Policy and Macro Signals from Central Bank Announcements*

Paul Hubert[a] and Becky Maule[b]
[a]Banque de France and Sciences Po – OFCE
[b]Bank of England

How do private agents understand central bank actions and communication? This paper investigates private agents' interpretation of central bank signals about future policy and the macroeconomic outlook that are conveyed by both policy decisions and macroeconomic communication. Using U.K. data, we assess the effects of these two types of central bank announcements on inflation swaps and stock returns at daily and monthly frequencies. We find that policy decisions convey signals about the macroeconomic outlook at the daily frequency, but that policy signals dominate at the monthly frequency such that asset prices respond negatively to contractionary policy, consistent with the usual transmission mechanism. We also find that inflation expectations respond positively to the Bank of England's macroeconomic information surprises, consistent with agents taking a signal about the economic outlook.

JEL Codes: E52, E58.

*We thank Christophe Blot, James Cloyne, Camille Cornand, Jérôme Creel, Martin Ellison, Rodrigo Guimarães, Refet Gürkaynak, Stephen Hansen, Frédéric Jouneau-Sion, Michael McMahon, Silvia Miranda-Agrippino, Jon Relleen, Giovanni Ricco, Garry Young, and seminar participants at the GATE, Bank of England, OFCE, European Central Bank, Deutsche Bundesbank, CEPII, Banque de France, the Workshop on Empirical Monetary Economics 2015, the Workshop on Probabilistic Forecasting and Monetary Policy, GDRE 2015, the Central Bank Design workshop of the 2015 BGSE Summer Forum, the 2015 World Congress of the Econometric Society, and AFSE 2015 for helpful discussions and comments at different stages of this project. We also thank Simon Strong for research assistance. Paul Hubert thanks the Bank of England for its hospitality. Any remaining errors are our own responsibility. Any views expressed are solely those of the authors and so cannot be taken to represent those of Banque de France, Bank of England, or members of the Monetary Policy Committee or Financial Policy Committee. Corresponding author: paul.hubert@sciencespo.fr. Address: 31 rue Croix des Petits Champs, 75001 Paris, France.

1. Introduction

Private agents' interpretation of monetary policy decisions and central bank communication is central to the formation of their beliefs and therefore to the transmission of monetary policy. The management of private expectations has thus become a key feature of central banking (Woodford 2005). In this respect, this paper proposes to investigate the effect of two different types of central bank announcements, one about the policy decision and the other about policymakers' assessment of the macroeconomic outlook.

In a framework with perfect information, private agents' and policymakers' expectations are aligned. So policy decisions only reveal monetary innovations, i.e., deviations from the systematic response of policy to the macroeconomic outlook. However, in a setup with different information sets (i.e., the central bank and the private sector do not share the same information set), the policy decision can convey information about changes in both policymakers' preferences and their view of future macroeconomic developments. For example, an increase in the policy rate could signal to private agents that an inflationary shock will hit the economy in the future, causing higher inflation. Alternatively, the same increase in the policy rate may be interpreted as a simple contractionary monetary shock, which will lead to lower inflation in the future. If the first interpretation is given more weight, then increasing the policy rate will lead to higher private inflation expectations, whereas if the second is given more weight, then increasing the policy rate will decrease private inflation expectations. The former effect has been labeled the "signaling channel" of monetary policy. Romer and Romer (2000) find evidence of the Federal Reserve's decisions revealing its private information about the state of the economy.[1] Ellingsen and Söderström (2001) establish that the private response to policy decisions may reflect a mix of the responses to the monetary innovation and to

[1] D'Agostino and Whelan (2008), Gamber and Smith (2009), Hubert (2015a, 2015b), and Rossi and Sekhposyan (2016) have challenged the result that central banks have a forecasting advantage relative to the private sector. Recent evidence suggests that the advantage has vanished in the most recent period. This result, however, does not rule out the fact that policy decisions reveal the central bank information set. Both information sets could be different and yield to similar forecasting performance.

the macroeconomic information conveyed by the policy instrument. Campbell et al. (2012, 2017), Tang (2015), Melosi (2017), and Nakamura and Steinsson (2018) complement the analysis of this information channel.[2]

The same issue applies to central bank macroeconomic communication. For instance, an increase in a central bank's inflation projections could signal a future inflationary shock, causing higher inflation expectations. Alternatively, because policy decisions are informed by the economic outlook, and the central bank might respond to developments which raise inflation by tightening policy to bring it back toward its target, the same increase in central bank inflation projections could be interpreted as a signal about a future policy tightening, leading to lower expected inflation. Hence, the central bank's projections can also send signals about its view of macroeconomic developments to private agents, influencing their beliefs about the economic outlook, as well as about the outlook for policy. We define the former channel as a "macro outlook signal" and the latter channel as a "policy signal."[3]

If a positive signal about the macro outlook is taken from either a policy decision or a change in central bank economic projections, inflation expectations will increase, whereas if either tighter policy or higher economic projections are taken to signal a contractionary policy shock, inflation expectations will decrease. Which channel—the macro outlook or policy signal—dominates matters, given that the effects of monetary policy depend on how private agents interpret changes in the policy rate or in central bank projections.

The contribution of this paper is to examine empirically which of those interpretations is given more weight and to document the

[2]This effect may be one of the reasons for the positive response of inflation to monetary shocks documented in the vector autoregression (VAR) literature as the "price puzzle" (Sims 1992). Castelnuovo and Surico (2010) finds that including inflation expectations in VARs removes this price puzzle. The signaling issue has also received attention from a theoretical perspective. See Angeletos, Hellwig, and Pavan (2006), Walsh (2007), Baeriswyl and Cornand (2010), and Kohlhas (2014).

[3]We use the term "policy signal" for the classical monetary transmission channel and the term "macro outlook signal" for what Melosi (2017) calls the "signaling channel" of monetary policy. That is because we study the information content of a central bank's macroeconomic projections, so the usual terminology is not appropriate.

importance of the signals that both policy decisions and central bank macroeconomic projection surprises send about the macroeconomic or the policy outlook. To do so, we assess, for the United Kingdom, whether and how market-based inflation expectations and stock prices respond to policy decisions and to the publication of the Bank of England's Inflation Report, which contains its macroeconomic projections.[4] The sign of the estimated effects of policy decisions and macroeconomic projections is indicative of the relative weight private agents put on each signal.

To estimate private agents' responses to central bank announcements, we make use of two features of the U.K. data. First, the fact that policy decisions and the Inflation Report (IR) containing the Bank of England (BoE)'s macroeconomic projections were released on different days until August 2015 enables us to carefully measure the surprise component of the two types of releases using daily data.[5] Second, a necessary requirement for identification is that the information set revealed by the central bank (such as its projections) is not a function of the current policy decision, so both monetary surprises and central bank information surprises can be separately identified.[6] We exploit the fact that the BoE publishes macroeconomic projections that are conditioned on the path for the policy instrument implied by financial market interest rates prior to the policy meeting.[7] As these projections are not conditioned on the

[4]It is worth stressing that the focus of this paper is on the effects of the release of central bank macroeconomic information, not communication about the future likely path of the policy rate, the forward guidance policy (see, e.g., Campbell et al. 2017; Andrade et al. 2019), or whether communication is relatively more hawkish or dovish (see, e.g., Ehrmann and Fratzscher 2007; Rosa and Verga 2007).

[5]After August 2015, both are released simultaneously at 12:00, so even intraday data would not enable us to do so.

[6]This paper focuses on quantitative communication, the release of central bank projections, and abstracts from the issue of quantifying qualitative communication like statements or minutes (see Hansen and McMahon 2016 for this kind of exercise, and Hubert 2017 for a comparison of the effects of both types of communication).

[7]For comparison, Federal Open Market Committee (FOMC) projections are conditioned on FOMC members' views of "appropriate monetary policy" which corresponds to the future interest rate path that best satisfies the Federal Reserve's mandate.

BoE's policy decision, it enables us to identify separately projection surprises and monetary innovations.

Our empirical analysis proceeds in two steps. First, we use a daily-frequency event-study analysis to provide a causal inference of the effect of both monetary policy decisions and the publication of central bank information on inflation swaps and stock prices. Following Hanson and Stein (2015), we use the daily change in two-year nominal interest rates around announcements to measure monetary and IR surprises. In the spirit of Cieslak and Schrimpf (2019) and Jarocinski and Karadi (2020), we exploit the fact that policy and macro signals have similar predictions for interest rates but different predictions for equity prices, such that the co-movement of these variables on the day of policy announcements should be informative of which signal, about policy or the state of the economy, dominates. Second, we estimate the effects of exogenous shocks to policy and to Bank's inflation and output projections at the monthly frequency in a framework derived from the information frictions literature, controlling for the contribution of inflation surprises, news shocks, and changes in private output and interest rate expectations.[8] We follow the identification strategy of Romer and Romer (2004) applied to U.K. data by Cloyne and Huertgen (2016). Following Blanchard, L'Huillier, and Lorenzoni (2013) and Miranda-Agrippino and Ricco (2020), we augment the original approach with the information set of private agents to take into account the influence of potential different information sets on the identification problem.

We find that private inflation expectations and stock prices respond positively to contractionary monetary surprises on average at the daily frequency, such that the dominant signal of policy decisions is about the macro outlook. However, in a monthly frequency framework, inflation expectations and stock prices respond negatively to contractionary monetary shocks. The signaling channel might still be at work in dampening the negative response of inflation expectations, but it is dominated by the effect of policy

[8] The use of inflation swaps in levels calls for correcting for potential term, liquidity, and inflation risk premiums. To do so, we use a regression-based approach following Gürkaynak, Levin, and Swanson (2010), Gürkaynak, Sack, and Wright (2010), and Soderlind (2011) described in section A.1 of the online appendix (available at http://www.ijcb.org).

signals. One potential explanation for the differentiated results is that differences in information sets are more pronounced at higher frequencies so private agents rely more on macro signals from policy actions. However, at lower frequencies, private agents are able to acquire more information, consistent with sticky-information models (see Mankiw and Reis 2002), such that the signaling effects are smaller.

With respect to the release of central bank information, we find that inflation expectations respond positively to positive IR surprises at the daily frequency, such that the dominant signal is about the macro outlook. The result holds at the monthly frequency with central bank inflation projections. Overall, that suggests that private agents put more weight on the signal that the central bank information set conveys about future economic developments than about the policy outlook, in contrast to the predictions of full-information models.

