

ECB Communication: What Is It Telling Us?

ROKAS KAMINSKAS

*Bank of Lithuania and ISM University of Management and Economics, Vilnius **

MODESTAS STUKAS

Ignitis Lithuania

LINAS JURKŠAS

Vilnius University and Bank of Lithuania

This study examines the changing nature of ECB communication and how it impacts euro area financial markets over the past two decades. We applied a combination of topic modelling and sentiment analysis for over 2000 public ECB Executive Board member speeches, as well as over 200 ECB press conferences. Topic analysis revealed that the ECB's main focus has shifted from strategy and objectives, at the inception of the euro area, to various policy actions during the global financial crisis and, later on, to policy instruments. Sentiment analysis showed a trend of a more negative communication tone during periods of turmoil and a gradual shift to a more dovish monetary policy tone over time. Regression analysis revealed that sentiment indices had the expected impact on financial market indicators, while press conferences exhibited substantially stronger effects than speeches. Among the different topics covered in policymaker speeches, only the topic on ECB instruments led to repricing in euro area markets.

Keywords: ECB, speeches, press conferences, text analysis, sentiments, financial markets.

JEL Classifications: C80, E43, E44, E58, G12

1 Introduction

Monetary policy communication, particularly in the most recent decade, has not only aimed to promote public awareness about actions by the central bank, but can be considered as a monetary policy tool by itself. A concrete example is forward guidance, a statement by the

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central bank about its future monetary policy intentions. Such guidance has been widely perceived as a separate policy tool which central banks in advanced economies have been employing widely since the 2007-2008 global financial crisis (GFC). Forward guidance works mainly by guiding economic agents' behaviour, thus playing a crucial role in the monetary policy transmission mechanism. Financial market participants, in turn, react to central bank communication and guidance by adjusting their expectations.

In this paper, we investigate the crucial link between the central bank's communication and financial markets. This interconnection between monetary policy and markets is widely discussed by economists as well as by central bankers themselves. ECB Vice President Luis de Guindos (2019), for example, has explicitly explained the two-way relationship between the central bank and financial markets. To start with, central bank affects pricing of assets in financial markets via communication tools. For instance, the bank could contribute to the decrease of government bond yields and the increase of inflation expectations by indicating forthcoming expansionary monetary policy actions. The opposite relationship may also hold, when changes in financial markets generate a reaction by the central bank. For example, if the central bank decides that interest rates as priced by financial markets are too high for its inflation goal to be reached, the bank may see a need to indicate a need for a more expansionary monetary policy stance. Glas & Müller (2021) argue that central banks can influence inflation expectations by explaining their decisions. When economic agents have better understanding of central bank's goals, their expectations can become more aligned and there would be less disagreement. This allows for anchored inflation expectations around central bank's target.

Compared with other relevant studies, we propose a more comprehensive analysis of ECB communication events. First, although other authors usually focus on one communication type, we analyse two different types of ECB communication events: both regular ECB press conferences and sporadic ECB communication (i.e., Executive Board speeches). Second, using topic modelling algorithms, we present not only the importance of different topics for the ECB as a whole (as done in previous studies, e.g., Ehrmann & Fratzscher, 2009; Hartmann & Smets, 2018), but also for each Executive Board member separately, during the past two decades. Third, although most of other studies estimate the effects on a one or several financial variables, we estimate the impact on a wider range of financial market indicators: stock indices, market volatility, proxies of fragmentation, and risk-free interest rates of different maturities. The comprehensive set of characteristics embedded in our analysis allows us to capture a fuller picture of ECB communication developments, as well as the corresponding reaction of a broader set of financial market indicators, than has been provided by previous studies.

Our results reveal important developments in the most widely addressed communication topics and sentiments over time, as well as their implications for financial markets. Topic analysis show that the main focus of ECB policymakers shifted from strategy and objectives, at the start of the euro area, to various policy actions during the GFC, and on to instruments in

more recent periods. Sentiment analysis revealed an increasingly negative tone in ECB communication during crisis periods and a gradual shift towards a more dovish monetary policy tone over time. From the regression analysis, we find that sentiment indices had the expected impact on financial market indicators (i.e., positive effect on risk-free rates), the effect of press conferences was substantially higher than that of speeches and that the policy instruments topic has the strongest impact. Therefore, we anticipate that interest in this paper could extend beyond academia, to market practitioners and policymakers. It should be noted, however, that the results are naturally somewhat sensitive to the choice of the concrete model specification.

The paper is structured as follows. The second section covers the main ideas in the relevant literature on central bank communication and its links to the financial markets. In the third section, the data used in the text and the regression analysis of our study are described. The fourth section covers the topic modelling. The fifth section presents the sentiment analysis. The sixth section reveals and explains the results of regression analysis. The final section presents our conclusions and potential directions for future research.

2 Literature Review

This section provides an overview of the relevant literature on central bank communication analysis and monetary policy effects on financial markets. It concludes by discussing the effects of communication, measured by text data analysis, on financial markets.

2.1 Central bank communication analysis

A significant strand of the economic literature concentrates on monetary policy communication estimations. This section reviews papers from two different communication angles: 1) topic and sentiment analysis of communication; and 2) central bank communication effects on future monetary policy decisions.

One strand of literature focuses on topic analysis from the perspective of central bank communication events. For instance, Edison & Carcel (2019) analyse transcripts from Federal Reserve's FOMC meetings from 2003 to 2012 using Latent Dirichlet Allocation (LDA) method. They show the developing importance of different topics such as communication, economic activity, forecasting, and others. They find that economic modelling discussions were crucial during the GFC, banking gained relevance in the following years, and the overall importance of central bank communication increased in more recent times. Born et al. (2014) apply DICTION 5.0 text analysis software showing that financial stability reports and speeches on financial stability of central banks affect stock prices and volatility, although the effect of speeches is prominent only in 2007-2010.

Text data analysis is also often expanded further in investigating speeches by ECB officials. Hartmann & Smets (2018) show the overall developments of different topics in speeches made

by ECB officials from 1999 to 2017. They first specify 50 different topics and then group them into 9 broader themes, employing the LDA method. They reveal that the main focus of ECB policymakers is on the areas of monetary policy and inflation, as well as financial instability and regulation. Using text mining techniques, Jurkšas & Klinevičius (2020) analyse the relevance of sovereign bond valuation in speeches made by ECB officials from 1997 to 2019. They show that the topic of sovereign bond valuation increased in significance during the sovereign debt crisis in Europe in 2010-2012 and has remained more popular than it was before the crisis, possibly due to the ECB's initiation of large-scale asset purchases. Structural topic modelling (STM) is being employed on central banks' speeches by Feldkircher et al. (2021) who show that three topics – European integration, monetary policy and price stability, financial stability – have been the most important ones from 1996 to 2019, although the importance of European integration topic decreased over time. By using ideal point analysis, Feldkircher et al. (2023) additionally reveal that ECB communication on monetary policy and financial stability is narrower compared to national central banks of the euro area.

Some further important work has been done in complementing topic modelling with sentiment analysis. Iglesias et al. (2017) analyse the communication of the Central bank of Turkey. They show the developments of different topics in central bank statements and minutes, as well as the Bank's reaction to monetary policy and economic activity reports. In order to do so, they apply the Dynamic Topic Modelling (DTM) technique and the LDA model, which assumes that a document comprises a mixture of topics. Sentiment analysis is conducted with lexicon methods such as the Loughran-McDonald (2011) dictionary, which helps to identify positive and negative words in financial and economic texts. The difference between those two categories serves as the basis for the average tone of a document.

Another method, providing sentiment analysis, identifies the “hawkishness” or “dovishness” of a policy communication. In this context, hawkishness is associated with policy tightening and dovishness with easing. Tobback et al. (2017) apply this approach to measure the media's perception of ECB communication events. They develop a “Hawkish-Dovish (HD) indicator” using semantic orientation and Support Vector Machines techniques. This analysis is extended further with topic analysis using LDA, correlation analysis with interest rates and inclusion of the Taylor rule. The results show that ECB communication analysis helps to anticipate policy stance and to better estimate the monetary policy reaction function. Hansen & McMahon (2016) apply LDA method to disentangle topics of sentences from FOMC statements. Employing both topic and sentiment analysis authors show that FOMC guidance on interest rates have been more important than on economic conditions.

Substantial work has also been done using text data analysis to estimate the monetary policy reaction function. Paloviita et al. (2020) use Loughran and McDonald's (2011) dictionary to measure sentiment with the ratio between positive and negative words in ECB introductory statements surrounding inflation. The researchers then take these sentiments as a dependent

variable, where independent variables are short-run inflation and output gap forecasts. They show that sentiment is most positive when inflation is around 1.7%. If the target is fixed at 2%, however, the loss function shows an asymmetric reaction, with the preference of inflation higher below the target than above it. Istrefi et al. (2023) find that speeches of Fed officials on financial stability are informative for the upcoming monetary policy decisions, while the more negative tone correlates with more accommodative monetary policy stance.

Picault & Renault (2017) propose a novel method for quantifying monetary policy communication on monetary policy outlook and economic outlook. They manually classify sentences from the ECB introductory statements separately into topics of economic outlook and monetary policy. In addition, they break these statements down by tone into positive, neutral and negative (or hawkish, neutral, and dovish for monetary policy). Next, they compute probabilities of words or groups of words from the sentences appearing in these categories. This allows measuring the share of all statements in the press conference related to monetary policy as dovish, neutral or hawkish, as well as statements on economic outlook as positive, neutral and negative. By aggregating these results, the authors then obtain monetary policy and economic outlook indicators over time for the press conference as a whole. They find that the contents of these conferences help to predict future decisions of the ECB, both standard and non-standard (forward guidance, credit-easing measures, commitments to buy euro-area assets).

Bennani et al. (2020) present similar findings. They analyse media reaction to ECB monetary policy communication in the period 2008-2014 by creating a communication indicator, with a positive value indicating better economic outlook and tighter monetary policy. The authors show a positive relationship between this indicator and rate change at the next monetary policy meeting. They conclude that ad-hoc communication provides valuable information about future monetary policy decisions, even when controlling for financial market expectations and previous policy decisions.

2.2 Effects of monetary policy on financial markets

This section reviews the literature on the perception of monetary policy communication events in financial markets. Although the reviewed papers do not use text data analysis, they still provide insights on the types of shocks created by monetary policy decisions and economic conditions.

The overall effectiveness of monetary policy could be measured via its impact on the term structure of market interest rates. Altavilla et al. (2019) identify different types of monetary policy shocks, looking at overnight index swap (OIS) rates. The authors employ high-frequency data to measure financial market conditions before the announcement of an ECB monetary policy decision, after such a decision, and after the press conference following the decision.

Using these financial variables, the authors identify the perceived policy target, timing, forward guidance and quantitative easing (QE) surprises. Identification depends on which part of the term structure is being affected the most, with a policy target affecting the shortest term and QE the longest. Leombroni et al. (2021) show that central bank communication can affect spreads identifying risk premium channel of communication.

Many studies have found that monetary policy communication affects market volatility, although the effect depends on the type of guidance as well as on market indicators. Kliesen et al. (2019) analyse different types of Fed monetary policy communication events and estimate their impact on the financial market using both daily and intraday data. Analysing stock market volatility and sovereign yields, they conclude that communication helps to decrease uncertainty and distortions in the market. The effect, however, varies according to type of communication, type of instrument and communicating official. Ehrmann et al. (2019) show that time-contingent forward guidance over the long horizon and state-contingent forward guidance reduce the responsiveness of asset prices to economic news. However, the authors also note that short-term time-contingent forward guidance and open-ended forward guidance do not have a modulating effect, and may even increase uncertainty. Ranaldo & Rossi (2010) analyse communication by the Swiss National Bank and show that the effect may also differ depending on the financial market indicator analysed (specifically, CHF/USD exchange rate, Swiss bond index and stock prices from 2000 to 2005). Gnan & Rieder (2023) reveal that ECB communication in quiet periods could be related to the more significant repricing in financial markets and reach levels close to market reactions during press conferences.

A combination of financial market indicators may help to identify the type of shock the economy is facing. In this respect, the relation between stock prices and the term structure of interest rates is particularly important. For example, with a hawkish monetary policy surprise, one may expect falling equity prices because of higher interest rates restricting investment opportunities, among other reasons. However, as Jarocinski & Karadi (2020) note, this may not always be the case. An indication of higher interest rates may be followed by an increase in stock prices if the indication is associated with good news about the economy. The same holds true for the opposite case – an accommodative surprise may be followed by a drop in stock prices if the surprise is related to bad news about the economy. The authors refer to such direct co-movement in these variables as an “information shock” and show that it plays a role in the short to medium term. Hansen et al. (2019) show the importance of an “information shock” in the long run. Analysing the Bank of England Inflation Reports, the authors conclude that economic uncertainty has a crucial role at the long end of the yield curve. They argue that central banks should pay attention to their communication strategy regarding risks and uncertainties surrounding economic conditions, especially during periods of effective lower bound, when there is limited scope to control short-term interest rates and longer-term rates take on relatively greater importance.

Andrade et al. (2021) refer to information and monetary policy shocks as “Delphic” and “Odyssean”. A Delphic shock can be understood – like the information shock– as a typical monetary policy reaction function in which the central bank only responds to macroeconomic developments. An Odyssean shock, by contrast, indicates a commitment to follow a particular interest rate path. The authors show that accommodative Odyssean surprises (e.g., a commitment to keep rates low for a while) tend to boost asset prices, while tightening surprises have a negative impact on these prices.

