State-Dependent Effects of Monetary Policy: the Central Bank Information Channel

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ABSTRACT

When policymakers and private agents do not share the same information, private agents may not be able to appreciate whether monetary policy responds to changes in the macroeconomic outlook or in policy preferences. This paper investigates whether the release of central bank macroeconomic information modifies private agents' interpretation of policy decisions. We find that the sign and magnitude of the effects of monetary policy depend on the publication of policymakers' macroeconomic views. In contrast with standard theoretical model predictions, contractionary monetary policy has negative effects on inflation expectations and stock prices only and only if associated with positive economic news.

KEY WORDS

Monetary policy, information processing, signal extraction, market-based inflation expectations, central bank projections, real-time forecasts.

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"Pound and gilts await Bank of England view on inflation", Financial Times, 10 May 2017

1. Introduction

There are at least two reasons why the private sector may not correctly anticipate monetary policy changes - and eventually be *surprised* by such a change. One reason is that the central bank and the private sector may not share the same information about the economic outlook. The other reason is that the private sector may not perfectly understand the objectives and preferences of the central bank.[1] It follows that, when facing a monetary policy surprise, private agents will adjust their beliefs about either the macroeconomic outlook or policymakers' preferences or both. The very responses of the private sector will depend on which interpretation dominates.

The fact that policy decisions may reveal information about the central bank's view of macroeconomic developments has been extensively documented in the literature. Romer and Romer (2000) provide evidence of the revelation of the Federal Reserve's private information about the future state of the economy through its decisions. Ellingson and Söderström (2001, 2005) find that private responses to policy decisions may reflect a mix of responses to the pure monetary innovation and to the macroeconomic information conveyed by the policy instrument. Campbell et al. (2012, 2017), Hanson and Stein (2015), Tang (2015), Winkelmann et al. (2016), Melosi (2017), Andrade and Ferroni (2018), Cieslak and Schrimpf (2019), Hansen et al. (2018), Lakdawala and Schaffer (2018), Miranda-Agrippino and Ricco (2017), Nakamura and Steinsson (2018), Jarocinski and Karadi (2019) and Kerssenfischer (2019) provide ample evidence of this signaling (or central bank information) channel of monetary policy.[2] They establish the presence of non-monetary news in policy announcements, quantify the nature of this information content (about the macroeconomic outlook or the term premium, for instance) and provide evidence of the importance of central bank information shocks.

The existence of the central bank information channel relies, in part, upon the fact that, when the central bank and private agents do not share the same information set, private agents observe the policy decision but do not observe whether it stems from a change in policymakers' views of the economic outlook (the endogenous policy response) or from an exogenous policy innovation. At first, private agents face a signal extraction issue and decompose the policy decision between a monetary shock and some central bank information revelation. However, when the central bank reveals its macroeconomic information set, private agents now observe policymakers' views of the state of the economy and could be able to appreciate the endogenous policy response. So the publication of central bank information may help reduce the dimensionality of private agents' signal extraction issue. Private agents could then update their initial decomposition between the monetary shock and the information revelation, and so revise their belief about the policy decision. This paper aims at investigating such a mechanism in the data.

So far the attention in the literature has focused on the effect of central bank communication on different macroeconomic and financial variables, or more recently on the central bank information channel itself. In contrast, the contribution of this paper is to examine the role of central bank information in the transmission of monetary policy. It provides original empirical evidence about whether the sign and magnitude of the effects of monetary policy depends on the publication by a central bank of its assessment of the economic outlook.

[1] A purely exogenous innovation in the policy rate, i.e. a monetary shock, would enter this category.
[2] On the theoretical side, see Walsh (2007), Baeriswyl and Cornand (2010), Berkelmans (2011) and Kohlhas (2014).

To empirically estimate private responses to monetary policy, we make use of three features of the United Kingdom (UK) data. First, a necessary requirement for identification is that the information set revealed by the central bank is not a function of the current policy decision, so both monetary surprises and central bank information surprises can be separately identified. We exploit the fact that the Bank of England (BoE) publishes macroeconomic projections in its Inflation Report (IR) that are conditioned on the path for the policy instrument implied by financial market interest rates *prior* to the policy meeting.[3] It enables us to single out monetary surprises and information surprises. Second, the fact that Monetary Policy Committee (MPC) policy decisions and the IR were released on different days until August 2015 enables us to carefully measure the surprise components of the two events using high-frequency data.[4] In addition, the policy announcement – a few purely descriptive sentences – was not followed by a press conference, so there was no information transfer at that moment. This enables us to clearly single out actions from statements or press conferences that contain macro information. Third, policy decisions happen every month whereas the IR is published quarterly, so private agents observe up-to-date central bank information for only one over three policy decisions.[5]

This paper estimates whether and how much the transmission of UK monetary policy to asset prices depends on central bank information surprises. We test the hypothesis that private agents revise their initial belief about policy once the IR is published.[6] We use a high-frequency event-study analysis to measure the causal effect of monetary policy decisions on the term structure of market-based measures of inflation expectations and stock prices.[7] We use an interaction term to uncover a state-dependent effect and revisions in beliefs conditional on the publication of central bank information. Following the literature, the surprise component of MPC announcements and the surprise component of the IR publication are computed as the daily change in one-year nominal gilt yields.[8] We measure whether and how monetary surprises associated with IR surprises impact changes in inflation swaps from 1-year to 5-year ahead and FTSE returns.[9] Our sample period starts in October 2004 when inflation swap data becomes available with sufficient liquidity and ends in July 2015 when the BoE started to release MPC decisions and the IR simultaneously.

The main result of this paper is that the interaction term between monetary and information surprises is significant and negative, such that the publication of the central bank's own assessment of the macroeconomic outlook does modify the effect of monetary policy. Whereas a positive (i.e. restrictive) 1 standard-deviation (SD) monetary surprise increases inflation expectations 3-year ahead by 2 bp during non-IR months or in the days before the IR is published, the same positive monetary surprise decreases inflation expectations 3-year ahead by 7 bp if associated with a positive 10 bp IR surprise. The opposite signs of the two responses

[3] 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 mandate.
[4] After August 2015, both are released simultaneously at 12:00 so even intraday data would not enable to do so.
[5] Until September 2016, the MPC held policy meetings every month, compared to 8 per year after that date.
[6] This paper focuses on the release of central bank *macroeconomic* information, not on the communication about future policy or its hawkishness/dovishness tone (see e.g. Rosa and Verga, 2007; or Lucca and Trebbi, 2011).
[7] An event-study approach enables us to abstract from quantifying qualitative communication like statements (see Hubert, 2017, and Detmers et al., 2018). Market surprises capture both quantitative and qualitative dimensions.
[8] Because the policy rate is at its effective lower bound during a significant part of the sample period and monetary policy has taken various dimensions over the last years, using changes in 1-year gilt yields enables to capture all dimensions of monetary policy into a single variable of the monetary stance. The drawback of such a specification is that we cannot decompose the effects of specific policies on asset prices.
[9] The use of inflation swaps calls for correcting for term, liquidity and inflation risk premia. We use a regression-based approach following Gürkaynak et al. (2010a, 2010b) and Soderlind (2011).

suggest a clear difference in the way private agents process monetary surprises if the central bank information set is revealed to them. We find evidence for this state-dependence of monetary policy on inflation swaps at 2, 3 and 4-year maturities and stock prices. This state-dependent effect of monetary policy also holds when considering BoE's inflation projection surprises as the state-contingent variable.[10,11] We also confirm that this state-dependent effect holds with ECB policy announcements and press conferences using euro area intraday data.

They are two main comments worth making from these estimates. First, we find that monetary policy *alone* does not yield the expected outcome and seems dominated by the signaling channel: a policy tightening produces an increase in inflation expectations and stock prices. Second, contractionary monetary policy has negative effects on inflation expectations and stock prices only and only if associated with positive economic news.

A potential concern with the main result is that the effect of IR surprises that modifies the impact of monetary surprises could be unrelated to central bank information and could instead reflect other macroeconomic news published in between the policy decision and the IR.[12] Another concern relates to the fact that ECB decisions were regularly published on the same day than MPC ones. In addition, the introduction of the Forward Guidance policy in the UK was made public during the press conference following the publication of the IR on August 1st, 2013 such that the release of this central bank macroeconomic information was mixed with a policy announcement. To address these concerns, we control for surprises in nine of the most important macroeconomic data releases (such as inflation or PMI), ECB monetary surprises and Forward Guidance announcements. We obtain similar estimates to our baseline results.

The negative sign of the interaction term - the fact that contractionary monetary policy has negative effects on inflation expectations and stock prices only and only if associated with positive economic news – appears puzzling in light of a standard Bayesian updating model that would predict that the increase in asset prices after a policy tightening – the effect of the signaling channel – should be reinforced by the publication of a positive economic news (i.e. a positive IR surprise), since both signals go in the same direction. The negative sign of the interaction term is also puzzling if we consider a standard reaction function interpretation of policy decisions: the policy tightening coupled with negative IR news should signal a positive exogenous policy innovation, so asset prices should go down.

One plausible explanation relates to how private agents solve their signal extraction issue. We explore further the mechanism at work and conduct different tests. Following the result of Ehrmann and Sondermann (2012) that central bank communication becomes stale, we find evidence that the role of central bank information flows for the transmission of monetary policy goes through the signaling/information channel. This suggests that central bank information helps private agents solve their signal extraction issue such that the policy innovation is single out from the endogenous response to macroeconomic outlook. Two interpretations of the information content published by policymakers would explain such a use of the IR. One interpretation relates to the fact that the macroeconomic information released would offset the signaling/information channel such that private agents revise their

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[10] The same is less true for output projection surprises, although that might be consistent with the remit of an inflation targeting central bank such as the Bank of England.

[11] We also assess the impact of monetary and central bank information surprises at the monthly frequency. In addition, we test the state-dependent effect of monetary shocks identified following Romer and Romer (2004). Finally, using local projections, we also find evidence of a persistent state-dependent effect of monetary policy on inflation swaps and stock prices, as well as on inflation and industrial production.

[12] The minutes of MPC meetings were published on average two weeks after the given meeting, so after the IR.

initial decomposition of the policy announcement. The second interpretation relates to the IR being seen as signals about the future policy path. The publication of central bank information and more specifically macroeconomic projections can provide information about the interest rate path and so be perceived as a sort of Delphic forward guidance (see Campbell et al., 2012). We find that central bank information surprises are not interpreted the same way after tightening and easing monetary surprises. The information content of the IR is seen as a policy signal after a tightening monetary surprise whereas it is processed as a macro signal after an expansionary monetary surprise.

These additional tests suggest that it may be the combination of the policy and macro signals conveyed by the policy announcement and the macroeconomic news published that drives the overall effect of policy decisions. The signaling effects of monetary policy are at work and are affected by the publication of central bank information. This information is interpreted differently by private agents conditional on the sign of monetary surprises some days before, such that it produces this negative interaction term between monetary and information surprises and ultimately drives this state-dependent effect of monetary policy.

One important policy implication is that the release of central bank macroeconomic information and its coordination with policy announcements matters for the transmission of monetary policy. Because private agents' interpretation of policy changes is crucial in determining the sign and magnitude of the effect of monetary policy, central bank communication policies that align private agents' and policymakers' information sets may take on a key importance for determining the transmission of monetary policy. Providing guidance about the future state of the economy enhance the effectiveness of monetary policy by allowing private agents to solve their signal extraction issue.

This paper lies at the intersection of different strands of the literature. A large literature studies the effects of central bank communication. Gürkaynak et al. (2005) is one of the first papers to show that FOMC statements contain information beyond the current policy decision about the future policy path, while Kohn and Sack (2003) show that FOMC statements provide information about the outlook for the economy.[13] In the meantime, despite a considerable empirical literature, there is still uncertainty about the effects of monetary policy. The sign and magnitude of the effect of monetary policy depend on the identification strategy, the model specification, and information issues.[14] Another strand of the literature focuses on the state-dependent effect of monetary policy. Weise (1999), Garcia (2002), Lo and Piger (2005), Angrist et al. (2013), Santoro et al. (2014), Barnichon and Matthes (2015) and Tenreyro and Thwaites (2016) analyze its dependence to the state of the economy or to the sign of monetary shocks. Hubrich and Tetlow (2015), Aikman et al. (2017), Alpanda and Zubairy (2019), Ottonello and Winberry (2017), Beraja et al. (2017), Cloyne et al. (2018) assess the effects of monetary policy conditional on financial and credit conditions, and debt or collateral values.

The rest of the paper is organized as follows. Section 2 describes the framework. Section 3 investigates the state-dependent effect at the daily frequency. Section 4 examines the state-dependent effect with inflation and output projection surprises, at the monthly frequency and with monetary shocks. Section 5 explores the mechanism at work. Section 6 concludes.

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[13] There is an ample literature on the role of central bank communication (see Woodford, 2005; Ehrmann and Fratzscher, 2007; Reis, 2013), its effects on private expectations (see Swanson, 2006; Ehrmann et al., 2012; Hubert, 2014, 2015), or for the predictability of policy decisions (see Jansen and De Haan, 2009; Hayo and Neuenkirch, 2010; Sturm and De Haan, 2011). Blinder et al. (2008) provide a survey of this literature.

[14] See Sims (1972), Bernanke and Blinder (1992), Romer and Romer (2004), Coibion (2012), Barakchian and Crowe (2013), Gertler and Karadi (2015), Cesa-Bianchi et al. (2016), Miranda-Agrippino (2016), Ramey (2016).

2. Monetary Policy Decisions and Central Bank Communication

2.1. The value of publishing central bank macroeconomic information

We first discuss why and how central bank communication may matter. In a standard macroeconomic framework such as a New-Keynesian model, when the central bank and private agents have the same information, private agents know the macroeconomic outlook to which the policy instrument responds to. In other words, private agents know the values of the variables entering the central bank reaction function. So contractionary monetary shocks have a negative effect on private expectations through the usual transmission channels, irrespective of whether the central bank publishes its information set. Private agents are able to infer the exogenous innovation from the policy rule, and there is no room for central bank macroeconomic communication to modify the effect of policy decisions. This is consistent with standard information theory or a simple Kalman filtering framework, in which the effect of monetary policy is independent of central bank communication.

In a framework where the central bank and private agents have different information sets, when observing the policy decision, private agents cannot disentangle whether it comes from the endogenous policy response to the economic outlook or whether it comes from an exogenous policy innovation (a pure policy shock or a change in the policy preferences).[15] In that case, when the central bank does *not* publish its information set, private agents face a signal processing issue as the unexpected policy decision can be due to, at least, two factors. Policy decisions convey signals about future macroeconomic developments and/or signals about the policy stance, so the effect of policy decisions would be a mix of private agents' responses to both signals, which gives rise to the signaling channel evidenced by e.g. Ellingsen and Söderström (2005), Melosi (2017) and Nakamura and Steinsson (2018).[16]

Alternatively, when the central bank *publishes* its macroeconomic information set, private agents may be able to infer whether it was driven by A. the endogenous response to the economy or B. an exogenous policy innovation. The publication of the central bank information set reduces the dimensionality of private agents' signal extraction. A standard Bayesian updating model would predict that the increase in asset prices after a policy tightening – the effect of the signaling channel – should be reinforced (reduced) by the publication of a positive (negative) IR surprise, since both signals go in the same (opposite) direction. The interaction term should be positive when the central bank information supports scenario A. The interaction term should also be positive if we consider a standard reaction function interpretation of policy decisions: a policy tightening coupled with a negative IR surprise should signal a positive exogenous policy innovation (scenario B), so asset prices should go down. Based on these predictions, the null hypothesis tested in this paper is that publishing central bank macroeconomic information introduces a positive non-linearity in the effects of monetary policy.

[15] The exogenous policy shock could either come from unexpected changes in policymakers' preferences (the parameters of the reaction function) or from a pure exogenous innovation. For the simplicity of the demonstration, we do not distinguish between both. Ultimately, this does not change the issue that without knowing the central bank information set, private agents cannot infer the exogenous policy shock.

[16] The signalling channel of monetary policy might then be one explanation for the positive response of inflation to monetary shocks documented in the VAR literature as the "price puzzle" (Sims 1992) and would be consistent with Castelnuovo and Surico (2010) that including the omitted information set in VARs solves this price puzzle.

2.2. The Bank of England's operating procedure

We present how policy decisions and the IR are communicated to the public. The Monetary Policy Committee (MPC) of the Bank of England is made up of nine members: five internal members – the Governor, the three Deputy Governors, and the Chief Economist - and four external members. The latter are appointed by the Chancellor of the Exchequer (subject to approval from the Treasury Select Committee) from outside the Bank. The governors serve five year terms while other members serve three year terms, after which they may be either replaced or reappointed. MPC meetings are chaired by the Governor and take place monthly since June 1997. Decisions concern the value for the Bank of England's official interest rate – and sometimes other measures, asset purchases for instance – in order to reach the inflation target. These decisions are made by simple-majority rule on a one-person, one-vote basis. Every member receives BoE staff briefings related to monetary policy and attends the monthly meetings. They happen during the first full week of each month on average.

Since February 1993, the Bank of England publishes the Inflation Report (IR) once a quarter, which provides an analysis of the UK economy and the factors influencing the policy decisions.[17] It includes the MPC's central projections for inflation. Since February 1996, the Bank's inflation forecast has been published in the form of a probability distribution known as "the fan chart" capturing the uncertainty and skewness of the forecasts.[18] The IR includes projections for output growth since November 1997. They are available for each quarter up to three years ahead. They are released in February, May, August and November.

One compelling feature of the Bank of England's set-up is that MPC decisions and the IR were not published on the same day until May 2015. The IR was published on average 4 business days after the MPC meeting, with a minimum of 2 days on May 2005, May 2010 and May 2015 and a maximum of 5 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. Another interesting feature of the BoE's set-up is that policy decisions happen every month whereas the BoE's projections are published quarterly.[19] That means that private agents do not observe up-to-date central bank macroeconomic projections for each decision, but only for one over three policy meetings. And when they observe it in IR months, they observe it with a delay of 4 days on average. So it is possible to identify and quantify the influence of the publication of the BoE macroeconomic information set on the effect of monetary policy.

The IR projections capture the judgement of the MPC on inflation and growth prospects, conditioned on specific assumptions including interest and exchange rates and some exogenous variables, as well as on general judgements about the future. Each IR specify that they "represent the MPC's best collective judgement about the most likely paths for inflation and output, and the uncertainties surrounding those central projections". Two sets of forecasts are published: one set is conditioned on a constant interest rate path which ex-post includes the effect of the Monetary Policy Committee's (MPC) most recent Bank Rate decision. The other set is conditioned on the path for Bank Rate implied by market interest rates just prior

[17] While there is variation in the content and style of central bank publications such as Monetary Policy Reports, a number of central banks, including the Federal Reserve, European Central Bank, Riksbank, Norges Bank and Reserve Bank of New Zealand, release such information on a regular basis.

[18] Analysing whether the uncertainty and skewness matter for the responses of inflation expectations is beyond the scope of this paper and left for future research about the balance of risks. In any case, the variance of these measures is actually small on our sample.

[19] Until September 2016, the Bank's Monetary Policy Committee held policy meetings every month, with 12 per year. After that point, the number of meetings has been lowered to 8 per year.

to the policy meeting. We use this second set since a crucial assumption to ensure identification of information surprises is that the central bank macroeconomic projections do not already contain the effect of the policy decision.

3. The State-Dependent Effect of Monetary Policy

3.1. The empirical model

Our analysis of whether private agents process monetary policy decisions differently when they receive central bank information uses a standard high-frequency event-study approach. To assess the effects of monetary policy on asset prices, the literature relies on this regression:

$$\Delta y_t = \alpha + \beta_1 \Delta x_t + \varepsilon_t \tag{1}$$

where Δx_t denotes the surprise component of the policy decision announced by the MPC, Δy_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.

