the response to the output gap. The blue solid line represents the estimated coefficient, while the shaded grey area represents the 95% confidence interval based on Newey-West standard errors.

we discuss a model that nests both hypotheses and incorporates monetary policy shocks and shocks to the parameter of the Taylor rule in a model with imperfect information. The model expands the framework of Miranda-Agrippino and Ricco (2021) by embedding an affine term structure model, of the type discussed in Smith and Taylor (2009), into a model in which agents receive noisy signals about the state of the economy and the policy rule's parameter. This framework allows for a formalisation of the argument of Bauer and Swanson (2023a) and delivers testable implications to disentangle monetary policy shocks, shocks to the rule's parameter, and information. In particular, the model shows that shocks to the rule's parameters move both the short and the long end of the yield curve, and differently from monetary policy shocks, which die out at business cycle frequency. These results are in line with the previously reported results of Smith and Taylor (2009) and Ellingsen and Soderstrom (2001).

Finally, in Section 5, using the results provided by the model, we construct empirical high-frequency IVs to identify the different types of shocks of interest and to assess their role in the observed puzzles. We adopt these IVs in Section 6 to study the macroeconomic propagation of monetary policy shocks, shocks to the rule's parameter, and information in a VAR setting.

Our results indicate that shocks to the policy rule play a small role in the propagation of monetary policy for the sample of interest and play close to no role in creating the puzzles reported in the literature. Conversely, the information channel appears to be the cause of the inconsistent response observed when raw surprises are used to identify monetary policy shocks. After correcting for information effects, no puzzle is visible in the dynamic responses to identified shocks, either in the full sample or in subsamples.

Related literature. This paper contributes to the literature on puzzles in the responses obtained using the high-frequency monetary policy surprises to identify monetary policy shocks. The foundational paper of the literature on the central bank information channel is Romer and Romer (2000), which led to the development of the narrative identification of monetary policy shocks Romer and Romer (2004).

A key paper in this literature is Nakamura and Steinsson (2018), which reports puzzles in the response of professional forecasts to monetary policy shocks and argues that monetary actions may reveal information about the natural rate of interest. Differently from this stronger informational hypothesis, Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021) argue that policy decisions disclose information about the state of the economy and fluctuations at business cycle frequency. These two papers focus on the identification of conventional monetary policy shocks, and the puzzles in that literature.

The approach proposed by Jarociński and Karadi (2020) disentangles monetary policy shocks from central bank information by looking at the positive or negative correlation of the surprises to interest rates and the stock market. A similar approach is also suggested by Cieslak and Schrimpf (2019) and Cieslak and Pang (2020). Several other papers have followed this idea.

A different methodology has been proposed by Miranda-Agrippino and Ricco (2021), who build an informationally robust instrument for monetary policy shocks by regressing the high-frequency surprises on the Greenbook forecasts, a measure of the Fed's expectations. The idea follows from the approach of Romer and Romer (2004), and more recently Campbell et al. (2012). This approach has also been applied to the euro area (see Ricco et al., 2024) and South Africa (see Pirozhkova et al., 2024).

Finally, Bu et al. (2021) separate monetary and non-monetary policy shocks using Fama-MacBeth cross-sectional regressions. Melosi (2016) identifies the information component in monetary policy announcements through a DSGE model. Holtemöller et al. (2024) adopts a strategy based on the heteroskedasticity of the changes in short-term and long-term interest rates, as well as exchange rates around the FOMC announcement, to identify a monetary policy shock, an information shock, and an unconventional monetary shock.

Bauer and Swanson (2023a) and Bauer and Swanson (2023b) have criticised the idea of an information channel of monetary policy, and propose a Fed response to news explanation of the observed puzzles. They also offer a correction of the monetary policy surprises that project on financial indicators to remove the endogenous component of monetary policy.

This paper provides an appraisal of the different proposed arguments. Jarociński and Karadi (2025) offers a different and complementary approach to the ideas presented in this paper, delivering similar conclusions.

Finally, our results add to and provide some generalisation of the literature on the sensitivity of the long end of the yield curve to news. That literature has provided evidence that – particularly prior to the formal adoption of an inflation target – the long end of the yield curve responded to macroeconomic news and monetary policy shocks, and argued that market participants were extracting information about the central bank's reaction function from monetary announcements. For example, it was observed that, before the Fed formalised its 2% inflation target in 2012, hawkish statements caused the short-term and long-term segments of the U.S. yield curve to move in opposite directions (see Gürkaynak et al., 2005b). Similarly, the announcement of the Bank of England's independence in 1998 led to a significant upward repricing of long-term gilts (see Gürkaynak et al., 2010).

2 The hypotheses and Occam's razor

The literature on monetary policy shocks has broadly established two well-documented stylised facts. First, when high-frequency monetary policy surprises are used to identify policy shocks, they can yield puzzling results, such as price and output puzzles, where a tightening of the policy stance appears to generate inflationary pressure and economic expansion. Second, policy surprises can be Granger-caused by lagged variables – whether private or central bank forecasts, financial variables, or macroeconomic indicators – and exhibit some degree of autocorrelation. These facts clearly violate the assumption of full-information rational expectations.

Broadly speaking, the 'information channel of monetary policy' argument attributes these facts to deviations from full information, whereas the 'Fed response to news' explanation focuses on deviations from perfect rationality. The former assumes that model parameters are known while the state of the economy is unobserved; the latter assumes that agents agree on the state of the economy but may use incorrect parameters to forecast the policy rule, and hence the interest rates. It is reasonable to assume that both arguments capture aspects of the problem to some extent. Yet, which one holds greater explanatory power for these stylised facts?

Let us start by presenting a simple framework – which we expand into a model of imperfect information in the next section – to illustrate the argument and weigh its different components.

To focus ideas, consider a standard monetary policy rule of the form:

$$r_t = r^* + (\phi + \widehat{\phi}_t)\pi_t, \tag{1}$$

where the central bank follows a Taylor rule by reacting to inflation, with $\widehat{\phi}_t$ representing a shift in the response parameter. If inflation is not directly observed, the policymaker must form expectations about inflation (denoted by F_t^{cb}) to set the policy rate, i.e.,

$$r_t = r^* + (\phi + \widehat{\phi}_t)F_t^{cb}\pi_t + \sigma^{mp}u_t^{mp}. \tag{2}$$

Monetary policy may be too tight or too loose due to exogenous factors, which we call monetary policy shocks, u_t^{mp}. These shocks have received significant attention, as they are crucial for identifying the causal effects of monetary policy on the economy.

If not perfectly informed, each market participant i must form expectations about inflation and the policy rule, leading to the expectation:

$$F_{\underline{t}}^i r_t = r^* + (\phi + F_{\underline{t}}^i\widehat{\phi}_t)F_{\underline{t}}^i\pi_t, \tag{3}$$

where $F_{\underline{t}}^i\pi_t$ represents the market participant's nowcast for inflation at time t before the rate announcement, and $F_{\underline{t}}^i\widehat{\phi}_t$ is the assumed shift in the policy coefficient. When the rate is announced, market participants realise a forecast error:

$$r_t - F_{\underline{t}}^i r_t = \underbrace{(\widehat{\phi}_t - F_{\underline{t}}^i\widehat{\phi}_t)F_t^i\pi_t}_{\text{Rule Misspecification}} + \underbrace{(\phi + \widehat{\phi}_t)(F_t^{cb}\pi_t - F_{\underline{t}}^i\pi_t)}_{\text{Information Effect}} + \sigma^{mp}u_t^{mp}. \tag{4}$$

High-frequency monetary policy surprises, which are typically used to identify policy shocks, can be understood as forecast errors aggregated across market participants and propagated to price revisions across bonds of different maturities. In a framework of full-information rational expectations, agents would observe the state of the economy and know the parameters of the true equations governing economic developments. Hence, the only source of monetary surprises would be monetary policy shocks. Equation (4) captures both sides of the argument: in the presence of deviations from full-information rational expectations, monetary surprises may be contaminated by two distinct effects.

The 'information argument' suggests that central banks and markets may disagree on the state of the economy due to imperfect information. Thus, surprises will be contaminated by forecast differences, which correlate with the endogenous component of monetary policy. Market participants who observe higher-than-expected interest rates might conclude that either a policy shock has occurred or that the policymaker anticipates higher inflation than they had forecast. In the latter case, depending on the specifics of the model, agents may update their expectations towards the central bank's forecast, anticipating higher rates and lower future inflation. Identifying policy shocks using surprises that are contaminated by the endogenous response of the central bank to economic conditions could explain the observed puzzles in impulse response functions, while the continual updating of expectations over time introduces autocorrelation and the forecastability of surprises (see Coibion and Gorodnichenko, 2012, 2015).

Now consider the 'Fed response to news' hypothesis of Bauer and Swanson (2023a,b). If agents and the central bank share the same information but agents use an incorrect policy response parameter, monetary policy surprises will be contaminated by a term dependent on the difference in parameter adopted by the agents as compared to the ones adopted by the bank. However, this term alone cannot explain the stylised facts. If parameter errors were symmetrically distributed, their misspecification effects would cancel out on average. To induce puzzles, the misspecification term must be systematically biased – implying that agents consistently underestimate the Fed's response to inflation. How could this occur? Bauer and Swanson (2023b) propose that agents never update the Taylor rule parameter due to strong bounded rationality. Alternatively, Bauer and Swanson (2023a) argue that the Fed's response to inflation has drifted over time, becoming increasingly hawkish, leading to systematic misestimation by market participants. However, this is a small-sample argument that would disappear in large samples. Yet, these set of assumptions still cannot explain the forecastability of SPF or Greenbook revisions, which Bauer and Swanson (2023a) ultimately attribute to imperfect information:

> [...] we also note that old economic news, released before the beginning-of-month Blue Chip forecast, can also be relevant if some of the Blue Chip forecasters do not update their forecasts immediately following the release of that news. The evidence in Coibion and Gorodnichenko (2012, 2015) on informational rigidities in the Blue Chip forecasts suggests that this is the case [...].

To summarise, the 'Fed response to news' argument involves three elements: (i) a misspecified policy rule, (ii) a persistent underestimation of the Fed's inflation response, and (iii) informational rigidities. However, this argument still relies on informational rigidities – the key mechanism in the information hypothesis – while also requiring additional assumptions. It is important to emphasise that the existence of an information channel of monetary policy only requires the assumption of imperfect information, which alone can explain all the observed facts.

Furthermore, the Fed response' explanation conflicts with evidence of disagreement among agents – an outcome that naturally arises from information frictions. This presents a challenge for the Fed response to news' argument, which must assume that all agents are consistently wrong in forecasting interest rates.

Another issue with the 'Fed response to news' argument is its U.S.-centric focus. Similar stylised facts have been documented for virtually all central banks with high-frequency surprise data, including the UK, Japan (Cieslak and Schrimpf, 2019), the euro area (Jarociński and Karadi, 2020; Ricco et al., 2024), South Africa (Pirozhkova et al., 2024), as well as a large number of other advanced and emerging economies (Bolhuis et al., 2024). If the Fed became more hawkish over time, how can we explain why markets across different economies appear to make the same dovish error?

Moreover, in the case of the euro area – where the ECB is generally criticised for being too dovish rather than too hawkish – information frictions that intensify during periods of market dislocation appear to be a key factor in explaining the large puzzles observed (see Ricco et al., 2024, for a discussion). An explanation based on the logic of the 'Fed response to news' argument seems implausible.

An often invoked principle of scientific research is 'Occam's razor', which states that, given multiple explanations, the simplest one with the fewest assumptions is usually the best. By this principle, the more straightforward explanation for the observed puzzles (and a few more facts) – imperfect information – should be preferred.

3 The Fed's response to news and some facts

The argument about the Fed's response to news is not fully formalised in a model, and requires the simultaneous presence of multiple moving parts. However, it roughly proceeds in the following steps. First, all the information on which the economic forecasts are based is public and equally available to both the Fed and market participants. Second, the Fed does not possess an information advantage concerning the state of the economy and the future economic outlook. Third, the private forecasters do not update their forecasts upon observing the Fed's decision. Hence, information effects are unlikely. Furthermore, and fourth, while it is true that market forecasts and monetary policy surprises are predictable using lagged and public economic news, one can forecast market surprises using either the Fed's or the market's forecasts. Fifth, while a misspecified Taylor rule would not be sufficient to explain the puzzles on its own, there has been a drift in the policy parameter governing the response to inflation, which would solve the puzzles. Therefore, the argument goes, one can safely conclude that there is no information effect, but that market participants have been using a misspecified Taylor rule to forecast rates. Let's now take a closer look at these points.

Does the Fed have access to more data? Yes, but it is not crucial. One key observation against the idea of an information channel of monetary policy is that the Fed does not have access to private information unavailable to market participants – all macroeconomic and financial data are public – aside from information on its own reaction function. From this perspective, public forecasts should be as accurate as the Fed's, except for differences in knowledge of the coefficients of the Taylor rule. The 'Fed's response to news' hypothesis thus appears to be a reasonable one.

However, this conclusion holds only if agents have unlimited capacity to process information. When agents cannot process all available information at once, as in models of rational inattention, access to the same expansive set of public data does not necessarily change the situation. Indeed, rationally inattentive agents behave as if they face private signals and exogenously given noise, even though this noise is endogenous and arises from information-processing constraints (see Sims, 2003; Fulton, 2017; Maćkowiak et al., 2023). In light of this, models of exogenously imperfect information can be viewed as stylised representations of a reality in which agents are bounded in their ability to process information.[2]

Therefore, it does not matter whether the monetary surprises are Granger-caused by financial variables, private forecasts, or the policymaker's forecast. As long as the lagged variables capture the relevant states, which in real time are not observed by the agents, they will have forecasting power over the market's expectation revisions. A regression on those variables will reduce the issue of endogeneity of the surprises. The approach of Bauer and Swanson (2023a), which corrects with financial variables, is equivalent to that proposed in Miranda-Agrippino and Ricco (2021), and in line with the predictions of a model of imperfect information. We develop this point more formally in the next section.

It is important to stress that the autocorrelation of forecast errors and forecast revisions, and their predictability with past information, is a signature of imperfect information (see Coibion and Gorodnichenko, 2012, 2015 for forecast errors, and Miranda-Agrippino and Ricco,

[2]In the linear-quadratic-Gaussian rational inattention framework, agents optimally choose signals about the variables of interest with Gaussian noise, similar to the model presented in the next section.

2023 for forecast revisions).

Also, it is not entirely true that the Fed does not have private information. In fact, it does, since it has, crucially, access to confidential and detailed information about the balance sheets of financial institutions.

Does the Fed have an information advantage? Yes. Another key argument in Bauer and Swanson (2023a) and Bauer and Swanson (2023b) is that the Fed does not possess an information advantage concerning the state of the economy and the future economic outlook. The observation that the Fed possesses superior information was first made in the influential paper by Romer and Romer (2000). This hypothesis has been foundational in the literature on information effects, albeit as discussed in the next section, a superior information is not necessary to generate information effects but only determines the strength of those.

Let's have a look at the data in Figures 2, 3 and 4, which reports the root mean square forecast errors (RMSFEs) over the sample period 1993 to 2019 for: (i) individual Blue Chip forecasters, shown as the average error across them; (ii) the errors of the mean and median forecaster; and compares these measures with (iii) the Greenbook's precision.[3] [4] The comparison is carried out either (i) using the closest Blue Chip forecasts to the FOMC date for which the Greenbook forecasts were prepared, whether preceding or following the meeting (Figure 2), or (ii) using the Blue Chip forecasts preceding the FOMC meeting.[5] Results under the two approaches are comparable.