However, Bauer & Swanson (2020) have challenged the importance of this information effect (or Delphic shock). They show that, on average, the US stock market responds negatively to a tightening monetary policy surprise. The fact that this reaction is strong and consistent suggests that the Fed’s information effect, if it exists at all, must not be very large. This observation is also confirmed by looking at the most important Federal Open Market Committee (FOMC) announcements: in nine out of ten of these announcements, the stock market responded strongly in the opposite direction to the interest rate shock, which measures monetary policy surprise.

2.3 Incorporation of text data analysis to measure monetary policy communication’s effect on financial markets

This section presents relevant papers which incorporate text data analysis in order to evaluate the effects of monetary policy communication on financial markets. The studies use official communication texts of a particular policy maker, or media interpretations of such communication, and estimate the effects of its tone, or topics covered, on various financial market indicators. It is worth mentioning, however, that there is a rather limited number of such analyses in the literature, and that those typically do not include more than one type of communication measure or more than a couple of financial market indicators (Table 1). In particular, we find a lack of studies considering the effects of ECB Executive Board speeches.

There is some evidence that monetary policy communication tone helps to steer interbank rates and asset prices. Iglesias et al. (2017) use interbank rates and bond swap rates up to 2 years to identify the effect of changes in sentiment on financial markets and policy rate expectations. The findings indicate that changes in sentiment, as well as communication about monetary policy, affect shorter term interbank rates and longer-term swap rates in the directions they expected. Statements that refer to tighter policy lead to higher rates, while statements that refer to looser policy lead to lower rates. Picault & Renault’s (2017) regression analysis reveals that the tone of monetary policy communication has a significant impact on Eurostoxx50 return and stock market volatility with 95% confidence interval on the day of the press conference. The relationship shows the expected sign: dovish messages induce higher market returns and

vice versa. Bouscasse et al. (2023) incorporate topics into construction of communication sentiments and show that tone differences between ECB and FED could be related to developments in EUR/USD exchange rate.

Similar findings are available regarding communication events other than ECB introductory statements. Gertler & Horwath (2018), who cover the period from 2008 to 2014, show the importance of ad hoc ECB communication on financial markets. The authors construct a dataset of speeches, conference discussions and interviews, and estimate their impact on financial variables using high-frequency data. They use ordinary least squares and quantile regressions and control for excess liquidity, a lagged dependent variable (OIS, exchange rate or stock prices), a previous trend in communication, and uncertainty in financial markets. The results indicate a significant effect on interest rates, but a weaker impact on stock market and exchange rates. Bennani et al. (2020) analyse media perception of ad hoc ECB communication using the communication dataset provided by Gertler & Horwath (2018), and assign a tightening, neutral or loosening characteristic to each statement. Using expectations on policy rates of Euribor rates up to 1 year, the authors demonstrate that communication provides information not fully priced in financial markets. In addition, they argue that conventional monetary policy is better understood by markets than unconventional policy. These results are in line with those of Pesci (2016). He estimates the effect of monetary policy stance, as perceived in the media, on Euribor forward rates. The relationship is significant in most cases, revealing that a more hawkish stance leads to higher expected ECB policy rates and vice versa. Tillmann & Walter (2019) study the differences between the communication of ECB and Bundesbank finding that long term interest rate response to monetary policy shocks is lower when cacophony in communication is higher.

Ehrmann & Fratzscher (2009) analyse the effect on financial markets of different topics covered in ECB communication events. They find that ECB press conferences add substantial information to policy decisions. In addition, analysis of newswire snaps helps to identify what type of data is most influential for financial markets. The analysis shows that statements on inflation and policy rates have the greatest impact on financial markets, while communications on economic outlook and money growth are less statistically significant. Jurkšas et al. (2024) show that ECB communication topics related to unconventional monetary policy, inflation objective and interest rate impose more significant reactions from financial markets.

In our examination of presented literature, we observe that certain facets of central bank communication analysis remain underdeveloped, presenting opportunities for further inquiry. Specifically, this pertains to the nuanced assessment of ad hoc communications from the ECB, encompassing both topic and sentiment analysis. Additionally, there is a need to extend the evaluation to a broader and more comprehensive spectrum of financial market indicators. We endeavour to address and bridge these identified gaps, at least partially, through our research.

Table 1. Key features of studies estimating monetary policy communication effects using text and financial market data analysis.

| | Communication type | Primary communication source vs media perception | Text analysis characteristic | Analysed financial market variables |
|-----------------------------|--|---|--|--|
| Bouscasse et al. (2023) | ECB and FED press conferences and speeches | Primary source | Sentiment and topic (only for press conf.) | OIS and foreign exchange |
| Bennani et al. (2020) | ECB non-meeting communication | Media perception | Sentiment | Money market rates (expectations) |
| Tillmann & Walter (2019) | ECB and Bundesbank President speeches | Primary source | Sentiment | OIS rates |
| Gertler & Horwath (2018) | ECB speeches and interviews | Media perception | Sentiment | OIS, foreign exchange, stocks |
| Iglesias et al. (2017) | Statements and minutes | Primary source | Sentiment | Yield curve |
| Picault & Renault (2017) | ECB meetings | Primary source | Sentiment | Stocks and volatility |
| Pesci (2016) | ECB meetings | Media perception | Sentiment | Euribor forward rates |
| Gade et al. (2013) | Statements of EU officials | Media perception | Sentiment | Sovereign spreads |
| Ehrmann & Fratzscher (2009) | ECB meetings | Media perception | Topic | 3-month Euribor and uncertainty |

3 Data

In this section, we briefly present our data and discuss its pre-processing. To measure ECB communication and test how it affects financial markets, we rely on combining text data, comprised of public ECB Executive Board member speeches and ECB introductory statements, with financial market data. In the following sub-sections, we elaborate on each data collection part separately.

3.1 ECB Executive Board members' speeches and press conferences

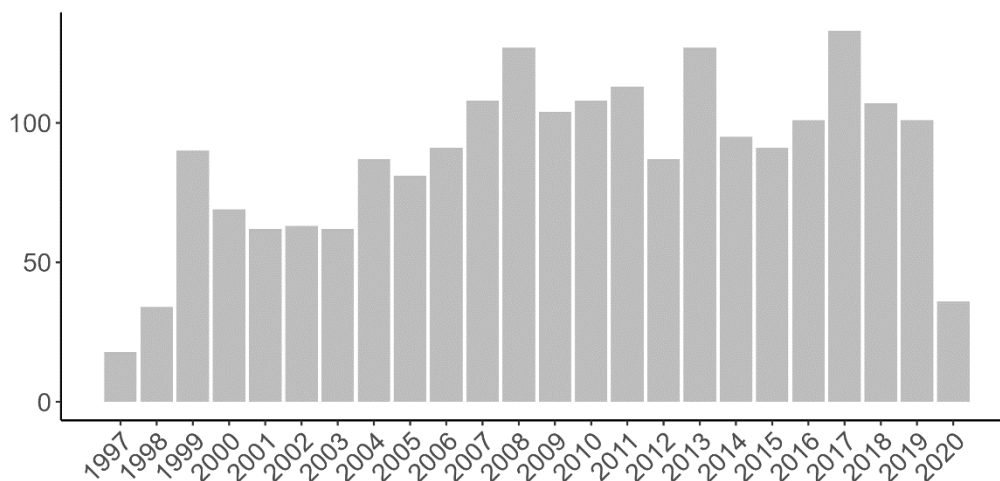
The speeches made by ECB Executive Board members during various international events signal the potential ECB monetary policy stance and the economic outlook in the euro area.

From the ECB website¹, we collected all speeches of Executive Board members dating from 1997 until July 2020. We removed non-English-language speeches as well as speeches that were relatively short (i.e., fewer than 250 characters).

Figure 1 below summarizes the distribution of the remaining 2150 speeches made by the members of the Executive Board. One can see that the number of policymakers' speeches varies somewhat over time, with the most evident peaks at the creation of the ECB in 1999 and during the GFC.

Each Governing Council meeting is followed by a press conference. Until 2015, the Governing Council met monthly; from 2015, the frequency was reduced to eight meetings per year. At the official ECB press conference after each meeting, the President of the ECB discusses how the economic situation has evolved since the last meeting, describes the current monetary policy stance, and announces what new instruments (if any) were decided on by the Governing Council. The official press releases after each press conference consist of two main elements: 1) the official introductory statement; and 2) questions and answers to the media. Here we deal with the first element only, referring to it for the remainder of the paper by the general term "press conference". Using web-scraping algorithms, we have collected a total of 245 press conferences from the official ECB website², covering the period from 1998 to 2020.

Figure 1. Number of Executive Board members' speeches by year



¹ The speeches of officials from the European Monetary Institute (EMI) are also used in this study, as this institution is the predecessor of the ECB. All speeches are publicly available on the ECB website: <https://www.ecb.europa.eu/press/key/html/index.en.html>

² All press conferences are publicly available on the ECB website: <https://www.ecb.europa.eu/press/pressconf/html/index.en.html>

3.2 Data pre-processing

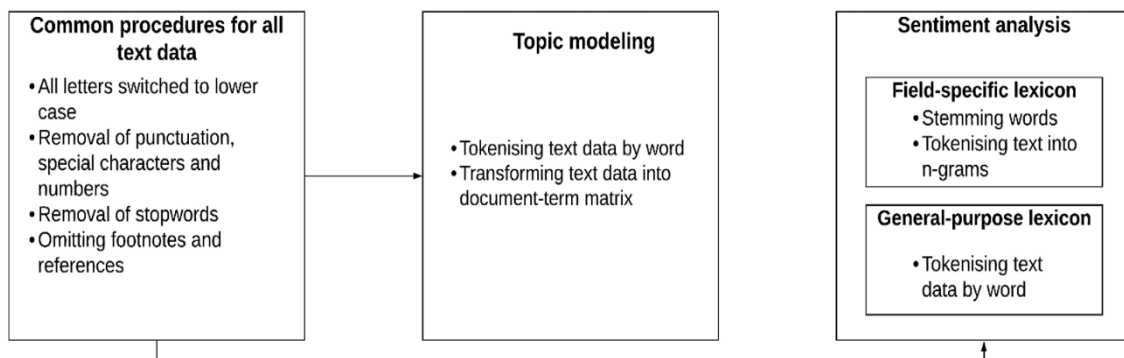
Prior to performing the text analysis of the ECB communications, we had to pre-process the downloaded text data of both the ECB Executive Board speeches and the press conferences. We follow the data pre-processing roadmap summarized in Figure 2 below. It consists of three major steps, each involving different procedures depending on the tools we apply for the text analysis of the ECB communication.

As a first step, we apply common text pre-processing procedures that are the basis for any text data analysis. First, we switch all capital letters to lower case. Next, we delete all the special characters and punctuation (e.g., commas, exclamation points, excess whitespace, quotation marks and numbers). Then, we omit all the stop-words, which are functional words in every article which do not represent any content (e.g., a, the, of, to, was). Additionally, footnotes and references are removed, as they are often of a more technical nature than the main text.

Text data preparation for the STM topic modelling includes two additional steps. First, we tokenise text data by word, namely, we split the full text of the document into a list of words. Second, we stem these words. This is a technique that essentially truncates the word ending, leaving only its stem, for example, “failures” or “failure” becomes “failur”. Third, we build a document-term matrix that is a simple matrix containing the frequency of each word for every paragraph.

For the sentiment analysis, text data preparation includes further additional steps. In order to conduct a lexicon-based sentiment analysis, we adjust the word structure in the text data to mirror the word structure used in the particular lexicon. For primary analysis of the ECB communication sentiment, we rely on Picault & Renault (2017). We also apply Hu & Liu (2004) lexicon to cross-check our results with a general-purpose lexicon. These two lexicons have different internal structures, thus requiring us to perform two different procedures to prepare data for the analysis. For the field-specific Picault & Renault (2017) lexicon, we first unify

Figure 2. Data pre-processing roadmap



Source: the authors.

words by stemming them. Then, we tokenise all text into n-grams that are sequences of words, which in our case range from a single word to a sequence of 10 words. For the general-purpose lexicon, the data preparation procedure is simpler, requiring only applying the above-mentioned tokenisation of all the text data into single words.

3.3 Financial market data

In the regression analysis, we use the following financial market indicators:

- Eurostoxx50 – the major stock index for the euro area, constituting an underlying metric for a variety of investment products.
- VSTOXX – a European volatility index (like VIX for the US) based on Eurostoxx50 option prices.
- IT-DE 10-year spread – the arithmetic difference between 10-year benchmark Government bond yields of Italy and Germany. It serves as a proxy for fragmentation in the euro area.
- OIS 3-month – overnight index swap rate for 3 months in the euro area. It serves as a proxy for very near-term expectations of ECB policy rate.
- OIS 2-year – overnight index swap rate for 2 years in the euro area. It serves as a proxy for short-term expectations of ECB policy rate.
- OIS 10-year – overnight index swap rate for 10 years in the euro area. It serves as a proxy for risk-free long-term rate.

All data used are from 1997 up to 2020, with the exception of OIS rates. OIS 2-year data are available from 2001 and OIS 10-year – from 2005. The source of financial market data is Refinitiv Datastream.

4 Topic modelling

In this section, we present the topic modelling methodology and then the developments of different topics during time.

4.1 Topic modelling methodology

We perform topic modelling analysis by employing the Structural Topic Modelling (STM) approach. This is a statistical method used for analysing large textual datasets (Egami et al., 2022). It extends traditional topic modelling methods, such as LDA, by incorporating document-level covariates, which are additional variables associated with each document that help explain the distribution of topics (Roberts et al., 2016). In our case, this approach helps to divide downloaded and cleaned text data into a pre-defined number of topics and find varying topical prevalence over time. By using this technique, we can determine what types of topics

are most often addressed over time by ECB Executive Board members in public speeches³ and, as a second step with the help of regression analysis, how different topics affect financial markets.

