ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/388267420

The Emotions of Monetary Policy

Preprint · January 2025

DOI: 10.2139/ssrn.5099686

CITATIONS
0

READS
353

6 authors, including:

Jens Klose
Mittelhessen University of Applied Sciences
65 PUBLICATIONS **487** CITATIONS
SEE PROFILE

Victor Smirnov
Mittelhessen University of Applied Sciences
1 PUBLICATION **0** CITATIONS
SEE PROFILE

All content following this page was uploaded by Victor Smirnov on 10 February 2025.

The user has requested enhancement of the downloaded file.

The Emotions of Monetary Policy*

Mamadou-Lamine Barry
Brenton Joey Bruns
Sinem Kandemir
Jens Klose
Victor Smirnov
Peter Tillmann

February 3, 2025

Abstract

We study the full scope of the communication of the ECB presidents during the post-meeting press conferences at a high frequency. Based on advances in facial and vocal recognition software and natural language processing, we not just quantify the spoken word of the ECB president, but also measure facial and vocal expressions at the minute frequency. First, the nature and the intensity of emotions differ between President Draghi and President Lagarde as well as between the introductory statement and the Q&A part of the press conferences. Second, average facial expressions during a press conference are correlated with inflation. Third, facial expressions and vocal arousal can moderate or amplify a hawkish policy message. In particular, positive emotions can support forward guidance statements of the ECB president.

Keywords: monetary policy communication, facial recognition, vocal expressions, natural language processing, financial markets
JEL classification: E58, E52, E44

*We are grateful to financial support from the Research Campus of Central Hessen. We thank Christian Münzenmayer for support on SHORE. Nicole Baerg, David Finck, Moritz Grebe and Peter Winker provided helpful comments on an earlier draft. We thank seminar participants at THM Business School for helpful discussions.

Affiliations: Barry, Bruns, Kandemir, Tillmann: Department of Business and Economics, Justus Liebig University Giessen, Germany; Klose, Smirnov: THM Business School, Giessen, Germany. **Contact:** mamadou-lamine.barry@wirtschaft.uni-giessen.de, brenton.joey.bruns@physik.uni-giessen.de, sinem.kandemir@wirtschaft.uni-giessen.de, jens.klose@w.thm.de, victor.smirnov@w.thm.de, peter.tillmann@wirtschaft.uni-giessen.de

1 Introduction

When central bankers speak, markets hang on their lips. A large body of literature studies the written and spoken words of central bankers using natural language processing (NLP) tools. This literature summarizes the multidimensional content of central bank communication into new indicators, often referred to as the tone or sentiment of central bank communication. In this paper, we push this literature one step forward: We "hang on the lips of central bankers" quite literally by quantifying not just the content of communication but also the facial and audio expressions of the president of the European Central Bank (ECB) during their post-meeting press conferences. We show that emotions reflected in facial and vocal expressions carry additional information beyond the spoken word, which is valued in financial markets.[1] Most articles in the literature, which we review below, address the expressions of the chair of the Federal Reserve. We contribute to this literature by studying the facial and vocal expressions of ECB presidents at a high frequency.

We concentrate on the press conferences held by the presidents of the ECB following the meetings of the Governing Council. This is the most important format for explaining the most recent monetary policy decisions and outlining the future path of policy (Ehrmann and Fratzscher, 2009). These press conferences consist of an introductory statement, which is read by the president, followed by a questions and answers (Q&A) session during which the president responds to questions from journalists. We collect video recordings of 100 ECB press conferences between 2012 and 2023 from the ECB's YouTube account.

Measuring the emotions conveyed in central bank communication based on video recordings is no trivial task (Baerg and Binder, 2024). We address this challenge by leveraging recent advances in facial recognition and natural language processing. First, we use facial recognition software to quantify two

[1] In a recent randomized control trial, Ash et al. (2024) confronted participants with ECB statements made during the press conference. The authors find that the medium of communication matters, with audio/video being most effective. Audiovisual communication is particularly effective in reaching participants with less economic literacy.

distinct types of emotions, each assigned a value between 0 and 100. The first category includes expressions such as "neutral", "angry", "happy", "sad", "surprised", "frightened", and "disgusted". The higher the score assigned to an expression, the greater the likelihood of a match between the detected facial expression and the specified value. The second category, valence, is defined by the poles "positive" and "negative". We aggregate the emotions for each video frame to a minute-by-minute frequency.

Second, we employ a pre-trained and fine-tuned transformer model that allows to classify vocal emotions into three dimensions: valence, which is the degree of pleasure or displeasure associated with an emotion; arousal, which the level of mental and physical engagement; and dominance, which degree of control over one's affective state. This data is also aggregated to the meeting frequency.

Third, we transcribe the spoken word and use a machine learning model to measure the degree of hawkishness at the sentence level. In each step, we pay utmost attention to precisely aligning the timing of the spoken word and the facial expressions. This alignment allows us to estimate the market impact of facial and vocal expressions controlling for the hawkishness of the spoken word.

We augment these data series by high-frequency asset price data, which we also aggregate to the minute frequency. The dataset includes bond yields of Germany, France, Italy and Spain, the Bund future, the Eurostoxx stock market index, and the euro-dollar exchange rate.

We find strong fluctuations of facial and vocal emotions both during each press conference and across the two presidents in our sample, Mario Draghi and Christine Lagarde. For both presidents, the degree of hawkishness fluctuates more during the introductory statement than the subsequent Q&A part of the press conference. In contrast, facial and vocal emotions exhibit larger fluctuations during the Q&A part than the introductory statement. Both aspects are plausible, as the introductory statement follows a much stricter format, with the president reading a prepared statement, leaving little room for emotions. Nevertheless, the variation in emotions that we *do* observe during the introductory statement has effects on financial markets. We also

find interesting differences in emotional expressions between the two presidents. Under President Lagarde, the levels of happy and angry expressions are generally higher than under President Draghi, while the opposite holds for sad expressions. The high frequency of the data also allows to conduct selected case studies, such as examining the press conferences in January 2015 (announcement of the Asset Purchase Programme) and July 2022 (lift-off of interest rates) or the press conference in March 2020 which included the communication misstep surrounding President Lagarde's statement that "we are not here to close spreads".

At the meeting frequency, we study the co-movement of emotions with both the level of inflation and the absolute deviation of inflation from the ECB's two percent target. If inflation increases, facial expressions turn more angry, even after controlling for the structural break associated with the transition from President Draghi to President Lagarde in 2019.[2]

Returning to the minute frequency, we find that a higher level of hawkishness in a statement made within a given minute coincides with higher level of vocal arousal and a more sad facial expression under President Draghi. Under President Lagarde, the degree of hawkishness appears less connected to specific facial or vocal expressions.

We link the data on facial and vocal expressions at the meeting frequency to financial markets. A happy expression from both President Draghi and President Lagarde tends to reduce bond yields. Importantly, we allow the level of hawkishness to interact with emotions. A happy face of President Draghi amplifies the impact of hawkishness on bond yields: yields increase more strongly if a hawkish sentence in the introductory statement is accompanied by a happy facial expression. In this sense, Draghi "kills with kindness". In contrast, an angry expression of President Lagarde strengthens the impact of a hawkish statement on bond yields.

Finally, we find that a happy expression of President Draghi supports the expansionary effects of a forward guidance statement. We select all minutes in which the ECB president makes an explicit comment of the ECB's for-

[2]This resembles the findings of Gennaro and Ash (2021), who study 150 years of speeches in the U.S. Congress and find an increase in emotions in times of war.

ward guidance policy. The decline in yields is stronger if we identify a happy expression on Draghi's face during the introductory statement. In contrast, a sad face undermines the impact of a forward guidance statement, leading to a rise in yields. We do not find a significant interaction between emotions and forward guidance for President Lagarde. These results are robust with respect to excluding the digital press conferences during the COVID-19 pandemic or excluding the minutes of the press conference in which faces other than the ECB president's are shown in most frames.

Overall, our results support the notion that the full scope of communication—comprising the content of the spoken word, the facial expressions, and the vocal expressions matters for the market impact. Investors should pay attention not just to the content of the policy message but also to the way the content is delivered.

The remainder of this paper is structured as follows. Section two sketches the related literature. Section three introduces our dataset in detail. Section four explores the properties of the data and illustrates their behavior in selected episodes. In Section five, we investigate the relationship between the hawkishness of the spoken word and the corresponding emotions. Section six reports the results on the market impact of emotions, while Section seven establishes the robustness of our findings. Section eight concludes.

2 Literature

Gorodnichenko et al. (2023) pioneer the analysis of the communication of the chair of the U.S. Federal Reserve (Fed) that goes beyond the spoken word. They employ a deep-learning model to uncover the vocal emotions from the post-meeting press conferences. After controlling for the Fed's policy decision and the sentiment reflected in the text of the written communication, a positive tone in the chair's voice is associated with an increase in stock prices, while bond yields do not seem to reflect vocal expressions. However, Gorodnichenko et al. (2023) do not examine the facial expressions of the Fed chair. Moreover, they conduct their analysis at the meeting frequency, which means that any high-frequency impact of the voice is washed out at a

lower frequency. Curti and Kazinnik (2023) extend this line of research by quantifying facial expressions of the Fed chair during press conferences at the minute frequency. They also align financial data with the evolution of facial expressions. Asset prices fall as a response to an increase in the negativity index, which summarizes emotions such as anger, disgust, and fear. Ng (2024) also shows that facial expressions of Fed chairs matter for financial markets during the press conference on FOMC meeting days. Furthermore, he finds that the market's interpretation of the chair's facial expressions varies over time.[3]

Besides the post-meeting press conferences, the congressional testimonies of the Fed chair are another important opportunity to communicate monetary policy to the public. Alexopoulos et al. (2024) use a machine learning model to measure the high-frequency variation in the emotions conveyed through the chair's words, voice and face during the testimony. More positive emotions, whether expressed in the text, the voice, or the face of the chair, raise the valuation of stock prices. The Fed chair's answers to questions about monetary policy are particularly powerful drivers of the stock market.

In contrast to these papers, we also examine how emotions interact with the hawkishness expressed in the spoken word. We aim to determine whether emotions moderate or amplify the policy message delivered through the spoken word. Furthermore, we focus on the ECB rather than the Fed. The only paper analyzing emotions during the ECB press conference is Kanelis and Siklos (2023).[4] They adopt speech emotion recognition software and combine the analysis of vocal emotions with the language used by ECB President Draghi. In their regression model, they estimate the impact of emotions and the interaction between voice and textual sentiment on financial data at the

[3] Marchal (2021) measures the complexity of the discussions between the Fed chair and journalists during the post-meeting press conferences. He finds that a higher level of complexity is associated with a greater volatility on the U.S. equity market. In a novel measure of complexity, the eye aspect ratio, he measures how often and for how long the chair looks at documents to answer journalists' questions. Schonhardt-Bailey (2017) manually codes the nonverbal communication of policymakers in the U.K. testifying in parliament, among them the Governor of the Bank of England.

[4] Büchel et al. (2019) compare the emotions expressed in the written texts of statements by the ECB and the Fed, but not the facial or vocal expressions during the press conferences.

meeting frequency. Importantly, we go beyond their work by, first, studying not just vocal but also a rich set of facial emotions and, second, by estimating the interaction between facial expressions, voice, content, and asset prices at a high frequency. As a third step forward, we cover not just the tenure of Mario Draghi but also that of Christine Lagarde.

Besides these papers on the role of emotions in monetary policy communication, our work draws on the large body of work on the information content of ECB press conferences, such as Pavelkova (2022), Klejdysz and Lumsdaine (2023), Parle (2022), Baranowski et al. (2023), and Angino and Robitu (2023), many of which also apply natural language processing techniques. Similarly, related papers address the transcripts of the spoken word during the press conferences of the Fed chair and the market responses, such as Gu et al. (2018), Narain and Sangani (2023), and Gómez-Cram and Grotteria (2022).

Finally, this paper is related to the extensive research on the market impact of policy decisions on meeting days, including works like Gürkaynak et al. (2005, 2007), Brand et al. (2010), Altavilla et al. (2019), Jarociński and Karadi (2020), Swanson (2021), and others.

3 Data

This section introduces our main data set: the videotaped press conferences of the ECB president on days of policy meetings of the ECB's Governing Council. We also explain how we measure the facial and vocal expressions of the ECB president shown in the videos.

3.1 ECB Press Conferences

The Governing Council is the ECB's policy-making committee. It holds eight regular meetings per year to decide on euro area monetary policy. The number of regular meetings was reduced in 2015 from twelve to eight. At 14:15 CET, the ECB publishes a press release with the main policy decisions. Starting at 14:45 CET, the ECB president and the vice-president hold a

press conference.[5] These press conferences are the most important occasion for the ECB president to communicate monetary policy. This includes an explanation of the current decision, an assessment of the economic situation, and an outlook for the future policy path.

The structure of the press conference is as follows: first, the president reads a prepared statement, known as the introductory statement. Second, the president, and very rarely also the vice president, answer questions from journalists. Before the COVID-19 pandemic, all journalists were present at the ECB's premise in Frankfurt. During the pandemic, the ECB president was joining at the ECB, while journalists participated remotely. After the pandemic, the press conferences adopted a hybrid format, with most journalists who ask questions being present in Frankfurt.

Our dataset spans from May 3, 2012, to July 27, 2023, and comprises 100 press conferences. This sample is dictated by the public availability of video recordings. Throughout the paper, we exclude the press conference on April 5, 2015, which was interrupted by protesters. The video available of this press conference is edited, and the scene in which a protester jumps on the podium is no longer included. Our analysis relies on an accurate match between the exact real-time of the spoken word and the responses of financial markets. Since we cannot uncover the exact length of the sequence cut from the video, we cannot include it in our analysis. This is unfortunate because the scene with the protester probably exhibits more extreme facial expressions compared to the regular conduct of the press conference. We examine this press conference separately in the appendix.

We downloaded all videos from the ECB's official YouTube channel.[6] We also downloaded the transcripts of the full press conferences from the ECB's website.

[5] These times changed in July 2022 from 13:45 CET (press release) and 14:30 CET (press conference) to 14:15 CET (press release) and 14:45 CET (press conference).

[6] See https://www.youtube.com/user/ecbeuro.

3.2 Measuring Facial Expressions

To measure facial expressions, we rely on the SHORE software (Sophisticated High-speed Object Recognition Engine) developed by the Fraunhofer Institute for Integrated Circuits IIS in Erlangen, Germany (Küblbeck and Ernst, 2006; Ruf et al., 2011).[7] SHORE enables the identification of faces in videos and the analysis of their emotional states, including discrete emotions such as "neutral", "angry", "happy", "sad", "surprised", "frightened", and "disgusted", as well as valence (positive or negative). Each discrete emotion is assigned a probability between 0 and 100, and the probabilities across all discrete emotions sum to 100. Additionally, SHORE provides measures of positive and negative valence on a scale from 0 to 100. We rescale the values between 0 and 1 to ensure consistency with the measures from our audio and text analysis.