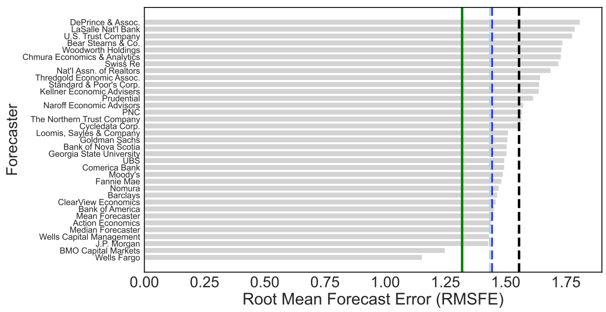
A few remarks are in order. First, it is clear that the Greenbook's forecasts (dashed green line) are competitive with respect to the professional forecasters (grey bars in Figures 2, and

[3]As is often done in the literature, including in Bauer and Swanson (2023a,b), the errors of the mean and median forecaster are obtained by taking a measure of central tendency across individual forecasts and computing forecast errors for it. This can be thought of as an 'aggregate' market forecast error.

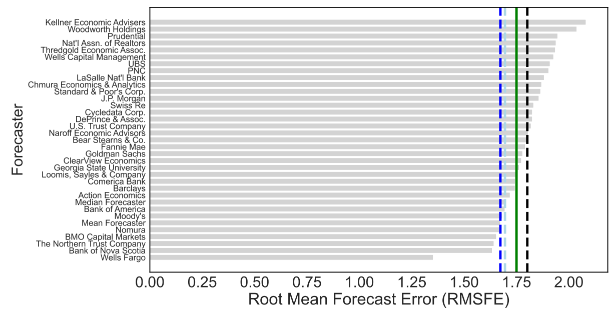
[4]We use data from the Blue Chip Financial Forecasts (BCFF), a monthly survey of professional forecasters. Even though the survey goes back to 1982, actual names for different forecasters have been available starting from 1993. Thus, we start our sample in 1993. When we compare Blue Chip forecasts with respect to Greenbook, we end our sample in 2019 based on the availability of Greenbook forecasts.

[5]Blue Chip forecasts are released at the beginning of each month, and thus using the following month's forecast – as done in Bauer and Swanson (2023a) – gives private forecasters the advantage of having seen the GDP and component releases, which arrive at the end of the previous month.

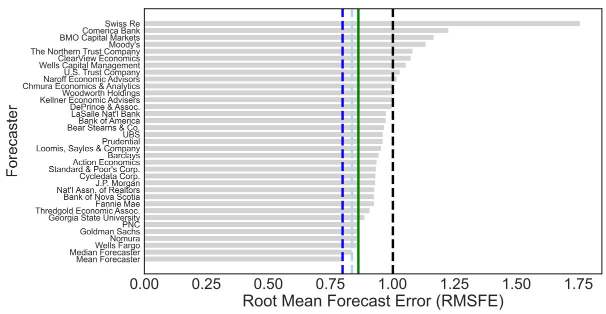
Figure 2: Market's and Greenbook's RMFEs (Blue Chip closest to Greenbook)



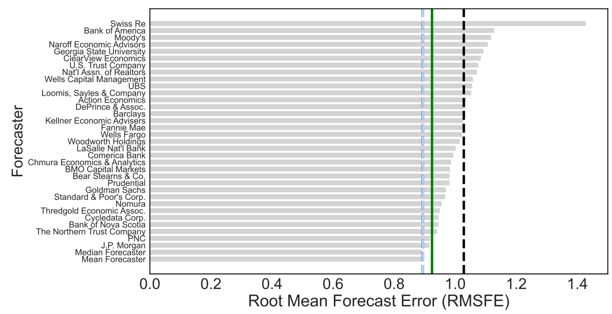
(a) GDP growth (current quarter)



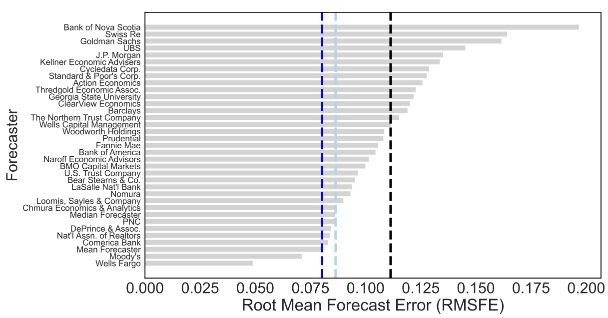
(b) GDP growth (next quarter)



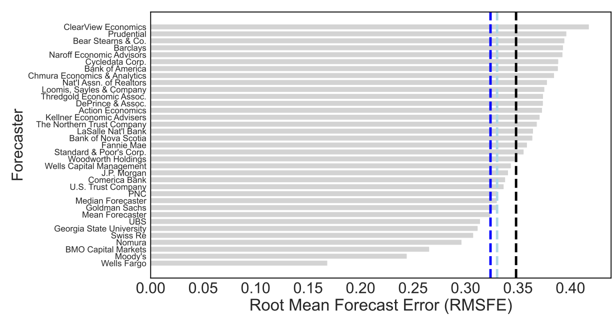
(c) GDP deflator (current quarter)



(d) GDP deflator (next quarter)



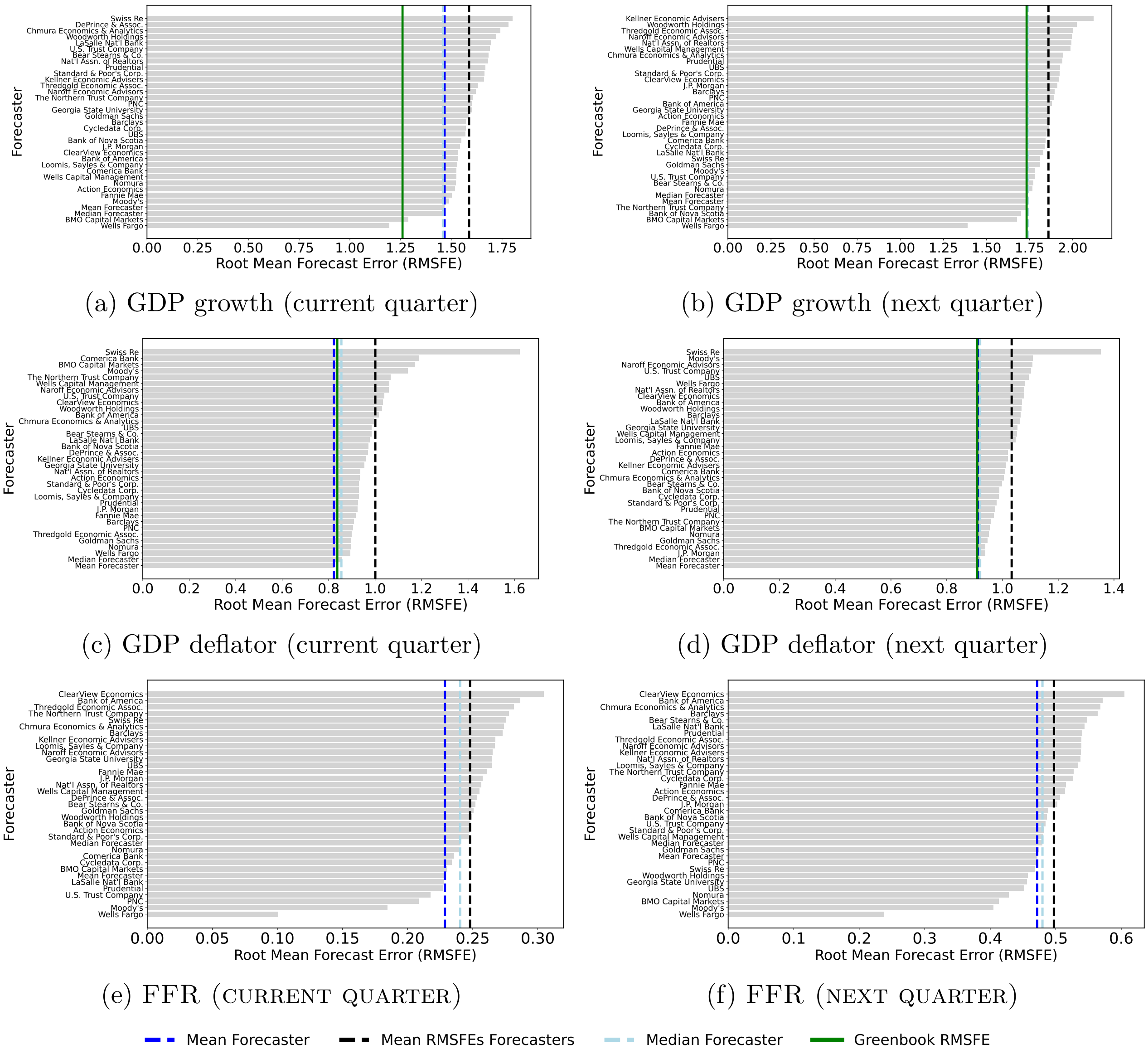
(e) FFR (current quarter)



(f) FFR (next quarter)

Notes: The figure displays the RMSFEs for forecast errors of: (a)-(b) quarter-over-quarter real GDP growth for the current quarter ($h = 0$) and the next quarter ($h = 1$); (c)-(d) quarter-over-quarter price deflator growth for the current and next quarter; and (e)-(f) the FFR for the current and next quarter. Each bar represents the RMSFE of an individual forecaster, excluding the Greenbook. The black dashed vertical line indicates the average RMSFEs across forecasters. The blue dashed line marks the RMSFE of the mean forecaster, while the light blue dashed line represents the RMSFE of the median forecaster. The solid green vertical line corresponds to the Greenbook RMSFE. Greenbook forecasts are aligned with the closest Blue Chip forecast date for each FOMC meeting for which the Greenbook forecasts were prepared, either preceding or following the meeting (as done by Bauer and Swanson, 2023a). Observations from March, June, September, and December are excluded, as the forecast quarter between the Greenbook and Blue Chip does not align. The sample includes only forecasters who have been consistently active for at least 15 years and have provided current quarter forecasts in at least 6 months of each year. Results with a larger set of forecasters confirm better performance of the Greenbook with respect to the average RMSFEs across forecasters and similar performance with the other forecasters. The sample goes from 1993 to 2019 (end of availability of the Greenbook).

Figure 3: Market's and Greenbook's RMFEs (Blue Chip same month Greenbook)



(a) GDP growth (current quarter)

(b) GDP growth (next quarter)

(c) GDP deflator (current quarter)

(d) GDP deflator (next quarter)

(e) FFR (current quarter)

(f) FFR (next quarter)

Notes: The figure displays the RMSFEs for forecast errors for: (a)–(b) quarter-over-quarter real GDP growth for the current quarter ($h = 0$) and the next quarter ($h = 1$); (c)–(d) quarter-over-quarter price deflator growth for the current and next quarters; and (e)–(f) the federal funds rate (FFR) for the current and next quarters. Each bar represents the RMSFE of an individual forecaster, excluding the Greenbook. The black dashed vertical line indicates the average RMSFE across forecasters. The blue dashed line marks the RMSFE of the mean forecaster, while the light blue dashed line represents that of the median forecaster. The solid green vertical line corresponds to the Greenbook RMSFE. Greenbook forecasts are aligned with the closest preceding Blue Chip forecast date for each FOMC meeting. The sample includes only those forecasters who were consistently active for at least 15 years and who provided current-quarter forecasts in at least six months of each year. The sample period runs from 1993 to 2019 (the end of Greenbook availability).

3), as they essentially outperform all of them.

Second, as is well known in the forecasting literature, the mean (median) forecaster

– obtained by averaging (taking the median across) forecasts – is more competitive than individual forecasters. This is evident from the difference between individual RMSFEs or their average (dashed black line) and those of the mean or median forecaster (light blue and blue dashed lines). In fact, the aggregate market forecasts are as good as the Fed's at longer horizons ($h = 1$), though slightly worse at shorter horizons ($h = 0$).

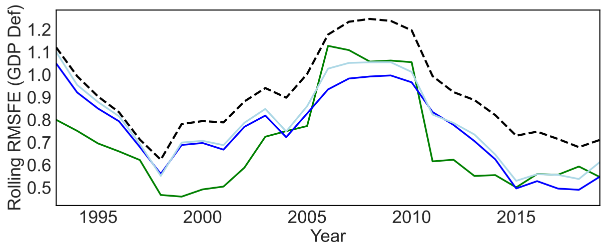
In the literature assessing the Fed's information advantage, the average forecaster is often compared to the Fed, as a way to benchmark the central bank against the aggregate market. This is also the case in Bauer and Swanson (2023a), which looks at the median as the market 'consensus'. However, this is somewhat misleading in the context of the information channel, since each forecaster and market participant has their own forecast (and disagrees with others), and the signals they receive from the central bank are informative relative to their individual information sets. The charts clearly show that the Fed's signals are indeed informative.

Third, while there is time variation in relative performance, a time-varying analysis using a 5-year rolling window confirms the overall picture (reported in Figure 4). While the Fed's advantage may appear larger or smaller depending on the subsample (see Table 1), it is generally present (see also Hoesch et al., 2023, for a recent appraisal).

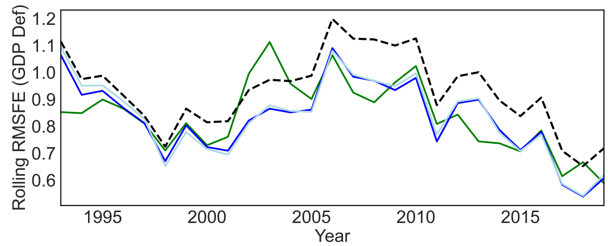
Do forecasters update forecasts after policy announcements? They do. An important piece of evidence is reported in Bauer and Swanson (2023a), who, in July 2019, conducted a small one-off survey of the Chief Economists of each member institution in the Blue Chip panel, asking them directly how they revise their unemployment, real GDP, and inflation forecasts in response to FOMC announcements. Out of the 52 forecasters surveyed, 36 responded.

The paper reports the responses regarding revisions to GDP forecasts, conditional on the policy decision. It shows that 13 respondents (i.e. 36%) do not revise their forecasts in response to changes in the federal funds rate, and 16 (44%) do not revise in response to the FOMC statement. The authors observe that this is a surprising result, since standard macroeconomic models and VARs imply that, for example, a tighter monetary policy stance

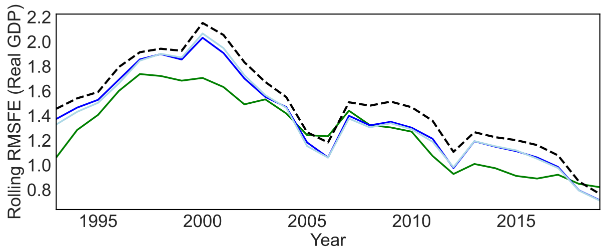
Figure 4: Rolling RMSFE (Blue Chip close to Greenbook)



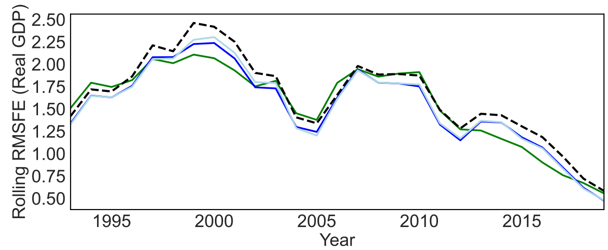
(a) GDP deflator RMSFE (current quarter)



(b) GDP deflator RMSFE (next quarter)



(c) Real GDP RMSFE (current quarter)



(d) Real GDP RMSFE (next quarter)

Notes: This figure shows rolling RMSFEs for quarter over quarter real GDP growth and quarter over quarter price deflator growth, for both the current quarter ($h = 0$) and the next quarter ($h = 1$). For each year, the RMSFEs are computed as 5-year centered moving averages of year over year averages of RMSFEs for each forecasters. The solid lines represent the rolling RMSFEs for the Greenbook (green), the mean forecaster (blue), and the median forecaster (light blue). The dashed black line corresponds to the average RMSFE across all individual forecasters. Greenbook forecasts are aligned with the closest Blue Chip forecast for each FOMC date. Only forecasters who have been consistently active for at least 15 years and provided current quarter forecasts in at least 6 months of each year are included in the computation of average RMSFEs. Results with a larger set of forecasters confirm better performance of the Greenbook with respect to the average RMSFEs across forecasters and similar performance with the other forecasters. Observations from March, June, September, and December are excluded to ensure proper quarterly alignment between Greenbook and Blue Chip data. Sample goes from 1993 to 2019 (end of availability of the Greenbook).

should cause GDP to fall. Of the remaining forecasters, 18 (50%) revise their GDP forecasts downward following a change in the funds rate, and 15 (42%) do so in response to FOMC announcements. Finally, 5 (14%) revise their forecasts in a direction that depends on other factors. Bauer and Swanson (2023a) conclude against the presence of information effects.

