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Non-standard monetary policy and ECB communication: Confusion or predictability? ☆

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ABSTRACT

Using a dataset of 273 press releases and introductory statements over the period 1999–2020, we investigate how the communication of the European Central Bank (ECB) influences the ability of market participants to predict its monetary decisions. We build four new indicators of communication intensity and frequency and measure predictability by decomposing the surprises on the variation of asset prices around monetary announcements into a “target” – which captures the standard dimension of monetary policy surprises – a “path” factor – which corresponds to the forward guidance dimension of monetary surprises – and a QE factor – which accounts for their quantitative easing dimension. Our findings reveal that the intensity and frequency of ECB communication reduce the surprise of market participants regarding non-standard dimensions of monetary policy. Moreover, the improvement of the predictability of monetary decisions is not achieved at the expense of greater confusion over standard monetary decisions. Additionally, the reduction in surprises operates through the information channel, by which monetary policy announcements transfer information about economic fundamentals from the central bank to market participants.

1. Introduction

Central bank communication follows a dynamic process that is shaped both by the macroeconomic and financial environment and the evolution of the reflective framework developed by academics and practitioners.

As noted by Taylor (2013) while talking of the Great Moderation, “during much of the 1980s and 1990s and until recently, monetary policy was more predictable, less discretionary, and more steadily focused on the goal of price stability, especially compared with the 1970s”. During the same period, central bank independence has become widespread (Crowe and Meade, 2007). This change in institutional design came with a greater requirement for transparency and accountability (Siklos, 2002; Ehrmann and Fratzscher, 2005; Woodford, 2005; Blattner et al., 2008; Blinder et al., 2008; Unsal et al., 2022), taking the form of published reports, open parliamentary scrutiny and sometimes the publication of meeting minutes (Cagliarini et al., 2010). In addition, “a further area of clarity by the 1990s was over the question of what the monetary policy instrument really was” (Cagliarini et al., 2010). Indeed, in the early 2000s, the overnight interest rate became the main tool of monetary policy. Moreover, following an instrument-based monetary policy rule, such as a Taylor rule,

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represented a new communication framework through which central banks release information about not only their instrument (the interest rate) but also their objective (price stabilisation) and their reactions to economic shocks.

The Global Financial Crisis (GFC) called for a profound overhaul change in both the statute and role of central banks. First, because most central banks faced the zero lower bound and a deterioration of transmission channels, they had to innovate and adopted a wide range of unconventional monetary policy measures, such as refinancing operations and various types of asset purchase programs. Second, central banks expanded their mandate (Lastra and Dietz, 2022) and completed their traditional concern for price stability with objectives in terms of market liquidity, financial stability and supervision. This evolution of central banks' toolkits has significantly transformed their communication strategies (Coenen et al., 2017; ECB, 2021). As underlined by Ehrmann et al. (2021) and Hayo et al. (2022), the complexity of monetary authorities' communication has dramatically increased and has been accompanied by an expansion in the range of topics covered in central bankers' announcements. This included an increase in the quantity of nonmonetary information shared during speeches and press conferences (Cieslak and Schrimpf, 2018). Note that the greater complexity of central banks' communication has sometimes manifested as something of a cacophony and disagreements among board members (Blinder, 2007; Tillman, 2021). Finally, communication has become a full instrument of monetary policy, as exemplified by forward guidance, by which central bankers provide communication to the public and financial markets about the likely future path of key policy variables.

As a result of these developments, central bank communication can now take on a wide variety of forms and modalities. Because different instruments or programs can be released simultaneously, central banks can adjust the intensity of each announcement, i.e., the number of measures that are released on the same date. Moreover, as monetary policy instruments, such as purchase programs, encompass various types of modalities that are disclosed at different moments (e.g., launch/renewal, maturity, amount of purchased asset, collateral, fixed/variable rate), the frequency of announcements can also be used as a communication instrument for monetary authorities. These arguments suggest that the intensity and frequency of information releases by monetary authorities represent new aspects of central banks' communication policy.

The goal of this paper is precisely to analyse the effect of both dimensions, i.e., the intensity and frequency of information releases, on market participants' reaction. To do so, we refer to the literature on central banks' transparency, which relates to the number, precision and comprehensiveness of releases as well as the degree of explanation provided for decisions and the amount of issues for which information is disclosed by central banks¹ (Winkler, 2000; Bini-Smaghi and Gros, 2006; DeHaan et al., 2004; Eijffinger and Geraats, 2006; Crowe and Meade, 2008; Dincer and Eichengree, 2014; Dincer et al., 2019; IMF, 2020). A first strand of literature suggests that increasing communication intensity and frequency improves transparency and therefore makes monetary decisions more predictable (Bernanke, 2004; Swanson, 2006; Blinder, 2007; Middeldorp, 2011; Neuenkirch, 2013; Eichler and Littke, 2018; Naszodi et al., 2016; Urbschat and Watzka, 2020). However, another series of papers find that increasing communication intensity and frequency generate confusion and surprises among market participants (Winkler, 2000; Kahnemann, 2003; Blinder, 2007; Ehrmann et al., 2012; Lustenberger and Rossi, 2020; Blinder et al., 2022).

To empirically assess which of these arguments prevails in the case of the ECB, we collected a set of 273 ECB press release and press conference dates between 7 January 1999, and 10 December 2020. We then classified them into four categories and fourteen subcategories of policy announcements. This allowed us to build four innovative indicators. The two first indicators measure the intensity of communication as the number of decision categories or subcategories that are observed simultaneously on each announcement date. The two other communication indicators measure the frequency of communication by considering, for each announcement date, the number of days since the last decision from the same category or subcategory. To account for market participants' reaction, we follow the approach taken by Altavilla et al. (2019) and Baumgärtner (2022). We thus measure monetary surprises, focusing on the unanticipated component of ECB announcements from high-frequency market surprises on the variation of several asset prices (OIS, sovereign bond yields, stock price indexes and exchange rates) around monetary policy meetings and decomposing it into three different factors. This allows us to distinguish the standard, forward guidance and quantitative easing dimensions of monetary policy surprise and to check whether they are affected in the same way by our communication indicators. Moreover, in line with the recent literature (Jarocinski, 2020; Jarocinski and Karadi, 2020; Andrade and Ferroni, 2021; Miranda-Agrippino and Ricco, 2021; Cecioni et al., 2011), we decompose these surprises into a pure monetary policy component – by which central banks' decisions directly affect agents' decisions – and an information component – by which monetary policy announcements transfer information about ECB macroeconomic outlooks to market participants. Our empirical strategy is to test whether our four new measures of communication frequency and intensity can predict monetary policy surprises.

Our results indicate that the intensity and frequency of ECB communication improve the clarity of non-standard monetary policy announcements, without increasing confusion on standard monetary decisions. Our results also reveal that the effect of intensity and frequency on market surprises operates through the information channel. Taken together, our findings confirm the idea that exploiting the intensity and frequency of monetary announcements, which is made possible by the increasing number of instruments and programs created in the context of post-crisis monetary policies, constitutes a real communication device that makes it possible to convey information from central banks to financial markets.

The rest of the paper is organized as follows. Section 2 provides a literature review. Section 3 presents the data. Section 4 describes our estimation framework, and the results are presented in Section 5. Section 6 concludes the paper.

¹ Indeed, central banks can disclose information about data and forecasts (economic transparency), the decision-making process (procedural transparency), monetary policy outcomes (policy transparency) and the way decisions are implemented (operational transparency) (Dincer and Eichengreen, 2009).

2. Literature

To study the effect of the intensity and frequency of the ECB's announcements on agents' reaction to monetary policy decisions, we refer to the literature on central banks' transparency. We first consider the predictability argument; we then address confusion effects.

2.1. Transparency and predictability

Because it allows monetary authorities to guide agents' forecasts and anchor expectations, transparency enhances clarity and a better understanding of monetary policy, thus mitigating surprise and uncertainty among the public and market participants (Bernanke, 2004; Blinder, 2007). The case of the Federal Reserve, whose transparency has significantly increased since the late 1980s exemplifies the existence of a positive effect of transparency on monetary policy predictability. For example, Swanson (2006) reports an improvement in the accuracy of interest rate forecasts by the private sector and a reduction in the surprise component of Federal Open Market Committee (FOMC) announcements since this date. Similarly, Poole and Rasche (2003) show that market participants' surprises, as measured by daily variations in the yield on futures contracts for federal funds, has decreased since the FOMC's decision, in 1994, to issue a statement after each meeting. Finally, Ehrmann and Fratzscher (2007) find that interest rate volatility has been significantly reduced since 1999, when forward-looking information about the future stance of monetary policy was included in the FOMC press statement.

The existence of a favourable impact of transparency on monetary policy predictability is also documented for other central banks. Using a sample of 24 countries between the end of the 1990s and the beginning of the 2000s, Middeldorp (2011) shows that more transparency reduces forecast errors of professional interest forecasters and interest rate volatility. This finding is confirmed by Naszodi et al. (2016) on a sample of 26 countries between 1989 and 2009. Neuenkirch (2013) also finds that transparency decreases the bias in money market expectations using a dataset of 25 emerging countries over the period 1998-2009. Similarly, based on a set of 62 currencies between 1998 and 2010, Eichler and Littke (2018) document that central banks' transparency reduces exchange rate volatility. Finally, focusing on the Public Sector Asset Purchase Program (PSPP) implemented by the ECB in 2014, Urbschat and Watzka (2020) investigate the effect of PSPP press releases on monetary policy surprises, as measured by bond yields and the spreads between the bond yield and the overnight index swap (OIS) rate over a two day window around these releases. They find that PSPP announcements decrease bond yields and spreads. However, they also observe that the reduction is particularly strong for the first announcement on the PSPP but vanishes progressively for the following announcements. This result suggests that market participants have become increasingly less surprised because their understanding of monetary policy has progressively improved since the program was implemented.