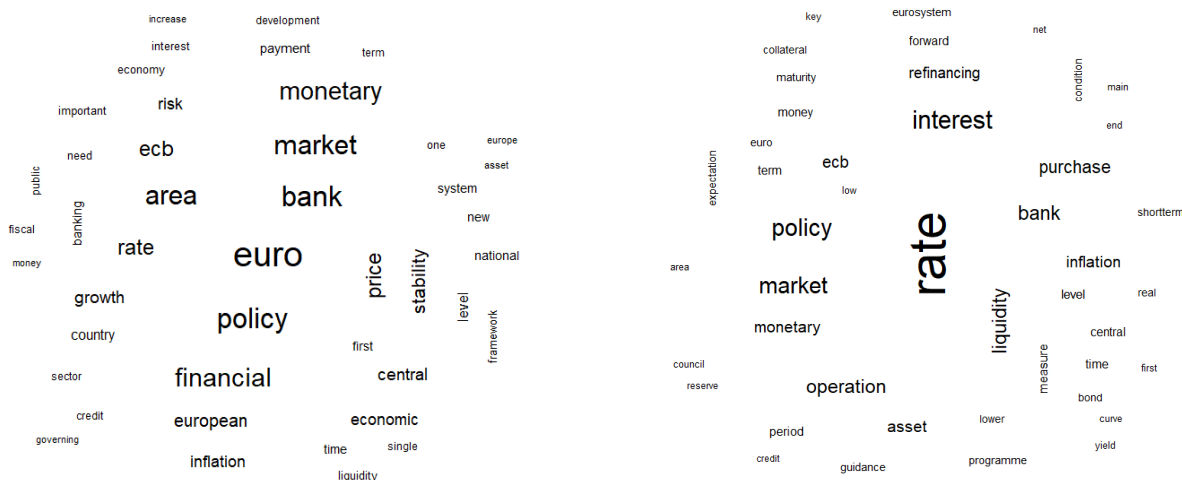
The application of the STM technique helped us to distinguish the particular topics for each paragraph of an ECB Executive Board member speech. First, we divided over 2000 speeches into over 60000 paragraphs. Although Hartmann & Smets (2018) use speeches rather than sentences or paragraphs, after careful analysis of a subset of speeches we determined that each speech usually contains several different topics, while a single paragraph is most often focused on just one concrete theme. Second, we classified the paragraphs into 25 different topics and their accompanying probabilities. A smaller number of pre-specified topics would have led to themes that were too broad, while a larger number led to final outcomes similar to those obtained with 25 topics (e.g., Hartmann & Smets (2018) chose 50 topics).

The final step of STM analysis was to manually distribute the 25 topics into broader buckets, covering most important areas of central banking. Following a procedure similar to that of Hartmann & Smets (2018), we used the top 5 keywords to decide which of the 25 topics belong to each of 9 broader topics (see Appendix 1 for further explanation on this procedure). After grouping the topics into 9 broader ones, we summed the accompanying probabilities (from 25 to 9 groups) for each paragraph. However, as the maximum probability of a particular paragraph (out of over 60000) often remained quite low, we decided to remove paragraphs with a maximum probability lower than 50%. This left us with 22009 paragraphs which have more clearly distinguished underlying topics.

The word clouds of the most frequently used words by Executive Board members are provided in Figure 3. As can be seen from LHS, some words are used much more often than other in the overall speeches. For instance, Executive Board members most often mention such words as “euro”, “monetary”, “policy”, “market”, “bank” and “financial”. The distinction between most frequently used words is even more evident when focusing on paragraphs on a narrower topic of ECB policy instruments (RHS of Figure 3). Then the word “rate” is dominating, followed by “interest”, “policy”, “bank”, “purchase”, “liquidity” and “operation”. Other topics are also distinguished by some particular keywords (see Appendix 1).

³ We decided to apply the STM technique only to Executive Board member speeches and not to the ECB press conferences for several reasons. First, press conferences after each regular monetary policy meeting follow a similar structure, mainly concentrating on one “standardised” topic of the two-pillar approach, i.e., cross-checking monetary and economic developments, as well as changes of instruments. Second, every second press conference encompasses the results of the projections exercise, meaning that the time-series variation would be somewhat harder to disentangle. Third, press conferences include only the highly standardised text agreed on by the whole Governing Council and read by the President of ECB, while we decided to focus our analysis on cross-variations of different Executive Board members. In this way, we can also check how the topics covered by different members relate to their assigned responsibilities.

Figure 3. Word clouds of the most used words by Executive Board members in all speeches (LHS) and only on policy instruments' topic (RHS)



For the regression estimation, we also transformed the results of text data analysis into quantitative variables for each speech. The remaining 22009 paragraphs in the above-described procedure were counted for each speech. This procedure left us with 2144 speeches and a distribution of the paragraphs of each speech into 9 topics. We then used these 9 topics in the regression analysis.

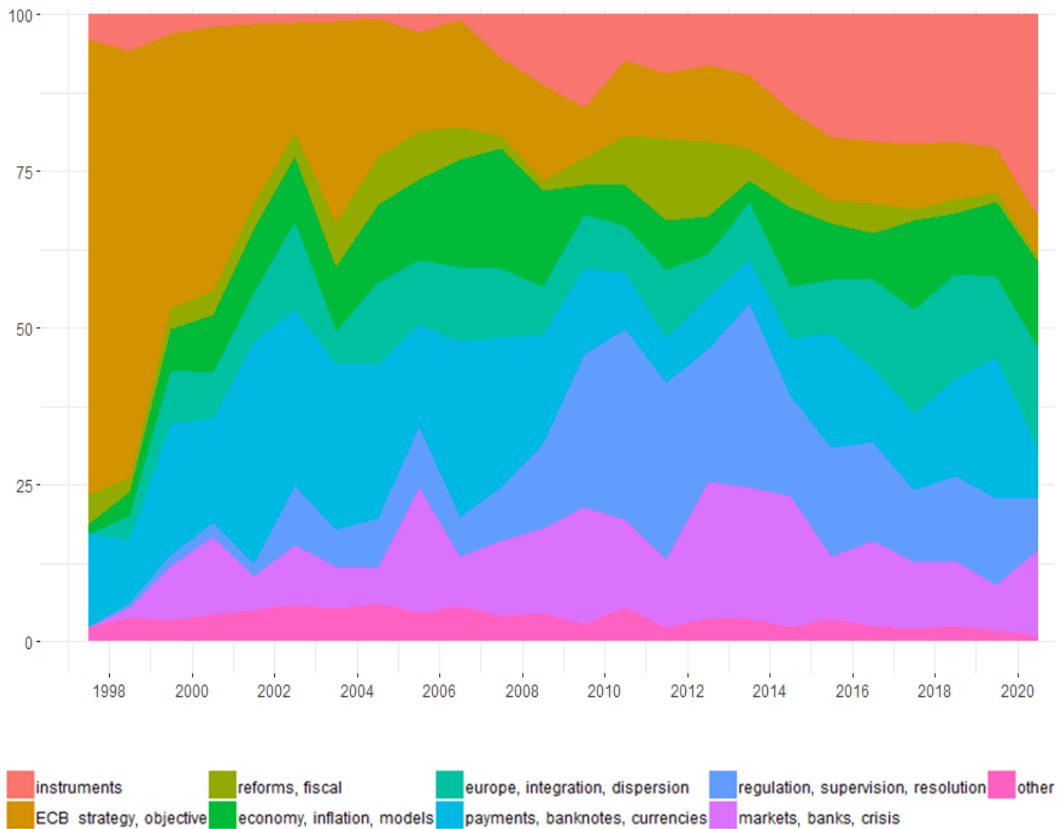
For robustness check, we have also used the Latent Dirichlet Allocation (LDA) technique for topic modelling. This is an unsupervised machine learning technique that identifies and describes thematic structures within a collection of text documents (Blei et al., 2003). This technique is widely used in various research fields, inter alia, in monetary policy analysis (e.g., Iglesias et al., 2017; Hartmann & Smets, 2018; Edison & Carcel, 2019).

4.2 Topic developments in ECB Executive Board speeches

The classification of ECB Executive Board member speeches by topic reveals that the importance of different topics has varied significantly over the two decades since the creation of the euro area (Figure 4). At the onset of the euro area, the main focus of the speeches was the strategy and objectives of the ECB. This finding is quite natural, as the newly created central bank had to communicate to society its role in the euro area's economic policymaking. This share began to decline significantly in the early 2000s as other important topics gained prominence: further European integration, payments and banknotes (particularly, when the cash euro was introduced in 2002), economic developments and etc. During the GFC in 2007-2008, the main focus shifted towards policy actions: banking regulation, supervision and resolution,

as well as ECB monetary policy instruments. This trend was further heightened during the European sovereign debt crisis in 2010-2012, when there was much discussion about introducing the Single Supervisory Mechanism (SSM) and when the ECB began increasingly introducing non-standard measures (such as the Securities Markets Programme and Outright Monetary Transactions). Hartmann & Smets (2018) also obtained similar findings, noting that ECB policymakers focused increasingly on financial regulation and monetary policy during financial turmoil. More recently, monetary policy instruments were being addressed by policymakers with increasing frequency, particularly since the start of QE in 2015. Economic developments and inflation have also become somewhat more acute topics, as economic growth has remained sluggish and the ECB has been unable to reach its inflation target for a number of years.

Figure 4. Speeches of Executive Board members by topic



Notes: Chart depicts yearly distribution of 9 topics that encapsulate the probabilities from the STM model (25 topics) on paragraphs in speeches by all EB members. Only paragraphs from 9 topics that have an assigned probability of over 50% are depicted here.

Topics covered in the speeches of ECB Presidents and Vice Presidents are presented in Figure 5. We begin with ECB Presidents (upper charts) and note that significant differences are evident during their presidencies. For instance, W. Duisenberg speculated frequently about ECB strategy and its objectives at the start of his term, but less so during the later years of his presidency. J. C. Trichet also began his presidency with a focus on ECB strategy (though less so than W. Duisenberg) and then spoke less about it over time. Overall, J. C. Trichet concentrated on further European integration, the economic shock during GFC in 2007-2008, and then about corrective actions through more elaborate regulation, supervision and resolution mechanisms, as well as ECB policy actions. M. Draghi continued this trend, but additionally placed much more emphasis on monetary policy tools. C. Lagarde, during her first year of presidency, tended to speculate on further European integration and potential issue of dispersion as well as other topics.

Similar patterns are also observable for Vice Presidents. C. Noyer started his work at the ECB, like W. Duisenberg, by emphasizing ECB strategy and goals, but also elaborated on more ‘technical’ topics such as payments, banknotes and euro currency. L. Papademos touched on topics of financial markets and banks as well as regulation and supervision more frequently than his predecessors. Meanwhile, V. Constâncio was the least ‘universal’ Vice President, as he mostly focused on topics of bank regulation, supervision and resolution (i.e., the area for which he was directly responsible among Executive Board members). During the second half of his vice presidency, he touched more frequently on the topics of markets, banks and crisis, as well as instruments. L. de Guindos has been dividing his speech time rather equally among several different topics.

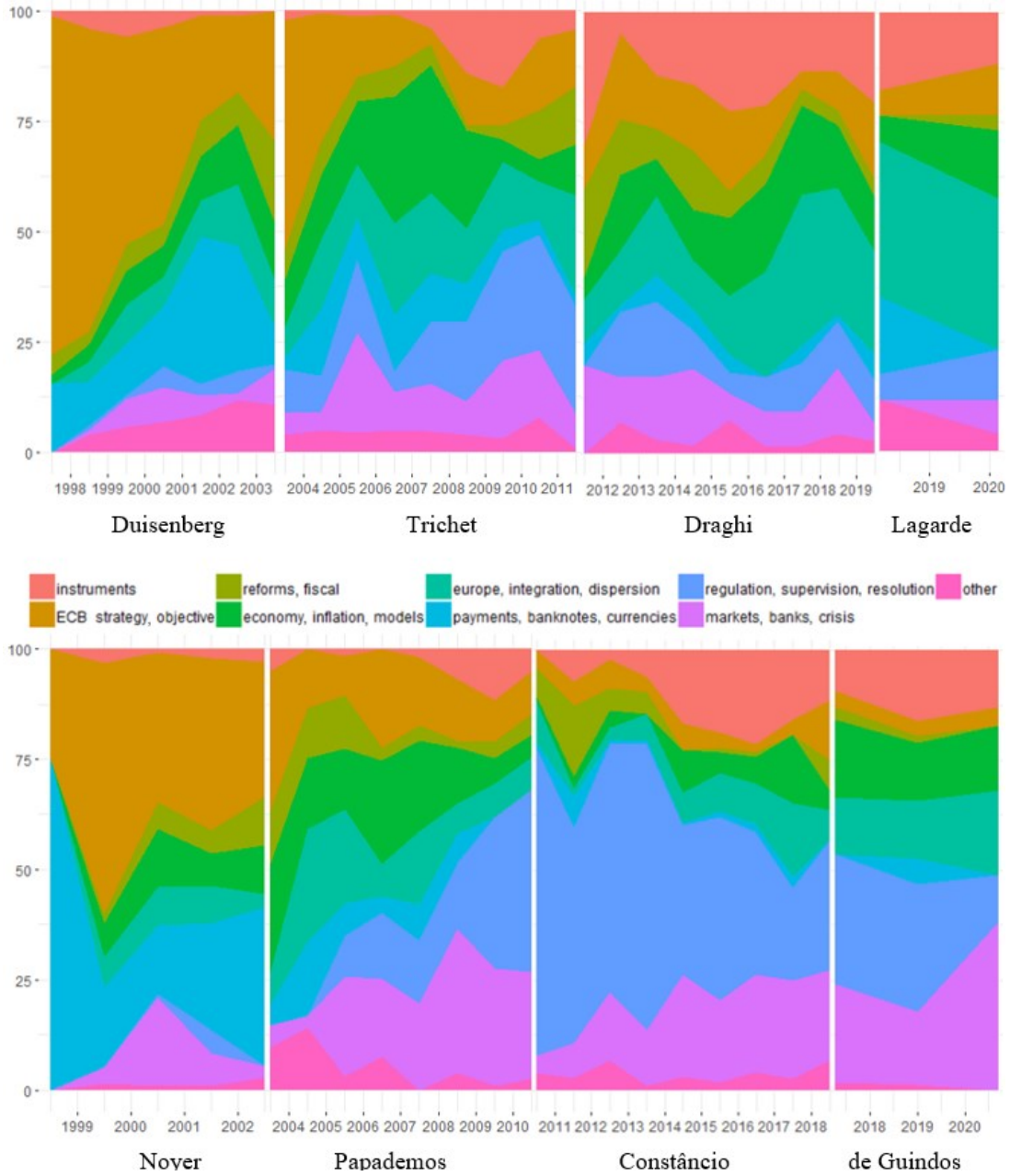
Topics covered in the speeches of other ECB Executive Board members are presented in Appendixes 2 and 3. It is evident that the topics of different members relate closely to their assigned responsibilities. For instance, chief economists elaborate more than other members on economic developments, inflation and modelling, while members responsible for operations focus more on instruments, markets and banks (Appendix 2). Meanwhile, members responsible for the area of payments / banknotes concentrated on this topic (Appendix 3). However, it is important to reiterate that members (regardless of assigned responsibility) touched on the topics of ECB strategy and objectives more often during the early phase of the euro area’s existence.