These conclusions are, however, surprising. While the findings may cast doubt on stronger forms of the information channel – where agents would simply extract information about growth from policy announcements – they provide strong support for the empirical findings of Miranda-Agrippino and Ricco (2021), and quite surprisingly so. First, the reported information

Table 1: RMSFEs Comparison (Blue Chip before Greenbook)

			FFR		GDP Defl (growth)		Real GDP (growth)	
Forecaster	H	Sample	$RMSFEs$	$\frac{RMSFEs}{std}$	$RMSFEs$	$\frac{RMSFEs}{std}$	$RMSFEs$	$\frac{RMSFEs}{std}$
Mean Forecaster	$h = 0$	Full Sample	0.23	0.10	0.82	0.91	1.47	0.77
		Pre2000	0.13	0.14	0.84	1.21	1.65	1.16
		Post2000	0.25	0.13	0.82	0.85	1.40	0.73
	$h = 1$	Full Sample	0.47	0.21	0.91	1.02	1.73	0.92
		Pre2000	0.35	0.40	0.95	1.46	1.82	1.29
		Post2000	0.51	0.27	0.90	0.94	1.70	0.90
Median Forecaster	$h = 0$	Full Sample	0.24	0.11	0.85	0.95	1.46	0.77
		Pre2000	0.14	0.16	0.87	1.25	1.65	1.16
		Post2000	0.27	0.14	0.85	0.88	1.39	0.72
	$h = 1$	Full Sample	0.48	0.22	0.92	1.03	1.74	0.92
		Pre2000	0.35	0.40	0.97	1.49	1.83	1.29
		Post2000	0.52	0.28	0.90	0.94	1.71	0.90
Greenbook	$h = 0$	Full Sample			0.84	0.93	1.26	0.66
		Pre2000			0.68	0.98	1.38	0.97
		Post2000			0.88	0.92	1.22	0.63
	$h = 1$	Full Sample			0.90	1.02	1.73	0.91
		Pre2000			0.83	1.27	1.83	1.29
		Post2000			0.94	0.97	1.70	0.90
Average RMSFEs	$h = 0$	Full Sample	0.25	0.11	1.01	1.11	1.59	0.84
		Pre2000	0.15	0.16	0.90	1.30	1.75	1.24
		Post2000	0.27	0.14	1.03	1.06	1.56	0.81
	$h = 1$	Full Sample	0.50	0.23	1.03	1.16	1.87	0.98
		Pre2000	0.38	0.44	1.00	1.53	1.99	1.40
		Post2000	0.52	0.28	1.03	1.08	1.84	0.97

Notes: This table reports the row RMSFEs and the corresponding ratios of RMSFEs to the standard deviation of the target variable, shown in the column $\frac{RMSFEs}{std(X)}$, across the relevant horizons and sample periods. We present results for the mean and median forecasters, the Greenbook, and the average RMSFEs across individual forecasters. We consider both the current quarter ($h = 0$) and the next quarter ($h = 1$). For each case, we compare performance over the full sample period (1993–2021), as well as the pre-2000 and post-2000 subsamples. In blue, we highlight the superior performance of the Greenbook relative to all other forecasters before 2000, a result consistent with Hoesch et al. (2023). Furthermore, as discussed in the text, the Greenbook outperforms the average RMSFE across individual forecasters for each horizon and variable. In this table, we match each Greenbook date with the previous closest date in the Blue Chip dataset. Results using the closest date in the Blue Chip with respect to Greenbook dates are similar, as shown in Figure 2 and 3.

effects explain a relatively low R^2 – less than 10%. Hence, the survey results are strikingly in line with the reported order of magnitude, perhaps even too strong. Second, in the presence of information frictions, the direction of the update depends on three factors: (i) whether the market participants are surprised by the policy change; (ii) the forecaster's pre-decision baseline projections; and (iii) the balance between the perceived monetary policy shock and the information disclosure, i.e. the bundle of shocks that drive the update. We conclude that the survey data constitutes strong evidence in favour of the information channel and against the proposed 'Fed's response to news' hypothesis (including the inattentive attitude of some of the forecasters). Yet, let us temper our enthusiasm: clearly, one datapoint does not make for robust statistics.

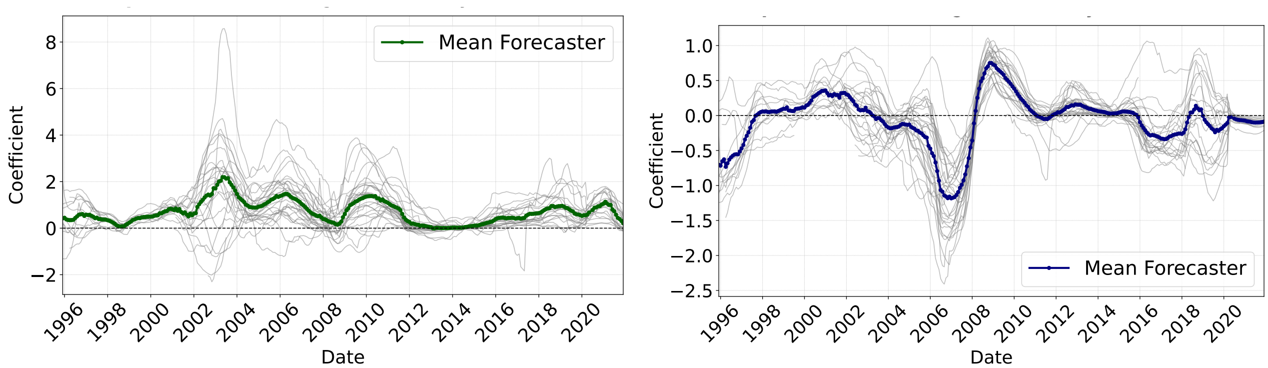
It is also worth noting that the survey results are all the more surprising given that even a small degree of rational inattention (or simply being preoccupied with other matters) would allow any reasonable forecaster – who is not immediately required to deliver a new projection – to delay updating the GDP forecast until more informative signals are released by statistical offices or the markets. Naturally, the behaviour of a market trader in a liquid market is very different and more reactive.

However, a natural question to ask is: how can a low degree of information contamination create puzzles? The explanation is provided in Miranda-Agrippino and Ricco (2023), who derive an analytical expression for the bias in the IRFs obtained using a contaminated IV. The size of the bias depends essentially on two factors: the strength of the contamination in the instrument and, crucially, how pervasive the shocks are in the economy – i.e. the proportion of the variance in the variables of interest that is explained by the contaminating shocks. This provides a useful interpretation: even in the presence of minor contamination from pervasive shocks – such as demand shocks – puzzles can still emerge.

Is there a drift in the coefficients of the policy rule? Not at all. Figure 1 shows the coefficients of a Taylor rule, which includes inflation and output gap, that are obtained by regressing the market yield on U.S. Treasury Securities at 2-year onto 1-year growth in Personal Consumption Expenditure and GDP growth, as in Bauer and Swanson (2023b). The first row shows estimates from an expanding window regression with exponential down-weighting of older observations, as done by Bauer and Swanson (2023b), while the second row presents results from a rolling-window estimation.[6]

[6]Specifically, the dependent variable in Figure 1 is the market yield on U.S. Treasury securities at a 2-year constant maturity (DGS2). The independent variables include the 1-year growth in Personal Consumption Expenditure (PCEPILFE) as a measure of inflation, and the output gap (OUTGAP), defined as the difference between real GDP (GDPC1) and potential GDP (GDPPOT), expressed as a percentage of potential GDP. All regressions include a constant term.

Figure 5: Market perception of Taylor Rule parameters



(a) GDP deflator growth coefficient

(b) GDP growth coefficient

Notes: The figure displays the dispersion of forecasters' estimated sensitivity to (a) price deflator growth and (b) GDP growth, in a Taylor Rule specification. The coefficients are obtained from pooled rolling regressions of forecasts of FFR on quarter over quarter GDP growth forecasts and price deflator growth forecasts, with a rolling window of 36 months. We align all the forecasts up to 5 quarters ahead and we do pooled OLS for each individual forecaster. Each grey line represents an individual forecaster's estimated coefficient on GDP growth, while the navy blue (GDP growth) and the dark green (price deflator) lines represents the cross-sectional average of these coefficients at each point in time. The data includes professional forecasters from the Blue Chip Financial Forecasts (BCFF) survey, covering the period from 1993 to 2021. Forecasters included in the sample meet a minimum consistency criterion of 15 years of participation with at least 6 monthly observations per year for the current quarter.

The top left chart replicates the results in Bauer and Swanson (2023b) and show the presence of a drift. Yet, as the other charts indicates, this is not a robust finding. A rolling window exercise, which is more appropriate to appraise the presence of time variation, shows that there is no trend and if any the coefficient on inflation is zero, puzzling. At the same time, the coefficient on output gap appears to have been drifting, indicating an increasingly dovish stance of the Fed.

A similar exercise with survey data is reported in Figure 5. The figure shows for the individual forecasters and the mean forecaster in the Blue Chip dataset the coefficients of a Taylor rule that are obtained from rolling regressions the forecasts for the effective federal funds rate onto the forecasts for GDP growth and inflation, with a rolling window of 36 months. It is worth observing that our results, chime with the ones reported by Bauer et al. (2024), who estimate perceptions of the Fed's monetary policy rule from the BCFF survey.

Do forecasts agree on the Taylor rule? No. Figure 5 also reports the dispersion in the estimated Taylor rule coefficients for GDP growth and inflation, across forecasters. It is important to notice that there are always some forecasters overestimating the sensitivity of monetary policy to economic conditions relative to the mean forecaster, while others underestimate it (and no drift is apparent). This dispersion suggests that perceptions about the monetary policy rule are not homogeneous but can vary substantially across market participants. (This is not important the aggregate dynamics, as long as the aggregated market is on average about right.)

However, the presence of substantial dispersion in forecasts contradicts one of the key tenets of the Fed's response to news channel, which cannot accommodate disagreement. If agents persistently disagree on their interpretation of the policy rule (or equivalently on the type of shocks to which the Fed has to respond) and have a large span of beliefs, they will tend to drive out of the market traders with large (negative) biases.

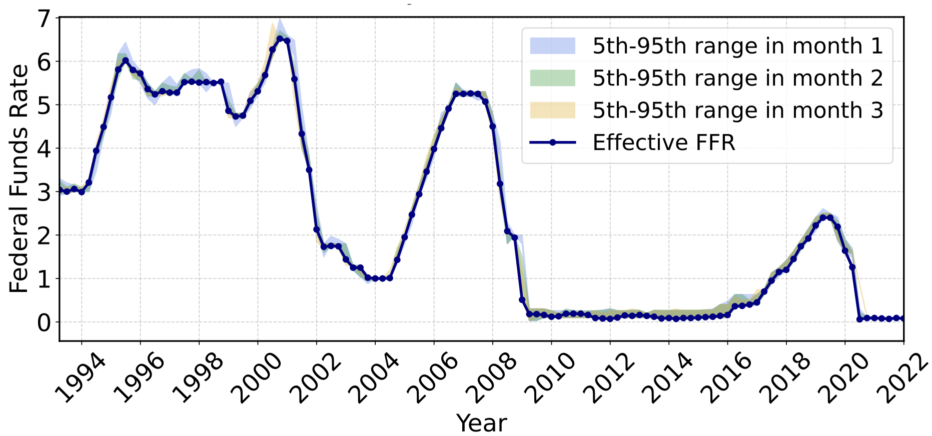
It is worth stressing that the results cannot be interpreted literally as the perceived Taylor rule, since the Fed and hence the forecasters are unlikely to employ a simple Taylor rule of the form estimated, and there are well know issues econometric issues of endogeneity with this type of estimates (see Carvalho et al., 2021).

Are all market participants always wrong about the policy rate? No. Figure 6 complements Figure 5 and plots the realised FFR along with the range between the 5th and 95th in the dispersion of Blue Chip forecasts. Together the two charts indicate that not all of the forecasters expect a substantially more dovish policy rate. If any, there is, on average, more mass above the realised rate, showing that forecasters are more hawkish than the policymaker.

It is important to observe that, in such a situation, if a market participant were to consistently trade based on a forecast that underestimates the inflation parameter of the Taylor rule, the rest of the market would quickly drive them out.

A related and important question is: how is it possible that market forecasts are as accurate

Figure 6: Dispersion of market forecasts for federal funds rate



Notes: The figure illustrates the dispersion of market forecasts for the current quarter of the average FFR alongside the actual average realised rate. The purple area represents the range between the 5^{th} and 95^{th} percentile of the forecasts done in the first month of each quarter. The green area represents the same range for the second month of each quarter, and the yellow area represents the same range for the last month of each quarter. The blue line corresponds to the realised quarterly average of the FFR.

as the Fed's when forecasting any variable other than policy rates? After all, the latter is an essential input in forecasting both inflation and GDP growth. Here, the inconsistency of the reasoning becomes apparent.

Indeed, the data show that this is not the case. This is also evident in the standardised performances across variables in Table 1, which show that market forecasts are as accurate (or more so) at predicting the FFRs as they are at forecasting other variables.

4 A model of imperfect information and policy shifts

The previous section highlighted potential inconsistencies in attributing reported information effects to a misspecification of the policy rule used by agents to forecast the policy rate – specifically, unexpected changes in the parameters of the Taylor rule. We also noted that, to some extent, the 'Fed response to news' hypothesis explains the same empirical facts as the information effects argument, making direct falsification difficult.

We now formalise the problem discussed in Section 2 and demonstrate that there are testable implications distinguishing the role of information from the effects of unexpected changes in the policy rule within monetary policy surprises. To do this, we proceed in steps.

First, we examine how to frame a Taylor rule with time-varying parameters within a standard linearised policy rule. This is relevant for two reasons. First, in the conventional approach to linearisation, a shift in the Taylor rule appears as a monetary policy shock. Second, it allows us to distinguish between first- and second-order terms in the policy rule, revealing that changes to the Taylor rule parameters are better understood as second-order effects.