2.2. Transparency and confusion

However, another strand of literature argues that transparency may increase confusion among market participants. As emphasised by Winkler (2000), a high level of transparency can reduce the ability of economic agents to process and understand the information disclosed by central banks. Indeed, a large quantity of released information can be difficult to interpret and "digest" (Kahnemann, 2003; Blinder, 2007; Blinder et al., 2022), thus being associated with information overload (Van der Cruysen et al., 2010) and excessive volatility in financial markets (Jensen, 2002). In the same vein, Koole et al. (2011) argues that the release of public information by a central bank tends to crowd out private information and reduce the ability of market participants to predict the future of interest rates.

These theoretical intuitions are confirmed by several empirical studies. Ehrmann et al. (2012) investigate the impact of transparency on the dispersion of analysts' and consumers' forecasts of macroeconomic variables, such as inflation, real gross domestic product (GDP) growth, unemployment, 3-month interest rates and 10-year government bond yield. Using different measures of monetary policy transparency on a set of 12 advanced countries, they show that more transparency on the inflation objective or inflation and output forecasts significantly reduces disagreement among forecasters. However, their results also indicate that this favourable impact becomes considerably weaker for high levels of transparency, suggesting the existence of a non-linear effect. Similarly, based on a dataset of 78 countries over the period 1998-2014, Lustenberger and Rossi (2020) reveal that forecast error and the dispersion among professional forecasts of financial and macroeconomic variables (short-term and long-term interest rates, consumer price index inflation and the growth rates of GDP) increase with the number of central bank press releases in the month preceding forecasts.

The goal of this paper is precisely to empirically assess which of these effects (predictability or confusion) is at work in the case of ECB monetary policy.

3. Data

3.1. ECB communication variables

The communication of ECB monetary policy proceeds in two steps. First, at 13:45 (local time), the ECB releases a short note about the evolution of the Marginal Refinancing Operation (MRO), the Marginal Lending Facility and the Deposit Facility rates, denoted the press release. Since June 2016, the ECB has started to introduce additional elements related to non-standard measures in its statement, notably quantitative easing and refinancing operations as well as forward guidance. Second, at 14:30 (local time) a press

conference is held, in which the measures adopted are commented on by the president of the ECB who proceeds with the reading of the introductory statement that contains reasons underlying choices for the present or future behaviour of the ECB and its views on the economic outlook.

To construct our central bank communication dataset, we thus focus on press releases and introductory statements, extracted from the ECB website.² The content of each announcement between 7 January 1999 and 10 December 2020 has been hand collected. This represents 273 announcement dates that have then been manually classified. Referring to the classification used by the ECB and Rostagno et al. (2019) (for forward guidance decisions), we distinguish four categories and fourteen subcategories of policy announcements:

- Standard monetary policy decisions (STAND):
 - Interest rate decisions: level and variation of the MRO rate, the Deposit Facility rate and the Marginal Lending Facility rate.
 - MRO tender procedure: initiation, allotment and settlement dates for fixed and variable rate tender procedure, as well as specific conditions applying when specified (i.e., MRO maturity lengthened).
 - Ad hoc fine-tuning operations
- Liquidity provision decisions (LIQ):
 - Long-Term Refinancing Operations (LTRO)
 - Targeted Long-Term Refinancing Operations (TLTRO)
 - Pandemic Emergency Longer Term Refinancing Operations (PELTRO)
 - Fixed Rate Full Allotment (FRFA)
 - Collateral decisions: enlargement or reduction of the scope of eligible assets and technical specifications for the collateral framework
- Asset purchase decisions (AP)³:
 - Outright Monetary Transactions (OMT) and Securities Market Transactions (SMT)
 - Asset Backed Securities Purchase Program (ABSPP)
 - Covered Bond Purchase Program (CBSPP)
 - Public Sector Purchase Program (PSPP)
 - Corporate Sector Purchase Program (CSPP)
 - Pandemic Emergency Purchase Program (PEPP)
 - Other asset purchase decisions; general and common decisions on several APPs simultaneously
- Forward guidance decisions (FG): communication instruments by which central banks convey their monetary policy orientation going forward, conditional on their assessment of the economic outlook.⁴

Appendix A provides an example of classification based on the 30 April 2015 introductory statement.

1 summarises the main characteristics of each announcement category and subcategory.

Based on our announcement dataset, for each decision date t , we build four monetary policy communication indicators (COM_t).⁵ The two first variables, denoted $NUMCAT_t$ and $NUMSUBCAT_t$, measure the intensity of communication:

• $NUMCAT_t$ measures the number of different announcement categories that are observed simultaneously at t ($NUMCAT_t \in [0; 4]$).

• $NUMSUBCAT_t$ stands for the number of different announcement subcategories that are observed simultaneously at t ($NUMSUBCAT_t \in [0; 14]$).

The two following variables, $FREQCAT_t$ and $FREQSUBCAT_t$, account for the frequency of communication⁶:

• $FREQ_{t,c}$ measures the average frequency of decisions across categories. To build this variable, we first define a variable $FREQ_{t,c}$ (with $c \in \{STAND, LIQ, AP, FG\}$), which accounts for the frequency of decision within each category c at date t :

$$FREQ_{t,c} = \frac{1}{n}$$

with n being the number of days since the last announcement of the same category c .

$FREQCAT_t$ is then defined as the average of $FREQ_{t,c}$ across the four announcement categories.

² <https://www.ecb.europa.eu/press/pr/date/html/index.en.html>.

³ Officially, the Asset Purchase Program (APP), which started in 2015, refers to the ABSPP, the third CBPP, PSPP and the SCPP. In this paper, the category AP not only encompasses APP but also other asset purchase decisions such as OMT, SMT, other CBPP and the PEPP.

⁴ Although ECB officially began to use forward guidance in July 2013, some announcements before this date can be considered as such.

⁵ Note that, as regards the press conference, we concentrate on introductory statements and do not account for “Q&A” (questions and answers). First, as underlined by Ehrmann and Fratzscher (2009), the content of the Q&A session is highly driven by the news released during the introductory statement. Hence, incorporating it into our communication indicators would generate endogeneity in our estimates. Second, the similarity between the content of the Q&A session and that of the introductory statement is very strong (Hayo et al., 2022). Moreover, because the Q&A session mainly aims to clarify the content of the introductory statement (Ehrmann and Fratzscher, 2009; Hayo et al., 2022), it does not include any *additional* category of announcement. This suggests that accounting for the Q&A session would not change the values of our communication indicators.

⁶ In Lustenberger and Rossi (2020), frequency and intensity indifferently refer to the number of central bank speeches in the month preceding inflation or interest rate forecasts. By contrast, in our paper, intensity indicators are associated with the cross-sectional dimension of communication, while frequency indicators refer to its time dimension.

Table 1
ECB announcement classification by categories and subcategories.

Decisions	Nb Obs	First obs date	Last obs date
Standard monetary policy decisions (STAND)	273	07/01/1999	10/12/2020
Interest rates decisions	273	07/01/1999	10/12/2020
MRO tender procedure	8	07/01/1999	21/06/2000
Ad hoc fine-tuning operations	3	15/12/1999	08/12/2011
Liquidity provision decisions (LIQ)	57	04/03/1999	10/12/2020
LTRO operations	26	04/03/1999	12/03/2020
TLTRO operations	16	05/06/2014	10/12/2020
PELTRO operations	2	30/04/2020	10/12/2020
FRFA	22	05/03/2009	10/12/2020
Collateral decisions	13	05/08/2004	10/12/2020
Asset purchase decisions (AP)	63	07/05/2009	10/12/2020
OMT and SMT	12	10/06/2010	05/06/2014
ABSPP	5	05/06/2014	22/01/2015
CBPP	9	07/05/2009	22/01/2015
PSPP	1	05/03/2015	05/03/2015
CSPP	3	10/03/2016	02/06/2016
PEPP	6	30/04/2020	10/12/2020
Other asset purchase decisions	40	15/04/2015	10/12/2020
Forward guidance decisions (FG)	93	03/12/2009	10/12/2020

• $FREQSUBCAT_t$, which measures the average frequency of decisions within each subcategory at date t , is built according to the same approach for subcategories.

Fig. 1 depicts the evolution of ECB communication variables. In line with Cieslak and Schrimpf (2018) and Ehrmann et al. (2021), it indicates that the intensity and frequency of the ECB's communication increased significantly between 1999 and 2020, with 2010 being a critical year.

$NUMCAT$ and $NUMSUBCAT$ measure the number of decision categories (or subcategories) mentioned by the central bank. In the mid-2000s, this number is generally equal to 1 because monetary policy is mainly based on interest rate policy: announcements consist of announcing that interest rates are unchanged. There exist a few rare exceptions in the early 2000s where the ECB's statements are associated with more than one category. These are the years when the euro was introduced, which sometimes induce changes in the operating procedures of open market operations or rules regarding liquidity, for example. A significant break is observed in Fig. 1 between the 2000s and the 2010s. In the latter period, because the central bank substantially renews its toolkit and multiplies the number of programs it mobilises, as mentioned earlier, $NUMCAT$ and $NUMSUBCAT$ starts to grow considerably. The higher $NUMCAT$ (or $NUMSUBCAT$) is, the larger the number of different programs mentioned by the central bank. If the predictability hypothesis developed in Section 2.2 is confirmed, then we expect this information to be incorporated by financial markets, enabling them to better understand the central bank's behaviour and predict its decisions. Hence, we should have a negative relationship with $NUMCAT$ (or $NUMSUBCAT$) and monetary policy surprises. Conversely, if the confusion hypothesis developed in Section 2.2 is verified, a large number of programs and different pieces of information mentioned at a given date should be associated with more confusion among market participants when the next decision is announced. In this case, we expect a positive relationship between $NUMCAT$ and surprises.

