Does Central Bank Tone Move Asset Prices?*

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Abstract

This paper shows that changes in the *tone* of central bank communication have a significant effect on asset prices. Tone captures how the central bank frames economic fundamentals and its monetary policy. When tone becomes more positive, stock prices increase, and more so for stocks with high systematic risk, whereas credit spreads and volatility risk premia decrease. These tone effects are robust to controlling for fundamentals, policy actions, and other features of central bank communication, which suggests that tone is a generic instrument of monetary policy that can affect risk premia embedded in asset prices.

JEL Classification: G10, G12, E43, E44, E58

Keywords: Monetary policy, central bank communication, textual analysis, risk premia, stock returns, volatility risk, credit spreads.

"As I had often remarked, monetary policy is 98 percent talk and 2 percent action."

Ben Bernanke (2016, p. 498)

"I don't think I'm stepping up my rhetoric on inflation, Draghi said [...]. Financial market analysts nonetheless detected a shift in tone if not in substance of monetary policy."

Reuters, April 4th, 2012

"Given the uncertainty, how Ms. Yellen frames what the Fed is doing will be as important as what the Fed actually does." Wall Street Journal, September 16th, 2015

"All eyes will be on the ECB this afternoon. If the tone is clearly dovish, then it could maybe stop the bleeding on the market." Reuters, August 7th, 2014

1. Introduction

Monetary policy strongly affects asset prices, a prime example being the effect of monetary policy announcements on stock prices (e.g., Bernanke and Kuttner, 2005; Lucca and Moench, 2015; Cieslak et al., 2018; Neuhierl and Weber, 2018a). A large part of the information released on announcement days comes in the form of verbal communication, rather than quantitative releases, and central banks (CBs) use such communication to explain their policy decisions, the economic outlook, and to shape market expectations. CB communication is thus closely followed by market participants, extensively covered by the financial press, and CBs evaluate the media coverage of their statements to gauge the effectiveness of their communication.[1] Importantly, market participants do not only pay attention to the content but also, as the above quotes illustrate, to the *tone* of CB statements, i.e., to *how the central bank frames* its policy decisions and the economic outlook. Hence, a natural question is: Does communication matter for asset prices beyond policy actions? Ben Bernanke's view that "monetary policy is 98 percent talk and 2 percent action" suggests that it should.

The contribution of our paper is to answer this question, by showing that tone matters

[1]For an overview of the literature on CB communication see, e.g., Woodford (2005) and Blinder et al. (2008). Berger et al. (2011) discuss how the ECB evaluates communication effectiveness via media reception.

for asset prices through a risk-based channel. A more positive (negative) tone is associated with higher (lower) equity market returns, and the cross-sectional responses of stocks to tone changes are proportional to their systematic risk. We also find that a more positive tone is associated with lower volatility risk premia (a proxy for risk aversion) and lower credit spreads (in particular for financial institutions), which further implies that CB tone affects risk premia embedded in asset prices. Hence, our results suggest that tone affects risk premia very similarly to policy actions, as shown by, e.g., Bernanke and Kuttner (2005) for stocks, Bekaert et al. (2013) for variance risk premia, and Gertler and Karadi (2015) for credit spreads. Importantly, our analysis controls for policy actions, which implies that communication tone is an additional policy tool that supplements other instruments of monetary policy.