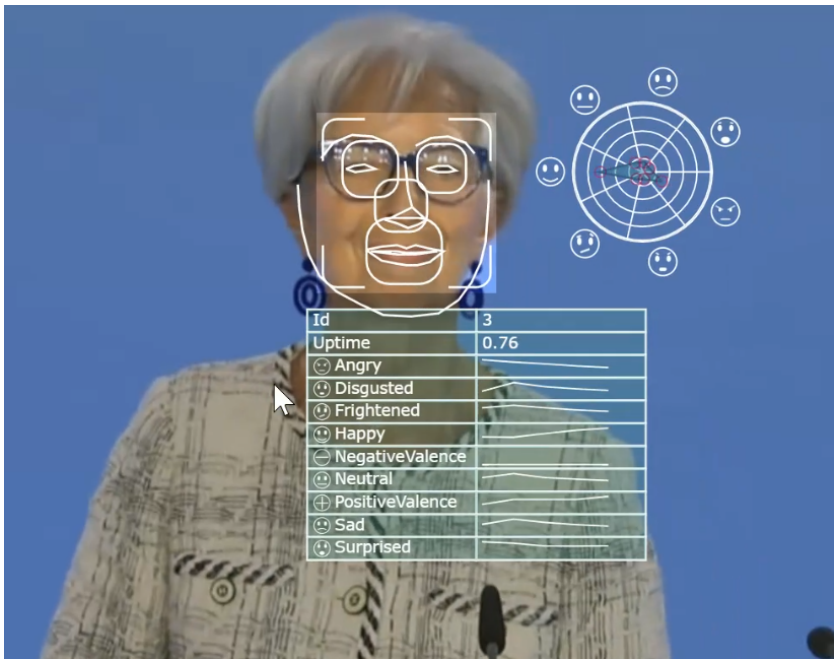
We analyze each press conference recording according to the respective frame rate of the video (i.e., 25 or 30 frames per second) and obtain probabilities for each discrete emotion present in frames where a single face is detected. Due to the software's unreliable ability to consistently recognize speakers, we perform the analysis without relying on this functionality. Figure (1) shows a screenshot of SHORE analyzing a frame during a press conference chaired by President Lagarde.

Throughout the paper, we aggregate all facial and vocal expressions, as well as the spoken text and the financial data, at a minute frequency. Nevertheless, it is useful to analyze the behavior of the average facial expressions across meetings. Hence, Figure (2) plots the six facial expressions (excluding the neutral expression) at the meeting frequency. As a reference series, we also plot the latest monthly year-on-year headline inflation rate measured by the Harmonized Index of Consumer Prices available on each meeting day.

We find strong fluctuations in facial expressions over time. All variables exhibit strong structural shifts coinciding with the transition from President Draghi to President Lagarde in November 2019. Sad expressions are much

[7] See https://www.iis.fraunhofer.de/en/ff/sse/affective-computing/facial-analysis-solutions.html.

Figure 1: Analyzing facial expressions using SHORE



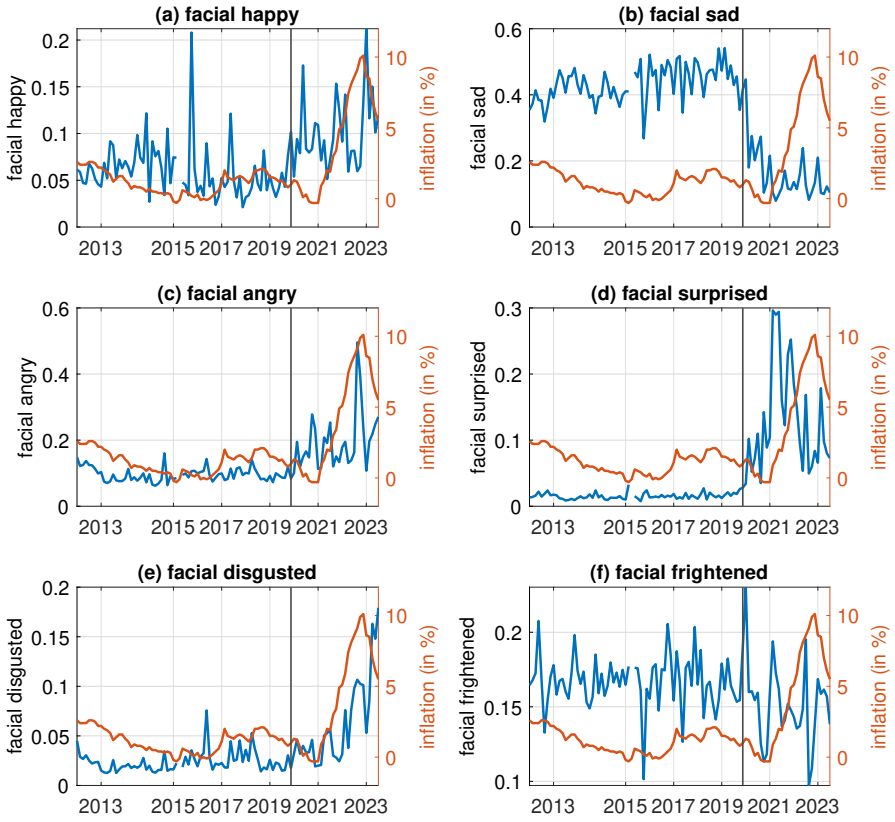
Notes: A selected frame from a press conference chaired by President Lagarde.

less pronounced under President Lagarde, while happy and angry expressions are much more pronounced. This underlines the importance of estimating the empirical model separately for the presidencies of Mario Draghi and Christine Lagarde to avoid problems with structural instability. The series of frightened expressions does not exhibit a clear trend break. Several facial expressions increase with the inflation rate after 2021 and also decline jointly with the inflation rate in 2023. We will explore this co-movement further below, when we assemble stylized facts on facial and vocal expressions.

3.3 Measuring Vocal Expressions

We apply a pre-trained and fine-tuned transformer model for the classification of vocal emotions. Specifically, we use the fine-tuned robust large `w2v2-L-robust-12` model (Wagner et al., 2023). We apply this model because it is relatively robust against background noise — which is an issue

Figure 2: Facial expressions at the meeting frequency



Notes: The graph shows the series of facial expressions aggregated at the meeting frequency. We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

for some of the ECB press conferences (Kanelis and Siklos, 2023) - when compared to a CNN baseline model. Additionally, the `w2v2-L-robust-12` model ensures group-based fairness, showing no performance difference between male and female speakers (Wagner et al., 2023). This is particularly important for our analysis because we analyze speakers of different genders, such as Mario Draghi and Christine Lagarde, as well as male and female journalists in the Q&A sessions. However, an issue remains regarding fairness at the speaker level, as the performance of predictions varies between different speakers. We therefore caution against the comparison of different speakers individually.

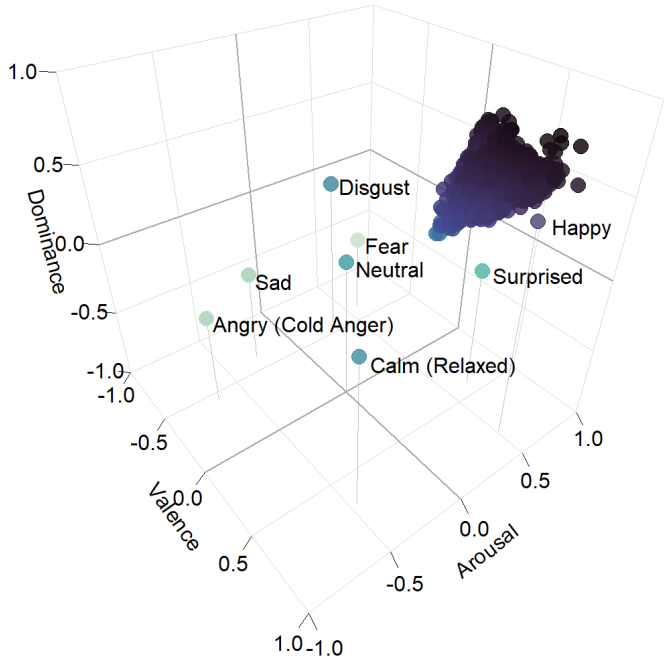
The fine-tuned `w2v2-L-robust-12` model classifies emotions using the Valence-Arousal-Dominance (VAD) framework (Russell and Mehrabian, 1977). This framework describes emotions along three independent dimensions: valence (the degree of pleasure or displeasure associated with an emotion, indicating how positive or negative an emotion is), arousal (the level of mental and physical engagement, indicating the intensity of the emotional state), and dominance (the degree of control over one's affective state in a situation). The VAD model, therefore, captures a wide variety of emotional states.

To classify each minute of each press conference, we extract the audio from each video, resample the audio stream at 16,000 Hz, and split the audio file into one-minute segments using the `FFmpeg` tool.[8] Subsequently, we apply the `w2v2-L-robust-12` model to each minute and extract the VAD values. Figure (3) maps the VAD scores for our dataset calculated with the `w2v2-L-robust-12` model into a VAD space. The VAD values for discrete emotions are from Russell and Mehrabian (1977). We find that the continuous emotion VAD classification is able to capture more nuanced emotions.

The valence, arousal, and dominance scores, averaging 0.54, 0.51 and 0.57, respectively, suggest an emotional state characterized by moderate to high control over the affective state. All three scores are limited to lie between -1 and 1. This indicates that the speakers are primarily experiencing emotions that are neutral to positive, with a moderate to high level of in-

[8]See `https://ffmpeg.org/`.

Figure 3: The spatial distribution of discrete emotions

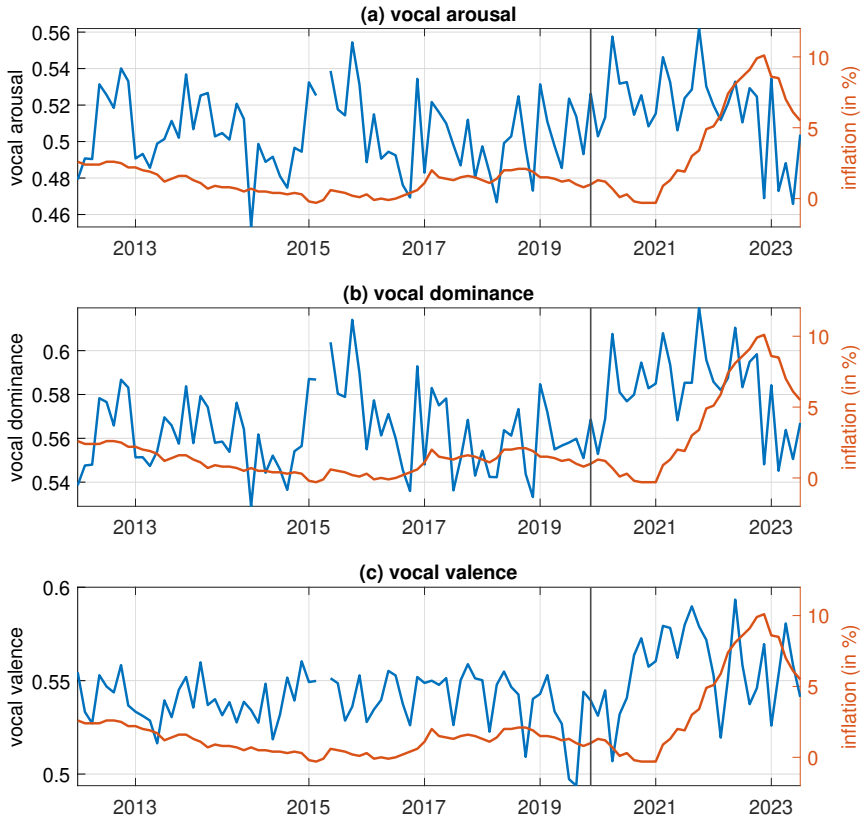


Notes: Each point represents an emotion in the VAD plane. The VAD values for discrete emotions are derived from Russell and Mehrabian (1977). Additionally, predicted VAD scores for our data derived from the `w2v2-L-robust-12` model are shown as a point cloud for each minute of the analyzed press-conferences.

tensity, where the speakers manage emotions effectively while maintaining a generally positive outlook. This observation aligns with our expectations, as the participants in the press conferences are professional speakers, including the president, vice president, and the journalists from mostly international outlets (Angino and Robitu, 2023).

Figure (4) shows the evolution of resulting vocal expressions at the meeting frequency, i.e. the average VAD scores. The scores remain stable over time, suggesting that the emotional states across different press conferences are relatively similar and consistent on average, which is expected given the

Figure 4: Vocal expressions at the meeting frequency



Notes: The graph shows the series of vocal expressions aggregated at the meeting frequency. We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

professional nature of the participants and the formal setting of the press conferences. In addition, the three series exhibit weaker signs of structural breaks coinciding with the appointment of Christine Lagarde compared to the series of facial expressions. All three series tend to increase during the COVID-19 pandemic and the post-pandemic period of high inflation. Overall, the movements in vocal expressions appear moderate compared to the strong fluctuations in facial expressions.

3.4 Transcription of the Press Conferences

For our purposes, the published transcripts of the press conference are not sufficient. We need to transcribe the videos ourselves in order to align the spoken word with each minute of the facial and vocal analysis and to capture content not included in the official transcript released by the ECB. For the transcription, we use an extension for the `Whisper` Python package.[9] This package enables the creation of timestamps at both the word and sentence levels. It utilizes the Silero Voice Activity Detector (VAD) method[10], Dynamic Time Warping Giorgino (2009), and the Whisper models Radford et al. (2022).[11]

We use the Whisper base model for transcription and assess the quality through a combination of sample-wise manual inspection and a `doc2vec` model (Le and Mikolov, 2014), which compares the similarity between the Whisper transcription and the official transcripts available on the ECB website. The resulting similarity scores are consistently close to one for each press conference, indicating that the semantic content is nearly identical.

[9] See https://github.com/linto-ai/whisper-timestamped.

[10] See https://github.com/snakers4/silero-vad.

[11] The press conference held on June 8, 2017, in Tallinn poses a challenge due to excessive background noise, which led to Whisper generating inaccurate transcriptions or hallucinations. This issue was mitigated by applying noise reduction using `Audacity`, see https://www.audacityteam.org/.

3.5 Introductory Statement vs Q&A Part

We identify the transition between the introductory statement and the Q&A session in press conference transcripts. For this purpose, we use key transition sentences from the official transcript to separate the Q&A session from the introductory statement part of the respective press conferences. Afterwards, we generate sentence embeddings for both the official transcript and the Whisper transcription using the sentence-embedding, (`SBERT`) package (Reimers and Gurevych, 2019) allowing for the comparison of semantic content between the two.

The classification process is conducted by taking the first five sentences from the Q&A section of the official transcript and calculating their cosine similarity with the Whisper-transcribed sentences. When the cosine similarity between the two sets of sentences first exceeds 0.8, this point is marked as the start of the Q&A session of the respective press conference, with all subsequent sentences categorized accordingly.[12] Finally, each minute of the press conference is classified as either the introductory statement or the Q&A session based on the previous sentence classification. If at least half of the sentences in a minute are identified as part of the introductory statement, the entire minute is classified accordingly. This binary classification allows us to distinguish the introductory statement from the Q&A part in the data.