One potential concern may relate to the fact that the policy has reached the effective lower bound (ELB) over the sample studied here, and that monetary policy has taken various dimensions in the meantime. We attempt to circumvent this issue in various ways. First, the daily-frequency setup measures private responses to all policy decisions (conventional and unconventional) on the announcement day. In addition, using two-year spot nominal interest rates, following Hanson and Stein (2015), enables us to capture news about the future policy path. Second, in the monthly-frequency setup, we use a shadow rate that encompasses the overall stance of monetary policy. Third, we estimate the robustness of our results on subsamples before and after the ELB. Another potential concern is that the estimated effect of signals could be unrelated to the central bank information set and could instead reflect other macroeconomic news. If so, our estimates would suffer from an omitted-variable bias. To address this concern, we modify our baseline daily frequency model and control for the news surprises in six of the most important macroeconomic data releases, such as inflation, PMI, industrial production, and earnings. At the monthly frequency, we attempt to control for as much information as possible: we include various measures of slack, inflation, and sentiment in addition to inflation surprises, news indexes, and other private macro forecasts.

This work is related to different strands of research about the role of central bank communication in policymaking (see, e.g., Woodford 2005; Blinder et al. 2008; Reis 2013), its effects on inflation expectations (see, e.g., Gürkaynak, Sack, and Swanson 2005a; King, Lu, and Pasten 2008; Pedersen 2015; Lyziak and Paloviita 2018) or their dispersion (see, e.g., Fujiwara 2005; Ehrmann, Eijffinger, and Fratzscher 2012; Hubert 2014), or how it may help in predicting future policy decisions (see, e.g., Jansen and De Haan 2009; Hayo and Neuenkirch 2010; Sturm and De Haan 2011).[9]

The rest of the paper is organized as follows. Section 2 describes our framework, section 3 the event-study estimation, section 4 the monthly-frequency analysis, and section 5 concludes.

2. Framework

2.1 Some Theoretical Predictions

First, we derive predictions for the expected effects of monetary policy and central bank projections on private inflation expectations based on a standard macroeconomic framework, such as a three-equation New Keynesian model. In such a framework where private agents have full information, so central bank projections and private expectations are aligned, contractionary monetary policy has a negative effect on private inflation expectations, through the usual transmission channels. Increases in central bank projections at a given horizon have a negative effect on private inflation

[9]This paper also refers to a large literature focusing on the expectation formation process departing from the full-information rational expectation hypothesis to account for some empirical regularities about the persistence of private expectations, with among others Evans and Honkapohja (2001), Bullard and Mitra (2002), Mankiw and Reis (2002), Sims (2003), Branch (2004, 2007), Orphanides and Williams (2005), or Mackowiak and Wiederholt (2009). Another strand of the literature tries to explain macroeconomic outcomes with expectations (see, e.g., Nunes 2010 and Adam and Padula 2011), while various empirical works focus on the characteristics, responsiveness to news, dispersion or anchoring of expectations (see, e.g., Swanson 2006; Capistran and Timmermann 2009; Crowe 2010; Gürkaynak, Levin, and Swanson 2010; Beechey, Johannsen, and Levin 2011; Coibion and Gorodnichenko 2012, 2015; Hubert 2014, 2015a; Ehrmann 2015).

expectations further ahead, because central bank projections enter the central bank reaction function and are interpreted as signals about future policy reactions: higher expected future inflation leads agents to anticipate higher future nominal interest rates, especially when the policy rate exhibits persistence. In this framework, neither policy decisions nor central bank projections convey signals about the macroeconomic outlook.

Second, we derive predictions for the expected effects of monetary policy and projection surprises under a framework with information frictions. That assumption is consistent with works by Coibion and Gorodnichenko (2012, 2015) and Andrade and Le Bihan (2013), which provide empirical evidence of rejection of full-information models.[10] In a framework with different information sets, we assume the central bank sets its interest rate i_t as a function of its own inflation, $\pi_{t,h}^{CB}$, and output, $x_{t,h}^{CB}$, projections for horizon h, and potentially some other macro variables, ω_t:

$$i_t = f(i_{t-1}, \pi_{t,h}^{CB},\ x_{t,h}^{CB}, \omega_t) + \varepsilon_t^i, \tag{1}$$

and where ε_t^i is the monetary innovation, capturing policymakers' deviations from their policy rule, and which is orthogonal to central bank inflation and output projections and to other macro variables in ω_t.

In this setup where private agents and the central bank have different information sets, when the observed policy rate differs from private agents' policy expectations, private agents would not be able to infer whether the central bank has changed its *own* view of future inflation and output or whether there has been a monetary shock. Changes in the policy rate may therefore convey signals about both future macroeconomic developments and the policy stance to private agents. Private agents face a multidimensional signal-processing problem: they could take either of two signals—one about macro developments and one about future policy—from one observable

[10]Rational expectation models with information frictions such as in Woodford (2001), Mankiw and Reis (2002), and Sims (2003) highlight how departing from the assumption of full information can account for empirical patterns about inflation expectations as well as leading to different policy recommendations.

variable. Said differently, private agents can misperceive changes in policy or projections for a mix of shocks in the economy, which gives room for macro or policy signals—as modeled by Melosi (2017). The same reasoning applies to surprises to central bank projections. Depending on the information set of private agents, central bank projections could either convey a signal to private agents about a change in the central bank's view of future inflation and output or convey a signal about future policy through the reaction function.

Policy and macro signals are expected to have different implications for private inflation expectations. If either a higher policy setting or higher projections are taken to signal a contractionary policy shock (i.e., the policy signal dominates the macro outlook signal), inflation expectations will decrease. In contrast, if a positive signal about the macro outlook is taken from either a policy decision or a change in the central bank's projections (i.e., the macro outlook signal outweighs the policy signal), inflation expectations will increase.

2.2 The Empirical Strategy

The literature commonly uses a high-frequency event-study analysis to estimate the effect of monetary policy on asset prices. The key assumption is that the reaction of asset prices that are continually affected by various factors can be specifically attributed to monetary news on the day of the policy announcement. If one assumes that the central bank (CB) and private agents (PA) have different forecasts (E[.]) about the state of the economy (Y_t), but private agents know the specification of the reaction function, then the signaling problem can be written as follows:

$$\begin{aligned} i_t &= \varphi \mathrm{E}^{CB}[\mathrm{Y}_t] + \varepsilon_t^i \\ \mathrm{E}^{\mathrm{PA}}[i_t] &= \varphi \mathrm{E}^{\mathrm{PA}}[\mathrm{Y}_t] \\ mps_t &= i_t - \mathrm{E}^{\mathrm{PA}}[i_t] = \varepsilon_t^i + \varphi(\mathrm{E}^{\mathrm{CB}}[\mathrm{Y}_t] - \mathrm{E}^{\mathrm{PA}}[\mathrm{Y}_t]), \end{aligned} \tag{2}$$

where i_t is the realized policy rate, $\mathrm{E}^{\mathrm{PA}}[i_t]$ is the expected policy rate, and mps_t is the monetary policy surprise. In this setup, the monetary policy surprise mps_t is a linear combination of the monetary policy shock ε_t^i and the information shock ε_t^Y which corresponds to the difference between the information sets of the central bank and private agents. Said differently, the monetary policy surprise can be seen as a shock to the information set of private agents. The most recent literature (Cieslak and Schrimpf 2019, Jarocinski and Karadi 2019) has exploited the fact that ε_t^i and ε_t^Y have the same theoretical prediction for interest rates but different predictions for equity prices, such that the co-movement of these variables on the day of the policy announcement should be informative about which signal—about policy or the state of the economy—dominates. One compelling feature of the Bank of England's setup is that Monetary Policy Committee (MPC) decisions and the IR were not published on the same day until August 2015, so it is possible to assess the interpretation given by private agents to each announcement separately.[11]

Another approach in the literature to identify the causal impact of monetary policy measures changes in the policy instrument (i_t) that are unrelated to macroeconomic conditions and the information set of policymakers ($\mathrm{E}^{\mathrm{CB}}[\mathrm{Y}_t]$). The residuals from that estimation (ε_t^i) are taken to represent monetary policy shocks, i.e., exogenous shocks to the policy instrument. We make use of a specific feature of the Bank data to test our research question. We exploit the fact that the Bank of England publishes macroeconomic projections that are conditioned on the path for the policy instrument implied by financial market interest rates prior to the policy meeting, rather than a preferred interest rate path of the MPC, so do not contain the effect of the policy decision.[12] As these projections are not conditioned on the Bank's policy decision, we are able to separately identify projection surprises and monetary shocks.

[11] The IR was published on average four business days after the MPC meeting, with a minimum of two days on May 2005, May 2010, and May 2015 and a maximum of five days in February 2015. From August 2015 and following Warsh (2014)'s report, the IR started to be published at the same time as policy decisions.

[12] For comparison, FOMC projections are conditioned on FOMC members' views of "appropriate monetary policy" which corresponds to the future interest rate path that best satisfies the Federal Reserve's dual objectives of maximum employment and price stability.

3. The Effect of Monetary and IR Surprises at the Daily Frequency

3.1 The Overall Effect of Monetary and IR Surprises

We use standard monetary surprises that have been extensively used in the literature to assess the effect of unexpected policy decisions on asset prices. We apply the same methodology to measure surprises related to the publication of the IR. We thus augment the regression with an additional term to assess the effects of the publication of the central bank macroeconomic information set. The literature relies on the following regression:

$$\Delta \mathrm{y}_t = \alpha + \beta_1 \mathrm{MPC}_t + \beta_2 \mathrm{IR}_t + \varepsilon_t, \tag{3}$$

where MPC_t denotes the surprise component of the policy decision announced by the MPC, IR_t captures the surprise component of the macroeconomic information published in the IR, $\Delta \mathrm{y}_t$ denotes the change in the asset price considered over an interval that brackets the monetary policy announcement, and ε_t is a stochastic error term that captures the effects of other factors that influence the asset price in question.

The literature commonly uses a high-frequency event-study analysis to estimate equation (3), which cannot be estimated with monthly or quarterly data due to reverse causality and omitted-variables bias. The measured effect of monetary policy on asset prices could easily capture the response of monetary policy to earlier changes in asset prices in the month or quarter. In addition, changes in monetary policy and asset prices could respond to macroeconomic news released during the month or quarter. Using higher-frequency data and a tight window around the policy decision enables us to address these two issues. The key assumption is that the reaction of asset prices that are continuously affected by various factors can be specifically attributed to monetary news on the day of the policy announcement. Since asset prices adjust in real time to macroeconomic news, their movements during the window of a policy announcement only reflect the effect of news about monetary policy. This is crucial for identification since it strips out the endogenous variation in asset prices associated with other shocks than monetary news. Using daily data, Cook and Hahn (1989), Kuttner (2001), Cochrane and Piazzesi (2002), or Faust, Swanson, and Wright (2004) have initiated this approach.