Next, we embed the Taylor rule with shifts in policy parameters into an affine term structure model. We consider two versions. The first follows the stylised framework of Ellingsen and Soderstrom (2001), which captures only the expectations component of interest rates without accounting for term premium dynamics. In this framework, we do not explicitly model the information flow between the central bank and market participants but instead focus on how the yield curve reacts to unexpected policy changes under different interpretations – information effects, policy rule changes, or monetary policy shocks. This provides the foundation for our empirical strategy.

We then extend the framework by incorporating an affine term structure model with an endogenous term premium, following Smith and Taylor (2009). This allows for a more comprehensive analysis of how shocks and shifts in policy parameters influence the entire yield curve.

In a subsequent step, we explore the implications of this setting for agents who are imperfectly informed about the state of the economy. These agents receive both private noisy signals about economic fundamentals and a noisy public signal in the form of the observed policy rate. To do this, we expand on the stylised imperfect information model of Miranda-Agrippino and Ricco (2021), following a similar approach to Pirozhkova et al. (2024).

Finally, we derive the structure of monetary policy surprises – that is, the price revisions of bonds with different maturities triggered by a policy announcement. This provides testable predictions to assess whether information effects or shifts in policy rule coefficients explain the observed puzzles. In the remainder of the paper, we evaluate these predictions.[7]

4.1 Nonlinear and linear (time-varying) policy rule

Let us consider a general nonlinear Taylor rule, following Woodford (2003):

$$R_t = \phi \left(\frac{\Pi_t}{\Pi_t^*}; \nu_t \right), \tag{5}$$

where R_t is the gross nominal interest rate, and $\phi(\cdot; \nu_t)$, the rule used by the central bank, is a bounded-below, non-decreasing function for each possible value of the shifter ν_t, while $\Pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate and Π_t^* is a possibly time-varying target rate.[8] ν_t represents shifts in the central bank's rule – i.e., variations in policy or its implementation – distinct from changes in the target inflation rate itself.

A standard first order log-linear Taylor expansion of the rule with respect to the point $(\Pi_t = \Pi^*; \nu_t = 0)$, as discussed in Woodford (2003), yields a fixed coefficient Taylor rule, i.e.

$$r_t = r^* + \phi(\pi_t - \pi^*) + \sigma^{mp}\nu_t + \mathcal{O}(2), \tag{6}$$

where r^* is interpreted as the nominal equilibrium rate, and ϕ is the elasticity of the policy rule with respect to deviations of inflation from the target. Interestingly, the policy rule shifter, ν_t, is the monetary policy shock itself. This implies that all the residual time variation is hidden in the remainder term of the expansion, $\mathcal{O}(2)$, that contains all the (assumed to be) sub-leading terms of second-order and beyond.

To obtain a time varying rule with a drift, we need to go back to the linearisation. Let us

[7] All derivations are provided in Section A of the Online Appendix.

[8] In general, ϕ captures the nonlinear behaviour of policy away from the steady state, where a small-perturbation approximation is inaccurate, or around the zero or effective lower bound, where its non-negative (or bounded-below) nature becomes evident.

assume that ν_t is stable around a possibly time-varying steady state $\bar{\nu}_t$, i.e

$$\nu_t = \bar{\nu}_t + \nu_t^{mp},$$

where $\bar{\nu}_t$, will become the point of expansion which we assume to undergo permanent shifts, similarly to a random walk, and ν_t^{mp} will be assumed to be a small and transitory process, orthogonal to $\bar{\nu}_t$. We can now linearise with respect to the point $(\Pi_t = \Pi_t^*; \nu_t = \bar{\nu}_t)$ to obtain the standard linear Taylor rule, but with time-varying coefficients, i.e.[9]

$$r_t = r_t^* + \phi_t(\pi_t - \pi_t^*) + \sigma_t^{mp}\nu_t^{mp} + \mathcal{O}(2). \tag{7}$$

Let us remark that for this log-linear expansion to be valid it has to be that the rule is relatively stable and the changes are not 'too large' otherwise the linear expansion around a time-varying point could be not valid and second order terms could be as large as or larger than first order terms.

The process $\bar{\nu}_t$ has to be thought of as the persistent part of the parameter characterising the variations in the policy or its implementation. Given the relative stability of the US monetary policy, we can think of it as a stochastic parameter evolving as a bounded random walk (see, for example, Nicolau, 2002). This allows for a formalisation of the problem where the policy rule is broadly stable over time but small changes of its parameters can appear as shocks to a random walk process to the agents in the model.

This observation allows us to consider a further expansion in ν_t around what we can think of the central point of the bounded random walk. If the area in which the process behaves like a random walk is not 'too large', then a Taylor expansion can provide an approximation to the policy rule. Let us focus on the inflation parameter of the Taylor rule and consider an

[9] The time-variation that has been captured through ν_t does not need to occur simultaneously in all the parameters of the Taylor rule and will depend on the nature of ϕ and the dimension of ν_t.

expansion at the centre of the area of the bounded random walk process, $\bar{\nu}$, i.e.

$$\phi_t = \left.\frac{\partial\phi\left(\Pi_t/\Pi_t^*;\nu_t\right)}{\partial\left(\Pi_t/\Pi_t^*\right)}\right|_{1;\bar{\nu}} + \left.\frac{\partial^2\phi\left(\Pi_t/\Pi_t^*;\nu_t\right)}{\partial\left(\Pi_t/\Pi_t^*\right)\partial\bar{\nu}_t}\right|_{1;\bar{\nu}} \bar{\nu}_t + \mathcal{O}(2) \equiv \phi + \widehat{\phi}_t + \mathcal{O}(2) \tag{8}$$

The expansion shows that we are now considering terms of the second order, and going beyond a first order expansion. For the sake of the exposition, let us focus on the ϕ parameter only.[10] We obtain:

$$r_t = r^* + (\phi + \widehat{\phi}_t)(\pi_t - \pi^*) + \sigma^{mp}\nu_t^{mp} + \mathcal{O}(2), \tag{9}$$

where $\mathcal{O}(2)$ stays for the remainder term which contains additional second order terms, i.e. $\sim (u_t^{mp})^2$, $(\pi_t - \pi_t^*)^2$, and $(\pi_t - \pi_t^*)\nu_t^{mp}$, albeit the expansion now features one term beyond the first oder, i.e. $\widehat{\phi}_t(\pi_t - \pi)$.

Let us summarise. Starting from a general nonlinear policy rule we derived a linearised Taylor with an inflation coefficient varying trough time, and with a shift behaving like a random walk, but effectively covering a bounded space (and hence being a stationary and ergodic process). It is important to stress that in doing so we have to consider second order terms beyond the standard first oder log-linearisation Taylor expansion. These terms, are likely to be sub-leading, if the expansion conditions are respected. Moreover, other second oder terms, of the same magnitude, may have been (erroneously) dropped in the expansion.

4.2 A simple framework for policy shocks and policy changes

Let us consider a simple affine term structure model of the type discussed in Svensson (1997, 1999) and based on the expectation hypothesis, following Ellingsen and Soderstrom (2001).[11] The model does not feature term premium dynamics, nor it models information frictions.

[10] Exogenous shifts causing transitory time variation in the other parameters of the central bank's reaction function can be absorbed into the monetary policy shock ν_t^{mp}.

[11] We refer to Ellingsen and Soderstrom (2001) for a discussion of some of the results reported in this section. Our derivations and additional results are reported in the Online Appendix in Section A.2.

The economy is described by a set of linear equations

$$\pi_t = \pi_{t-1} + \iota y_{t-1} + \sigma_\pi u_t^\pi, \tag{10}$$

$$y_t = \beta y_{t-1} - \delta(r_{t-1} - \pi_{t-1}) + \sigma_y u_t^y, \tag{11}$$

$$r_t \equiv i_t^{(0)} = (\phi + \phi_t)\pi_t + (\omega + \omega_t) y_t + \sigma_{mp} \nu_t^{mp} , \tag{12}$$

$$\nu_t^{mp} = \zeta \nu_{t-1}^{mp} + u_t^{mp}, \tag{13}$$

where all the variables are considered in deviation from their steady state. The model features an accelerationist Phillips curve in which the change in the inflation rate is positively related to the previous period's output gap (Eq. 10), with $\iota > 0$, and u_t^π representing an i.i.d. supply shock with mean zero. The output gap is mean reverting and negatively related to the real short interest rate (Eq. 11).[12] The short term interest rate is set according to a Taylor rule that responds to inflation and output gap (Eq. 12), and possibly with time-varying parameters as discussed in the previous section. The monetary policy disturbance, ν_t^{mp}, follows an autoregressive process of order one (Eq. 13), which captures the persistence of the deviations. The yield curve is specified following the expectation hypothesis, as

$$i_t^{(n)} = \frac{1}{n} \sum_{i=0}^{n-1} E_t[r_{t+i}] + \xi_t^{(n)}, \tag{14}$$

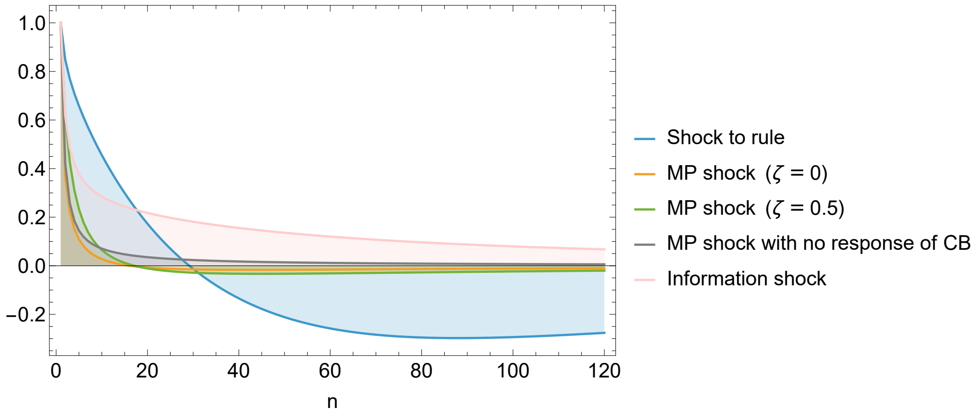
where the n-periods ahead interest rate is given by the expected path of the short term interest rate plus an exogenous term premium, $\xi_t^{(n)}$ (Eq. 14).

The policy rule can be obtained as optimal solution of the problem of a central bank trying to minimise a loss function specified as

$$\mathcal{L} = E_t \sum_{i=0}^{\infty} \vartheta^i \frac{1}{2} \left(\pi_{t+s}^2 + \lambda_t y_{t+s}^2 \right), \tag{15}$$

[12]The output equation is obtained from $y_t = \hat{\beta} y_{t-1} - \delta(r_{t-1} - E_{t-1}[\pi_t]) + \sigma_y u_t^y$, where the output gap depends on the ex ante real short interest rate.

Figure 7: THE REACTION OF THE YIELD CURVE TO SHOCKS (MODEL I)



Notes: The figure compares the impact on the term structure of interest rates resulting from a shift in the policy rule (blue), a monetary policy shock (orange when $\zeta = 0$ and green when $\zeta = 0.5$), and an information shock (light red). The calibration follows Smith and Taylor (2009). In grey, the figure shows the term structure's reaction under the assumption that the central bank does not respond to the macroeconomic consequences of its own monetary policy shock. This shock follows an AR(1) process with an autocorrelation coefficient of 0.5. The time horizon is $n = 120$ quarters (i.e., 30 years).

where the parameter λ_t is the weight of output stabilisation relative to inflation stabilisation, which in our setting may change over time. It can be show that if λ_t evolves as a bounded random walk, then ϕ_t and ω_t inherit the bounded random walk dynamics, with a shock to the policy preferences, u_t^ϕ, shifting the parameters as

$$\phi_t = \phi_{t-1} + \sigma_\phi u_t^\phi, \qquad \omega_t = \omega_{t-1} + \iota\sigma_\phi u_t^\phi. \tag{16}$$

The model can be solved analytically, to obtain an affine expression for the yield curve, i.e.

$$i_t^{(n)} = a_n + b_n^\pi \pi_t + b_n^y y_t + c_n \nu_t^{mp} + \xi_t^{(n)}. \tag{17}$$

The rate changes triggered by a monetary policy announcement, i.e. the policy surprises, can be studied by assuming that the announcement is interpreted by the agents as disclosing information either about (i) a permanent change in the central bank preferences, or (ii) information about realised supply or demand shocks which were not observed by the agents, or (iii) conventional monetary policy shocks.

The following proposition presents key results relevant to this study, while Figure 7 provides an illustration.

Lemma 1 (Monetary Policy Surprises). *Assume that agents are imperfectly informed about realised macroeconomic shocks and the central bank's preferences. Then, conditional on a change in the policy rate that surprise the market:*

(a) If the policy decision reveals a change in the central bank's preferences, monetary policy surprises satisfy

$$\Delta_{[\bar{t}-\underline{t}]} i_t^{(n)} = \sigma_\phi \frac{\partial i_t^{(n)}}{\partial \phi_t} u_t^\phi, \tag{18}$$

where $\Delta_{[\bar{t}-\underline{t}]} i_t^{(n)}$ denotes the difference in yields before and after the announcement. Interest rates on bonds of sufficiently long maturity move in the opposite direction to the unexpected policy rate change: an unexpectedly high central-bank rate tilts the yield curve clockwise, while an unexpectedly low rate tilts it counterclockwise.

(b) If the policy decision conveys information about a supply or demand shock, the change in market interest rates

$$\Delta_{[\bar{t}-\underline{t}]} i_t^{(n)} = \frac{\partial i_t^{(n)}}{\partial u_t^\pi} u_t^\pi + \frac{\partial i_t^{(n)}}{\partial u_t^y} u_t^y = \sigma_\pi b_n^\pi u_t^\pi + \sigma_y b_n^y u_t^y \tag{19}$$

will comove with the policy rate change at all maturities, with the magnitude of the effect decreasing over longer maturities.

(c) If the policy decision reflects a monetary policy shock, interest rates will rise at the short end of the yield curve, with smaller (and possibly negative) effects at longer maturities:

$$\Delta_{[\bar{t}-\underline{t}]} i_t^{(n)} = \frac{\partial i_t^{(n)}}{\partial \nu_t^{mp}} u_t^{mp} = c_n u_t^{mp}. \tag{20}$$

(d) Under a standard calibration, the impact of a monetary policy shock on yields at longer maturities is negligible, whereas a shift in policy rule parameters has sizeable effects.

These results provide the core intuition for the empirical strategy to disentangle rule-based monetary policy shocks from information transmission effects. While the model helps to explain how different shocks may affect the yield curve, it does not explicitly describe information transmission under imperfect information. Moreover, it does not account for endogenous term premia, which may be particularly important at the long end of the yield curve. In the next section, we address these aspects of the model.

4.3 A term structure with policy shocks and rule changes

Let us now embed the time-varying policy rule discussed in the previous section into an affine term structure model with endogenous term premium, of the type discussed in Smith and Taylor (2009).[13] All the variables are considered in deviation from their steady state:

$$r_t = (\phi + \widehat{\phi}_t)\pi_t + \sigma_{mp}\nu_t^{mp}, \tag{21}$$

$$\nu_t^{mp} = \zeta\nu_{t-1}^{mp} + u_t^{mp} \tag{22}$$

$$\widehat{\phi}_t = \widehat{\phi}_{t-1} + \sigma_\phi u_t^\phi \tag{23}$$

$$i_t^{(n)} = -\frac{1}{n}\log P_t^{(n)}, \tag{24}$$

$$P_t^{(n+1)} = \mathbb{E}_t\left[m_{t+1}P_{t+1}^{(n)}\right], \tag{25}$$

$$m_{t+1} = e^{-r_t - \frac{1}{2}\lambda_t^2 - \lambda_t u_{t+1}^\pi}, \tag{26}$$

$$\lambda_t = -\gamma - \psi\pi_t, \tag{27}$$

$$\pi_t = \alpha\pi_{t-1} - \delta(r_{t-1} - \pi_{t-1}) + \sigma_\pi u_t^\pi, \tag{28}$$

As discussed, Eq. (21) is the (linearised) monetary policy rule in which the short-term nominal interest rate r_t depends on the inflation rate with a policy response coefficient $\phi > 0$. Eq. (22) models the transitory policy shock as an AR(1) process, with coefficient $0 \leq \zeta < 1$. Eq.