3.6 Quantifying the Spoken Word

In addition to analyzing facial and vocal expressions, we need to quantify the actual content of the spoken word within each minute. We conduct this quantification based on the sentence-level `Whisper` transcription. Specifically, we use an improved version of `BERT-CBSI` (Niţoi et al., 2023). This is our preferred model as it uses hawkish, dovish, and neutral labels. In contrast, alternative models like `FinBERT`, which also includes a neutral label, or `CentralBankRoBERTa`, classify text sequences as positive or negative, which is difficult to interpret in the context of central banking.

[12] A few press conferences require manual post-processing, in particular when the introductory statement appears excessively long upon review.

`BERT-CBSI` is an improved replication of the `BERT-CBSI` model trained by Niţoi et al. (2023). While the authors provide the replication dataset (Mihai et al., 2023), they do not share their fine-tuned model. Therefore, we fine-tune `bert-large-uncased` on the replication dataset, which consists of 1,998 manually labeled sentences from central bank minutes: 651 dovish sentences, 660 neutral sentences, and 687 hawkish sentences.

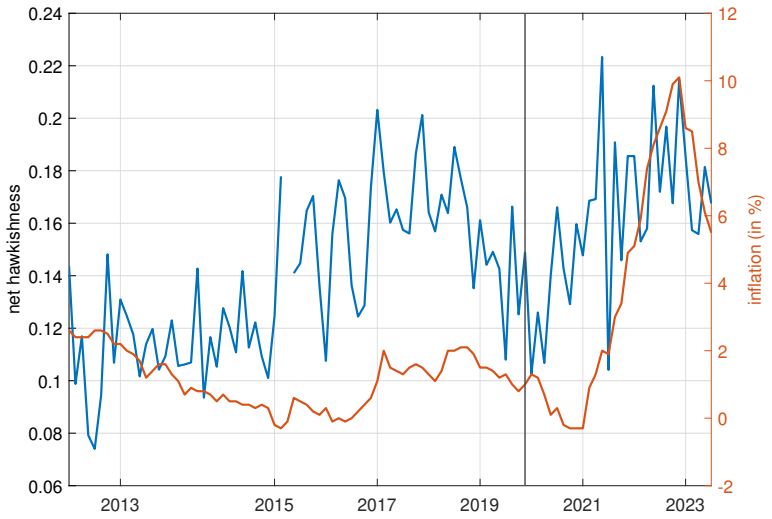
Given the relatively small size of the dataset, we aim to further improve the model by leveraging the findings of Zhang et al. (2021) and Mosbach et al. (2021). We test various pre-trained models to determine which performs best on the dataset, including `distilbert/distilroberta-base`, `bert-base-uncased`, `bert-large-uncased`, `roberta-base`, `roberta-large`, and `yiyanghkust/finbert-tone`. Consistent with Niţoi et al. (2023), we find `bert-large-uncased` to perform best. We then conduct a grid search to optimize the hyperparameters, including the learning rate, the number of epochs and re-initialized layers.[13]

We assign each classified sentence that concludes within a specific minute to that corresponding minute. We do not use the start of a sentence for this assignment because the timestamps for these were often inaccurate at the beginning of the press conferences, when no spoken word had yet been recorded. For each minute and label, we calculate the mean probability. Then, for each minute, we compute the net hawkishness as the probability of the dovish label minus the probability of the hawkish label.

Figure (5) shows the series of net hawkishness at the meeting frequency. We spot a close co-movement with inflation, both during the recovery of inflation in 2017 and the episode of high inflation post-pandemic. Below, we study the co-movement between hawkishness and inflation at the low frequency more formally. In the appendix, we show that our measure of net hawkishness tracks the KOF Monetary Policy Communicator index very well and is also highly correlated with the cumulative surprises in the press

[13]We use an unbiased `AdamW` optimizer with a weight decay of 0.1 and a learning rate decay with warm-up steps. As inNiţoi et al. (2023), we use 10% of the replication dataset as a validation set. The final model is fine-tuned over seven epochs with a learning rate of 2×10^{-5}, and the first three layers were reinitialized. The resulting metrics were a loss of 0.34, an F1 score of 0.92, and an accuracy of 0.92.

Figure 5: Net hawkishness at the meeting frequency



Notes: The graph shows the series of net hawkishness at the meeting frequency. We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

conference window from the Altavilla et al. (2019) database.

4 Facial and Vocal Emotions: Stylized Facts

We now aim to understand the behavior of facial and vocal emotions, both at the meeting frequency and the minute frequency. For the remainder of the paper, we focus on the three facial expressions: happy, sad and angry, as well as the level of vocal arousal. These three facial expressions can be most clearly interpreted as positive (happy) or negative (sad, angry). This follows Curti and Kazinnik (2023), who summarize individual emotions in indicators of negativity or positivity. In addition, these dimensions exhibit the largest variation of all facial emotions over all press conferences. In Table (1), we present summary statistics for the key variables at the minute frequency.

Table 1: Summary statistics

	hawkish	facial			vocal
		happy	sad	angry	arousal
	(a) Introductory Statement: Draghi				
mean	0.084	0.017	0.622	0.046	0.535
median	0.099	0.009	0.636	0.038	0.536
std. dev.	0.290	0.025	0.073	0.026	0.042
max	0.788	0.227	0.770	0.263	0.782
min	-0.999	0.001	0.145	0.019	0.397
	(b) Introductory Statement: Lagarde				
mean	0.095	0.101	0.156	0.172	0.477
median	0.095	0.081	0.107	0.141	0.473
std. dev.	0.294	0.070	0.129	0.114	0.039
max	0.995	0.414	0.675	0.617	0.753
min	-0.999	0.002	0.027	0.032	0.393
	(c) Q&A part: Draghi				
mean	0.018	0.072	0.379	0.110	0.495
median	0.003	0.052	0.373	0.095	0.497
std. dev.	0.149	0.062	0.113	0.060	0.054
max	0.740	0.560	0.719	0.589	0.780
min	-0.713	0.003	0.027	0.026	0.238
	(d) Q&A part: Lagarde				
mean	0.044	0.101	0.176	0.195	0.533
median	0.012	0.088	0.146	0.171	0.528
std. dev.	0.155	0.059	0.106	0.107	0.057
max	0.993	0.428	0.710	0.679	0.795
min	-0.749	0.003	0.028	0.031	0.357

Notes: The table reports summary statistics based on the series at the minute frequency.

4.1 Emotions and Inflation

In Figures (2) and (4), we visually observe the co-movement of facial and vocal expressions at the meeting frequency with the rate of inflation. Several of our variables appear to closely co-move with inflation. We now concentrate on the three selected facial expressions and the degree of vocal arousal and investigate the correlation with inflation more formally. In a simple regression

model, we regress each facial or vocal emotion either on the level of headline inflation or on the absolute deviation of headline inflation from the ECB's 2% inflation target. In addition, we include a step dummy that is one during the presidency of Christine Lagarde and zero before.[14] The inflation rate is the last available realized year-on-year percentage change of the harmonized index of consumer prices before each meeting day.

Table 2: Emotions and inflation

	facial expression			vocal
	happy	sad	angry	arousal
		(a) inflation level		
inflation	0.001	−0.008	0.009	−0.002
	(0.002)	(0.005*)	(0.004**)	(0.001*)
Lagarde	0.039	−0.242	0.069	0.019
	(0.006***)	(0.036***)	(0.014***)	(0.005***)
R^2	0.25	0.78	0.50	0.12
# obs.	100	100	100	100
	(b) absolute inflation deviation from target			
|inflation − 2%|	0.004	−0.011	0.013	−0.003
	(0.003)	(0.008)	(0.006**)	(0.001*)
Lagarde	0.033	−0.240	0.066	0.020
	(0.007***)	(0.042***)	(0.014***)	(0.005***)
R^2	0.30	0.78	0.50	0.12
# obs.	100	100	100	100

Notes: The table reports the coefficients from a regression of the dependent variable at the meeting frequency on the most recent rate of headline inflation available on the meeting day and a binary dummy indicating the presidency of Christine Lagarde. A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table (2) reports the estimated coefficients. The level of inflation is closely associated with an angry facial expression, but also with a lower level of sad expressions and a lower vocal arousal. A deviation of inflation from the ECB's inflation target, wether positive or negative, strongly increases the

[14] As President Lagarde took office just three months before the COVID-19 pandemic, this dummy might also reflect structural breaks due to the pandemic.

angry expression, while the other two facial expressions do not respond. As expected from the figures discussed earlier, we find that the Lagarde dummy enters with highly statistically significant coefficients, supporting the notion of a structural break in the behavior of facial and vocal expressions. In fact, averages of facial expressions over the press conferences (which last around 70 minutes) wash out a lot of the interesting dynamics of emotions at a high frequency. Therefore, we now turn to the behavior of the variables at the minute frequency during two selected press conferences.

4.2 Emotions During Two Selected Press Conferences

To highlight the behavior of our key variables at a high frequency, in our case minute-by-minute, we show the variables over two selected press conferences. Each of the two press conferences occurred following important decisions by the Governing Council. The first meeting day took place on January 22, 2015. The Governing Council decided to expand the asset purchase program in order to prevent inflation from falling further. This is a major step as the ECB fully endorsed Large Scale Asset Purchases as a monetary policy instrument. At the same time, this decision was widely anticipated. ECB officials had been communicating this instrument for months, at least since the summer of 2014. Hence, the decision should not be considered a major dovish surprise.

The second press conference we examine occurred on the meeting day of July 21, 2022. On this day, the Governing Council decided to raise key ECB interest rates for the first time after many years with interest rates at or below zero. In fact, the ECB returned to conventional, i.e., interest rate-based monetary policy, to fight the strong surge in inflation in the euro area. Again, this step was widely anticipated.

Figure (6) shows the minute-by-minute comparison over the two press conferences. The level of net hawkishness is indeed higher during the press conference in July 2022 than in January 2015. However, this is visible during the introductory statement only. In the Q&A part, net hawkishness hardly differs between the events. When comparing the levels of the facial and vocal

expressions across the two events, we should not forget that the president is different. To the extent that President Draghi and President Lagarde differ in their use of vocal and facial expressions, whether willingly or unwillingly, the levels of the variables will be different. Thus, we should concentrate on the evolution of the variables over time rather than the cross-sectional comparison.

A striking difference between the two parts of the press conferences pertains to volatility: net hawkishness is much more volatile during the introductory statement, while the series of vocal arousal and facial expressions are much more volatile during the Q&A part than the introductory statement. Sad, happy, and angry expressions remain remarkably stable during the introductory statement. This certainly reflects the fact that the introductory statement is much more formatted as the president reads a prepared statement. This leaves less room for vocal and facial expressions. Below, we test whether this also means that vocal and facial emotions during the press conference are particularly informative to market participants.

4.3 Emotions and a Communication Misstep: March 2020

The press conference following the Governing Council meeting on March 12, 2020, took place against the backdrop of the COVID-19 pandemic, with almost all countries entering lockdowns the week after. As a result of the anticipated fiscal burden of the pandemic, some European debt markets, most notably Italy, came under pressure. During the Q&A part of the press conference, President Lagarde said

Figure 6: Comparing two selected press conferences

Notes: The figure shows the evolution of the key variables over at the minute frequency for the two selected press conferences. The vertical line indicates the end of the introductory statement.

12.03.2020

Transcript: "My point number two has to do with more debt issuance coming down the road depending on the fiscal expansion that will be determined by policymakers. Well, we will be there, as I said earlier on, using full flexibility, but we are not here to close spreads. This is not the function or the mission of the ECB. There are other tools for that, and there are other actors to actually deal with those issues."

The ECB quickly considered this surprisingly rigorous statement a mistake.[15] Later that day, Lagarde apologized for the misguided communication.[16] In a rare revision of the transcript, a footnote was added reading:

12.03.2020

Footnote to transcript: "[Statement in CNBC interview after press conference:] I am fully committed to avoid any fragmentation in a difficult moment for the euro area. High spreads due to the coronavirus impair the transmission of monetary policy. We will use the flexibility embedded in the asset purchase programme, including within the public sector purchase programme. The package approved today can be used flexibly to avoid dislocations in bond markets, and we are ready to use the necessary determination and strength."

Figure (7) sheds light on the immediate market response to the original statement and the facial expressions accompanying it. The graphs show the evolution of each time series in a window of three minutes before to three minutes after the statement. In the minute of the statement, the spread between Italian and German government bond yields increases by more than 10bp. With a net hawkishness score of about 0.10, President Lagarde's words are not classified as particularly hawkish, at least not when compared to the full sample.

[15] See the transcript at https://www.ecb.europa.eu/press/press_conference/monetary-policy-statement/2020/html/ecb.is200312~f857a21b6c.en.html.

[16] See https://www.ft.com/content/ce39716e-66c0-11ea-a3c9-1fe6fedcca75.

At the same time, her vocal arousal reached values slightly above the sample mean and median, respectively. The arousal falls only one minute after the statement. The level of sad and angry emotions is also relatively high in minute 0. Overall, this episodes suggests that strong market movements appear to coincide with elevated levels of arousal, while the relationship with the other facial expressions is more mixed. We will therefore evaluate the connection between financial market responses, vocal arousal, and emotions more formally in the next section.