Now turning to frequency indicators, recall that they are based on n , the duration since the last announcement in the same category (or subcategory). A large duration n means that the central bank has not spoken for a long time while a low duration indicates a short time since the last announcement. Considering the reverse of n , i.e., frequency, allows us to align our interpretation with that of intensity indicators. If $FREQCAT$ (or $FREQSUBCAT$) is high, then agents receive information frequently. According to the predictability hypothesis mentioned in Section 2.2, this should allow market participants to make better forecasts and to be less surprised by the next monetary policy announcement. In this case, we should observe a reverse relationship between frequency variables and monetary surprises. Conversely, if the confusion hypothesis developed in paragraph 2.2 prevails, it means that a high level of $FREQCAT$ (or $FREQSUBCAT$) induces very little time for market participants to digest, interpret and analyse information, leading to more confusion and larger surprises. Hence, we should expect a positive relationship between frequency variables and monetary surprises.

3.2. Monetary policy surprises and factors

To measure market participants' reaction to ECB communication, we consider the unexpected component of market reaction. We thus retrieve high-frequency monetary policy surprises from the EURO AREA MONETARY POLICY EVENT-STUDY DATABASE Altavilla

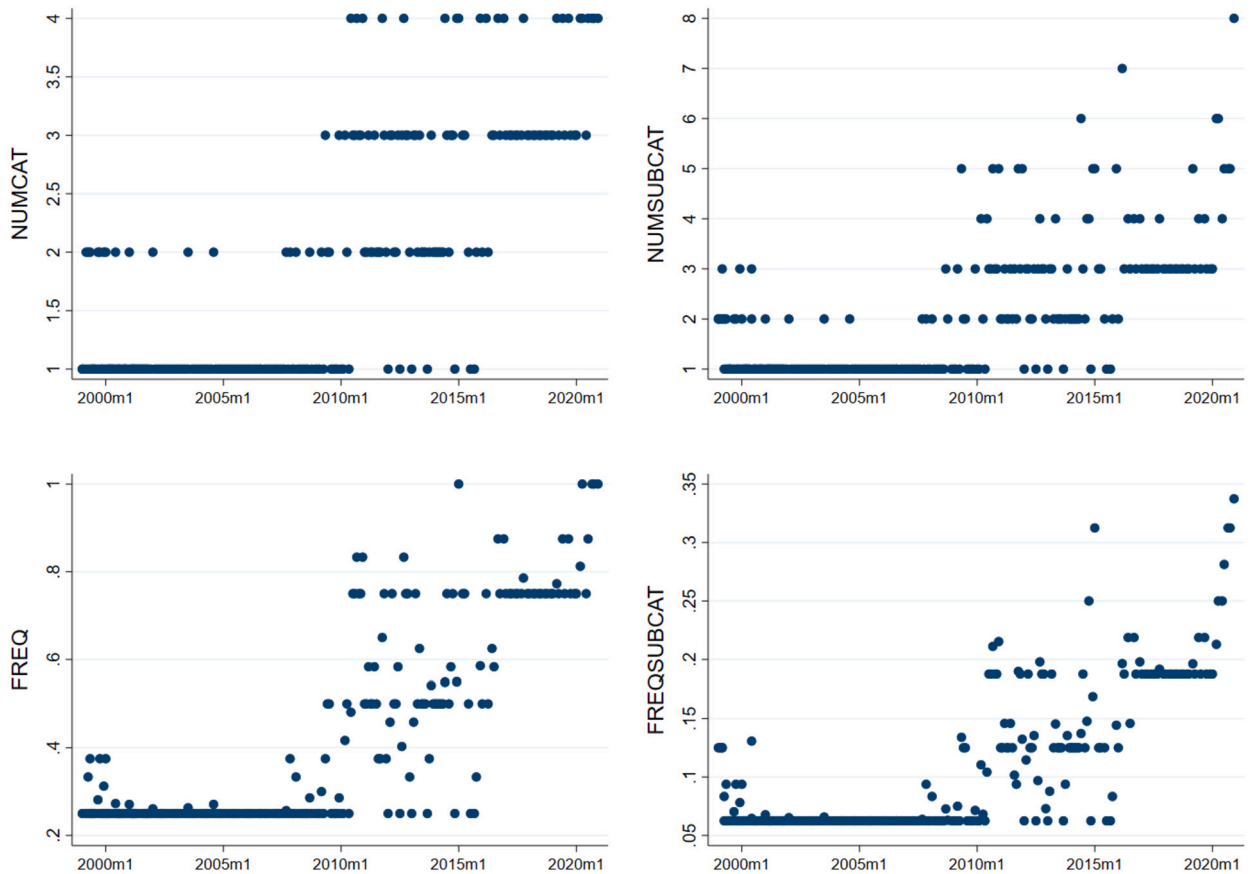


Fig. 1. Evolution of $NUMCAT_t$, $NUMSUBCAT_t$, $FREQ_t$, $FREQSUBCAT_t$.

et al. (2019).^{7,8} The main advantage in the use of market surprises around monetary policy announcements is that it ensures that the reaction of markets is not contaminated by other events.

As described in Fig. 2, monetary surprises are extracted from the intraday variation of various rates (OIS rates at different maturities, sovereign yields for France, Germany, Italy and Spain, the STOXX50 and SX7E, and EUR:U.S.D, EUR:GDP, and EUR:JPY exchange rates) around the monetary event window (which encompasses the press release and the press conference windows).

We then summarise these surprises by extracting monetary policy factors. The idea behind this approach is to assess how many dimensions are necessary to adequately characterise monetary policy announcements, which allows us to distinguish the effects of multiple decisions announced during the same meeting. The underlying identifying assumption is that monetary policy does not respond to intraday asset price changes. Consequently, causality goes from monetary policy to asset prices only.

Following the existing literature on the topic (notably Altavilla et al., 2019 and Baumgärtner, 2022), we extract three factors from that window over the January 1999 - December 2020 time span.⁹ The extraction procedure, which is described in detail in Appendix B, consists to consider a departure matrix that includes OIS rates at 1- and 3-, 6-month, 1-, 2-, 5-, 10-year maturities. Three dimensions are highlighted with regard to the rate maturities their associated factors load on. Based on the rates they load on, we interpret the first factor as being related to shocks on the short-term policy rate (target factor, denoted by $TARGET_t$) or, more broadly, to standard monetary measures. The second is a path factor (forward guidance, denoted by $PATH_t$), which accounts for revisions in market expectations about the future path of policy rates. The third (QE_t), is related to shocks that affect longer maturity rates. Consequently, we associate it with monetary easing measures (quantitative easing factor) or, alternatively, to non-standard

⁷ The dataset can be retrieved at https://www.ecb.europa.eu/pub/pdf/annex/Dataset_EA-MPD.xlsx.

⁸ Recall that before July 2016, press releases only concerned interest rate decisions. Hence, over this period, the only source of variation for communication variables is the press conference window. For this reason, it could be argued that it is enough to focus on the press conference window rather than also considering the press release window. However, as explained above, we consider the value of communication variables at $t - 1$, which by construction may influence market reaction from the very beginning of the monetary event window at t , i.e., during the press release at t . As a consequence, whatever period is considered (before or after July 2016), market reaction must be measured over the whole monetary event window (press release + press conference).

⁹ We remove three outliers, that is, the meetings held on 17 September 2001 (following 11 September 2001), 8 October 2008 (coordinated action by major central banks to reduce strains in financial markets) and 6 November 2008 (bank rate 150 basis points (bps) cut by the Bank of England).

ECB Communication Timeline

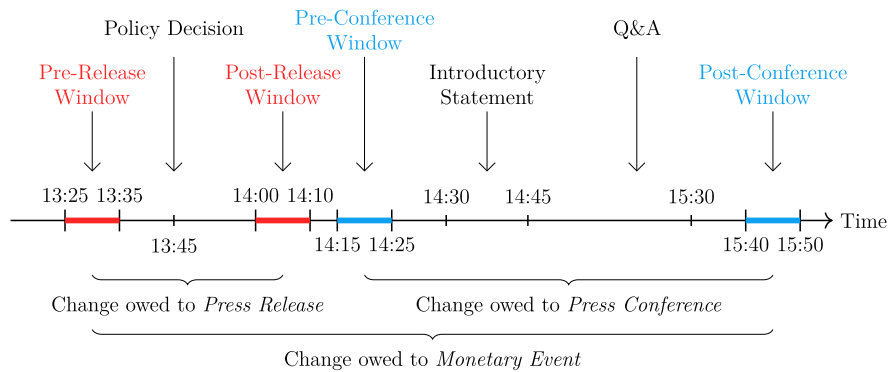


Fig. 2. Monetary event windows setup (Altavilla et al., 2019).