[13] The derivations are reported in Section A.3 of the Online Appendix. While for later ease of exposition, in this model, we consider a central bank that only targets inflation in Section A.4, in the Online Appendix, we consider the extension to a Taylor rule targeting output gap as well as inflation.

(24) gives the yield to maturity of a zero-coupon bond with face value of one, that matures in n periods, where $P_t^{(n)}$ is the price of the bond at time t. Eq. (25) is a no-arbitrage condition showing that the price of an $n+1$ period bond at time t must equal the expected present discounted value of the price of an n-period bond at time $t+1$, where m_t is the stochastic discount factor. Eq. (26) describes this stochastic discount factor, whose functional form is borrowed from the affine term structure literature. Eq. (27) models the risk factor as depending on a constant risk premium, γ, and a time-varying risk premium, ψ, connected to changes in inflation. Finally, in Eq. (28) the dynamics of inflation is function of the lagged real interest rate and past inflation. The three shocks in the model – an inflation shock, a conventional monetary policy shock, and a shifter of the policy rule – are independent and identically distributed normal white noise processes, $u_t^i \sim i.i.d.\mathcal{N}(0,1)$ for $i \in (\pi, mp, \phi)$.

Although we will consider shifts in Taylor rule parameter, we assume that the central bank and the private agents at any time view it as certain and constant. Any changes in the Taylor rule parameters are thus fully unanticipated, and seen as permanent. This is in line with the intuition proposed by Bauer and Swanson (2023a).

This model implies the affine structure of the yield curve, which is described by the following Lemma.

Lemma 2. *The yield curve described by the model in Eq.s (21-28) is*

$$i_t^{(n)} = a_n + b_n \pi_t + c_n u_t^{mp} \tag{29}$$

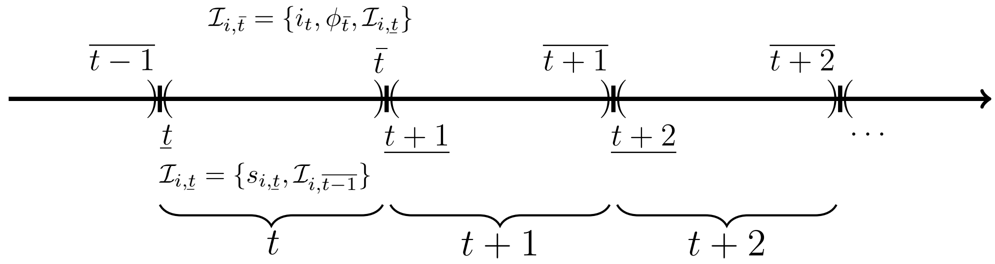
with coefficients of the disturbances given by

$$b_n = \frac{\phi \sum_{i=1}^{n-1} \kappa^i}{n}, \quad c_n = \frac{\sigma_{mp}\left(1 - \delta\phi \sum_{i=0}^{n-2} \kappa^i\right)}{n}, \tag{30}$$

for $\kappa = \alpha + \delta(1-\phi) + \sigma_\pi \psi$.[14]

[14] We assume $|\kappa| < 1$.

Figure 8: **The information flow.**



4.4 Imperfect information and policy signals

The term structure model, described in the previous section, can now be embedded into an environment characterised by imperfect information, following Miranda-Agrippino and Ricco (2021) and Pirozhkova et al. (2024). (For ease of exposition, in the remainder of this section, we focus on the case where $\zeta = 0$ and $\nu_t^{mp} = u_t^{mp}$.)

Each agent i in the economy does not directly observe π_t, but receives a private noisy signal of π_t at the beginning of the time period $t = [\underline{t}, \bar{t}]$ (see Figure 8):

$$s_{i,\underline{t}} = \pi_t + \nu_{i,\underline{t}} \ , \qquad\qquad \nu_{i,\underline{t}} \sim \mathcal{N}(0, \sigma_{n,\nu}) \ . \tag{31}$$

Agents also form beliefs about the Taylor rule parameter, i.e. $\phi + \widehat{\phi}_{t-1}$, by assuming that it is equal to last period, i.e.

$$\phi_{\underline{t}} = \phi_{\overline{t-1}} = F_{\overline{t-1}}\left(\phi + \widehat{\phi}_{t-1}\right) .$$

Given the signal and conditional on their information set $\mathcal{I}_{\underline{t}} = \{s_{i,\underline{t}}, \phi_{\underline{t}}, \mathcal{I}_{\overline{t-1}}\}$, agents update their expectations from the closing time of the previous period, $F_{i,\overline{t-1}}\pi_t$, and form expectations $F_{i,\underline{t}}\pi_t$ given their information set via the Kalman filter

$$F_{i,\underline{t}}\pi_t \quad = \quad K_1 s_{i,\underline{t}} + (1 - K_1) F_{i,\overline{t-1}}\pi_t \ , \tag{32}$$

$$F_{i,\underline{t}}\pi_{t+h} \quad = \quad (\alpha - \delta(\phi_{\underline{t}} - 1))^h F_{i,\underline{t}}\pi_t, \qquad \forall h > 0 \ , \tag{33}$$

where K_1 is the Kalman gain, which represents the relative weight placed on new information compared to previous forecasts. When the signal is perfectly revealing, $K_1 = 1$, while in the presence of noise $K_1 < 1$. The higher the noise, the lower K_1 is. Thus $(1 - K_1)$ can be seen as the degree of information rigidity faced by the agents.

Given their forecasts, at $\underline{t}$, agents trade bonds of different maturities with the following interest rates

$$i_{\underline{t}}^{(n)} = a_n + b_n F_{i,\underline{t}} \pi_t \ . \tag{34}$$

At opening time $\underline{t}$ the central bank observes a private noisy signal of the state of the economy in period t

$$s_{cb,\underline{t}} = \pi_t + \nu_{cb,\underline{t}} \ , \qquad \nu_{cb,\underline{t}} \sim \mathcal{N}(0, \sigma_{cb,\nu}) \ . \tag{35}$$

We can assume, without loss of generality, that the signal observed by the central bank is more precise than that observed by agents: $\sigma_{cb,\nu} < \sigma_{n,\nu}$. Given the signal, the central bank updates its expectations from the closing time of the previous period, given its information set, via the Kalman filter,

$$\begin{aligned} F_{cb,\underline{t}} \pi_t &= K_{cb} s_{cb,\underline{t}} + (1 - K_{cb}) F_{cb,\overline{t-1}} \pi_t \ , && (36) \\ F_{cb,\underline{t}} \pi_{t+h} &= (\alpha - \delta(\phi + \widehat{\phi}_t - 1))^h F_{cb,\underline{t}} \pi_t, \qquad \forall h > 0 \ , && (37) \end{aligned}$$

where K_{cb} is the bank's Kalman gain. Given its nowcast for inflation, the central bank sets and announces the interest rate, by following its policy rule:

$$i_t^{(1)} = r_t = (\phi + \widehat{\phi}_t) F_{cb,\underline{t}} \pi_t + \sigma_{mp} u_t^{mp}. \tag{38}$$

At closing time $\bar{t}$, agents observe the new interest rate r_t and receive a noisy signal about the Taylor rule parameter of the central bank, i.e.

$$\phi_{\bar{t}} = \phi + \widehat{\phi}_t + \zeta_t \ , \qquad\qquad \zeta_t \sim \mathcal{N}(0, \sigma_\zeta) \ .$$

Given these two signals and conditional on the new information set, $\mathcal{I}_{\bar{t}} = \{i_t, \phi_{\bar{t}}, \mathcal{I}_{\underline{t}}\}$, they update their expectations, and trade bonds at different maturities.

The policy rate serves as a public signal about the state of the economy for agents. In fact, conditionally on observing r_t and r_{t-1} (and knowing K_{cb}), agents extract a public signal on π_t, i.e. $\tilde{s}_{cb,t} = \pi_t + \widetilde{\nu}_{cb,\underline{t}}$.[15]

Thus, at $\bar{t}$, conditional on the public signals, the agents' forecasts are

$$F_{i,\bar{t}}\pi_t \quad = K_2 \tilde{s}_{cb,\bar{t}} + (1 - K_2) F_{i,\underline{t}}\pi_t \ , \tag{39}$$

$$F_{i,\bar{t}}\pi_{t+1} = (\alpha + \delta) F_{i,\bar{t}}\pi_t - \delta r_t \ , \tag{40}$$

$$F_{i,\bar{t}}\pi_{t+h} = (\alpha - \delta(\phi_{\underline{t}}^{-1} - 1))^{h-1} F_{i,\bar{t}}\pi_{t+1}, \qquad\qquad \forall h > 1 \ , \tag{41}$$

where K_2 is the Kalman gain, determined by the noise in the public signal $\tilde{\nu}_{cb,\underline{t}}$ conveyed by the policy rate.

The solution of the model yields a set of interesting results. Let us begin with the revisions of expectations regarding the state of the economy, which are captured by the following proposition.

Lemma 3 (Expectation revisions). *A policy announcement triggers a market revision of*

[15] The noise in the signal $\tilde{s}_t$ is coloured and not orthogonal to the state. Hence, it does not satisfy the standard conditions under which the Kalman filter is derived. Unmodelled dynamics can degrade the filter's performance. Here, we abstract from these considerations, which would require robust control methods.

expectations, i.e. the information effects, of the form

$$
\begin{aligned}
F_{\bar{t}}\pi_t - F_{\underline{t}}\pi_t = {} & (1-K_1)(1-K_2)(F_{\overline{t-1}}\pi_t - F_{\underline{t-1}}\pi_t) \\
& + (1-K_1)(1-K_2)\delta(r_{t-1} - F_{\underline{t-1}}r_{t-1}) \\
& + K_2\left[(1-K_1)\sigma_\pi u_t^\pi - (1-K_1)(\alpha+\delta)\tilde{\nu}_{cb,\overline{t-1}} + \tilde{\nu}_{cb,\bar{t}}\right].
\end{aligned}
\tag{42}
$$

The lemma generalises the findings of Miranda-Agrippino and Ricco (2021). Two remarks are in order. First, the expectation revisions triggered by a policy announcement are autocorrelated due to the slow absorption of information and the fact that agents continue to revise their backcasts. This is a hallmark of models of imperfect information, as discussed in Coibion and Gorodnichenko (2012, 2015).

Second, these revisions blend current and past shocks and are therefore predictable based on past information, such as macroeconomic and financial variables. Third, the term featuring the current shock to inflation, i.e. u_t^π, can be interpreted as the direct information effect of the announcement, which reveals information about the current state of the economy. The strength of these information effects depends on $K_2(1-K_1)$, which increases with the noise in the private signal and decreases with the noise in the public signal. This suggests that, while the presence of information effects does not require the central bank to have superior information, the strength of the information channel is determined by the relative precision of the policy signal compared to the signals received by private agents.

We can now derive the structure of the monetary policy surprise. Observing that, from the agents' perspective, it must hold that $i_t^{(0)} = r_t = \delta F_{i,\bar{t}}\pi_t + \sigma^{mp} F_{i,\bar{t}} u_t^{mp}$, we obtain the following result.

Lemma 4 (Policy rate surprise). *The average market forecast error on the policy rate can* *be written as*

$$\begin{aligned}
r_t - F_{\underline{t}} r_t = & \underbrace{(1-K_1)(1-K_2)\,(\alpha+\delta)\,(r_{t-1} - F_{\underline{t-1}} r_{t-1})}_{autocorrelation} \\
& + \underbrace{(1-K_1)(1-K_2)\,(\alpha+\delta)\,\phi^{-1}\sigma_\phi u^\phi_{t-1}(r_{t-1} - F_{\underline{t-1}} r_{t-1})}_{rule\ parameter\ change} \\
& + \underbrace{\sigma_\phi u^\phi_t F_{\bar{t}}\pi_t - \sigma_\phi u^\phi_{t-1}(\alpha+\delta) F_{\overline{t-1}}\pi_{t-1} + \widehat{\phi}_{t-1} K_2(1-K_1)\sigma_\pi u^\pi_t}_{rule\ parameter\ change} \\
& + \underbrace{\phi K_2(1-K_1)\sigma_\pi u^\pi_t}_{information\ effect} + \underbrace{\sigma^{mp} F_{\bar{t}} u^{mp}_t}_{monetary\ policy\ shock} + \upsilon_t, \qquad (43)
\end{aligned}$$

where υ_t is a convolution of past and current shocks.

The expression in Eq. (43) shows how the average market forecast errors on the realised policy rate are a function of (i) shocks to the parameters of the policy rule, (ii) information effects, and (iii) monetary policy shocks. The presence of imperfect information also induces autocorrelation in the forecast errors. This expression provides a model-based counterpart to, and reinforces the intuition given by, Eq. (4) in Section 2.

We can now discuss the effect of a policy announcement on the yield curve.

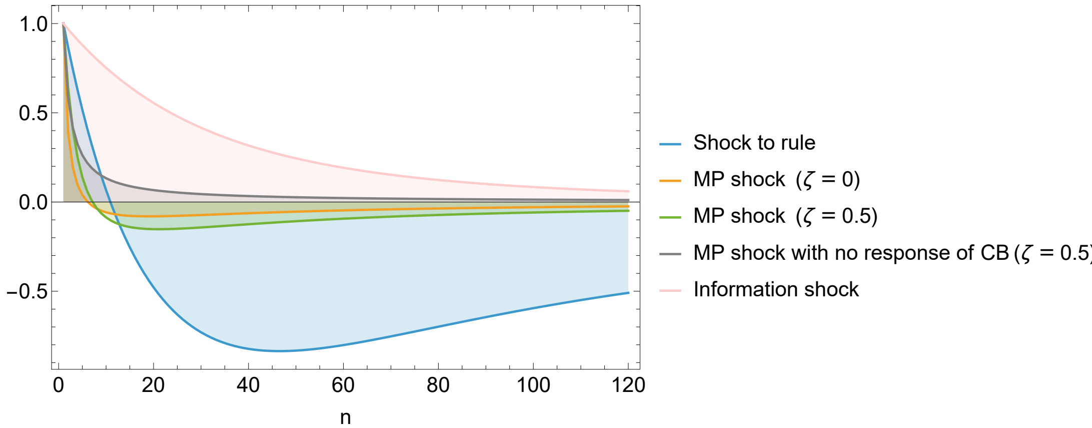
Lemma 5 (Monetary policy surprises). *The price revisions, i.e. the monetary policy surprises, for bonds at longer maturities are given by*

$$\Delta_{[\bar{t}-\underline{t}]} i^{(n)}_t = \underbrace{b_n(F_{\bar{t}}\pi_t - F_{\underline{t}}\pi_t)}_{information\ effect} + \underbrace{\frac{\partial b_n}{\partial u^\phi_t}(\phi_{\bar{t}} - \phi_{\underline{t}})(F_{\bar{t}}\pi_t - F_{\underline{t}}\pi_t)}_{rule\ parameter\ change} + \underbrace{c_n F_{\bar{t}} u^{mp}_t}_{monetary\ policy\ shock}, \qquad (44)$$

where the derivative of b_n with respect to u^ϕ_t captures the shift in the policy parameter and hence its effect on yields at different maturities.