We have performed the same topic analysis with LDA method, in a similar vein as done by Hartmann & Smets (2018). However, the results remain qualitatively very similar to the STM results, even when concentrating on separate Executive Board members and their responsibilities.

4

⁴ The results can be provided upon request to corresponding author.

Figure 5: Topics of ECB Presidents and Vice Presidents throughout their terms



Notes: Chart depicts yearly distribution of 9 topics that encapsulate the probabilities from the STM model (25 topics) for paragraphs of speeches of a particular EB member. Only paragraphs from 9 topics that have an assigned probability of over 50% are depicted here.

5 Sentiment analysis

This section presents methodology for calculations of sentiment indices and then the results of the sentiment analysis.

5.1 Sentiment analysis methodology

We use lexicon-based sentiment analysis to identify the tone of each ECB communication, separating the economic outlook of the euro area and the monetary policy stance. Lexicon-based sentiment analysis is a method requiring dictionary with a list of negative and positive words, where a specific sentiment value is assigned to each word. In the lexicon-based approach, each message is represented as a set of words, where the merging function matches sentiment values from a particular dictionary to the negative or positive words within a message. An overall sentiment is then calculated as an average for each speech. As already discussed in the data pre-processing sub-section above, we apply two sentiment lexicons for our analysis: a field-specific lexicon introduced by Picault & Renault (2017) and the general-purpose Hu & Liu (2004) lexicon.

5.1.1 Field-specific lexicon sentiment analysis

We rely on the Picault & Renault (2017) field-specific lexicon for primary sentiment analysis, as this lexicon is specifically tailored to reflect central bank communications. Picault & Renault (2017) constructed this lexicon in five steps. First, they collected all sentences in the ECB introductory statements between January 2006 and December 2014. Second, they manually inspected each sentence and grouped them into the two categories (monetary policy or economic outlook) and three inclinations (dovish, neutral or hawkish for monetary policy; negative, neutral or positive for economic condition). Third, they split all sentences into n-grams of different lengths. Fourth, they calculated how frequently these n-grams appear in one of the categories and inclinations. Fifth, based on these frequencies, they calculated probabilities for each n-gram belonging to one of the above-mentioned categories and inclinations. The latest version of the Picault & Renault (2017) lexicon consists of 61600 entries.

Table 2 represents a small sample of lexicon entries and their associated probabilities. As one would expect, n-gram "low inflationari pressur" is assigned to the dovish monetary policy sentiment because such words imply the ECB official's concern with too-low inflation that might necessitate monetary policy accommodation. Meanwhile the n-gram "stronger wage" is assigned to hawkish sentiment, as such words show concern with a too-tight labour market which could lead to higher price pressure. However, one can observe that the n-gram "accommod monetari" has an equal probability of being classified as dovish or hawkish

Table 2. Picault & Renault (2017) lexicon sample with associated probabilities⁵

| Keyword | Monetary policy | | | Economic outlook | | |
|---------------------------------------|-----------------|---------|---------|------------------|---------|----------|
| | Dovish | Neutral | Hawkish | Negative | Neutral | Positive |
| low inflationari | 0.929 | 0 | 0.071 | 0 | 0 | 0 |
| low inflationari pressur | 0.929 | 0 | 0.071 | 0 | 0 | 0 |
| low inflationari pressur money | 1 | 0 | 0 | 0 | 0 | 0 |
| stronger wage | 0 | 0 | 1 | 0 | 0 | 0 |
| stronger wage price | 0 | 0 | 1 | 0 | 0 | 0 |
| stronger wage price develop | 0 | 0 | 1 | 0 | 0 | 0 |
| accommod monetari | 0,113 | 0,019 | 0,113 | 0 | 0 | 0,755 |
| accommod monetari polici | 0,113 | 0,019 | 0,113 | 0 | 0 | 0,755 |
| accommod monetari polici stanc | 0,098 | 0,02 | 0,118 | 0 | 0 | 0,765 |
| accommod monetari polici stanc improv | 0 | 0 | 0 | 0 | 0 | 1 |

monetary policy. While such an observation at first might seem to be somewhat odd, the reason behind this is that “accommod monetari” appeared an equal number of times both in dovish and hawkish sentences in the ECB press conferences. In Appendix 4, we provide several examples where this n-gram appears in sentences reflecting dovish, hawkish and neutral monetary policy. The sentiment lexicon becomes more explicit with an increasing number of words in the n-grams, as sentiment probabilities concentrate more on one of the inclinations than all the others.

We assess the tone for a given ECB Executive Board member speech or press conference following the methodological path suggested by Picault & Renault (2017). For each text, we analyse all words and groups of words (n-grams) using a term-weighted approach. More precisely, we calculate average probability P for a communication event e being classified in the category c with the inclination i as:

$$P_e^{c,i} = \frac{\sum_{n=1}^l P_{n,e}^{c,i}}{\sum_{n=1}^l P_{n,e}^c} \quad (1)$$

where l is the number of matching n-grams in the analysed communication event and p is the associated probability that the matched n-gram belongs to the category c and i is the inclination. Furthermore, to evaluate the tone of a communication event more precisely, we exclude all n-grams which are the size of 1. Also, when similar n-grams are found in one sentence, we keep only the n-gram with the highest number of words. For example, if a sentence contains a four-

⁵ Keywords are different from the original text due to data pre-processing techniques such as stemming, tokenization and removing stopwords.

gram “price stability euro area” and a five-gram “maintain price stability euro area”, we consider associated probabilities of the latter and not the former.

We summarise the sentiments of each ECB communication event e into two indicators. For monetary policy stance, we quantify I_e^{MP} , which is the difference between hawkish monetary policy and dovish monetary policy sentiment probabilities. Analogically, we calculate the economic condition index I_e^{EC} by subtracting the negative economic outlook sentiment probability from the positive economic outlook sentiment probability. Putting it mathematically:

$$(I_e^{MP}, I_e^{EC}) = \begin{cases} I_e^{MP} = P_e^{MP,hawkish} - P_e^{MP,dovish}, I_e^{MP} \in [-1,1] \\ I_e^{EC} = P_e^{EC,positive} - P_e^{EC,negative}, I_e^{EC} \in [-1,1] \end{cases} \quad (2)$$

5.1.2 Hu & Liu general-purpose lexicon sentiment analysis

The Hu & Liu (2004) general-purpose lexicon is the standard in the field when performing lexicon-based sentiment analysis. It consists of 6786 words which have been categorized as either positive or negative. Table 3 illustrates a sample of the Hu & Liu (2004) lexicon.

The application of a general-purpose lexicon in the context of our research, however, suffers from two major drawbacks. First, unlike a field-specific lexicon, the general-purpose one does not distinguish between economic and monetary policy sentiment. This drawback is relatively technical, and we can circumvent this issue by applying topic modelling to sort paragraphs in ECB communication events into the two categories of monetary policy or economic condition.

A more fundamental drawback is that the application of general-purpose lexicons may fail to capture the specificity of a central bank communication (Picault & Renault, 2017). For example, the most common sentiment lexicons may classify the word “downward” as negative but fail to classify its opposite (“upward”). Additionally, the most common lexicons contain only single words. Therefore, word combinations such as “lower unemployment” may be

Table 3. Hu & Liu (2004) lexicon sample

| Word | Sentiment |
|---------------|-----------|
| Sluggish | negative |
| Volatile | negative |
| Risk | negative |
| Weaker | negative |
| Difficulty | negative |
| Ideally | positive |
| Regard | positive |
| Stability | positive |
| Effectiveness | positive |

incorrectly classified as negative, relating to the two words “unemployment” and “lower” each as negative, rather than understanding the combination to be positive.

Nevertheless, we make use of the general-purpose lexicon to cross-check sentiment indices calculated with a field-specific lexicon. More specifically, we only use the Hu & Liu (2004) sentiment lexicon to evaluate paragraphs that refer to economic condition, assuming that matching phrases on economic condition are more general than the monetary policy ones, thus them more amenable to being captured with a general-purpose sentiment lexicon.

We apply a methodological strategy similar to the one for the field-specific lexicon above, with a few modifications. As before, we generalize overall economic sentiment for the ECB press conference or Executive Board member statement P with the term-weighted formula:

$$P_e^i = \frac{\sum_{n=1}^l W_{n,e}^c}{\sum_{n=1}^l W_{n,e}} \quad (3)$$

where l is the number of matching n-grams in the analysed communication event. Each matched word W belongs to a category c (positive or negative).

As before, we summarize the sentiment probabilities of each statement into sentiment indicators. In this case, as explained above, we calculate the sentiment indicator only for the economic condition EC . Therefore, to calculate I_e^{EC} we subtract the negative economic outlook sentiment probability from the positive economic outlook sentiment probability:

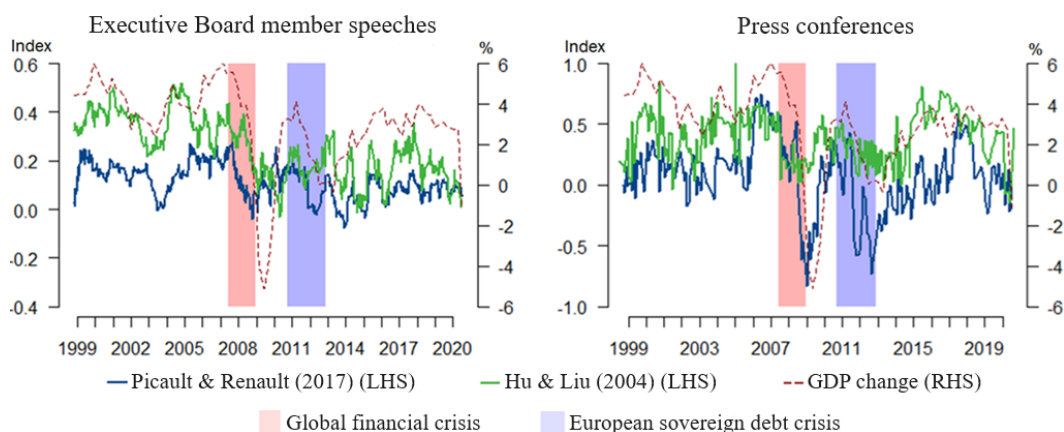
$$I_e^{EC} = P_e^{EC,positive} - P_e^{EC,negative}, I_e^{EC} \in [-1,1] \quad (4)$$

Additionally, to prevent the case in which a few matching n-grams or phrases drive the whole sentiment index, we exclude ECB communication events with the smallest number of matching n-grams or keywords in both lexicons. More specifically, we exclude half of the observations with the lowest matching number of n-grams or keywords for speeches and fewer than 10 matching n-grams or keywords for press conferences. The reason for treating press conferences more leniently is that the problem of skewing due to a few matches is less significant for these more structured statements (see Table 4 and 5 for more details). To evaluate the accuracy of our restrictions, we compare our sentiment indices with those calculated by Picault & Renault (2017) (see Appendix 5 for more details).

5.2 Results of sentiment analysis

Sentiment analysis of ECB communication yields an overview of the tonal development of ECB messages over time. In this section, we survey the developmental trajectory of economic condition and monetary policy sentiments in the speeches of Executive Board members.

Figure 6. Developments of the economic condition sentiment in ECB communications



Notes: The red area indicates the Global financial crisis,, while the blue denotes the European sovereign debt crisis. The sentiment index (LHS) takes values from -1 to 1. For descriptive purposes, the economic condition sentiment index for the Executive Board member speeches is smoothed using a 15-observation moving average. The red dashed line indicates the euro-area annual GDP change in % (RHS). It represents the euro-area economic performance throughout the 20-year period.