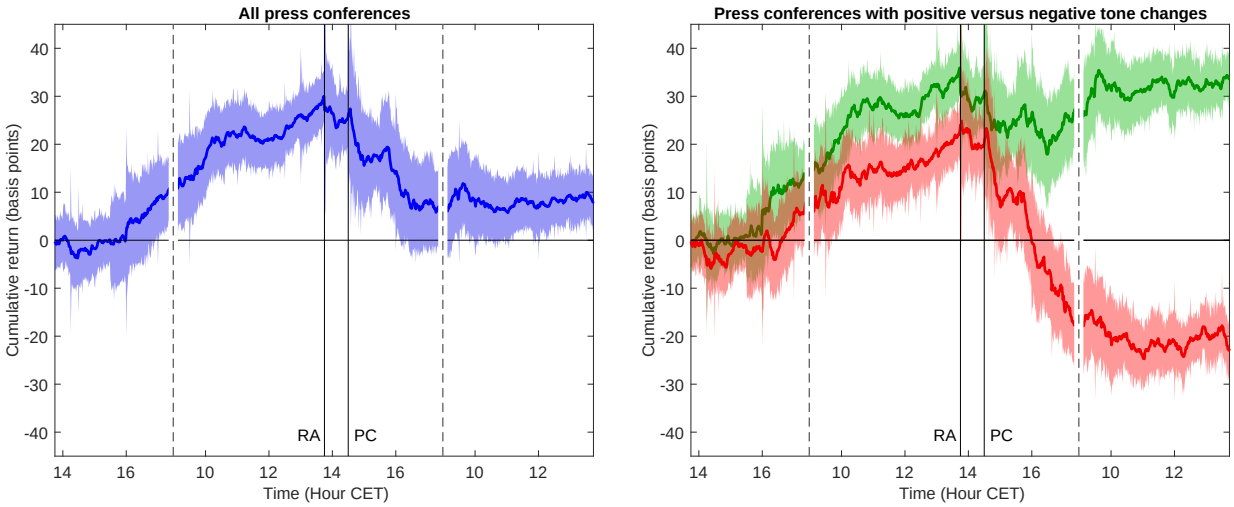
In the empirical analysis, we measure the tone of the ECB president in press conferences held after ECB policy meetings. The ECB was the first major central bank to use press conferences to inform the public about the rationale behind its decisions and to provide an outlook, but recently, other central banks (including the Fed) have started to adopt similar communication strategies. The setup is ideal for our analysis: The ECB holds scheduled monetary policy meetings on Thursdays, announces its interest rate decision at 13:45 CET, and holds a press conference (PC) at 14:30. Since PCs take place during trading hours, financial markets can react to new information instantaneously, and the staggered timing of rate announcement and PC allows to disentangle market reactions to news about policy rates and communication (e.g., Ehrmann and Fratzscher, 2009). We use the ECB in our empirical analysis because it offers the longest history, with 209 PCs between 1999 and 2017, but our results should also provide a useful benchmark for communication effects of other central banks that have started to hold PCs more recently, such as the Fed since April 2011.

To quantify tone, we use the financial dictionary developed by Loughran and McDonald (2011) to identify *negative* words and evaluate each statement's tone by assessing the prevalence of negative words. First, we verify that tone indeed captures how the ECB frames macroeconomic fundamentals, by showing that phrases such as "global imbalances", "disorderly correction", "excessive deficit" and discussions about fundamentals that, e.g., "remain weak" are among the most important drivers of tone. Second, we document a positive relation

between changes in tone and government bond yields. In additional analyses we show, on the one hand, that policy actions and economic projections are correlated with tone changes but have limited explanatory power, on the other hand, that tone changes predict changes in policy rates and, to some extent, fundamentals. These results support the view that the ECB uses tone to communicate its views on the future path of the economy and future monetary policy.

Turning to the relation between CB communication and asset prices, we first study how equity markets respond to changes in tone. Figure 1 provides a preview of our results by plotting the average cumulative returns of the EuroStoxx 50 (a European large cap stock index) in a 48-hour window around policy rate announcements of the ECB.

Figure 1: Stock returns in the 48 hours around ECB policy rate announcements



This Figure shows cumulative returns of the EuroStoxx 50 index in the 48 hours around ECB policy rate announcements. The ECB announces its rate decision at 13:45 (CET) and then holds a press conference, which starts at 14:30 CET. The time-window shown is from 13:45 on the day before until 13:45 on the day after the announcement. The dashed vertical lines indicate the end of a trading day whereas the two solid lines indicate the time of the policy rate announcement ("RA") and the start of the press conference ("PC"), respectively. The left figure shows average cumulative returns across all 209 announcement days from January 1999 to October 2014. The right figure plots average cumulative returns separately for press conferences with tone being more positive than at the previous press conference (green, upper line) and more negative tone (red, lower line).

The plot on the left shows the average cumulative return across all 209 press conferences in our sample. There is a pre-announcement drift before the policy rate announcement at 13:45 CET (indicated by the solid vertical line labeled "RA"), akin to the findings in Lucca

and Moench (2015) for FOMC meetings. Contrary to the FOMC pre-announcement drift, however, these returns are completely reversed in the 24 hours after the announcement. The plot on the right shows average cumulative returns over the same time window but separately for press conferences (PCs) with a more positive tone (green line) and PCs with a more negative tone (red line) compared to the previous PC. Three effects stand out from this figure. First, PCs with a positive tone are associated with significantly higher returns than PCs with a more negative tone. Second, returns are not significantly different at the time of the policy rate announcement ("RA") but only start to diverge significantly after the press conference has started at 14:30 CET (vertical line labeled "PC"). Hence, the return spread of about 50 to 60 basis points between a more positive versus more negative tone is unlikely to be driven by the policy rate decision. Rather, it must be driven by information communicated during the press conference. Third, the return spread between PCs with positive and negative tone changes appears to persist beyond policy meeting days.