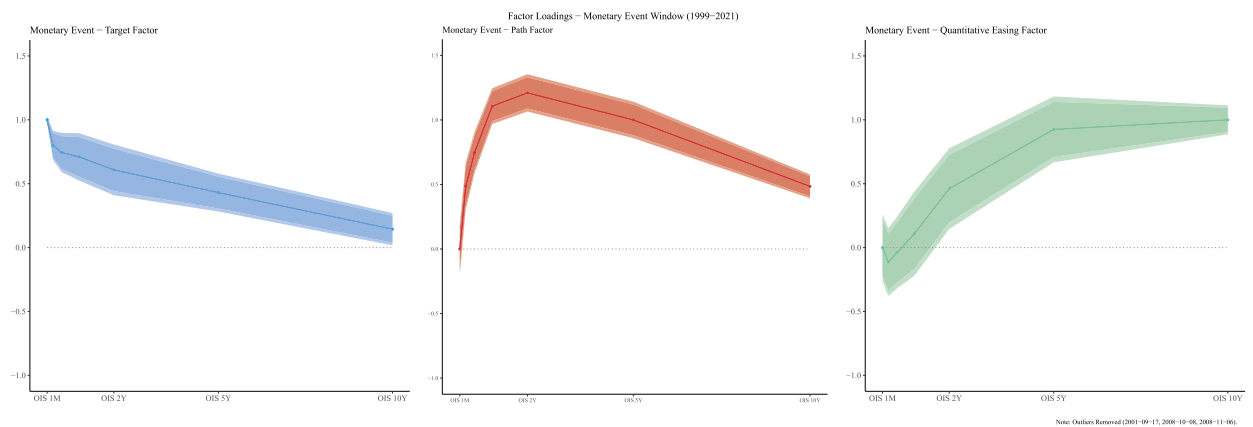


Fig. 3. Target, Path and QE factors.

measures.¹⁰ As depicted in Fig. 3, factors are scaled to have unit impact on the 1-month OIS rate for the target factor and the 10-year OIS rate for the quantitative easing factor. As such, they are also positively correlated with such rates. Hence, a positive contribution can be interpreted as expressing a restrictive (or negative) monetary surprise.

3.3. Controls

To account for the macroeconomic context of monetary policy announcements, we also consider several control variables.

We first use the logarithm of industrial production in the Euro Area (*PRODUCTION*), which is a monthly variable (source: OECD). For each announcement date t , *PRODUCTION* corresponds to the level of industrial production in the month during which the announcement is made, in year-on-year log change. Our second control variable, denoted by *INFLATION*, measures 1-year ahead HICP inflation forecasts by Survey of Professional Forecasters (source: ECB). For each announcement date t , *INFLATION* corresponds to the inflation forecast in the quarter during which the announcement is made, in percentage. *SPREAD* measures the first difference of the Euro Area spread, calculated as the logarithm of the spread between the Euro Area average 10-year bond yield and the German Bund yield (source: Datastream). At date t , *SPREAD* corresponds to the spread change with respect to the previous announcement date $t - 1$. We also consider the 1-month Vstox index (*VSTOXX*). This variable, which is calculated on a daily basis (source: Macrobond), accounts for volatility and uncertainty in stock markets. For each announcement date t , *VSTOXX* relates to the index value at t . Finally, note that control variables are included the regression with lags, as explained in the next section.

Summary statistics for the dependent and explanatory variables are provided in Table 18 (Appendix C).

¹⁰ The variance of the second factor, associated with quantitative easing, is minimised over the period before the meeting held on 3 December 2015, which corresponds to the date of the meeting preceding the change in communication of the ECB in its press release, with the introduction of statements on non-standard measures in addition to those related to the bank rates.

4. Empirical strategy

To measure the effect of ECB communication on monetary surprises, we estimate the following model:

$$|SURPRISE_t| = \alpha + \beta COM_{t-1} + \gamma CONTROL_{t-1} + \epsilon_t \quad (1)$$

where $|SURPRISE_t|$ accounts for the absolute value of our monetary policy surprise variables (i.e., $TARGET_t$, $PATH_t$ and QE_t successively). Subscript t denotes the announcement date, used as the observations. Indeed, we focus on the *size* of the monetary surprise rather than on its *sign*.

COM_{t-1} is a monetary policy communication variable ($NUMCAT_{t-1}$, $NUMSUBCAT_{t-1}$, $FREQCAT_{t-1}$ and $FREQSUBCAT_{t-1}$, successively). Note that this variable is considered at $t - 1$. This allows us to capture the fact that the market participants' skill in *predicting* the content of a monetary decision (at t) depends on the characteristics (frequency, intensity) of the previous announcement (at $t - 1$). In other words, we aim to capture the extent to which the intensity or the frequency of communication at $t - 1$ pave the way for predicting the following announcement. For example, because at $t - 1$, a high level of communication intensity at t may make it particularly difficult (confusion argument) or particularly easy (clarity argument) for market agents to predict the announcement that will be made at t .

Finally, $CONTROL_{t-1}$ is a vector of control variables consisting of $PRODUCTION_{t-1}$, $INFLATION_{t-1}$, $SPREAD_{t-1}$ and $VSTOXX_{t-2}$. As $VSTOXX_{t-2}$ is usually a driver of other macroeconomic variables, we consider its value at $t - 2$ to avoid collinearity.

To estimate Equation (1), we use an ordinary least squares (OLS) estimator.

We pay particular attention to β , the coefficient for COM_{t-1} . According to the confusion argument (Winkler, 2000; Jensen, 2002; Kahnemann, 2003; Blinder, 2007; Van der Cruijssen et al., 2010; Koole et al., 2011; Ehrmann et al., 2012; Lustenberger and Rossi, 2020; Blinder et al., 2022), stronger intensity and frequency should increase market participants' surprise. Hence, β should be significant and positive. In contrast, in line with Poole and Rasche (2003), Swanson (2006), Middeldorp (2011), Neuenkirch (2013), Eichler and Littke (2018), Naszodi et al. (2016) and Urbschat and Watzka (2020), if ECB communication improves monetary policy predictability and clarity, greater intensity and frequency should reduce the size of market participants' surprise. In this case, β should be significant and negative.

5. Results

5.1. Baseline estimations

As we aim to analyse the impact of ECB communication in the framework of non-standard monetary policy, we estimate Equation (1) over the period that starts in January 2008.

The results for OLS estimations are reported in Tables 2 and 3. In both tables, Columns [1]-[2] present the results obtained when including the target factor as the explained variable, Columns [3]-[4] present the results when considering the path factor, and Columns [5]-[6] refer to the regression with the QE factor as the explained variable. Variants [1], [3] and [5] in Table 2 focus on $NUMCAT$ as the intensity indicator, while variants [2], [4] and [6] consider $NUMSUBCAT$. Symmetrically, variants [1], [3] and [5] in Table 3 use $FREQCAT$ as the frequency indicator, while variants [2], [4] and [6] consider $FREQSUBCAT$.

First, the results reported in Columns [1]-[2] in Tables 2 and 3 indicate that intensity and frequency variables do not influence the target factor, i.e., the standard dimension of monetary policy. However, both types of variables have a significant and negative effect on the path factor (Columns [3]-[4] in Tables 2 and 3). Similarly, frequency variables ($FREQCAT$ and $FREQSUBCAT$) have a negative impact on the QE factor (Columns [5]-[6] in Table 3). This indicates that when focusing on the non-standard (forward guidance and quantitative easing) dimension of monetary surprises, an increase in the intensity and frequency of monetary policy communication improves the predictability of monetary policy decisions and reduces surprises in financial markets. Hence, a high level of communication intensity and frequency makes it easier for market participants to predict the following ECB announcement.

Taken together, these findings are in line with Poole and Rasche (2003), Bernanke (2004), Swanson (2006), Blinder (2007), Middeldorp (2011), Neuenkirch (2013), Eichler and Littke (2018), Naszodi et al. (2016) and Urbschat and Watzka (2020). They also suggest that improving the predictability of the non-standard dimension of monetary decisions is not obtained at the cost of greater confusion regarding its standard dimension.

5.2. Robustness and extensions

5.2.1. Estimations over the 1999-2020 period

To assess whether our baseline results are affected by the estimation period, we estimate Equation (1) over the 1999-2020 period, which also accounts for the standard monetary policy period. The results are reported in Tables 4 and 5.

One observes that the frequency and intensity variables have no effect on the target factor (specifications [1]-[2] in Tables 4 and 5). Variants [5]-[6] in Table 4 also indicate that the intensity variables ($NUMSUBCAT$ and $NUMSUBSU BCAT$) have no effect on the QE factor, while specifications [3]-[4] in Table 5 show a negative effect of the frequency variables ($FREQSUBCAT$ and $FREQSUBSU BCAT$) on the path factor. These findings are in line with those obtained in the baseline estimations.

Table 2
Baseline estimations with *NUMCAT* or *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1}	0.03 (0.10)		-0.23** (0.09)		-0.12 (0.07)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.00 (0.07)		-0.12** (0.06)		-0.07 (0.06)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.04** (0.02)	0.04** (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.32 (0.33)	0.28 (0.32)	0.82** (0.33)	0.90** (0.36)	-0.24 (0.32)	-0.22 (0.33)
<i>SPREAD</i> _{<i>t</i>-1}	0.54 (0.40)	0.55 (0.38)	-0.21 (0.45)	-0.13 (0.46)	0.29 (0.31)	0.34 (0.31)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.01)
<i>Constant</i>	0.29 (0.35)	0.36 (0.29)	1.48*** (0.41)	1.21*** (0.34)	1.07*** (0.19)	0.95*** (0.18)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 3
Baseline estimations with *FREQCAT* or *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.05 (0.36)		-1.21*** (0.37)		-0.78** (0.34)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.03 (1.33)		-3.63*** (1.19)		-2.97** (1.21)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.04** (0.02)	0.03** (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.27 (0.30)	0.28 (0.32)	0.76** (0.33)	0.80** (0.34)	-0.32 (0.34)	-0.35 (0.34)
<i>SPREAD</i> _{<i>t</i>-1}	0.54 (0.40)	0.54 (0.40)	-0.26 (0.45)	-0.26 (0.45)	0.26 (0.30)	0.25 (0.30)
<i>VSTOXX</i> _{<i>t</i>-1}	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
<i>Constant</i>	0.38 (0.31)	0.36 (0.30)	1.59*** (0.41)	1.41*** (0.36)	1.21*** (0.18)	1.17*** (0.17)
<i>Nb Obs</i>	130	130	130	130	130	130

However, in contrast with previous results, the intensity variables (*NUMSUBCAT* and *NUMSUBSUBCAT*) do not influence the path factor (specifications [3]-[4] in Table 4). Similarly, the frequency indicators (*FREQSUBCAT* and *FREQSUBSUBCAT*) have no effect on the QE factor (specifications [5]-[6] in Table 5).