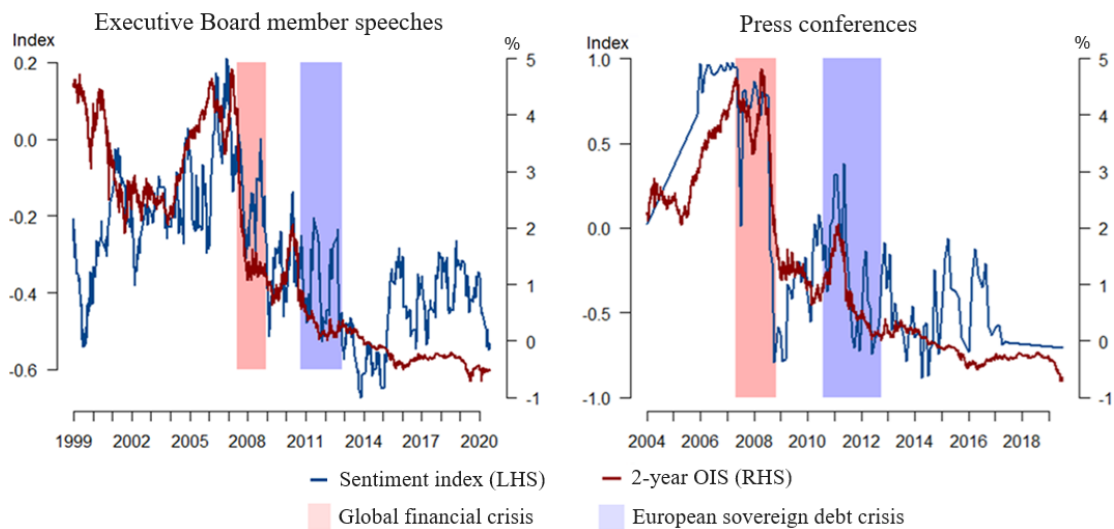
The dynamics in the economic condition sentiment index over the past 20 years reveal significant differences between press conferences and policymaker speeches (Figure 6 above). First, due to the less structured nature of the Executive Board member speeches, the sentiment index naturally shows larger short-term volatility than the sentiment index of the more structured press conferences. Hence, for descriptive purposes, we minimize these sentiment index disturbances by using a 15-observation moving average. Second, the methodological approach to calculating the sentiment index differs between lexicons. Thus, one should compare sentiment index trends rather than raw absolute numbers.

Despite differences between the two sentiment indicators, they both mimic the general path of economic performance in the euro area. The lowest points of the ECB communication sentiment also coincide with the deteriorating economic outlook during the main economic recessions of the past two decades, in both channels of ECB communication. For illustrative purposes, we extracted statements in press conferences and Executive Board member speeches, starting with the deteriorating sentiment index and reaching the lowest sentiment index score. The ECB official press conferences started expressing a deteriorating economic outlook in 2007 due to the turbulence in financial markets just before the escalation of the GFC. We observe the deteriorating economic sentiment in Executive Board member speeches in late 2007 as well. For instance, in October 2007 José Manuel González-Páramo conveyed concerns that “financial market volatility has added to the uncertainty surrounding the outlook for euro area economic

growth” (González-Páramo, 2007). From that point on, the ECB publicly expressed more and more negative signals on the economic condition, reaching the lowest point in late 2008. During this low point of euro-area economic performance, the Vice President of the ECB L. Papademos declared that “in most euro area countries, commercial property inflation continued to decline, and prices were even falling in seven out of the twelve countries” (Papademos, 2008). Economic sentiment in ECB communications improved later on, in line with the recovery of the euro area in the aftermath of the GFC.

The ECB’s economic sentiment deteriorated again in 2011 with the onset of the euro-area debt crisis. The ECB announced a significant downward forecast revision in their press conferences in November 2011. From there, our indices detect a worsening economic condition sentiment in ECB communications. The negative economic outlook during the euro area crisis culminated in late 2012, when both the President of the ECB and several other members of the Executive Board communicated an ongoing contraction of economic activity. In 2013, the economic sentiment started gradually improving again, in line with the onset of the euro area’s economic recovery.

Figure 7. Developments of monetary policy sentiment in ECB communications



Notes: The red area indicates the Global financial crisis,, while the blue denotes the European sovereign debt crisis. The monetary policy sentiment index (LHS) takes values from -1 to 1. For descriptive purposes, the monetary policy sentiment index for the Executive Board member speeches is smoothed using a 15-observation moving average. The plot on the right starts only in 2005 because the earlier years were filtered out as cases with the smallest number of matching phrases. Also, to evaluate the accuracy of the monetary policy index we included an additional plot, the development of the 2-year OIS rate in % (RHS).

Developments in the monetary policy index over the past two decades show similar differences that also appear when we measure economic condition sentiment. Like with the economic condition sentiment index, due to the less structured nature of the ECB Executive Board member speeches, the monetary policy sentiment index in the Executive Board member speeches displays a larger short-term volatility than the monetary policy index in the press conferences (Figure 7). Despite this, we observe similar shifts from a more hawkish to a more dovish monetary policy stance and vice versa in both channels of ECB communications. Additionally, our monetary policy sentiment index more or less matches the changes in the 2-year OIS rate, especially regarding ECB press conferences. We have also extracted ECB statements during turning points of the monetary policy index in order to illustrate the shift in tone of the ECB monetary policy at those times.

Major shifts in monetary policy sentiment coincide with the periods of the GFC and the European sovereign debt crisis. As indicated by both the press conferences and the Executive Board member speeches, ECB communications on monetary policy from 2006 to 2008 were relatively hawkish. The tone of the monetary stance became more dovish from October 2008 on, when the ECB started decreasing their main interest rates as a reaction to the raging GFC. Monetary policy sentiments became more hawkish again in early 2011, when the ECB increased the key interest rates in response to rising price pressures. As particularly evident in ECB press conferences, this hawkish attitude lasted for a brief time and the ECB monetary policy stance softened, when the ECB started implementing various non-conventional monetary policy measures in reaction to slowing economic activity during the European debt crisis. Even after this crisis, ECB communications on monetary policy remained more dovish than before the GFC.

Before dealing with the regression analysis, we also investigated how the sentiment indices correlate with the most prominent financial variables (see Appendixes 6-8). We found modest correlations with most of the coefficients being rather small. Nevertheless, the correlation between financial variables (i.e., changes in 10-year OIS, changes in IT-DE spreads and changes in stock prices) and sentiment indices, though small, mostly points in the direction that we expect based on literature review. For instance, the economic condition index positively correlates with the 10-year OIS rate and changes in stock prices, while the relationship between these variables and the monetary policy index is negative. To test whether there is a statistically significant relationship between the tone of ECB communications and changes in the financial market in a more robust way, we ran a series of regressions, which we describe in greater detail in the next section.

6 Regression analysis

This section presents the specifications of two types of regressions and then the results of these regressions.

6.1 Specifications of regression analysis

We estimate the impact of different topics and sentiments on financial market variables by using regression analysis. As in the study of Picault & Renault (2017), we measure the effect of policy sentiment on stock prices and market volatility and include a lagged financial market indicator as an independent variable. However, financial markets are also affected by other factors besides monetary policy announcements that have to be controlled (Hubert & Labondance, 2021; Picault & Renault, 2017). To account for this effect, we additionally include dummy variables such as releases of euro area HICP inflation and GDP, systemic financial stress indicator and long-term market inflation expectations. It is important to note that compared to Picault & Renault (2017), our research incorporates a broader scope of financial market indicators (as a dependent variable) in sentiment analysis (eq. 5) and also measures the effect of different topics in a separate regression (eq. 6).

$$\Delta R_t = \alpha + \beta_1 * \Delta R_{t-1} + \beta_2 * I_t^{MP} + \beta_3 * I_t^{EC} + \beta_4 * HICP_t + \beta_5 * GDP_t + \beta_6 * CISS_t + \beta_7 * 10y_t^{inf} + \varepsilon_t \quad (5)$$

where ΔR_t denotes the daily change of a particular financial market variable (explained in section 3.3) on the day of the monetary policy communication event, while ΔR_{t-1} reflects the daily change on the previous day. Daily change is measured as a percentage change for index variables (except for VSTOXX, which is measured as a first difference) and percentage point changes for variables expressed in percentage terms (such as interest rates). I_t^{MP} and I_t^{EC} denote the value of sentiment surrounding monetary policy and economic outlook, respectively. $HICP_t$ and GDP_t are the dummy variables denoting days of euro area HICP and GDP data releases, $CISS_t$ is the systemic stress index, $10y_t^{inf}$ denotes 10-year market-based inflation expectations, ε_t is the error term.

$$R_t = \alpha + \beta_1 * R_{t-1} + \beta_2 * Topic_t + \beta_3 * HICP_t + \beta_4 * GDP_t + \beta_5 * CISS_t + \beta_6 * 10y_t^{inf} + \varepsilon_t \quad (6)$$

where $Topic_t$ represents dummies of different topics in a monetary policy communication event on a day t .

In these regressions we have also included observations a day before the monetary policy communication event ($t-1$). The rationale to include such observations is that there is a need to account for financial market changes when there is no speech or press conference on a particular

day. Therefore, including these observations serves as an alternative to a heteroskedastic estimation procedure, which was not possible to implement due to the absence of sentiments on days with no monetary policy event.

Assuming that Odyssean monetary policy guidance dominates, we would expect hawkish monetary policy sentiment to have a negative effect on stock prices and to be directly related with the volatility indicator. We would expect a different scenario if Delphic guidance would dominate, i.e., stock prices would go up and volatility would go down. Expectations of tighter monetary policy should increase sovereign spreads, as the impact on peripheral economies is likely to be larger and thus would drive their bond yields upwards. More hawkish monetary policy would also lead to higher risk-free rates across the different maturities.

Regarding economic sentiment, we expect it to be positively related with stock prices and negatively – with volatility. Improved economic conditions should lead to increased OIS rate, as better economic conditions would require tighter monetary policy in order to maintain the price stability objective.

We used several different regression configurations for the robustness check. Regressions for Executive Board member speeches were estimated with various observation pooling techniques and constructions of sentiment indicators. To be specific, the regressions for speeches were conducted with varying restrictions on matching n-grams and keywords in order to account for biases in the lexicons used. As topics and language tend to vary significantly among different speeches, there are cases in which lexicons would not be able to find large numbers of matching keywords or n-grams, thus increasing randomness in the obtained sentiment indicators. Therefore, some observations with the lowest number of matching n-grams or keywords were removed in order to make sentiments more reliable. On the other hand, if the share of eliminated observations would be too large, this would reduce the likelihood of capturing reliable results, given that many other factors impact financial variables throughout the day. Two types of regressions were thus conducted in order to maintain the right balance: eliminating one-third and half of observations with the lowest number of matching keywords or n-grams. Observations with the Picault & Renault (2017) lexicon were included only if both economic and monetary policy sentiments followed the rules specified above. Regarding the regressions using press conference text data, the issue of varying language and topics is less pronounced, as the communication events are much more homogenous: during a press conference, the President of the ECB delivers a highly standardised introductory statement. In this case, observations with fewer than 10 matching n-grams or keywords were eliminated.

6.2 Results of regression analysis

Using regression analysis, we observe several important findings of the financial market's reaction to ECB communication (Table 4 and Table 5). First, we find statistically significant effects that are in line with economic theory. Similarly as in Gertler & Horwath (2018), we find

that economic and monetary policy sentiments are positively related to a range of risk-free rates. Economic sentiment is also positively related to stock prices and negatively to stock market volatility being in line with the findings of Picault & Renault (2017)⁶. Also, we find that more hawkish monetary policy sentiment is associated with higher stock market volatility, similarly as in Picault & Renault (2017). In addition to that, we find sovereign spreads to be negatively related to economic sentiment and positively related to monetary policy sentiment. This could be explained by the higher sensitivity of peripheral states to negative economic surprises and higher interest rate prospects, e.g., due to higher debt levels.

Table 4. Results of regressions of economic and monetary policy sentiments on OIS rates at different maturities

| | OIS 3-month | | | OIS 2-year | | | OIS 10-year | | |
|---------------------|-------------------------|--------------------|---------------------|-------------------------|--------------------|---------------------|-------------------------|--------------------|---------------------|
| | Speeches: restricted | Speeches: loose | Press conference | Speeches: restricted | Speeches: loose | Press conference | Speeches: restricted | Speeches: loose | Press conference |
| Picault_ec | 0.00046 | -0.00032 | 0.0066* | 0.019*** | 0.0065 | 0.016 | 0.0017 | -0.0014 | 0.024* |
| Std error | 0.0018 | 0.0015 | 0.004 | 0.0059 | 0.0046 | 0.0097 | 0.0079 | 0.0061 | 0.013 |
| Picault_mp | 0.000014 | 0.0002 | 0.000095 | 0.002 | 0.0013 | -0.0012 | 0.0055 | 0.0065** | -0.012 |
| Std error | 0.00092 | 0.00076 | 0.0025 | 0.003 | 0.0024 | -0.0012 | 0.004 | 0.0032 | 0.0084 |
| <i>Observations</i> | 1315 | 1855 | 358 | 1206 | 1702 | 340 | 1002 | 1402 | 308 |
| Hu & Liu_ec | 0.0019* | 0.00025 | 0.0038 | 0.0059 | 0.0026 | 0.012 | 0.0081 | 0.0024 | 0.013 |
| Std error | 0.0011 | 0.00091 | 0.0027 | 0.0037 | 0.0029 | 0.0074 | 0.0052 | 0.0042 | 0.01 |
| <i>Observations</i> | 1460 | 1932 | 464 | 1336 | 1782 | 422 | 1056 | 1426 | 314 |

Notes: Picault_ec refers to economic conditions sentiment constructed using lexicon from Picault & Renault (2017); Picault_mp refers to monetary policy sentiment constructed using lexicon from Picault & Renault (2017); Hu & Liu_ec refers to economic conditions sentiment constructed using lexicon from Hu & Liu (2004). Restricted regression type refers to the adjustment where half of all observations are removed, those with the lowest number of matching keywords or n-grams. These include speeches with fewer than 12 matches for Picault_mp, fewer than 21 for Picault_ec and fewer than 36 for Hu & Liu_ec sentiment. Loose regression type refers to the adjustment where a third of all observations are removed, those with the lowest number of matching keywords or n-grams. These include speeches with fewer than 8 matches for Picault_mp, fewer than 13 for Picault_ec and fewer than 22 for Hu & Liu_ec sentiment. Press conference regressions are restricted to have 10 or more matching n-grams and keywords. Stars denote statistical significance with 90% “*”; 95% “**” and 99% “***”.