A large consensus has formed about the content of monetary policy news: the main piece of information on central bank announcement days relates to changes in the future likely policy path. Following Gürkaynak, Sack, and Swanson (2005a), Campbell et al. (2012), and Hanson and Stein (2015), our identification strategy is based on the idea that a primary share of the news contained in MPC announcements is about the expected path of future policy (whether it is the policy rate during a period of conventional monetary policy or asset purchases in the most recent period) over the next several quarters as opposed to surprise changes in the current policy stance. A simple and transparent way to capture revisions to the expected path of policy over a given horizon is to use the daily change in the nominal gilt yield at this horizon on MPC announcement dates as our proxy for monetary policy news. Following Hanson and Stein (2015), we use interest rates at the two-year maturity to measure MPC_t. The key point is that this measure captures news about the expected medium-term policy path as opposed to news only about the contemporaneous policy decision, meaning that it encompasses the so-called target and path factors (Gürkaynak, Sack, and Swanson 2005a) of monetary news. Since there is no single measure of the overall stance of monetary policy during unconventional times, another advantage of this simple measure is that it can capture the multidimensional aspects of monetary policy such as extended liquidity provisions, forward guidance, or asset purchases which are also likely to affect interest rates at this horizon.[13]

We consider the surprise component of the IR publication as a reasonable proxy for surprises to central bank inflation and output projections that would enter in the central bank reaction function in standard macroeconomic models. We use the same measure as monetary news to capture IR news and compute the daily change in the two-year nominal gilt yield on IR publication dates (IR_t). Figure 1, shown later in this paper, plots the MPC and IR surprises over our sample. A simple visual inspection confirms the effect of the 2008–09

[13]Bean and Jenkinson (2001) suggest that the BoE is more likely to change policy in IR months, which would affect policy expectations. Our sample includes seven interest rate changes in IR months and eight in non-IR months.

financial crisis on the policy and macroeconomic outlook with large negative changes in both series around these dates.

With respect to the dependent variables considered, since the remit of the Bank of England's MPC is to target inflation, a natural candidate to investigate the effect of monetary policy is to measure their impact on inflation expectations. At the daily frequency, inflation swaps are a standard proxy for measuring compensation for expected inflation and inflation risk (Beechey, Johannsen, and Levin 2011).[14] These instruments are financial market contracts to transfer inflation risk from one counterparty to another. Most of the liquidity is driven by corporate firms at shorter maturities and pension, insurance, and retirement funds at longer maturities for hedging inflation exposures. We consider instantaneous forwards at different maturities, from two to five years ahead, which provide a proxy measure for expected inflation at the date of the maturity of the contract.[15] These are available since October 2004, which determines the starting date of our sample.[16] For robustness and comparison with the literature, we also consider daily returns in the Financial Times Stock Exchange (FTSE) price index, the share index of the 100 companies listed on the London Stock Exchange with the highest market capitalization.

We are then able to assess how private agents interpret monetary and IR surprises. We test the null hypothesis that tighter-than-expected monetary policy reduces inflation swaps, i.e., policy signals dominate macro signals. We also test the hypothesis that the publication of a higher economic prospects—a positive IR news surprise—increases inflation swaps, i.e., macro signals dominate policy signals. In equation (3), the two null hypotheses imply β_1 being negative and β_2 being positive. Table 1 presents our results for equation (3) estimated by ordinary least squares (OLS) using daily data.

[14]One advantage of these financial instruments is that they are directly related to payoff decisions. One drawback, however, is that they may be affected by term, liquidity, and inflation risk premiums.

[15]In the United Kingdom, they are linked to the Retail Price Index (RPI) measure of inflation, rather than the Consumer Prices Index (CPI), which is the measure the Bank's inflation target is currently based on.

[16]Table A.1 in the online appendix provides data sources and description while table A.2 provides some descriptive statistics.

Table 1. Estimates at the Daily Frequency

	(1) FTSE	(2) swap_2y	(3) swap_3y	(4) swap_4y	(5) swap_5y
MPC Surprises	0.111***	0.231*	0.256	0.199	0.156**
	(0.03)	(0.14)	(0.18)	(0.12)	(0.08)
IR Surprises	0.030	0.603**	0.423***	0.209***	0.041
	(0.02)	(0.25)	(0.11)	(0.07)	(0.11)
N	173	173	173	173	173
R^2	0.13	0.13	0.11	0.06	0.02
Separate Estimations					
MPC Surprises Only					
MPC Surprises	0.112***	0.233*	0.263	0.207*	0.162**
	(0.03)	(0.14)	(0.18)	(0.12)	(0.08)
N	130	130	130	130	130
R^2	0.15	0.03	0.04	0.03	0.03
IR Surprises Only					
IR Surprises	0.025	0.596**	0.394***	0.177**	0.012
	(0.02)	(0.25)	(0.11)	(0.07)	(0.11)
N	43	43	43	43	43
R^2	0.04	0.26	0.39	0.17	0.00

Notes: Heteroskedasticity-robust standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column corresponds to the OLS estimation of equation (3). The constant is equal to zero and never significant, so it has been removed from each panel for the sake of parsimony. The sample period goes from October 2004 to July 2015. The independent variables are the surprise component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in two-year gilt nominal yields. The dependent variable is the daily change in FTSE and in inflation swaps at different maturities from two years to five years. The lower two panels show estimates when equation (3) is estimated on MPC or IR dates exclusively.

We compute heteroskedasticity-robust standard errors. Our sample period goes from October 2004 to July 2015 and covers 130 MPC announcements and the publication of 43 IRs. The independent variables are the surprise component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in two-year nominal gilt yields. The dependent variables are the daily changes in inflation swaps at different maturities from two years to five years and stock prices.

Our results show that, first, the parameter associated with monetary surprises, β_1, is positive and significant at the 1 percent level for stock prices. It is also positive for inflation swaps at two- to five-year maturities, although it is only significant at the 5 percent level for the five-year maturity. This positive effect means that monetary surprises convey macro signals to private agents, in contrast to the prediction of full-information models and our null hypothesis, and consistent with Melosi (2017). Second, IR surprises are estimated to have no effect on stock prices and five-year-ahead inflation swaps, but they have a strong positive effect on inflation swaps at two- to four-year maturities. This suggests that IR surprises convey macro signals that dominate policy signals, consistent with our null hypothesis. We also estimate two separate equations for each type of surprise. The estimated parameters are very similar. It is interesting to note that IR surprises are estimated to explain 39 percent of the variance of inflation swaps three years ahead, while monetary surprises only explain 4 percent. In contrast, monetary surprises explain 15 percent of the variance of stock prices compared with 4 percent only for IR surprises. This difference suggests that monetary surprises and IR surprises, and their respective information content, are interpreted differently by private agents.

3.2 Using Co-movement to Disentangle Policy and Macro Signals

In the previous section, we have examined the overall effects of monetary and IR surprises. We now aim to provide intuition for the relevance of each signal embedded in these monetary and IR surprises. Following Cieslak and Schrimpf (2019) and Jarocinski and Karadi (2020), we use how policy and macro signals are expected to affect the co-movement of stock returns and interest rates following central bank policy announcements or the publication of central bank macroeconomic information.

Table 2. Identification through Co-movements

Signals	Interest Rates	Stock Prices	Co-movement
Policy	+	−	−
Macro	+	+	+

Policy signals are akin to monetary shocks and operate through the real short-term interest rate. A monetary tightening depresses stock prices by increasing the discount rate but increases longer-term yields through the expectations hypothesis of the term structure. The propagation mechanism of monetary policy across the term structure is confirmed by a number of studies (Rigobon and Sack 2004; Gürkaynak, Sack, and Swanson 2005a). Macro signals are similar to expected growth shocks and correspond to private expectations about real activity. In the Gordon growth model, positive shocks to growth expectations raise stock prices via the cash-flow news channel. Such shocks also lead to an increase in interest rates, through the investment channel and the response of policymakers to real activity news. The effect of real activity news on the yield curve is typically found to be positive and hump shaped (e.g., Gürkaynak, Sack, and Swanson 2005b). Table 2 summarizes the expected effects of policy and macro signals on stock returns and the yield curve, and their co-movement.

Both interest rates and stock prices co-vary negatively in response to policy signals, akin to monetary policy shocks, but both co-vary positively in response to macro signals, akin to growth shocks. Therefore, in order to disentangle the two signals, we compute the co-movement of daily changes in interest rates and stock prices, $\rho(r,s)$. We are then left with two options. The first option is to consider monetary (or IR) surprises as mainly about policy signals when the co-movement is negative and mainly about macro signals when the co-movement is positive. This discrete categorization has the benefit of simplicity but may hide some subtlety in the way the signals are perceived by private agents. In order to avoid to consider all positive (resp. negative) co-movement as a macro (policy) signal, we estimate a transition function such that we can decompose monetary (or IR) surprises in two components based on the strength of the co-movement. Monetary (or IR) surprises are then represented as weighted average of the two signals, the weight being obtained from the transition function. We compute the following transition function:

$$\mathrm{F}(\rho_t) = 1 - (\exp(-\gamma\rho_t)/(1 + \exp(-\gamma\rho_t))). \tag{4}$$

F(.) is a smooth transition function with a range between 0 (negative co-movement) and 1 (positive co-movement), ρ_t is a variable measuring the co-movement, and γ is the parameter governing the degree of smoothness of the transition from one state to the other with $\gamma > 0$. We can thus decompose daily monetary (or IR) surprises as a linear combination of policy and macro signals, $\mathrm{MPC}_t = \mathrm{S}_t^{\mathrm{pol}} + \mathrm{S}_t^{\mathrm{macro}}$, using the weight $\mathrm{F}(\rho_t)$ such that $\mathrm{S}_t^{\mathrm{pol}} = \mathrm{MPC}_t \times (1 - \mathrm{F}(\rho_t))$ and $\mathrm{S}_t^{\mathrm{macro}} = \mathrm{MPC}_t \times (\mathrm{F}(\rho_t))$.

Using the co-movement in stock prices and interest rates and the estimated weight, we compute policy and macro signals for both monetary and IR surprises. Table 3 presents our results for equation (3) modified to include the signal decomposition for each of the two types of surprises, and estimated by OLS using daily data. Our sample period is unchanged and covers 130 MPC announcements and the publication of 43 IRs. The independent variables are the surprise component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in two-year gilt nominal yields. The dependent variable is the daily change in stock prices and inflation swaps at different maturities from two years to five years. We compute heteroskedasticity-robust standard errors.