Taken together, these findings suggest that the favourable effect of intensity and frequency on the non-standard dimensions of monetary surprises, i.e., QE and path factors, vanishes when one also considers the standard monetary policy period. In line with the literature (Cieslak and Schrimpf, 2018; Coenen et al., 2017; ECB, 2021; Ehrmann et al., 2021), our results thus suggest that non-standard monetary policies provide a favourable field for new central bank communication practices. Specifically, the increase in the number of programs and instruments creates a new communication framework by which the intensity and frequency of announcements are not neutral on the predictability of central bank communication.

5.2.2. Estimations with alternative specifications

We further assess the robustness of our baseline results by considering alternative specifications. First, we estimate Equation (1) without control variables. The results, which are provided in Tables 6 and 7, indicate that communication indicators have no effect on the target dimension of monetary surprises while they have a positive impact on path and QE factors. Hence, our baseline findings are robust to the change in the econometric specification.¹¹

Second, Fig. 1 suggests the existence of a trend in our communication variables. Because this may bias our findings, we thus estimate Equation (1) using detrended series for *NUMCAT*, *NUMSUBCAT*, *FREQCAT* and *FREQSUBCAT*. Tables 8 and 9 show that our findings remain qualitatively unchanged.

¹¹ Note that we also estimate Equation (1) using a Newey estimator. The results, not displayed here, remained unchanged.

Table 4
Estimations over the 1999-2020 period with *NUMCAT* or *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1}	-0.03 (0.08)		-0.05 (0.04)		0.08 (0.05)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.04 (0.06)		-0.03 (0.03)		0.05 (0.04)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.02* (0.01)	-0.02* (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.11 (0.25)	0.07 (0.24)	0.42** (0.20)	0.44** (0.20)	-0.21 (0.23)	-0.23 (0.24)
<i>SPREAD</i> _{<i>t</i>-1}	0.48 (0.42)	0.51 (0.40)	-0.22 (0.42)	-0.19 (0.42)	0.29 (0.32)	0.26 (0.31)
<i>VSTOXX</i> _{<i>t</i>-2}	0.02** (0.01)	0.02** (0.01)	0.01* (0.00)	0.01** (0.00)	0.00 (0.00)	0.00 (0.00)
<i>Constant</i>	0.22 (0.22)	0.24 (0.20)	0.65*** (0.17)	0.62*** (0.16)	0.47*** (0.15)	0.51*** (0.14)
<i>Nb Obs</i>	255	255	255	255	255	255

Table 5
Estimations over the 1999-2020 period with *FREQCAT* or *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.20 (0.32)		-0.37** (0.18)		0.14 (0.23)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.64 (1.19)		-1.32** (0.66)		0.24 (0.88)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.02** (0.01)	-0.02** (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.08 (0.23)	0.10 (0.24)	0.37* (0.20)	0.37* (0.20)	-0.29 (0.25)	-0.33 (0.25)
<i>SPREAD</i> _{<i>t</i>-1}	0.47 (0.43)	0.47 (0.43)	-0.23 (0.41)	-0.23 (0.41)	0.30 (0.32)	0.30 (0.31)
<i>VSTOXX</i> _{<i>t</i>-2}	0.02** (0.01)	0.02** (0.01)	0.01* (0.00)	0.01* (0.00)	0.00 (0.00)	0.00 (0.00)
<i>Constant</i>	0.25 (0.22)	0.24 (0.21)	0.71*** (0.17)	0.69*** (0.17)	0.53*** (0.14)	0.57*** (0.14)
<i>Nb Obs</i>	255	255	255	255	255	255

Table 6
Estimations without control variables with *NUMCAT* or *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1}	-0.03 (0.06)		-0.30*** (0.10)		-0.10 (0.06)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.02 (0.05)		-0.19*** (0.07)		-0.05 (0.05)
<i>Constant</i>	0.52*** (0.16)	0.51*** (0.14)	1.39*** (0.31)	1.15*** (0.25)	1.20*** (0.17)	1.10*** (0.14)
<i>Nb Obs</i>	130	130	130	130	130	130

5.2.3. Accounting for the stance of monetary policy

In this section, we account for the tone of ECB monetary policy and check whether its inclusion in the estimations affects our baseline results. To do so, we reproduce the methodology developed by Picault and Renault (2017) to capture the stance of ECB monetary policy. They first manually classify all sentences in ECB introductory statements into three inclinations (positive, neutral, and negative). Then, for each work or group of words appearing in at least two statements—having removed all unnecessary words and punctuation marks—, they compute the probability that the group of words belongs to one of the inclinations. We reproduce and extend their results using an automated procedure rendered available in the *sentopics* R package. Based on the text of all press releases and press conferences since 1999, for each announcement date, we compute the probability of each group of word belonging to one of the three above mentioned categories taking advantage of Picault and Renault (2017)'s lexicon. These probabilities, displayed

Table 7
Estimations without control variables with *FREQCAT* or *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.33 (0.23)		-1.49*** (0.40)		-0.65** (0.26)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.97 (0.84)		-4.93*** (1.38)		-2.48*** (0.85)
<i>Constant</i>	0.64*** (0.15)	0.59*** (0.14)	1.46*** (0.29)	1.33*** (0.26)	1.31*** (0.17)	1.30*** (0.15)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 8
Estimations without control variables with detrended *NUMCAT* or detrended *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1} detrended	-0.00 (0.09)		-0.22** (0.10)		-0.11 (0.07)	
<i>NUMSUBCAT</i> _{<i>t</i>-1} detrended		-0.00 (0.07)		-0.12* (0.07)		-0.05 (0.05)
<i>Constant</i>	0.45*** (0.07)	0.45*** (0.07)	0.65*** (0.09)	0.64*** (0.09)	0.96*** (0.06)	0.95*** (0.06)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 9
Estimations without control variables with detrended *FREQCAT* or detrended *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1} detrended	-0.35 (0.30)		-1.30*** (0.44)		-0.90** (0.35)	
<i>FREQSUBCAT</i> _{<i>t</i>-1} detrended		-0.89 (1.15)		-4.16*** (1.43)		-3.35*** (1.15)
<i>Constant</i>	0.45*** (0.07)	0.45*** (0.07)	0.64*** (0.08)	0.63*** (0.08)	0.95*** (0.06)	0.95*** (0.06)
<i>Nb Obs</i>	130	130	130	130	130	130

in Fig. 4, in Appendix D, indicate that the stance of the ECB monetary policy is mainly restrictive between 2005 and 2008, and becomes accommodative after the GFC.

Then, we build two dummy variables, denoted by *ACCOM*_{*t*} and *RESTRICT*_{*t*}, respectively. *ACCOM*_{*t*} equals 1 if the value of the probability to be accommodative at date *t* is above the 90th percentile of its distribution, 0 otherwise. Symmetrically, *RESTRICT*_{*t*} equals 1 if the value of the probability to be restrictive at date *t* is above the 90th percentile of its distribution, 0 otherwise. Both variables account for the idea that an announcement characterized by a very high probability to be accommodative (or restrictive) should be particularly clear and easily interpretable for participants in financial market. We then estimate Equation (1) in which *ACCOM* and *RESTRICT* are successively included as explained variables. The results are provided in Tables 10, 11, 12 and 13.

The results reported in Tables 10 and 12 show that the coefficient for *ACCOM*_{*t*} is not significant, which suggests that financial markets are not surprised by announcements that have a strong accommodative tone. However, in specifications [1] to [4] in Tables 11 and 13, the coefficient for *RESTRICT*_{*t*} is significant. When one considers the conventional dimension of monetary policy decisions (*TARGET*) (specifications [1] and [2] in Tables 11 and 13), this coefficient is negative. Hence, a strongly restrictive tone reduces surprises in financial markets, e.g. is associated to more clarity. Conversely, when focusing on the unconventional dimension of monetary policy decisions (*PATH*) (specifications [3] and [4] in Tables 11 and 13), the coefficient is positive. Hence, a strongly restrictive tone increases surprises in financial markets, e.g. induces more confusion. Indeed, because unconventional monetary policies initially aimed to boost economic activity after the GFC, they are intuitively associated with accommodative decisions, making non-standard restrictive announcements quite difficult to understand for financial markets.

Finally, turning to the coefficients for variables *NUMCAT*, *NUMSUBCAT*, *FREQCAT* and *FREQSUBCAT*, the results provided in Tables 10 to 13 show that are not affected by the inclusion of *ACCOM* and *RESTRICT* in the estimations. This provides evidence that beyond the content and the tone of announcements, the intensity and the frequency of communication also matter as regards the clarity of monetary policy decisions.