⁶ Although our results are broadly in line with the ones presented in Picault & Renault (2017), some differences remain due to differences in time period and the set of independent variables, as well as a slightly modified sentiment calculation method.

Secondly, in line with our prior expectations, there are more statistically significant coefficients for press conference communication sentiments, and these tend to be larger than the ones for speeches. This is evident across different financial market variables. It might be related to the fact that speeches are more frequent and are often interpreted as expressing positions of particular official and not the overall Governing Council. Press conferences, by contrast, occur less frequently than speeches and are delivered by the ECB President on behalf of the entire Governing Council.

Thirdly, the application of Hu & Liu (2004) sentiment lexicon for economic communication topics appears to provide some valuable insights, complementing the analysis using sentiments based on the Picault & Renault (2017) lexicon. Although the two types of sentiments are applied using different methodologies, are not closely correlated and are only sometimes significant for the same regression configurations, their effect on financial market variables were found to be with the same sign and of relatively similar size, thus increasing the reliability of the results.

Table 5. Results of regressions of economic and monetary policy sentiments on Eurostoxx50, VSTOXX and 10-year spread between Italian and German yields.

| | Eurostoxx50 | | | VSTOXX | | | 10y IT-DE spread | | |
|---------------------|----------------------|-----------------|------------------|----------------------|-----------------|------------------|----------------------|-----------------|------------------|
| | Speeches: restricted | Speeches: loose | Press conference | Speeches: restricted | Speeches: loose | Press conference | Speeches: restricted | Speeches: loose | Press conference |
| Picault_ec | -0.00008 | 0.00091 | 0.0062* | 0.029 | -0.24 | -0.9*** | -0.0086 | -0.011* | -0.025* |
| Std error | 0.0024 | 0.0018 | 0.0036 | 0.24 | 0.18 | 0.32 | 0.0079 | 0.006 | 0.015 |
| Picault_mp | -0.00059 | -0.00016 | -0.0029 | -0.14 | -0.095 | 0.64*** | 0.0045 | -0.0014 | 0.017* |
| Std error | 0.0012 | 0.00092 | 0.0022 | 0.12 | 0.096 | 0.2 | 0.0039 | 0.0031 | 0.0088 |
| <i>Observations</i> | 1362 | 1922 | 370 | 1338 | 1882 | 364 | 1362 | 1922 | 370 |
| Hu & Liu_ec | 0.00057 | 0.00018 | 0.0025 | 0.063 | 0.027 | -0.55** | -0.0022 | 0.00019 | -0.014* |
| Std error | 0.0013 | 0.0011 | 0.0025 | 0.14 | 0.12 | 0.22 | 0.0042 | 0.0035 | 0.0076 |
| <i>Observations</i> | 1512 | 2020 | 478 | 1478 | 1958 | 470 | 1512 | 2020 | 478 |

Notes: Picault_ec refers to economic conditions sentiment constructed using lexicon from Picault & Renault (2017); Picault_mp refers to monetary policy sentiment constructed using lexicon from Picault & Renault (2017); Hu & Liu_ec refers to economic conditions sentiment constructed using lexicon from Hu & Liu (2004). Restricted regression type refers to the adjustment where half of all observations are removed, those with the lowest number of matching keywords or n-grams. These include speeches with fewer than 12 matches for Picault_mp, fewer than 21 for Picault_ec and fewer than 36 for Hu & Liu_ec sentiment. Loose regression type refers to the adjustment where a third of all observations are removed, those with the lowest number of matching keywords or n-grams. These include speeches with fewer than 8 matches for Picault_mp, fewer than 13 for Picault_ec and fewer than 22 for Hu & Liu_ec sentiment. Press conference regressions are restricted to have 10 or more matching n-grams and keywords. Stars denote statistical significance with 90% “*”; 95% “**” and 99% “***”.

In particular, we find that economic sentiments from both lexicons have statistically significant effects and are of similar size on stock market volatility and sovereign spread.

Finally, it is important to mention that we do not find any regression configuration to be clearly superior to all others. All configurations tend to be statistically significant only in certain cases, depending on the lexicon and financial market indicator used.

Regression analysis of topic developments on volatility of financial markets has revealed only one market-moving topic (see in Appendix 9). We find that overall stock indices are somewhat more volatile on the days when Executive Board members cover the topic of monetary policy instruments in their speeches. In addition, the changes of short-term OIS rate are larger when the speeches focus on monetary policy instrument topic. These effects can be explained by the fact that messages regarding monetary policy instruments might provide more information for market participants about the future conduct of monetary policy than other topics, thus leading to some repricing in financial markets.

To sum up, our results provide a number of insights for policymakers and market participants. Financial markets seem to somewhat react to the tone of ECB communications. In conjunction, we found that some market indicators are sensitive not only to regular press conferences, but also to sporadic Executive Board speeches. In particular, we detect an impact on future risk-free rates (OIS). Although the effect of speeches tends to be smaller than the effect of press conferences, our results imply that ECB officials' communications are being carefully observed by market participants even during ad hoc events. ECB policymakers should take into account that what they say may signal additional information, in particular about policy instruments, and that such information might have immediate effects on financial markets. At the same time, this means that communication by Executive Board members could indeed work as a policy tool and help to steer expectations in the intended direction. This is especially important in a setup where Executive Board members represent only a subset of the ECB Governing Council, which is responsible for making policy decisions.

Although we see some signs of robustness in our results across different models, it is important to emphasize that there is also uncertainty about them. On the one hand, the majority of regression outcomes was found to be statistically insignificant. This can potentially be explained by the biases in the construction of sentiment indicators (mentioned in Section 4.2) and a combination of other factors impacting financial market variables but not included in our regression specifications. Furthermore, a portion of the speeches may have greater effects on markets the day after they are delivered if such speeches are given late in the evening, when markets are already closed (we do not have the exact time stamp of each speech). Some of these caveats may be resolved with more advanced data and methodological approaches. Most

importantly, intraday data would help to reduce the noise that affects movements in financial markets. The research could be further expanded to text data on media perceptions of ECB communications in addition to official communication events. Such steps would facilitate the confirmation or refutation of the results from this research. Nonetheless, all results that we found to be statistically significant had the expected signs. The results also mostly remain the same if we change the number of observations, regression method and even sentiment indicator.

7 Conclusions

Monetary policy communication has been playing a crucial role in policy transmission, especially since the GFC, when forward guidance became increasingly important policy tool. However, we found that some angles of evaluating ECB communication and its effects on financial markets were overlooked in the literature, and thus we have addressed them in this paper. We analysed not only press conferences of the ECB (i.e., the main events where ECB decisions are announced), but also sporadic speeches of Executive Board members. We deconstructed these communication events using both topic modelling and sentiment analysis, and then employed regression models to measure the impact on a variety of different euro area financial market indicators.

Topic analysis revealed that the importance of different topics varied significantly over time and among Executive Board members. At the inception of the euro area, the main focus of policymakers' speeches was the strategy and objectives of the ECB, but the focus shifted during the GFC to various policy actions, e.g., banking regulation and supervision, as well as ECB monetary policy instruments. More recently the topic on monetary policy instruments is being addressed much more frequently. There are also significant differences in the topics covered by different Executive Board members, mostly due to the fact that members are responsible for different areas.

Sentiment analysis shed some light on how the tone of the ECB communication has developed over the years. Our constructed indices captured major turning points of the economic outlook expressed in ECB statements during the main crises of the past two decades. Moreover, we observed that ECB communication became more dovish during the GFC and with the introduction of non-conventional monetary policy measures.

The performed regression analysis provided results with the signs we expected, although outcomes often differed depending on the concrete specification. We found that economic sentiment indices were directly related with daily changes in stock prices, but inversely – with market volatility and sovereign spreads. The opposite was true for monetary policy indices. Both monetary and economic sentiment indices had direct effects on OIS rates. Another broad

tendency was that the effect of sentiment in press conferences tended to be larger than the one in Executive Board speeches. Regression analysis of topic developments showed that only the topic on monetary policy instruments had a significant impact on euro area stock prices and short-term OIS rates. Further analysis is highly welcome, particularly studies using higher-frequency data and additional estimating techniques.

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Appendices.

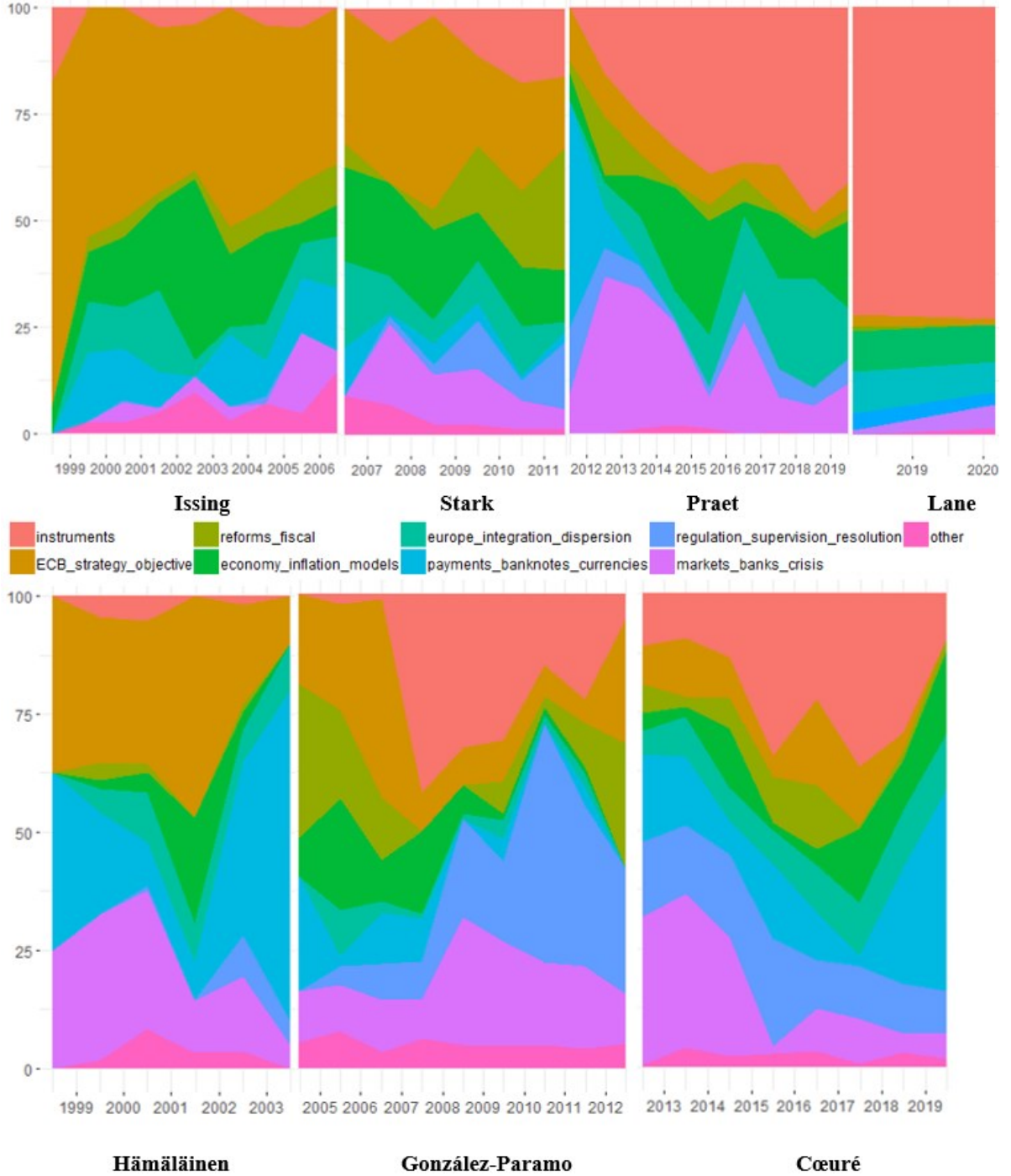
Appendix 1. Procedure description of distributing narrower topics to broader ones

Out of 25 narrower topics for each paragraph, we have manually grouped them into 9 broader buckets, covering most important areas of central banking. Hartmann & Smets (2018) at first specify 50 different topics and then group them into 9 broader themes. By analysing paragraphs with the STM model, we obtained 25 narrower topics which are described by a number of stemmed keywords (5 main keywords are provided in Table A) and accompanying probabilities of each paragraph belonging to the particular topic. By using expert judgement, we then distributed those 25 topics to 9 broader ones. For instance, several different topics (out of 25) had similar keywords (e.g., “ECB”, “Governing Council”, “monetary policy”, “price stability”), so we attributed them all to one comprehensive topic of “ECB strategy and its objective”. However, to double-check this analysis, we also read around 10-15 paragraphs with the highest attributed probability for each of the 25 topics, and then decided on the final grouping. By continuing this manual exercise, we obtained 9 different topics (see last column of the Table A) with their summed probabilities for each paragraph.