Looking at the responses of FTSE returns, the parameters associated with policy signals, whether they come from monetary or IR surprises, have a negative impact whereas macro signals have a positive impact. This is also true for inflation swaps, with the effect of macro signals from monetary surprises dominating the effect of policy signals, consistent with table 1. Regarding the effect of IR surprises on inflation swaps, the policy signals conveyed have no effect (except at the one-year maturity) whereas macro signals have a positive impact. These outcomes are confirmed when estimating two separate equations for each type of surprise. These findings suggest first that policy and macro signals affect inflation swaps

Table 3. Co-movement Identification of Policy and Macro Signals

	(1) FTSE	(2) swap_2y	(3) swap_3y	(4) swap_4y	(5) swap_5y
MPC Policy Signals	−0.435***	−0.762**	−1.791***	−1.078***	−0.254
	(0.13)	(0.36)	(0.38)	(0.24)	(0.18)
MPC Macro Signals	0.522***	0.985***	1.798***	1.161***	0.464***
	(0.12)	(0.36)	(0.27)	(0.14)	(0.10)
IR Policy Signals	−0.254***	−1.760**	−0.373	−0.076	−0.134
	(0.07)	(0.76)	(0.44)	(0.22)	(0.50)
IR Macro Signals	0.277***	2.655***	1.119***	0.461**	0.194
	(0.07)	(0.65)	(0.37)	(0.19)	(0.30)
N	173	173	173	173	173
R^2	0.37	0.26	0.23	0.13	0.03
Separate Estimations					
MPC Surprises Only					
MPC Policy Signals	−0.435***	−0.762**	1.793***	−1.080**	−0.256
	(0.13)	(0.35)	(0.38)	(0.24)	(0.18)
MPC Macro Signals	0.524***	0.982***	1.810***	1.176***	0.478***
	(0.12)	(0.36)	(0.27)	(0.14)	(0.10)
N	130	130	130	130	130
R^2	0.36	0.06	0.17	0.12	0.04
IR Surprises Only					
IR Policy Signals	−0.253***	−1.760**	−0.373	−0.076	−0.133
	(0.08)	(0.78)	(0.45)	(0.22)	(0.51)
IR Macro Signals	0.270***	2.668***	1.068***	0.400**	0.141
	(0.07)	(0.67)	(0.38)	(0.20)	(0.31)
N	43	43	43	43	43
R^2	0.42	0.55	0.49	0.20	0.01

Notes: Heteroskedasticity-robust standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column corresponds to the OLS estimation of equation (3) where MPC and IR surprises are replaced by their respective policy and macro signals based on equation (4). The constant is equal to zero and never significant, so it has been removed from each panel for the sake of parsimony. The sample period goes from October 2004 to July 2015. The independent variables are the surprise component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in two-year gilt nominal yields. The dependent variable is the daily change in FTSE and in inflation swaps at different maturities from two years to five years. The lower two panels show estimates when equation (3) is estimated on MPC or IR dates exclusively.

in the expected direction and second that MPC policy decisions have a strong macroeconomic content consistent with the signaling channel of Melosi (2017). He finds that inflation expectations may respond positively to contractionary monetary shocks under certain calibrated parameters. If the quality of private information is poor relative to that of central bank information, and/or if the policy rate is more informative about nonmonetary shocks than about monetary shocks, then the macro outlook signaling channel may be at work. Similarly, Tang (2015) finds such a positive effect when prior uncertainty about inflation is high. At the opposite, the publication of the IR has almost no policy content, i.e., private agents do not interpret IR surprises as news about future policy, but only about the future state of the economy.

A potential concern with the specification of equation (3) is that the effect of monetary and IR surprises could reflect other macroeconomic news published at these dates. To address this concern, we augment equation (3) with news surprises in six of the most important macroeconomic data releases that have been released on MPC or IR dates: employment change, International Labour Organisation (ILO) unemployment rate, industrial production, PMI Services, average weekly earnings, and producer price index (PPI). These surprises are computed as the difference between actual releases and Bloomberg surveys on the days before the release. For instance, industrial production has been released 30 times on MPC dates over our sample, while earnings and unemployment have been published 27 times each on IR dates.

Table A.3 in the online appendix (available at http://www.ijcb.org) presents the results for equation (3) augmented with these news surprises. The sign and magnitude of the effect both policy and macro signals of monetary and IR surprises is confirmed. Table A.3 also includes a specification in which surprises are computed as change in the one-year interest rate, following the maturity used in Gürkaynak, Sack, and Swanson (2005a), and a specification based on monetary surprises from Cesa-Bianchi, Thwaites, and Vicondoa (2020) obtained with intraday data and a 30-minute window around policy announcements. Finally, equation (3) is estimated on a subsample starting on September 15, 2008 with the bankruptcy of Lehman Brothers. These estimates confirm the respective dominant signal of monetary and IR surprises.

4. The Effect of Monetary and Projection Shocks at the Monthly Frequency

Since policy decisions happen every month and central bank projections are published every quarter, an additional way to assess the effects of policy and macro signals is to work at a monthly frequency. Doing so has at least three advantages. First, it is possible to estimate monetary shocks—i.e., shocks to the policy instrument—in contrast with monetary surprises that are akin to shocks to private agents' information set. Identifying monetary shocks enables us to control for changes in policymakers' information set. Second, we are able to identify central bank projection surprises.[17] Third, it enables us to use a standard inflation expectation formation model derived from the information friction literature.

4.1 Estimating Exogenous Innovations

Estimating the effects of the policy rate and Bank's inflation and output projections raises a major econometric challenge mentioned earlier: at the monthly frequency, our three variables of interest are likely to be endogenous to inflation expectations. We therefore perform first-stage regressions to extract the unpredictable components of $i, \pi^{\mathrm{CB}}, x^{\mathrm{CB}}$ orthogonal to their systematic components. We follow the Romer and Romer (2004) approach applied to U.K. data by Cloyne and Huertgen (2016) such that we remove the contribution of the most relevant endogenous factors that would underlie the evolution of these variables.

In order to cope with the potential presence of different information sets (see Blanchard, L'Huillier, and Lorenzoni 2013, and Miranda-Agrippino and Ricco 2020), we make sure that exogenous innovations are orthogonal not only to the central bank's information set but also to private agents' information set. The inclusion of both private and central bank forecasts in the regression model enables us to deal with three concerns. First, forecasts encompass rich information sets and work as a factor-augmented vector autoregressive

[17] Months during which no central bank projections are published are treated as missing observations, since no new information is conveyed by policymakers. We detail how we proceed more specifically later on.

(FAVAR) model (see Bernanke, Boivin, and Eliasz 2005). Second, forecasts are not revised so they capture real-time information. Third, forecasts capture forward-looking information sets.

Our identification works through timing restrictions. We aim to remove the contribution of *lagged* macro and private forecasts (so that innovations can have contemporaneous effects on these) and the contribution of *contemporaneous* Bank variables (to remove the information of policymakers). Starting with the monetary shock, we estimate the following equation:

$$i_t = f\left(\pi^{CB}_{t,pca}, x^{CB}_{t,pca}, mc_{t,pca}, \Psi_{t-1}, I_{t,IR}\right) + \varepsilon^i_t. \tag{5}$$

We assume that changes in i_t are driven by the policymakers' response to its own inflation $\pi^{\text{CB}}_{t,pca}$ and output $x^{\text{CB}}_{t,pca}$ projections; to the market interest rate curve ($mc_{t,pca}$) used as conditioning path for the Bank's macroeconomic projections; to a vector (Ψ_{t-1}) comprising private inflation, output, and short-term interest rate expectations as well as macroeconomic controls; and to whether the policy decision is made during IR months ($I_{t,IR}$) or not. $f(\cdot)$ is the function capturing its systematic reaction, and the error term ε^i_t reflects monetary shocks orthogonal to the macroeconomic outlook.

We introduce inflation and output projections using the respective first principal component of the Bank's inflation and output projections for different maturities. We also include $mc_{t,pca}$, the first principal component of the market interest rate curve at the one- to three-year maturities used as conditioning path for the Bank's macroeconomic projections. The vector Ψ_{t-1} includes a lag of the change in the policy rate capturing the last policy decision, a lag of the first principal component of inflation swaps from 1 to 10 years ahead, a lag of the first principal component of private output forecasts from 1 quarter to 3 years ahead measured from surveys, and a lag of the first principal component of private short-term interest rate forecasts from 1 to 10 years ahead measured from nominal government bonds.[18] The vector Ψ_{t-1} also includes the following macroeconomic controls that are likely to affect future

[18]We use a principal component analysis and consider the first principal component for each forecast variable so as not to include all horizons in the estimated model and avoid multicollinearity. The first principal component intends to capture the overall forward-looking information set of forecasters for all horizons together. The first principal component of inflation swaps captures 76 percent of

inflation dynamics and hence inflation expectations: CPI inflation, industrial production, oil prices, net lending, the sterling effective exchange rate, and housing prices (all included as annual growth rates) together with dummies for when the forward-guidance policy started and when the economy has reached its ELB. These macroeconomic controls are grouped in a vector denoted Z_t.[19] Finally, we also include a dummy for when the Bank publishes its Inflation Report (IR). It is meant to capture that expectations of policy decisions may be different in IR and non-IR months, as private agents may expect the central bank to update its policy more frequently during IR months when it updates its assessment of the state of the economy.[20]

During a significant part of the sample period considered, the policy rate has been at the ELB, and monetary policy has taken various dimensions in the meantime. In a complementary specification, the policy instrument is proxied by a shadow rate that measures U.K. monetary policy as the U.K. policy rate (Bank Rate) until 2009 and then mechanically adjusts for the quantitative easing (QE) undertaken by the Bank of England's Monetary Policy Committee to capture the overall stance of monetary policy.[21]

Central bank inflation or output projection shocks at a given horizon should be seen as the unpredictable innovation of a projection at a given horizon, conditional on the information available to private agents at the date when the projections are published.

---

the common variance of the underlying series, the one of the market curve 97 percent, and the one of private output forecasts 85 percent. In the robustness section, we replace these first principal components with the underlying series at all different horizons.

[19] Some of these macroeconomic controls are revised vintages. We acknowledge that this is a limitation of the present study since due to data availability we cannot work with true real-time data.

[20] While Bean and Jenkinson (2001) report that the Bank is more likely to change interest rates in Inflation Report months, our sample includes seven interest rate changes in IR months and eight changes in non-IR months.