Equation (1) estimated with monthly or quarterly data would magnify reverse causality and omitted variables biases. The measured effect of monetary policy on asset prices could easily capture the response of policy to earlier changes in asset prices in the month or quarter. In addition, changes in policy and asset prices could respond to macroeconomic news released earlier in the month or quarter. Using high-frequency data and a tight window around the policy decision enables to address these two issues. The key assumption is that, since asset prices adjust in real-time to 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 et al. (2004) have initiated this approach.

To test the hypothesis that the effect of monetary surprises varies with the IR publication, we augment equation (1) with a variable, Δz_t, capturing the surprise component of the macroeconomic information published in the IR and an interaction term, $\Delta x_t \cdot \Delta z_t$, which is the product of the surprise components of the policy decision and of the publication of the IR:

$$\Delta y_t = \alpha + \beta_1 \Delta x_t + \beta_2 \Delta z_t + \beta_3 \Delta x_t \cdot \Delta z_t + \varepsilon_t \tag{2}$$

When estimating equation (2), the parameter associated to the interaction term, β_3, indicates the marginal effect of monetary surprises conditional on the publication of the IR. If β_3 equals zero, the effect of monetary policy does not depend on IR surprises. Otherwise, if β_3 is different from zero, it sheds light on how the effect of monetary surprises on a given asset price is modified by the publication of the IR.

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 et al. (2005), 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 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 a proxy for monetary policy news. We follow Gürkaynak et al. (2005) that use a 1-year maturity while Hanson and Stein (2015) use 2-year. As described in our robustness tests in the Appendix, we obtain similar results with different maturities.[20] 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.[21] Since there is no observable measure of the overall stance of monetary policy during unconventional times, another advantage of this simple measure is that it allows encompassing in one single variable the multidimensional aspects of monetary policy such as extended liquidity provisions, forward guidance or asset purchases.[22]

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 for monetary news to capture IR news and compute the daily change in the one-year nominal Gilt yield on IR publication dates. Figure 1 plots the MPC and IR surprises over our sample. A visual inspection confirms the effect of the 2008-2009 financial crisis on the policy and macroeconomic outlook with large negative surprises in both series around these dates.

Since the remit of the Bank of England's MPC is to target a 2% inflation rate, 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 et al., 2011). [23] 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 1 to 5-year ahead, that provide a proxy measure for expected inflation at the date of the maturity of the contract.[24] These are available since October 2004, which determines the starting date of our sample.[25]

3.2. The issue of interacting events on different days

One advantage (until May 2015) of the BoE's institutional set-up for disentangling the information contents of MPC news and IR news – the fact that they happen on different days – raises an empirical challenge to assess their interaction. Indeed, MPC announcements and the publication of the IR do not happen in the same period, so the interaction we included in equation (2) would be null by construction. In order to assess the impact of the publication of the IR on the effect of monetary surprises, we interact the news component of the IR

[20] Cesa-Bianchi et al. (2016) use intraday data from 10 minutes before to 20 minutes after the policy announcement to measure monetary policy surprises. See the Appendix for robustness tests using their data series.

[21] This means that it encompass the so-called "target" and "path" factors (Gürkaynak et al, 2005) of monetary news.

[22] Bean and Jenkinson (2001) suggest that the BoE is more likely to change policy in IR months – what would affect policy expectations. Our sample includes 7 interest rate changes in IR months and 8 in non-IR months. We also control for the sign and size of these interest rate decisions. Eventually, the main result of this paper holds if we only focus on IR months, so is not driven by the potential difference between IR and non-IR months.

[23] One advantage of these financial instruments are that they are available at a high frequency and are directly related to payoff decisions. One drawback however is that they may be affected by term, liquidity and inflation risk premia. Inflation swaps tend to be a better market measure for deriving inflation expectations than inflation-indexed gilts because they are generally less sensitive to term and liquidity premia. As described in our robustness tests below, we correct inflation compensation, the raw measure extracted from inflation swaps, for term, liquidity and inflation risk premia using a regression based approach following the methodology used by Gürkaynak et al. (2010a, 2010b) and Soderlind (2011). This procedure is detailed in the Appendix.

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

[25] Table A1 in the Appendix provides data sources and description while Table A2 some descriptive statistics.

publication identified in t+i with the news component of the MPC decision identified in t. Equation (2) is therefore modified as following:

$$\Delta_w y_t = \alpha + \beta_1 \Delta x_t + \beta_2 \Delta z_{t+i} + \beta_3 \Delta x_t \cdot \Delta z_{t+i} + \varepsilon_t \quad (3)$$

The product of two variables, the MPC (Δx_t) and IR news (Δz_{t+i}), at two different dates raises the question of the window w to consider so as to measure the response of the dependent variable ($\Delta_w y_t$). Figure 2 shows the different options considered and detailed below.

For a MPC meeting on day t during non-IR months, we follow the baseline specification of Hanson and Stein (2015) and compute the change in inflation swaps over a 2-day window from t–1 to t+1 to capture the full market response to the MPC announcement. The implicit assumption is that the full reaction to an MPC announcement might not be instantaneous, particularly for longer term horizons. This could be because investors are uncertain about the implications of the released news and update their beliefs as asset prices and volumes, and media reports reveal others' beliefs. Thus, it could take some time for private agents to process the information content of a policy decision, a statement or an economic report.[26]

For a MPC meeting at date t during IR months, computing the change in inflation swaps over a window from t–1 to t+1 does not enable to test our research question. The IR has not yet been published so by construction it cannot influence the effect of the MPC policy news. A first option is to consider a window that encompasses the full central bank announcement period, from the MPC announcement to the IR publication, so from t–1 to t+i+1. The main advantage is that all relevant information is observed, but this means that the windows considered have different sizes in IR and non-IR months. A second option is to consider the sum of *(i)* the change in inflation swaps around the MPC announcement, so over the window from t–1 to t+1, and *(ii)* the change in inflation swaps around the IR publication, so from t+i–1 to t+i+1. The advantage here is to abstract from the days in between the MPC announcement and the IR publication in case that other data are released. A third option, the most restrictive, is to consider only the change in inflation swaps around the IR publication, so from t+i–1 to t+i+1. It has the benefit of measuring the response of inflation swaps over a window of the same size between IR and non-IR months. Such a window abstracts from the initial response of private agents to MPC monetary surprises and focus specifically on revisions in private beliefs about policy once the IR is published.

3.3. The effect of monetary surprises conditional on IR surprises

We empirically assess whether private agents give monetary surprises a different interpretation when the IR is published. We test the null hypothesis that the publication of the central bank information set, the IR news surprises, modifies private agents' responses to monetary surprises. In equation (3), this would translate into β_3 being significantly different from zero. In the case that $\beta_3 \neq 0$, the sign of β_3 would document how private agents interpret central bank macroeconomic information surprises.

Table 1 presents our results for equation (3) estimated by OLS using daily data.[27] We compute heteroskedasticity robust standard errors. Our sample period goes from October 2004 to July 2015 and covers 130 MPC announcements. The independent variables are the surprise

[26] However, we obtain similar results with a 1-day window (from t-1 to t).

[27] We have estimated single-variable regressions including only MPC surprises (in non-IR or IR months) or IR surprises. Estimates in Table A3 in the Appendix confirm the individual mean effects shown in Table 1. Table A2 also shows that there is no difference in MPC surprises in IR and non-IR months.

component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the three different windows described above.[28]

The first result is that the parameter associated to the interaction term, β_3, is significant at the 2, 3 and 4-year horizons of inflation swaps in all three specifications of window sizes. This means that central bank information surprises do convey some useful information to private agents to interpret monetary surprises such that it modifies the effect of policy. The second result is related to the negative sign of β_3. Thus, whereas a positive 1-SD monetary surprise increases inflation swaps 3-year ahead by 2 bp during non-IR months or in the days before the IR is published, the same positive 1-SD monetary surprise decreases (increases) inflation swaps 3-year ahead by 7 (10) bp if associated with a positive (negative) 10 bp IR surprise.[29] The opposite sign of the two responses suggests a clear difference in the way private agents revise their beliefs about monetary surprises when the IR is published.[30] An interesting result is that monetary policy *alone* has no effect, or even the opposite effect to what is usually expected. This effect is consistent with the signaling channel of monetary policy evidenced by Melosi (2017) and Nakamura and Steinsson (2018) among others. However, when interacted with positive central bank information surprises, the impact of monetary policy has its standard expected effect on inflation expectations. The fact that *(i)* the state-dependent effect materializes at horizons (2 to 4 years) consistent with the policy horizons of central banks and the transmission lags of monetary policy, and *(ii)* the magnitude of the effect gradually decreases with the horizon consistent with the transmission of monetary policy suggests that the main result is economically grounded.

One key issue may affect the estimated state-dependence effect. Both financial markets and policymakers may behave differently in IR and non-IR months. Boguth et al. (2019) show that markets seem to pay less attention to policy decisions that are not followed by a press conference, so that might be true with IR releases as well. From a policymaker perspective, IR months enable more communication. On the econometric side, a limitation of equation (3) is that since the interaction term is equal to zero by construction two times every three observations, this may bias the estimation of the interaction term. Zeros in non-IR months are different from zeros in IR months. The former relates to the absence of macroeconomic information published by the central bank whereas the latter relates to IR news which informational content was expected. However, zeros in non-IR months can be seen as measurement errors since there may be policymakers' speeches in these months that may reveal part of the central bank information set. We test and confirm that the state-dependent effect holds when estimating equation (3) on IR-months only (see Table A4 in the Appendix).

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[28] Estimating equation (3) along the term structure of inflation swaps allows us to assess whether surprises have different effects at different horizons. The term structure could be split into three groups: (i) the short term (i.e. 1 year ahead), which should be barely affected by policy decisions given the transmission lags of monetary policy, (ii) the medium term (i.e. 2-4 years ahead), when policy instruments are generally thought to affect the economy, and (iii) the longer term (i.e. 5 years ahead), when the impact of any monetary decisions should have died out.

[29] The distribution of IR surprises with respect to MPC surprises is uniform. The main result is not driven by a skewed distribution of MPC and IR surprise pairs. There are as many cases where surprise pairs are consistent (negative MPC and IR surprises and positive MPC and IR surprises) than the opposite (positive MPC but negative IR surprises and negative MPC but positive IR surprises) – 51% versus 49% respectively.

[30] The sign of the overall effect of monetary policy depends on the size of the MPC and IR surprises considered. As an extreme case, for very small IR surprises and very large MPC surprises, the overall effect would not be different in both cases (positive and negative IR surprises) and would be positive.

We also estimate a specification of equation (3) where we control for differences between IR and non-IR months in both policy decisions (the sign and size of interest rate changes) and market responses (the conditional volatility of the dependent variable).[31] We have also tested that the state-dependent effect is not driven by outliers (removing the 3 largest MPC and IR surprises), by changes in risk or liquidity premia in inflation swaps. We have also used Rigobon (2003)'s heteroskedasticity-based estimation approach to take into account "background noise" arising from other shocks during the event window considered. Finally, as visible on Figure 1, MPC and IR surprises exhibit some degree of autocorrelation in some sub-periods of the sample. We regress each surprise on its own lags in order to focus specifically on the residual part of each surprise and re-estimate equation (3) with these corrected MPC and IR surprises (see Table A5 in the Appendix).[32]

In addition, we estimate equation (3) with stock price returns (FTSE) and 10-year sovereign yields (Gilts) as dependent variables.[33] The state-dependent effect is confirmed on stock prices considering all months and IR months only, whereas the interaction term for 10-year rates is not significant. We also assess this state-dependent effect with euro area data. ECB policy announcements and Press Conferences (PC) happen on the same day but at different times (13.45 and 14.30 CET), so it is possible to single out monetary and PC surprises using intraday data.[34] Table A6 in the Appendix confirms that the state-dependent effect is at work on stock prices, the exchange rate and long-term rates. A contractionary monetary policy has its expected effects (a positive monetary surprise decreases stock prices and increases the exchange rate and long-term rates) if and only if associated with positive PC surprises.

We have also estimated equation (3) on two different subsamples ending in March 2009, before the policy rate reached its lower bound, and in July 2013, when the forward guidance policy was introduced. It is all the more important to check for this since the first forward guidance announcement was made during the press conference of the release of the IR of the August 1st, 2013. After August 2013, the publication of the IR can therefore be a mix of macroeconomic information news and policy news. We find that the state-dependent result is robust to subsamples when the short-term interest rate is the only policy instrument and when the central bank did not commit to a future policy path or disclosed signals about the future interest rate path. We have also tested that the state-dependent effect is not driven by exceptional events at the heart of the global financial crisis by excluding from the sample the 6 months that followed the Lehman Brothers' bankruptcy (see Table A7 in the Appendix).

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[31] As a placebo test, we also run an exercise where we compare changes in inflation swaps 4 days after the MPC announcement during IR-months (so on the day of the IR publication) to changes on the fourth day after the MPC during non IR-months, when no event happens. Excess trading and volatility on MPC days could bias the comparison. We obtain a similar result when doing so. Estimates are available from the author upon request.

[32] The main result (the negative interaction term) holds on a subsample excluding the episode when IR surprises are autocorrelated and on a subsample ending before that period as shown later (see Table A7 in the Appendix).

[33] Using FTSE returns also enables us to examine whether the state-dependent result is driven by risk premia in inflation swaps or by the possibility that investors that trade inflation swaps follow some heuristics and have biases.

[34] The sample period goes from January 2014 to June 2019. The surprise components of policy announcements and PC are computed as the change in one-year OIS rate in a 30min window around the policy announcement and a 90min window around the PC. The dependent variable is the change in the EuroStoxx50, the EUR/USD exchange rate and German and French 10-year nominal sovereign interest rates over the overall 140min window. Using euro area data has two drawbacks however. First, the information content of press conferences is not orthogonal to the information content of policy announcements. Second, if it takes some time for private agents to process information flows, such tight windows could miss their responses.

3.4. Controlling for macroeconomic news releases and ECB decisions

A potential concern with the specification of equation (3) is that the effect of IR surprises that modifies the impact of monetary surprises could be unrelated to the central bank information set and could instead reflect other macroeconomic news published in between the policy decision and the IR. To address this concern, we augment equation (3) with additional controls. More specifically, we include in equation (4) the news surprises in nine of the most important macroeconomic data releases: employment change, ILO unemployment rate, industrial production, PMI Services, PMI Manufacturing, GDP, average weekly earnings, producer price index (PPI) for output, and Consumer Price Index (CPI) inflation. These surprises are computed as the difference between actual releases and Bloomberg surveys on the days before the release. Table A8 shows that while some series were never released on, or between, MPC and IR dates such as GDP, some other series have been and regularly. For instance, industrial production has been released 30 times on MPC dates over our sample. Earnings and unemployment have been published 27 times each on IR dates. In addition, PPI inflation figures have been 32 times during the days between the MPC and IR dates.

$$\Delta_w y_t = \alpha + \beta_1 \Delta x_t + \beta_2 \Delta z_{t+i} + \beta_3 \Delta x_t \cdot \Delta z_{t+i} + \beta_4 Z_t + \varepsilon_t \tag{4}$$

Z_t comprises the news surprises of the nine macroeconomic data releases. Table 2 presents our results for equation (4) estimated by OLS using daily data. We obtain similar estimates to our baseline results, such that β_3 is significantly different from zero and negative at similar horizons. Although the releases of macroeconomic news certainly play a role in the revisions of private beliefs about policy, the publication of the central bank macroeconomic information set has its own influence on private agents' changes in their interpretation of policy decisions.

In addition to the macroeconomic news released around MPC and IR dates, ECB policy decisions were regularly released on the same day than MPC policy decisions. From October 2004 to July 2015, this situation happened 89 times (see Table A8). It is therefore essential to control that the effect we attribute to MPC surprises comes from BoE rather than ECB decisions. We test an alternative specification of equation (4) in which Z_t comprises either a dummy for when ECB decisions happened on the day of MPC announcements or ECB monetary surprises for these days – measured as the daily change in the one-year OIS rate. The middle and bottom panels of Table 2 show estimates of β_3 when controlling for these 2 variables. The state-dependent effect holds beyond the effect of ECB decisions.

3.5. The timeline of private beliefs' revisions

This subsection investigates the dynamic effect of monetary surprises following the MPC announcement, and in particular, how the IR publication modifies the response of inflation swaps some days later. Our preferred approach is to use local projections as proposed by Jordà (2005) with our externally identified instruments for monetary and IR surprises. This method has become a very popular tool to compute impulse responses because of its robustness to model misspecification and because it can easily account for non-linearities. This method requires estimating a series of k regressions for each horizon, with the estimated coefficient representing the response of the dependent variable at the horizon k to a given exogenous shock at time t. Equation (3) is therefore estimated k times as follows:

$$\Delta_w y_{t+k} = \alpha_k + \beta_{1k} \Delta x_t + \beta_{2k} \Delta z_{t+i} + \beta_{3k} \Delta x_t \cdot \Delta z_{t+i} + \varepsilon_{t+k} \tag{5}$$

From t (the date of the MPC policy announcement) to t+i-1 (the day before the IR publication), equation (5) only comprises the MPC surprises variable (Δx_t) measured similarly for IR and non-IR months. From the day of the IR publication (t+i) and after, equation (5) is fully specified as shown above. The dependent variable, the change in inflation swaps, is considered on a similar window for both IR and non-IR months, what corresponds to the third specification described in section 3.2 with the smallest window.

Figure 3 plots the sequence of the overall effect of monetary surprises on inflation swaps across 6 days. This overall effect corresponds to the β_{1k} coefficient for k = 0 to i-1 when the effect of monetary policy is linear. The overall effect corresponds to the sum of the average effect and the marginal effect when the interaction term is introduced. After the publication of the IR so for k = i to i+2, the effect of monetary surprises is a combination of β_{1k} and β_{3k}. In contrast with estimates of equation (3) that represent the static state-dependent effect of monetary surprises, this timeline of the effect of MPC news is meant to represent in a dynamic fashion how private agents form and revise their beliefs about policy before and after the IR is published. In particular, it is interesting to observe whether the state-dependent effect builds up in the days before the publication of the IR. Such a case would mean that either the IR surprises are not well identified, or that the state-dependent effect captures other pieces of information that are released before the IR publication (in the spirit of the omitted variable bias discussed before).

Figure 3 shows that the effects of monetary surprises in IR and non-IR months are similar until the day before the IR is published. Then, the effects of both monetary surprises diverge. A tightening monetary surprise during IR months, that has no significant effect before the publication of the IR, has a negative effect on inflation swaps when complemented with a positive IR surprise once the IR is published. This dynamic evidence provides additional support for this state-dependent effect of monetary policy.

Overall, these findings suggest that the IR publication thrusts private agents to revise their beliefs about policy. The fact that these findings are at odds with a standard Bayesian updating model or a reaction function-based interpretation of the two information flows suggests that it could be the combination of the macro signal conveyed by the policy announcement and the macroeconomic news released later that drives the overall effect of the policy decision.

3.6. Sensitivity analysis

We first investigate the robustness of the main result to the measures of MPC and IR surprises. We use a different maturity of spot nominal yields for computing the monetary and IR surprises. Assuming that unconventional monetary policy has had a direct effect on asset prices further away along the term structure of interest rates and that forward guidance has disclosed policy signals beyond a 1-year horizon, we use the daily changes in 2-year spot nominal yields to measure monetary and IR surprises. We also use the estimated intraday monetary surprises series of Cesa-Bianchi et al. (2016) to circumvent at maximum the potential interference of confounding factors happening on MPC days. In addition, we use both series of monetary surprises of Miranda-Aggripino (2016). The first one is a standard surprise based on short sterling futures, while the second one controls for some information transfer and information frictions. Estimates shown in Table A9 in the Appendix confirm the main result. It is worth stressing that the effect of monetary surprises on inflation swaps becomes negative when using the orthogonal monetary surprises of Miranda-Aggripino (2016), as expected. However, the state-dependent effect evidenced by the interaction term remains at work: the effect of monetary surprises is magnified with positive IR surprises for instance.