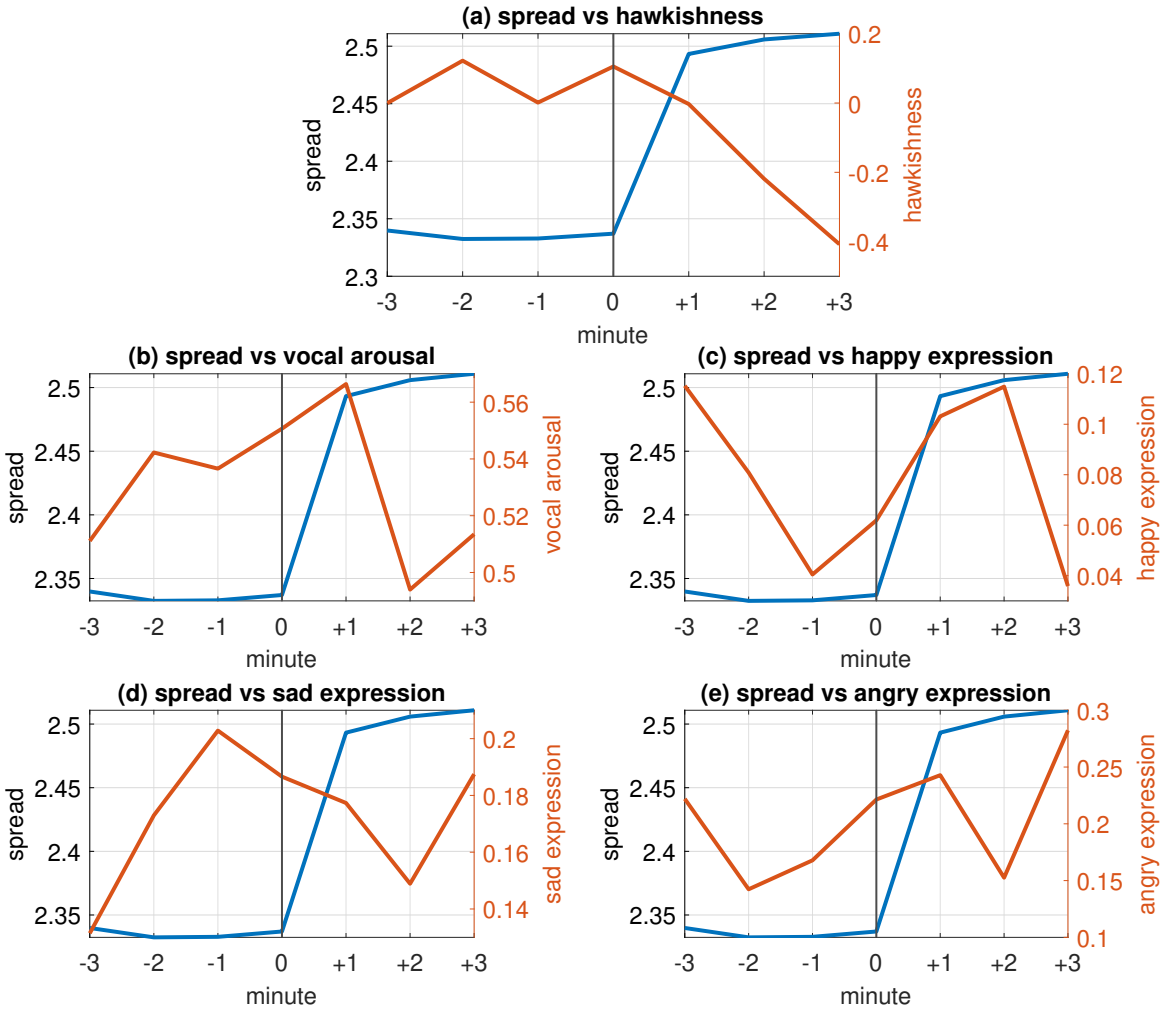
5 Hawkishness and Emotions

Are facial expressions and vocal arousal systematically related to the degree of (net) hawkishness expressed in the spoken words? To investigate these connections, we regress each facial and vocal expression at the minute frequency on the degree of hawkishness, allowing for meeting fixed effects. We run these regressions separately for the introductory statement and the Q&A part, and separately for President Draghi and President Lagarde.

Table (3) reports the estimated coefficients. For the introductory statement, these simple regressions uncover a causal effect. This is because we can exclude any feedback from the facial and vocal expressions to the text of the introductory statement, which is prepared before the press conference and just read by the president. A more hawkish statement causes a significantly less happy but more sad facial expression of President Draghi. In addition, a more hawkish statement causes a higher level of vocal arousal. Under President Lagarde, we do not detect any systematic relationship between hawkishness and facial expressions.

During the Q&A part, a more hawkish statement of President Draghi is also associated with a more sad and less angry expression, as well as a higher level of vocal arousal. In contrast to the introductory statement, we cannot rule out that the level of emotions drives the degree of hawkishness, as the ECB president does not follow a written script. Thus, we should interpret these estimates as reflecting correlations only. A hawkish statement by President Lagarde is associated with a less sad facial expression; the

Figure 7: Variables in a tight window around President Lagarde's "we are not here to close spreads"-statement in March 2020



Notes: The graph shows the variables in a window of three minutes before to three minutes after President Lagarde's "we are not here to close spreads"-statement, which is normalized to happen in minute 0. Each graph also shows the spread between Italian and German 10-year bond yields (in percentage points).

remaining coefficients are not statistically significant.

Table 3: Hawkishness and emotions

	dependent variable			
	facial			vocal
	happy	sad	angry	arousal
	(a) Introductory Statement: Draghi			
hawkish	−0.005 (0.002**)	0.015 (0.005***)	−0.003 (0.002)	0.021 (0.003***)
FE	yes	yes	yes	yes
# obs	887	887	887	887
	(b) Introductory Statement: Lagarde			
hawkish	0.002 (0.005)	−0.007 (0.005)	−0.010 (0.008)	0.005 (0.004)
FE	yes	yes	yes	yes
# obs	495	495	495	495
	(c) Q&A: Draghi			
hawkish	−0.002 (0.006)	0.025 (0.012**)	−0.014 (0.007**)	0.021 (0.006***)
FE	yes	yes	yes	yes
# obs	3164	3164	3164	3165
	(d) Q&A: Lagarde			
hawkish	−0.003 (0.0009)	−0.028 (0.011**)	0.012 (0.013)	−0.003 (0.0007)
FE	yes	yes	yes	yes
# obs	1258	1258	1258	1259

Notes: The table reports the coefficients from a regression of the dependent variable on the degree of (net) hawkishness at the minute frequency. A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 4: Hawkishness (squared) and emotions

	dependent variable			
	facial			vocal
	happy	sad	angry	arousal
	(a) Introductory Statement: Draghi			
$(\text{hawkish})^2$	−0.016 (0.004***)	0.037 (0.011***)	−0.002 (0.004)	0.026 (0.008***)
FE	yes	yes	yes	yes
# obs	887	887	887	887
	(b) Introductory Statement: Lagarde			
$(\text{hawkish})^2$	−0.010 (0.010)	0.013 (0.010)	−0.035 (0.016**)	−0.019 (0.008**)
FE	yes	yes	yes	yes
# obs	495	495	495	495
	(c) Q&A: Draghi			
$(\text{hawkish})^2$	−0.070 (0.021***)	0.127 (0.038***)	−0.078 (0.022***)	−0.007 (0.020)
FE	yes	yes	yes	yes
# obs	3164	3164	3164	3165
	(d) Q&A: Lagarde			
$(\text{hawkish})^2$	−0.045 (0.026*)	0.025 (0.033)	−0.050 (0.036)	−0.030 (0.020)
FE	yes	yes	yes	yes
# obs	1258	1258	1258	1259

Notes: The table reports the coefficients from a regression of the dependent variable on the squared degree of (net) hawkishness at the minute frequency. A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

These regressions can only reflect a linear connection. It is possible that both a very hawkish statement and a very dovish statement are associated with high levels of vocal arousal. In other words, the connection between hawkishness and expressions could be nonlinear. It is conceivable that intermediate levels of hawkishness are not associated with specific expressions, but more extreme realizations of hawkishness are. To uncover such a non-

linear connection, we re-estimate the regressions but use the squared level of hawkishness as our explanatory variable. The results are presented in Table (4). The results do not change much compared to the linear regression model. Again, we find a much closer connection between the degree of hawkishness and the four expressions for President Draghi than for President Lagarde. Under Draghi, statements expressing a very dovish or very hawkish policy stance are associated with a less happy and more sad facial expression and, during the introductory statement, are presented with a significantly higher level of vocal arousal.

6 The Market Impact of Emotions

We aim to evaluate whether the facial and vocal expressions identified in the previous sections are relevant to financial market prices during the press conference.

6.1 Model

Our empirical model has the following general structure: we regress the yield or the log price of asset i in minute t, y_t^i, on meeting fixed effects, μ_m, the semantic content of the words spoken, $hawkish_t$, a vector of facial expressions $facial_t$, the degree of vocal arousal, $arousal_t$; and the interaction between the content and the facial expressions and the vocal arousal,

$$\begin{aligned} y_t^i &= c + \mu_m + \beta_1 hawkish_t + \delta_1 facial_t + \delta_2 arousal_t \\ &\quad + \gamma_1 \left(hawkish_t \times facial_t\right) + \gamma_2 \left(hawkish_t \times arousal_t\right) + e_t^i. \end{aligned} \tag{1}$$

In this model, $hawkish_t$ refers to the index of net hawkishness at minute t introduced previously. Our vector of facial expressions includes the series of happy, sad, and angry expressions. Importantly, we estimate this model separately for the presidencies of Mario Draghi and Christine Lagarde in order to avoid structural breaks in the series of facial expressions and vocal arousal due to the change in the presidency. Furthermore, we estimate this regression

model separately for the introductory statement, the Q&A part and the full press conference to shed light on differences in the relationship between emotions, the degree of hawkishness, and the financial market responses. The fixed effects account for the macroeconomic environment, particularly the inflation rate, as well as the monetary policy decision taken by the Governing Council on each meeting day.

We include the following financial variables, all measured minute-by-minute: the yields on 10-year German, French, Italian, and Spanish government bonds, the log of the 10-year German bund future, the log of the Euro Stoxx 50 stock market index and the log of the dollar-euro exchange rate. The interest rates are measured in percentage points. All logs are multiplied by 100 to interpret the responses in terms of percent. The data definitions, sources, and transformations are explained in the appendix.

6.2 Results Without Interaction Terms

Table (5) reports the estimated coefficients for the introductory statements and the plain model without interaction terms. It is imperative to keep in mind that markets should respond only to unexpected levels of hawkishness, as the expected policy stance is already incorporated into asset prices. The same applies to facial and vocal expression: to the extent markets expect an angry or happy president, we should not see a market reaction. Put differently, a significant response suggests that market participants did not anticipate the specific wording or emotions, respectively.

Under President Draghi, see panel (a), the degree of hawkishness is insignificant. This is a surprising result, which we will revisit below. One potential explanation is that the hawkishness remains insignificant on average but becomes statistically significant when interacted with specific facial or vocal expressions. Among the facial expressions, the estimates on the happy expression stands out: a happier facial expression has an easing effect, thus reducing long-term interest rates, causing an increase in the bund future and a depreciation of the euro. In contrast, a higher level of vocal arousal is restrictive: bond yields of Germany and France increase, while the bund

future and stock prices fall as a result. Consistently, the euro appreciates against the dollar.

Under President Lagarde, see panel (b), the degree of hawkishness is a significant driver of asset prices. A higher level of hawkishness raises bond yields and lowers the bund future as well as the stock market index. These responses are in line with the large literature on the high-frequency impact of central bank communication. The effect of hawkishness is stronger for riskier bonds, e.g. the estimated coefficient is 0.003 for German yields, 0.005 for French yields, and 0.007 for Italian yields. A happy facial expression again coincides with lower bond yields for Germany, France, and Spain, as well as a higher bund future, higher stock prices, and a depreciation of the euro. Hence, a happy expression has expansionary effects. Overall, facial expressions play a larger role under President Lagarde than under Draghi, while vocal arousal matters more for market reactions during press conferences led by President Draghi.

Table (6) lists the coefficients for the Q&A part of the press conference, again separately for the two ECB presidents in our sample. For both presidents, the degree of hawkishness of their spoken words does not drive market responses. Financial markets perceive a sad expression of President Draghi as expansionary: yields fall, the bund future and stock prices increase, and the euro depreciates. For President Lagarde, we hardly find any significant coefficient. It seems that markets are much more sensitive to facial and vocal expressions during the introductory statement. This is a surprising finding, as the communication during the introductory statement is much more formal, with the president reading a prepared statement than during the Q&A part. Apparently, it is exactly this strict format that makes facial expressions even more informative.

The results for the full press conference, reported in Table (7), are a combination of the results for the introductory statement and the Q&A part, respectively. Surprisingly, for some assets, both happy and sad expressions have the same effect. For example, French bond yields fall and the euro depreciates if President Draghi's face exhibits either sentiment. For German bond yields, a happy face has an easing effect, while sad expressions do not

enter the equation with a significant coefficient. If the voice of President Draghi is aroused, financial markets tighten.

A happy face of President Lagarde during the full press conference also significantly lowers German 10-year yields, raises the Bund future and prompts a depreciation of the euro vis-a-vis the dollar. In contrast to President Draghi, the extent of vocal arousal does not matter for asset prices.

6.3 Results with Interaction Terms

We now turn to the full model that allows for an interaction between the degree of net hawkishness, the degree of vocal arousal, and the three facial expressions, as specified in equation (2). Panel (a) of Table (8) reports the estimated coefficients for the introductory statements of President Draghi. The degree of hawkishness of the spoken words does not enter significantly, which is consistent with the results shown earlier for Draghi. Strikingly, hawkishness has the expected sign only when interacted with the extent of happy facial expressions. The effect is highly statistically significant for each of the seven financial variables. Hence, a hawkish statement causes an increase in bond yields, a fall in stock prices, and a nominal appreciation only if Draghi's face exhibits some degree of happiness. It seems that Draghi "kills with kindness" - his words have the intended effect if spoken with a happy face. This interaction effect is twice as large for Italian yields compared to safe German yields. The remaining interaction terms do not enter with significant coefficients.

Under President Lagarde, see Panel (b), the only interaction effect that is significant is the one between hawkishness and the degree of angry expressions on her face. An angry expression while making a hawkish statements causes higher bond yields. Again, the coefficient on this interaction term is higher for Italian and Spanish bonds than for safe German bonds.

Table (9) shows the interacted model for the Q&A part of the press conferences. A sad expression of President Draghi has expansionary effects as bond yields fall. The interaction terms remain insignificant. In particular, the magnifying effect of a happy facial expression on a hawkish statement,

which we find for President Draghi's introductory statements, is absent from the Q&A part. For President Lagarde, high emotions - whether happy, sad or angry - diminish the impact of a hawkish statement on German yields.

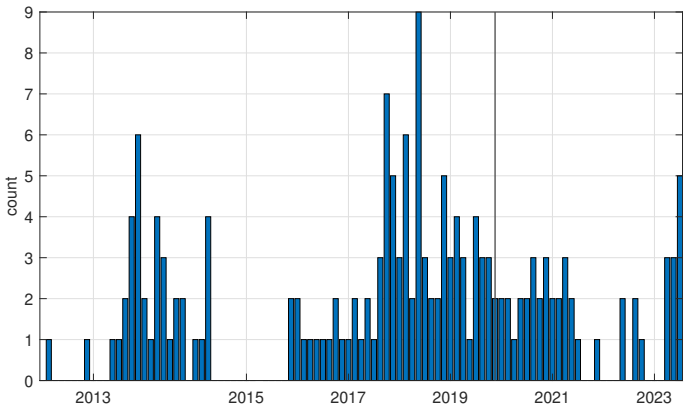
The coefficients for the full press conference are shown in Table (10). For President Draghi, less happy and less sad expressions raise bond yields. Vocal arousal is again positively related to bond yields and stock prices and negatively to the Bund future. The most notable interaction is between the level of hawkishness and the level of vocal arousal. Making a hawkish statement with a more aroused voice is associated with higher interest rates on Italian and Spanish bonds and a lower stock market index. For President Lagarde, the consistently significant interaction term is between hawkishness and the president's angry expression. More anger on her face magnifies the hawkish impact on bond yields and the Bund future.

6.4 Do Facial Expressions Support Forward Guidance?

When interest rates hit the Effective Lower Bound (ELB), the ECB adopted forward guidance as an unconventional policy tool to implement further easing of monetary conditions. To be effective, guidance on future interest rates requires clear and consistent communication. Given the central role of forward guidance in the ECB's toolkit over the past decade, we should expect that the ECB presidents carefully craft any statement of forward guidance during the press conferences to send a clear and unambiguous message.