Lemma 5 shows that the yield curve reacts to the policy announcement due to (i) the market updating its expectations about the state of the economy, (ii) the revised understanding of the policy rule, and (iii) the monetary policy shock. These three factors can affect yields in

Figure 9: The reaction of the yield curve to shocks (model II)



Notes: The figure compares the impact on the term structure of interest rates in a model with an endogenous term premium, considering a shift in the policy rule (blue), a monetary policy shock (orange when $\zeta = 0$ and green when $\zeta = 0.5$), and an information shock (light red). The calibration, based on quarterly data, follows Smith and Taylor (2009). The time horizon is $n = 120$ quarters (i.e., 30 years). Finally, in grey, the chart shows the term structure?s reaction under the assumption that the central bank does not respond to the macroeconomic consequences of its own monetary policy shock, which follows an AR(1) process with an autocorrelation coefficient of 0.5.

different ways, as summarised by the following results and illustrated in Figure 9.

Lemma 6 (Policy shocks, shocks to the rule, and information). *Under imperfect information:*

(a) The effect of a shock to the policy parameter on the yield curve is given by

$$\frac{\partial b_n}{\partial u_t^\phi} = \frac{\sigma_\phi}{n} \frac{1}{(1-\kappa^2)} [n\delta\phi\kappa^{n-1}(1-\kappa) - (1-\kappa^n)(\delta\phi + \kappa - 1)], \tag{45}$$

which, for $\alpha + \delta + \sigma_\pi > 1$, implies the existence of a unique n^* such that

$$\frac{\partial b_n}{\partial u_t^\phi} = \begin{cases} > 0 & \text{if } n < n^*, \\ < 0 & \text{if } n > n^*, \end{cases}$$

Hence, it causes interest rates on bonds with sufficiently long maturities to move in the opposite direction to both the parameter change and the short-term rate forecast error.

(b) An information shock raises the entire yield curve, with its effects, b_n, diminishing over

longer horizons.

(c) *If inflation persistence significantly exceeds the autocorrelation of monetary policy shocks, a monetary policy shock raises short-term yields, exerts small negative effects, c_n, on medium-term maturities, and has negligible effects on long-term maturities.*

There are a few points worth emphasising. First, if a central bank becomes more responsive to inflation, yields at short maturities increase, whereas those at longer maturities decrease. This prediction aligns with the results reported by Smith and Taylor (2009) and Ellingsen and Soderstrom (2001), but is embedded in a model with imperfect information. Second, revised expectations of higher inflation due to information effects will lead to higher interest rates at all maturities, with decreasing effects over longer horizons. Third, the behaviour of monetary policy shocks critically depends on two aspects of the model: (i) the degree of autocorrelation of the shock, which determines its persistence, and (ii) whether the central bank responds to the effects of its own shocks. Importantly, these effects will dissipate at business cycle frequency, becoming close to zero at long maturities.

4.5 A few takeaways

Let us summarise our results and add a few remarks. First, the presence of imperfect information implies that surprises are predictable based on past information, whether from policymakers' or private forecasts, or financial and macroeconomic variables. Using policymakers' pre-meeting forecasts to control for information effects, as done in Miranda-Agrippino and Ricco (2021), is potentially more effective since (i) it aligns the econometric information set with the one on which the decision was based, and (ii) it employs non-stale forecasts, potentially capturing current shocks rather than only past shocks. However, using financial variables to control for the endogenous component of surprises, as done by Bauer and Swanson (2023a), can be seen as an equivalent approach.

Second, the presence of information effects does not depend on the central bank having superior information in the stronger sense of Romer and Romer (2000). However, the strength of the information channel depends on the relative precision of the policy signal compared to the signals obtained by individual agents, rather than the aggregate market. In the previous section, in line with Romer and Romer (2000), we showed that the Fed appears to have a non-negligible information advantage over individual forecasters.

Third, information effects shift the entire yield curve in the same direction, with decreasing weights. Shocks to the rule impose a rotation on the yield curve, with its long end moving in the opposite direction to shorter maturities. The effects of monetary policy shocks depend on their persistence and on whether the central bank responds to the macroeconomic effects caused by its own shocks. However, these effects are close to zero at longer maturities. In the next section, we will use the model's predictions to disentangle monetary policy shocks, shocks to the rule, and information effects. In particular, we will employ them in the most stylised form possible: we will distinguish monetary policy shocks from shocks to the rule by assuming that the former have negligible effects, while the latter have larger effects at longer maturities.

5 Measures of policy changes and policy shocks

The previous section outlines an empirical strategy to identify policy shocks and disentangle the role of information from shocks to the policy rule by examining the response of the entire yield curve to policy announcements. In this section, in particular, we adopt a stylised version of the predictions from the models discussed, in order to identify two types of monetary policy surprises: one related to conventional monetary policy shocks, and the other to shocks to the parameters of the policy rule.

Compared to the classic approach of Gurkaynak et al. (2005c), which identifies a single 'target factor' as the only driver of the short end of the yield curve – i.e. conventional policy actions – we identify two factors affecting the shortest maturities. We distinguish between them by imposing that only one has sizeable effects at the long end of the yield curve: the factor related to shocks to the policy rule. Conversely, the conventional monetary policy factor is expected to have negligible effects on the long end.

It is important to emphasise, however, that we do not impose any sign on the effects of shocks to the rule at the long end of the curve, nor do we impose a zero restriction on the effects of conventional monetary policy. The information component in this approach is instead best understood as an unspanned factor, which is subsequently identified in a second step using the Fed's Greenbook forecasts.

5.1 The dimensions of monetary policy

To extract measures of monetary policy surprises, we rely on an extended version of the dataset of high-frequency price revisions compiled by Gurkaynak et al. (2005c), which captures the high-frequency responses of financial markets to monetary policy announcements. The dataset records price changes for a range of assets in the minutes surrounding FOMC announcements, isolating the policy surprise from other economic news. In particular, we consider the following assets:

- Federal funds futures contracts with maturities from 1 to 6 months (FF1–FF6),
- Eurodollar futures with maturities up to 1 year (ED1–ED4),
- On-the-run U.S. Treasury securities with maturities of 3 months, 6 months, 2 years, 5 years, 10 years, and 30 years,
- S&P 500 stock index.

We employ principal component analysis (PCA) to extract factors capturing the relevant commonalities in asset price movements following FOMC announcements, with the estimated factor model taking the form:

$$Y = F\Lambda + \epsilon, \tag{46}$$

where Y is a $T \times 17$ matrix of intraday surprises, F is a $T \times 4$ matrix of principal components, Λ is the 4×17 loading matrix, and ϵ represents the idiosyncratic components.

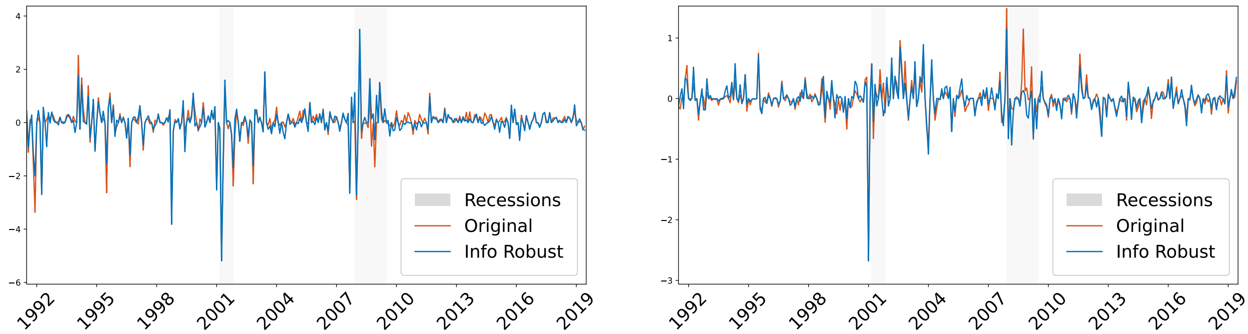
The principal components are unique up to an orthonormal rotation. To obtain an economically meaningful decomposition, and following Gurkaynak et al. (2005c), we impose a set of identification restrictions. Specifically, we adopt the following assumptions:

- The first (F1) and second (F2) factors are the only ones affecting the shortest-term interest rate (FF1).
- The second factor (F2) has the largest effects on the long end of the yield curve (30-year Treasury yield). This assumption, grounded in the predictions of the model presented in Section 4, enables us to distinguish between a factor capturing conventional monetary policy (F1) and a factor encapsulating shocks to the policy rule (F2).
- The third factor (F3) is restricted so as to minimise its variance prior to August 2008 and to have zero effect on FF1, thereby isolating quantitative easing/tightening (QE/QT) shocks, as suggested by Swanson (2021).
- The fourth factor (F4) is treated as a residual factor in the rotation, subject to the constraint that it has zero impact on FF1. This factor captures forward guidance.

It is worth noting that the restrictions identifying the last two factors are not strictly necessary for this study, since by imposing that only two factors have a non-zero effect on the short end of the yield curve, we already identify an orthogonal subspace.

Figure 10 presents the time series of the two identified factors: the one that relates to monetary policy shocks and the other that captures shocks to the policy rule's parameters. Two observations are worth highlighting. First, the time series for F1 closely resembles the FF4 surprises commonly used to identify monetary policy shocks, as in the work of Gertler and Karadi (2015b). Second, the time series for F2 appears symmetrically distributed around zero, with no evidence of one-sided errors across periods of tightenings and loosenings, as would be expected if the policy parameters had been drifting upwards over time.

Figure 10: Identified and informationally robust factors



(a) F1 (conventional monetary policy) (b) F2 (shift to the policy rule)

Notes: The figure presents the time series of the identified monetary policy shock (first panel) and the shock to the rule (second panel) distinguishes between original instruments without information correction (in orange) and informationally robust instruments (in blue). Recession bands are in light grey.

Table 2: Variance decomposition

	FF1	FF2	FF3	FF4	FF5	FF6	ED1	ED2	ED3
Conventional	65.22	81.61	81.61	76.10	65.64	56.57	81.67	78.75	71.53
Shock to rule	10.71	2.31	0.92	0.31	0.13	0.34	0.69	0.81	5.33
FG	0.00	4.70	8.08	13.41	22.30	26.36	0.94	0.00	0.21
QE	0.00	0.20	1.87	3.13	6.22	6.57	6.59	12.54	15.05
Res	24.05	11.15	7.50	7.03	5.69	10.14	10.09	7.89	7.85
	ED4	TRE3M	TRE6M	TRE2	TRE5	TRE10	TRE30	SP500	
Conventional	60.95	81.22	84.57	61.65	29.36	6.50	0.00	17.99	
Shock to rule	9.97	0.07	1.33	13.67	23.46	23.04	27.18	33.75	
FG	0.88	2.01	3.13	0.81	2.06	1.35	0.00	2.01	
QE	17.76	0.21	2.36	16.81	37.93	61.78	54.60	43.13	
Res	10.42	16.46	8.58	7.04	7.17	7.31	18.21	3.10	

Notes: The table reports the variance of the prices revisions for federal funds futures (FF), eurodollar future (ED), on-the-run treasuries (TRE), and the stock market (SP500) triggered by policy announcements explained by the identified factors. Values are in percentage.

The inclusion of S&P 500 surprises yields factors that exhibit a specific correlation with the market and incorporates the intuition of the approach proposed by Jarociński and Karadi (2020), which distinguishes monetary policy shocks from information effects based on the sign of their correlation with the stock market.

The first factor (F1/conventional) explains the largest share of the variance of the assets spanning the yield curve at shortest maturities (Table 2). The second factor (F2/shock to rule) explains a smaller share at shorter maturities but a larger share at the end of the curve, and of the stock market. Figure 11 displays the loadings of different asset prices onto the factors. It shows that F1 has a loading pattern that decreases over the maturities which is compatible with standard monetary policy shocks (and information). It also has a negative impact on the stock market. The loadings for the second factor decline more rapidly over the maturities and turn negative after three quarters, with a stronger negative effect on the stock market.

5.2 Information effects

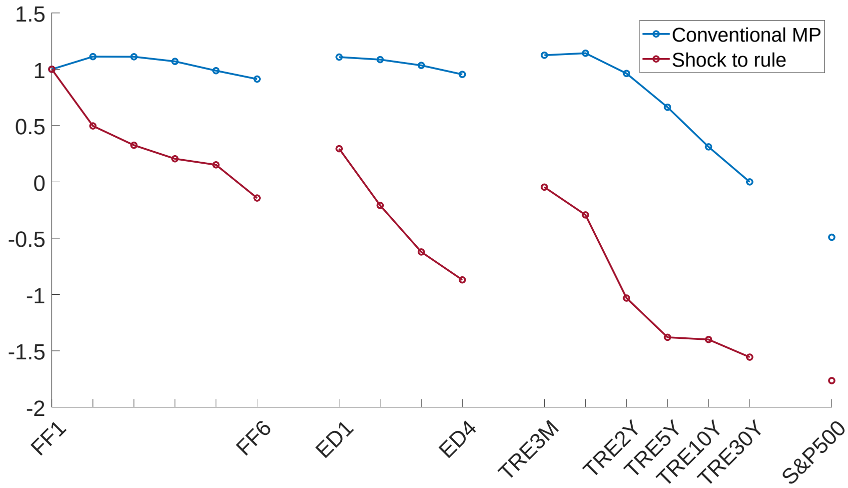
To isolate the true policy surprises, following the intuition provided by the model, we estimate an information regression of the type proposed by Miranda-Agrippino and Ricco (2021):

$$ms_t^i = \beta_0 + \sum_{j=0}^{J} \theta_j^i F_t x_{q+J} + \sum_{j=0}^{J-1} \eta_j \Delta F_t x_{q+j} + \widetilde{ms}_t^i, \tag{47}$$

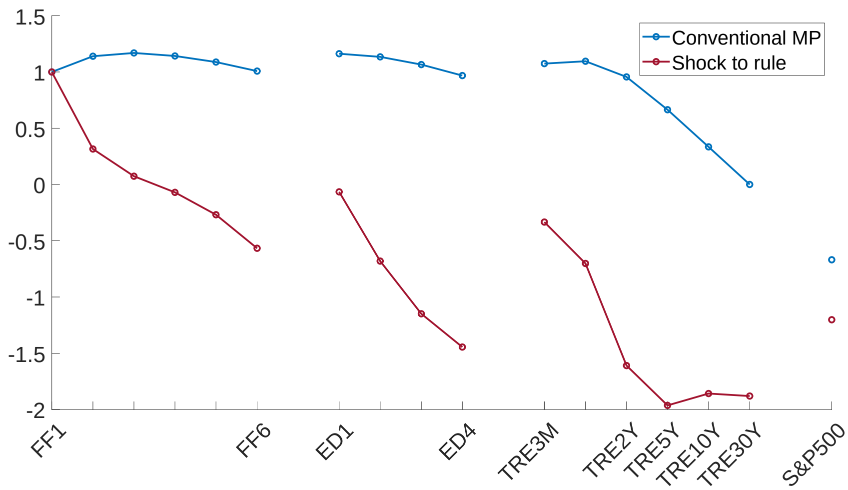
where ms_t^i represents the monetary surprise for asset i at time t. The regressors include the Greenbook forecasts for unemployment, inflation and GDP growth ($F_t x_{q+J}$) and their forecast revisions ($\Delta F_t x_{q+j} = F_t x_{q+j} - F_{t-1} x_{q+j}$). We include backcasts, nowcasts and forecasts up to three quarters ahead. The set of regressors follows the suggestion of Romer and Romer (2000). The residual $\widetilde{ms}_t^i$ are the informationally robust IVs for monetary policy shocks.