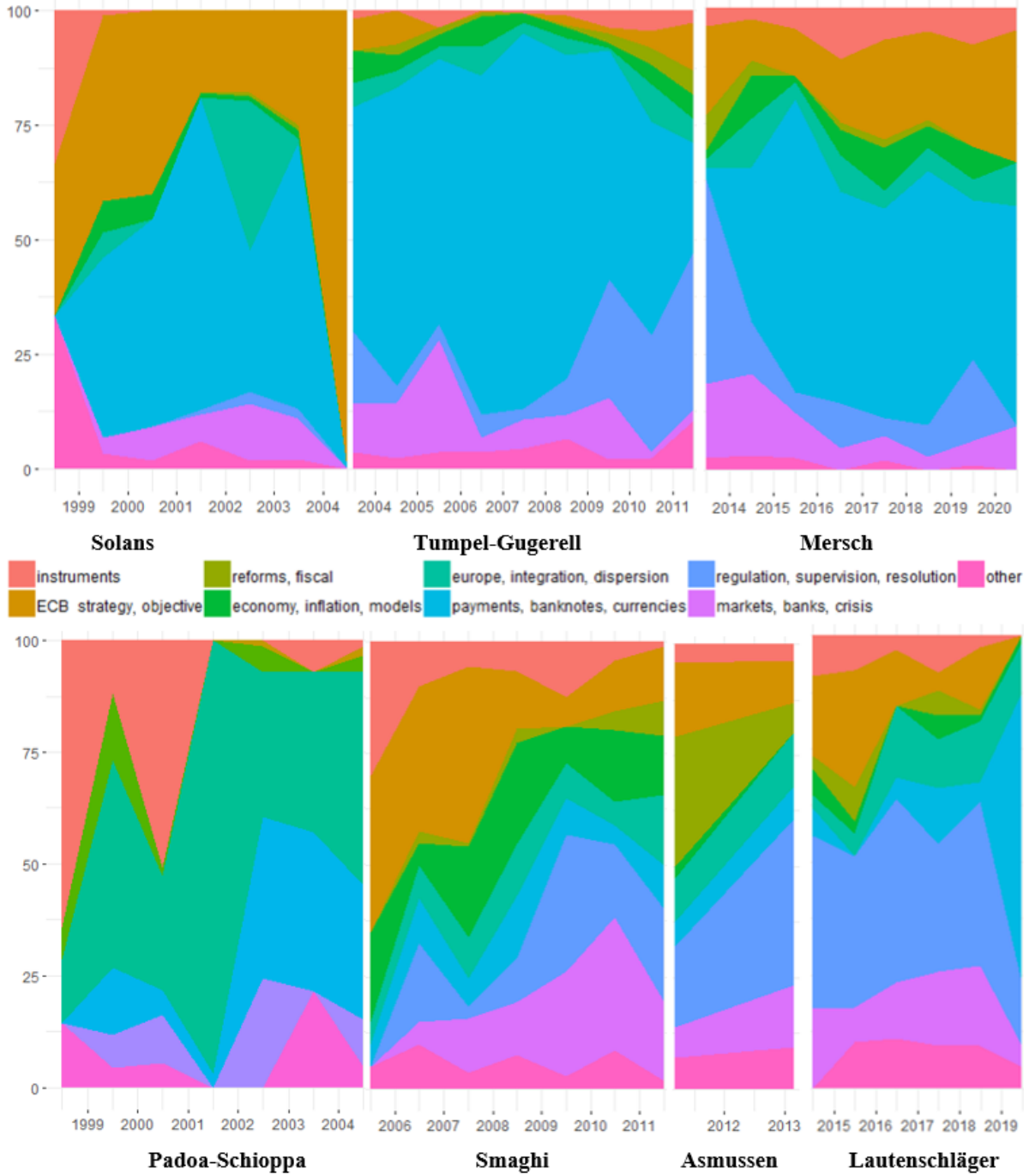
Table A. 10 keywords for 25 topics and grouping into 9 broader ones.

| Topic | Keyword1 | Keyword2 | Keyword3 | Keyword4 | Keyword5 | Broader topic |
|----------|----------|----------|----------|---------------|------------|--|
| Topic 1 | product | labour | competit | increas | invest | <i>economy, inflation, models</i> |
| Topic 2 | price | inflat | expect | risk | increas | <i>economy, inflation, models</i> |
| Topic 3 | bank | credit | fund | asset | sector | <i>markets, banks, crisis</i> |
| Topic 4 | model | even | one | use | may | <i>economy, inflation, models</i> |
| Topic 5 | fiscal | public | govern | sustain | countri | <i>reforms, fiscal</i> |
| Topic 6 | inform | ecb | assess | analysi | data | <i>ECB strategy, objective</i> |
| Topic 7 | can | structur | reform | need | economi | <i>reforms, fiscal</i> |
| Topic 8 | europ | european | econom | union | integr | <i>Europe, integration, divergence</i> |
| Topic 9 | will | secur | initi | infrastructur | sepa | <i>payments, banknotes, currencies</i> |
| Topic 10 | ecb | european | central | govern | council | <i>ECB strategy, objective</i> |
| Topic 11 | area | growth | euro | year | econom | <i>Europe, integration, divergence</i> |
| Topic 12 | germani | countri | unit | greec | german | <i>Europe, integration, divergence</i> |
| Topic 13 | bank | nation | author | european | supervisor | <i>regulation, supervision, resolution</i> |
| Topic 14 | crisi | financi | economi | sever | sovereign | <i>markets, banks, crisis</i> |
| Topic 15 | rate | interest | inflat | expect | low | <i>instruments</i> |
| Topic 16 | financi | system | risk | institut | manag | <i>regulation, supervision, resolution</i> |
| Topic 17 | market | integr | euro | financi | area | <i>markets, banks, crisis</i> |
| Topic 18 | euro | area | countri | will | currenc | <i>payments, banknotes, currencies</i> |
| Topic 19 | intern | global | exchang | currenc | economi | <i>payments, banknotes, currencies</i> |
| Topic 20 | payment | money | servic | bank | use | <i>payments, banknotes, currencies</i> |
| Topic 21 | differ | may | specif | certain | whether | <i>other</i> |
| Topic 22 | polic | monetari | stabil | price | central | <i>ECB strategy, objective</i> |
| Topic 23 | liquid | oper | market | purchas | measur | <i>instruments</i> |
| Topic 24 | like | will | today | year | discuss | <i>other</i> |
| Topic 25 | clear | least | take | reach | second | <i>other</i> |

Appendix 2. Topics of ECB Chief Economists (upper) and EB members responsible for Operations (lower) throughout their terms



Appendix 3. Topics of EB Members responsible for Payments/Banknotes (upper) and other areas (lower) throughout their terms



Appendix 4. Examples of different classification of n-gram “accommodative monetary” in ECB press conferences

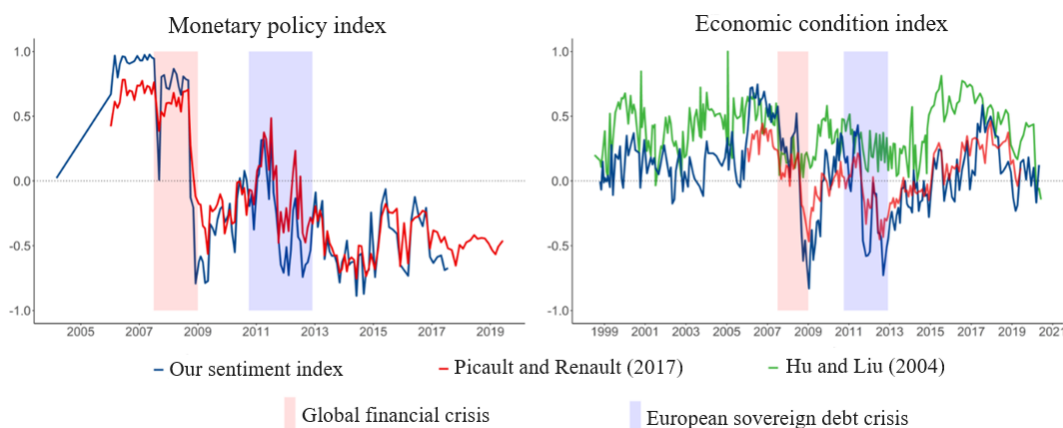
| Dovish monetary policy | Neutral monetary policy | Hawkish monetary policy |
|---|---|--|
| <p>Fourth, we decided to launch a new series of four targeted longer-term refinancing operations (TLTRO II), starting in June 2016, each with a maturity of four years. These new operations will reinforce the ECB’s accommodative monetary policy stance and will strengthen the transmission of monetary policy by further incentivising bank lending to the real economy. (2016-03-10)</p> | <p>The swift and effective implementation of structural reforms, in an environment of accommodative monetary policy, will not only lead to higher sustainable economic growth in the euro area but will also make the euro area more resilient to global shocks. (2015-10-22)</p> | <p>On the basis of our regular economic and monetary analyses, we have decided to increase the key ECB interest rates by 25 basis points, after two and a half years of maintaining rates at historically low levels. Our decision to increase interest rates was warranted so as to adjust our accommodative monetary policy stance, while taking into account the risks to price stability that we have identified in our economic analysis, cross-checked by our monetary analysis. (2005-12-01)</p> |
| <p>The Governing Council also assessed that, at this point in time, the positive contribution of negative interest rates to the accommodative monetary policy stance and to the sustained convergence of inflation is not undermined by possible side effects on bank-based intermediation. However, we will continue to monitor carefully the bank-based transmission channel of monetary policy and the case for mitigating measures. (2019-06-06)</p> | <p>In an environment of accommodative monetary policy, the swift and effective implementation of structural reforms will not only lead to higher sustainable economic growth in the euro area but will also make the euro area more resilient to global shocks. (2016-09-08)</p> | <p>To sum up, the Governing Council decided to increase the key ECB interest rates by 25 basis points. The adjustment of the current very accommodative monetary policy stance is warranted in the light of upside risks to price stability that we have identified in our economic analysis. (2011-04-07)</p> |
| <p>Overall, our accommodative monetary policy stance, including the measures taken today, will safeguard favourable bank lending conditions and will continue to support access to financing, including for those affected most by the ramifications of the coronavirus and, in particular, for small and medium-sized enterprises. (2020-03-12)</p> | <p>Moreover, our accommodative monetary policy stance, continued employment gains resulting from past structural reforms and the still relatively low price of oil should provide ongoing support for households’ real disposable income and private consumption. (2016-04-21)</p> | <p>Based on its regular economic and monetary analyses, the Governing Council decided to keep the key ECB interest rates unchanged following the 25-basis point increase on 7 April 2011. The information that has become available since then confirms our assessment that an adjustment of the very accommodative monetary policy stance was warranted. We continue to see upward pressure on overall inflation, mainly owing to energy and commodity prices. (2011-05-05)</p> |

Appendix 5. Comparison of different sentiment indices

In Figure A1 below, we compare different monetary policy and economic condition sentiment indices from ECB press conferences with the baseline indices calculated by Picault & Renault (2017). Since we rely on the Picault & Renault (2017) sentiment lexicon in our calculation, there are only slight differences between our monetary policy and economic condition indices and the baseline ones of Picault & Renault (2017). The small differences mainly arise due to adjustments we made to quantify sentiments. As mentioned before, unlike Picault & Renault (2017), we have excluded all the matching n-grams which consists of only one word in order to increase the accuracy of the sentiment. Moreover, we excluded those press conferences with the least matching phrases from the sentiment lexicon. Thus, our sentiment indices take slightly larger values, but overall do not drift significantly away from the Picault & Renault (2017) calculations.

There are, however, significant differences between sentiment indices calculated with the general-purpose Hu & Liu (2004) lexicon and the field-specific Picault & Renault (2017) lexicon. The economic condition sentiment calculated with a general-purpose lexicon is more volatile than the same sentiment index calculated with field-specific lexicon. Also, it rarely takes negative values. Thus, with this lexicon we put lower weight on negative economic sentiment during the major recessions of the past decade. Nevertheless, the general-purpose lexicon does not fail to identify changes of tone in ECB communications, since the sentiment trend is similar across different lexicons. For instance, both indices deteriorate during the GFC and the European sovereign debt crisis.