[21] As in Forbes, Hjortsoe, and Nenova (2018), the shadow rate series is mechanically constructed by comparing the estimated effects of QE to the economic multipliers assigned to conventional changes in Bank Rate. For further detail on the economic impact of U.K. asset purchases, see Joyce, Tong, and Woods (2011). The underlying assumption is that QE is a close substitute as a monetary policy instrument to Bank Rate such that the lower bound was not an effective constraint on monetary policy over the period in question.

We estimate these shocks by using the Bank's inflation and output projections conditioned on the path for Bank Rate implied by market interest rates prior to the policy meeting, so independent from the policy decision. We estimate the following two equations, for inflation and output projections, respectively:

$$\pi_{t,h}^{CB} = g(mc_{t,pca}, \Psi'_{t-1}, I_{t,ZLB}) + \varepsilon_t^{\pi_{CB,h}} \tag{6}$$

$$x_{t,h}^{\mathrm{CB}} = g'(mc_{t,pca}, \Psi'_{t-1}, I_{t,ZLB}) + \varepsilon_t^{x_{CB,h}}. \tag{7}$$

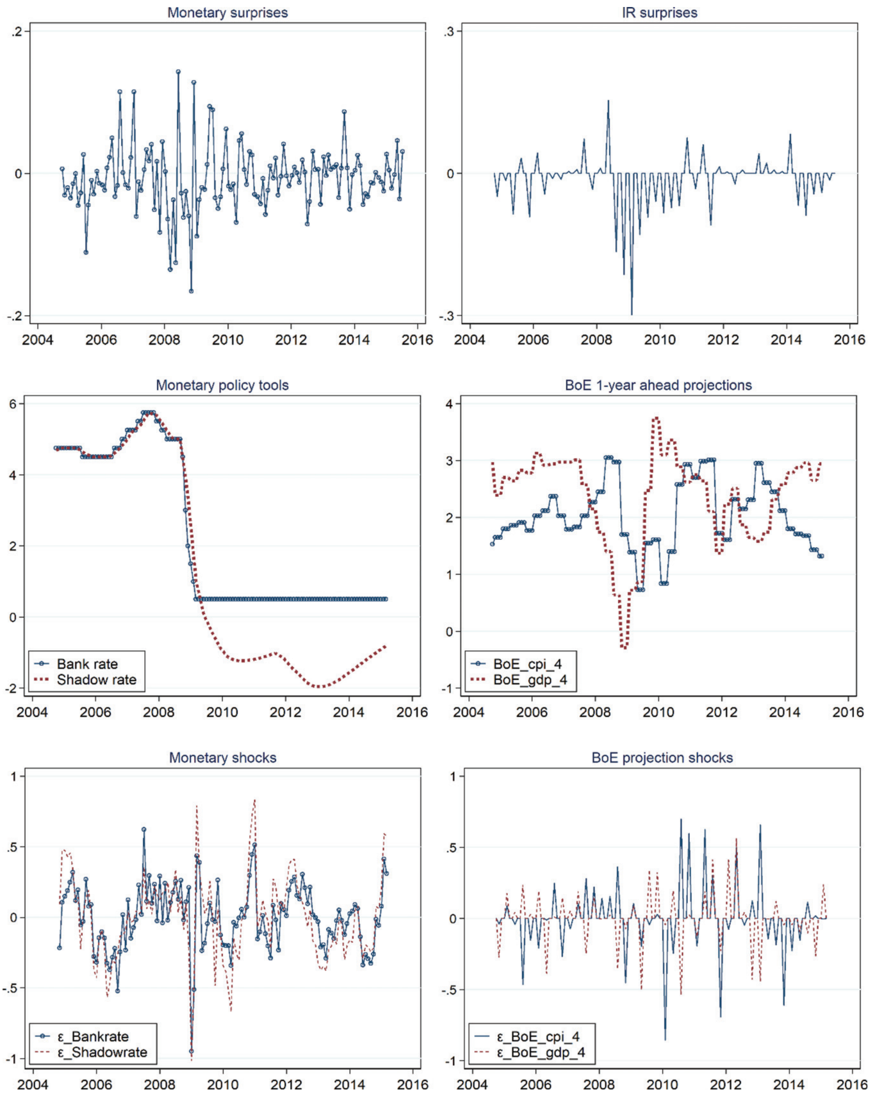
So changes in $\pi_{t,h}^{\mathrm{CB}}$ and $x_{t,h}^{\mathrm{CB}}$ are driven by $mc_{t,pca}$, the first principal component of the market interest rate curve at the one- to three-year maturities. The vector Ψ'_{t-1} includes a lag of the first principal components of the Bank's inflation and output projections, a lag of the policy (or shadow) rate, a lag of the first principal component of private inflation expectations, private output forecasts, and private short-term interest rate forecasts, together with the vector of macroeconomic controls Z_{t-1}. We also add a dummy for when Bank Rate is at its effective lower bound. Equations (6) and (7) are estimated on IR months only, since no projections are published during non-IR months (during which, by construction, projection shocks are zero).[22] This is performed without affecting the lag structure—for instance, February projections take January values for the lagged variables.

Figure 1 plots the estimated monetary and projection shocks. Table A.4 in the online appendix shows the estimated parameters of equations (7)–(9), and the properties and the correlation structure of innovations. For these estimated exogenous series to be relevant, they should be unpredictable from movements in data. We assess the predictability of these series with Granger-causality type tests.[23] The F-stats and adjusted R^2 shown in table A.4 suggest that the

[22] An alternative, tested in the robustness section, is to proceed to a constant-interpolation of projection shocks for the following two months after the IR publication, as one could argue that these projection shocks are available to private agents updating their information set later on.

[23] We consider a set of standard macro and financial variables: inflation, industrial production, oil prices, wages, net lending, the U.K. move, and expected future short-term interest rates.

Figure 1. Daily-Frequency Monetary and IR Surprises and Monthly-Frequency Monetary and Projection Shocks



Notes: The first row shows MPC and IR surprises. The surprise component of MPC decisions and of the IR publication are both computed as the daily change in two-year gilt nominal yields on MPC and IR dates. The second row shows the value of Bank Rate and the Bank of England's shadow rate together with inflation and output projections one year ahead. The third row shows exogenous shocks to these variables estimated from equations (5) through (7). Parameters are presented in table A.4 in the online appendix.

null hypothesis that these estimated innovations are unpredictable cannot be rejected.

4.2 The Empirical Model

Our empirical setup is motivated by two theoretical models with rational expectations and information frictions. In the sticky-information model of Mankiw and Reis (2002) and Carroll (2003), private agents update their information set infrequently as they face costs of absorbing and processing information. When private agents update their information set, they gain perfect information. In the noisy-information models of Woodford (2001) and Sims (2003), private agents continuously update their information set but observe only noisy signals about the true state of the economy. Their inertial reaction arises from the inability to pay attention to all the information available. Internalizing their information-processing capacity constraint, they remain inattentive to a part of the information (Moscarini 2004).

Under the assumption that private agents have homogeneous inflation expectations, we can bridge these two strands of the literature in a simple and general specification.[24] Private inflation expectations—the average of daily observations in each month—are modeled as a linear combination of prior beliefs about future inflation, lagged expectations $\pi^{PF}_{t-1,h}$, and new (and potentially noisy) information relevant for future inflation released between $t-1$ and t, measured by the vector Λ_t:[25,26]

[24]This assumption matches the point forecasts nature of inflation swaps. We acknowledge that point forecasts may suffer an aggregation bias because agents may have heterogeneous beliefs due to differences in their own information sets, but we abstract from this issue in this paper.

[25]Section A.1 of the online appendix describes the regression-based approach used to correct inflation swaps in levels for potential term, liquidity, and inflation risk premiums, and extract inflation expectations.

[26]In sticky- and noisy-information models, expectations for a given date in the future can be represented as a weighted average of new information and previous expectations for the same date in the future. Because of data limitations, it is not possible to test exactly this specification. We therefore need to assume that the private forecast process is persistent to bridge our empirical exercise to these models. This has been shown by Coibion and Gorodnichenko (2012, 2015) and Andrade and Le Bihan (2013), among others.

$$\pi_{t,h}^{PF} = \beta_0 + \beta_L \pi_{t-1,h}^{PF} + \beta_\Lambda \Lambda_t + \varepsilon_t. \tag{8}$$

This specification allows us to be agnostic about the nature of information frictions.[27] The vector Λ_t could include any variable that is likely to affect inflation and that can be used to predict future inflation. We decompose this vector into three groups of variables.

The first group comprises our externally identified instruments for monetary shocks (ε_t^i) as well as inflation ($\varepsilon_t^{\pi CB,h}$) and output ($\varepsilon_t^{xCB,h}$) projection shocks. To test our research question, we explicitly assume that these surprises are incorporated in private agents' forecasting function.[28] A second group includes the macroeconomic variables listed in the vector Z_t. A third group, denoted with the vector X_t, aims to capture news shocks and surprises to macro developments that are contemporaneous to monetary and projection shocks. It includes a news variable π^s which captures the information content of any data released between $t-1$ and t that may affect inflation (see Andersen et al. 2003). This news variable is defined as the difference between the actual value of CPI inflation in t and private inflation forecasts formed at date $t-1$ for the quarter t ($\pi^s = \pi_t - \mathrm{E}_{t-1}\pi_t$). This is equivalent to an inflation forecast error. Bloomberg Consensus provides the market average expected one-month-ahead CPI inflation at a monthly frequency. X_t also comprises the change between $t-1$ and t in private output and interest rate forecasts, to control for their link with private inflation forecasts as evidenced by Fendel, Lis, and Rülke (2011), Paloviita and Viren (2013), and Dräger, Lamla, and Pfajfar (2016). Finally, we capture the presence of macro news by using the three indexes estimated by Scotti (2016) for the United Kingdom: the real activity index, capturing the state of economic conditions; the surprise index,

[27]The value of β_L, expected to be positive, sheds light on whether the limited adjustment mechanism in which information is only partially absorbed over time is at work in the data.

[28]The timing of policy decisions and IR releases—detailed in section 2—which are made public in the early days of the given months should ensure that their information content is not already contained in private inflation expectations and that inflation expectation dynamics are not responsible for these shocks. We test the robustness of this assumption by considering only the last daily observation of each month for our left-hand-side variable so as to remove any potential endogeneity issue.

summarizing economic data surprises; and the uncertainty index, measuring uncertainty related to the state of the economy.