We now investigate whether the interaction between the spoken word and the facial and vocal expressions is particularly pronounced for statements about forward guidance. European Central Bank (2022) provides a list of the key phrases and expressions used by ECB officials to communicate forward guidance. These cover both time-based and state-based guidance about future interest rates. The ECB president typically uses phrases such as "for an extended period of time" or "well past the horizon of our net asset purchases" to guide markets. We run a search for all these expressions listed in European Central Bank (2022) across our text corpus at the minute frequency. This results in 170 hits, i.e., 170 minutes include a refer-

Figure 8: Number of forward guidance statements per press conference



Notes: The graph shows the number of forward guidance statements in each press conference. We count the statements listed in European Central Bank (2022). We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

ence to forward guidance. Figure (8) shows the number of forward guidance statements for each press conference. We clearly see the adoption of forward guidance in 2013 and its intensive use in 2017 and 2018. The overwhelming majority of these statements are made during the president's introductory statement. We construct a dummy variable that is one for each minute with a forward guidance statement and zero otherwise and include this dummy in our regression, both in isolation and interacted with the facial and vocal expressions.

The results in Table (11) support the notion that the communication of forward guidance is indeed different from the rest of the communication during the press conference. Under the presidency of Mario Draghi, when forward guidance was introduced, markets respond to forward guidance even after controlling for the degree of hawkishness. Bond yields fall and the Bund future rises as a result of a forward guidance statement. Interestingly, the response is smallest for the yield on safe German bonds and twice as large for yields on riskier Italian and Spanish bonds. The interaction between forward

guidance and the facial expressions is significant for most assets. Delivering a forward guidance statement with a happy facial expressions amplifies the market impact as bond yields fall even more. In contrast, delivering forward guidance with an angry facial expression weakens the market response, as does a sad facial expression. Thus, the ECB president could enhance the effectiveness of forward guidance by positive facial expressions.

Under President Lagarde, we do not find a significant impact of forward guidance statements after controlling for the degree of hawkishness. This is not surprising, as most forward guidance was used under the tenure of Mario Draghi. We also do not find a significant interaction between forward guidance and President Lagarde's facial expressions.

7 Robustness

In this section, we address two additional aspects in order to support the robustness of our findings. First, we account for the fact that the facial expressions computed at the minute frequency, which we assign to the ECB president, could be compromised by the other people's faces being shown on camera. In particular, during the Q&A part, the camera typically also shows the journalist asking questions. Although the questions asked are typically short relative to the answers given by the president, we cannot exclude that within a minute, the camera mostly captures faces other than the president's.

We select only those minutes in which the camera shows the face of the ECB president for more than 30 seconds.[17] These 30 seconds do not necessarily appear en bloc but could be spread throughout the minute. We estimate our baseline model for these minutes only. Tables (12) and (13) show the coefficients for the introductory statement and the Q&A part, respectively. Overall, we do not find important qualitative difference when comparing the results to Tables (8) and (9).

Second, we study the effect of press conferences during the pandemic, where the ECB president was at the ECB's premises but all journalists joined

[17] In the online appendix, we provide a detailed account of the facial recognition procedure, including accuracy checks.

digitally. This applies to the press conferences from April 2020 to September 2021. Since then, journalists routinely join online as the press conference has switched to a hybrid format. However, after the pandemic, most journalists who ask questions are again physically present at the ECB.

Speaking to a camera only might lead to a different nature of expressions on the president's face. If any, this effect should be stronger for the Q&A part, where the usual interaction with the audience is limited, than for the introductory statement, which involves only limited interaction even during the pre-pandemic press conferences held offline in Frankfurt. We address this point by excluding the aforementioned digital press conferences from our baseline regression model. Obviously, we estimate this specification only for the introductory statement and the Q&A part under President Lagarde. Table (14) reports the results, which remain broadly unchanged when compared to panels (b) of Tables (8) and (9). During the introductory statement, a hawkish statement raises yields if it coincides with an angry facial expression from President Lagarde. Hence, excluding the press conferences held digitally does not change our results.

8 Conclusions

We studied the facial and vocal emotions of the ECB presidents during the post-meeting press conferences at a high frequency. Using a battery of state-of-the-art facial and vocal recognition models, as well as machine learning models, we obtained time series of facial expressions, vocal arousal, and hawkishness of the spoken word at the minute frequency. We obtain three main findings. First, the nature and intensity of emotions differ between President Draghi and President Lagarde, as well as between the introductory statement and the Q&A part of the press conferences. Second, facial expressions are correlated with inflation; the level of angry emotions increases with the absolute deviation of inflation from the ECB's inflation target. Third, facial expressions and vocal arousal can moderate or amplify a hawkish policy message. In particular, emotions can support forward guidance statements made by the ECB president.

These findings offer lessons for the interpretation of ECB communication. It should pay off to monitor not just the language the president chooses, but also the emotions that accompany this language. To the extent that recent advances in technology will allow for the study of facial expressions in more detail and in real time, ECB officials will be able to optimize their communication style.

Moreover, the transition to digital and hybrid press conferences, particularly during the pandemic, requires continuous attention and adaptation. As digital interactions on social media and post-conference explainers increase, grasping the emotional nuances of communication becomes increasingly crucial. A deeper understanding of non-verbal communication cues and emotional undertones can lead to more accurate market forecasts and potentially stabilize financial markets. The dynamics of interpersonal interactions, such as the absence or presence of a physical audience, can greatly influence the expressions of emotions. With that in mind, training and preparation of ECB and central bank officials should focus on emotional awareness and management. By intentionally conveying emotions, whether in form of facial expressions or vocal tone, officials can improve the clarity and effectiveness of policy communication to diverse audiences. Thus, in an ever-evolving digital landscape, it is essential to strategically incorporate non-verbal communication efforts and their effects into central bank communication strategies.

References

Alexopoulos, M., Han, X., Kryvtsov, O. and Zhang, X. (2024). More than word: Fed chair's communication during congressional testimonies, Journal of Monetary Economics **142**: 103515.

Altavilla, C., Brugnolini, R. S., Gürkaynak, R., Motto, R. and Ragusa, G. (2019). Measuring euro area monetary policy, Journal of Monetary Economics **108**: 162–179.

Angino, S. and Robitu, R. (2023). One question at a time! A text mining analysis of the ECB Q&A session, No. 2852, ECB Working Paper.

Ash, E., Mikosch, H., Perakis, A. and Sarferaz, S. (2024). Seeing and hearing is believing: the role of audiovisual communication in shaping inflation expectations, unpublished, ETH Zurich.

Baerg, N. and Binder, C. (2024). Automated Detection of Emotion in Central Bank Communication: A Warning, unpublished.

Baranowski, P., Bennani, H. and Doryn, W. (2023). Stock price reaction to ECB communication: Introductory Statements vs Questions & Answers, Finance Research Letters **52**: 103528.

Brand, C., Buncic, D. and Turunen, J. (2010). The impact of the ECB monetary policy decisions and communication on the yield curve, Journal of the European Economic Association **8**: 1266–1298.

Büchel, S., Junker, S., Schlaak, T., Michelsen, C. and Hahn, U. (2019). A Time Series Analysis of Emotional Loading in Central Bank Statements, Proceedings of the Second Workshop on Economics and Natural Language Processing pp. 16–21.

Curti, F. and Kazinnik, S. (2023). Let's face it: quantifying the impact of nonverbal communication in FOMC press conferences, Journal of Monetary Economics **139**: 110–126.

Ehrmann, M. and Fratzscher, M. (2009). Explaining Monetary Policy in Press Conferences, International Journal of Central Banking **5**: 41–48.

European Central Bank (2022). Rate forward guidance in an environment of large central bank balance sheets: a Eurosystem stock-taking assessment, No. 290, ECB Occasional Paper.

Gennaro, G. and Ash, E. (2021). Emotion and reason in political language, The Economic Journal **132**(643): 1037–1059.

Giorgino, T. (2009). Computing and visualizing dynamic time warping alignments in r: The dtw package, Journal of Statistical Software **31**(7): 1–24. **URL:** *https://www.jstatsoft.org/index.php/jss/article/view/v031i07*

Gómez-Cram, R. and Grotteria, M. (2022). Real-time price discovery via verbal communication: method and application to Fedspeak, Journal of Financial Economics **143**: 993–1025.

Gorodnichenko, Y., Pham, T. and Talavera, O. (2023). The voice of monetary policy, American Economic Review **113**: 548–584.

Gu, C., Kurov, A. and Wolfe, M. H. (2018). Relief rallies after FOMC announcements as a resolution of uncertainty, Journal of Empirical Finance **49**: 1–18.

Gürkaynak, R., Sack, B. T. and Swanson, E. T. (2005). Do actions speak louder than words? The response of asset prices to monetary policy actions and statements, International Journal of Central Banking **1**: 55–93.

Gürkaynak, R., Sack, B. T. and Swanson, E. T. (2007). Market-based measures of monetary policy expectations, Journal of Business & Economic Statistics **25**: 201–212.

Jarociński, M. and Karadi, P. (2020). Deconstructing monetary policy surprises: The role of information shocks, American Economic Journal: Macroeconomics **12**: 1–43.

Kanelis, D. and Siklos, P. L. (2023). Emotion in euro area monetary policy communication and bond yields: the Draghi era, No. 75/2022, CAMA Working Paper, Australian National University.

Kanelis, D. and Siklos, P. L. (2024). The ECB press conference statement: deriving a new sentiment indicator for the euro area, International Journal of Finance and Economics **forthcoming**.

Klejdysz, J. and Lumsdaine, R. L. (2023). Shifts in ECB communication: a textual analysis of the press conferences, International Journal of Central Banking **19**: 473–542.

Küblbeck, C. and Ernst, A. (2006). Face detection and tracking in video sequences using the modifiedcensus transformation, Image and Vision Computing **24**(6): 564–572.

Le, Q. V. and Mikolov, T. (2014). Distributed representations of sentences and documents.
URL: *https://arxiv.org/abs/1405.4053*

Marchal, A. (2021). Risk and returns around FOMC press conferences: a novel perspective from computer vision, unpublished, University of Lausanne.

Mihai, N., Maria-Miruna, P. and Ștefan Constantin, R. (2023). Replication Data for: Unveiling the sentiment behind central bank narratives: A novel deep learning index.

Mosbach, M., Andriushchenko, M. and Klakow, D. (2021). On the stability of fine-tuning bert: Misconceptions, explanations, and strong baselines.
URL: *https://arxiv.org/abs/2006.04884*

Narain, N. and Sangani, K. (2023). The market impact of Fed communication: the role of the press conference, unpublished, Harvard University.

Ng, H. (2024). Strategic Control of Facial Expressions by the Fed Chair, unpublished, Baruch College.

Niţoi, M., Pochea, M.-M. and Ştefan Constantin Radu (2023). Unveiling the sentiment behind central bank narratives: A novel deep learning index, Journal of Behavioral and Experimental Finance **38**: 100809.
URL: *https://www.sciencedirect.com/science/article/pii/S2214635023000230*

Parle, C. (2022). The financial market impact of ECB monetary policy press conferences — A text based approach, European Journal of Political Economy **74**: 102230.

Pavelkova, A. (2022). The ECB press conference: a textual analysis, No. 2742, ECB Working Paper.

Radford, A., Kim, J. W., Xu, T., Brockman, G., McLeavey, C. and Sutskever, I. (2022). Robust speech recognition via large-scale weak supervision.
URL: *https://arxiv.org/abs/2212.04356*

Reimers, N. and Gurevych, I. (2019). Sentence-bert: Sentence embeddings using siamese bert-networks, Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing, Association for Computational Linguistics.
URL: *https://arxiv.org/abs/1908.10084*

Ruf, T., Ernst, A. and Küblbeck, C. (2011). Face detection with the sophisticated high-speed object recognition engine (shore), Microelectronic systems: circuits, systems and applications pp. 243–252.

Russell, J. A. and Mehrabian, A. (1977). Evidence for a three-factor theory of emotions, Journal of Research in Personality **11**(3): 273–294.

Schonhardt-Bailey, C. (2017). Nonverbal contention and contempt in U.K. parliamentary oversight hearings on fiscal and monetary policy, Politics and the Life Sciences **36**: 27–46.

Swanson, E. T. (2021). Measuring the effects of Federal Reserve forward guidance and asset purchases on financial markets, Journal of Monetary Economics **118**: 32–53.

Wagner, J., Triantafyllopoulos, A., Wierstorf, H., Schmitt, M., Burkhardt, F., Eyben, F. and Schuller, B. W. (2023). Dawn of the transformer era in speech emotion recognition: Closing the valence gap, IEEE Transactions on Pattern Analysis and Machine Intelligence **45**(9): 10745–10759.
URL: *http://dx.doi.org/10.1109/TPAMI.2023.3263585*

Zhang, T., Wu, F., Katiyar, A., Weinberger, K. Q. and Artzi, Y. (2021). Revisiting few-sample bert fine-tuning.
URL: *https://arxiv.org/abs/2006.05987*

Table 5: The effect on financial variables: introductory statement

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
				(a) Introductory Statement: Draghi			
hawkish	0.000	0.000	0.003	0.000	0.001	−0.025	−0.010
	(0.001)	(0.001)	(0.002)	(0.002)	(0.009)	(0.030)	(0.020)
facial happy	−0.046	−0.038	−0.025	−0.018	0.382	0.448	−0.763
	(0.020**)	(0.021*)	(0.040)	(0.036)	(0.185**)	(0.625)	(0.414*)
facial sad	−0.023	−0.020	−0.024	−0.024	0.193	0.614	−0.419
	(0.010**)	(0.010*)	(0.020)	(0.018)	(0.091**)	(0.307**)	(0.203**)
facial angry	−0.049	−0.035	−0.012	0.006	0.371	0.703	−0.140
	(0.024*)	(0.026)	(0.050)	(0.044)	(0.228)	(0.773)	(0.512)
vocal arousal	0.017	0.027	0.016	0.009	−0.254	−0.786	0.508
	(0.009*)	(0.010***)	(0.019)	(0.017)	(0.088***)	(0.294***)	(0.195***)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	853	871	873	875	863	887	887
				(b) Introductory Statement: Lagarde			
hawkish	0.003	0.005	0.007	0.004	−0.036	−0.049	0.005
	(0.001**)	(0.001***)	(0.003***)	(0.001**)	(0.013***)	(0.028*)	(0.010)
facial happy	−0.030	−0.033	−0.026	−0.035	0.258	0.664	−0.260
	(0.014**)	(0.015**)	(0.026)	(0.016**)	(0.132*)	(0.282**)	(0.098***)
facial sad	−0.028	−0.020	−0.010	−0.025	0.190	0.527	−0.250
	(0.013**)	(0.013)	(0.024)	(0.015*)	(0.119)	(0.256**)	(0.089***)
facial angry	0.000	−0.002	0.018	−0.002	0.057	0.002	−0.025
	(0.008)	(0.009)	(0.016)	(0.009)	(0.078)	(0.168)	(0.058)
vocal arousal	−0.034	−0.016	−0.018	−0.013	0.178	−0.505	−0.181
	(0.017**)	(0.017)	(0.031)	(0.019)	(0.157)	(0.336)	(0.117)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	490	495	492	455	495	495	495