Table 10
Estimations with accommodative stance (*ACCOM*) and *NUMCAT* or *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1}	-0.00 (0.08)		-0.23** (0.10)		-0.09 (0.08)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.04 (0.05)		-0.11* (0.07)		-0.04 (0.07)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.04** (0.02)	0.04** (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.36 (0.34)	0.32 (0.33)	0.81** (0.34)	0.89** (0.36)	-0.28 (0.33)	-0.25 (0.33)
<i>SPREAD</i> _{<i>t</i>-1}	0.55 (0.40)	0.57 (0.39)	-0.21 (0.45)	-0.14 (0.46)	0.29 (0.31)	0.31 (0.32)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.01)
<i>ACCOM</i> _{<i>t</i>}	0.28 (0.33)	0.33 (0.35)	-0.04 (0.14)	-0.08 (0.14)	-0.27 (0.17)	-0.28 (0.18)
<i>Constant</i>	0.37 (0.32)	0.43 (0.29)	1.47*** (0.43)	1.19*** (0.36)	1.00*** (0.20)	0.89*** (0.19)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 11
Estimations with restrictive stance (*RESTRICT*) and *NUMCAT* or *NUMSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>NUMCAT</i> _{<i>t</i>-1}	0.02 (0.10)		-0.19** (0.08)		-0.12 (0.08)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.01 (0.07)		-0.10* (0.05)		-0.07 (0.06)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.03* (0.02)	0.03* (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.37 (0.34)	0.33 (0.33)	0.61* (0.32)	0.65* (0.33)	-0.23 (0.33)	-0.21 (0.34)
<i>SPREAD</i> _{<i>t</i>-1}	0.55 (0.40)	0.55 (0.39)	-0.24 (0.44)	-0.17 (0.44)	0.30 (0.31)	0.34 (0.32)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01* (0.01)	0.00 (0.00)	0.00 (0.01)
<i>RESTRICT</i> _{<i>t</i>}	-0.31** (0.14)	-0.33** (0.15)	1.58* (0.89)	1.67* (0.89)	-0.09 (0.20)	-0.03 (0.20)
<i>Constant</i>	0.35 (0.35)	0.41 (0.30)	1.17*** (0.37)	0.95*** (0.30)	1.09*** (0.21)	0.95*** (0.20)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 12
Estimations with accommodative stance (*ACCOM*) and *FREQCAT* or *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.24 (0.31)		-1.21*** (0.41)		-0.66* (0.36)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.95 (1.10)		-3.72*** (1.40)		-2.42* (1.31)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.04** (0.02)	0.04** (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.31 (0.32)	0.31 (0.32)	0.76** (0.34)	0.82** (0.35)	-0.35 (0.34)	-0.34 (0.34)
<i>SPREAD</i> _{<i>t</i>-1}	0.54 (0.41)	0.54 (0.40)	-0.26 (0.45)	-0.26 (0.45)	0.26 (0.30)	0.26 (0.31)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
<i>ACCOM</i> _{<i>t</i>}	0.32 (0.35)	0.35 (0.36)	-0.00 (0.14)	0.03 (0.16)	-0.21 (0.16)	-0.16 (0.16)
<i>Constant</i>	0.48 (0.30)	0.48 (0.29)	1.59*** (0.43)	1.43*** (0.39)	1.15*** (0.19)	1.11*** (0.18)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 13
Estimations with restrictive stance (*RESTRICT*) and *FREQCAT* or *FREQSUBCAT*.

	TARGET (1)	TARGET (2)	PATH (3)	PATH (4)	QE (5)	QE (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.10 (0.37)		-0.98*** (0.34)		-0.80** (0.35)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.18 (1.32)		-2.92*** (1.07)		-2.91** (1.21)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.03* (0.02)	0.03* (0.02)	-0.01 (0.01)	-0.01 (0.01)
<i>INFLATION</i> _{<i>t</i>-1}	0.31 (0.31)	0.33 (0.32)	0.57* (0.31)	0.60* (0.32)	-0.30 (0.34)	-0.31 (0.35)
<i>SPREAD</i> _{<i>t</i>-1}	0.55 (0.41)	0.55 (0.41)	-0.28 (0.44)	-0.28 (0.44)	0.26 (0.30)	0.26 (0.30)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
<i>RESTRICT</i> _{<i>t</i>}	-0.35** (0.15)	-0.33** (0.15)	1.54* (0.90)	1.59* (0.90)	-0.15 (0.21)	-0.13 (0.21)
<i>Constant</i>	0.46 (0.31)	0.43 (0.31)	1.27*** (0.36)	1.12*** (0.31)	1.24*** (0.20)	1.19*** (0.18)
<i>Nb Obs</i>	130	130	130	130	130	130

5.2.4. The information channel

Finally, we refine our analysis by acknowledging the fact that monetary surprises are likely to be contaminated by “information shocks” (Jarocinski, 2020, Jarocinski and Karadi, 2020, Miranda-Agrippino and Ricco, 2021). Indeed, due to the existence of information asymmetries between central banks and market participants (Romer and Romer, 2000), monetary policy actions may transfer information about economic fundamentals towards financial markets (Andrade and Ferroni, 2021). This so-called “signalling” or “information channel” of monetary policy (Melosi, 2017) is prominent for non-standard monetary measures (Cecioni et al., 2011). The distinction between pure monetary and information shocks can be seen in the light of the opposition between “Delphic” and “Odyssean” shocks (Campbell et al., 2012, Andrade and Ferroni, 2021). In Odyssean surprises, the central bank commits to future deviations from its usual reaction function. In the case of Delphic surprises, the central bank serves as an oracle regarding the macroeconomic outlook.

We thus follow the methodology of Jarocinski (2020) and Jarocinski and Karadi (2020) and exploit comovements between short-term interest rates and stock prices in the EA MPD to extract two factors. The first reflects monetary policy shocks per se (pure monetary policy channel or Odyssean surprises) and is associated to opposite movements between interest rates and stock prices, as expected by standard monetary policy theory. The second implies comovements in rates and stock prices, which is interpreted as the central bank revealing private information about current and future demand conditions and tightening its policy to counter their impact on the economy (information channel or Delphic surprises). The details of this methodology are described in Appendix E. We disaggregate target, path and QE factors estimated in Section 3.2 with regard to opposite variations between 2-year OIS rate and Stoxx 50 to extract their Odyssean component. The Delphic component is then obtained as the residual of the regression of the factor over its Odyssean component to ensure that both components are orthogonal to each other. Factors are then rescaled to unit variance. We thus obtain three Odyssean factors, denoted by *TARGET*_{odys}, *PATH*_{odys}, and *QE*_{odys}, respectively, and three Delphic factors, denoted by *TARGET*_{del}, *PATH*_{del} and *QE*_{del}, respectively. Table 19 in Appendix F provides summary statistics for these variables.

We then estimate Equation (1) in which *TARGET*_{odys}, *TARGET*_{del}, *PATH*_{odys}, *PATH*_{del}, *QE*_{odys} and *QE*_{del} are successively included as explained variables. The results for the Delphic factors are reported in Tables 14 and 15, and the results for Odyssean factors are reported in Tables 16 and 17.

Variants [3], [5] and [6] in Table 14 and specifications [3], [4], [5] and [6] in Table 15 show that when considering Delphic factors, the coefficients for *NUMCAT*, *NUMSUBCAT*, *FREQ* and *FREQSUBCAT* are negative and significant. Conversely, for the Odyssean factors, the coefficients for *NUMCAT*, *NUMSUBCAT*, *FREQ* and *FREQSUBCAT* are not significant, except in specifications [3] and [4] in Table 17.

This indicates that the results obtained in previous sections still hold when considering the information channel but not in the case of the pure monetary policy channel. Hence, the impact of intensity and frequency on path and QE factors mainly passes through the information that is conveyed by the central bank through its announcements. A more intense and frequent monetary communication increases the predictability of the central bank’s decisions by improving the clarity of its outlook and its conception of the economic situation. This finding is in line with the idea that beyond the content of ECB announcements, increasing the intensity and the frequency of monetary decisions has to do with a pure communication effect.

6. Conclusion

This paper aims to study the effect of ECB communication on the ability of market participants to predict monetary decisions, using a dataset of 273 press releases over the period 1999-2020. The first contribution of this paper is methodological. Based on a hand-

Table 14
Estimations with Delphic factors with *NUMCAT* or *NUMSUBCAT*.

	TARGETdel (1)	TARGETdel (2)	PATHdel (3)	PATHdel (4)	QEdel (5)	QEdel (6)
<i>NUMCAT</i> _{<i>t</i>-1}	-0.03 (0.06)		-0.15* (0.09)		-0.22** (0.09)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		-0.04 (0.04)		-0.08 (0.07)		-0.14* (0.07)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.02)	-0.00 (0.02)	-0.00 (0.02)	-0.00 (0.02)
<i>INFLATION</i> _{<i>t</i>-1}	0.30 (0.28)	0.27 (0.25)	0.55 (0.33)	0.61* (0.36)	-0.06 (0.32)	-0.02 (0.33)
<i>SPREAD</i> _{<i>t</i>-1}	0.64 (0.58)	0.66 (0.57)	0.33 (0.50)	0.38 (0.52)	0.60 (0.40)	0.69 (0.42)
<i>VSTOXX</i> _{<i>t</i>-2}	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)
<i>Constant</i>	0.48** (0.20)	0.49** (0.20)	1.10*** (0.41)	0.92*** (0.35)	1.08*** (0.34)	0.87*** (0.30)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 15
Estimations with Delphic factors with *FREQCAT* or *FREQSUBCAT*.