The figure suggests that the link between tone changes and equity market returns should also be significant in daily returns, and we show that it is. Moreover, we present evidence for similar tone effects on Eurozone industry sector and country index returns. Our key finding is that the effect of tone changes on returns is robust to controlling for ECB policy rate and unconventional policy announcements, revisions of macroeconomic projections, interest-rate based measures of monetary policy shocks, and past returns. Additionally, we control for other textual characteristics (similarity, complexity, and lexical diversity) to ensure that it is changes in tone and not other communication features that matter for stock prices.

To better understand *how* tone matters for equities, we also study the responses of stocks to tone changes in the cross section. First, we look at industry returns and find that stocks with a higher exposure to systematic risk (as measured by betas) are more sensitive to tone changes; this points to a risk-based channel of tone, akin to Bernanke and Kuttner (2005) who find that risk premia account for most of the stock price response to policy actions in the US. Second, we sort stocks into portfolios based on their ex-ante betas to construct portfolios that directly track their exposures to systematic risk. We find that return sensitivities to tone changes increase with ex-ante betas. In robustness checks, we show that the link between

tone sensitivities and market betas is also significant at the level of individual stocks.

To further test whether tone matters for risk premia embedded in asset prices, we analyze tone-effects in realized and options-implied volatility as well as in corporate credit spreads. When ECB tone becomes more positive, the VSTOXX volatility index (similar to the VIX in the US) decreases, which implies that volatility insurance becomes cheaper. At the same time, realized volatility is essentially unrelated to tone changes. As a consequence, changes in the price of volatility insurance are primarily driven by lowered risk premia required by investors in excess of expected volatility. This, in turn, implies that positive tone changes are associated with market participants lowering their risk aversion. Thus, our finding represents a communication-based analogue to Bekaert et al. (2013), who find that monetary easing decreases risk aversion measured by variance risk premia. Similarly, we find that the yield spread between BBB- and AAA-rated firms decreases when tone becomes more positive, in particular for financial firms. Since variation in credit spreads is mostly driven by risk premia, our results complement evidence of policy effects on credit spreads (e.g., Gertler and Karadi, 2015) and show that tone affects market prices through a risk-based channel as well.

In additional analyses, we show that our results are robust over subsample periods and discuss the link between central bank tone, policy actions, and economic fundamentals in more detail. Moreover, we benchmark our dictionary-based tone measure to other, more sophisticated approaches and we also provide evidence that tone changes do not simply reflect differences in topics discussed at different meetings.

Taken together, our results are consistent with the idea that central bank tone is a generic policy tool that supplements other instruments of monetary policy. Similar to the risk-taking channel of policy actions (see the survey of Adrian and Liang, 2018), our results suggest that tone affects the risk-taking of market participants and the risk premia they require. Hence, our answer to the question posed in the title of this paper is that central bank tone indeed moves asset prices even after controlling for policy actions.

2. Relation to literature

On a general level, our work relates to previous research that analyzes the effect of monetary policy on asset prices and risks. Bernanke and Kuttner (2005) are among the first to show that policy decisions of the Federal Reserve have a strong effect on stock prices. Other studies of equity returns around policy meetings provide evidence for a pre-announcement drift leading up to FOMC meetings (e.g., Lucca and Moench, 2015) and weekly return patterns over FOMC cycles (Cieslak et al., 2018). Neuhierl and Weber (2018b) show that the expected path of monetary policy, measured from Fed Fund futures, predicts stock returns. Other papers that document monetary policy effects on various assets include, e.g., Rigobon and Sack (2004); Bjornland and Leitermo (2009); Buraschi et al. (2014); Campbell et al. (2018). Related, there is a literature that quantifies monetary policy shocks from changes in market prices (e.g. bond yields) in short windows around policy announcements (e.g., Kohn and Sack, 2004; Guerkaynak et al., 2005; Brand et al., 2010; Krishnamurthy and Vissing-Jorgensen, 2011; Hanson and Stein, 2015; Chodorow-Reich, 2014; Nakamura and Steinsson, 2018; Boguth et al., 2018; Ferrari et al., 2017).