Second, we measure the responses of inflation swaps over a 1-day window (from t-1 to t). This goes against the view that it could take some time for market participants to digest the information content of central bank communication, especially when statements are published around noon and markets close around 5pm. However, considering a 1-day window reduces the scope for other news to interfere with the estimation of the effect of monetary surprises. Table A10 shows that the state-dependent effect does not depend on this assumption.

4. Extensions

4.1. The state-dependent effect conditional on central bank projection surprises

Up to now, central bank information surprises have been measured by market participants' responses to the publication of the IR that captures the central bank's overall assessment of the macroeconomic outlook. However, the mechanism driving the state-dependence in monetary policy effects described in section 2.1 relies on the central bank macroeconomic projections that enter policymakers' reaction function.

BoE's inflation or output projection surprises are identified as the unpredictable component of these projections, conditional on the information available to private agents at the date when these projections are published. Effectively, this comes back to estimate the best in-sample prediction of these variables such that the residuals would be the surprises. A crucial assumption to ensure identification of the effect of central bank projection surprises is that they do not already contain the effect of the contemporaneous policy decision. We exploit the fact that the BoE publishes macroeconomic projections conditioned on the path for the policy instrument implied by financial market interest rates prior to the policy meeting.[35] The methodology and estimates are described in the Appendix.

Equation (3) is estimated with BoE's inflation (or output) projection surprises instead of IR surprises. We are interested in the value and sign of the parameter (β_3) associated with the interaction variable. Table A13 in the Appendix shows that the interaction term is negative and significant for inflation projections but this is less pronounced for output projections. The main result that a tightening monetary surprise has a negative effect on inflation swaps at medium-term horizons if associated with a positive (inflation) surprise holds. The fact that private agents use inflation projections more than output ones to interpret policy decisions may be consistent with a central bank pursing an inflation targeting strategy, like the BoE.

4.2. The state-dependent effect at the monthly frequency

Since policy decisions happen every month, a complementary way to measure the state-dependent effect of monetary policy conditional on the publication of central bank information is to work at the monthly frequency. This has one major advantage. Because policy decisions and the IR (so BoE projections) are released on different days in a given month, working at the monthly frequency enables us to interact monetary and IR (and projection) surprises at the same date – i.e. within the same month. The assumptions about the window size for the dependent variable described in section 3.2 are not required. We measure inflation swaps as the average of all working day observations in each month.

Our empirical model is motivated by models with rational expectations and information frictions. Private inflation expectations are modelled as a linear combination of a prior belief about future inflation, i.e. lagged expectations, and new information relevant for future

[35] Table A11 and Figure A1 in the Appendix show the estimated parameters and the time series of 4-quarter ahead inflation and output projection surprises. Table A12 shows media reports on the day of the three largest values of inflation projection surprises. Table A14 provides complementary analyses.

inflation; namely monetary and central bank information surprises, news shocks and surprises to macroeconomic developments, and macroeconomic variables that are likely to affect future inflation dynamics. Table A15 in the Appendix shows the specification with IR surprises (upper panel) and inflation projection surprises (lower panel). The main result is that the interaction term is significantly different from zero and negative for 1- to 5-year inflation swaps, both when the effect of monetary surprises is conditioned on IR surprises and inflation projection surprises. This state-dependent effect is more significant at the monthly frequency than at the daily frequency and spans over the full term structure of inflation swaps. A tightening monetary surprise reduces (increases) inflation swaps when associated with positive (negative) inflation projection surprises. The main result holds at a lower frequency.

4.3. The state-dependent effect of monetary shocks

Working at the monthly frequency also enables us to estimate monetary shocks – i.e. shocks to the policy instrument – in contrast with high-frequency monetary surprises that are shocks to the information set of private agents. Working with monetary shocks enables us to focus on potential central bank information transfer through actions, not through statements. We follow the Romer and Romer (2004) approach applied to UK data by Cloyne and Huertgen (2016) to identify monetary shocks. These shock series are estimated as residuals from a regression of the policy instrument on the BoE's projections augmented with private forecasts. Blanchard et al. (2013) and Miranda-Agrippino and Ricco (2017) have shown how different information sets modify the econometric identification problem. These monetary shocks are orthogonal to central bank projections but could still convey some information not included in the projections. Because the policy rate is at the ZLB during a significant part of the sample period and monetary policy has taken various dimensions in the meantime, the policy instrument is proxied by a BoE in-house shadow rate that translates unconventional policies into a single variable expressed in the interest rate space and captures the overall stance of monetary policy.[36] This identification and estimation are described in the Appendix.[37]

Table A17 in the Appendix shows that the parameter associated to the interaction term between monetary shocks and central bank information surprises is significantly different from zero and negative. The state-dependent effect is at work over the full term structure of inflation swaps from the 1 to 5-year horizons. It is worth stressing that the magnitude of the effect gradually decreases with the horizon consistent with the transmission of monetary policy. A 25 bp tightening monetary shock reduces inflation swaps by 0.46 percentage point at the 3-year horizon when associated with a 15 bp positive inflation projection surprises, but increases 3-year horizon inflation swaps by 0.50 percentage point when associated with a 15 bp negative inflation projection surprises. Central bank information is therefore processed and interpreted the same way whether we consider monetary surprises or shocks: positive economic news yield a negative effect of a policy tightening on inflation swaps.[38] Finally, we have controlled that the state-dependent effect of monetary policy evidenced here is specific to central bank information and should not be confused with a non-linear effect of monetary policy with the business cycle (see e.g. Tenreyro and Thwaites, 2016).[39]

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[36] For robustness, we also use the ones of Krippner (2013) and Wu and Xia (2016).

[37] Table A16 and Figure A2 in the Appendix show the estimated parameters and the time series of monetary shocks. Tables A18 and A19 provide a sensitivity analysis of the identification of monetary shocks.

[38] See Tables A20 and A21 in the Appendix for a robustness analysis of the main result at the monthly frequency, with a particular emphasis on the information set considered to capture information flows.

[39] Under the assumption that inflation projection surprises are a proxy for the output gap, one could suppose that the amplified effect of monetary shocks with positive surprises captures the effect of monetary policy during

4.4. Dynamic macroeconomic effects

This section investigates the dynamic state-dependent effects of monetary shocks conditional on central bank projection surprises on inflation swaps but also some macroeconomic variables using the local projections method of Jordà (2005). The procedure is described in the Appendix. Figure A3 plots the impulse response over 6 months of inflation swaps 3-year ahead, FTSE returns, CPI and industrial production to a contractionary monetary shock interacted with inflation projection surprises. Monetary shocks interacted with positive or negative projection surprises have statistically different effects on all four variables.[40] These dynamic estimates show that the state-dependent effect of monetary policy conditional on central bank inflation projections is persistent. It also suggests that the role of the publication of central bank information for monetary policy transmission has aggregate effects.

5. Exploring the mechanism at work

The previous two sections provide evidence that the state-dependent effect of monetary policy conditional on the publication of central bank information holds at both daily and monthly frequencies. Table 3 recapitulates the main result as a function of the sign of monetary and central bank information surprises.

The negative sign of the interaction term appears puzzling in light of a standard Bayesian updating model that would predict that the increase in asset prices after a policy tightening – the effect of the signaling channel – should be reinforced by the publication of a positive economic news (i.e. a positive IR surprise), since both signals go in the same direction. The negative sign of the interaction term is also puzzling if we consider a standard reaction function interpretation of policy decisions: the policy tightening coupled with a negative IR news should signal a positive exogenous policy innovation, so asset prices should go down.

One way to shed light on whether the role of central bank information flows for the transmission of monetary policy goes through the signaling effect of monetary surprises is to look at how monetary surprises affect inflation swaps outside IR months. Ehrmann and Sondermann (2012) have shown that central bank communication becomes stale with time passing since the latest release of the IR. Based on their work, we formulate the hypothesis that the effect of monetary surprises on inflation swaps should depend on how far the policy decision is from the last publication of the IR. More precisely, we use the fact that the IR is published once every quarter whereas policy decisions are taken every month. We test the hypothesis that the effect of monetary surprises is dominated by policy signals when the publication of the IR is recent (i.e. the month after the publication of the IR) and is dominated by macro signals when the publication of the IR is more distant (i.e. the second month after the publication of the IR). This pattern in the effect of monetary surprises would be consistent with the idea that central bank information helps private agents solve their signal extraction issue such that the policy innovation is single out from the endogenous response to macroeconomic outlook. We test that hypothesis by estimating the following equation:

$$\Delta y_t = \alpha + \beta_1 \Delta x_t + \varepsilon_t \ \text{ if} \begin{cases} t = IR + 1 \\ t = IR + 2 \end{cases} \quad (6)$$

expansions. However, this assumption relies on the view that business cycles are driven mainly by demand shocks. The data does not support this assumption: the correlation between inflation projection surprises and a standard HP measure of the output gap is null and non-significant.

[40] This is true for inflation swaps from 1 to 5-year ahead.

Equation (6) is estimated with OLS at the daily frequency for MPC announcements. Figure 4 plots the estimates of β_1 for the different maturities of inflation swaps from 1 to 5-year ahead in both IR+1 months and IR+2 months. Monetary policy surprises have a negative effect on inflation swaps at shorter maturities and no effect at longer maturities in the month following the IR publication (IR+1), whereas it has a positive effect on inflation swaps at shorter maturities and no effect at longer maturities in the second month after the IR (IR+2). In the month just after the publication of the IR, policy signals dominate consistent with the idea that central bank information helps private agents solve their signal extraction issue. At the opposite, as central bank information becomes stale in the second month after the publication of the IR, macro signals dominate such that inflation swaps increase after a policy tightening.

This result reinforces the idea that central bank information is used to process monetary surprises and ultimately drives their effects. Two interpretations of the content published by policymakers would explain such a use of central bank information. The first interpretation relates to the fact that, at the date of the policy announcement, private agents only observe the policy decision and decompose the monetary policy surprise between some policy news or some macro signals, which corresponds to the difference between the information sets of the central bank and private agents. However, at the date of the IR publication, private agents are now able to observe central bank projections. They can therefore compare the macro signal they *inferred* from the policy decision with the central bank information surprise they now *observe*. So private agents can update their belief about the decomposition of the monetary surprise. If the positive economic signal conveyed by a tightening policy announcement is reflected in a positive IR surprise some days later, the information content of the economic signal is weak: the same information content can be observed in the IR published. Private agents revise their initial decomposition of the policy announcement such that the information/signaling effect disappears. The tightening policy decision therefore produces negative asset price responses.

The second interpretation relates to the idea that the IR provide signals about the future policy path. The publication of central bank information and macroeconomic projections can be seen as a sort of Delphic forward guidance (see Campbell et al., 2012). This description of forward guidance suggests that this communication policy enables private agents to better form expectations about future policy by describing future macroeconomic fundamentals. Positive IR surprises are therefore both a signal about an improving state of the economy and a tightening of the policy stance. In that respect, when private agents are able to observe central bank projections at the date of the IR publication, they can therefore compare the policy signal they *inferred* from the policy decision with the policy signal they now infer from the IR. So private agents can update their belief about the decomposition of the monetary surprise. If the tightening policy announcement is reflected in a positive IR surprise some days later, the policy signal is strong. Private agents revise their initial decomposition of the policy announcement such that the information/signaling effect disappears. The tightening policy decision therefore produces negative asset price responses. In other words, the Delphic forward guidance signals from the IR offset the information effect of the MPC decisions.

However, there remains a puzzle as the negative interaction term implies that these two interpretations work policy tightening but not for policy easing. As shown in Table 3, the effect the IR has on the interpretation of policy decisions is reversed. We therefore investigate the potential sources of this negative interaction term. We first test whether the effect of monetary surprises on inflation swaps is different for tightening and easing monetary surprises, and whether the effect of information surprises is different for positive and negative IR surprises.

Equation (7) shows the regression estimated to test for such an effect in the case of MP surprises (Δx_t). We also test equation (3) with the same condition about the sign of Δx_t.

$$\Delta y_t = \alpha + \beta_1 \Delta x_t + \varepsilon_t \text{ if } \begin{cases} \Delta x_t > 0 \\ \Delta x_t < 0 \end{cases} \quad (7)$$

The left panel of Figure 5 shows the parameter estimates of equation (7) and of the model augmented with the interaction term (equation 3). Although the confidence interval can greatly vary in the case of the interaction term of equation (3), the point estimates are very similar in both models. The same equation (7) with Δz_t instead of Δy_t and equation (3) are used to test for the hypothesis that positive and negative information surprises may have different effects on inflation swaps. We simply replace the condition on the sign of Δx_t by a condition by the sign Δz_t. The middle panel of Figure 5 shows the parameter estimates of equation (7) and of the model augmented with the interaction term (equation 3) for positive and negative IR surprises. Once again, the point estimates are not significantly different between positive and negative IR surprises in both models.

Another potential source for the negative interaction term relates to the switching interpretation given to information surprises conditional on monetary surprises. We then test whether the effect of information surprises on inflation swaps is different for tightening and easing monetary surprises. Equation (8) is used to test for such a cross-effect.

$$\Delta y_t = \alpha + \beta_1 \Delta z_t + \varepsilon_t \text{ if } \begin{cases} \Delta x_t > 0 \\ \Delta x_t < 0 \end{cases} \quad (8)$$

We estimate a linear version of equation (8) – mixing both positive and negative information surprises (Δz_t) – and an asymmetric version of equation (8) – for either positive or negative information surprises. The right panel of Figure 5 shows the parameter estimates of the linear and asymmetric version of equation (8). We find that IR has a positive effect on inflation swaps after an expansionary monetary surprise but a negative effect after a tightening monetary surprise. To double check that this is not due to a composition effect – i.e. different IR surprises after tightening and expansionary surprises –, we estimate the effect of positive IR surprises only using the asymmetric version of equation (8). We again find that a positive IR has a positive effect on inflation swaps after an expansionary monetary surprise but a negative effect after a tightening monetary surprise. The two effects are significantly different one from the other. This result suggests that central bank information is not interpreted the same way after tightening and easing monetary surprises.[41] The information content of the IR is seen as a policy signal after a tightening monetary surprise whereas it is processed as a macro signal after an expansionary monetary surprise.

These additional tests about the mechanism at work between monetary and information surprises suggest that it may be the combination of the macroeconomic news published and the policy and macro signals conveyed by the policy announcement that drives the overall effect of policy decisions. The signaling effects of monetary policy seems particularly strong and these are affected by the publication of central bank information. In turn, the IR is interpreted differently by private agents conditional on the sign of monetary surprises some days before. This produces this negative interaction term between monetary and information surprises and ultimately drives this state-dependent effect of monetary policy.

[41] We have also tested whether tightening and easing monetary surprises have different effects after the last policy statement's tightening and easing monetary surprises. This is not the case, consistent with the left panel of Figure 5. Estimates are available from the author upon request.

6. Conclusion

This paper investigates the extent to which the effects of monetary policy depend on the macroeconomic information published by the central bank. We document that monetary policy has state-dependent effects on inflation swaps and stock prices when the IR or inflation projections are published in the days following the policy decision. A tightening monetary surprise has a negative impact on asset prices when associated with positive economic news whereas it has a positive effect on asset prices when associated with negative economic news. The latter finding is consistent with the literature about the signaling channel of monetary policy. This paper suggests that private agents' interpretation of policy decisions depends on the combination of the macroeconomic news published and the macroeconomic signal inferred by private agents from the policy announcement. Private agents update their beliefs about policy decisions when the central bank publishes its own macroeconomic information.

This state-dependent effect of monetary policy conditional on the publication of central bank information may have important implications for the transmission and effectiveness of monetary policy. It suggests that providing guidance about the future state of the economy may actually enhance the effectiveness of monetary policy. In addition, publishing economic projections could reduce the adverse effects of expansionary policies – such as the forward guidance policy – that signal a weak expected future economic outlook (see Michelacci and Paciello, 2017, or Andrade et al., 2019).

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Table 1 - The effect of monetary surprises conditional on IR surprises

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
CB-announcement-period window					
Monetary surprises	0.027*	0.025**	0.016**	0.007	-0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.058	0.030*	0.023	0.020	0.017*
	[0.07]	[0.02]	[0.02]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.033	-0.048***	-0.052***	-0.028**	-0.007
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.03	0.25	0.32	0.17	0.04
Effect of a positive monetary surprise with:					
a 10 bp positive IR surprise	0.081	-0.052*	-0.067***	-0.038*	-0.011
	[0.07]	[0.03]	[0.02]	[0.02]	[0.02]
a 10 bp negative IR surprise	-0.026	0.103***	0.099***	0.052***	0.010
	[0.07]	[0.02]	[0.01]	[0.02]	[0.02]
Sum of MPC and IR windows					
Monetary surprises	0.023	0.024**	0.017**	0.008	0.001
	[0.02]	[0.01]	[0.01]	[0.00]	[0.00]
IR surprises	-0.051	-0.002	0.024	0.024	0.02
	[0.14]	[0.03]	[0.02]	[0.02]	[0.01]
Monetary surprises * IR surprises	0.037	-0.044*	-0.045***	-0.023*	-0.005
	[0.07]	[0.02]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.04	0.17	0.33	0.18	0.05
Smallest window (on IR day only)					
Monetary surprises	0.020	0.024**	0.016**	0.007	0.000
	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
IR surprises	0.028	0.026	0.017***	0.007	0.000
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.035	-0.038**	-0.037***	-0.019***	-0.005
	[0.03]	[0.02]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.02	0.25	0.29	0.09	0.00

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, ***p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the different windows considered. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

Table 2 - Controlling for other news releases

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Controlling for macroeconomic data releases					
CB-announcement-period window					
Monetary surprises * IR surprises	0.078	-0.052**	-0.061***	-0.024*	0.008
	[0.06]	[0.03]	[0.02]	[0.01]	[0.01]
Sum of MPC and IR windows					
Monetary surprises * IR surprises	0.018	-0.050**	-0.044***	-0.022*	-0.004
	[0.07]	[0.02]	[0.01]	[0.01]	[0.01]
Smallest window (on IR day only)					
Monetary surprises * IR surprises	0.019	-0.042***	-0.035***	-0.017***	-0.005
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
Controlling for ECB policy decisions					
CB-announcement-period window					
Monetary surprises * IR surprises	0.033	-0.049***	-0.052***	-0.028**	-0.007
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
Sum of MPC and IR windows					
Monetary surprises * IR surprises	0.037	-0.044**	-0.046***	-0.024*	-0.005
	[0.07]	[0.02]	[0.01]	[0.01]	[0.01]
Smallest window (on IR day only)					
Monetary surprises * IR surprises	0.035	-0.038**	-0.037***	-0.019***	-0.005
	[0.03]	[0.02]	[0.01]	[0.01]	[0.01]
Controlling for ECB policy surprises					
CB-announcement-period window					
Monetary surprises * IR surprises	0.034	-0.048***	-0.052***	-0.028**	-0.007
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
Sum of MPC and IR windows					
Monetary surprises * IR surprises	0.037	-0.044*	-0.045***	-0.024*	-0.005
	[0.07]	[0.02]	[0.01]	[0.01]	[0.01]
Smallest window (on IR day only)					
Monetary surprises * IR surprises	0.035	-0.038**	-0.037***	-0.019***	-0.005
	[0.03]	[0.02]	[0.01]	[0.01]	[0.01]

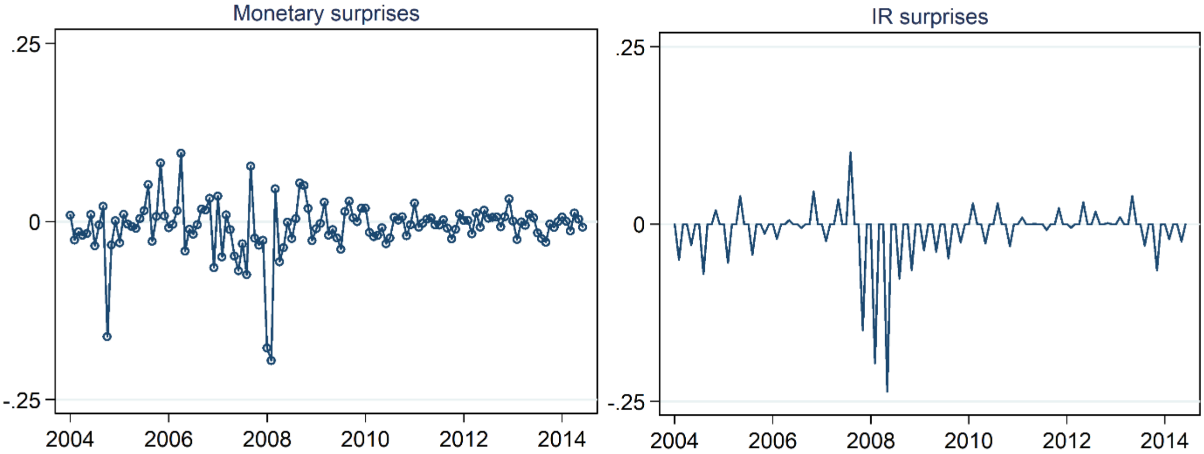
Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. The independent variables are the surprise component of MPC announcements and the surprise component of the IR publication, both computed as the daily change in one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the different windows considered. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony. Equation (3) also includes as controls a dummy for ECB policy decisions (upper panel), ECB policy surprises measured with daily changes in 2-year OIS (middle panel), and surprises to the following nine macro data series: Employment Change 3M, ILO Unemployment Rate 3M, Industrial Production MoM, PMI Services, PMI Manufacturing, GDP QoQ, Avg Wkly Earnings 3M YoY, PPI Output MoM, CPI MoM (bottom panel). These surprises are included correspondingly with the window considered for the dependent variable. All surprises are considered for the CB-announcement-period window, only releases on MPC and IR dates in the second case and finally, releases on MPC dates for the third case. For parsimony, only the key coefficients are reported. Parameter estimates for the ECB decision dummy or surprises and macro surprises are available from the author upon request.