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 6: The effect on financial variables: Q&A part

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
				(a) Q&A: Draghi			
hawkish	0.000	−0.002	−0.002	−0.002	0.002	0.040	−0.024
	(0.001)	(0.001)	(0.002)	(0.002)	(0.011)	(0.025)	(0.019)
facial happy	−0.007	−0.011	0.008	−0.006	0.046	0.061	−0.059
	(0.004*)	(0.005**)	(0.008)	(0.006)	(0.038)	(0.085)	(0.063)
facial sad	−0.011	−0.011	−0.006	−0.007	0.095	0.136	−0.078
	(0.003***)	(0.003***)	(0.005)	(0.004*)	(0.024***)	(0.054**)	(0.040*)
facial angry	−0.000	−0.005	−0.001	−0.009	0.006	0.257	−0.099
	(0.005)	(0.005)	(0.008)	(0.007)	(0.041)	(0.093***)	(0.068)
vocal arousal	0.003	0.002	0.004	−0.000	−0.011	−0.107	−0.058
	(0.004)	(0.004)	(0.007)	(0.006)	(0.025)	(0.079)	(0.058)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	3013	3067	3022	3073	3071	3164	3164
				(b) Q&A: Lagarde			
hawkish	−0.000	0.002	−0.001	0.003	0.005	0.061	−0.003
	(0.002)	(0.003)	(0.005)	(0.003)	(0.019)	(0.030**)	(0.024)
facial happy	−0.001	−0.009	−0.039	−0.006	0.028	0.029	0.081
	(0.008)	(0.011)	(0.018**)	(0.010)	(0.067)	(0.107)	(0.086)
facial sad	−0.007	−0.013	−0.024	−0.010	0.059	−0.060	0.004
	(0.006)	(0.008)	(0.014*)	(0.008)	(0.053)	(0.084)	(0.068)
facial angry	−0.008	−0.021	−0.028	−0.010	0.082	−0.089	0.033
	(0.005)	(0.007***)	(0.012**)	(0.007)	(0.046*)	(0.073)	(0.059)
vocal arousal	−0.012	−0.011	−0.008	−0.015	0.110	0.005	−0.292
	(0.009)	(0.012)	(0.021)	(0.011)	(0.078)	(0.125)	(0.101***)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	1238	1258	1241	1166	1258	1258	1258

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 7: The effect on financial variables: full press conference

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
			(a) full press conference: Draghi				
hawkish	−0.001	−0.002	0.001	0.001	0.012	−0.031	−0.038
	(0.001)	(0.001)	(0.002)	(0.002)	(0.010)	(0.026)	(0.018**)
facial happy	−0.022	−0.025	−0.007	−0.020	0.189	0.124	−0.307
	(0.006***)	(0.005***)	(0.010)	(0.008**)	(0.047***)	(0.121)	(0.084***)
facial sad	−0.014	−0.015	−0.025	−0.018	0.110	0.497	−0.138
	(0.003)	(0.003***)	(0.005***)	(0.004***)	(0.025***)	(0.064***)	(0.044***)
facial angry	−0.007	−0.005	−0.003	−0.013	0.039	0.230	−0.065
	(0.006)	(0.006)	(0.010)	(0.008)	(0.052)	(0.132*)	(0.092)
vocal arousal	0.019	0.014	−0.003	−0.009	−0.145	0.132	0.085
	(0.005***)	(0.005***)	(0.008)	(0.007)	(0.042***)	(0.107)	(0.075)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	3867	3939	3896	3949	3935	4052	4052
			(b) full press conference: Lagarde				
hawkish	0.003	0.005	0.003	0.003	−0.027	0.049	0.012
	(0.002)	(0.002*)	(0.004)	(0.002)	(0.016*)	(0.028*)	(0.020)
facial happy	−0.026	−0.020	−0.021	−0.020	0.243	0.271	−0.158
	(0.009***)	(0.011*)	(0.018)	(0.011*)	(0.076***)	(0.127**)	(0.089*)
facial sad	0.000	−0.003	0.010	0.007	0.001	−0.391	−0.004
	(0.007)	(0.009)	(0.015)	(0.009)	(0.062)	(0.104***)	(0.073)
facial angry	−0.006	−0.018	−0.001	−0.004	0.082	−0.336	−0.051
	(0.006)	(0.008**)	(0.012)	(0.007)	(0.052)	(0.088***)	(0.062)
vocal arousal	−0.002	0.013	0.030	−0.001	0.030	−0.165	−0.312
	(0.009)	(0.012)	(0.019)	(0.012)	(0.081)	(0.136)	(0.096***)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	1728	1753	1733	1621	1753	1753	1753

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 8: The effect on financial variables: introductory statement

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
			(a) Introductory Statement: Draghi				
hawkish	−0.001	0.002	−0.022	0.010	−0.010	0.371	−0.010
	(0.024)	(0.025)	(0.048)	(0.042)	(0.224)	(0.762)	(0.494)
facial happy	−0.054	−0.047	−0.039	−0.031	0.444	0.641	−0.862
	(0.020***)	(0.021**)	(0.040)	(0.035)	(0.184**)	(0.639)	(0.414**)
facial sad	−0.022	−0.018	−0.021	−0.021	0.181	0.512	−0.391
	(0.010**)	(0.010*)	(0.020)	(0.017)	(0.090**)	(0.313)	(0.202*)
facial angry	−0.044	−0.030	−0.006	0.012	0.358	0.716	−0.135
	(0.024*)	(0.026)	(0.050)	(0.044)	(0.229)	(0.798)	(0.516)
vocal arousal	0.017	0.026	0.015	0.009	−0.265	−0.786	0.510
	(0.009*)	(0.010***)	(0.019)	(0.017)	(0.088***)	(0.798)	(0.198**)
facial happy × hawkish	0.316	0.332	0.629	0.533	−2.782	−7.879	4.617
	(0.078***)	(0.083***)	(0.160***)	(0.141***)	(0.733***)	(0.254***)	(1.646***)
facial sad × hawkish	−0.001	−0.018	−0.010	−0.046	−0.024	0.298	−0.175
	(0.025)	(0.026)	(0.050)	(0.044)	(0.227)	(0.788)	(0.510)
facial angry × hawkish	−0.071	−0.081	−0.098	−0.154	0.200	0.149	−0.423
	(0.059)	(0.062)	(0.118)	(0.103)	(0.541)	(1.868)	(1.210)
vocal arousal × hawkish	0.002	0.015	0.051	0.035	0.104	−0.920	0.127
	(0.026)	(0.027)	(0.052)	(0.046)	(0.245)	(0.827)	(0.535)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	853	871	873	875	863	887	887
			(b) Introductory Statement: Lagarde				
hawkish	−0.042	−0.044	−0.058	−0.033	0.395	−0.567	−0.154
	(0.024*)	(0.024*)	(0.044)	(0.027)	(0.217*)	(0.483)	(0.163)
facial happy	−0.029	−0.031	−0.024	−0.035	0.242	−0.779	−0.250
	(0.014**)	(0.015**)	(0.026)	(0.016**)	(0.131*)	(0.292***)	(0.163)
facial sad	−0.025	−0.016	−0.005	−0.021	0.157	0.527	−0.251
	(0.013*)	(0.013)	(0.024)	(0.015)	(0.120)	(0.266**)	(0.090***)
facial angry	0.000	−0.002	0.017	−0.003	0.057	0.082	−0.028
	(0.008)	(0.009)	(0.016)	(0.009)	(0.079)	(0.175)	(0.059)
vocal arousal	−0.040	−0.024	−0.029	−0.019	0.257	−0.739	−0.204
	(0.017**)	(0.018)	(0.032)	(0.019)	(0.160)	(0.357**)	(0.121*)
facial happy × hawkish	0.013	0.012	0.028	0.025	−0.106	0.008	−0.040
	(0.022)	(0.023)	(0.041)	(0.025)	(0.204)	(0.454)	(0.154)
facial sad × hawkish	−0.001	−0.001	0.003	−0.005	0.016	0.144	0.046
	(0.013)	(0.013)	(0.024)	(0.014)	(0.119)	(0.264)	(0.089)
facial angry × hawkish	0.031	0.040	0.049	0.041	−0.309	−0.103	0.111
	(0.013**)	(0.013***)	(0.023**)	(0.014***)	(0.114***)	(0.255)	(0.086)
vocal arousal × hawkish	0.084	0.087	0.113	0.059	−0.785	1.088	0.288
	(0.048*)	(0.048*)	(0.087)	(0.052)	(0.429*)	(0.955)	(0.323)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	490	495	492	455	495	495	495

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 9: The effect on financial variables: Q&A part

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
				(a) Q&A part: Draghi			
hawkish	−0.009	−0.011	−0.022	−0.013	0.066	0.267	−0.258
	(0.016)	(0.017)	(0.028)	(0.023)	(0.127)	(0.309)	(0.227)
facial happy	−0.007	−0.011	0.008	−0.006	0.047	0.063	−0.065
	(0.004*)	(0.004**)	(0.008)	(0.006)	(0.038)	(0.085)	(0.063)
facial sad	−0.011	−0.011	−0.007	−0.007	0.094	0.145	−0.081
	(0.003***)	(0.003***)	(0.005)	(0.004*)	(0.024***)	(0.055***)	(0.040**)
facial angry	0.000	−0.004	−0.001	−0.009	−0.002	0.272	−0.114
	(0.005)	(0.005)	(0.008)	(0.007)	(0.042)	(0.094***)	(0.069)
vocal arousal	0.003	0.002	0.004	−0.000	−0.010	−0.104	−0.061
	(0.004)	(0.004)	(0.007)	(0.006)	(0.035)	(0.080)	(0.059)
facial happy × hawkish	0.015	0.014	0.006	0.037	−0.183	−0.240	0.688
	(0.028)	(0.029)	(0.048)	(0.039)	(0.239)	(0.539)	(0.396*)
facial sad × hawkish	−0.001	0.008	0.026	0.027	−0.004	−0.468	0.258
	(0.016)	(0.017)	(0.028)	(0.023)	(0.138)	(0.311)	(0.229)
facial angry × hawkish	−0.013	−0.012	0.015	0.021	0.159	−0.632	0.624
	(0.028)	(0.028)	(0.047)	(0.038)	(0.232)	(0.523)	(0.384)
vocal arousal × hawkish	0.019	0.014	0.016	−0.008	−0.135	0.073	0.046
	(0.027)	(0.027)	(0.046)	(0.036)	(0.220)	(0.497)	(0.366)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	3013	3067	3022	3073	3071	3164	3164
				(b) Q&A part: Lagarde			
hawkish	0.027	0.027	−0.038	0.047	−0.205	0.520	0.311
	(0.028)	(0.039)	(0.064)	(0.036)	(0.244)	(0.389)	(0.315)
facial happy	0.004	−0.007	−0.034	−0.001	−0.009	−0.015	0.125
	(0.008)	(0.011)	(0.018*)	(0.010)	(0.068)	(0.109)	(0.088)
facial sad	−0.005	−0.012	−0.023	−0.008	0.040	−0.066	0.028
	(0.006)	(0.008)	(0.014*)	(0.008)	(0.053)	(0.085)	(0.068)
facial angry	−0.004	−0.018	−0.024	−0.006	0.049	−0.110	0.057
	(0.005)	(0.008**)	(0.012*)	(0.007)	(0.047)	(0.076)	(0.061)
vocal arousal	−0.013	−0.011	−0.012	−0.015	0.121	0.049	−0.298
	(0.009)	(0.013)	(0.021)	(0.012)	(0.080)	(0.128)	(0.103***)
facial happy × hawkish	−0.116	−0.038	−0.088	−0.106	0.894	0.802	−1.141
	(0.042***)	(0.060)	(0.099)	(0.055*)	(0.374**)	0.597	(0.484**)
facial sad × hawkish	−0.060	−0.032	0.044	−0.053	0.587	−0.572	−0.842
	(0.026**)	(0.037)	(0.060)	(0.033)	(0.227**)	(0.362)	(0.294***)
facial angry × hawkish	−0.071	−0.050	−0.043	−0.075	0.610	0.262	−0.521
	(0.025***)	(0.035)	(0.057)	(0.032**)	(0.215***)	(0.344)	(0.279*)
vocal arousal × hawkish	0.015	−0.010	0.089	−0.018	−0.182	−0.924	0.085
	(0.051)	(0.072)	(0.119)	(0.066)	(0.448)	(0.716)	(0.580)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	1238	1258	1241	1166	1258	1258	1258

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 10: The effect on financial variables: full press conference

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
			(a) full press conference: Draghi				
hawkish	−0.007	−0.029	−0.085	−0.067	0.115	1.383	−0.385
	(0.017)	(0.016*)	(0.028***)	(0.023***)	(0.140)	(0.354***)	(0.247)
facial happy	−0.022	−0.025	−0.006	−0.019	0.192	0.099	−0.314
	(0.006***)	(0.005***)	(0.010)	(0.008**)	(0.047***)	(0.121)	(0.084***)
facial sad	−0.014	−0.015	−0.025	−0.018	0.110	0.503	−0.140
	(0.003***)	(0.003***)	(0.005***)	(0.004***)	(0.025***)	(0.064***)	(0.045***)
facial angry	−0.006	−0.005	−0.005	−0.014	0.031	0.254	−0.082
	(0.006)	(0.006)	(0.010)	(0.009)	(0.053)	(0.134*)	(0.093)
vocal arousal	0.019	0.014	−0.007	−0.012	−0.144	0.205	0.076
	(0.005***)	(0.005***)	(0.009)	(0.007*)	(0.043***)	(0.108*)	(0.076)
facial happy × hawkish	0.061	0.043	−0.032	0.027	−0.481	0.795	0.900
	(0.035*)	(0.034)	(0.059)	(0.048)	(0.294)	(0.748)	(0.523*)
facial sad × hawkish	0.014	0.011	−0.002	0.023	−0.085	−0.023	0.259
	(0.016)	(0.015)	(0.029)	(0.022)	(0.134)	(0.340)	(0.238)
facial angry × hawkish	−0.011	0.009	0.038	0.061	0.069	−0.655	0.697
	(0.034)	(0.032)	(0.057)	(0.046)	(0.282)	(0.716)	(0.501)
vocal arousal × hawkish	−0.005	0.036	0.166	0.099	−0.088	−2.688	0.247
	(0.027)	(0.025)	(0.044***)	(0.036***)	(0.220)	(0.559***)	(0.391)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	3867	3939	3896	3949	3935	4052	4052
			(b) full press conference: Lagarde				
hawkish	0.007	0.025	0.065	0.016	−0.080	0.013	−0.286
	(0.022)	(0.0296)	(0.047)	(0.029)	(0.197)	(0.331)	(0.233)
facial happy	−0.023	−0.017	−0.019	−0.017	0.221	0.256	−0.127
	(0.009***)	(0.011)	(0.018)	(0.011)	(0.077***)	(0.130**)	(0.091)
facial sad	0.001	−0.004	0.006	0.007	−0.005	−0.361	0.009
	(0.007)	(0.009)	(0.015)	(0.009)	(0.062)	(0.105***)	(0.074)
facial angry	−0.010	−0.022	−0.009	−0.008	0.109	0.314	−0.057
	(0.006*)	(0.008***)	(0.013)	(0.008)	(0.054**)	(0.090***)	(0.064)
vocal arousal	−0.002	0.015	0.037	−0.000	0.030	−0.171	−0.345
	(0.009)	(0.012)	(0.020*)	(0.012)	(0.083)	(0.139)	(0.098***)
facial happy × hawkish	−0.066	−0.068	−0.076	−0.084	0.580	0.265	−0.527
	(0.031**)	(0.040*)	(0.066)	(0.040**)	(0.276**)	(0.130**)	(0.327)
facial sad × hawkish	−0.011	0.006	0.051	0.002	0.147	−0.462	−0.164
	(0.018)	(0.024)	(0.039)	(0.023)	(0.162)	(0.273*)	(0.192)
facial angry × hawkish	0.042	0.053	0.100	0.056	−0.315	−0.240	0.080
	(0.018**)	(0.023**)	(0.038***)	(0.023**)	(0.158**)	(0.265)	(0.187)
vocal arousal × hawkish	−0.007	−0.049	−0.163	−0.030	0.055	0.266	0.734
	(0.043)	(0.055)	(0.090*)	(0.055)	(0.376)	(0.633)	(0.446*)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	1728	1753	1733	1621	1753	1753	1753