Tables 3 and 4 report the information effects regressions for different market surprises. Table 3 reports information effects on short-term rates and eurodollar futures. The R^2 values indicate that short-term interest rates (FF1-FF6) exhibit significant predictability based on Greenbook forecasts, with values ranging between $7-12\%$, and in line with the results of Miranda-Agrippino and Ricco (2021), who only consider FF4 surprises. Eurodollar futures (ED1-ED4) display even stronger predictability, with R^2 values in the $10-15\%$ range. Similarly, table 4 reports information effects on long-term yields and the stock market

Figure 11: Identified and informationally corrected factors



(a) Loadings on raw surprises



(b) Loadings post information correction

Notes: The figure reports the loadings of the asset price revisions onto (a) the identified factors, and (b) the identified factors corrected for information effects. F1 (blue) captures conventional monetary policy shocks, while F2 (red) absorbs changes to the parameters of the policy rule.

surprises. For longer-term yields (on-the-run 3M - on-the-run 30 year), the R^2 values increase, averaging 10%. This pattern of information is in line with the intuition that monetary policy decisions disclose information about developments in the economy at business cycle frequency.

Finally, to obtain an instrument for the information component, we consider the fitted values from the information regressions. Specifically, we extract the first principal component across these fitted values, using an OLS post-Lasso approach, as an instrument for the

Table 3: Information effects on market surprises I

	FF1	FF2	FF3	FF4	FF5	FF6	ED1	ED2	ED3	ED4
$\text{RGDP}_{h=-1}$	-0.001	-0.003	-0.001	-0.000	0.000	-0.002	-0.001	0.000	0.001	0.003
	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
$\text{RGDP}_{h=0}$	0.006	0.010*	0.008*	0.009**	0.009*	0.013***	0.009*	0.013**	0.011**	0.009*
	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\text{RGDP}_{h=1}$	-0.002	0.002	-0.000	0.003	-0.001	0.001	0.008	0.006	0.009	0.007
	(0.006)	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)
$\text{RGDP}_{h=2}$	0.004	0.002	0.003	-0.004	0.001	-0.003	-0.008	-0.007	-0.006	-0.003
	(0.004)	(0.007)	(0.006)	(0.007)	(0.008)	(0.008)	(0.008)	(0.009)	(0.010)	(0.011)
$\text{RGDP}_{h=3}$	-0.005	-0.004	-0.005	-0.004	-0.004	-0.004	0.001	-0.002	-0.002	-0.005
	(0.005)	(0.008)	(0.007)	(0.007)	(0.009)	(0.009)	(0.008)	(0.010)	(0.011)	(0.011)
$\text{PGDP}_{h=-1}$	-0.002	0.001	0.001	0.001	0.000	0.002	-0.001	0.002	0.006	0.009*
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\text{PGDP}_{h=0}$	0.003	0.000	-0.001	-0.001	-0.002	0.006	-0.001	-0.002	-0.000	0.001
	(0.005)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)
$\text{PGDP}_{h=1}$	-0.018	-0.012	-0.005	-0.007	-0.005	-0.006	-0.005	0.001	0.005	0.009
	(0.012)	(0.014)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)	(0.011)
$\text{PGDP}_{h=2}$	0.018*	0.006	0.007	0.011	0.012	-0.002	0.009	0.004	0.001	0.001
	(0.010)	(0.013)	(0.012)	(0.014)	(0.015)	(0.017)	(0.013)	(0.013)	(0.014)	(0.015)
$\text{PGDP}_{h=3}$	-0.005	-0.000	-0.005	-0.012	-0.013	-0.008	0.002	-0.000	-0.003	-0.010
	(0.010)	(0.011)	(0.009)	(0.013)	(0.014)	(0.015)	(0.010)	(0.011)	(0.012)	(0.014)
$\text{Unemp}_{h=0}$	0.003	0.002	0.003	0.002	0.001	0.000	0.004	0.004	0.004	0.004*
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
$\Delta\text{RGDP}_{h=-1}$	-0.000	-0.001	-0.003	-0.006	-0.006	-0.003	-0.001	-0.001	-0.001	-0.004
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
$\Delta\text{RGDP}_{h=0}$	-0.001	-0.001	-0.002	-0.001	-0.003	-0.005	-0.002	-0.001	0.005	0.008
	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
$\Delta\text{RGDP}_{h=1}$	0.004	0.003	0.008	0.008	0.010	0.004	0.004	0.007	0.006	0.006
	(0.006)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.011)
$\Delta\text{RGDP}_{h=2}$	-0.007	-0.011	-0.003	-0.004	-0.002	0.012	-0.004	0.004	0.008	0.013
	(0.006)	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)	(0.009)	(0.010)	(0.010)	(0.011)
$\Delta\text{PGDP}_{h=-1}$	-0.001	-0.008	0.001	0.001	0.003	0.000	-0.006	-0.006	-0.004	-0.003
	(0.006)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)
$\Delta\text{PGDP}_{h=0}$	-0.002	0.002	0.005	0.006	0.004	-0.004	0.012	0.013	0.011	0.010
	(0.006)	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)	(0.013)	(0.012)	(0.012)	(0.012)
$\Delta\text{PGDP}_{h=1}$	0.019	0.012	0.012	0.016	0.014	0.009	0.008	-0.001	-0.010	-0.014
	(0.012)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)
$\Delta\text{PGDP}_{h=2}$	-0.015	-0.005	-0.011	-0.006	-0.007	0.011	-0.002	0.003	0.009	0.017
	(0.014)	(0.018)	(0.016)	(0.017)	(0.018)	(0.018)	(0.018)	(0.017)	(0.018)	(0.019)
$\Delta\text{Unemp}_{h=0}$	0.017	0.009	0.022	0.004	0.002	-0.008	0.018	0.026	0.029	0.028
	(0.022)	(0.023)	(0.019)	(0.020)	(0.020)	(0.022)	(0.025)	(0.025)	(0.026)	(0.029)
Constant	-0.025	-0.028	-0.034	-0.013	-0.012	-0.004	-0.058*	-0.064**	-0.078**	-0.077**
	(0.020)	(0.030)	(0.028)	(0.031)	(0.033)	(0.037)	(0.029)	(0.031)	(0.032)	(0.032)
$\mathcal{R}^2$	0.108	0.108	0.100	0.139	0.098	0.131	0.148	0.170	0.180	0.163
F	1.821	1.507	1.259	1.741	1.274	2.361	1.341	1.662	2.193	2.157
$P-value$	0.019	0.080	0.208	0.028	0.197	0.001	0.154	0.040	0.003	0.004
N	261	261	261	261	261	257	261	261	261	261

Notes: This table presents the results of the information effect regressions for short-term interest rates (FF1-FF6) and Eurodollar futures (ED1-ED4). The dependent variables are the monetary surprises, while the explanatory variables include Greenbook forecasts and revisions of quarter over quarter Real GDP growth up to 3 quarters ahead, quarter over quarter GDP deflator growth up to 3 quarters ahead and the nowcast for unemployment. Sample goes from 1990m1 to 2019m6 (availability of Greenbook).

information 'shocks'.[16]

[16] Appendix C in the Online Appendix reports additional tables based on the OLS post-Lasso approach, whereby the relevant regressors are first selected using Lasso, followed by an OLS regression estimated on the set of selected regressors. This approach allows for a cleaner extraction of the information component,

Table 4: INFORMATION EFFECTS ON MARKET SURPRISES II

	TRE3M	TRE6M	TRE2	TRE5	TRE10	TRE30	SP500
$RGDP_{h=-1}$	0.002	0.000	0.002	0.002	0.002	0.002	-0.025
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.028)
$RGDP_{h=0}$	0.005	0.006*	0.007	0.007	0.010	0.006	-0.046
	(0.004)	(0.004)	(0.004)	(0.005)	(0.007)	(0.005)	(0.051)
$RGDP_{h=1}$	-0.000	0.003	0.006	0.004	-0.004	-0.004	0.009
	(0.008)	(0.009)	(0.010)	(0.008)	(0.006)	(0.005)	(0.066)
$RGDP_{h=2}$	-0.001	-0.002	-0.003	-0.003	-0.005	-0.005	0.017
	(0.005)	(0.007)	(0.009)	(0.009)	(0.007)	(0.005)	(0.099)
$RGDP_{h=3}$	-0.001	-0.002	-0.001	0.001	0.009	0.009	-0.023
	(0.006)	(0.008)	(0.010)	(0.009)	(0.008)	(0.006)	(0.109)
$PGDP_{h=-1}$	0.001	0.003	0.009**	0.010**	0.010***	0.007**	-0.025
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.051)
$PGDP_{h=0}$	0.007	0.005	0.008	0.007	0.003	-0.000	0.013
	(0.006)	(0.006)	(0.006)	(0.005)	(0.004)	(0.003)	(0.068)
$PGDP_{h=1}$	-0.011	-0.002	0.007	0.013	0.003	0.002	0.025
	(0.011)	(0.012)	(0.012)	(0.010)	(0.010)	(0.009)	(0.151)
$PGDP_{h=2}$	0.002	-0.003	-0.000	-0.001	-0.004	-0.001	-0.035
	(0.011)	(0.012)	(0.014)	(0.013)	(0.011)	(0.016)	(0.135)
$PGDP_{h=3}$	-0.004	-0.004	-0.022*	-0.026*	-0.007	-0.007	-0.043
	(0.009)	(0.011)	(0.013)	(0.013)	(0.011)	(0.016)	(0.150)
$Unemp_{h=0}$	0.003	0.003	0.002	-0.000	0.001	0.001	-0.012
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.031)
$\Delta RGDP_{h=-1}$	-0.004	-0.001	-0.005	-0.003	0.002	0.003	0.004
	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.003)	(0.046)
$\Delta RGDP_{h=0}$	0.003	0.004	0.006	0.008	0.004	0.002	-0.076
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.055)
$\Delta RGDP_{h=1}$	0.000	0.001	0.005	0.003	0.004	0.002	0.121
	(0.008)	(0.009)	(0.011)	(0.009)	(0.008)	(0.006)	(0.085)
$\Delta RGDP_{h=2}$	-0.003	-0.002	0.011	0.022**	0.031**	0.026**	0.016
	(0.008)	(0.009)	(0.010)	(0.011)	(0.015)	(0.011)	(0.107)
$\Delta PGDP_{h=-1}$	-0.004	-0.005	-0.003	-0.001	0.004	0.001	0.112
	(0.006)	(0.006)	(0.007)	(0.008)	(0.008)	(0.006)	(0.090)
$\Delta PGDP_{h=0}$	-0.010	-0.002	0.001	0.002	-0.001	-0.001	-0.081
	(0.006)	(0.007)	(0.009)	(0.009)	(0.010)	(0.007)	(0.111)
$\Delta PGDP_{h=1}$	0.008	-0.005	-0.013	-0.015	-0.003	0.000	0.036
	(0.011)	(0.012)	(0.014)	(0.014)	(0.014)	(0.011)	(0.174)
$\Delta PGDP_{h=2}$	-0.006	0.008	0.023	0.030*	0.019	0.004	0.080
	(0.012)	(0.013)	(0.016)	(0.017)	(0.014)	(0.015)	(0.211)
$\Delta Unemp_{h=0}$	0.031	0.022	0.019	0.030	0.033*	0.029**	0.205
	(0.022)	(0.021)	(0.025)	(0.024)	(0.019)	(0.014)	(0.234)
Constant	-0.022	-0.034	-0.044	-0.032	-0.045*	-0.022	0.387
	(0.025)	(0.031)	(0.033)	(0.029)	(0.027)	(0.020)	(0.303)
$\mathcal{R}^2$	0.074	0.078	0.149	0.189	0.269	0.220	0.067
F	1.267	1.110	2.693	2.331	2.467	2.155	0.924
P-value	0.203	0.340	0.000	0.002	0.001	0.004	0.557
N	243	243	243	243	243	243	261

Notes: This table presents the results of the information effect regressions for treasury yields (TRE3M-TRE30Y) and Stock Market (SP500). The dependent variables are the monetary surprises, while the explanatory variables include Greenbook forecasts and revisions of quarter over quarter Real GDP growth up to 3 quarters ahead, quarter over quarter GDP deflator growth up to three quarters ahead and the nowcast for unemployment. Sample goes from 1990m1 to 2019m6 (availability of Greenbook).

mitigating issues of collinearity among the regressors.

6 Policy shocks and information

We now adopt the three instrumental variables constructed in the previous section to identify and study the propagation of two monetary shocks a 'conventional monetary policy shock' and a 'shock to the rule's parameters' as well as an 'information shock'. In particular, we identify the three shocks using the external IV approach of Stock and Watson (2012) and Mertens and Ravn (2013), within a VAR model featuring 12 lags of the endogenous variables,[17]

$$Y_t = C + \sum_{i=1}^{12} A_i Y_{t-i} + \varepsilon_t, \tag{48}$$

where the vector of endogenous variables incorporates a rich set of monthly macroeconomic and financial indicators: industrial production (IP), the consumer price index (CPI), unemployment, the Federal Funds Rate (FFR), Treasury yields at 1, 5, and 10 years, the excess bond premium measure of Gilchrist and Zakrajšek (2012) (EBP), and a measure of stock market prices (S&P 500). We estimate the VAR using Bayesian techniques and standard Minnesota priors over the sample 1980 to 2019. The informativeness of the priors is calibrated following Giannone et al. (2015). The monetary policy factors are available for the sample 1991m7–2019m6.[18]

6.1 The relevance of the IVs

To assess the relevance of the instruments, Table 5 reports the mean F-statistics in the regression of the VAR residuals of the policy rate on the identified factors. Higher statistics indicate stronger instrument relevance, with values above ten generally considered acceptable for reliable identification.

The results confirm that conventional monetary policy shocks are well-identified, partic-

[17] The external IV approach is valid under mild conditions of relevance and exogeneity, and the invertibility of the shocks of interest for the model adopted (see Miranda-Agrippino and Ricco, 2023).

[18] Additional results and robustness checks are reported in Section C of the Online Appendix.

Table 5: F-STAT (MEAN OVER BVAR DRAWS) FOR DIFFERENT SAMPLES

Factor	**Information Type**	**Sample 1980-2019** Normalisation on: **Treasury 1Y**	**FFR**
Conventional MP	Raw	10.76	19.75
	Info robust (surprises)	7.31	18.58
	Info robust (assets)	8.12	18.98
Shock to Rule	Raw	0.30	0.30
	Info robust (surprises)	2.18	2.19
	Info robust (assets)	0.34	0.30

Notes: This table reports the mean F-statistic from the first-stage regression in a Proxy-SVAR of residuals on the selected factors. 'Conventional MP' refers to standard monetary policy shocks, while 'Shock to Rule' captures shocks to the policy rule. Info robust instruments are constructed either by regressing market surprises on Greenbook forecasts (surprises) or the raw factors on Greenbook forecasts (assets). Monetary policy factors are extracted from 1991m7 to 2018 (latest date in which Greenbook forecasts are available).