Table 3 - The state-dependent effect of monetary policy

Asset price responses between *t* and *t+i*		
	t+i	
t	Δ+ IR	Δ- IR
Δ+ MPS	-	+
Δ- MPS	+	-

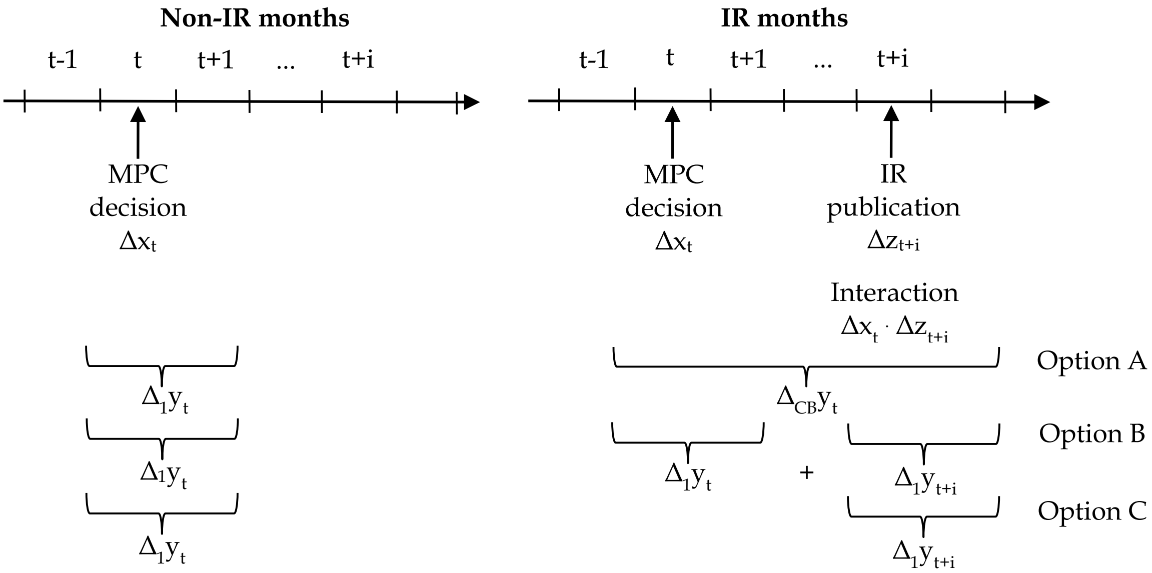
Note : This table recapitulates the main result of this paper from Tables 1 and A13, A16 and A18 in the Appendix. It lists how private agents revise their beliefs about policy, i.e. asset price dynamics, in response to the combination of monetary policy announcements in *t* and the publication of central bank information in *t+i* . For instance, a positive monetary surprise associated with a positive IR surprise yields a negative response of asset prices.

Figure 1 – Monetary and IR surprises



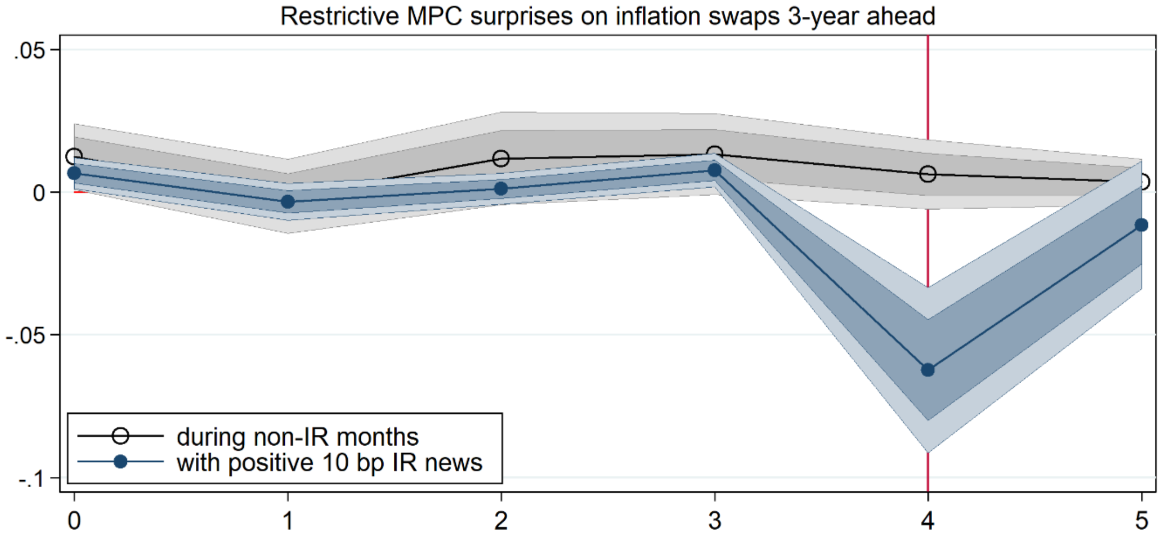
Note: The monetary surprises and the IR publication surprises are computed as the daily change in one-year gilt nominal yields on the day of policy decision announcements and the publication of the Inflation Report.

Figure 2 – The interaction term and windows for the response of inflation swaps



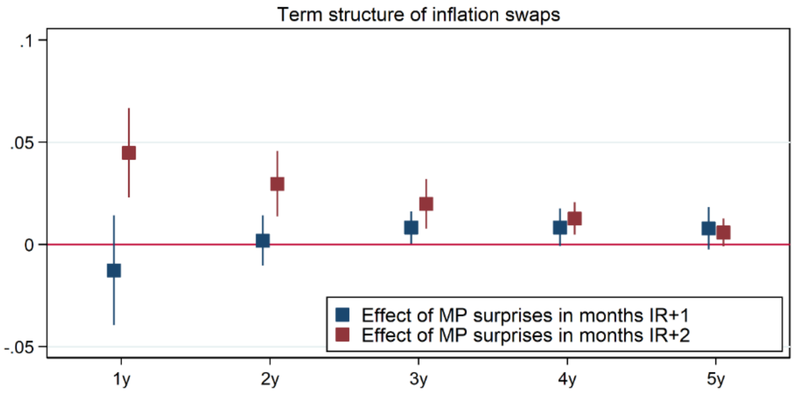
Note: These timelines represent the days around MPC announcement and IR publication dates in IR and non-IR months. The MPC policy announcement and the publication of the IR are separated by 4 days on average. The figure shows the different options for allocating the interaction term to a date and the different options for the window on which to compute the response of inflation swaps. MPC monetary surprises and IR surprises are computed as the daily change in one-year gilt nominal yields. Note that the interaction term during non-IR moths is not represented in this figure since it is zero by construction. As a reminder, the IR is published once every quarter and the two remaining months are non-IR months.

Figure 3 – Timeline of the effects of monetary surprises



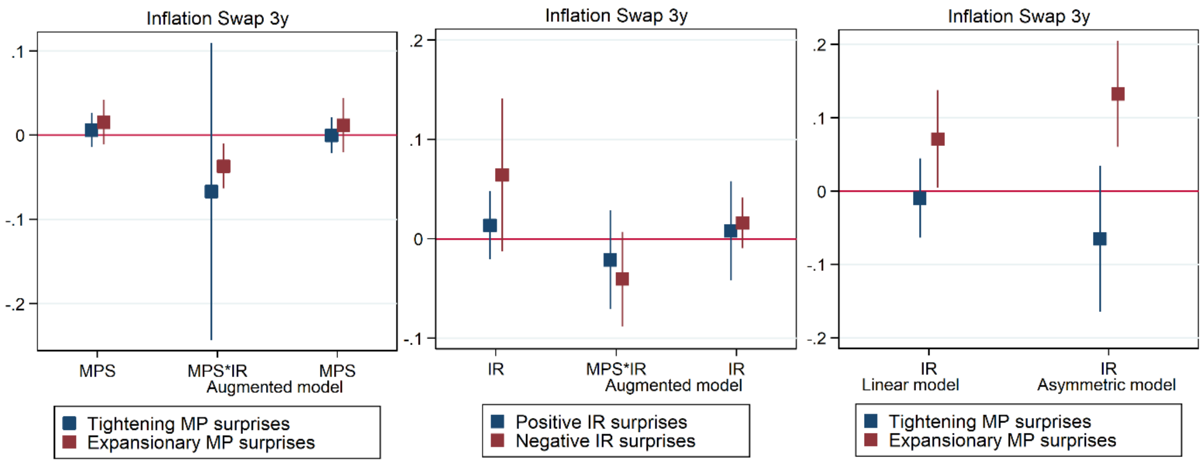
Note: The x-axis represents business days, with the date 0 corresponding to the MPC decision, and the red vertical line to the IR publication. The monetary surprises and the IR publication surprises are computed as the daily change in one-year gilt nominal yields on the day of MPC decisions and of the IR publication. Impulse responses are estimated for each horizon h separately following Jordà (2005) and based on equation (5). Shaded areas represent the 68 and 90% confidence intervals.

Figure 4 – Staleness of central bank information



Note: Based on the OLS estimation of equation (6). This graph shows parameter estimates of the effect of monetary surprises in the month after the publication of the IR (IR+1 – in blue) and in the second month after the IR publication (IR+2 – in red) for different horizons of inflation swaps.

Figure 5 – Testing for non-linear effect of MP and IR surprises



Note: Based on the OLS estimation of equations (3), (7) or (8). The left panel shows parameter estimates of the effect of monetary surprises (β_1) in equation (7) and of the interaction term (β_3) and monetary surprises (β_1) in equation (3) for positive MP surprises (blue dot) and negative MP surprises (red dot). The middle panel shows parameter estimates of the effect of IR surprises (β_1) in equation (7) and of the interaction term (β_3) and IR surprises (β_1) in equation (3) for positive IR surprises (blue dot) and negative IR surprises (red dot). The right panel shows parameter estimates of the effect of IR surprises (β_1) in equation (8) for positive MPC surprises (blue dot) and negative MPC surprises (red dot) in a linear version of equation (8) on the left-hand side and in an asymmetric version of equation (8) that focuses on positive IR surprises only.

APPENDIX
NOT FOR PUBLICATION

Table A1 - Data description

Variable	Source	Description
		Daily data
Swap_h	Bloomberg and Bank of England calculations	Inflation expectation measures derived from inflation swaps. Instantaneous forward inflation rates for annual RPI inflation h years ahead. Monthly average of daily observations.
Monetary surprises	Datastream	Daily change in the 1-year spot nominal interest rate on the day of the policy decision announcement
IR surprises	Datastream	Daily change in the 1-year spot nominal interest rate on the day of the publication of the Inflation Report
FTSE	Datastream	Daily returns of the FTSE 100 index
spot_10y	Datastream	Gilts 10-year spot nominal interest rates
		Monthly data
$E^{BoE}\pi_{t+h}$	Bank of England	Bank of England's modal projections for annual CPI inflation h quarters
$E^{BoE}x_{t+h}$	Bank of England	Bank of England's modal projections for annual GDP growth h quarters ahead, based on market interest rate expectations.
BoE_SR	Bank of England	Bank Rate adjusted for internal estimates of the impact of QE.
BoE_SR1	Wu and Xia (2016)	UK shadow rate estimated using a nonlinear term structure model.
BoE_SR2	Krippner (2013, 2014)	UK shadow rate estimated using a two state-variable yield curve model.
Bank Rate	Bank of England	Bank of England's policy interest rate.
FG	Authors' computation	Dummy that equals 1 when the Forward Guidance policy is in place.
ZLB	Authors' computation	Dummy that equals 1 when the policy rate is at 0.5%.
mc_h	Bank of England	Market interest rate curve used as conditioning path for BoE's macroeconomic projections.
PF_gdp_h	Consensus Forecasts / Survey of External Forecasters	Consensus Forecasts' average projections for annual GDP growth h quarters ahead, for h=1 to 6. Survey of External Forecasters' average projections for annual GDP growth h quarters ahead, for h=8 and 12. Monthly constant interpolation from quarterly frequency.
Oil	FRED	Crude oil spot prices, Brent - Europe. Annual % change.
Sterling	Bank of England	Effective exchange rate index, January 2005 = 100. Annual % change.
CPI	ONS	Annual % change in the Consumer Price Index.
Indpro	ONS	Annual real Industrial Production growth seasonally adjusted.
Netlending	Bank of England	12 month growth rate of monetary financial institutions' sterling net lending to private non-financial corporations (excluding the effects of securitisations and loan transfers) (SA).
Housing	Halifax and Nationwide	Average of (SA) Halifax and Nationwide measures of average house prices. Annual % change.
RPI surprises	ONS and Bloomberg	Difference between the outturn for annual RPI inflation in a given month and the market median forecast 1 month before.
scottiactiv	Scotti (2016)	UK real-time real activity index, capturing the economic conditions.
scottinews	Scotti (2016)	UK real-time surprise index, summarizing economic data surprises.
scottiuncert	Scotti (2016)	UK real-time uncertainty index, measuring uncertainty related to the state
FTSE	Bloomberg	FTSE index. Annual change.
UKmove	Bank of England	The Merrill lynch Option Volatility Estimate (MOVE) Index is a yield

Table A2 - Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Daily data					
Swap1y	2829	2.69	0.55	-1.20	4.08
Swap2y	2829	2.82	0.36	0.17	3.99
Swap3y	2829	2.93	0.29	0.93	3.98
Swap4y	2829	3.04	0.26	1.63	4.01
Swap5y	2829	3.14	0.27	2.34	4.04
MPC surprises	130	0.0	0.04	-0.19	0.10
MPC surprises (IR months)	87	0.0	0.04	-0.18	0.10
MPC surprises (non-IR months)	43	0.0	0.04	-0.19	0.08
IR surprises	43	0.0	0.06	-0.24	0.10
FTSE returns	2829	0.0	1.17	-9.27	9.38
10y yields	2829	3.5	1.07	1.39	5.44
Monthly data					
Swap1y	126	3.13	0.38	1.50	4.15
Swap2y	126	3.07	0.26	2.04	3.72
Swap3y	126	3.02	0.22	2.19	3.57
Swap4y	126	3.02	0.23	2.23	3.42
Swap5y	126	3.05	0.27	2.26	3.50
MPC surprises	126	0.0	0.04	-0.19	0.10
IR surprises	42	0.0	0.06	-0.24	0.10
Exogenous innovations estimated from equations (9) and (12)					
$E^{BoE}\pi_{t+4}$	126	0.0	0.14	-0.51	0.60
$E^{BoE}\pi_{t+8}$	126	0.0	0.06	-0.15	0.30
$E^{BoE}x_{t+4}$	126	0.0	0.13	-0.52	0.47
$E^{BoE}x_{t+8}$	126	0.0	0.12	-0.41	0.42
BoE_SR	125	0.0	0.06	-0.32	0.19
BoE_SR1	125	0.0	0.29	-0.89	1.82
BoE_SR2	125	0.0	0.46	-1.34	2.32
Bank Rate	125	0.0	0.12	-0.49	0.29
mc_1y	125	2.42	2.02	0.22	5.93
mc_2y	125	2.88	1.81	0.28	5.89
mc_3y	125	3.22	1.61	0.56	5.79
PF_gdp_1	126	1.42	1.67	-3.90	3.10
PF_gdp_4	126	1.81	0.73	-0.70	2.60
PF_gdp_8	126	2.30	0.24	1.82	2.63
Oil	126	14.9	35.2	-56.1	86.4
Sterling	126	-1.07	6.49	-21.60	11.00
CPI	126	2.62	1.04	0.00	5.20
Indpro	126	-0.98	3.44	-11.10	5.10
Netlending	126	4.65	8.77	-4.40	19.60
Housing	126	2.71	7.27	-17.10	17.60
RPI surprises	126	0.03	0.17	-0.50	0.70
scottiactiv	126	-0.17	0.62	-2.44	0.51
scottinews	126	-0.08	0.28	-0.96	0.53
scottiuncert	126	0.92	0.32	0.41	1.98
FTSE	126	6.04	15.50	-36.20	51.20
UKmove	126	90.3	32.6	52.6	220.0

Table A3 - Single variable estimations

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
All MPC announcements					
Monetary surprises	0.011	0.013	0.014**	0.010**	0.006
	[0.02]	[0.01]	[0.01]	[0.00]	[0.00]
N	130	130	130	130	130
R^2	0.01	0.03	0.05	0.03	0.01
MPC announcements during non-IR months					
Monetary surprises	0.027	0.022*	0.016*	0.010*	0.005
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
N	87	87	87	87	87
R^2	0.04	0.07	0.05	0.03	0.01
MPC announcements during IR months					
Monetary surprises	-0.014	-0.003	0.010*	0.010*	0.008*
	[0.02]	[0.01]	[0.01]	[0.01]	[0.00]
N	43	43	43	43	43
R^2	0.01	0.00	0.04	0.05	0.03
IR publication (IR months)					
IR surprises	0.013	0.058**	0.045***	0.021**	0.004
	[0.03]	[0.03]	[0.02]	[0.01]	[0.01]
N	43	43	43	43	43
R^2	0.00	0.26	0.40	0.21	0.01

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over a window from t–1 to t+1. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

Table A4 - Estimation on IR months only

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
CB-announcement-period window					
Monetary surprises	0.024	0.030	0.013	-0.004	-0.017
	[0.04]	[0.02]	[0.02]	[0.01]	[0.01]
IR surprises	0.057	0.031	0.023	0.019	0.015*
	[0.07]	[0.02]	[0.02]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.031	-0.045**	-0.054***	-0.036**	-0.018
	[0.05]	[0.02]	[0.02]	[0.01]	[0.01]
N	43	43	43	43	43
R^2	0.03	0.36	0.53	0.37	0.18
Sum of MPC and IR windows					
Monetary surprises	0.007	0.027*	0.017*	0.001	-0.011
	[0.04]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	-0.053	-0.001	0.024	0.023	0.019
	[0.14]	[0.04]	[0.02]	[0.02]	[0.01]
Monetary surprises * IR surprises	0.025	-0.043*	-0.045***	-0.029**	-0.013
	[0.08]	[0.02]	[0.01]	[0.01]	[0.01]
N	43	43	43	43	43
R^2	0.04	0.25	0.62	0.39	0.17
Smallest window (on IR day only)					
Monetary surprises	-0.01	0.024*	0.014**	-0.002	-0.015*
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.025	0.026	0.017***	0.006	-0.001
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.014	-0.038**	-0.038***	-0.026***	-0.016
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
N	43	43	43	43	43
R^2	0.01	0.43	0.71	0.38	0.09