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 11: The effect on financial variables: interaction with forward guidance

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
				(a) Introductory Statement: Draghi			
hawkish	−0.000	−0.000	0.003	−0.000	0.003	−0.021	−0.012
	(0.001)	(0.001)	(0.002)	(0.002)	(0.009)	(0.030)	(0.020)
forward guidance (FG)	−0.035	−0.044	−0.081	−0.073	0.388	0.938	−0.704
	(0.020*)	(0.021**)	(0.039**)	(0.035**)	(0.184**)	(0.618)	(0.413)
facial happy	−0.048	−0.039	−0.028	−0.019	0.397	0.542	−0.821
	(0.020**)	(0.021*)	(0.040)	(0.035)	(0.186**)	(0.628)	(0.420*)
facial sad	−0.029	−0.029	−0.042	−0.039	0.253	0.840	−0.534
	(0.010***)	(0.011***)	(0.020**)	(0.018**)	(0.093***)	(0.315***)	(0.211**)
facial angry	−0.060	−0.051	−0.040	−0.019	0.481	1.005	−0.291
	(0.025**)	(0.026*)	(0.050)	(0.044)	(0.231*)	(0.779)	(0.520)
vocal arousal	0.014	0.025	0.016	0.008	−0.224	−0.821	0.480
	(0.010)	(0.010**)	(0.019)	(0.017)	(0.089**)	(0.301***)	(0.201**)
facial happy × FG	−0.150	−0.298	−0.547	−0.529	1.745	4.347	−1.977
	(0.067**)	(0.079***)	(0.135***)	(0.119***)	(0.628***)	(2.124**)	(1.420)
facial sad × FG	0.037	0.055	0.121	0.103	−0.366	−1.717	0.861
	(0.021*)	(0.023**)	(0.043***)	(0.038***)	(0.199*)	(0.672**)	(0.449*)
facial angry × FG	0.123	0.200	0.329	0.312	−1.393	−3.172	1.615
	(0.068*)	(0.072**)	(0.135**)	(0.119***)	(0.630**)	(2.124)	(1.420)
vocal arousal × FG	0.014	0.008	−0.003	0.003	−0.226	0.411	0.240
	(0.022)	(0.023)	(0.044)	(0.039)	(0.209)	(0.692)	(0.462)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	853	871	873	875	863	887	887
				(b) Introductory Statement: Lagarde			
hawkish	0.003	0.005	0.007	0.004	−0.038	−0.046	0.006
	(0.001**)	(0.001***)	(0.003***)	(0.002***)	(0.013***)	(0.028*)	(0.010)
forward guidance (FG)	−0.051	−0.025	−0.019	−0.057	0.187	0.087	−0.096
	(0.033)	(0.034)	(0.061)	(0.036)	(0.305)	(0.655)	(0.225)
facial happy	−0.030	−0.034	−0.028	−0.035	0.265	0.677	−0.272
	(0.014**)	(0.015**)	(0.026)	(0.016**)	(0.132**)	(0.284**)	(0.097***)
facial sad	−0.029	−0.020	−0.009	−0.026	0.192	0.541	−0.266
	(0.013**)	(0.013)	(0.024)	(0.015*)	(0.120)	(0.258**)	(0.088***)
facial angry	0.000	−0.002	0.017	−0.002	0.059	0.006	−0.027
	(0.008)	(0.009)	(0.016)	(0.009)	(0.079)	(0.169)	(0.058)
vocal arousal	−0.039	−0.019	−0.024	−0.018	0.203	−0.563	−0.163
	(0.017**)	(0.018)	(0.032)	(0.019)	(0.160)	(0.343)	(0.118)
facial happy × FG	−0.031	−0.019	0.023	−0.031	0.174	−0.555	−0.213
	(0.037)	(0.039)	(0.069)	(0.042)	(0.346)	(0.743)	(0.255)
facial sad × FG	0.007	0.005	−0.044	0.009	−0.028	−0.318	0.162
	(0.014)	(0.014)	(0.025)	(0.015)	(0.127)	(0.273)	(0.094*)
facial angry × FG	0.024	0.010	0.003	0.015	−0.067	−0.064	0.015
	(0.015)	(0.015)	(0.027)	(0.017)	(0.137)	(0.294)	(0.101)
vocal arousal × FG	0.099	0.044	0.023	0.112	−0.347	0.047	0.141
	(0.067)	(0.069)	(0.123)	(0.075)	(0.619)	(1.330)	(0.457)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	490	495	492	455	495	495	495

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 12: Results for the introductory statement with the president's face only

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
			(a) Introductory Statement: Draghi				
hawkish	−0.002	0.003	−0.034	−0.000	−0.005	0.524	−0.006
	(0.025)	(0.026)	(0.089)	(0.041)	(0.233)	(0.766)	(0.511)
facial happy	−0.051	−0.046	−0.048	−0.054	0.409	0.542	−0.752
	(0.021**)	(0.021**)	(0.041)	(0.035)	(0.190**)	(0.640)	(0.427*)
facial sad	−0.022	−0.019	−0.025	−0.030	0.170	0.558	−0.382
	(0.010**)	(0.011*)	(0.020)	(0.017*)	(0.094*)	(0.315*)	(0.210*)
facial angry	−0.046	−0.035	−0.010	0.003	0.363	0.735	−0.267
	(0.025*)	(0.027)	(0.051)	(0.043)	(0.239)	(0.804)	(0.536)
vocal arousal	0.016	0.025	0.011	0.006	−0.255	−0.706	0.494
	(0.010*)	(0.010**)	(0.019)	(0.016)	(0.090***)	(0.301**)	(0.201**)
facial happy × hawkish	0.339	0.344	0.633	0.522	−3.009	−7.739	4.896
	(0.082***)	(0.087***)	(0.166***)	(0.141***)	(0.775***)	(2.600***)	(1.733**)
facial sad × hawkish	0.002	−0.015	0.005	−0.030	−0.054	0.065	−0.105
	(0.025)	(0.026)	(0.050)	(0.042)	(0.234)	(0.785)	(0.523)
facial angry × hawkish	−0.092	−0.080	−0.046	−0.136	0.306	−1.124	−0.437
	(0.065)	(0.069)	(0.130)	(0.109)	(0.611)	(2.039)	(1.359)
vocal arousal × hawkish	−0.000	0.011	0.051	0.034	0.127	−0.815	0.026
	(0.027)	(0.028)	(0.052)	(0.044)	(0.252)	(0.822)	(0.548)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	828	842	844	847	834	858	858
			(b) Introductory Statement: Lagarde				
hawkish	−0.049	−0.047	−0.066	−0.032	0.412	−0.591	−0.207
	(0.027*)	(0.026*)	(0.048)	(0.028)	(0.240*)	(0.542)	(0.179)
facial happy	−0.034	−0.034	−0.020	−0.041	0.264	0.857	−0.283
	(0.017**)	(0.018*)	(0.032)	(0.019**)	(0.162)	(0.365**)	(0.121**)
facial sad	−0.021	−0.011	0.015	−0.016	0.116	0.491	−0.204
	(0.015)	(0.015)	(0.027)	(0.016)	(0.140)	(0.316)	(0.104*)
facial angry	−0.004	−0.008	0.016	−0.009	0.115	0.255	−0.072
	(0.010)	(0.011)	(0.020)	(0.011)	(0.099)	(0.225)	(0.074)
vocal arousal	−0.044	−0.026	−0.030	−0.015	0.281	−0.832	0.304
	(0.021**)	(0.022)	(0.041)	(0.024)	(0.203)	(0.458*)	(0.151**)
facial happy × hawkish	0.026	0.014	0.042	0.041	−0.063	0.013	−0.251
	(0.031)	(0.031)	(0.057)	(0.033)	(0.288)	(0.649)	(0.251)
facial sad × hawkish	0.002	0.000	0.008	−0.001	0.024	0.130	−0.001
	(0.014)	(0.014)	(0.026)	(0.015)	(0.130)	(0.294)	(0.097)
facial angry × hawkish	0.030	0.039	0.048	0.042	−0.298	−0.155	0.067
	(0.013**)	(0.013***)	(0.024**)	(0.014***)	(0.120*)	(0.271)	(0.090)
vocal arousal × hawkish	0.096	0.092	0.127	0.053	−0.840	1.172	0.493
	(0.053*)	(0.052*)	(0.097)	(0.056)	(0.481*)	(1.087)	(0.359)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	426	431	428	392	431	431	431

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 13: Results for the Q&A part with the president's face only

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
				(a) Q&A: Draghi			
hawkish	−0.011	−0.010	−0.020	−0.011	0.092	0.212	−0.344
	(0.019)	(0.020)	(0.033)	(0.027)	(0.162)	(0.363)	(0.269)
facial happy	−0.008	−0.012	0.012	−0.008	0.048	0.087	−0.088
	(0.005)	(0.005**)	(0.009)	(0.007)	(0.044)	(0.099)	(0.074)
facial sad	−0.013	−0.014	−0.006	−0.008	0.111	0.120	−0.103
	(0.003***)	(0.003***)	(0.005)	(0.004*)	(0.027***)	(0.061**)	(0.045**)
facial angry	0.004	0.001	0.002	−0.009	−0.063	0.258	−0.073
	(0.007)	(0.007)	(0.012)	(0.009)	(0.057)	(0.127**)	(0.094)
vocal arousal	0.002	0.002	0.008	0.006	−0.004	−0.248	−0.067
	(0.005)	(0.005)	(0.009)	(0.007)	(0.043)	(0.097**)	(0.072)
facial happy × hawkish	0.004	−0.009	−0.022	0.026	−0.092	0.092	0.617
	(0.033)	(0.034)	(0.057)	(0.046)	(0.278)	(0.621)	(0.460)
facial sad × hawkish	−0.007	−0.003	0.018	0.027	0.041	−0.461	0.205
	(0.018)	(0.019)	(0.031)	(0.025)	(0.153)	(0.341)	(0.253)
facial angry × hawkish	−0.029	−0.017	0.037	0.045	0.293	−0.198	0.544
	(0.043)	(0.045)	(0.075)	(0.062)	(0.371)	(0.826)	(0.612)
vocal arousal × hawkish	0.033	0.027	0.019	−0.015	−0.261	0.064	0.282
	(0.032)	(0.033)	(0.055)	(0.045)	(0.269)	(0.604)	(0.447)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	2565	2604	2571	2619	2612	2692	2692
				(b) Q&A: Lagarde			
hawkish	0.048	0.060	−0.032	0.070	−0.397	0.928	0.484
	(0.035)	(0.050)	(0.084)	(0.046)	(0.303)	(0.450**)	(0.382)
facial happy	0.001	−0.014	−0.056	−0.006	0.025	0.014	0.066
	(0.010)	(0.015)	(0.025**)	(0.014)	(0.091)	(0.135)	(0.114)
facial sad	−0.008	−0.018	−0.035	−0.012	0.064	0.025	0.020
	(0.009)	(0.013)	(0.021*)	(0.012)	(0.077)	(0.114)	(0.097)
facial angry	−0.002	−0.025	−0.038	−0.006	0.035	−0.030	0.163
	(0.007)	(0.011**)	(0.018**)	(0.010)	(0.064)	(0.096)	(0.081**)
vocal arousal	−0.026	−0.021	−0.005	−0.023	0.253	0.058	−0.324
	(0.013**)	(0.018)	(0.030)	(0.017)	(0.109**)	(0.162)	(0.138**)
facial happy × hawkish	−0.090	0.007	−0.092	−0.079	0.634	1.194	−0.808
	(0.053*)	(0.077)	(0.129)	(0.071)	(0.466)	(0.693*)	(0.588)
facial sad × hawkish	−0.066	−0.043	0.023	−0.071	0.678	−0.040	−0.948
	(0.031**)	(0.045)	(0.075)	(0.041*)	(0.273**)	(0.406)	(0.345***)
facial angry × hawkish	−0.067	−0.038	−0.033	−0.075	0.573	0.313	−0.455
	(0.030**)	(0.043)	(0.072)	(0.040*)	(0.261**)	(0.389)	(0.330)
vocal arousal × hawkish	−0.028	−0.081	0.081	−0.059	0.206	−1.838	−0.303
	(0.064)	(0.094)	(0.156)	(0.086)	(0.563)	(0.837**)	(0.710)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	962	982	969	901	982	982	982

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Table 14: The effect on financial variables: excluding digital press conferences