	TARGETdel (1)	TARGETdel (2)	PATHdel (3)	PATHdel (4)	QEdel (5)	QEdel (6)
<i>FREQCAT</i> _{<i>t</i>-1}	-0.12 (0.26)		-0.93*** (0.33)		-0.86** (0.42)	
<i>FREQSUBCAT</i> _{<i>t</i>-1}		-0.50 (0.78)		-2.77** (1.09)		-2.67* (1.47)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.00 (0.01)	0.00 (0.01)	-0.00 (0.02)	-0.01 (0.02)	-0.00 (0.02)	-0.00 (0.02)
<i>INFLATION</i> _{<i>t</i>-1}	0.31 (0.27)	0.30 (0.26)	0.47 (0.31)	0.51 (0.33)	-0.03 (0.32)	-0.01 (0.33)
<i>SPREAD</i> _{<i>t</i>-1}	0.63 (0.58)	0.63 (0.58)	0.29 (0.48)	0.29 (0.49)	0.56 (0.39)	0.56 (0.40)
<i>VSTOXX</i> _{<i>t</i>-2}	0.00 (0.00)	0.00 (0.00)	-0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
<i>Constant</i>	0.48** (0.19)	0.48** (0.19)	1.25*** (0.39)	1.11*** (0.36)	1.04*** (0.32)	0.93*** (0.32)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 16
Estimations with Odyssean factors with *NUMCAT* or *NUMSUBCAT*.

	TARGETody (1)	TARGETody (2)	PATHody (3)	PATHody (4)	QEody (5)	QEody (6)
<i>NUMCAT</i> _{<i>t</i>-1}	0.07 (0.13)		-0.17 (0.10)		0.04 (0.10)	
<i>NUMSUBCAT</i> _{<i>t</i>-1}		0.03 (0.09)		-0.09 (0.06)		0.03 (0.08)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.05** (0.02)	0.05** (0.02)	-0.01 (0.02)	-0.01 (0.02)
<i>INFLATION</i> _{<i>t</i>-1}	0.16 (0.39)	0.13 (0.39)	0.57 (0.38)	0.63 (0.40)	-0.28 (0.47)	-0.28 (0.48)
<i>SPREAD</i> _{<i>t</i>-1}	0.17 (0.30)	0.15 (0.28)	-0.54 (0.44)	-0.48 (0.43)	-0.14 (0.41)	-0.16 (0.41)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)
<i>Constant</i>	-0.03 (0.43)	0.06 (0.35)	1.06** (0.52)	0.86** (0.42)	0.47 (0.30)	0.50* (0.29)
<i>Nb Obs</i>	130	130	130	130	130	130

Table 17
Estimations with Odyssean factors with *FREQCAT* or *FREQSU BCAT*.

	TARGETody (1)	TARGETody (2)	PATHody (3)	PATHody (4)	QEody (5)	QEody (6)
<i>FREQCAT</i> _{<i>t</i>-1}	0.04 (0.45)		-0.80* (0.44)		-0.27 (0.50)	
<i>FREQSU BCAT</i> _{<i>t</i>-1}		0.40 (1.74)		-2.39* (1.39)		-1.57 (1.74)
<i>PRODUCTION</i> _{<i>t</i>-1}	0.01 (0.02)	0.01 (0.02)	0.05** (0.02)	0.05** (0.02)	-0.01 (0.02)	-0.01 (0.02)
<i>INFLATION</i> _{<i>t</i>-1}	0.08 (0.36)	0.10 (0.38)	0.55 (0.39)	0.58 (0.40)	-0.41 (0.49)	-0.47 (0.49)
<i>SPREAD</i> _{<i>t</i>-1}	0.17 (0.31)	0.18 (0.31)	-0.58 (0.45)	-0.57 (0.45)	-0.16 (0.41)	-0.17 (0.41)
<i>VSTOXX</i> _{<i>t</i>-2}	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)
<i>Constant</i>	0.11 (0.36)	0.08 (0.36)	1.10** (0.52)	0.98** (0.46)	0.69** (0.33)	0.75** (0.32)
<i>Nb Obs</i>	130	130	130	130	130	130

collected dataset of ECB press releases and press conferences, we propose an innovative approach to investigate ECB communication by constructing new indicators that aim to account for communication intensity and frequency. Following the approach of Altavilla et al. (2019) and Baumgärtner (2022), we also decompose monetary surprises on the variation of asset prices around press releases into a target, a path and a quantitative easing factor.

The second contribution of the paper consists in demonstrating that the intensity and frequency of ECB communication reduces the surprise of market participants regarding the non-standard (path and QE) dimensions of monetary policy. Moreover, the improvement of the predictability of non-standard monetary announcements is reached without increasing confusion about standard monetary decisions. This effect vanishes when the estimation period also includes the pre-crisis period, which provides evidence that non-standard monetary policies that were implemented during and after the financial crisis are characterised by the use of new communication practices based on the intensity and frequency of announcements. Finally, our results also indicate that the reduction in market participants' surprise regarding the quantitative easing component of monetary policy operates through the information channel, by which monetary policy announcements allow to transfer information about economic fundamentals from the central bank to market participants.

Our article undoubtedly calls for further investigations. First, a valuable extension could consist in assessing whether communication intensity and frequency also improve the predictability of central banks' decisions in the new context of monetary tapering and quantitative tightening. Second, it would also be interesting to investigate whether communication intensity and frequency affect other dimensions of market reaction, such as financial stability or systemic risk.

CRedit authorship contribution statement

Quentin Bro de Comères: Methodology, Data curation. **Cornel Oros:** Writing – original draft, Validation, Project administration, Conceptualization. **Marc Pourroy:** Writing – original draft, Validation, Supervision, Formal analysis, Data curation, Conceptualization. **Léonore Raguideau-Hannotin:** Data curation, Investigation. **Anne-Gaël Vaubourg:** Writing – original draft, Validation, Supervision, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Vaubourg reports financial support was provided by Région Nouvelle-Aquitaine (AAPR2020-2019-8316410). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Examples of classification

The following example is based on the 2020-04-30 Introductory Statement.¹² In this introductory statement, we have:

¹² The statement is available at <https://www.ecb.europa.eu/press/pressconf/2020/html/ecb.is200430~ab3058e07f.en.html>.

- Standard monetary policy decisions (STAND)
 - Interest rates decisions: “In addition, we decided to keep the key ECB interest rates unchanged.”
- Liquidity provision decisions (LIQ)
 - TLTRO: “Accordingly, the Governing Council decided today to further ease the conditions on our targeted longer-term refinancing operations (TLTRO III).”
 - PELTRO: “We also decided on a new series of non-targeted pandemic emergency longer-term refinancing operations (PELTROs) to support liquidity conditions in the euro area financial system and contribute to preserving the smooth functioning of money markets by providing an effective liquidity backstop.”
- Asset purchase decisions (AP)
 - PEPP: “Since the end of March we have been conducting purchases under our new pandemic emergency purchase programme (PEPP), [...]”
 - Other asset purchase decisions: “Moreover, net purchases under our asset purchase programme (APP) will continue at a monthly pace of 20 billion euros, [...]”
- Forward guidance decisions (FG): “Let me now explain our assessment in greater detail, starting with the economic analysis.”

We then obtain $NUMCAT = 4$ and $NUMSUBCAT = 6$.

Appendix B. Factor extraction

Let \mathbf{X} be a $T \times N$ matrix with rows (T) corresponding to monetary policy announcements and columns corresponding to high-frequency variations in asset prices (N)—each column corresponding to one asset. To identify factors, \mathbf{X} is rewritten into a factor model:

$$\mathbf{X} = \mathbf{F}\mathbf{\Lambda} + \varepsilon. \tag{2}$$

With \mathbf{F} a $T \times k$, $k < n$ matrix of unobserved factors, $\mathbf{\Lambda}$ a $k \times n$ matrix of factor loadings and ε a $T \times n$ matrix of white noise disturbances. \mathbf{X} is normalised to zero-mean and unit variance.

Factors—principal components—are obtained as the k first column of the matrix \mathbf{F} , obtained from a singular value decomposition of \mathbf{X} :

$$\mathbf{X} = \mathbf{F} \times \mathbf{S} \times \mathbf{V}' + \mu. \tag{3}$$

In (3), \mathbf{X} is decomposed into a set of orthogonal vectors $\mathbf{F}_i, i \in \{1, n\}$ with \mathbf{F}_1 the vector that has maximum explanatory power for \mathbf{X} , \mathbf{F}_2 the vector that has maximum explanatory power for the residuals of \mathbf{X} after projecting each column on \mathbf{F}_1 and so on. The matrix of loadings $\mathbf{\Lambda}$ is obtained by multiplying the first k rows of \mathbf{S} by \mathbf{V}' . The error term, μ is computed as $\mathbf{X} - \mathbf{F}\mathbf{\Lambda}$. However, as principal components are only a statistical decomposition, one needs to rotate them to make them admit a structural interpretation. Let \mathbf{U} be a $k \times k$ rotation matrix satisfying $\mathbf{U}'\mathbf{U} = \mathbf{I}$, where \mathbf{I} is the identity matrix. Then, \mathbf{X} can equivalently be expressed as:

$$\mathbf{X} = \tilde{\mathbf{F}}\tilde{\mathbf{\Lambda}} + \varepsilon, \tilde{\mathbf{F}} = \mathbf{F}\mathbf{U}, \tilde{\mathbf{\Lambda}} = \mathbf{U}'\mathbf{\Lambda}. \tag{4}$$

To ensure the unicity of matrix \mathbf{U}^* , two sets of identifying restrictions are imposed. The first set of restrictions comes from orthogonality requirements, which means that the columns of \mathbf{U} must have unit length ($\mathbf{U}'_{\bullet n} \mathbf{U}_{\bullet n} = 1, \forall n \in \{1, k\}$) and be orthogonal ($\mathbf{U}'_{\bullet n} \mathbf{U}_{\bullet m} = 0, \forall n \neq m \in \{1, k\}$). The second set of restrictions has economic meaning. It imposes that factors other than the first one do not load on the short-term rate, to differentiate additional factors from the short-term oriented measures ($\mathbf{U}'_{\bullet n} \mathbf{\Lambda}_{\bullet 1} = 0, \forall n \in \{2, k\}$). Second, the last (k -th) factor must have minimal variance before a given date. Then, let \mathbf{F}^{pre} denote the factor matrix of all monetary policy events before the selected date, and T the number of policy events before that date. The variance of the k -th factor is given by $\frac{1}{T} \sum_{t=1}^T (\mathbf{F}_k^{pre} \mathbf{U}_{k\bullet})^2$. The idea behind this is that if a factor does not exist, it should have a minimal variance. Considering a $k \times k$ matrix, the final matrix \mathbf{U}^* is then the solution of the optimisation problem displayed in (5).