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the different windows considered. By construction, in non-IR months, the window considered around the MPC day is similar in all cases. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

Table A5 - Robustness tests

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Removing outliers					
Monetary surprises	0.019	0.022*	0.020**	0.016**	0.011
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.139*	0.044	0.016	0.016	0.018
	[0.08]	[0.03]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.056	-0.013	-0.050***	-0.054***	-0.047***
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
N	125	125	125	125	125
R^2	0.06	0.05	0.10	0.12	0.11
Controlling for differences between IR and non-IR months					
Monetary surprises	0.028	0.027**	0.016**	0.006	-0.002
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.092	0.041*	0.030*	0.027*	0.023*
	[0.06]	[0.02]	[0.02]	[0.02]	[0.01]
Monetary surprises * IR surprises	0.005	-0.049***	-0.055***	-0.027**	-0.005
	[0.04]	[0.01]	[0.01]	[0.01]	[0.01]
Controls	Yes	Yes	Yes	Yes	Yes
N	130	130	130	130	130
R^2	0.08	0.30	0.41	0.28	0.19
Risk premia correction					
Monetary surprises	-0.001	0.010	0.007	0.004	0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.047	0.025	0.02	0.018	0.017
	[0.06]	[0.02]	[0.02]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.036	-0.046**	-0.052***	-0.031***	-0.012
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.01	0.17	0.26	0.16	0.05
Correcting for the autocorrelation of MPC and IR surprises					
Monetary surprises	0.025	0.026**	0.017**	0.007	-0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.076	0.034	0.02	0.02	0.022*
	[0.06]	[0.02]	[0.02]	[0.02]	[0.01]
Monetary surprises * IR surprises	0.024	-0.051***	-0.055***	-0.030***	-0.007
	[0.03]	[0.02]	[0.01]	[0.01]	[0.01]
N	128	128	128	128	128
R^2	0.04	0.24	0.29	0.16	0.05
Heteroskedasticity based Identification					
Monetary surprises	-0.005	0.035	0.022	-0.003	-0.021
	[0.04]	[0.02]	[0.02]	[0.02]	[0.02]
IR surprises	0.011	0.018	0.023	0.015	0.006
	[0.06]	[0.02]	[0.02]	[0.02]	[0.02]
Monetary surprises * IR surprises	-0.027	-0.061***	-0.053***	-0.037***	-0.022*
	[0.04]	[0.01]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.04	0.26	0.34	0.16	-0.05

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon, for the upper three panels. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the CB-announcement-period window. By construction, in non-IR months, the window considered around the MPC day is similar in all cases. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony. In the first panel, the 3 largest values of MPC surprises and the 3 largest IR surprises have been removed. In the second panel, we control for the conditional volatility of the dependent variable (estimated with a GARCH(1,1)), a dummy that equals 1 when MPC announcements are not followed by the publication of the IR, the actual change in the policy rate to control for the sign and size of the policy decision. The third panel uses inflation swaps corrected for risk premia as dependent variables. The premia correction follows a regression-based method and uses the VIX and the the average of UK major banks' CDS premia. The fourth panel shows estimates when including MPC and IR surprises corrected for autocorrelation. The fifth panel uses a heteroskedasticity-based estimation approach. The sample of "treatment" days for the Rigobon (2003)'s method is all MPC and IR days. The sample of "control" days is all Mondays, Tuesdays and Wednesdays that are not MPC or IR days over our sample.

Table A6 - Alternative data

	1	2	3	4
Alternative UK data				
	All months		IR months only	
	FTSE	10y yields	FTSE	10y yields
Monetary surprises	0.006***	0.025**	0.003	0.023*
	[0.00]	[0.01]	[0.00]	[0.01]
IR surprises	0.000	0.097***	0.000	0.097***
	[0.00]	[0.02]	[0.00]	[0.02]
Monetary surprises * IR surprises	-0.008***	0.018	-0.010***	0.017
	[0.00]	[0.01]	[0.00]	[0.02]
N	130	130	43	43
R^2	0.23	0.26	0.31	0.52
EA data				
	EuroStoxx50	EURUSD	DE_10y	FR_10y
Monetary surprises	0.042	0.133***	0.325	0.610**
	[0.07]	[0.02]	[0.23]	[0.26]
PC surprises	-0.151**	0.189***	1.265***	1.415***
	[0.07]	[0.03]	[0.24]	[0.28]
Monetary surprises * PC surprises	-0.123***	0.038***	0.235***	0.268***
	[0.02]	[0.01]	[0.09]	[0.10]
N	69	69	69	69
R^2	0.37	0.53	0.42	0.46

Note : Heteroskedasticity robust standard errors in brackets. *p < 0.10, **p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different variable. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony. In the UK (upper) panel, 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in the FTSE index and 10-year nominal spot rates over the CB-announcement-period window. In the EA (bottom) panel, the sample period goes from January 2014 to June 2019. The independent variables are the surprise component of policy announcements and the surprise component of the Press Conference (PC), both computed as the change in one-year OIS rate in a 30min window around the policy announcement and a 90min window around the PC, and their interaction. The dependent variable is the change in the EuroStoxx50, the EUR/USD exchange rate and German and French 10-year nominal sovereign interest rates over the overall 140min window.

Table A7 - Subsample estimates

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Subsample before February 2009					
Monetary surprises	0.045***	0.026**	0.010	0.000	-0.007
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.079***	0.022	0.011	0.016	0.021
	[0.02]	[0.02]	[0.03]	[0.02]	[0.02]
Monetary surprises * IR surprises	0.040**	-0.059***	-0.062***	-0.033**	-0.008
	[0.02]	[0.01]	[0.02]	[0.01]	[0.01]
N	52	52	52	52	52
R^2	0.26	0.57	0.57	0.36	0.12
Subsample ending in July 2013					
Monetary surprises	0.028*	0.025**	0.016**	0.007	-0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.067	0.038**	0.029*	0.025*	0.020*
	[0.07]	[0.02]	[0.02]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.039	-0.044**	-0.048***	-0.025**	-0.005
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
N	105	105	105	105	105
R^2	0.04	0.26	0.35	0.20	0.05
Removing the GFC subsample					
Monetary surprises	0.001	0.011	0.012	0.008	0.004
	[0.02]	[0.01]	[0.01]	[0.01]	[0.00]
IR surprises	0.162**	0.048	0.006	0.006	0.012
	[0.08]	[0.03]	[0.02]	[0.02]	[0.01]
Monetary surprises * IR surprises	0.225	0.037	-0.066*	-0.078**	-0.067**
	[0.14]	[0.06]	[0.04]	[0.03]	[0.03]
N	121	121	121	121	121
R^2	0.09	0.04	0.04	0.07	0.07

Note : Heteroskedasticity robust standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the CB-announcement-period window. The third panel uses a sample where the 9 months that followed the Lehman Brothers' bankruptcy are excluded. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

Table A8 - ECB & Macro releases and associated surprises

Variable	Obs	Mean	Min	Max
ECB decisions on MPC dates				
IR months	31	-0.02	-0.17	0.13
Non-IR months	58	0.00	-0.09	0.19
Macro releases and associated surprises on MPC dates				
PPI	2	0.15	0.00	0.30
PMI Services	4	0.18	-1.70	2.10
Ind. Pro.	30	-0.08	-1.40	0.70
Macro releases and associated surprises on IR dates				
Earnings	27	0.02	-0.40	1.90
Ind. Pro.	1	0.30	0.30	0.30
Unemp.	27	0.00	-0.20	0.10
Employment	7	-14000	-103000	64000
Macro releases and associated surprises between MPC and IR dates				
CPI	16	0.01	-0.20	0.30
PPI	32	0.17	-0.50	0.90
Earnings	1	0.60	0.60	0.60
PMI Manuf.	2	-0.65	-3.00	1.70
PMI Services	15	0.11	-2.10	2.40
Ind. Pro.	34	0.04	-1.40	1.70
Unemp.	1	0.20	0.20	0.20

Note : Descriptive statistics for the news surprises in the following nine macroeconomic data series (Employment Change 3M, ILO Unemployment Rate 3M, Industrial Production MoM, PMI Services, PMI Manufacturing, GDP QoQ, Avg Wkly Earnings 3M YoY, PPI Output MoM, CPI MoM) around central bank announcement days.

Table A9 - Alternative monetary and IR surprises

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
2-year nominal spot rates					
Monetary surprises	0.005	0.019*	0.014**	0.005	-0.001
	[0.02]	[0.01]	[0.01]	[0.00]	[0.01]
IR surprises	0.035	0.030	0.017**	0.007	0.000
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.031	-0.034	-0.038**	-0.022***	-0.009
	[0.04]	[0.03]	[0.02]	[0.00]	[0.01]
N	130	130	130	130	130
R^2	0.01	0.18	0.23	0.08	0.01
Cesa-Bianchi, Thwaites and Vicondoa (2016)'s monetary surprises					
Monetary surprises	-0.002	0.019	0.012	-0.001	-0.008
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.016	0.030**	0.024***	0.013**	0.004
	[0.04]	[0.01]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.003	-0.029	-0.025**	-0.020	-0.013
	[0.05]	[0.02]	[0.01]	[0.01]	[0.02]
N	130	130	130	130	130
R^2	0.00	0.23	0.24	0.07	0.01
Miranda-Agrippino (2016)'s monetary surprises					
Monetary surprises	0.035**	0.016**	0.001	-0.003	-0.003
	[0.02]	[0.01]	[0.00]	[0.01]	[0.01]
IR surprises	0.009	0.057***	0.046***	0.022***	0.005
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	-0.017	-0.047***	-0.029**	-0.013**	-0.005
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
N	123	123	123	123	123
R^2	0.05	0.24	0.20	0.06	0.01
Miranda-Agrippino (2016)'s orthogonal monetary surprises					
Monetary surprises	0.03	0.016	-0.002	-0.012**	-0.017**
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
IR surprises	0.008	0.034***	0.030***	0.017***	0.005
	[0.04]	[0.01]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.034	-0.036**	-0.043***	-0.033***	-0.024**
	[0.04]	[0.01]	[0.01]	[0.01]	[0.01]
N	123	123	123	123	123
R^2	0.02	0.24	0.23	0.09	0.04

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the smallest window. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

Table A10 - Changes in inflation swaps over a 1-day window

	1 Swap1y	2 Swap2y	3 Swap3y	4 Swap4y	5 Swap5y
CB-announcement-period window					
Monetary surprises	0.029**	0.025**	0.013	0.003	-0.003
	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
IR surprises	0.058	0.030*	0.023	0.019	0.016*
	[0.07]	[0.02]	[0.02]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.034	-0.049***	-0.054***	-0.030***	-0.008
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.03	0.26	0.30	0.18	0.05
Sum of MPC and IR windows					
Monetary surprises	0.018	0.026**	0.019**	0.009**	0.002
	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
IR surprises	0.015	0.011	0.022*	0.019**	0.011
	[0.07]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	0.024	-0.055***	-0.045***	-0.018*	0.001
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.01	0.32	0.34	0.17	0.02
Smallest window (on IR day only)					
Monetary surprises	0.020	0.023*	0.014*	0.006*	0.001
	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
IR surprises	0.000	0.022	0.026***	0.015**	0.004
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * IR surprises	-0.070***	-0.035**	-0.004	0.005	0.008
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.15	0.27	0.15	0.04	0.01

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. 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 one-year gilt nominal yields, and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the different windows considered. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

A1. The identification and effect of central bank projection surprises

Central bank inflation and output projection surprises are identified as the unpredictable component of these projections, conditional on the information available to private agents at the date when these projections are published. Effectively, this comes back to estimate the best in-sample prediction of these variables such that the residuals would be the surprises. This is similar in spirit to the approach of Romer and Romer (2004) for the policy instrument and applied to UK data by Cloyne and Huertgen (2016).[1]

A crucial assumption to ensure identification of the effect of central bank projection surprises is that they do not already contain the effect of the contemporaneous policy decision. We therefore 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. We estimate these surprises using the following equation (for inflation projections at the horizon h, $\pi_{t,h}^{CB}$, as an example):

$$\pi_{t,h}^{CB} = \phi_0 + \phi_1 i_{t-1}^{CB} + \sum_{h=1}^{3} \phi_{2,h} \pi_{t-1,h}^{CB} + \sum_{h=1}^{3} \phi_{3,h} x_{t-1,h}^{CB} + \phi_4 mc_{t,h} + \phi_5 \Psi_{t-1} + \varepsilon_{t,h}^{\pi_{CB}} \quad (9)$$

where the level of the previous central bank inflation ($\pi_{t-1,h}^{CB}$) and output ($x_{t-1,h}^{CB}$) projections at horizons h = 4, 8 and 12 quarters ahead is included together with the market interest rate curve, $mc_{t,h}$, used as conditioning path for BoE's macroeconomic projections at the same three horizons and a lag of the policy instrument, i_{t-1}^{CB}. The vector Ψ_{t-1} includes a lag of the first principal components of private inflation and output expectations at various maturities and a lag of various macro variables likely to determine future inflation: CPI inflation, industrial production, oil prices, the sterling effective exchange rate, net lending, and housing prices (included as annual growth rates).[2] The timing of the variables in equation (9) is driven by the assumption that projection surprises can affect private expectations and macro and financial variables contemporaneously, so these variables enter with a lag in equation (9). Because the formation of the BoE projections precedes the MPC policy decision, the policy instrument enters with a lag in equation (9). The error term $\varepsilon_{t,h}^{\pi_{CB}}$ reflects the inflation projection surprises.

The inclusion of both private and central bank forecasts in the regression model enables us to deal with an important concern. Private agents and policymakers' information sets include a large number of variables. Forecasts encompass rich information sets. Bernanke et al. (2005) show that a data-rich environment approach modifies the identification of monetary shocks. Forecasts work as a FAVAR model as they summarize a large variety of macroeconomic

[1] The main advantage of this approach over a VAR estimation is that the identification of innovations does not rely on a full set of short-run timing restrictions in a recursive set-up. Only one restriction is required: projections are not a function of the current policy rate and cannot react contemporaneously to it whereas the opposite is true. Moreover, estimating a VAR might also raise the issue of the number of degrees of freedom. Because there is no obvious instrument for these variables, an instrumental variable strategy does not appear relevant.

[2] Private inflation and output expectations are included through their respective first principal components (from a Principal Component Analysis, PCA) using five inflation expectation series from 1 to 5 years ahead, and five output expectation series from 1-quarter to 2 years ahead. Private output expectations are obtained from Consensus Forecasts for 1 to 6 quarters ahead and from the Survey of External Forecasters for 2 years ahead. We use first principal components so as not to include all horizons in the estimated model and then avoid multi-collinearity or losing too many degrees of freedom. First principal components intend to capture the information set of forecasters for all horizons together. The first principal component of inflation forecasts captures 76% of the variance of the underlying series, while the first principal component of output forecasts captures 85%. For robustness purposes, we estimate equation (5) with all individual forecast series together as described later.

variables as well as their expected evolutions. Identifying these projection surprises requires to control for policymakers' and private agents' forward-looking information set.

Since no projections are released during non-IR months, equation (9) is estimated on IR months only without affecting the lag structure. This means that the inflation projections published in early February is regressed on the market curve prior to the February policy decision and on macro variables as of the end of January. The estimated projection surprises therefore have non-zero values during IR months and zeros otherwise, which is consistent with the fact that no revisions in or releases of the BoE's projections happen during these months.[3]

Table A11 - Estimation of projection surprises

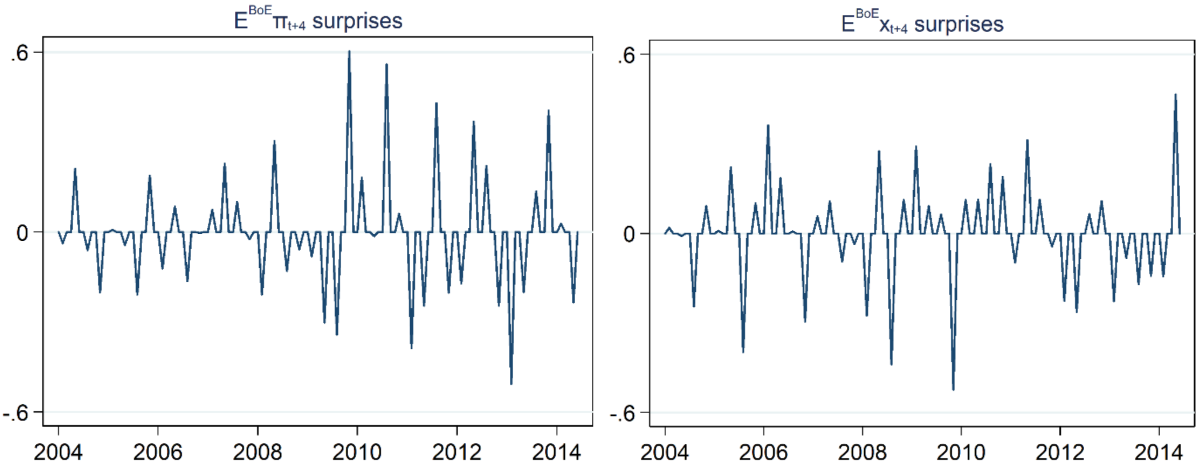
	1	2	3	4
	$E^{BoE}\pi_{t+4}$	$E^{BoE}\pi_{t+8}$	$E^{BoE}x_{t+4}$	$E^{BoE}x_{t+8}$
L.BoE_SR	-0.469**	-0.288***	-0.898***	-0.184
	[0.17]	[0.07]	[0.15]	[0.14]
L.PCA_PF_cpi	-0.076	-0.01	-0.160***	-0.067
	[0.05]	[0.02]	[0.05]	[0.04]
L.PCA_PF_gdp	0.116	0.146***	0.057	-0.047
	[0.10]	[0.05]	[0.09]	[0.09]
$L.E^{BoE}\pi_{t+4}$	-0.205	-0.042	-0.438**	0.107
	[0.23]	[0.10]	[0.21]	[0.19]
$L.E^{BoE}\pi_{t+8}$	0.458	0.465	0.746	-0.819
	[0.80]	[0.35]	[0.70]	[0.67]
$L.E^{BoE}\pi_{t+12}$	-0.793	-0.59	-0.532	1.085
	[0.96]	[0.41]	[0.84]	[0.80]
$L.E^{BoE}x_{t+4}$	0.041	-0.408***	0.207	0.212
	[0.26]	[0.11]	[0.23]	[0.22]
$L.E^{BoE}x_{t+8}$	-0.462	0.357*	0.074	-0.373
	[0.40]	[0.17]	[0.35]	[0.33]
$L.E^{BoE}x_{t+12}$	-0.156	-0.412**	0.561	0.832**
	[0.40]	[0.17]	[0.35]	[0.33]
mc_1y	2.013***	1.143***	0.651	-1.082**
	[0.57]	[0.25]	[0.50]	[0.47]
mc_2y	-2.884*	-1.558**	0.195	2.511**
	[1.45]	[0.63]	[1.27]	[1.20]
mc_3y	1.695	0.902*	0.029	-1.484*
	[1.04]	[0.45]	[0.91]	[0.86]
Constant	4.102**	3.485***	-0.658	-0.792
	[1.47]	[0.63]	[1.29]	[1.22]
Controls: Z_{t-1}	Yes	Yes	Yes	Yes
N	42	42	42	42
R^2	0.81	0.92	0.93	0.77
Predictability of exogenous shock series				
	$E^{BoE}\pi_{t+4}$	$E^{BoE}\pi_{t+8}$	$E^{BoE}x_{t+4}$	$E^{BoE}x_{t+8}$
VAR(3) - F-stat	1.01	0.64	0.89	0.86
VAR(3) - *p* -value	0.45	0.83	0.58	0.61
VAR(6) - F-stat	0.64	0.48	0.78	0.57
VAR(6) - p-value	0.92	0.99	0.78	0.96

Note : Standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. L is the lag operator. Columns 1 to 4 correspond to the OLS estimation of equation (9). The Z vector of controls includes CPI, industrial production, net lending, housing prices as well as oil prices and the sterling effective exchange rate.

[3] As described in our robustness tests below, a potential alternative is to proceed to a constant-interpolation of the BoE's projection surprises for the following two months during each quarter to fill the missing observation gaps. One may argue that the projections remain available during the following two months. We choose to focus on the most conservative choice and keep zeros for the months during non-IR months.

Table A11 shows the estimated parameters of equation (9) and Figure A1 plots the estimated series of 4-quarter-ahead projection surprises. The inflation series shows quite large positive surprises around 2010 and 2011 when inflation in the UK spiked around 4-5%. Table A12 shows the three largest value of inflation projection surprises with media reports on the day of the publication of the IR. This narrative evidence tends to suggest that commentators were actually surprised on these days. In addition, the largest surprises for output projection are on the negative side in 2009 and 2010 consistent with the real effects of the financial crisis. Finally, for these estimated series of exogenous surprises to be relevant, they must be unpredictable from movements in data. The null hypothesis that these estimated series are unpredictable from a set of standard macro variables cannot be rejected, so they are relevant as externally identified instruments for central bank projection surprises.[4]

Figure A1 – BoE's projection surprises



Note: BoE's inflation and output projection surprises are estimated using equation (9). Parameter estimates are shown in Table A11 in the Appendix.

Table A12 - Three largest values of 4Q-ahead inflation projection surprises

IR date	value	commentary
August 2010	0.603	"Bank of England forecasts 'choppy' economic recovery (...) as inflation would stay higher for longer than previously forecasted", BBC News, August 11.
May 2011	0.559	"Inflation could go higher, Mervyn King warns. The rise in the cost of living could become so great that workers rebel against the lack of pay increases." The Telegraph, May 17
November 2013	-0.506	"Inflation had been lower than expected and is on course to fall back to around its target "over the next year or so". Daily Express, November 13.

Note : Media reports at the date corresponding to the three largest Bank of England's 4-quarter ahead inflation projection surprises identified from equation (9).

4 We assess the predictability of projection surprises with Granger-causality type tests and regress these series on a set of standard macro variables: inflation, industrial production, oil prices, the sterling effective exchange rate and net lending growth. The bottom panel of Table A11 in the Appendix shows the F-stats of this test.

Equation (3) is estimated with BoE's inflation (or output) projection surprises replacing IR surprises. We are interested in the value and sign of the parameter (β_3) associated with the interaction variable. Table A13 shows that the interaction term is negative and mostly significant for inflation projections. It is less the case with output projection surprises. The main result that a tightening monetary surprise has a negative effect on inflation swaps at medium-term horizons if associated with a positive (inflation) surprise holds. The fact that private forecasters use inflation projections more than output ones to interpret policy decisions appears consistent with a central bank pursing an inflation targeting strategy, like the BoE. Positive inflation projection surprises themselves have a positive impact on inflation swaps whereas positive output projection surprises have a negative effect on inflation swaps. It suggests that central bank projections may be interpreted as macro signals (in the case of inflation) or policy signals (in the case of output). This finding is consistent with Hubert and Maule (2016).

Table A13 - The effect of monetary surprises conditional on central bank projection surprises

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
$E^{BoE}\pi_{t+4}$ surprises					
Monetary surprises	0.028*	0.034***	0.024***	0.012*	0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
$E^{BoE}\pi_{t+4}$ surprises	0.035	0.028	0.018	0.015*	0.014**
	[0.06]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	0.011	-0.033	-0.037*	-0.022*	-0.008
	[0.04]	[0.03]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.03	0.18	0.20	0.10	0.03
$E^{BoE}\pi_{t+8}$ surprises					
Monetary surprises	0.022	0.036**	0.028**	0.014**	0.002
	[0.01]	[0.01]	[0.01]	[0.01]	[0.00]
$E^{BoE}\pi_{t+8}$ surprises	-0.022	0.009	0.020*	0.019**	0.015**
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}\pi_{t+8}$ surprises	-0.036	-0.043***	-0.037**	-0.026**	-0.018*
	[0.03]	[0.02]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.03	0.18	0.22	0.14	0.06
$E^{BoE}x_{t+4}$ surprises					
Monetary surprises	0.021	0.029**	0.023**	0.012**	0.003
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
$E^{BoE}x_{t+4}$ surprises	-0.007	-0.006	-0.006	-0.01	-0.014**
	[0.03]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}x_{t+4}$ surprises	-0.026	-0.047*	-0.032	-0.013	0.000
	[0.02]	[0.03]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.02	0.18	0.17	0.07	0.02
$E^{BoE}x_{t+8}$ surprises					
Monetary surprises	0.018	0.025**	0.020**	0.011*	0.002
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
$E^{BoE}x_{t+8}$ surprises	0.04	-0.001	-0.018	-0.021**	-0.020***
	[0.04]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}x_{t+8}$ surprises	-0.035	-0.056**	-0.038	-0.018	-0.004
	[0.02]	[0.02]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.04	0.19	0.19	0.10	0.04

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. The independent variables are the surprise component of MPC announcements computed as the daily change in one-year gilt nominal yields, inflation or output projection surprises estimated based on equation (9), and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the CB-announcement-period window. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

We provide two robustness tests for the identification of projection surprises. First, we use a constant-interpolated measure of the projections such that they take the value of the projections released in a given month during the two months after the IR publication. We then estimate equation (9) on all months rather than on IR months only. If projection surprises are well identified, this should not affect the state-dependent estimates. We also use a constant-interpolated measure of the projection *surprises* such that the value of the IR surprise during an IR month is also attributed to the next two non-IR MPC decisions. We test that private agents interpret the next two policy decisions in light of the last information set published, so the state-dependent effect would persist across policy decisions. Table A14 shows the estimates for these two specifications. While the state-dependent effect holds, as expected, with interpolated projections, this is not the case when the last IR surprise is interacted with the next two MPC surprises. The state-dependent coefficient is negative but not significant.

Table A14 - Alternative specifications for estimating projection surprises

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Projections interpolated in equation (9)					
Monetary surprises	0.022	0.028***	0.020***	0.009	0
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
$E^{BoE}\pi_{t+4}$ surprises	-0.021	0.016	0.026**	0.024***	0.019**
	[0.03]	[0.01]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.032	-0.060***	-0.049***	-0.029***	-0.013
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.03	0.23	0.28	0.16	0.05
Projection surprises attributed to following non-IR months					
Monetary surprises	0.027*	0.033***	0.024**	0.011*	0.001
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
$E^{BoE}\pi_{t+4}$ surprises	0.022	0.024	0.017	0.014*	0.013**
	[0.05]	[0.02]	[0.01]	[0.01]	[0.01]
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	0.006	-0.032	-0.035*	-0.021*	-0.008
	[0.04]	[0.03]	[0.02]	[0.01]	[0.01]
N	130	130	130	130	130
R^2	0.02	0.17	0.19	0.10	0.02

Note : Heteroskedasticity robust standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (3) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. The independent variables are the surprise component of MPC announcements computed as the daily change in one-year gilt nominal yields, inflation projection surprises estimated based on equation (9), and their interaction. The dependent variable is the change in inflation swaps at different maturities from 1-year to 5-year over the CB-announcement-period window. The constant is around zero and never significant, so has been removed from each panel for the sake of parsimony.

A3. The state-dependent effect at the monthly frequency

A3.1. 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. Internalising 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,[5] we can bridge these two strands of the literature in a simple and general specification. Private inflation expectations are modelled as a linear combination of a prior belief about future inflation, the past expectations $\pi_{t-1,h}^{PF}$, and new (and potentially noisy) information relevant for future inflation released between t-1 and t, measured by the vector Λ_t.

$$\pi_{t,h}^{PF} = \beta_0 + \beta_L \, \pi_{t-1,h}^{PF} + \beta_\Lambda \, \Lambda_t + \varepsilon_t \qquad (10)$$

This specification allows us to be agnostic about the nature of information frictions.[6] 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.

A first vector MP_t comprises our externally identified instruments for monetary surprises as well as IR surprises or inflation and output projection surprises. It also includes their interaction term. To test our research question, we explicitly assume that these surprises are incorporated in private agents' forecasting function.[7]

A second vector X_t aims to capture news shocks and surprises to macro developments that are contemporaneous to monetary surprises and IR or projection surprises. 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. Following Andersen et al. (2003), this inflation surprises variable is defined as the difference between the actual value of CPI inflation in *t* and the private inflation forecast, measured by the Bloomberg Consensus, formed at date *t-1* for the quarter *t* ($\pi^s = \pi_t - E_{t-1}\pi_t$). This is equivalent to an inflation forecast error and captures the news published between the two dates. Bloomberg provides the market average expected one-month ahead CPI inflation at a monthly frequency. We also capture the presence of macro news by using

[5] 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.

[6] 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. We show in section 6 that including more lags does not alter our main results.

[7] 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.

the three indices estimated by Scotti (2016) for the UK: the real activity index, capturing the state of economic conditions, the surprise index, summarizing economic data surprises, and the uncertainty index, measuring uncertainty related to the state of the economy. Finally, we include two high-frequency financial indices, the UK move and the FTSE, that are supposed to react in real-time to information flows.

A third vector Z_t includes macroeconomic variables that are likely to affect future inflation dynamics and so inflation expectations. It includes CPI inflation, industrial production, oil prices, net lending, the sterling effective exchange rate, and housing prices (included as annual growth rates).

A3.2. The low-frequency effect of monetary surprises

Independently of whether we are interested in the standard effects of monetary policy or in its state-dependent effects, the concern that confounding factors may bias the estimation is more stringent at the monthly frequency. The inclusion of the two vectors X_t and Z_t specifically aims to capture other news and macroeconomic shocks that could occur contemporaneously to the publication of the IR and central bank projections and that would bias the response of inflation swaps. Equation (10) can be written as following:

$$\pi_{t,h}^{PF} = \beta_0 + \beta_L \, \pi_{t-1,h}^{PF} + \beta_{MP} \, MP_t + \beta_X \, X_t + \beta_Z \, Z_t + \varepsilon_t \quad (11)$$

The dependent variable is the level of monthly-average inflation swaps. The vector MP_t comprises the monetary surprises, the IR or BoE's 4-quarter ahead inflation projection surprises and the interaction of both. Monetary surprises and IR surprises are computed as the daily change in one-year gilt nominal yields. Alternatively, projection surprises are computed based on equation (9). We are primarily interested in the β_{MP} parameters which include the coefficient associated with the interaction term between monetary surprises and IR or projection surprises. We estimate equation (11) by OLS for different horizons of the term structure of inflation swaps.[8] Because our dependent variables is now in levels, we compute heteroskedasticity and autocorrelation robust Newey-West standard errors assuming that the autocorrelation dies out after three lags.[9]

Table A15 presents estimates for equation (11). The upper panel shows the specification with IR surprises while the lower panel shows the one with 4-quarter ahead inflation projection surprises.[10] The main result is that the coefficient associated to the interaction term is significantly different zero and negative from 1- to 5-year horizon inflation swaps, both when the effect of monetary surprises is conditioned on IR surprises and inflation projection surprises. This state-dependent effect is more significant at the monthly frequency than at the daily frequency and spans over the full term structure of inflation swaps. A tightening monetary surprise reduces inflation swaps when associated with positive inflation projection surprises, but increases inflation swaps when associated with negative inflation projection surprises. So the main result evidenced at the daily frequency holds at a lower frequency.

[8] Introducing an interaction term in equation (11) resembles the smooth transition model of Teräsvirta (1994) but abstract from defining a specific transition function.

[9] This correction also helps circumvent the "generated regressor" bias due to externally identified instruments.

[10] Estimates show that β_L is positive and significant, consistent with inertia in inflation swaps, suggesting that the information frictions framework is likely to be appropriate for this analysis.

Table A15 - A low frequency model of inflation expectations updating

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Monetary surprises * IR surprises					
Monetary surprises	0.020	0.042*	0.039**	0.027	0.013
	[0.03]	[0.02]	[0.02]	[0.02]	[0.01]
IR surprises	-0.079	-0.035	-0.014	-0.005	0.001
	[0.07]	[0.05]	[0.04]	[0.03]	[0.03]
Monetary surprises * IR surprises	-0.061***	-0.041***	-0.030***	-0.022**	-0.016*
	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]
Lag dep var	0.694***	0.683***	0.742***	0.814***	0.875***
	[0.10]	[0.09]	[0.08]	[0.08]	[0.07]
Constant	1.161**	1.139***	0.903***	0.661**	0.468**
	[0.44]	[0.36]	[0.31]	[0.27]	[0.23]
Controls: X_t & Z_t	Yes	Yes	Yes	Yes	Yes
N	125	125	125	125	125
R^2	0.83	0.78	0.77	0.79	0.84
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises					
Monetary surprises	0.022	0.044*	0.041**	0.027*	0.013
	[0.04]	[0.02]	[0.02]	[0.02]	[0.01]
$E^{BoE}\pi_{t+4}$ surprises	0.316*	0.201*	0.146	0.113	0.087
	[0.18]	[0.12]	[0.10]	[0.08]	[0.07]
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.912***	-0.660***	-0.522***	-0.411***	-0.312***
	[0.29]	[0.19]	[0.14]	[0.12]	[0.10]
Lag dep var	0.704***	0.697***	0.751***	0.816***	0.872***
	[0.09]	[0.08]	[0.07]	[0.06]	[0.06]
Constant	1.101***	1.092***	0.887***	0.667***	0.488**
	[0.37]	[0.31]	[0.25]	[0.22]	[0.19]
Controls: X_t & Z_t	Yes	Yes	Yes	Yes	Yes
N	125	125	125	125	125
R^2	0.84	0.80	0.78	0.80	0.85

Note : Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to equation (7) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. The surprise component of MPC announcements and the surprise component of the IR publication are both computed as the daily change in one-year gilt nominal yields. Inflation projection surprises are estimated based on equation (9). The dependent variable is the level of monthly averaged inflation swaps at different maturities from 1-year to 5-year. 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 real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Z_t includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

A4. The identification and effects of monetary shocks

We follow the Romer and Romer (2004) approach applied to UK data by Cloyne and Huertgen (2016) to identify monetary shocks. These shock series are estimated as residuals from a regression of the policy instrument on the BoE's information set. Blanchard et al. (2013) and Miranda-Agrippino and Ricco (2017) have shown how information frictions modify the econometric identification problem. In the presence of different information sets, exogenous monetary innovations should also be made orthogonal to private agents' information set. We aim to remove the contribution of lagged private forecasts and macroeconomic variables (so that monetary innovations can have contemporaneous effects on these) and the contribution of *contemporaneous* BoE's inflation and output projections (so as to remove the information set of policymakers).

Table A16 - Estimation of monetary shocks

	Δ BoE_SR		
L.BoE_SR	-0.021*	$E^{BoE}x_{t+12}$	0.015
	[0.01]		[0.05]
L.PCA_PF_cpi	0.014***	$\Delta E^{BoE}\pi_{t+4}$	-0.012
	[0.00]		[0.03]
L.PCA_PF_gdp	0.017*	$\Delta E^{BoE}\pi_{t+8}$	0.135
	[0.01]		[0.11]
$E^{BoE}\pi_{t+4}$	0.024	$\Delta E^{BoE}\pi_{t+12}$	-0.094
	[0.03]		[0.13]
$E^{BoE}\pi_{t+8}$	0.071	$\Delta E^{BoE}x_{t+4}$	-0.018
	[0.11]		[0.04]
$E^{BoE}\pi_{t+12}$	-0.004	$\Delta E^{BoE}x_{t+8}$	-0.018
	[0.13]		[0.06]
$E^{BoE}x_{t+4}$	0.052*	$\Delta E^{BoE}x_{t+12}$	0.066
	[0.03]		[0.08]
$E^{BoE}x_{t+8}$	-0.057	Constant	-0.241
	[0.06]		[0.19]
Controls: Z_{t-1} & IR_t		Yes	
N		125	
R^2		0.84	
Predictability of exogenous shock series			
VAR(3) - F-stat	0.42	VAR(6) - F-stat	0.63
VAR(3) - *p* -value	0.97	VAR(6) - p-value	0.92

Note: Standard errors in brackets. *p < 0.10, **p < 0.05, *** p < 0.01. L is the lag operator and Δ the first difference operator. OLS estimation of equation (12). The Z vector of controls includes CPI, industrial production, net lending, housing prices as well as oil prices and the sterling effective exchange rate.

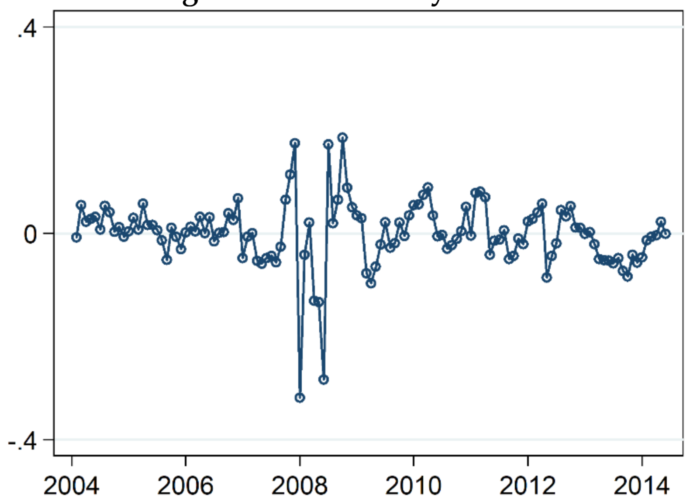
However, the policy rate is at the ZLB during a significant part of the sample period and monetary policy has taken various dimensions in the meantime. The policy instrument is proxied by a shadow rate that translates unconventional policies into a single variable expressed in the interest rate space and captures the overall stance of monetary policy. Our baseline measure is a BoE in-house shadow rate that we compare to the ones of Krippner (2013) and Wu and Xia (2016).[11] We estimate the following equation:

$$\Delta i_t^{CB} = \alpha_0 + \alpha_1\, i_{t-1} + \sum_{h=1}^{3} \alpha_{2,h}\, \pi_{t,h}^{CB} + \sum_{h=1}^{3} \alpha_{3,h}\, x_{t,h}^{CB} + \sum_{h=1}^{3} \alpha_{4,h}\, \Delta\pi_{t,h}^{CB} + \sum_{h=1}^{3} \alpha_{5,h}\, \Delta x_{t,h}^{CB} + \alpha_6\, \Psi_{t-1} + \alpha_7\, IR_t + \varepsilon_t^i \quad (12)$$

[11] The BoE shadow rate is derived by computing a sequence of unanticipated monetary shocks to match the estimated effect of QE on GDP using estimates from Joyce et al. (2011) – see also Section 8.4 of Burgess et al. (2013). The underlying assumption is that QE is a close substitute as a monetary policy instrument to Bank Rate such that the zero lower bound was not an effective constraint on monetary policy over the period in question.

We assume that changes in the policy instrument, Δi_t^{CB}, are driven by the policymakers' response to the level and change in their own inflation ($\pi_{t,h}^{CB}$ and $\Delta\pi_{t,h}^{CB}$) and output ($x_{t,h}^{CB}$ and $\Delta x_{t,h}^{CB}$) projections at horizons h = 4, 8 and 12 quarters ahead. We also include the vector Ψ_{t-1} which encompasses the first principal components of lagged private inflation and output expectations and macro variables (CPI, industrial production, oil prices, sterling effective exchange rate, net lending, and housing prices). We also include a dummy IR_t that takes the value 1 in months when the BoE publishes the IR. The error term ε_t^i reflects monetary shocks. Table A16 in the Appendix shows the estimated parameters of equation (12). Figure A2 plots the series of estimated monetary shocks. As expected, the largest values happen around 2008 and 2009 with strong negative (expansionary) shocks. We have tested that these monetary shocks are unpredictable from movements in macroeconomic data (see bottom of Table A16).

Figure A2 – Monetary shocks



Note: Estimated with equation (12). Parameter estimates are shown in Table A17 in the Appendix.

Equation (11) is estimated with monetary shocks instead of monetary surprises and 4-quarter ahead projection surprises. Table A17 shows that the parameter associated to the interaction term is again significantly different from zero and negative. The state-dependent effect is at work over the full term structure of inflation swaps from the 1 to 5-year horizons. It is worth stressing that the magnitude of the effect gradually decreases with the horizon consistent with the transmission of monetary policy. In this set-up, a 25 bp tightening monetary shock reduces inflation swaps by 0.46 percentage point at the 3-year horizon when associated with a 15 bp positive inflation projection surprises, but increases 3-year horizon inflation swaps by 0.50 percentage point when associated with a 15 bp negative inflation projection surprises. Central bank information is therefore processed and interpreted the same way whether we consider monetary surprises or shocks. Central bank information provides a signal about the rationale for the policy decision and reinforces the interpretation of the observed sign of the monetary shock: a positive economic news confirms a policy tightening.

Table A17 - The state-dependent effect of monetary shocks

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises					
Monetary shocks	-0.003	0.004	0.005	0.001	-0.003
	[0.03]	[0.02]	[0.02]	[0.01]	[0.01]
$E^{BoE}\pi_{t+4}$ surprises	0.111	0.07	0.056	0.041	0.026
	[0.15]	[0.10]	[0.09]	[0.07]	[0.06]
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.992***	-0.675***	-0.481***	-0.372***	-0.288***
	[0.34]	[0.22]	[0.16]	[0.13]	[0.10]
Lag dep var	0.685***	0.679***	0.737***	0.809***	0.869***
	[0.10]	[0.10]	[0.10]	[0.09]	[0.07]
Constant	1.219***	1.201***	0.970***	0.719**	0.520**
	[0.43]	[0.40]	[0.35]	[0.29]	[0.24]
Controls: X_t & Z_t	Yes	Yes	Yes	Yes	Yes
N	125	125	125	125	125
R^2	0.83	0.77	0.74	0.77	0.84
Effect of a positive 25 bp monetary shock with:					
a 15 bp positive $E^{BoE}\pi_{t+4}$ surprise	-1.002***	-0.661***	-0.462***	-0.369***	-0.301***
	[0.39]	[0.24]	[0.17]	[0.14]	[0.12]
a 15 bp negative $E^{BoE}\pi_{t+4}$ surprise	0.982***	0.689***	0.499***	0.375***	0.276***
	[0.33]	[0.23]	[0.18]	[0.14]	[0.10]

Note : Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Inflation projection surprises are estimated based on equation (9). Monetary shocks are estimated based on equation (12). The dependent variable is the level of monthly averaged inflation swaps at different maturities from 1-year to 5-year. 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 real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Z_t includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

We assess the robustness of the estimation of monetary shocks in five ways. First, we estimate monetary shocks with two alternative shadow rate measures by Wu and Xia (2016) and Krippner (2013). Second, because 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, expectations of policy changes may be different in IR and non-IR months. We therefore estimate equation (12) on IR months only but extract residuals for all months. We also proceed to two estimations for IR and non-IR months and extract series of residuals for each that we combine in a single time series. Third, because the ZLB may affect macroeconomic dynamics, the transmission of macroeconomic shocks and the way private agents form their expectations, we estimate equation (12) on two subsamples pre and post ZLB using Bank Rate in the former case and the shadow rate in the latter case. Fourth, we reproduce the monetary shock measure of Cloyne and Huertgen (2016) with shadow rate measures. Fifth, we replace the first principal components of private inflation and output expectations in the vector Ψ_{t-1} by all individual series of private inflation and output expectations at different horizons. Tables A18 and A19 confirm that the state-dependent effect does not depend on these factors.

Table A18 - Robustness: Alternative identifications of monetary shocks

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Alternative policy variables - Benchmark identification					
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-1.414***	-1.133***	-0.916***	-0.705***	-0.519***
	[0.28]	[0.23]	[0.23]	[0.20]	[0.17]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.806**	-0.644**	-0.549**	-0.468**	-0.395***
	[0.33]	[0.28]	[0.24]	[0.19]	[0.14]
Estimation on IR months only / shocks prediction on all months					
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.555	-0.397	-0.27	-0.195	-0.133
	[0.45]	[0.30]	[0.21]	[0.17]	[0.14]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.562***	-0.466***	-0.385***	-0.297***	-0.219***
	[0.16]	[0.11]	[0.09]	[0.08]	[0.07]
Krippner (2015)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.481**	-0.389**	-0.314**	-0.258**	-0.213**
	[0.20]	[0.15]	[0.13]	[0.10]	[0.08]
Two estimations of monetary shocks (IR and non-IR months)					
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.467	-0.333	-0.225	-0.16	-0.108
	[0.37]	[0.25]	[0.18]	[0.14]	[0.12]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.388***	-0.333***	-0.277***	-0.214***	-0.157***
	[0.11]	[0.07]	[0.07]	[0.06]	[0.05]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.408**	-0.316**	-0.251**	-0.207**	-0.173**
	[0.17]	[0.13]	[0.11]	[0.09]	[0.07]

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. *p < 0.10, **p < 0.05, ***p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Inflation projection surprises are estimated based on equation (9). Monetary shocks are estimated based on modified versions of equation (12). The dependent variable is the level of monthly averaged inflation swaps at different maturities from 1-year to 5-year. For parsimony, only the key coefficient is reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1 and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

Table A19 - Robustness: Alternative identifications of monetary shocks

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Two estimations (Pre/Post ZLB)					
Bank Rate + BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.711*	-0.473	-0.37	-0.300*	-0.236*
	[0.42]	[0.30]	[0.23]	[0.17]	[0.12]
Bank Rate + Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.676***	-0.455**	-0.311	-0.226	-0.168
	[0.26]	[0.22]	[0.19]	[0.16]	[0.13]
Bank Rate + Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.106	-0.089	-0.079	-0.073	-0.065
	[0.19]	[0.12]	[0.10]	[0.08]	[0.07]
Cloyne and Huertgen (2016)					
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.224	-0.102	-0.076	-0.072	-0.069
	[0.30]	[0.20]	[0.15]	[0.12]	[0.10]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.426***	-0.331***	-0.281***	-0.220***	-0.159***
	[0.10]	[0.10]	[0.09]	[0.07]	[0.05]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.117	-0.100	-0.098	-0.098	-0.088
	[0.15]	[0.11]	[0.08]	[0.07]	[0.06]
No PCA variables in equations (12)					
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.683	-0.267	-0.098	-0.063	-0.059
	[0.47]	[0.32]	[0.24]	[0.19]	[0.15]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.653***	-0.506***	-0.395***	-0.310***	-0.239***
	[0.18]	[0.16]	[0.14]	[0.11]	[0.09]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.405**	-0.308**	-0.245**	-0.199**	-0.160**
	[0.16]	[0.13]	[0.11]	[0.08]	[0.06]

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. *p < 0.10, **p < 0.05, ***p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Inflation projection surprises are estimated based on equation (9). Monetary shocks are estimated based on modified versions of equation (12). The dependent variable is the level of monthly averaged inflation swaps at different maturities from 1-year to 5-year. For parsimony, only the key coefficient is reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1 and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

A5. Dynamic macroeconomic effects

This section investigates the dynamic state-dependent effects of monetary shocks conditional on central bank projection surprises using the local projections method of Jordà (2005) described in section 3.5. We modify equation (11) in the following respect:

$$\pi^{PF}_{t+k,h} = \beta_{0,k} + \beta_{L,k}\,\pi^{PF}_{t-1,h} + \beta_{MP,k}\,MP_t + \beta_{X,k}\,X_t + \beta_{Z,k}\,Z_t + \varepsilon_{t+k} \qquad (13)$$

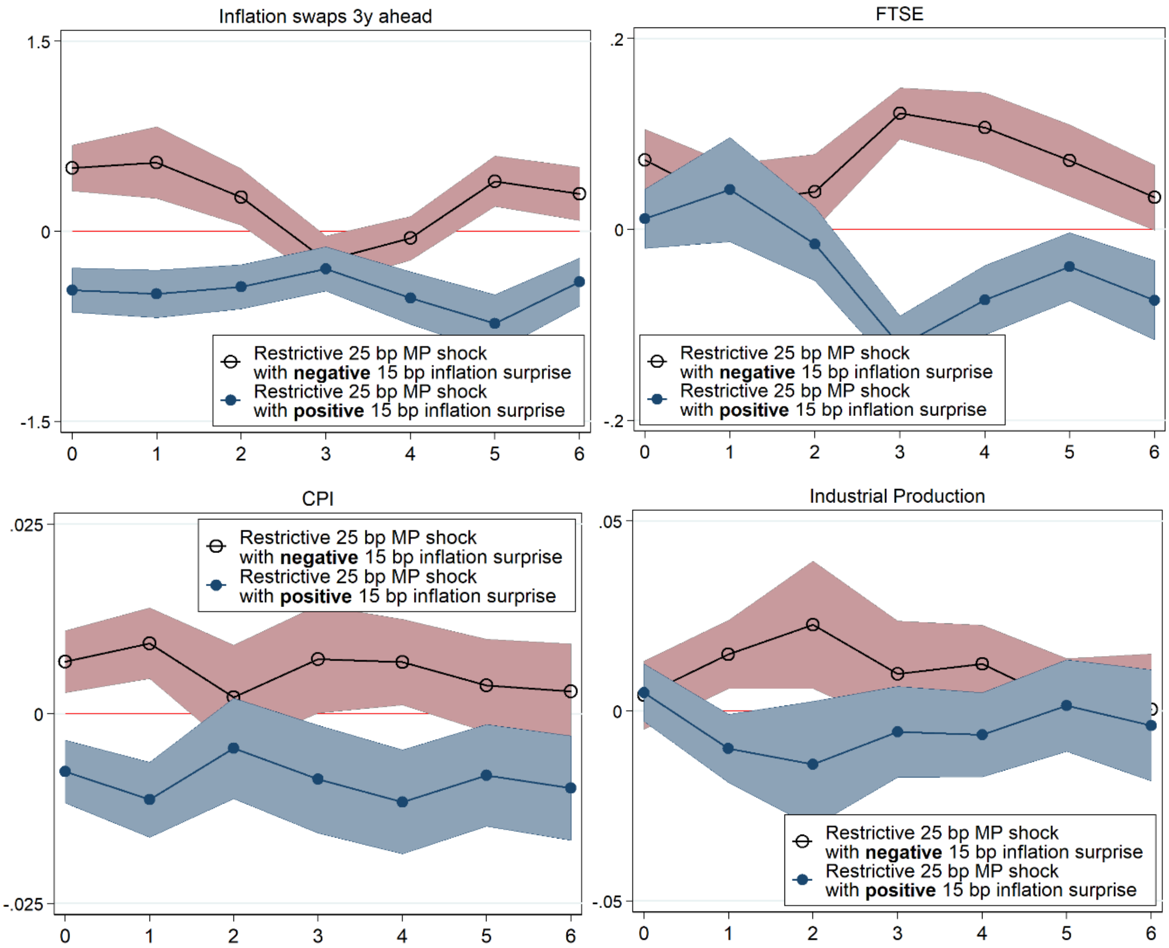
where $\pi^{PF}_{t+k,h}$ is the level of inflation swaps for different maturities h-year ahead at different horizons k, the vector MP_t comprises the monetary shock (ε^{i}_{t}), BoE's 4-quarter ahead inflation projection surprises ($\varepsilon^{\pi^{CB}}_{t}$) and the interaction of both ($\varepsilon^{i}_{t} \cdot \varepsilon^{\pi^{CB}}_{t}$). X_t and Z_t are vectors of news and macroeconomic controls respectively. Equation (13) is estimated with OLS.

Figure A3 plots the impulse response over 6 months of inflation swaps 3-year ahead to a contractionary monetary shock interacted with a positive or negative inflation projection surprises. Monetary shocks associated with positive or negative projection surprises have statistically different effects on inflation swaps during 2 months after the policy decision. This is true for inflation swaps from 1 to 5-year ahead.[12] The positive response of inflation swaps to a contractionary monetary shock when associated with a negative projection surprise is consistent with the findings of Melosi (2017). It is worth stressing that the contemporaneous state-dependent effect is not reversed afterwards. Both responses to monetary shocks gradually vanish across time, but the difference in the cumulated effects over the following months is not offset. These dynamic estimates show that the state-dependent effect of monetary policy conditional on central bank inflation projections is persistent.

Finally, we estimate equation (13) with FTSE returns, CPI and industrial production as dependent variables. Figure A3 plots the impulse response over 6 months of these three variables to a contractionary monetary shock interacted with a positive or negative inflation projection surprises. The state-dependent effect of monetary policy is confirmed with these financial and macroeconomic variables. Restrictive monetary policy has a negative effect on these three variables when interacted with a positive projection surprise. This suggests that the influence of the publication of the central bank macroeconomic information on the monetary policy transmission may have aggregate dynamic effects.

[12] Estimates are available from the author upon request.

Figure A3 – Dynamics macro effects



Note: Impulse responses to a restrictive monetary shock (estimated from equation 12) when interacted with positive (black line) or negative (blue line) inflation projection surprises (estimated from equation 9), over six months, using local projections à la Jordà (2005) as described in equation (13) with 1 S.E. confidence intervals.

A6. Sensitivity analysis

We assess the robustness of the monthly estimates along various dimensions. Starting with the dependent variable, we first consider a more extreme information assumption, replacing the monthly average of all daily observations of inflation swaps by the last observation of the month. By doing so, we ensure that: (i) all shocks or information happening during a month are incorporated in the last observation of the month; and (ii) that there is no endogeneity issue between our left-hand side variable and its potential explanatory variables. Second, we replace inflation swaps by the break-even inflation rates obtained from the difference between inflation-indexed and nominal gilts. Because of liquidity issues on short maturities, inflation-indexed bonds are only considered from the 3-year horizon onwards. Third, we replace the level of inflation swaps by their first difference. Table A20 shows that these alternatives about the dependent variable does not affected the state-dependent result.

We then estimate equation (11) on IR months only for the reasons discussed in section 3.3. Turning to right-hand side variables, we first estimate equation (11) without the vectors X_t and Z_t to examine potential over-identification issues. Second, we augment the vector of macro controls with a Value Added Tax (VAT) dummy which takes the value of one in December 2008, January 2010 and January 2011 when the UK government raised the VAT causing inflation to rise. Third, 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.[13] Fourth, because news shock at time t may raise private inflation expectations as well as central bank inflation projections, the estimation requires controlling for news shocks. Our benchmark specification already includes some instruments for that. Yet, we augment the X_t to include the change in private output and interest rate forecasts between $t-1$ and t, to control for their link with private inflation forecasts.[14] That allows us to control for the changes in private inflation expectations which are related to changes in private beliefs about other macro variables. Fifth, we control for sentiment measures and add the three European Commission (EC)'s UK sentiment measures for the industry, services and consumers. Sixth, we also test a specification in which we include various other macroeconomic, financial and expectation variables to further control that our result is not driven by some omitted variable bias. We add to equation (11) the growth rate of retail prices, input producer prices, output producer prices, wages, import prices, the level of unemployment, capacity constraints, capacity utilization, the (HP filtered) cycle component of real GDP, the change in the VIX and the Saint-Louis Financial Stress Index, and private output expectations at the 2 and 3-years horizon. Table A21 shows that the state-dependent effect evidenced does not stem from an omitted variable bias or from inflation projection surprises capturing the presence of news.

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[13] The Monetary Policy Committee has provided guidance on the setting of future monetary policy since 7 August 2013. For details, see http://www.bankofengland.co.uk/monetarypolicy/Pages/forwardguidance.aspx. 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.

[14] We use Consensus Forecasts and the market curve used by the BoE as conditioning path for its projections for private output and interest rate expectations.

Table A20 - Robustness monthly estimates - Alternative dependent variables

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Last observation of the month					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-1.029***	-0.705***	-0.528***	-0.395***	-0.302***
	[0.29]	[0.24]	[0.19]	[0.14]	[0.11]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.288	-0.251	-0.184	-0.125	-0.089
	[0.22]	[0.17]	[0.14]	[0.11]	[0.09]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.653*	-0.518*	-0.359	-0.226	-0.147
	[0.35]	[0.28]	[0.23]	[0.16]	[0.11]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.348**	-0.179	-0.077	-0.023	0.007
	[0.17]	[0.14]	[0.12]	[0.08]	[0.06]
Gilts					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	.	.	-0.526***	-0.427***	-0.306**
			[0.19]	[0.14]	[0.12]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	.	.	-0.253	-0.301**	-0.340**
			[0.17]	[0.15]	[0.14]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	.	.	-0.257**	-0.199**	-0.115
			[0.12]	[0.09]	[0.08]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	.	.	-0.338**	-0.271**	-0.255***
			[0.15]	[0.12]	[0.09]
First difference					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-1.150**	-0.762**	-0.551**	-0.394**	-0.252**
	[0.48]	[0.31]	[0.23]	[0.17]	[0.11]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.778***	-0.458**	-0.340**	-0.257**	-0.178**
	[0.30]	[0.19]	[0.15]	[0.11]	[0.08]
Wu and Xia (2016)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.543***	-0.419***	-0.324***	-0.244***	-0.169***
	[0.18]	[0.14]	[0.11]	[0.07]	[0.04]
Krippner (2013, 2014)'s UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.483***	-0.379***	-0.297**	-0.234***	-0.178***
	[0.18]	[0.14]	[0.11]	[0.09]	[0.06]

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Inflation projection surprises are estimated based on equation (9). Monetary shocks are estimated based on equation (12). The dependent variable is defined in each panel header for different maturities from 1-year to 5-year. For parsimony, only the key coefficient is reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1 and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

Table A21 - Robustness monthly estimates - Alternative specifications

	1 Swap1y	2 Swap2y	3 Swap3y	4 Swap4y	5 Swap5y
Estimation on IR-months only					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.937**	-0.696**	-0.558**	-0.465**	-0.382**
	[0.34]	[0.25]	[0.20]	[0.18]	[0.15]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-1.072***	-0.813***	-0.631***	-0.508***	-0.404***
	[0.31]	[0.21]	[0.16]	[0.13]	[0.10]
No controls					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-1.064***	-0.771***	-0.611***	-0.469***	-0.353***
	[0.28]	[0.19]	[0.15]	[0.12]	[0.09]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.881**	-0.589**	-0.451**	-0.378***	-0.309***
	[0.37]	[0.23]	[0.18]	[0.14]	[0.12]
Including a VAT dummy					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.918***	-0.663***	-0.524***	-0.414***	-0.317***
	[0.30]	[0.20]	[0.15]	[0.12]	[0.10]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.991***	-0.676***	-0.482***	-0.373***	-0.288***
	[0.34]	[0.22]	[0.16]	[0.13]	[0.10]
Including dummies for FG dates					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.931***	-0.667***	-0.525***	-0.414***	-0.314***
	[0.29]	[0.19]	[0.14]	[0.12]	[0.10]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.990***	-0.675***	-0.481***	-0.372***	-0.289***
	[0.35]	[0.22]	[0.16]	[0.13]	[0.10]
Change in private output and interest rate forecasts between *t-1* and *t*					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.976**	-0.680***	-0.530***	-0.422***	-0.325***
	[0.37]	[0.24]	[0.18]	[0.14]	[0.11]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-1.084**	-0.759**	-0.549**	-0.421**	-0.322**
	[0.42]	[0.29]	[0.22]	[0.17]	[0.13]
Including EC sentiment measures					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.863***	-0.649***	-0.521***	-0.411***	-0.311***
	[0.29]	[0.20]	[0.15]	[0.12]	[0.09]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.985***	-0.665***	-0.473***	-0.368***	-0.288***
	[0.36]	[0.23]	[0.17]	[0.13]	[0.10]
More macro controls					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.941**	-0.673**	-0.507***	-0.370**	-0.250**
	[0.42]	[0.26]	[0.19]	[0.15]	[0.11]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.924***	-0.590***	-0.399***	-0.287**	-0.202**
	[0.29]	[0.19]	[0.15]	[0.11]	[0.09]

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to modified versions of equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Inflation projection surprises are estimated based on equation (9). Monetary shocks are estimated based on equation (12). The dependent variable is the level of monthly averaged inflation swaps at different maturities from 1-year to 5-year. For parsimony, only the key coefficient is reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

A7. Correcting market-based expectation measures

We aim to derive accurate estimates of market-based measures of inflation expectations by correcting inflation compensation, as measured by inflation swaps, for term, liquidity and inflation risk premia. Market-based measures of inflation compensation are an appropriate indicator of inflation expectations if investors are risk neutral and there is no liquidity premium. However, that is unlikely to be the case, and these premia might have sizable values and be time-varying. We use a model-free regression approach to correct our compensation measure, rather than a no arbitrage approach based on term-structure models.

Gürkaynak et al. (2010a, 2010b) decompose inflation compensation, $\pi_{t,h}^{COMP}$, obtained from inflation swaps maturing h-years ahead into: expected inflation, $\pi_{t,h}^{PF}$, a liquidity premium, $\varphi_{t,h}^{l}$, that investors demand to encourage them to hold these assets when they are illiquid, and an inflation uncertainty premium, $\varphi_{t,h}^{ir}$, that compensates investors for bearing inflation risk. We include a term premium, $\varphi_{t,h}^{risk}$, compensating investors for holding a risky asset.[15] Assuming t is the time subscript and h is the horizon, this breakdown can be written:

$$\pi_{t,h}^{COMP} = \pi_{t,h}^{PF} + \varphi_{t,h}^{risk} + \varphi_{t,h}^{l} + \varphi_{t,h}^{ir} \qquad (14)$$

We estimate a linear regression model of inflation compensation on proxy measures capturing the different premia. In the spirit of Chen, Lesmond and Wei (2007) who control for risk premium using bond ratings, the credit risk premium is proxied by the Libor-OIS spread and by the average of UK major banks' CDS premia. Those measures should capture the riskiness of holding financial instruments, especially during the global financial crisis. The liquidity premium is proxied by the FTSE Volatility index (the UK-equivalent of the VIX), following Gürkaynak et al. (2010b) and Soderlind (2011). For the inflation risk premium, we use the implied volatility from swaptions – options on short-term interest rate swaps – maturing in 20 years which captures inflation uncertainty as Soderlind (2011).[16] This leads us to estimate the following equation:

$$\pi_{t,h}^{COMP} = \alpha + \beta_h^{s}\, spread + \beta_h^{cds}\, cds + \beta_h^{f}\, ftsev + \beta_h^{i}\, impvol + \varepsilon_{t,h}^{COMP} \qquad (15)$$

We estimate equation (15) using OLS for each horizon of inflation compensation from 1 to 5 years ahead. We use monthly observations because of data availability constraints for the independent variables used. The term, liquidity and inflation risk premia – directly related to

15 The term premium has been neglected in most of the literature so far for two reasons. First, most of the studies focus on US treasury bonds and TIPS, and therefore implicitly assume there is no credit risk, those bonds being considered as risk-free (see Gürkaynak et al. 2010b). Second, when considering swap contracts to derive inflation expectations, the collateral is supposed to remove any potential credit risk. However, in a post-Great Recession sample in which sovereign bonds have been shown to be not as risk-free as previously thought and collateral value may have changed rapidly, we explicitly assess whether proxies for credit risk correlate with supposedly risk-free inflation compensation rather than assuming ex ante the absence of a term premium.

16 The LIBOR (3-Month London Interbank Offered Rate) and OIS (3-Month Overnight Indexed Swap rates) measures are obtained from FRED and Thomson DataStream. The CDS measure is the unweighted average of the five-year CDS premia for the major UK lenders from Markit Group Limited and BoE calculations. The FTSEvol measure is the FTSE 100 Implied Volatility Index (3 months constant maturity) from Bloomberg. The ImpVol20 measure is the at-the-money implied volatility of 1 year LIBOR swaptions for 20 years constant maturity, from Barclays Live. All variables are available as monthly average of daily observations.

inflation uncertainty – should all push inflation compensation up.[17] So we expect the coefficients on the LIBOR-OIS spread, CDS premia, the FTSE Volatility index (*ftsev*) and implied volatility (*impvol*) variables to be positive.[18] We also expect the term and inflation risk premia to increase with the maturity of the swap. We estimate equation (15) on the full sample and on two subsamples pre and post ZLB. Because the ZLB may affect the transmission of shocks and macro and financial dynamics, the pricing relationship of premia may also change pre and post ZLB. Table A22 shows the estimated coefficients for each maturity of the term structure of inflation swaps.

Using these estimated parameters, we adjust the inflation compensation series by subtracting the fitted values of the contributions of the term, liquidity and inflation risk premia to obtain corrected inflation expectation series. Figure A4 in the Appendix shows on the left-hand side the raw inflation compensation series and the corrected inflation expectations series (either with constant pricing or pre/post ZLB pricing), and on the right-hand side the evolution of the estimated term premium (in blue), the liquidity premium (in red) and the inflation risk premium (in green) in the constant pricing estimation.[19]

While the risk proxies started to become non-null and positive in mid-2007, they had effects of different signs for short and long maturities during the financial turmoil of late 2008: they had a negative contribution to inflation compensation when financial stress was most acute after Lehman Brothers' collapse for maturities under 6-years, pushing inflation compensation to negative values, whereas their effects remained positive for longer maturities. After this episode of severe financial stress, the term premium had a positive contribution for all maturities of around 20-50 basis points. The liquidity premium spiked at almost 120 basis points for longer maturities in the second half of 2008 and remained elevated at around 40-50 basis points after that. The inflation risk premium has declined over time, particularly at longer maturities, and became negative during 2011 (moving from +20 basis points to -10 basis points), which might be associated with the implementation of QE. Overall, the correction results in flatter series for inflation expectations and in lower inflation expectations at the longer horizons for which the difference between the unadjusted and adjusted series is larger.

For comparison, D'Amico, Kim and Wei (2010) find that the liquidity premium on US TIPS has varied between 0 and 130 basis points. Gürkaynak et al. (2010b) find that the liquidity premium has varied between 0 and 140 basis points. Risa (2001) finds an inflation risk premium in the UK of around 170 basis points, and Joyce et al. (2010) estimate it to be between 75 and 100 basis points. Ang et al. (2008) find an inflation risk premium of between 10 and 140 basis points in the US over the last two decades. Finally, Guimarães (2012) finds a total combined premium of 190 basis points over 1985-1992 and of 30 basis points over 1997-2002 for 10-years inflation compensation derived from UK gilts.

Table A23 shows the estimates of equation (11) when considering these corrected measures of inflation expectations. The state-dependent effect of monetary policy holds. We finally assess the robustness of this correction in two ways. First, we correct inflation compensation

[17] This is in contrast to inflation compensation derived from inflation indexed bonds, for which we would expect the liquidity proxy to have a negative coefficient, because they are generally less liquid than nominal bonds.
[18] Because these proxies might be correlated with the business cycle, we use an alternative methodology based on survey expectation measures that do not contain these various premia by construction. We consider the predicted value of market-based expectations when regressed on survey expectations, which we use as instruments.
[19] The constant in equation (15) may include other constants related to term, liquidity or inflation risk. This does not invalidate the main result since the mean of inflation expectations has no effect when estimating equation (11). However, the series on the left-hand side of Figure A4 should be considered cautiously and are indicative only.

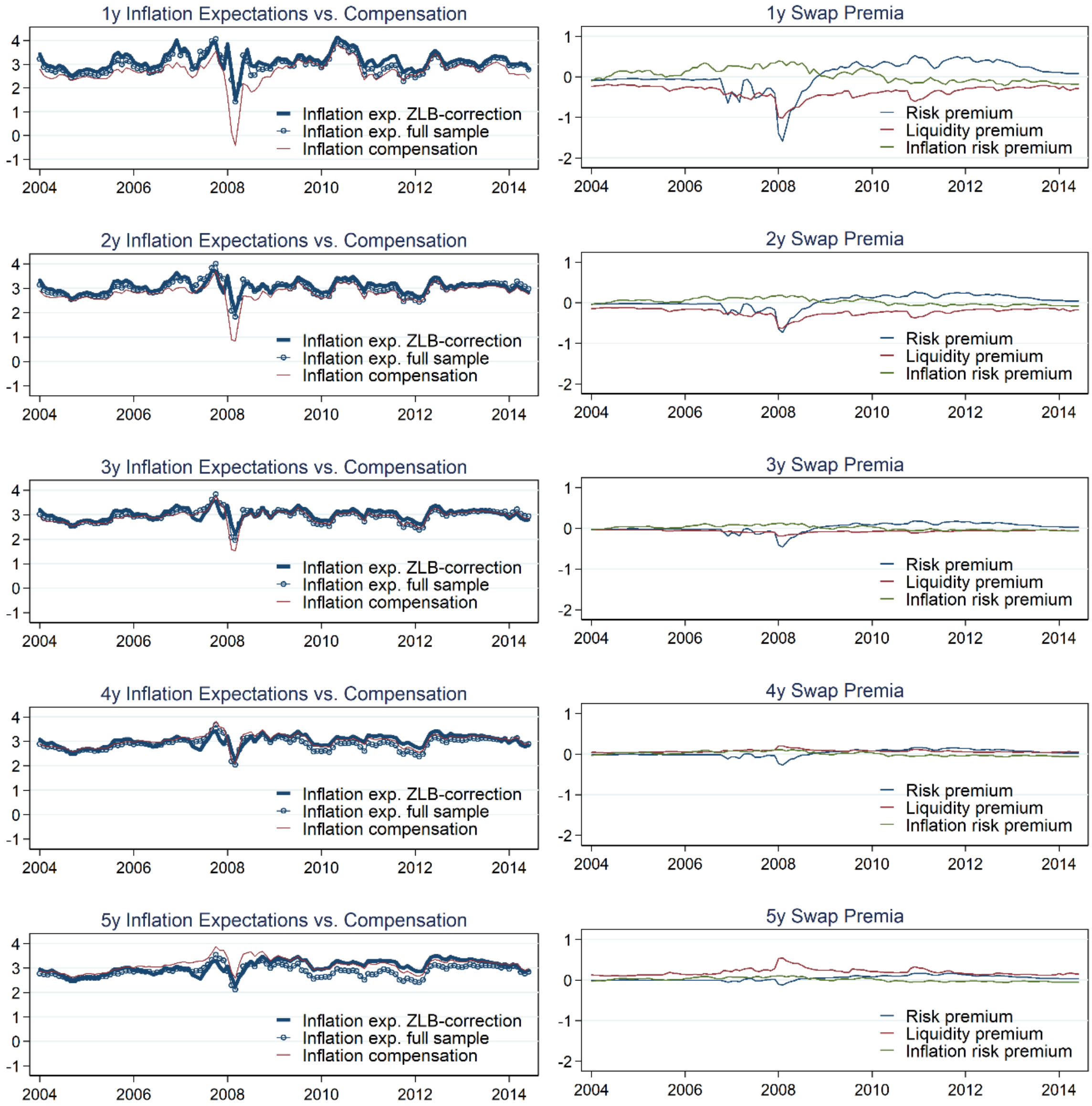
measures for term, liquidity, inflation risk premia on the full sample, therefore assuming a constant pricing of these premia. Second, because central banks may intend to affect the inflation risk premium as well as inflation expectations, we compute adjusted series for term and liquidity premia only. Table A24 shows that the state-dependent effect of monetary policy is robust to these corrections of inflation swaps.

Table A22 - Correction of raw market-based measures for premia

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Two subsamples					
Pre ZLB sample					
LIBOR-OIS	-0.867**	-0.732**	-0.597**	-0.465**	-0.347*
	[0.42]	[0.30]	[0.25]	[0.21]	[0.19]
CDS	0.996***	0.963***	0.846***	0.733***	0.637***
	[0.29]	[0.21]	[0.17]	[0.15]	[0.13]
FTSE-Vol	-0.044*	-0.030*	-0.019	-0.009	-0.001
	[0.02]	[0.02]	[0.01]	[0.01]	[0.01]
ImpVol20	-0.037*	-0.028*	-0.027**	-0.027**	-0.027***
	[0.02]	[0.02]	[0.01]	[0.01]	[0.01]
Constant	3.064***	3.031***	2.965***	2.889***	2.825***
	[0.25]	[0.18]	[0.15]	[0.13]	[0.11]
N	53	53	53	53	53
R^2	0.53	0.51	0.45	0.44	0.55
Post ZLB sample					
LIBOR-OIS	-1.183***	-0.174	0.138	0.304**	0.396***
	[0.26]	[0.17]	[0.15]	[0.14]	[0.14]
CDS	0.219**	-0.08	-0.167***	-0.207***	-0.232***
	[0.09]	[0.05]	[0.05]	[0.05]	[0.05]
FTSE-Vol	-0.017	-0.003	0.006	0.009	0.011
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
ImpVol20	-0.030**	0.006	0.011	0.006	0.000
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Constant	3.186***	3.099***	3.054***	3.121***	3.217***
	[0.18]	[0.12]	[0.10]	[0.10]	[0.10]
N	73	73	73	73	73
R^2	0.40	0.22	0.16	0.26	0.40
Full sample					
LIBOR-OIS	-0.881***	-0.412***	-0.263*	-0.166	-0.096
	[0.20]	[0.15]	[0.14]	[0.13]	[0.12]
CDS	0.349***	0.170***	0.117**	0.095**	0.084*
	[0.07]	[0.06]	[0.05]	[0.05]	[0.04]
FTSE-Vol	-0.021*	-0.013	-0.004	0.004	0.011
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
ImpVol20	-0.030***	-0.014*	-0.01	-0.009	-0.009
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Constant	2.982***	3.005***	2.952***	2.906***	2.875***
	[0.13]	[0.10]	[0.09]	[0.08]	[0.08]
N	126	126	126	126	126
R^2	0.46	0.29	0.12	0.06	0.17

Note : Standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (15) estimated with OLS for a different horizon.

Figure A4 – Raw and corrected inflation expectations (in %) and the predicted values of the three premia (in pp)



Note: The first row is for 1-year ahead inflation expectations, the second for 2-years ahead, and so on. Inflation expectations with the ZLB correction correspond to the upper two panels of Table A24 whereas inflation expectations estimated on the full sample correspond to the lower panel of Table A24 The different premia on the right-hand are the full sample ones.

Table A23 - Correcting inflation swaps for risk, liquidity and inflation risk premia

	1	2	3	4	5
	Swap1y_c	Swap2y_c	Swap3y_c	Swap4y_c	Swap5y_c
Monetary surprises * IR surprises					
Monetary surprises	-0.044	-0.013	-0.003	-0.002	-0.001
	[0.06]	[0.04]	[0.03]	[0.03]	[0.02]
IR surprises	-0.035	0.005	0.017	0.02	0.021
	[0.06]	[0.04]	[0.03]	[0.03]	[0.02]
Monetary surprises * IR surprises	-0.051***	-0.031***	-0.023**	-0.016**	-0.009
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Lag dep var	0.728***	0.739***	0.765***	0.807***	0.833***
	[0.08]	[0.08]	[0.08]	[0.07]	[0.06]
Constant	0.683	0.619*	0.578*	0.534*	0.538**
	[0.45]	[0.35]	[0.31]	[0.27]	[0.24]
N	125	125	125	125	125
R^2	0.59	0.58	0.61	0.73	0.85
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises					
Monetary surprises	-0.038	-0.007	0.002	0.003	0.002
	[0.06]	[0.04]	[0.03]	[0.03]	[0.02]
$E^{BoE}\pi_{t+4}$ surprises	0.228	0.126	0.075	0.038	0.009
	[0.15]	[0.10]	[0.09]	[0.07]	[0.06]
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.755**	-0.519**	-0.395**	-0.293**	-0.185*
	[0.34]	[0.24]	[0.19]	[0.15]	[0.10]
Lag dep var	0.721***	0.722***	0.735***	0.778***	0.811***
	[0.08]	[0.08]	[0.07]	[0.06]	[0.06]
Constant	0.708*	0.701**	0.704**	0.654**	0.634***
	[0.40]	[0.32]	[0.29]	[0.25]	[0.23]
N	125	125	125	125	125
R^2	0.59	0.57	0.59	0.72	0.84
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises					
Monetary shocks	-0.100***	-0.057*	-0.035	-0.026	-0.023
	[0.04]	[0.03]	[0.03]	[0.02]	[0.02]
$E^{BoE}\pi_{t+4}$ surprises	0.04	0.021	0.004	-0.017	-0.033
	[0.11]	[0.08]	[0.07]	[0.06]	[0.05]
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.598***	-0.346***	-0.235**	-0.190***	-0.143**
	[0.20]	[0.11]	[0.09]	[0.07]	[0.06]
Lag dep var	0.696***	0.670***	0.687***	0.750***	0.802***
	[0.08]	[0.09]	[0.09]	[0.07]	[0.06]
Constant	0.833**	0.891**	0.871***	0.759***	0.676***
	[0.40]	[0.34]	[0.30]	[0.26]	[0.23]
N	125	125	125	125	125
R^2	0.63	0.59	0.59	0.71	0.84

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Monetary and IR surprises are computed as the daily change in one-year gilt nominal yields. Inflation projection surprises are computed from equation (9). Monetary shocks are computed from equation (12). The dependent variable is the change in monthly averaged inflation swaps at different maturities from 1-year to 5-year corrected for risk, liquidity and inflation risk premia as described in section A6 in the Appendix. For parsimony, only the key coefficients are reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1 and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

Table A24 - Robustness: Alternative dependent variables

	1	2	3	4	5
	Swap1y	Swap2y	Swap3y	Swap4y	Swap5y
Constant pricing of premia correction					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.936***	-0.681***	-0.527***	-0.395***	-0.274***
	[0.34]	[0.21]	[0.15]	[0.12]	[0.10]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.831**	-0.575***	-0.429**	-0.355**	-0.297***
	[0.33]	[0.21]	[0.17]	[0.14]	[0.11]
Without correcting for the inflation risk premium					
High-Frequency monetary surprises					
Monetary surprises * $E^{BoE}\pi_{t+4}$ surprises	-0.967***	-0.690***	-0.533***	-0.400***	-0.279***
	[0.33]	[0.20]	[0.15]	[0.12]	[0.10]
BoE's UK shadow rate					
Monetary shocks * $E^{BoE}\pi_{t+4}$ surprises	-0.838**	-0.576***	-0.433**	-0.360**	-0.302***
	[0.34]	[0.22]	[0.17]	[0.14]	[0.11]

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to equation (11) estimated with OLS for a different horizon. The sample period goes from October 2004 to July 2015. Monetary and IR surprises are computed as the daily change in one-year gilt nominal yields. Inflation projection surprises are computed from equation (9). Monetary shocks are computed from equation (12). The dependent variable is the change in monthly averaged inflation swaps at different maturities from 1-year to 5-year corrected for risk, liquidity and inflation risk premia as described in section A6 in the Appendix. For parsimony, only the key coefficients are reported. Complete tables are available from the authors upon request. Xt includes a news variable capturing the information flow between t-1 and t of macro data releases related to inflation, the real activity, uncertainty and news indices of Scotti (2016), the changes in the FTSE and UK move indices. Zt includes CPI, industrial production, oil prices, the sterling effective exchange rate, net lending, housing prices.

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