	DE10y	FR10y	IT10y	ES10y	BundF	Stocks	USDEUR
			(a) Introductory Statement: Lagarde				
hawkish	−0.053	−0.048	−0.071	−0.032	0.445	−0.529	−0.058
	(0.037)	(0.036)	(0.064)	(0.038)	(0.328)	(0.658)	(0.221)
facial happy	−0.038	−0.038	−0.028	−0.039	0.335	0.593	−0.320
	(0.021*)	(0.021*)	(0.038)	(0.023*)	(0.194*)	(0.389)	(0.131**)
facial sad	−0.041	−0.028	−0.028	−0.033	0.290	0.576	−0.356
	(0.020**)	(0.020)	(0.036)	(0.021)	(0.185)	(0.370)	(0.124***)
facial angry	0.000	−0.005	0.018	−0.006	0.082	0.092	−0.041
	(0.013)	(0.013)	(0.023)	(0.014)	(0.119)	(0.239)	(0.080)
vocal arousal	−0.047	−0.025	−0.022	−0.017	0.274	−0.971	−0.106
	(0.026*)	(0.027)	(0.048)	(0.028)	(0.243)	(0.488**)	(0.164)
facial happy × hawkish	0.017	0.011	0.028	0.016	−0.120	0.257	0.054
	(0.033)	(0.033)	(0.058)	(0.035)	(0.300)	(0.602)	(0.202)
facial sad × hawkish	0.001	−0.001	0.001	−0.001	0.005	0.253	0.089
	(0.020)	(0.020)	(0.035)	(0.021)	(0.181)	(0.364)	(0.122)
facial angry × hawkish	0.034	0.041	0.052	0.042	−0.324	−0.061	0.169
	(0.018*)	(0.018**)	(0.031*)	(0.018**)	(0.159)	(0.318)	(0.107)
vocal arousal × hawkish	0.104	0.097	0.141	0.062	−0.888	0.875	0.025
	(0.071)	(0.070)	(0.124)	(0.074)	(0.629)	(1.260)	(0.423)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	290	295	292	282	295	295	295
			(b) Q&A: Lagarde				
hawkish	0.023	0.041	0.009	0.062	−0.205	0.653	0.031
	(0.040)	(0.057)	(0.094)	(0.051)	(0.346)	(0.466)	(0.434)
facial happy	0.006	−0.013	−0.053	−0.005	−0.017	−0.095	0.250
	(0.012)	(0.016)	(0.027*)	(0.015)	(0.101)	(0.136)	(0.127**)
facial sad	−0.006	−0.020	−0.035	−0.009	0.054	−0.088	0.063
	(0.008)	(0.012*)	(0.020*)	(0.010)	(0.073)	(0.098)	(0.091)
facial angry	−0.008	−0.035	−0.046	−0.013	0.092	−0.112	0.144
	(0.009)	(0.012***)	(0.021**)	(0.011)	(0.076)	(0.103)	(0.096)
vocal arousal	−0.021	−0.017	−0.016	−0.026	0.187	0.104	−0.517
	(0.013)	(0.018)	(0.031)	(0.017)	(0.113*)	(0.152)	(0.142***)
facial happy × hawkish	−0.167	−0.030	−0.042	−0.110	1.250	1.674	−1.794
	(0.064***)	(0.092)	(0.154)	(0.081)	(0.561**)	(0.755**)	(0.704**)
facial sad × hawkish	−0.077	−0.051	0.012	−0.082	0.765	−0.838	−0.750
	(0.039**)	(0.055)	(0.092)	(0.049*)	(0.338**)	(0.455*)	(0.424*)
facial angry × hawkish	−0.089	−0.044	−0.011	−0.068	0.738	0.184	−0.525
	(0.036**)	(0.051)	(0.085)	(0.045)	(0.311**)	(0.420)	(0.390)
vocal arousal × hawkish	0.045	−0.034	−0.021	−0.039	−0.359	−1.272	0.745
	(0.075)	(0.107)	(0.177)	(0.096)	(0.652)	(0.879)	(0.819)
fixed effects	yes	yes	yes	yes	yes	yes	yes
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# obs.	773	793	776	746	793	793	793

Notes: A significance level of 10%, 5% and 1% is indicated by *, **, ***, respectively.

Appendices

These online appendices are not part of the published paper.

Appendix A Consistency of Hawkishness

Figure (A.1) plots the net hawkishness at the meeting frequency, i.e. the meeting averages of the hawkishness in each minute, and the KOF Monetary Policy Communicator provided by the KOF Swiss Economic Institute.[18] The Communicator is an index that summarizes statements of the ECB presidents about the risks to price stability during the press conference. As in Kanelis and Siklos (2024), our measure of net hawkishness tracks the KOF Communicator index very well. The correlation between both series is 0.43.

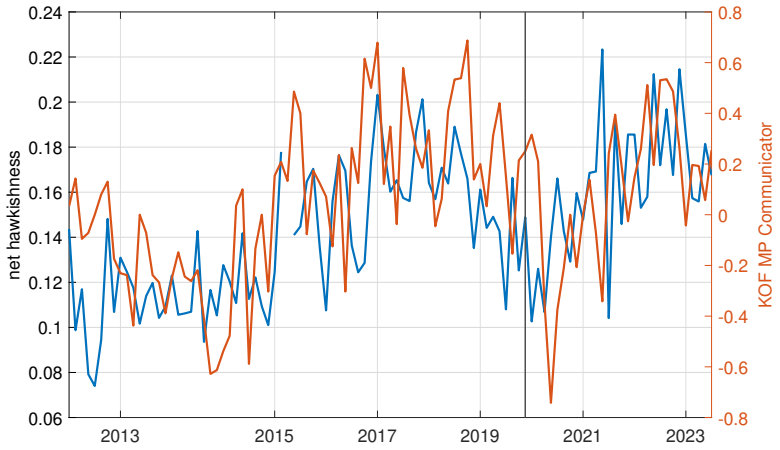
Figure (A.2) shows the series of net hawkishness and the surprise changes in two bond yields, the two year Overnight Index Swap (OIS) rates and two-year German Bund yields. In each case, we cumulate the surprise changes during the press conferences over time in order to construct an index of the monetary policy stance similar to our measure of net hawkishness. The market data is taken from Altavilla et al. (2019). The correlation of net hawkishness with the cumulative change of OIS rates (German Bund yields) is 0.57 (0.54).

Appendix B April 2015 Press Conference

During the press conference on April 15, 2015, a protester jumped on the podium and threw confetti on President Draghi. The incident happened during the introductory statement. The video available on the ECB's YouTube Channel does not include this incident. However, it is available on other YouTube Channels.

[18] See https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-monetary-policy-communicator.html.

Figure A.1: Net hawkishness at the meeting frequency and the KOF Monetary Policy Communicator



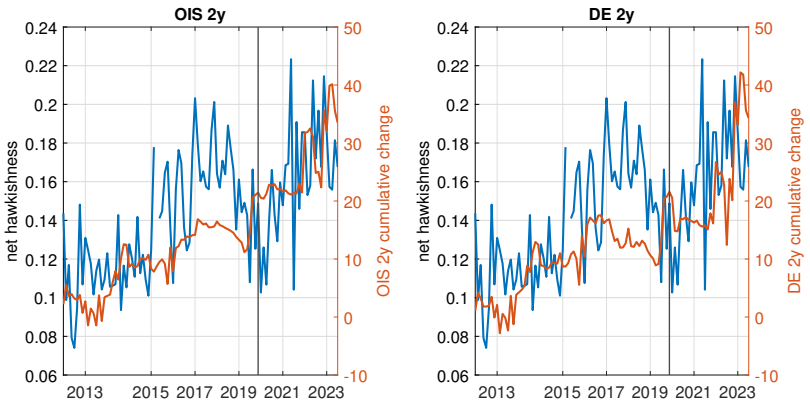
Notes: The graph shows the series of net hawkishness at the meeting frequency and the KOF Monetary Policy Communicator time series (right axis). We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

Figure B.3: Draghi attacked by protester (April 2015)

Notes: A selected frame from the press conference on April 15, 2015.

We now study the facial expressions of President Draghi during the at-

Figure A.2: Net hawkishness at the meeting frequency and cumulative market surprises



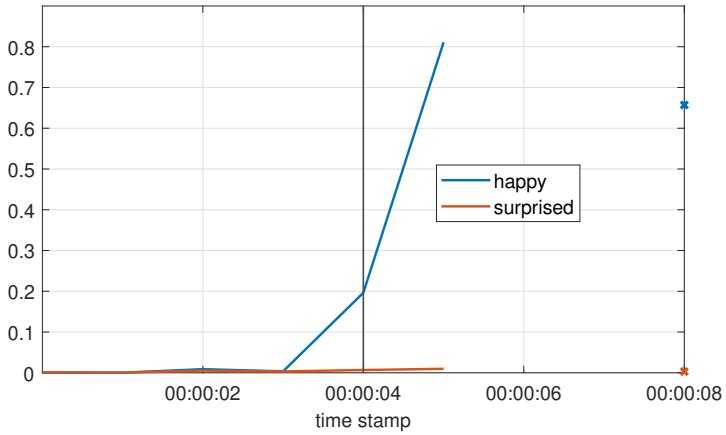
Notes: The graph shows the series of net hawkishness at the meeting frequency and the cumulative surprise changes in two-year OIS rates and two-year German Bund yields in the press conference window (right axis). The surprises are from Altavilla et al. (2019). We drop the observation in May 2015. In 2015, the meeting frequency changes from 12 to eight scheduled meetings per year. The vertical line indicates the change from President Draghi to President Lagarde.

tack, which are probably more extreme than during the remaining videos of the introductory statements. Figure (B.3) shows a screenshot of the attack at minute 00:04.[19]

Figure (B.4) shows the evolution of the surprised and happy expressions. While the dimension surprised remains essentially flat, the dimension happy jumps to extremely high levels of about 0.8. There are two potential interpretations possible. First, the software has difficulties distinguishing between these two emotions. This is our preferred explanation as this incident is certainly exceptional. The second interpretation is that Draghi's calm reaction could also reflect that Draghi expected the attack. In fact, the *Financial Times* argues that "rumours had circulated before the press conference that anti-capitalist protesters would disrupt the meeting."[20]

[19]We use this video: https://www.youtube.com/watch?v=koKU6sD3kLQ.
[20]See https://www.ft.com/content/b3e05190-e379-11e4-aa97-00144feab7de.

Figure B.4: Facial expressions during the attack on Draghi



Notes: The figure shows the evolution of facial expressions surprised and happy during the press conference of April 15, 2015. The vertical line indicates the moment the protester jumped on the podium. We do not have facial expressions between 00:00:05 and 00:00:08 as Draghi's face was not visible. The format of the time stamp is hh:mm:ss.

Appendix C Surprise, Surprise

We consider two (minor) instances of unexpected disruptions of the routine conduct of the press conference. The purpose is to check whether facial expressions, in this cased the surprised expression, respond as expected. In each case, we have to move to the one second-frequency in order to shed light on the facial response.

The first instance happened during the press conference on March 12, 2020 at 14:53 CET when President Lagarde acknowledges a mistake and corrects herself.

12.03.2020

Transcript: "... the euro-area governments and the European institutions to act now strongly and together in response to the repercussions of the further spread of the coronavirus. Before I take your questions together with the Vice President, we would like on behalf of the governing Council to express our profound gratitude to all those who are dedicating their time and the efforts in saving life and containing the spread of the coronavirus. With that, and also let me just announce ... **Oh dear, I made a mistake. The APPs envelope that we are putting together as part of our increased special effort is 120 billion euros, not 100. That's 120 billion.**"

This incidence at 14:53 CET occurs at time stamp 00:23:38 of the YouTube video. Panel (a) of Figure (C.5) shows the evolution of the surprise dimension around this instant. We clearly see the strong increase at the moment President Lagarde notices and corrects her mistake.

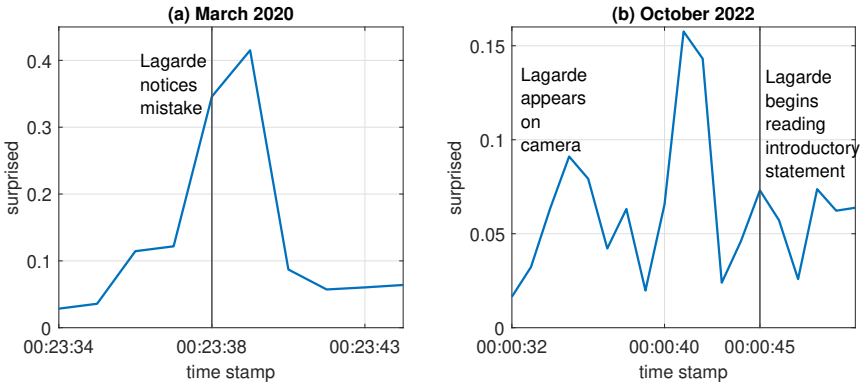
The second incident occurred on October 27, 2022. The press notices that the teleprompter is not working.

27.10.2022

DER SPIEGEL: "She takes a breath; every word has to be right. It's at this moment that she realizes that the teleprompter isn't working."

President Lagarde appears at 00:00:32 of the YouTube video, makes some welcoming remarks and starts her introductory statement at 00:00:45. Panel (b) of Figure (C.5) shows the increase in the surprised emotion at the beginning of the introductory statement when President Lagarde had to switch to the paper manuscript.

Figure C.5: Two minor surprises



Notes: The figure shows the evolution of facial expression surprised around two instances: In panel (a), President Lagarde notices a mistake in her remarks. In Panel (b), President Lagarde notices the teleprompter is not working. The format of the time stamp is hh:mm:ss.

Appendix D Facial Recognition

To determine whether the facial expressions analyzed by the `SHORE` software are those of the ECB president, we apply a facial recognition software to the `SHORE` results aggregated at one-second intervals. We conduct the facial recognition with the `face_recognition` Python package and limit it to frames that have been analyzed by `SHORE`, with a further restriction to those frames in which only a single face is detected.[21] This is because the `SHORE` SingleFace-Module analyzes only one face, but we do not know which one. To further save computing time, we process only the first frame analyzed by SHORE in each second. The software calculates the similarity between an encoded reference image and an encoded frame using Euclidean distance. A detection of the president or vice-president is confirmed if the distance exceeded a threshold of 0.6.

We check the accuracy of the facial recognition with a custom algorithm. It detects and corrects false-negatives. False-positives are not detected. The algorithm is not deterministic, thus, it is possible that some seconds were

[21] See https://github.com/ageitgey/face_recognition/tree/master.

therefore mislabeled. Subsequently, the results from the facial recognition and SHORE analyses are aggregated at the minute level by calculating the mean of the facial expression values across the frames analyzed within each minute. The facial recognition classification is then determined by assigning the minute to the president if their faces are detected in more than half of the frames during that minute.

Appendix E Financial Data

We obtain high frequency data on the level of microseconds from Refinitiv. We aggregate the data to the minute frequency, so that the value of a variable at a given minute is calculated as the mean of micro-second-data for that variable during the given minute. In the empirical analysis, we use the following series:

1. DE10y: German ten-year government bond yields. We calculate it as the arithmetic mean of the bid yield and the ask yield for each given minute. In case of missing observations, we usually define the yield value to be missing for a given minute. If the number of subsequent missing values does not exceed three missing values in a row, we fill the gaps using a linear interpolation.

2. FR10y: French ten-year government bond yields. The calculation is identical to that of DE10y.

3. IT10y: Italian ten-year government bond yields. The calculation is identical to that of DE10y.

4. ES10y: Spanish ten-year government bond yields. The calculation is identical to that of DE10y.

5. BundF: The log price of the Bund Future, which is a publicly traded futures contract on the purchase of a German ten-year government bond. The underlying asset is a German government bond with a nominal value of EUR 100,000, a fixed annual coupon of 6%, and a

maturity of 10 years. For each given minute in the time series, we compute the return of the Bund Future as the discrete growth rate of its price. We get the price values from the high frequency data and apply the same routine for handling missing values which we use for the other variables. Finally, we apply the natural log and multiply the resulting values by 100.

6. Stocks: Eurostoxx50 stock price index. We apply the natural log and multiply the resulting values by 100.

7. USDEUR: EUR exchange rate against the USD. A higher value implies a nominal appreciation of the euro against the dollar. We apply the natural log and multiply the resulting values by 100.

View publication stats