Figure A1. Comparison of different sentiment indices in ECB press conferences

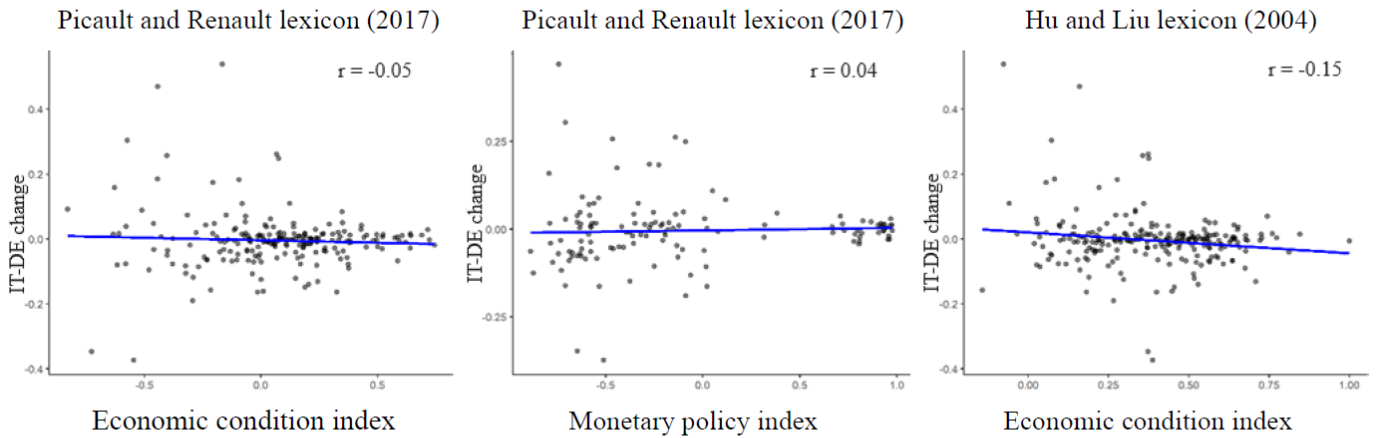


Notes: The red area indicates the Global financial crisis, while the blue area denotes the European sovereign debt crisis. The sentiment index takes values from -1 to 1. The plot on the left starts only in 2005 because the earlier years were filtered out as cases with the smallest number of matching phrases. Our sentiment index follows a slightly different methodological approach than Picault & Renault (2017) but relies on the same lexicon.

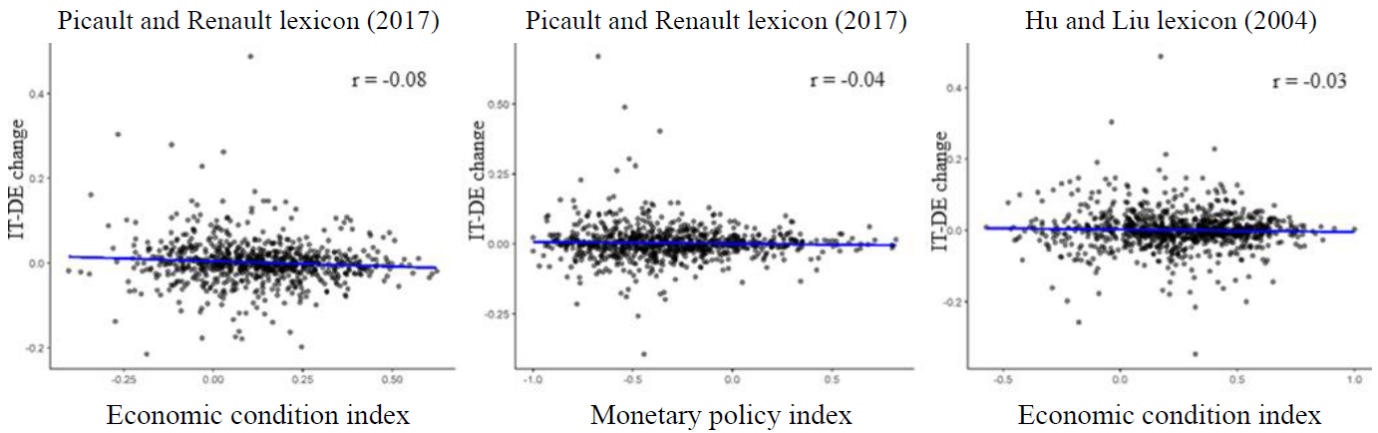
Appendix 6. Correlations between sentiment indices (x axis) and changes in stock prices (y axis)

IT-DE spread change

Introductory statements



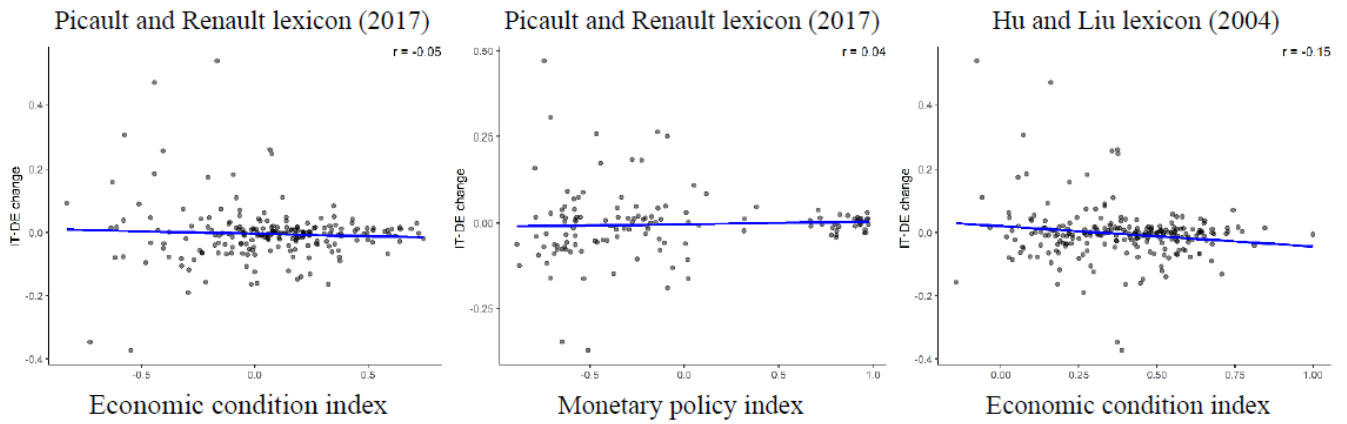
ECB speeches



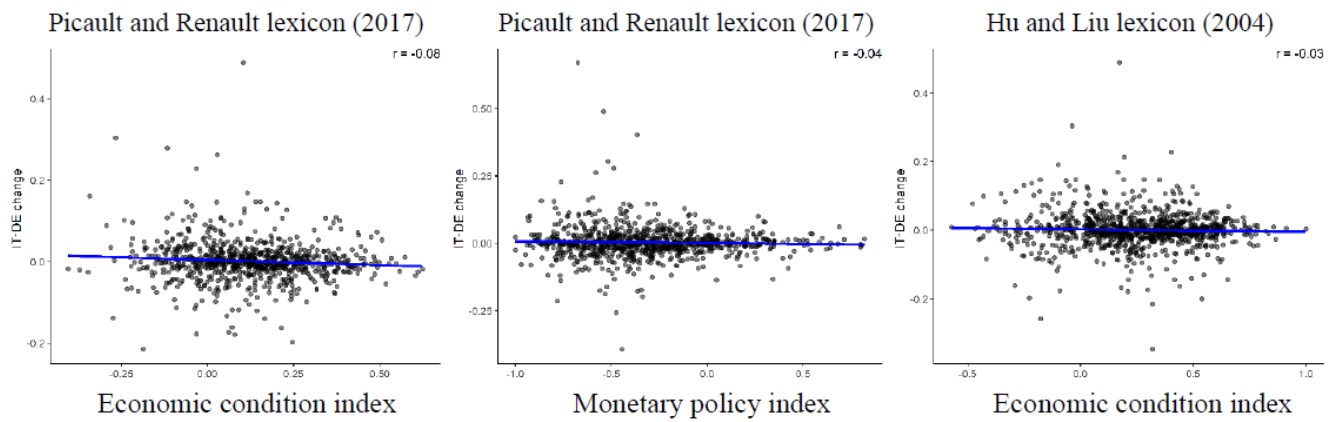
Appendix 7. Correlations between sentiment indices (x axis) and changes in IT-DE spread (y axis)

IT-DE spread change

Introductory statements



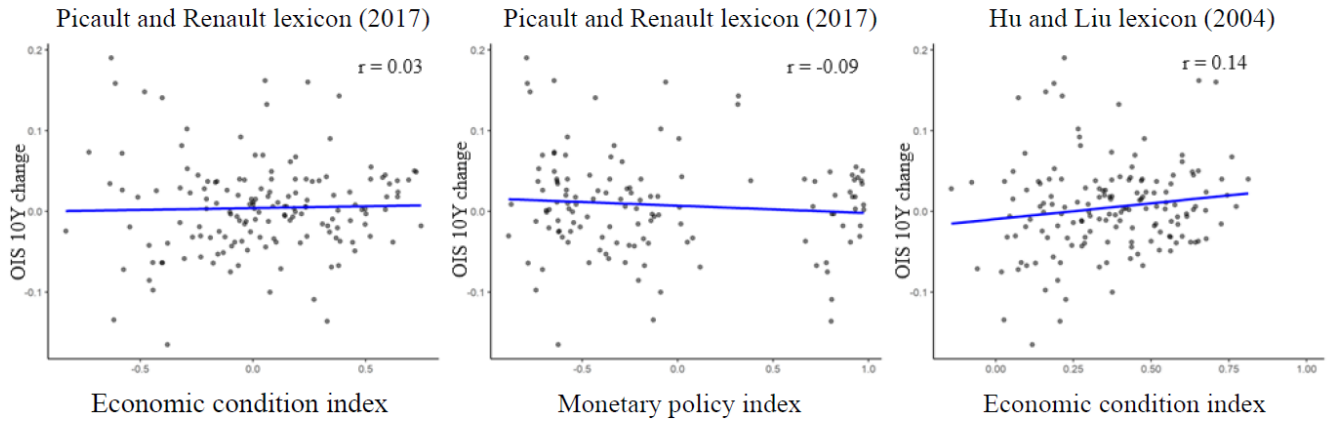
ECB speeches



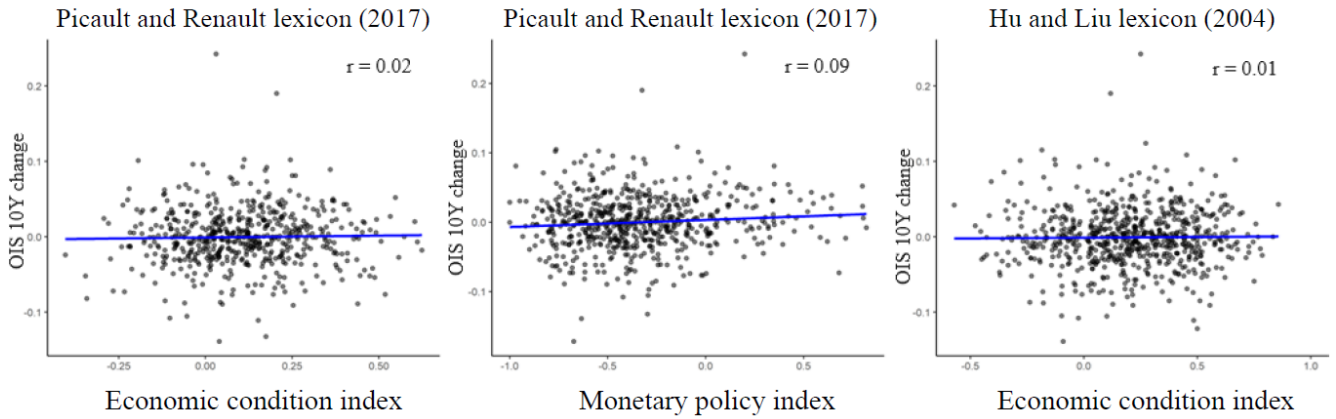
Appendix 8. Correlations between sentiment indices (x axis) and changes in 10-year OIS rate (y axis)

OIS 10-year rate change

Introductory statements



ECB speeches



Appendix 9. Results of regression analysis on different topics on euro area financial market (top row)

| Topic/financial market indicator | Eurostoxx50 | Short-term OIS |
|---|--------------------|-----------------------|
| Intercept | 0.004120*** | -0.01330*** |
| | -0.00109 | -0.00245 |
| Lag variable | 0.02097 | 0.2218*** |
| | -0.02571 | -0.02286 |
| Instruments | 0.00019* | 0.000386* |
| | -0.00009 | -0.00021 |
| ECB strategy and objective | 0.000124 | -0.000018 |
| | -0.00015 | -0.00034 |
| Reforms and fiscal | 0.000045 | -0.00021 |
| | -0.00016 | -0.00036 |
| Economy, inflation and models | 0.000079 | -0.00013 |
| | -0.0001 | -0.00023 |
| European integration and fragmentation | 0.0002 | 0.00013 |
| | -0.00013 | -0.00028 |
| Payments, banknotes and currencies | 0.0000239 | 0.000043 |
| | -0.000099 | -0.00022 |
| Regulation, supervision and resolution | 0.00003 | -0.00013 |
| | -0.000065 | -0.00015 |
| Markets, banks and crisis | 0.0000927 | 0.00017 |
| | -0.00014 | -0.0003 |
| Other | -0.00012 | 0.000272 |
| | -0.00028 | -0.00064 |
| HICP release | -0.00092 | 0.000989 |
| | -0.00082 | -0.00185 |
| GDP release | 0.004931** | -0.00037 |
| | -0.00244 | -0.00547 |
| CISS | 0.01678*** | 0.03385*** |
| | -0.00136 | -0.00295 |
| 10y inflation swap | 0.000238 | 0.01162*** |
| | -0.00065 | -0.00149 |
| Observations | 1212 | 1212 |
| R-squared | 0.18 | 0.38 |

Note: stars denote statistical significance with 90% “*”; 95% “**” and 99% “***”. First line for each variable shows the estimate, while the second one – the standard error.