Since we find that central bank communication affects the pricing of risk, our results are consistent with a risk-based channel of monetary policy. Early work on this channel includes Shiller et al. (1983), who find that the response of long-term yields to money stock announcements suggests that monetary policy affects term premia. Related, Hanson and Stein (2015) argue that monetary policy affects the risk-taking behavior of investors in their choice of short- versus long-term bonds. Similarly, Gertler and Karadi (2013, 2015) document monetary policy effects on term premia and credit spreads. Moreover, Bernanke and Kuttner (2005) find that monetary policy affects stock prices mostly via expected excess returns. Recent empirical and theoretical work that provides evidence for a risk-taking channel (surveyed by Adrian and Liang, 2018) emphasizes institutional realities and market frictions arising via financial intermediation and regulation (e.g., Borio and Zhu, 2012; Morris and Shin, 2014; Stein, 2014; Brunnermeier and Sannikov, 2016; Drechsler et al., 2018). Studies that focus on unconventional policy include, e.g., Krishnamurthy and Vissing-Jorgensen (2011); Chodorow-

Reich (2014); Hattori et al. (2016); Krishnamurthy et al. (2018). A main contribution of our paper is to show how the tone of central bank communication affects asset prices even when controlling for policy actions.

Since we measure tone from central bank statements, our work relates to the large literature on central bank communication (e.g., Woodford, 2005; Blinder et al., 2008, for a comprehensive survey). Early work includes Romer and Romer (2004) who apply a narrative approach to identify monetary policy shocks from central bank documents. Lucca and Trebbi (2009) analyze the content of FOMC statements by semantic orientation scores estimated from a large information set obtained through search engines. Jegadeesh and Wu (2017) assess how the market responds to different topics discussed in FOMC minutes. Hansen et al. (2017) investigate how transparency affects deliberation of FOMC members, and Hansen and McMahon (2016) study how FOMC communication about economic conditions and forward guidance affect economic and financial variables. More recently, Ehrmann and Talmi (2017) use a human scoring approach to investigate how (small) changes in central bank communication affect financial markets. Other papers that analyze different communication characteristics (such as content, tone, similarity, readability, etc.) include Bligh and Hess (2007); Rosa and Verga (2007); Rosa (2011); Amaya and Filbien (2015). To the best of our knowledge, we are the first to show that central bank tone conveys generic information for asset prices through a risk-taking channel.

3. Measuring central bank tone

Our empirical analysis focuses on the European Central Bank (ECB). The ECB holds its monetary policy meetings on Thursdays (scheduled well in advance), announces its interest rate decision at 13:45 CET, and holds a press conference (PC) at 14:30. Since PCs take place during European trading hours, financial markets can react to new information instantaneously, and the staggered timing of rate announcement and PC provides an ideal setup for disentangling market reactions to news about policy rates and communication tone.

The ECB was the first major central bank to adopt this form of communication and thus offers the longest history to study the impact of central bank tone on asset prices.

Importantly, other central banks have recently followed the ECB's example and started to hold press conferences after their policy meetings. For example, the Federal Reserve has started to hold press conferences very similar to the ECB's setup in April 2011, but only after every other FOMC meeting. Boguth et al. (2018) provide first evidence that markets pay higher attention and respond more strongly to FOMC meetings with PCs than without PCs. In 2018, chairman Jay Powell has announced that the Fed will hold PCs after every FOMC meeting from 2019, emphasizing that increasing the number of press conferences is no indication about future policy actions but only about improving communication.[2] With more and more central banks seeking to improve communication with the public by holding PCs after policy meetings, our results should be a useful benchmark for assessing the likely effects of PCs on financial markets as central banks adopt this form of communication as well.[3]

In total, our sample covers 209 ECB press conferences from January 1999 (the introduction of the Euro) to September 2017. For these PCs, we obtain transcripts of the ECB president's opening statements, which are carefully drafted in advance with a twofold purpose: to inform the general public about the rationale underlying the interest rate decision made by the Governing Council and to provide a general outlook.[4]

Below, we discuss how we measure tone, present summary statistics for ECB tone, and provide evidence that the ECB uses its tone to frame its judgement about economic conditions and to adumbrate its future actions.

3.1. Measuring tone from ECB press conference statements

The objective of our paper is to quantify how changes in central bank tone matter for asset prices. For our main analysis, we deliberately choose a simple dictionary-based measure of tone that we quantify from ECB statements as described below. Additionally, we use the

[2] In his PC on June 13, 2018 (link), Chairman Powell states, "As Chairman, I hope to foster a public conversation about what the Fed is doing to support a strong and resilient economy. And one practical step in doing so is to have a press conference like this after every one of our scheduled FOMC meetings. [...] I want to point out that having twice as many press conferences does not signal anything about the timing or pace of future interest rate changes. This change is only about improving communications."

[3] Other central banks include the Bank of England, who started to hold press conferences after inflation reports in 2015, but also the central banks of, e.g., New Zealand, