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Alexander Jung, Patrick Kühn Can central bank communication help to stabilise inflation expectations?

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Abstract

This paper examines whether central bank communication stabilises euro area inflation expectations through the information and news channel. A novelty of the study is its use of data from Google Analytics on ECB website traffic as proxy for visitors' attention to its communication. We conduct several econometric tests with daily data to measure the impact of ECB communication on the information demand of the public and ultimately on inflation expectations. Overall, this study shows that website attention, as captured by search volumes of visitors, influences euro area inflation expectations. We find that increased website attention contributes to narrowing the gap between market-based forecasts and (the mean of) longer-term professional inflation expectations. Our findings add to the theoretical evidence on the existence of an information and news channel.

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Keywords: website attention, high-frequency identification, forward guidance, information demand, information and news channel.

NON-TECHNICAL SUMMARY

Over the last decades, central banks around the world have increasingly used public communication to support their policy goals including the stabilisation of inflation expectations. This undertaking was greatly facilitated by an Internet revolution providing central banks with new means to communicate monetary policy messages to a wide range of audiences, while allowing the public a better access to central bank information. Many studies find that information provided by central banks is a key driver of inflation expectations. There is, however, a debate about whether the success of central banks to stabilise inflation close to target has made economic actors less attentive to news. To address this issue, we examine whether website attention of visitors - mainly professionals such as market participants, analysts, wire services, journalists (but may also include the general public) - to ECB communication has increased over time, and whether this has helped to stabilise euro area inflation expectations.

According to theoretical models, the expectation formation process proceeds in two stages: before the central bank communication, when people form expectations based on atheoretical beliefs; and after the communication, when the central bank credibly announces its monetary policy, people must incorporate this news in their expectation model. This setting allows detecting announcement effects through the information channel (updating of beliefs) or the news channel (change in the number of informed subjects) or both. The empirical measurement of the transmission is facilitated by the provision of clear information about central banks' policy objectives, the economic outlook, and possibly the likely path for future monetary policy decisions. Especially communication at press conferences contains helpful information about current and future interest rate decisions and may increase media coverage.

This paper examines whether central bank communication stabilises euro area inflation expectations through the information and news channel. Overall, this study shows that website attention, as captured by search volumes of visitors, influences euro area inflation expectations. We find that increased website attention contributes to narrowing the gap between market-based forecasts and (the mean of) longer-term professional inflation expectations. Our findings add to the theoretical evidence on the existence of an information and news channel. In terms of methodology, a high frequency identification (HFI) is at the core of the econometric analysis. It explains (daily) movements in search activities on press conference days by coinciding (high-frequency) monetary policy shocks and controls. The HFI method has received particular attention in studies using financial asset prices that

aim at disentangling the causal impact of monetary policy communication on financial asset prices. Applications of HFI in the field of monetary policy communication and media are scant, however.

A novelty of the study is its use of daily data from Google Analytics on ECB website traffic as proxy for visitors' attention to its communication. Search activity, as measured by Unique Page Views, captures information demand of website visitors on monetary policy news. Google Analytics is a tool that tracks website traffic and provides statistics about website visits and search activity by users in real time. The new data set covers search activities by the general public during 2008 and 2017 for the ECB website and three of its subsections (namely media news, monetary policy news and news related to research and publications). Because previous studies on media attention measure the information supply derived from newspapers or TV, they only allow inference about whether agents were actively looking for the respective information, if information demand and supply are equal. Our approach based on search volumes of visitors is more targeted than supply-based approaches, since the proxy for information on demand captures the deliberate decision of agents to obtain more (or less) information on the ECB's monetary policy. We show that the public's information demand for monetary news is driven by the (absolute) size of the ECB's monetary policy shock and is also sensitive to different degrees of uncertainty and the complexity linked to non-standard measures.

1. Introduction

Over the last decades, central banks around the world have increasingly used public communication to support their policy goals including the stabilisation of inflation expectations. This undertaking was greatly facilitated by an Internet revolution providing central banks with new means to communicate monetary policy messages to a wide range of audiences, while allowing the public a better access to central bank information. Because of its timely and non-discriminatory information provision, the website has evolved into a key communication tool for central banks that provides the public with precise information about its monetary policy narrative (Fracasso, Genberg and Wyplosz, 2013). For this reason, knowledge about visitors' search behaviour on the central bank's website not only can give clues about their information needs on monetary policy, but also on the formation of their inflation expectations, given that the primary objective of the ECB's monetary policy is price stability.² Indicators on search activity based on big data can support macroeconomic forecasting (e.g., Choi and Varian, 2012; d'Amuri and Marcucci, 2017; Nymand-Andersen and Pantelidis, 2018) and the analysis of the monetary policy transmission (Meinusch and Tillmann, 2017; Benamar, Foucault and Vega, 2020; Tillmann, 2020).

There is a debate about whether the success of central banks to stabilise inflation close to target has made economic actors less attentive to news. To address this issue, we examine whether website attention of visitors - mainly professionals such as market participants, analysts, wire services, journalists (but may also include the general public) - to ECB communication has increased over time, and whether this has helped to stabilise euro area inflation expectations.³ Theoretically, the model by Eusepi and Preston (2010) makes the case that central bank communication can lead to increased macroeconomic stability, when agents face uncertainty about the interest rate path, while the central bank has uncertainty about the economic state. Accordingly, the expectation formation process proceeds in two stages: before the central bank communication, when people form expectations based on atheoretical beliefs; and after the communication, when the central bank credibly announces its monetary policy, people must incorporate this news in their expectation model. This setting allows to detect announcement effects through the information channel (updating of beliefs) or the news channel (change in the number of informed subjects) or both (Lamla and Vinogradov, 2019). Furthermore, a

² Economic actors' information seeking behaviour often involves search engines. Among existing search engines Google is by far the leading contender. Individuals with higher incomes normally rely more on the Internet when gathering information for investment decisions. A gender bias may exist whereby males rely more on the Internet than females (Lee and Cho, 2005).

³ The term "website attention" is closely related to the term "media attention", which has been applied more widely in the literature and refers to coverage in TV, newspapers and other media (Binder, 2017). By comparison, website attention extracts information on visitors' interest in ECB communication at the source.

theoretical model by Lamla and Lein (2014) predicts that more news provided through the media would allow agents to make their inflation forecasts more accurate.

A growing number of studies points to the key role of central bank information for steering market expectations and for successful monetary policy at large (e.g., Bernanke, 2015; Blinder, 1999; Blinder, Ehrmann, Fratzscher and de Haan, 2008; Disyatat, 2008; Ehrmann and Fratzscher, 2007; Gürkaynak, Sack and Swanson, 2005; Issing, 2005; Shin, 2017; Woodford, 2012).⁴ The literature has also shown that information provided by a central bank may have a larger impact on market expectations than private information (Amato and Shin, 2003). On the one hand, public information can help to stabilise market expectations, particularly in periods of heightened uncertainty (Eusepi and Preston, 2010). On the other hand, public information can crowd out private information, thereby creating a negative externality (Morris and Shin, 2005; Amador and Weill, 2012). The empirical literature finds that especially communication at press conferences, which contain helpful information about current and future interest rate decisions, may increase media coverage (Berger, Ehrmann and Fratzscher, 2011; Binder, 2017; Blinder, Ehrmann, Fratzscher, de Haan, 2008; Jansen and de Haan, 2009; Rosa and Verga, 2007; Sturm and de Haan, 2011).⁵ At the same time, unclear communication by central banks may destabilise expectations, if they trigger large unintended market reactions and lead to adverse real economic effects (Poole, 2005).

The measurement of the transmission is facilitated by the fact that the ECB has a clear primary objective of price stability and gives detailed information on the economic outlook, and since 2013 on the likely path for future monetary policy decisions. In terms of methodology, a high frequency identification (HFI) allows inference about the causal effect from ECB communication to website attention, as measured by search volumes of visitors.⁶ We explain (daily) movements in search volumes of visitors on press conference days by coinciding (high-frequency) monetary policy shocks and controls. Then, controlling for the monetary policy shock, we test whether website attention has a significant influence on euro area inflation expectations and on the gap between market-based and professional forecasts.

We contribute to the understanding of the empirical transmission of central bank

⁴ Market expectations may also respond to the tone and sentiment of central bank communications (Hansen, McMahon and Prat, 2018; Hubert and Labondance, 2017).

⁵ A too high degree of transparency can also confuse the public, more information provided by a central bank may not necessarily increase clarity (Gersbach, 2003; Issing, 2005; Winkler, 2000). The term transparency refers to a “continuous flow” of relevant information about monetary policy to an external audience (Neumann, 2002).

⁶ The HFI was pioneered by Cook and Hahn (1989), Kuttner (2001) and Cochrane and Piazzesi (2002). The HFI method has received attention in studies using financial asset prices. Following Gürkaynak, Sack and Swanson (2005), several studies have used this technique to disentangle the causal impact of monetary policy communication on financial asset prices.

communication to euro area inflation expectations exploiting information on website attention from a unique data set. A novelty of the study is the use of data from Google Analytics on ECB website traffic as proxy for visitors' attention to its communication. It conducts several econometric tests with daily data to measure the impact of ECB communication on the information demand of the public and ultimately on inflation expectations. Overall, this study shows that website attention, as captured by search volumes of visitors, influences euro area inflation expectations. We find that increased website attention contributes to narrowing the gap between market-based forecasts and (the mean of) longer-term professional inflation expectations. In addition to the findings, our study quantifies the information demand dynamics. Overall, our findings add to the theoretical evidence on the existence of an information and news channel. The structure of the paper is as follows. Section 2 explains the data, Section 3 the methods, Section 4 presents the empirical results, and Section 5 concludes.

2. Data⁷

To explain the public's information demand to ECB communication, we use a unique data set on website search volumes of visitors extracted with Google Analytics covering daily searches on the ECB website for the sample June 2008 to March 2017 (see Figure 1).⁸ Statistics obtained from Google Analytics contain information about where website traffic originates from, the number of website visitors, and through which search engines and keywords they found the website. Breakdowns on search activity by external users are available by sections of the ECB website, thereby distinguishing the information demand by content. The ECB supplies information with a 'news' character in the subsection 'Media', and background and institutional information on the ECB monetary policy can be found in the subsections 'Research & Publications' and 'Monetary Policy'. Taken together, this allows us to disentangle search activities for monetary news from those related to background and institutional information on the ECB's monetary policy.

Google Analytics provides anonymous tracking of website visitors and relies on cookies which are stored on the user's device. The tool tracks users who have initiated at least one session during the specified date range.⁹ A *Unique Page View* (UPV) aggregates page views that are generated by the

⁷ For an overview of the data used in this study, see Table A1, Annex A.

⁸ To track the attention of institutional investors other measures exploiting information from Google Trends or from Bloomberg News have been used in the literature (see Da, Engelberg, Gao, 2011; Ben-Rephael, Da, Israelsen, 2017). A shortcoming of these measures for measuring information demand is their sensitivity to the search query or the financial instrument that is applied when retrieving the data.

⁹ Google Analytics provides information about the number of website views, while detailed information on the users is not accessible. The IP is anonymous and cannot be used to identify single users. In Google Analytics a

same user during the same session.¹⁰ It refers to the number of sessions during which a website page was viewed. When a user visits a page several times during a session, it is counted as one UPV. Likewise, information about the number of visitors is available at the same frequency. The number of *unique visitors* refers to individuals visiting the ECB website and is measured by the visitor's IP address.

As is standard in the literature (e.g., Kuttner, 2001; Gürkaynak, Sack and Swanson, 2005), we extract monetary policy surprises ($mp1$) from the 1-month Overnight Index Swap (OIS) contract (OIS(30)) as the expected change in interest rates on Governing Council decision days during a small window around policy announcements with length $\mu+\tau$, where t is the time of the announcement of the decision, $(t-\mu)$ refers to the start and $(t+\tau)$ to the end of the window. When coding the high-frequency data for monetary policy surprises, we refer to monetary policy surprises observed coinciding with ECB press conferences. We use tick-by-tick data on OIS rates and define the window to start 10 minutes before the announcement of the press release and to end 110 minutes after it, so that the total length of the window is 120 minutes.¹¹

$$mp1_t = (OIS(30)_{t+\tau} - OIS(30)_{t-\mu}) \frac{30}{30-D(t)} \quad (1)$$

We measure the change in OIS rates to regular ECB interest rate announcements on Governing Council decision days during a time window that includes both the press release and the subsequent press conference.¹² The window starts at 13:35 and ends at 15:35 (CET). We also adjust for the remaining days of the current maintenance period, since in the case of the ECB the policy rate change becomes effective with the settlement of the next MRO, usually after six (sometimes five) days after the Governing Council decision, and we therefore set $D(t)=6$, where t refers to the Governing Council decision day. Previous studies for the euro area have shown that - abstracting from a few important announcements (e.g., the OMT announcement) - surprises in the inter-meeting period owing to other central bank communication such as speeches were in fact small. We therefore code no policy surprises in intermeeting months for which there was no Governing Council decision day.

session usually relates to 24 hours.

¹⁰ Three of the most important metrics are Unique Visitors, Visits by Session, and Unique Page Views. “Unique Visitors” are the number of people that visited a website over a selected time period. A “Visit by Session” refers to a single browsing session.

¹¹ To quantify monetary policy surprises, we use intradaily data on OIS rates, as suggested by research identifying the impact of monetary policy surprises on financial asset prices (e.g., Ehrmann and Fratzscher, 2009; Andersson, 2010; Brand, Buncic and Turunen, 2010; Altavilla, Brugnolini, Gürkaynak, Motto and Ragusa, 2019).

¹² While most event studies for the ECB use the press conference window, a recent study for the Federal Reserve suggests that monetary policy had effects on asset prices outside the eight scheduled FOMC meetings (Neuhierl and Weber, 2019).

To compute monetary policy shocks for the euro area, we follow Jung and Uhlig (2019) applying principal component analysis (PCA) on the surprises in four OIS rates (1 month, 6 months, 1 year, 10 years) in a tight window around ECB policy announcements. We use the first principal component of the unanticipated change in four OIS rates over a short window of 120 minutes around Governing Council announcements. Because it captures the response of the whole yield curve to monetary policy announcements, shocks derived from the first principal component contain information about the impact of level changes of the term structure related to standard (and non-standard) monetary policy measures.¹³ The monetary policy shock is scaled so that its average effect on the change in the 2-year German government bond yield around Governing Council meeting days is equal to one throughout the full sample considered. Figure 2 shows that in our sample monetary policy shocks varied in size and sign, but largely moved in sync with monetary policy surprises (mp1).

We distinguish between three types of uncertainty, namely financial, political and economic uncertainty (see Figure 3) for which daily information is available. First, we use a daily index capturing financial uncertainty (VSTOXX) that measures market expectations of near-term volatility conveyed by (Euro Stoxx 50) stock index option prices (source: Datastream). Second, macroeconomic data releases impact on the information demand, since they may help markets to reassess the (future) monetary policy stance of the central bank. Despite the focus on the euro area, our preferred measure is the Aruoba-Diebold-Scotti business conditions index (POLUN), which tracks real business conditions in the United States at the daily frequency (Aruoba, Diebold and Scotti, 2009; source: Federal Reserve of Philadelphia).¹⁴ The inclusion of the ADS index in the regressions allows capturing spillover effects from changes in real business conditions for the United States to the European economy, which are relevant for the ECB's monetary policy reaction function (Cour-Thiman and Jung, 2020). We also consider combined surprise and uncertainty indices for the euro area at the daily frequency (Scotti, 2016).¹⁵ However, it turns out that the Scotti (2016) uncertainty and surprise index for Europe is not significant in regressions of (3) in combination with the ADS index. Third, to capture the signal from political events, we use a recently developed daily measure for political uncertainty, which counts keywords from newspaper articles relating to economic policy uncertainty for Europe (Baker, Bloom and Davis, 2016; source: FRED, St. Louis Fed).

Survey-based measures of inflation expectations have the advantage that they are free of risk

¹³ The literature has shown that the first three principal components of a term structure have an economic interpretation as level, slope, and curvature of it, respectively.

¹⁴ Note that the average value of the ADS index is zero and that progressively bigger positive (negative) values indicate progressively better (worse)-than-average conditions.

¹⁵ Surprise indices measure agents' optimism (pessimism) about the economy from macroeconomic news surprises, while uncertainty indices measure agents' perceived (current) state of the economy.

premia, though they are not available in real time at higher frequency. By comparison with break-even inflation rates (BEIRs), ILS rates provide a cleaner measure of longer-term inflation expectations in terms of inflation risk premia. Nevertheless, in the aftermath of the financial crisis a large share of their variation could be attributed to movements in these risk premia (Böninghausen, Kidd and de Vincent-Humphreys, 2018). To measure inflation expectations, we obtain data for survey- and market-based indicators (see Figure 4). First, we use (quarterly) data on shorter- and longer-term inflation expectations (mean point estimates of one-year- and five-year-ahead inflation rates) from the Survey of Professional Forecasters (SPF), which are reported by the ECB. Second, we use (daily) data on inflation expectations by markets extracted from inflation-linked swaps (ILS) with different maturities (1y1y and 5y5y ILS rates for the euro area; source: Thomson Reuters). Third, we compute gap measures (*gap_short*, *gap_long*) using the squared deviations of each market-based measure (ILS1y1y, ILS5y5y) from the five-year-ahead forecast from SPF (see Figure 5). Within our sample, the longer-term (five-year-ahead) inflation forecasts from the SPF were in a range of 1.7% to 1.9%, which corresponds to the ECB’s inflation aim of “below, but close to 2%” (see Issing, 2003; Hartmann and Smets, 2018). Therefore, the gap measures provide information on the extent to which market expectations are anchored.

3. Methods

3.1 Determinants of the information demand for monetary news

The finance literature widely suggests that public information is effortlessly obtained and immediately processed by markets (e.g., Merton, 1987). The “law of large demand for information” predicts that the public’s information demand should be inversely related to the quality of the central bank signal (Moscarini and Smith, 2002).¹⁶ Because policy decisions by a central bank may have consequences for financial decisions of private agents, news releases by the ECB on monetary policy decision days should show up in a higher volume of website searches (information demand) relative to days on which there are no news releases. In this respect, a theoretical model by Lamla and Lein (2014) shows that more news that could also come from the media would allow agents to address the signal extraction problem and make their inflation forecasts more accurate. Moreover, economic decision theory emphasises that uncertainty (or risk-aversion) of actors should increase agents’ information

¹⁶ Moscarini and Smith (2002) examine Internet settings where information has high demand but is available at a very small price. They prove that information demand is a decreasing function of the informational content of a signal. Informational content measures how well a signal can help in distinguishing between different states of the world. For example, the informational content of a signal would be very high, if there is (almost) certainty with respect to the state of the world, and information demand thus would be lower.

demand (e.g., Vlastakis and Markellos, 2012), because they believe that more information may help them to overcome their limited knowledge about present facts and future outcomes.

Taken together and abstracting from search costs, we write down a reduced form of the information demand for monetary news (I^D):¹⁷

$$I^D = \Phi(Q, \sigma, T) \quad (2)$$

(-) (+)(+)

where Q denotes quality of the information signal, σ summarizes different sources of uncertainty and T denotes a time trend. We argue that the size of a monetary policy shock, which is extracted from movements in OIS-rates on decision days in tight announcement windows, captures the quality of the central bank signal, since it contains information on the extent to which new information about the state of the economy was released by the central bank (see Section 2). Moreover, exogenous developments such as the increasing popularity of the Internet and an increase in the number of website visitors over time are captured by a trend.¹⁸

To gain first insights about the driving factors of the ECB's information demand, we apply a (one way) Analysis of Variance (ANOVA) analysis, which uses the F-statistics for inference. ANOVA is a parametric procedure that can be used to determine the statistical significance of the difference between the means of two or more groups of values, if the data is normally distributed.¹⁹ The outcome variable can be analysed based on one factor or on several factors.²⁰ The null hypothesis is that the means are all equal ($H_0: \mu_1 = \mu_2 = \dots = \mu_n$), where n = the number of independent comparison groups), and it is tested against the alternative hypothesis that at least one of the means is different. The test can be also used to check whether variances across groups are different. Given that the data may not be normally distributed when using daily data, we also report the results from the Kruskal-Wallis H test. Because that test is a non-parametric method for testing whether samples originate from the same distribution, it serves as a check for robustness of the results.

To explain the information demand on Governing Council decision days, we apply high-frequency identification. The method explains incremental changes in the information demand during short-time spans around policy announcements by monetary shocks and some controls. The

¹⁷ We concede that statistics on search counts may also reflect trading volumes (Herzog, 2015). Moreover, other factors, which are unrelated to information demand, such as search engine ranking, the time it takes web pages to load may have some impact on website traffic.

¹⁸ An alternative modelling strategy with similar results would be to detrend the data.

¹⁹ Note that these tests do not allow inference about which group displays a higher mean, if the test has rejected the null hypothesis. However, it is still possible to conduct (pairwise) checks of the sample means by category to find out for which characteristics the information demand was higher or lower.

²⁰ Note that a comparison based on standard t-tests could be biased in the presence of more than two groups.

identification specifies a causal link between a monetary policy shock and the information demand of the public for which we use website searches from ‘Total views’, and the views on three different subsections of the ECB website, namely ‘Media’, ‘Research & Publications’ and ‘Monetary Policy’. The OLS regression explains one-day growth rates of website views on press conference days by the absolute value of high-frequency monetary policy shocks derived from a two-hour window around policy announcements and adding controls (i.e., several forms of uncertainty and non-standard monetary policy measures):²¹

$$\Delta \log(d_t) = \alpha + \beta \Delta |ps_t| + \sum \gamma_i \phi_{i,t} + \delta D_t + \varepsilon T + u_t \quad (3)$$

where d is the number of website views by external audiences in levels on day t , $|\Delta ps|$ is the absolute value of the monetary policy shock computed for the two-hour window surrounding the press conference, ϕ_i refers to three distinct measures for financial, economic and political uncertainty (e.g., the VSTOXX, the Aruoba-Diebold-Scotti business conditions index (ADS), and the Baker-Bloom-Davis index (POLUN)), and a dummy (D_t) that captures non-standard monetary policy measures of the ECB such as the announcement of the OMT, forward guidance and the introduction of the APP, T is a time trend and u is an error term. As controls, we include monthly changes of proxies for uncertainty (political, economic and financial).

Because the validity of the high-frequency identification requires that no other shock distorts our proxies for market expectations during the period of measurement, we make the windows for which we compute monetary policy shocks as tight as possible using intradaily data.²² If non-monetary news is present, the dependent variable could respond to both monetary and non-monetary shocks, thereby distorting the high-frequency identification. Such other news would imply that the error term in equation (3) above would not be orthogonal to the monetary policy shock.

²¹ The econometric literature has shown that when using OLS to estimate models with generated regressors, this can generally lead to inefficient and inconsistent estimates of the standard errors. Ignoring uncertainty regarding the construction of monetary policy shocks could have led to understating standard errors and overstating t -statistics. To address the issue, in regressions using monetary policy shocks we correct the residuals using a heteroscedasticity-consistent covariance matrix (HCCM). More precisely, we apply the jackknife estimator of the variance (HC3) to obtain heteroskedastic-consistent estimates of the residuals, which are accurate even for smaller samples (Long and Ervin, 2000).

²² In the literature other strategies have been applied to address the possible presence of event study biases. One is identification through heteroskedasticity (Rigobon, 2003; Rigobon and Sack, 2004). Another one is to estimate daily regressions of (2) which include monetary policy shocks on non-Governing Council decision days as a latent variable that accounts for the feedback from information demand to monetary policy shocks (Thornton, 2014).

3.2 Information demand and inflation expectations

Previous studies analysed whether inflation expectations respond to media attention using data on information supply from newspaper and TV reports (Coibion, Gorodnichenko, Kumar and Pedemonte, 2020). These studies have shown that media attention related to central bank communication impacts on inflation expectations and that effects may differ across sectors (e.g., consumers adjust their expectations sluggishly). Carroll (2003) provided evidence that the provision of more media news by a central bank reduces the gap between inflation expectations of households and professional forecasters. The gap arises, because professional watchers follow closely announcements by central banks and are mainly interested in monetary news, which potentially drive financial market developments.²³ By comparison, search activities by non-experts are largely attributable to the financial literacy motive (Hayo and Neuenkirch, 2018). Because households are sluggish in updating their inflation expectations and tend to ignore media news if central banks succeed in anchoring inflation expectations, inflation expectations of households are generally found to be less accurate (and rational) than those by professional forecasters. Because the public is heterogeneous, information demand may vary within subgroups, such as sectors (households, firms) and professions (academics, traders, journalists).²⁴ Recent research by Pfaihar and Santoro (2013) suggests that news on inflation may not necessarily improve forecast accuracy, but it will still increase the responsiveness of households to unfavourable news on prices, thus exerting a positive effect on the expectation gap between households' and professional forecasters' mean expectations.

A possible shortcoming of these studies is that they measure the information supply, which does not allow to make inference about whether agents were actively looking for the respective information. Our approach based on search activity does not need to assume that information demand equals supply, since it extracts information on demand as proxy for website attention, and thus directly captures the decision of agents to obtain more (or less) information on the ECB's monetary policy. Taking a demand perspective, we analyse whether search activity on the website influences private forecasts of future inflation and whether it reduces the gap between market forecasts and professional forecasters. In this study, we estimate daily OLS regressions explaining measures of inflation expectations by search volumes of the public, while controlling for several sources of uncertainty, the

²³ They normally prefer information issued by central banks to information from the media, such as newswire reports (Hayo and Neuenkirch, 2010; Kool, Middeldorp and Rosenkranz, 2011). Despite the higher costs, professional traders predominantly rely on information disseminated by wire services (Oberlechner and Hocking, 2004).

²⁴ For confidentiality reasons, our data set does not allow identifying individuals or user groups. We can also not distinguish between new and returning visitors.

ECB's monetary policy shock and the ECB's non-standard monetary policy measures.²⁵

To examine whether visitors' attention on the ECB website impacts on euro area inflation expectations, we estimate a daily OLS regression:²⁶

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 \log(d_t) + \beta_3 \log(d_t) * ADS_t + \beta_4 \Delta ps_t + \sum \gamma_i \phi_{i,t} + \delta_i D_{i,t} + \varepsilon T + u_t \quad (4)$$

where the dependent variable y_t is a measure of inflation expectations (π^e_t) or an expectation gap (gap_short , gap_long) between market-based expectations and the (mean) professional forecast of inflation 5 years ahead, d is the number of website views by external audiences in levels on day t , Δps_t is the monetary policy shock computed for the two-hour window surrounding the press conference, ϕ_i refers to (daily) changes in financial, economic and political uncertainty, respectively (e.g., the VSTOXX, the Aruoba-Diebold-Scotti business conditions index (ADS), and the Baker-Bloom-Davis index (POLUN)), T is a time trend and u_t is an error term. Since our website attention proxy only allows inference about the volume effect, but we would also like to capture the direction of the news, we include an interaction term, as the product of Total views (in logs) and the macroeconomic news index (ADS). A set of dummies ($D_{i,t}$) controls for announcements related to the ECB's non-standard monetary policy measures, namely the OMT, the ECB's forward guidance and the APP.

4. Empirical results²⁷

4.1 Results for the inflation demand

We use ANOVA analysis to test hypotheses on the ECB website information demand related to known events or patterns (for a summary of the hypotheses see Table 2, second column). We thereby study the effect of a qualitative variable (e.g., change of the website design) on website traffic. In general, we find that the information demand is lower on weekends than during the week (we reject the null hypothesis that there was “no impact of the weekend” at the 5%-level, see Table 2, fifth

²⁵ This way, we do not analyse the causality from website attention to inflation expectations, but it can be done applying the HFI method on ECB press conference days. We run separate OLS regressions such that the dependent variable is the change in our proxy for inflation expectations (we do this for different maturities) and the independent variable is the change in website attention (both changes are measured for the event window of 120 minutes around the policy announcement). We find no evidence that website attention has a causal effect on longer-term (market-based) inflation expectations, but detect a significant impact on short-term inflation expectations, though the size of the coefficient is very small. Consistent with this result we find no causal effect from monetary policy shocks on inflation expectations using the same window and sample. Hence, we caution on the causal interpretation of our findings. For brevity of the analysis, these results are not reported here.

²⁶ We also control for weekday effects in this regression. We checked that the results remain robust, if instead of the lagged endogenous variable a measure of lagged inflation is included.

²⁷ Before assessing the driving factors for the information demand by the public, we check the stationarity properties of the variables and find them to be stationary (Table 1).

column). We make additional tests to find out whether users' information demand peaks on ECB press conference days, which are held on a Thursday following the Governing Council's monetary policy meeting. By confirming that the information demand on the website is by far higher on press conference days than on the other days, this exercise corroborates previous evidence suggesting that press conferences are important communication events. Our results show that the increase in website visits on Governing Council decision days is attributable to 'Media views', which relates to the information demand by professional watchers (traders, journalists). This analysis also confirms that speeches contain important monetary policy signals. According to our tests, there is a significant pick-up in the information demand on days when members of the Executive Board gave speeches. However, data releases on money and credit by the ECB - or its official publications like the Monthly (or Economic) Bulletin - summarizing current economic and monetary developments had no significant impact on the information demand.²⁸ While this seems surprising at first glance, given that markets are using these data for predicting interest rates (Jung, 2018), most market observers obtain the same information on ECB data releases via wire services.²⁹ Therefore, markets do not expect to gain any new information from these releases.

Next, we analyse the impact of special events. The results show that the OMT announcement, which was generally perceived as a game changer in restoring financial stability in the euro area, left the information demand of the public fairly unchanged. By comparison, other non-standard monetary policy measures of the ECB involving (large-scale) asset purchases and forward guidance significantly changed the information demand. Given that search activity is linked to complexity of communication, one would expect that the APP increases the information demand, whereas forward guidance reduces it. However, our simple hypothesis tests, which compare mean (or median) differences, only detect an effect that led to an increase in the information demand. This could be related to a coincidence in timing of both measures, which hides the individual effect of any of these measures on the information demand, and we provide a more thorough analysis of this aspect in the next subsection. Lastly, we examine whether the introduction of a new website design in July 2015 by the ECB changed the

²⁸ Once a month, the ECB publishes new information about money and credit data. The Monthly Bulletin was published from January 1999 to December 2014, when it was replaced by the Economic Bulletin. The ECB Monthly Bulletin was published one week after each monetary policy meeting of the Governing Council. It explained the monetary policy decision and provided a detailed analysis of the current economic situation and risks to price stability. The Economic Bulletin has been published ten days after the Governing Council meeting.

²⁹ Other information intermediaries (e.g., wire services, media) may publish the same information on monetary policy, though typically with a lag. For example, ECB press conferences are simultaneously broadcasted on the ECB website and by wire services (e.g., Bloomberg and Reuters). Because their information is tailored to the communication needs of specific audiences, wire services may play a role, when assessing the information demand of these groups, but we lack precise information on the demand for these outlets.

information demand, for example by attracting new users, and find that this is the case.³⁰

*4.2 Results for the link between monetary policy shocks and information demand*³¹

To explain the information demand by monetary policy shocks, we estimate (3) with OLS for ‘Total views’. A significant parameter β in (3) would confirm that the monetary policy shock in absolute terms explains changes in the information demand. Its value also provides information about the direction and the strength of the relationship. To account for generated regressor problems related to the principal components analysis, the residuals are corrected for heteroskedasticity (HC3). In addition, we report results on website views from three related ECB website subsections with different monetary policy contents (‘Media views’, ‘Research & Publications views’, ‘Monetary Policy views’). The decomposition helps to identify the demand from different audiences, because the subsection ‘Media’ contains news on monetary policy decisions most of which is released on Governing Council decision days, whereas the other two subsections (‘Research & Publications’, ‘Monetary Policy’) largely cover background information on monetary policy with rarely any news content.³² Professional watchers normally consult the ‘Media’ subsection, because they have an interest to be immediately informed about a decision by the ECB and the official reasoning for it. Searches from the general public are mainly motivated by financial literacy considerations and are dominant in the other two subsections.

Table 3 shows that, on press conference days, the information demand for ‘Total views’ and the three subcategories is significantly explained by (the absolute size of) the monetary policy shock and a positive trend (for ‘Research & Publications views’ the trend is not significant). According to our estimates of β , a monetary policy shock lifting the term structure by 10 basis points on average caused the information demand for ‘Total views’ (and ‘Media views’) to increase by around 28% at the meeting day. In this respect, we detect that the effect is stronger for ‘Research & Publications views’ and ‘Monetary Policy views’ (43% and 58%, respectively). Moreover, we find that financial uncertainty had no additional influence, while political uncertainty is significant with the ‘wrong’ sign.

³⁰ One may argue that also here a possible identification issue arises, because the introduction of the new website design to some extent coincided with the introduction of the APP program in March 2015. Therefore, we repeat the tests, but this time for the number of users instead of search activity. The results (not reported for brevity of the analysis) show a significant increase in the number of users, which better illustrates that a more user-friendly design of the website helped to attract new users.

³¹ For comparison, we also estimate a regression explaining monthly changes in website views (d_t) by its driving factors (see Annex B, Table B1). We provide results of HFI regressions using a decomposition of monetary policy shocks into pure monetary policy shocks and information shocks (see Annex B, Table B2 and B3).

³² In the subsection ‘Monetary Policy views’ the ECB also provided information on all marketable eligible assets with daily updates of the information, which was relevant for many banks in the euro area during the crisis.

In terms of complexity of the monetary policy signal, we find that especially two non-standard monetary policy measures (OMT, APP) contributed to increases in the information demand relative to a trend for all sections. A new finding is that ‘forward guidance’ dampened search activity both for ‘Total views’ and ‘Media views’ - though not for the other two subsections. We check whether the reduction in the information demand on Governing Council decision days owing to forward guidance may have come from a decrease of the number of users. Though, website traffic suggests that the number of users has actually increased since July 2013.

In a regime of (credible) forward guidance, public information should crowd out private information (Morris and Shin, 2005). However, forward guidance may not always ensure that market expectations on future monetary policy are consistent with the policy intentions of the respective central bank.³³ While purely qualitative forward guidance does little to anchor expectations of future policy rates (Campbell, 2019), the publication of an interest rate path may potentially enhance a central bank's leverage on the medium term structure of interest rates (Andersson and Hofmann, 2009). If markets have more information on the likely future path of interest rates, they should also be less responsive to macroeconomic news (Swanson and Williams, 2014). However, we discover that the overall information demand remained sensitive to macroeconomic news, since economic uncertainty, as measured by the ADS index, contributed to increases in the overall information demand (negative values of the index signal increased economic uncertainty; see Table 3, column 1).³⁴ The decomposition by website section captures that the observed sensitivity to macroeconomic news is not attributable to ‘Media views’, but to ‘Monetary Policy views’, and shows that the public attempted to get a better understanding of the ECB’s monetary policy approach, given elevated levels of uncertainty post-crisis. Taken together, the evidence in this subsection suggests that forward guidance led to reduced website attention, while stabilising expectations about the future path of interest rates.

4.3 Results for the link between website attention and euro area inflation expectations

To measure the impact of search activity on inflation expectations, we estimate (4) with daily data. In

³³ For example the code words, which were used in the Introductory Statement and in speeches in the first years of the ECB’s existence, did not create full certainty to markets about forthcoming interest rates, but left ample scope for macroeconomic uncertainty to influence policy decisions (Heinemann and Ullrich, 2007). A recent study by Hayo, Henseler and Rapp (2019) shows that the Q&A sessions at the ECB press conference have generally facilitated market participants’ understanding of the policy messages contained in the President’s Introductory Statement. Ehrmann, Gaballo, Hoffmann and Strasser (2019) find that forward guidance may lower the informativeness of market signals.

³⁴ We also estimated (2) including the Scotti (2016) uncertainty and surprise indices for Europe, but found them not to be significant.

these regressions, ‘Total views’ is our preferred proxy for search volumes of visitors, since it is the broadest measure of website attention.³⁵ Table 4 (column 1 and 2) shows that the coefficient β_2 for the (volume of the) information demand (‘Total views’) is significant and positive for short-term and longer-term market expectations (ILS) implying that inflation expectations are responsive to search activity. Moreover, the results show that the coefficient β_2 is significant and negative for the short-term and the longer-term expectation gap (Table 4, column 3 and 4). Taken together, these results show that website attention based on visitors’ search volumes contributes to narrowing the gap between market-based forecasts and (the mean of) longer-term inflation expectations by professional forecasters.

Next, we examine the impact of macroeconomic news on the relationship between information demand and the expectation gap. The coefficient β_3 reflects the joint impact from the interaction of the information demand and the ADS index. We detect a significant, positive effect for the short-term expectation gap, suggesting that unfavourable news contribute to widening the short-term expectation gap by increasing long-term inflation expectations (and vice versa for favourable news). This is because positive (negative) values of the ADS index indicate better (worse)-than-average business conditions and thus mirror favourable (unfavourable) news. Previous approaches focusing on information supply found that unfavourable media news enlarge the short-term expectation gap between households’ and professional forecasters’ mean expectations.³⁶ In addition, we discover that website attention has no significant influence on the longer-term inflation gap (the coefficient β_3 for the longer-term expectation gap is insignificant), which mirrors the observation that these inflation expectations are well anchored.

Lastly, we show how the monetary policy shock, uncertainty and the ECB non-standard measures influence euro area inflation expectations, as indicated by the significant controls (Table 4, column 1 and 2). The results show that, in line with monetary theory and with Kerssenfischer (2019), tightening (easing) monetary policy shocks are significant and lead to lower (higher) inflation expectations along the term structure. An interesting observation is that monetary policy shocks contribute to narrowing the longer-term inflation gap, but the opposite effect is observed for the shorter-term inflation gap (Table 4, column 3 and 4). Because higher financial uncertainty leads to stronger reductions in (the level) of short-term market-based inflation expectations than for longer-term ones, it contributes to a widening of the short-term expectation gap and to decreases in the

³⁵Note that our findings are generally robust to the use of more granular measures like ‘Media views’ that targets professional watchers.

³⁶The study by Pfaihar and Santoro (2013) makes this finding for one-year ahead inflation forecasts.

longer-term gap. In our sample that is characterised by deflationary threats, higher economic uncertainty tends to reduce (the level) of longer-term market-based inflation expectations and thereby the short-term expectation gap. In this environment, a higher level of political uncertainty is found to reduce both expectation gaps. Regarding the non-standard monetary policy measures of the ECB (OMT, APP and forward guidance), overall, we find them to decrease market-based inflation expectations and to increase the inflation expectation gaps, though to different degrees and significance. To check for robustness, we replace the SPF inflation forecasts by similar measures from Consensus Economics for euro area HICP and fully confirm the above results.³⁷

5. Conclusions

This article has provided an empirical analysis on whether central bank communication stabilises euro area inflation expectations through the information and news channel. A novelty of the study is its use of daily data from Google Analytics on ECB website traffic as proxy for visitors' attention to its communication. Search activity, as measured by Unique Page Views, captures information demand of website visitors on monetary policy news. Because previous studies on media attention measure the information supply derived from newspapers or TV, they only allow inference about whether agents were actively looking for the respective information, if information demand and supply are equal. Our approach based on search volumes of visitors is more targeted than supply-based approaches, since the proxy for information on demand captures the deliberate decision of agents to obtain more (or less) information on the ECB's monetary policy. We show that the public's information demand for monetary news is driven by the (absolute) size of the ECB's monetary policy shock and is also sensitive to different degrees of uncertainty and the complexity linked to non-standard measures.

There is a central role of financial market expectations in the conduct of monetary policy, because of a tight two-way relationship between central banks and financial markets. For this reason, a central bank may not aim to directly reach all private actors, but its website-based communication may increase the awareness of consumers about central bank announcements. In this respect, both the website and the media are important transmission devices between the central bank and the greater public. While a seminal study by Carroll (2003) showed that the provision of more media news influences inflation expectations, there is a controversy whether the success of central banks to stabilise inflation close to target has made economic actors less attentive to news. In line with the predictions from theoretical communication models, this study shows that website attention, as captured by search volumes of visitors, influences euro area inflation expectations and contributes to

³⁷ The results are available from the authors upon request.

narrowing the gap between market-based forecasts and (the mean of) longer-term professional inflation expectations. Our findings add to the theoretical evidence on the existence of an information and news channel.

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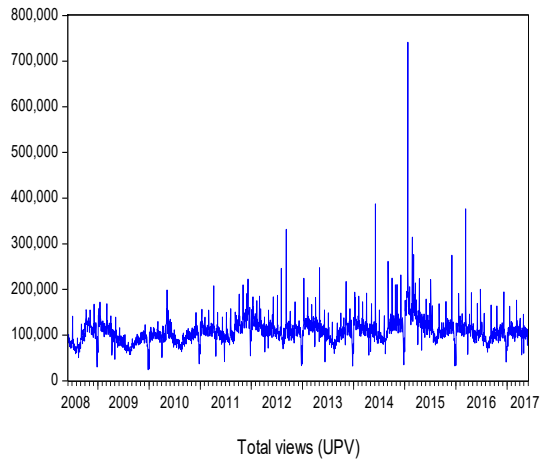
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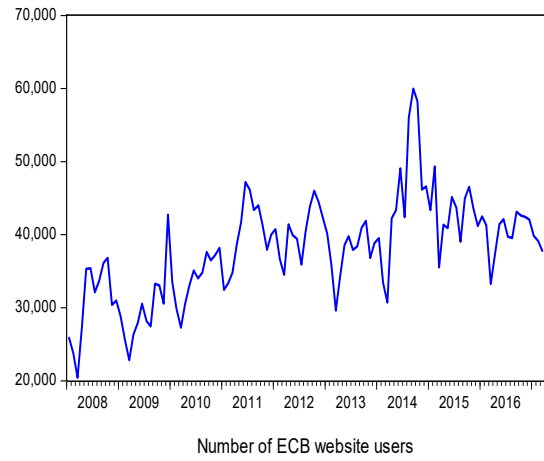
Annex A: Figures and Tables

Figure 1: Website views and website users

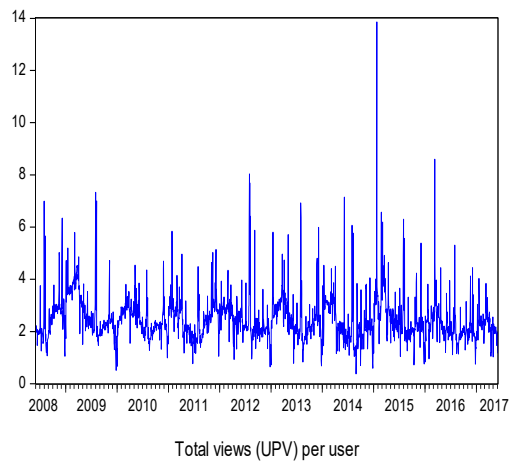
ECB website views



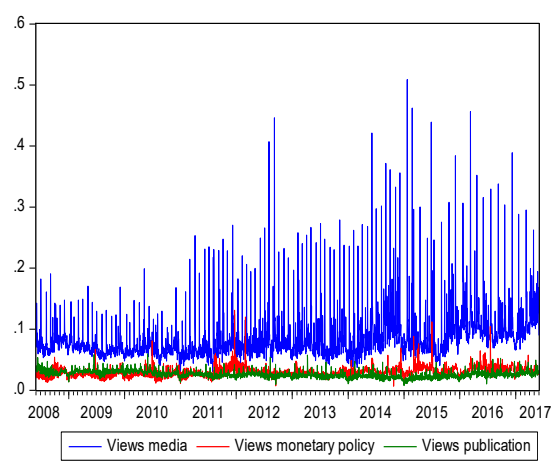
ECB website users



ECB website views per user



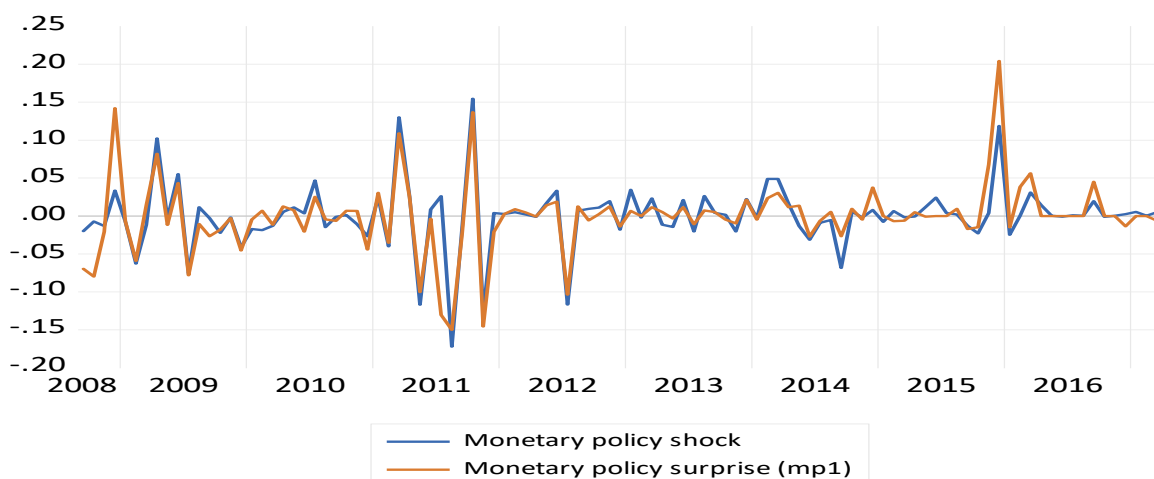
Share of total views of the ECB website by subsection



Source: Google Analytics.

Figure 2: Monetary policy shocks and surprises

(in percentage points)

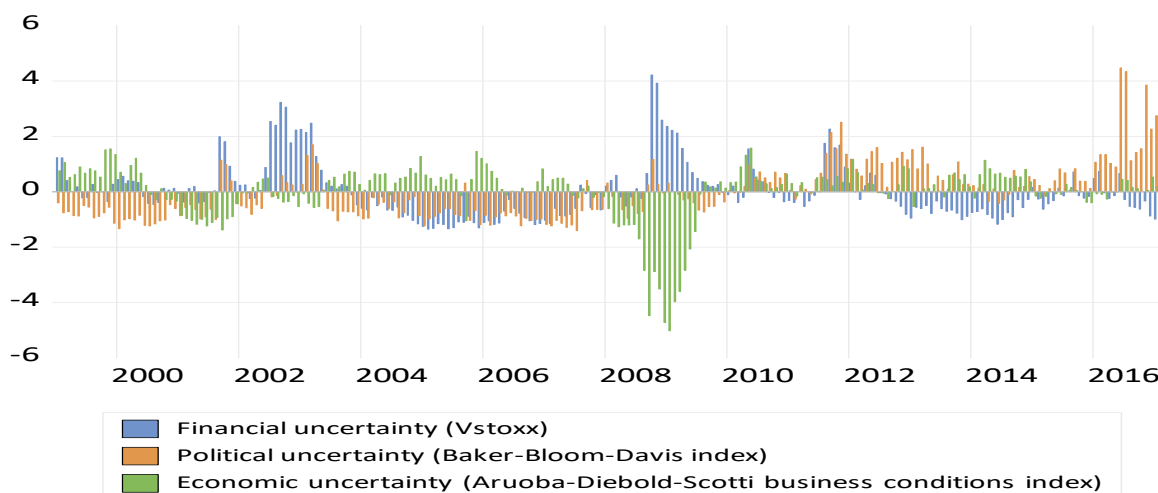


Source: Thomson Reuters, own calculations.

Notes: Based on intradaily data for euro area OIS rates and window of 120 minutes around policy announcements (covering ECB press release and press conference).

Figure 3: Dimensions of uncertainty

(percentages per annum, normalised)

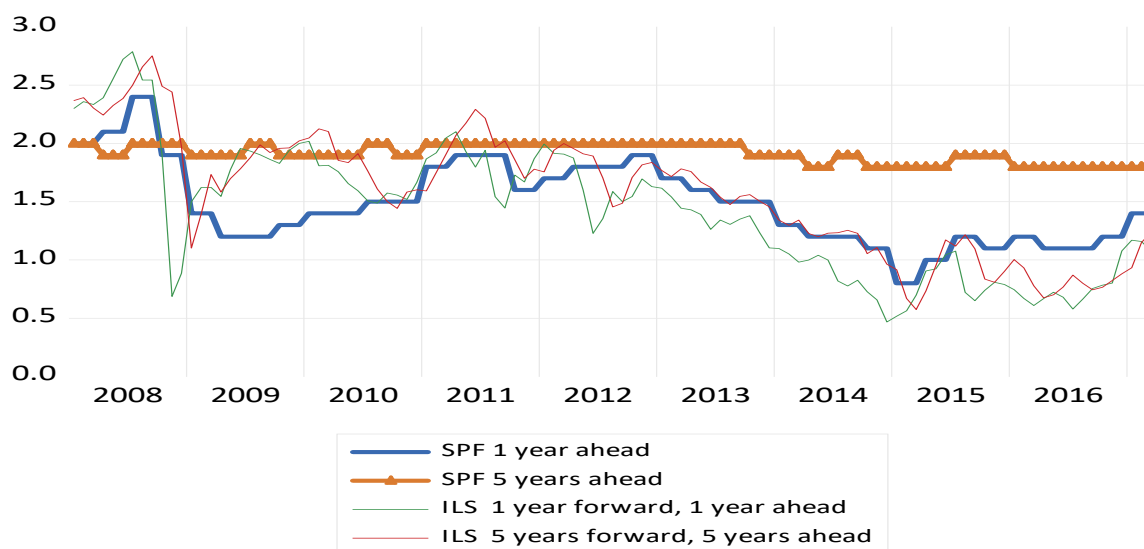


Source: Datastream; website of Baker, Bloom and Davis index from FRED, St. Louis Fed; Aruoba-Diebold-Scotti business conditions index is from Fed Philadelphia real-time website.

Notes: The VSTOXX index is based on Dow Jones EURO STOXX 50 options prices and is designed to reflect the market expectations of near-term (30-day) volatility as measured by the square root of the annualized implied variance across all options of a given time to expiration. The Aruoba-Diebold-Scotti index (ADS), which tracks real business conditions at high frequency using data on economic activity from various sources, is on average zero. Progressively bigger positive values indicate progressively better-than-average conditions, whereas progressively more negative values indicate progressively worse-than-average conditions. The Baker-Bloom-Davis index measuring political uncertainty is based on newspaper articles relating to economic policy uncertainty for Europe (at the daily frequency).

Figure 4: Euro area inflation expectations: survey-based and market-based measures

(percentages per annum)

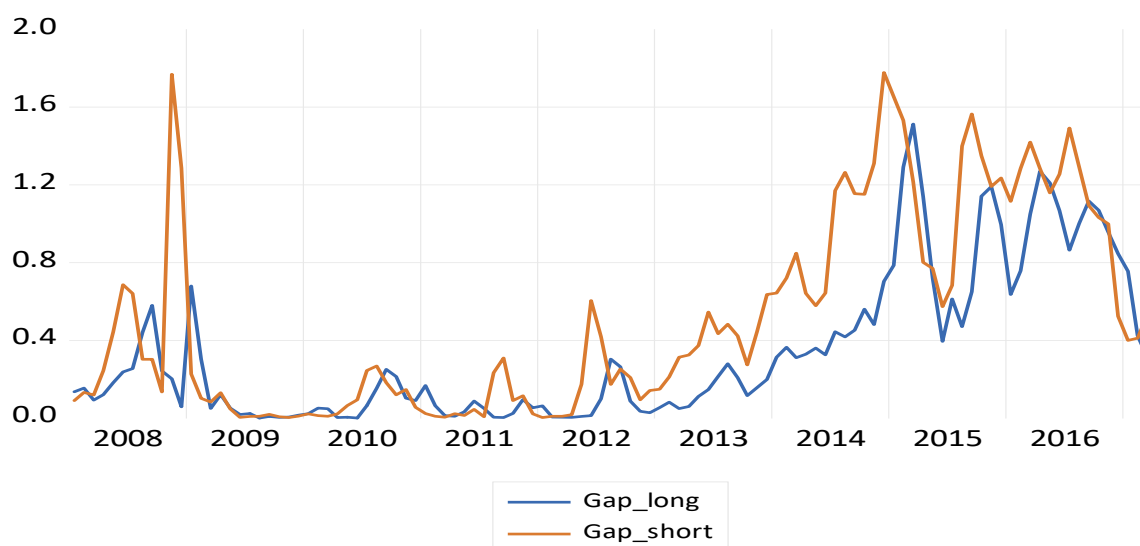


Source: ECB, Thomson Reuters.

Notes: We show monthly observations. SPF denotes inflation forecasts from the ECB's Survey of Professional Forecasters. We report mean point estimates from the SPF.

Figure 5: Gap measures of euro area inflation expectations

(percentages per annum)



Source: ECB, Thomson Reuters.

Notes: We show monthly observations. Gap_short (Gap_long) is the squared deviation between ILS1y1y (ILS5y5y) and the 5-year ahead inflation forecast from SPF.

Table 1: Results of tests for unit roots (ADF test statistics)

Variable	Daily data		Monthly data		Order of integration
	<i>Level of series</i>	<i>Series in first differences</i>	<i>Level of series</i>	<i>Series in first differences</i>	
Views (UPVs) and users					
<i>Total</i>	-5.46***		-9.76***		I(0)
<i>Media</i>	-6.96***		-9.32***		I(0)
<i>Research & Publications</i>	-6.43***		-10.67***		I(0)
<i>Monetary Policy</i>	-5.23***		-8.62***		I(0)
<i>Users</i>	-5.03***		-3.71***		I(0)
Monetary policy surprises and shocks					
<i>Surprises (mp1)</i>			-3.66***		I(0)
<i>Shocks</i>			-9.82***		I(0)
Uncertainty measures					
<i>VSTOXX</i>	-5.11***		-3.01**		I(0)
<i>Baker-Bloom-Davis index</i>	-7.77***		-4.25***		I(0)
<i>ADS index</i>	-2.04	-12.54***	-2.10	-9.43***	I(1)
<i>ADS index⁽¹⁾</i>	-7.07***		-6.53***		I(0)

Notes: the null hypothesis is that the series contains a unit root versus the alternative of no unit root; tests performed over the sample 2008.6-2017.3; *** indicates rejection of null at 1% significance; ** indicates rejection of null at 5% significance. The abbreviations of the variables are explained in the data section of the main text. (1) results refer to the ADF test with break point as indicated by the test on 11/04/2009 and June 2009, respectively.