Equation (8) can be written as

$$\pi_{t,h}^{PF} = \beta_0 + \beta_L \pi_{t-1,h}^{PF} + \beta_1 \varepsilon_t^{i} + \beta_2 \varepsilon_t^{\pi CB,h} + \beta_3 \varepsilon_t^{xCB,h} + \beta_Z Z_t + \beta_X X_t + \varepsilon_t, \quad (9)$$

where ε_t^{i}, $\varepsilon_t^{\pi CB,h}$, and $\varepsilon_t^{xCB,h}$ are the monetary and projection shocks—h being the horizon of the given projection. The sign of the $\beta_1 - \beta_3$ parameters sheds light on how monetary shocks and inflation or output projection shocks are interpreted by private agents. If the macro signal dominates, these parameters will be positive; if the policy signal dominates, they will be negative.

4.3 The Effect of Monetary and Projection Shocks

We estimate equation (9) with OLS for the term structure of inflation expectations and stock prices and compute heteroskedasticity-robust standard errors.[29] Our baseline analysis focuses on central bank projections four quarters ahead. This horizon falls before interest rates are generally estimated to have their peak effect on inflation—around 18–24 months ahead—and therefore enables us to minimize the control issue.[30] On the other hand, the shortest horizon of the term structure of inflation expectations studied here (two years) falls after this horizon of central bank projections, so strategic forecasting motives should be absent.

Table 4 provides evidence that contractionary shocks to Bank Rate decrease stock prices and private inflation expectations at all horizons from two to five years ahead—β_1 is negative. That is consistent with contractionary policy shocks affecting these variables through the usual transmission mechanism channel and suggests that a policy signal is taken from monetary shocks. The magnitude of the effect decreases with the horizon of expectations, consistent

[29] Because our empirical strategy proceeds in two steps, we also estimate equation (9) with bootstrapped standard errors so we can take into account the estimation uncertainty from the first-stage regressions (equations (5)–(7)).

[30] The interest rate instrument gives the central bank some control over the forecasted variables, and this issue is circumvented when the horizon of forecasts is shorter than the transmission lag of monetary policy.

Table 4. Monthly-Frequency Estimates

	(1) FTSE	**(2) PF_2y**	**(3) PF_3y**	**(4) PF_4y**	**(5) PF_5y**
A. Baseline					
ε_Bankrate	−0.033*	−0.204**	−0.171**	−0.154**	−0.140**
	(0.02)	(0.09)	(0.08)	(0.07)	(0.07)
ε_BoE_cpi_4	−0.022	0.217**	0.181**	0.138*	0.099*
	(0.03)	(0.11)	(0.09)	(0.07)	(0.06)
ε_BoE_gdp_4	0.004	0.096	0.074	0.042	0.007
	(0.03)	(0.11)	(0.09)	(0.08)	(0.08)
Lag. Dep. Var.	0.672***	0.728***	0.767***	0.793***	0.807***
	(0.07)	(0.09)	(0.09)	(0.08)	(0.08)
Constant	0.096*	0.662**	0.555**	0.529**	0.533**
	(0.05)	(0.26)	(0.24)	(0.23)	(0.22)
Controls: X_t and Z_t	Yes	Yes	Yes	Yes	Yes
N	125	125	125	125	125
R^2	0.91	0.70	0.75	0.78	0.81
B. Separate Estimations					
Bank Rate Only					
ε_Bankrate	−0.032*	−0.189**	−0.158**	−0.147**	−0.138**
	(0.02)	(0.09)	(0.08)	(0.07)	(0.06)
CB Projections Only					
ε_BoE_cpi_4	−0.022	0.214*	0.178*	0.136*	0.097*
	(0.03)	(0.11)	(0.09)	(0.07)	(0.06)
ε_BoE_gdp_4	−0.007	0.031	0.019	−0.007	−0.038
	(0.03)	(0.10)	(0.09)	(0.08)	(0.07)
C. Bootstrapped Standard Errors					
ε_Bankrate	−0.033	−0.204*	−0.171*	−0.154*	−0.140*
	(0.02)	(0.11)	(0.09)	(0.08)	(0.07)
ε_BoE_cpi_4	−0.022	0.217*	0.181*	0.138*	0.099
	(0.03)	(0.12)	(0.10)	(0.08)	(0.06)
ε_BoE_gdp_4	0.004	0.096	0.074	0.042	0.007
	(0.04)	(0.12)	(0.10)	(0.09)	(0.08)
D. Shadow Rate					
ε_Shadowrate	−0.056***	−0.151**	−0.130**	−0.114**	−0.100*
	(0.02)	(0.07)	(0.06)	(0.05)	(0.05)
ε_BoE_cpi_4	−0.021	0.222**	0.186**	0.143**	0.103*
	(0.03)	(0.11)	(0.09)	(0.07)	(0.06)
ε_BoE_gdp_4	0.016	0.086	0.067	0.035	−0.001
	(0.03)	(0.10)	(0.08)	(0.08)	(0.07)

(*continued*)

Table 4. (Continued)

	(1) FTSE	(2) PF_2y	(3) PF_3y	(4) PF_4y	(5) PF_5y
Lag. Dep. Var.	0.611***	0.738***	0.775***	0.797***	0.807***
	(0.08)	(0.10)	(0.09)	(0.09)	(0.08)
Constant	0.101*	0.660**	0.553**	0.532**	0.541**
	(0.05)	(0.27)	(0.25)	(0.24)	(0.23)
Controls: X_t and Z_t	Yes	Yes	Yes	Yes	Yes
N	125	125	125	125	125
R^2	0.92	0.70	0.75	0.78	0.81

Notes: Heteroskedasticity-robust standard errors are in parentheses. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column corresponds to the OLS estimation of equation (9). The sample period goes from October 2004 to July 2015. Monetary and projection shocks are estimated based on equations (5)–(7). The dependent variable is the level of monthly averaged FTSE price index and inflation swaps at different maturities from two years to five years. These swaps are corrected for premiums based on equation (A.2). For parsimony, only the key coefficients are reported. Complete tables are available from the authors upon request. X_t includes a news variable capturing the information flow between $t-1$ and t of macro data releases related to inflation, the change between $t-1$ and t in private output and interest rate forecasts, the real activity, uncertainty, and news indexes of Scotti (2016). Z_t includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices, and forward-guidance (FG) and zero lower bound (ZLB) dummies. Panel B shows estimates when equation (9) is estimated with monetary shocks or projection shocks separately. Panel C shows estimates with bootstrapped standard errors to take into account the estimation uncertainty from equations (5)–(7). Panel D shows estimates when equation (9) is estimated with monetary shocks based on a shadow rate measure.

with waning effects of monetary policy on inflation. The transmission lags of monetary policy are often estimated to be around 18 to 24 months for inflation (see, e.g., Bernanke and Blinder 1992 or Bernanke and Mihov 1998), so negative effects at horizons longer than the transmission lags could be interpreted as a policy signal effect going through the expectations channel.[31] Even if macro signals may still be at work, there is no evidence that it outweighs the policy signal given the consistently negative effect.

[31] Fatum and Hutchison (1999) find no evidence in the United States supporting the policy signaling hypothesis that policy actions are related to changes in expectations about the stance of future monetary policy. However, their analysis focuses specifically on foreign exchange market interventions.

We also test whether the dominant signal that the Bank's inflation and output projections convey is about the state of the economy or about the policy path. Table 4 reports that positive shocks to the Bank's inflation projections at four quarters ahead have no significant effect on stock prices but increase private inflation expectations two to five years ahead—β_2 is positive. That effect is strongest two years ahead and again decreases with the horizon. The sign of the effect suggests that the information conveyed about the macro outlook outweighs the policy signal conveyed by these projections. That is consistent with private agents and the central bank having different information sets. At the opposite, shocks to the Bank's output projections have no effect.

Table 4 also shows estimates when Bank Rate is replaced by a shadow rate measure in order to take into account the ELB and the implementation of various unconventional measures. The results are similar: contractionary monetary shocks have a negative effect on inflation expectations and stock prices. In order to check that the signals conveyed by each piece of information are specific to it (i.e., that an inflation projection shock is not interpreted differently when we include or do not include monetary shocks in our specification, for instance), we have also estimated equation (9) with monetary shocks or projection surprises alone. These additional estimates, also shown in table 4, confirm the stability of the baseline results.

Table 5 shows that the Bank's inflation projections 8 quarters ahead also have a positive effect on inflation expectations between two and five years ahead, although those 12 quarters ahead have no effect. Output projections, at 8 or 12 quarters ahead, still have no effect. The fact that surprises to the Bank's short- and medium-term inflation projections affect private inflation expectations at medium- and long-term horizons suggests that private agents take a signal about the inflation outlook further ahead. This result holds when considering shocks to the shadow rate as well.

Overall, these results suggest that, in contrast to the theoretical predictions of full-information models described in section 2.1, there is some evidence that some weight is placed on the signals about the macro outlook that projections contain. One interpretation of these results is that when private agents face a signal-extraction problem from one piece of information, they rely on the underlying nature of the information disclosed by the central bank: a monetary shock

Table 5. Longer-Horizon BoE Projection Estimates

	(1) FTSE	(2) PF_2y	(3) PF_3y	(4) PF_4y	(5) PF_5y
8-Quarter-Ahead BoE Projections					
ε_Bankrate	−0.034*	−0.216**	−0.182**	−0.167**	−0.156**
	(0.02)	(0.09)	(0.08)	(0.07)	(0.07)
ε_BoE_cpi_8	0.026	0.404*	0.364**	0.313**	0.263**
	(0.06)	(0.22)	(0.18)	(0.15)	(0.13)
ε_BoE_gdp_8	0.02	0.184	0.154	0.137	0.118
	(0.03)	(0.15)	(0.12)	(0.10)	(0.08)
N	125	125	125	125	125
R^2	0.91	0.69	0.74	0.78	0.81
Shadow Rate					
ε_Shadowrate	−0.058***	−0.164**	−0.142**	−0.128**	−0.116**
	(0.02)	(0.07)	(0.06)	(0.05)	(0.05)
ε_BoE_cpi_8	0.048	0.432**	0.390**	0.336**	0.282**
	(0.06)	(0.21)	(0.17)	(0.15)	(0.12)
ε_BoE_gdp_8	0.034	0.185	0.156	0.138	0.118
	(0.03)	(0.15)	(0.12)	(0.09)	(0.08)
N	125	125	125	125	125
R^2	0.92	0.69	0.74	0.78	0.81
12-Quarter-Ahead BoE Projections					
ε_Bankrate	−0.036**	−0.189**	−0.161**	−0.151**	−0.144**
	(0.02)	(0.09)	(0.08)	(0.07)	(0.07)
ε_BoE_cpi_12	0.109	0.078	0.094	0.093	0.084
	(0.08)	(0.22)	(0.18)	(0.16)	(0.15)
ε_BoE_gdp_12	0.012	−0.042	−0.015	0.022	0.053
	(0.05)	(0.14)	(0.12)	(0.11)	(0.10)
N	125	125	125	125	125
R^2	0.91	0.68	0.73	0.77	0.81
Shadow Rate					
ε_Shadowrate	−0.058***	−0.138**	−0.121**	−0.111**	−0.103**
	(0.02)	(0.07)	(0.06)	(0.05)	(0.05)
ε_BoE_cpi_8	0.131*	0.086	0.103	0.101	0.089
	(0.07)	(0.23)	(0.18)	(0.16)	(0.15)
ε_BoE_gdp_8	0.016	−0.047	−0.018	0.019	0.049
	(0.04)	(0.14)	(0.12)	(0.11)	(0.10)