$$\mathbf{U}^* = \underset{\{u_{i,j}\}}{\operatorname{argmin}} \frac{1}{T} \sum_{t=1}^T (\mathbf{F}_k^{pre} \mathbf{U}_{k\bullet})^2, \quad i, j \in \{1, k\}, \tag{5}$$

$$\text{s.t. } \mathbf{U}'_{\bullet n} \mathbf{U}_{\bullet n} = 1, \quad \forall n \in \{1, k\},$$

$$\mathbf{U}'_{\bullet n} \mathbf{U}_{\bullet m} = 0, \quad \forall n \neq m \in \{1, k\},$$

$$\mathbf{U}'_{\bullet n} \mathbf{\Lambda}_{\bullet 1} = 0, \quad \forall n \in \{2, k\}.$$

The columns of \mathbf{F}^* are then scaled according to their interpretation regarding their structural loadings, to be positively correlated with relevant assets. As such, positive factors can be interpreted as expressing restrictive monetary surprises. Finally, to facilitate their interpretation, factors are scaled to unit variance, while they already display zero mean by construction.

Appendix C. Summary statistics

Table 18
Summary statistics for the explanatory variables.

Variable	Obs	Mean	Std.Dev.	Min	Max
NUMCAT	273	1.78	1.01	1	4
NUMSUBCAT	273	1.95	1.31	1	8
FREQCAT	272	0.40	0.22	0.25	1
FREQSUBCAT	272	0.10	0.06	0.06	0.34
TARGET	273	-0.00	1.01	-5.98	5.10
PATH	273	0.00	1.01	-4.91	6.07
QE	273	0.00	1.00	-3.50	3.87
PRODUCTION	273	0.81	5.02	-24.01	8.94
INFLATION	256	-0.37	0.29	-1.24	0.40
SPREAD	272	0.00	0.12	-0.74	0.45
VSTOXX	273	24.80	10.13	11.34	91.28

Appendix D. Stance of ECB announcements

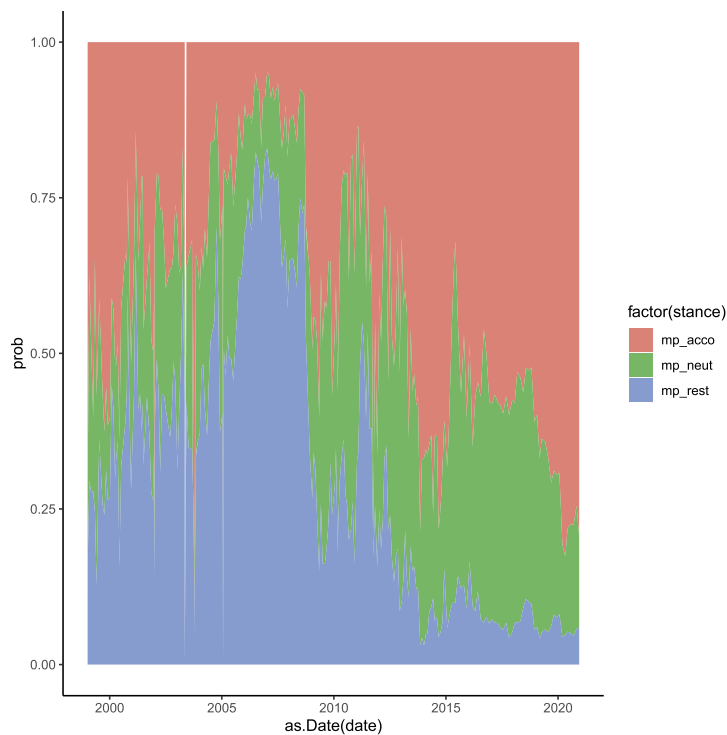


Fig. 4. Share of accommodative, neutral and restrictive stance of ECB announcements. (For interpretation of the colours in the figure(s), the reader is referred to the web version of this article.)

Appendix E. Information shocks

Let one depart from a \mathbf{X} including 1-, 3-, 6-month and 1-year OIS rates, and the Euro Stoxx 50 index (Stoxx 50) surprises from the press release window.¹³ The interest rate surprises vector i^{Total} is the first principal component of a principal component analysis applied on the OIS rates, with variance rescaled to equal that of the 1-year OIS rate in the original matrix. Stock price surprises s are the Stoxx 50 surprises. Interest rate surprises are then decomposed into an Odyssean (i^{ody}) and a Delphic (i^{del}) factors (or equivalently, proxies for monetary policy and information shocks), orthogonal to each other, as in (6). i^{ody} is assumed to be negatively correlated with s , and i^{del} to be positively correlated with s . The latter originates from the fact that economic agents imperfectly observe the state of the economy, and infer information on the own view of the central bank on that matter from monetary policy decisions.

¹³ Monetary event window in Jarocinski and Karadi (2020) and Jarocinski (2020).

$$i^{Total} = i^{ody} + i^{del}. \quad (6)$$

Following Jarocinski (2020), a first decomposition is performed by imposing sign restrictions, displayed in (7) and (8).

$$i^{ody} = i^{Total} \text{ if } i^{Total} \times s < 0, 0 \text{ otherwise}, \quad (7)$$

$$i^{del} = i^{Total} \text{ if } i^{Total} \times s \geq 0, 0 \text{ otherwise}. \quad (8)$$

The share of the variance of the monetary policy factor is $\frac{\text{Var}(i^{ody})}{\text{Var}(i^{Total})} \approx 0.67$ (0.65 for the 1999-2020 period).

The second approach is rotational and implies that a central bank announcement may simultaneously convey both shocks. Let $\mathbf{M} = (i^{Total}, s)$ be decomposed as:

$$\mathbf{M} = \mathbf{UC}, \text{ where:} \quad (9)$$

$$\mathbf{U} = (i^{ody}, i^{del}),$$

$$i^{MP'} i^{ody} = 0,$$

$$\mathbf{C} = \begin{pmatrix} 1 & c^{ody} < 0 \\ 1 & c^{ody} > 0 \end{pmatrix}.$$

Matrix \mathbf{C} captures how the factors translate into financial market surprises, with c^{ody} and c^{del} the elasticities of stock prices to i^{MP} and i^{CBI} . \mathbf{U} and \mathbf{C} are computed in three steps. First, \mathbf{M} is decomposed into two orthogonal components using a QR decomposition:

$$\mathbf{M} = \mathbf{QR}, \text{ where:} \quad (10)$$

$$\mathbf{Q}'\mathbf{Q} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix},$$

$$\mathbf{R} = \begin{pmatrix} r_{11} > 0 & r_{12} \\ 0 & r_{22} > 0 \end{pmatrix}.$$

Second, the orthogonal components are rotated using matrix \mathbf{P} :

$$\mathbf{P} = \begin{pmatrix} \cos \alpha & \sin \alpha \\ -\sin \alpha & \cos \alpha \end{pmatrix}, \quad (11)$$

$$\alpha \in \left(0, \arctan \frac{-r_{22}}{r_{12}}\right) \text{ if } r_{1,2} < 0,$$

$$\alpha \in \left(\arctan \frac{r_{12}}{r_{22}}, \frac{\pi}{2}\right) \text{ if } r_{1,2} \geq 0.$$

To pin a unique decomposition, the angle α is set to:

$$\alpha = \arccos \sqrt{\frac{\text{Var} i^{MP}}{\text{Var} i^{Total}}}, \quad (12)$$

with $\frac{\text{Var} i^{ody}}{\text{Var} i^{Total}} = 0.75$ (0.80, 0.68 in Jarocinski and Karadi, 2020 over the monetary event window), that is, the value obtained from the first “naïve” decomposition to get the same share of variance. One then gets $\alpha_{2002-2020} \approx 0.53$ and $\alpha_{1999-2020} \approx 0.46$. Third, the rotated components are rescaled with a diagonal matrix \mathbf{D} to ensure they add up to the interest rate surprises i^{Total} , with:

$$\mathbf{D} = \begin{pmatrix} r_{11} \cos \alpha & 0 \\ 0 & r_{11} \sin \alpha \end{pmatrix}. \quad (13)$$

Finally, \mathbf{U} and \mathbf{C} are computed as $\mathbf{U} = \mathbf{QPD}$ and $\mathbf{C} = \mathbf{D}^{-1}\mathbf{P}'\mathbf{R}$. Both factors tend to load similarly and more heavily on the 2-year OIS rate. They are scaled accordingly.

Appendix F. Summary statistics for Odyssean and Delphic factors

See Table 19.

Table 19
Summary statistics for Odyssean and Delphic factors.

Variable	Nb Obs	Mean*	Std. Dev.	Min	Max
<i>TARGET</i> _{Today}	273	0.00	1.01	-7.99	5.13
<i>PATH</i> _{Today}	273	0.00	1.01	-6.27	7.56
<i>QE</i> _{Today}	273	0.00	1.01	-4.71	5.22
<i>TARGET</i> _{del}	273	-0.00	1.01	-7.75	7.72
<i>PATH</i> _{del}	273	0.00	1.01	-6.33	4.55
<i>QE</i> _{del}	273	0.00	1.00	-4.58	4.51

*(1.E-18)

Data availability

Data will be made available on request.

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