Table 2: Results of the hypotheses tests

Number	Hypothesis	Test for equality of means	F-statistic/ χ^2-statistic	P-value
1	No impact of change in the ECB website design (on 10 July 2015)	ANOVA F-test	5.19	0.02
		Kruskal-Wallis H test	6.18	0.01
2	No impact of the working day	ANOVA F-test	789.67	0.00
		Kruskal-Wallis H test	2083.16	0.00
3	No impact of the weekend	ANOVA F-test	499.14	0.00
		Kruskal-Wallis H test	535.85	0.00
4	No impact of statistical press release days (money and credit data)	ANOVA F-test	1.49	0.22
		Kruskal-Wallis H test	1.97	0.16
5	No impact of press conference days (Governing Council decisions)	ANOVA F-test	506.23	0.00
		Kruskal-Wallis H test	166.16	0.00
6	No impact of days on which Executive Board members publish speeches	ANOVA F-test	239.62	0.00
		Kruskal-Wallis H test	287.63	0.00
7	No impact of days on which official publications are released (i.e., Monthly/Economic Bulletin)	ANOVA F-test	0.21	0.65
		Kruskal-Wallis H test	1.63	0.20
8	No impact of the OMT announcement	ANOVA F-test	0.12	0.73
		Kruskal-Wallis H test	1.52	0.22
9	No impact of the APP program	ANOVA F-test	19.58	0.00
		Kruskal-Wallis H test	12.57	0.00
10	No impact of forward guidance	ANOVA F-test	49.39	0.00
		Kruskal-Wallis H test	45.45	0.00

Notes: Sample 2008.6 to 2017.3; bold-faced p-values indicate rejection of the null hypothesis. The one-way ANOVA F-test is a parametric procedure to determine the statistical significance of the difference between the means of two or more groups of values and the null hypothesis is that the means are all equal. The Kruskal-Wallis H test is a non-parametric method for testing whether samples originate from the same distribution and the null hypothesis is that the medians of all groups are equal.

Table 3: Information demand on press conference days (HFI)

<i>Dependent variable</i>	<i>Total views</i>	<i>Media views</i>	<i>Research & Publications views</i>	<i>Monetary Policy views</i>
<i>Explanatory variable</i>	(1)	(2)	(3)	(4)
Constant	6.11*** (0.73)	5.40*** (0.64)	3.85** (1.63)	3.48*** (1.26)
Policy shock (absolute)	2.76* (1.31)	2.74** (1.25)	4.30** (1.90)	5.79*** (1.67)
Financial uncertainty	0.29 (0.93)	0.23 (0.79)	-0.66 (2.00)	0.57 (1.14)
Political uncertainty	-0.23* (0.12)	-0.20* (0.11)	-0.17 (0.26)	-0.20 (0.28)
Economic uncertainty	-0.19** (0.09)	-0.10 (0.07)	-0.14 (0.13)	-0.24** (0.10)
OMT dummy	1.02** (0.46)	1.03* (0.55)	0.86* (0.48)	1.12*** (0.40)
APP dummy	0.97** (0.46)	0.91* (0.48)	1.19*** (0.36)	1.40*** (0.60)
Forward guidance	-0.48* (0.26)	-0.39** (0.18)	-0.41 (0.51)	0.01 (0.47)
Trend	0.03*** (0.01)	0.03*** (0.00)	0.02 (0.01)	0.02** (0.01)
R ² adjusted	0.60	0.71	0.19	0.41

Notes: Sample 2008.6 to 2017.3; Equation (3) estimated applying OLS with HC3 standard errors in parenthesis: * indicates significance at 10%; ** at 5%; *** at 1%. The variables ‘views’ are specified in logs. The OMT dummy takes the value 1 in 2012.7 to 2012.9 and is otherwise zero. The APP dummy takes the value 1 in 2014.12 to 2015.3 and 2016.3 and is otherwise zero. Forward guidance captures all Governing Council meetings with press conferences starting in July 2013.

Table 4: Information demand and inflation expectations (daily regressions)

<i>Dependent variable</i>	<i>ILS1y1y</i>	<i>ILS5y5y</i>	<i>Gap_short</i>	<i>Gap_long</i>
<i>Explanatory variable</i>	(1)	(2)	(3)	(4)
Constant	0.76*** (0.22)	0.72*** (0.20)	0.60** (0.27)	0.15 (0.17)
Lagged dependent	0.48*** (0.03)	0.64*** (0.02)	0.36*** (0.03)	0.53*** (0.02)
Total views (in logs)	0.14*** (0.02)	0.07*** (0.02)	-0.19*** (-0.02)	-0.06*** (-0.02)
Total views *	0.02 (0.03)	0.13** (0.06)	0.09* (0.05)	-0.02 (0.02)
Economic uncertainty	-0.28** (-0.13)	-0.25*** (-0.09)	0.57*** (0.16)	-0.25*** (-0.07)
Financial uncertainty	-1.46*** (-0.10)	-0.38*** (-0.07)	1.56*** (0.14)	-0.12** (-0.05)
Political uncertainty	0.03*** (0.01)	0.02** (0.01)	-0.06*** (-0.01)	-0.05*** (0.00)
Economic uncertainty	-0.25 (-0.32)	-1.45** (0.64)	-1.05** (0.53)	0.17 (0.26)
OMT dummy	0.05** (0.02)	-0.16*** (-0.02)	-0.08*** (-0.03)	0.05*** (0.01)
APP dummy	-0.23*** (-0.02)	-0.23*** (0.02)	0.47*** (0.03)	0.40*** (0.03)
Forward guidance	-0.13*** (-0.03)	-0.05* (-0.03)	0.16*** (0.04)	0.03 (0.04)
R ² adjusted	0.83	0.86	0.73	0.79

Notes: Sample 2008.6 to 2017.3; Equation (4) estimated applying with OLS and Huber-White standard errors in parenthesis: * indicates significance at 10%; ** at 5%; *** at 1%. ILSxyxy stands for inflation-indexed swap rate x years forward x years ahead. Gap_short (Gap_long) is the squared deviation between ILS1y1y (ILS5y5y) and the 5-year ahead inflation forecast from SPF. The OMT dummy takes the value 1 in 2012.7 to 2012.9 and is otherwise zero. The APP dummy takes the value 1 in 2014.12 to 2015.3 and 2016.3 and is otherwise zero. Forward guidance captures all Governing Council meetings with press conferences starting in July 2013. The above regression includes weekday dummies and a time trend. Political uncertainty is measured by the index (POLUN) for the US.

Table A1: Overview on data used in this study

Variable	Source	Explanation
Website traffic: <ul style="list-style-type: none"> - Total - Media - Research & Publications - Monetary Policy 	Google Analytics	tracking of web visitors, unique page views (UPV), daily data (sample 2008 to 2017) for ECB website and for three subsections (daily)
Interest rate swaps¹⁾	Thomson Reuters	Euro Overnight Index Swap, average of ask and bid prices, for 1, 6, 12 months and 10 years (intradaily)
Monetary policy shock <ul style="list-style-type: none"> - Pure monetary policy shock and - Information shock 	Jung and Uhlig (2019) Kerssenfischer (2019)	First principal component on the change in four OIS interest rates (1 month, 6 months, 1 year, 10 years), press conference window Decomposition of first principal component of high-frequency futures for 2-year German bond yields and Euro Stoxx 50, press conference window
Inflation expectations	Thomson Reuters ECB	Index-linked swaps (ILS) for maturities one year forward, one-year-ahead and five-year-forward five-year-ahead (daily) Survey of Professional Forecasters (SPF), one-year- and five-year-ahead (quarterly)
Uncertainty indicators: <ul style="list-style-type: none"> - POLUN - ADS - VSTOXX 	FRED Fed Philadelphia Thomson Reuters	Baker, Bloom and Davis index (daily, monthly) Aruoba-Diebold-Scotti business conditions index; real-time website (daily, monthly) measures market expectations of near- and longer-term volatility conveyed by (Euro Stoxx 50) stock index option prices (daily, monthly)

Notes: 1) An overnight swap (OIS) is a financial contract between two counterparties to exchange a fixed interest rate against a geometric average of overnight interest rates (in the euro area, the EONIA) over the contractual life of the swap.

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