(*continued*)

Table 5. (Continued)

	(1) FTSE	(2) PF_2y	(3) PF_3y	(4) PF_4y	(5) PF_5y
N	125	125	125	125	125
R^2	0.92	0.68	0.73	0.77	0.80

Notes: Heteroskedasticity-robust standard errors are in parentheses. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column corresponds to the OLS estimation of equation (9). The sample period goes from October 2004 to July 2015. Monetary and projection shocks are estimated based on equations (5)–(7). The dependent variable is the level of monthly averaged FTSE price index and inflation swaps at different maturities from two years to five years. These swaps are corrected for premiums based on equation (A.2). For parsimony, only the key coefficients are reported. Complete tables are available from the authors upon request. X_t includes a news variable capturing the information flow between $t-1$ and t of macro data releases related to inflation, the change between $t-1$ and t in private output and interest rate forecasts, the real activity, uncertainty, and news indexes of Scotti (2016). Z_t includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices, and FG and ZLB dummies.

primarily conveys a policy signal and a projection shock primarily conveys a macro outlook signal.

4.4 Sensitivity Analysis

We run several alternative tests to assess the robustness of the baseline results. They are decomposed into tests about the identification of the monetary and projection shocks, and about additional right-hand-side variables and subsample estimates.

Focusing on the identification of monetary shocks, we first identify monetary shocks without controlling for the specificity of IR months. Second, we assess the effects of big and small monetary shocks (greater and lesser than 25 basis points) to control for potential outliers. Third, because the ELB may affect how private agents form their expectations, we estimate equation (5) on two subsamples pre- and post-ELB. Fourth, we replace the first principal components of private expectations in equations (5)–(7) with all individual series at different horizons. Table A.7 in the online appendix confirms the dominant signal for monetary and projection shocks, respectively.

We assess the impact of variations to projection shocks. First, we use a constant-interpolated measure of the projection shocks, so the observations during the two months after the IR publication take the value of the shock happening in the first month instead of zeros. Second, we interpolate projections the same way and estimate equations (6) and (7) on all observations rather than on IR months only. Third, we replace the shadow rate measure with the Bank Rate in equation (5). Table A.8 in the online appendix confirms the sign and magnitude of the main effects.

Because the variables in X_t and Z_t in equation (9) are also likely to be endogenous to inflation expectations, the estimation of the parameters associated to monetary and projection shocks may be biased. We estimate equation (9) with no controls to examine whether this potential bias affects our results. In addition, because contemporaneous news shocks may affect inflation expectations as well as central bank projections, the estimation would require controlling for as many news shocks as possible. First, we augment equation (9) with different measures of inflation: retail prices (RPI), core CPI, and input producer prices (PPI). Second, we augment equation (9) with different measures of economic slack: unemployment, capacity utilization, and the output gap computed by the Office for Budget Responsibility (OBR). Third, we augment equation (9) with different measures of financial stress: the Chicago Board Options Exchange Volatility Index (VIX), the U.K. move, and the St. Louis Fed Financial Stress Index, three daily-frequency indexes reacting in real time to macroeconomic and financial developments. Fourth, we augment equation (9) with a value added tax (VAT) dummy which takes the value of one in December 2008, January 2010, and January 2011 when the U.K. government raised the VAT, causing inflation to rise. Finally, we augment the model with the three European Commission (EC) U.K. sentiment measures for the industry, services, and consumers. Table A.9 in the online appendix confirms the magnitude and sign of the effects of monetary and projection shocks.

We estimate equation (9) on two subsamples before and after March 2009, when Bank Rate reached its ELB, so as to investigate the robustness of our results when Bank Rate was considered the main policy instrument and when macroeconomic dynamics may be affected by the policy rate being at the ELB. In addition, we test a specification in which we introduce a dummy for the dates of the announcements of explicit forward guidance on future policy rates in August 2013 and February 2014.[32] Table A.10 in the online appendix shows that our main results are robust to these alternatives.

We conclude this robustness section with another set of tests related to the specification of the left-hand-side variables. First, we replace the level of inflation expectations with their first difference. Second, we replace the level with their deviation from the Bank's inflation target (corrected for the sample mean of the wedge between RPI and CPI).[33] Third, we consider a more extreme information assumption, replacing the monthly average of all observations with the last daily observation of the month. While this option discards all data points before the last observation, it ensures that (i) all shocks or news released during a month are available to private agents and incorporated in the last observation; and (ii) there is no endogeneity issue between left-hand-side variables and explanatory variables. Table A.11 in the online appendix shows that the sign and magnitude of monetary and projection shocks are confirmed.

5. Conclusion

This paper investigates the effect of two types of central bank announcements private inflation expectations. We find that policy decisions convey some signals about the macroeconomic outlook, but that policy signals dominate such that inflation expectations respond negatively to contractionary policy, as would be expected given the transmission mechanism of monetary policy. However, we also find that inflation expectations respond positively to surprises in the Bank of England's macroeconomic projections, consistent with private agents putting more weight on the signal that they convey

[32]The Monetary Policy Committee has provided guidance on the setting of future monetary policy since August 7, 2013. Because this policy is supposed to affect the private agents' expected future policy path via a commitment device, it may affect private inflation expectations, and we need to control for this potential effect at the end of our sample.

[33]The wedge is computed as the difference between RPI and CPI inflation corrected for the uncertainty created by the announcement by the Office for National Statistics' Consumer Prices Advisory Committee (CPAC) of a potential revision in the RPI calculation methodology, between May 2012 and January 2013.

about future economic developments than the signal about the policy outlook. That provides evidence of the existence of a macro outlook signaling channel, in contrast to the theoretical predictions of full-information models. One interpretation of the empirical results could be that policy decisions and central bank inflation projections together enable private agents to differentiate the inflationary shock and the monetary shock, thus reducing the signaling effect of policy actions. The analysis of this hypothesis is left for future research. The results of this paper give policymakers some insights on how private agents interpret and respond to policy decisions and central bank information. The signals provided by central bank action and communication appear to be important for the management of private expectations.

References

Adam, K., and M. Padula. 2011. "Inflation Dynamics and Subjective Expectations in the United States." *Economic Inquiry* 49 (1): 13–25.

Andersen, T., T. Bollerslev, F. Diebold, and C. Vega. 2003. "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange." *American Economic Review* 93 (1): 38–62.

Andrade, P., G. Gaetano, E. Mengus, and B. Mojon. 2019. "Forward Guidance and Heterogeneous Beliefs." *American Economic Journal: Macroeconomics* 11 (3): 1–29.

Andrade, P., and H. Le Bihan. 2013. "Inattentive Professional Forecasters." *Journal of Monetary Economics* 60 (8): 967–82.

Angeletos, G.-M., C. Hellwig, and A. Pavan. 2006. "Signaling in a Global Game: Coordination and Policy Traps." *Journal of Political Economy* 114 (3): 452–84.

Baeriswyl, R., and C. Cornand. 2010. "The Signaling Role of Policy Actions." *Journal of Monetary Economics* 57 (6): 682–95.

Bean, C., and N. Jenkinson. 2001. "The Formulation of Monetary Policy at the Bank of England." *Quarterly Bulletin* (Bank of England) Winter (Q4): 434–41.

Beechey, M., B. Johannsen, and A. Levin. 2011. "Are Long-Run Inflation Expectations Anchored More Firmly in the Euro Area than in the United States?" *American Economic Journal: Macroeconomics* 3 (2): 104–29.

Bernanke, B., and A. Blinder. 1992. "The Federal Funds Rate and the Channels of Monetary Transmission." *American Economic Review* 82 (4): 901–21.

Bernanke, B., J. Boivin, and P. Eliasz. 2005. "Measuring the Effects of Monetary Policy: A Factor-augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics* 120 (1): 387–422.

Bernanke, B., and I. Mihov. 1998. "Measuring Monetary Policy." *Quarterly Journal of Economics* 113 (3): 869–902.

Blanchard, O., J.-P. L'Huillier, and G. Lorenzoni. 2013. "News, Noise, and Fluctuations: An Empirical Exploration." *American Economic Review* 103 (7): 3045–70.

Blinder, A., M. Ehrmann, M. Fratzscher, J. De Haan, and D.-J. Jansen. 2008. "Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence." *Journal of Economic Literature* 46 (4): 910–45.

Branch, W. 2004. "The Theory of Rationally Heterogeneous Expectations: Evidence from Survey Data on Inflation Expectations." *Economic Journal* 114 (497): 592–621.

———. 2007. "Sticky Information and Model Uncertainty in Survey Data on Inflation Expectations." *Journal of Economic Dynamics and Control* 31 (1): 245–76.

Bullard, J., and K. Mitra. 2002. "Learning about Monetary Policy Rules." *Journal of Monetary Economics* 49 (6): 1105–29.

Campbell, J., C. Evans, J. Fisher, and A. Justiniano. 2012. "Macroeconomic Effects of Federal Reserve Forward Guidance." *Brookings Papers on Economic Activity* (Spring): 1–80.

Campbell, J., J. Fisher, A. Justiniano, and L. Melosi. 2017. "Forward Guidance and Macroeconomic Outcomes Since the Financial Crisis." *NBER Macroeconomics Annual 2016*, Vol. 31, ed. M. Eichenbaum and J. A. Parker, 283–357. University of Chicago Press.

Capistran, C., and A. Timmermann. 2009. "Disagreement and Biases in Inflation Expectations." *Journal of Money, Credit and Banking* 41 (2–3): 365–96.

Carroll, C. 2003. "Macroeconomic Expectations of Households and Professional Forecasters." *Quarterly Journal of Economics* 118 (1): 269–98.

Castelnuovo, E., and P. Surico. 2010. "Monetary Policy, Inflation Expectations and the Price Puzzle." *Economic Journal* 120 (549): 1262–83.