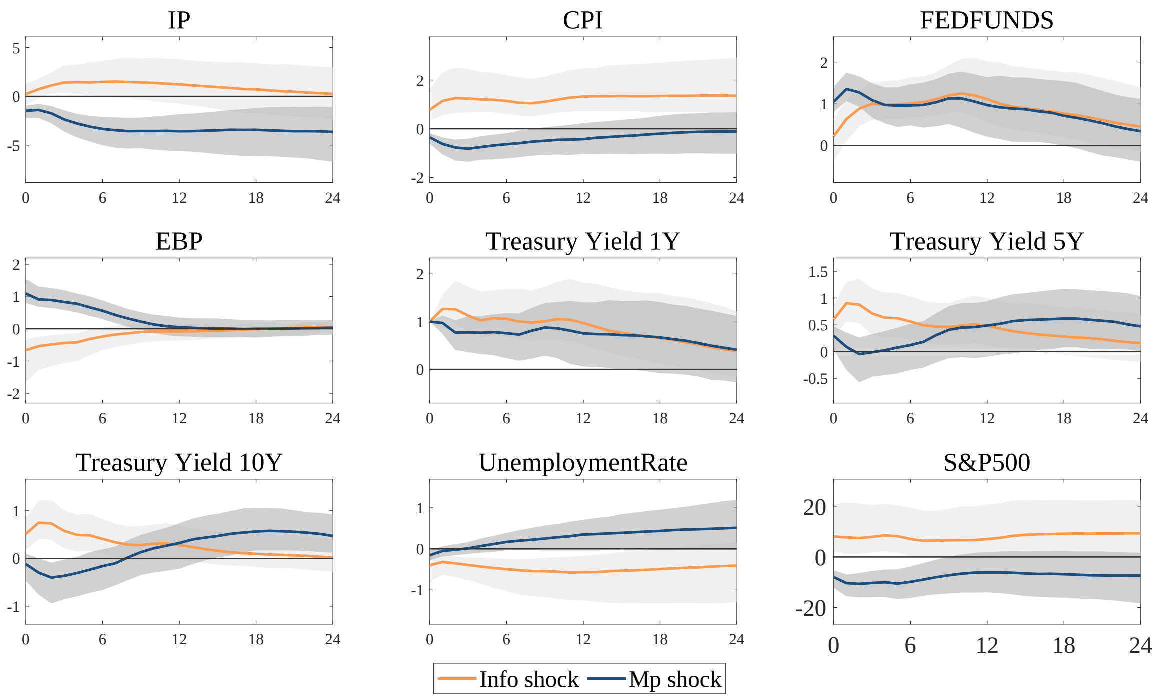
ularly when normalising on the Federal Funds Rate. The F-statistics for these shocks are consistently above ten, reaching values as high as 19.75 in the full sample. Information-robust instruments tend to reduce the F-statistics slightly, but they remain within an acceptable range.

In contrast, the identification of shock to the rule's parameters is much weaker. The raw instruments produce F-statistics below one in most cases, suggesting severe weak instrument problems. The information-corrected instruments improve the identification somewhat, with F-statistics increasing to around four in the 1991m7-2019 sample. However, even after correction, the identification remains less robust than for conventional monetary policy shocks. These results indicate that shocks to the policy rule are not particularly important in the sample considered and cannot be the explanation for the observed puzzles.

6.2 Monetary policy shocks and shocks to the rule

Let us start by looking at the propagation of a conventional monetary policy shock (Figure 12). An exogenous tightening, identified with the informationally robust IV for monetary policy

Figure 12: Conventional monetary policy shock and information shock



Notes: This figure presents the IRFs to a conventional monetary policy shock (blue) and the information shock obtained as the first principal component of the information regression (orange). Both shocks are normalised to induce a 100 basis point increase in the one-year Treasury rate.

shocks, causes a standard economy-wide contractionary response, with economic activity and inflation decreasing after the shock and unemployment increasing. These results are in line with the findings in Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021).

The information shock is identified using as an IV the first principal component of the fitted components of the Greenbook-based information regressions. While the monetary policy shock leads to a decline in economic activity, the information shock produces the opposite effect, increasing both output and inflation in line with the effects of a demand shock and the results in Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021).

It is important to stress that the information component cannot be interpreted as a structural shock or an information shock delivered by the central bank. The correct interpretation of this component, in line with the model in Section 4, is that it represents a bundle of different structural shocks to which the Fed responds via its systematic reaction function.

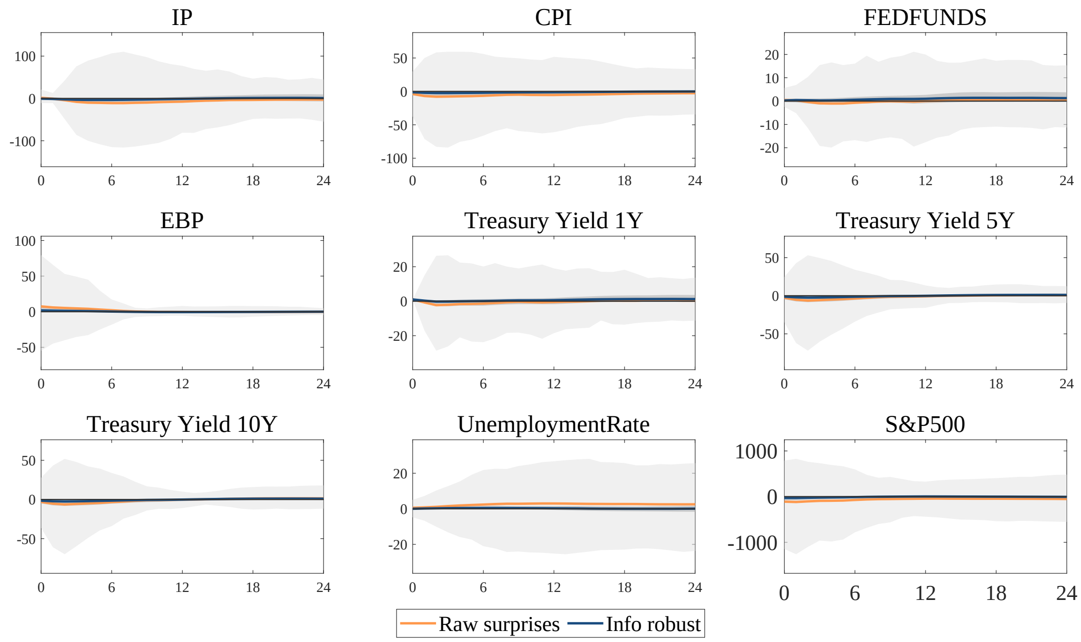
The presence of imperfect information delivers contamination of the market surprises by these shocks. While the policy decision and communication inform the market participants of the view of the central bank, they cannot be seen as 'delivering' the shocks but only as being part of their transmission through the economy. Hence, the IRFs to the information component in Figure 12 should be seen as informative of the reaction function of the Fed and not as structural response functions to a given shock.

We conclude by identifying the effects of a shock to the rule's parameters (Figure 13). Without information correction (Figure 13a), the IV is too weak to identify any shock, as evidenced by the wide confidence bands of the impulse responses, consistent with the reported F-statistic. After correcting for information effects (Figure 13b), the estimated responses become slightly more stable, although the identification remains relatively weak compared to the conventional monetary policy shock. Overall, the effects of the shocks are contractionary and do not appear to directly account for the puzzle observed in high-frequency surprises.

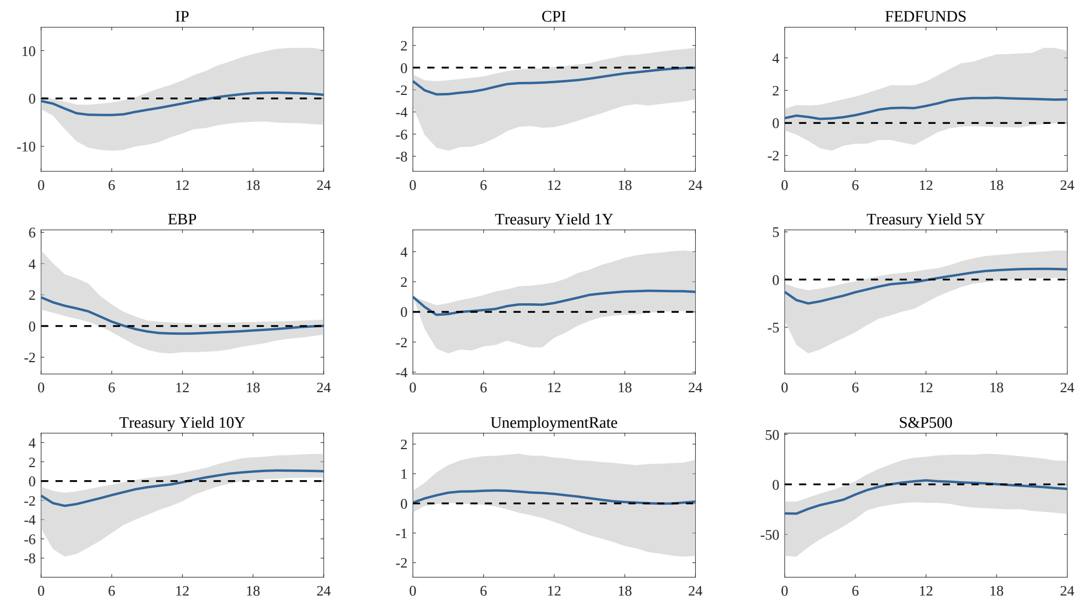
6.3 Robustness of the IRFs over different samples

The rolling estimates of the IRFs, in Figure 14, confirm that the effects of monetary policy shocks are generally stable across different time periods. For conventional monetary policy, the responses show a contractionary effect on industrial production and inflation, with financial markets also reacting negatively. The effects vary slightly in magnitude across different rolling windows, and the overall direction remains unchanged.

Figure 13: Shock to the rule's parameters



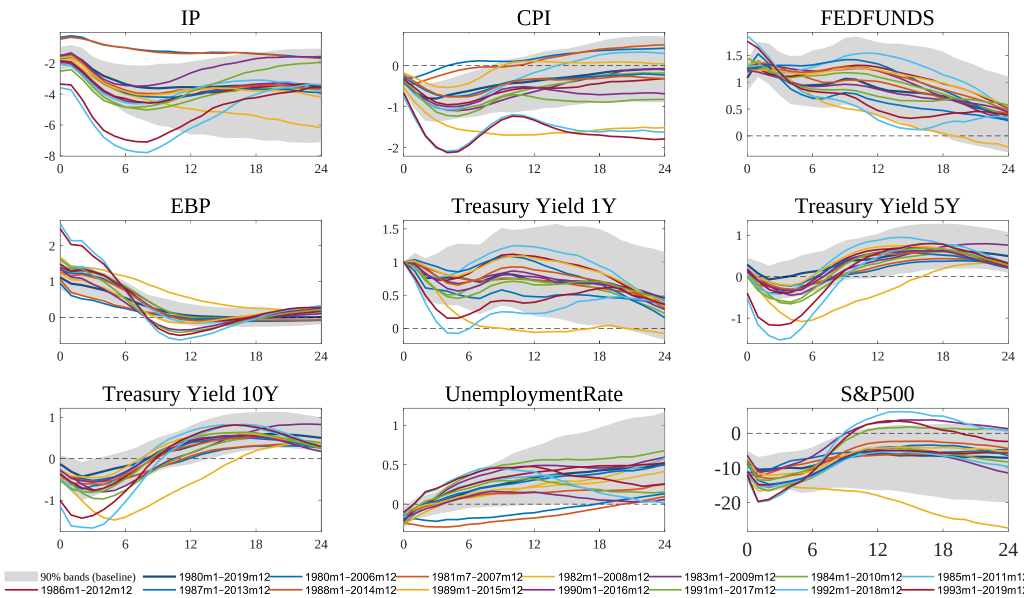
(a) Shock to the rule's parameters



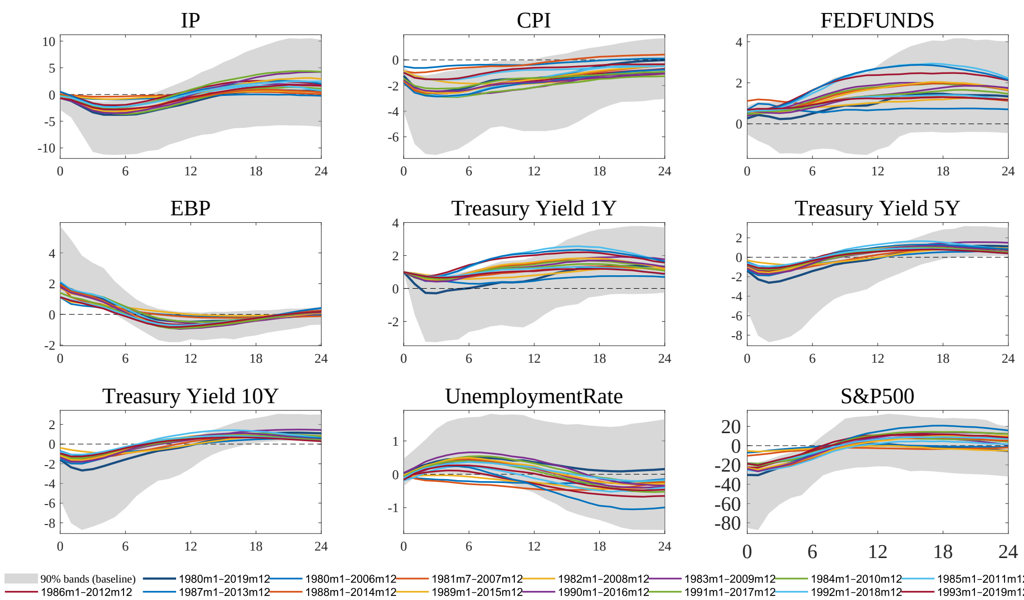
(b) Shock to the rule's parameters (with information correction)

Notes: The figure presents in the top panel the IRFs to a shock to the rule's parameters, comparing the raw factor without information effects (orange) with the informationally robust factor (blue). In the bottom panel, it reports the IRFs to a shock to the rule's parameters, identified using only the information-corrected instrument (blue). The shock is identified with the shock to the rule's factor and is normalised to induce a 100 basis point increase in the one-year Treasury rate.

Figure 14: Rolling samples mp shock and shock to the rule's parameters



(a) Rolling sample – conventional mp shock



(b) Rolling sample – shock to the rule's parameters

Notes: The figure reports the impulse response functions (IRFs) to a conventional monetary policy shock and a shock to the rule's parameters, estimated over different rolling subsamples. The subsamples are 1980m1–2006m12, 1981m1–2007m12, ..., 1992m1–2018m12, and 1993m1–2019m12. The shocks are identified using the conventional monetary policy informationally robust factor and the rule shock informationally robust factor, and are normalised to induce a 100 basis point increase in the 1-year Treasury rate. The grey shaded areas represent 90 per cent coverage bands from the baseline specification.

7 Conclusions

Our analysis reassesses the causes of the puzzling macroeconomic responses to monetary policy shocks identified with the high-frequency monetary policy surprises of Gürkaynak et al. (2005a). In particular, we evaluate two competing explanations: the information channel of monetary policy and the 'Fed response to news' hypothesis. By incorporating both monetary policy shocks and shocks to the parameter of the policy rule in a framework of imperfect information, equipped with an affine term structure model, we derive empirical implications to disentangle the two hypotheses.

Our empirical findings reveal that the anomalies observed in traditional identification approaches stem from market participants' belief revisions triggered by the policy announcements, rather than systematic misestimation of the Fed's reaction function. Once information effects are accounted for, the so-called price and output puzzles disappear.

These results challenge the 'Fed response to news' hypothesis, which requires persistent forecasting errors by market participants and struggles to explain similar puzzles across multiple central banks. Our framework provides a clearer interpretation of monetary policy transmission and highlights the need to account for central bank information effects when using high-frequency identification strategies.

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