Cesa-Bianchi, A., G. Thwaites, and A. Vicondoa. 2020. "Monetary Policy Transmission in the United Kingdom: A High Frequency Identification Approach." *European Economic Review* 123 (April): 103–375.

Cieslak, A., and A. Schrimpf. 2019. "Non-Monetary News in Central Bank Communication." *Journal of International Economics* 118 (May): 293–315.

Cloyne, J., and P. Huertgen. 2016. "The Macroeconomic Effects of Monetary Policy: A New Measure for the United Kingdom." *American Economic Journal: Macroeconomics* 8 (4): 75–102.

Cochrane, J., and M. Piazzesi. 2002. "The Fed and Interest Rates—High-Frequency Identification." *American Economic Review* 92 (2): 90–95.

Coibion, O., and Y. Gorodnichenko. 2012. "What Can Survey Forecasts Tell Us about Informational Rigidities?" *Journal of Political Economy* 120 (1): 116–59.

———. 2015. "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts." *American Economic Review* 105 (8): 2644–78.

Cook, T., and T. Hahn. 1989. "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s." *Journal of Monetary Economics* 24 (3): 331–51.

Crowe, C. 2010. "Testing the Transparency Benefits of Inflation Targeting: Evidence from Private Sector Forecasts." *Journal of Monetary Economics* 57 (2): 226–32.

D'Agostino, A., and K. Whelan. 2008. "Federal Reserve Information during the Great Moderation." *Journal of the European Economic Association* 6 (2–3): 609–20.

Dräger, L., M. Lamla, and D. Pfajfar. 2016. "Are Survey Expectations Theory-Consistent? The Role of Central Bank Communication and News." *European Economic Review* 85 (June): 84–111.

Ehrmann, M. 2015. "Targeting Inflation from Below: How Do Inflation Expectations Behave?" *International Journal of Central Banking* 11 (Supplement 1, September): 213–49.

Ehrmann, M., S. Eijffinger, and M. Fratzscher. 2012. "The Role of Central Bank Transparency for Guiding Private Sector Forecasts." *Scandinavian Journal of Economics* 114 (3): 1018–52.

Ehrmann, M., and M. Fratzscher. 2007. "Communication by Central Bank Committee Members: Different Strategies, Same Effectiveness?" *Journal of Money, Credit and Banking* 39 (2–3): 509–41.

Ellingsen, T., and U. Söderström. 2001. "Monetary Policy and Market Interest Rates." *American Economic Review* 91 (5): 1594–1607.

Evans, G., and S. Honkapohja. 2001. *Learning and Expectations in Macroeconomics*. Princeton University Press.

Fatum, R., and M. Hutchison. 1999. "Is Intervention a Signal of Future Monetary Policy? Evidence from the Federal Funds Futures Market." *Journal of Money, Credit and Banking* 31 (1): 54–69.

Faust, J., E. Swanson, and J. Wright. 2004. "Do Federal Reserve Policy Surprises Reveal Superior Information about the Economy?" *Contributions to Macroeconomics* 4 (1).

Fendel, R., E. Lis, and J.-C. Rülke. 2011. "Do Professional Forecasters Believe in the Phillips Curve? Evidence from the G7 Countries." *Journal of Forecasting* 30 (2): 268–87.

Forbes, K., I. Hjortsoe, and T. Nenova. 2018. "The Shocks Matter: Improving Our Estimates of Exchange Rate Pass-Through." *Journal of International Economics* 114 (September): 255–75.

Fujiwara, I. 2005. "Is the Central Bank's Publication of Economic Forecasts Influential?" *Economics Letters* 89 (3): 255–61.

Gamber, E., and J. Smith. 2009. "Are the Fed's Inflation Forecasts Still Superior to the Private Sector's?" *Journal of Macroeconomics* 31 (2): 240–51.

Gürkaynak, R., A. Levin, and E. Swanson. 2010. "Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from the US, UK, and Sweden." *Journal of the European Economic Association* 8 (6): 1208–42.

Gürkaynak, R., B. Sack, and E. Swanson. 2005a. "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements." *International Journal of Central Banking* 1 (1, May): 55–93.

———. 2005b. "The Sensitivity of Long-term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models." *American Economic Review* 95 (1): 425–36.

Gürkaynak, R., B. Sack, and J. Wright. 2010. "The TIPS Yield Curve and Inflation Compensation." *American Economic Journal: Macroeconomics* 2 (1): 70–92.

Hansen, S., and M. McMahon. 2016. "Shocking Language: Understanding the Macroeconomic Effects of Central Bank Communication." *Journal of International Economics* 99 (Supplement 1): S114–S133.

Hanson, S., and J. Stein. 2015. "Monetary Policy and Long-Term Real Rates." *Journal of Financial Economics* 115 (3): 429–48.

Hayo, B., and M. Neuenkirch. 2010. "Do Federal Reserve Communications Help Predict Federal Funds Target Rate Decisions?" *Journal of Macroeconomics* 32 (4): 1014–24.

Hubert, P. 2014. "FOMC Forecasts as a Focal Point for Private Expectations." *Journal of Money, Credit and Banking* 46 (7): 1381–1420.

———. 2015a. "Do Central Bank Forecasts Influence Private Agents? Forecasting Performance versus Signals." *Journal of Money, Credit and Banking* 47 (4): 771–89.

———. 2015b. "Revisiting the Greenbook's Relative Forecasting Performance." *Revue de l'OFCE* 137: 151–79.

———. 2017. "Qualitative and Quantitative Central Bank Communication and Inflation Expectations." *B.E. Journal of Macroeconomics* 7 (1): 1–41.

Jansen, D.-J., and J. De Haan. 2009. "Has ECB Communication Been Helpful in Predicting Its Interest Rate Decisions?" *Applied Economics* 41 (16): 1995–2003.

Jarocinski, M., and P. Karadi. 2020. "Deconstructing Monetary Policy Surprises: The Role of Information Shocks." *American Economic Journal: Macroeconomics* 12 (2): 1–43.

Joyce, M., M. Tong, and R. Woods. 2011. "The United Kingdom's Quantitative Easing Policy: Design, Operation and Impact." *Quarterly Bulletin* (Bank of England) 51 (Q3): 200–212.

King, R., Y. Lu, and E. Pasten. 2008. "Managing Expectations." *Journal of Money, Credit and Banking* 40 (8): 1625–66.

Kohlhas, A. 2014. "Learning-by-Sharing: Monetary Policy and the Information Content of Public Signals." Manuscript.

Kuttner, K. 2001. "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market." *Journal of Monetary Economics* 47 (3): 523–44.

Lyziak, T., and M. Paloviita. 2018. "On the Formation of Inflation Expectations in Turbulent Times: The Case of the Euro Area." *Economic Modelling* 72 (June): 132–39.

Mackowiak, B., and M. Wiederholt. 2009. "Optimal Sticky Prices under Rational Inattention." *American Economic Review* 99 (3): 769–803.

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

Melosi, L. 2017. "Signalling Effects of Monetary Policy." *Review of Economic Studies* 84 (2): 853–84.

Miranda-Agrippino, S., and G. Ricco. 2020. "The Transmission of Monetary Policy Shocks." Forthcoming in *American Economic Journal: Macroeconomics*.

Moscarini, G. 2004. "Limited Information Capacity as a Source of Inertia." *Journal of Economic Dynamics and Control* 28 (10): 2003–35.

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

Nunes, R. 2010. "Inflation Dynamics: The Role of Expectations." *Journal of Money, Credit and Banking* 42 (6): 1161–72.

Orphanides, A., and J. Williams. 2005. "The Decline of Activist Stabilization Policy: Natural Rate Misperceptions, Learning, and Expectations." *Journal of Economic Dynamics and Control* 29 (11): 1927–50.

Paloviita, M., and M. Viren. 2013. "Are Individual Survey Expectations Internally Consistent?" Working Paper No. 140, National Bank of Poland.

Pedersen, M. 2015. "What Affects the Predictions of Private Forecasters? The Role of Central Bank Forecasts in Chile." *International Journal of Forecasting* 31 (4): 1043–55.

Reis, R. 2013. "Central Bank Design." *Journal of Economic Perspectives* 27 (4): 17–44.

Rigobon, R., and B. Sack. 2004. "The Impact of Monetary Policy on Asset Prices." *Journal of Monetary Economics* 51 (8): 1553–75.

Romer, C., and D. Romer. 2000. "Federal Reserve Information and the Behavior of Interest Rates." *American Economic Review* 90 (3): 429–57.

———. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review* 94 (4): 1055–84.

Rosa, C., and G. Verga. 2007. "On the Consistency and Effectiveness of Central Bank Communication: Evidence from the ECB." *European Journal of Political Economy* 23 (1): 146–75.

Rossi, B., and T. Sekhposyan. 2016. "Forecast Rationality Tests in the Presence of Instabilities, with Applications to Federal Reserve and Survey Forecasts." *Journal of Applied Econometrics* 31 (3): 507–32.

Scotti, C. 2016. "Surprise and Uncertainty Indexes: Real-Time Aggregation of Real-Activity Macro-Surprises." *Journal of Monetary Economics* 82 (September): 1–19.

Sims, C. 1992. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36 (5): 975–1000.

———. 2003. "Implications of Rational Inattention." *Journal of Monetary Economics* 50 (3): 665–90.

Soderlind, P. 2011. "Inflation Risk Premia and Survey Evidence on Macroeconomic Uncertainty." *International Journal of Central Banking* 7 (2, June): 113–33.

Sturm, J.-E., and J. De Haan. 2011. "Does Central Bank Communication Really Lead to Better Forecasts of Policy Decisions? New Evidence Based on a Taylor Rule Model for the ECB." *Review of World Economics* 147 (1): 41–58.

Swanson, E. 2006. "Have Increases in Federal Reserve Transparency Improved Private Sector Interest Rate Forecasts?" *Journal of Money, Credit and Banking* 38 (3): 792–819.

Tang, J. 2015. "Uncertainty and the Signaling Channel of Monetary Policy." Working Paper No. 15-8, Federal Reserve Bank of Boston.

Walsh, C. 2007. "Optimal Economic Transparency." *International Journal of Central Banking* 3 (1, March): 5–36.

Warsh, K. 2014. "Transparency and the Bank of England's Monetary Policy Committee." Technical Report, Bank of England (December).

Woodford, M. 2001. “Imperfect Common Knowledge and the Effects of Monetary Policy.” NBER Working Paper No. 8673.

———. 2005. “Central-Bank Communication and Policy Effectiveness.“ In *The Greenspan Era: Lessons for the Future*, 399–474. Kansas City: Federal Reserve Bank of Kansas City.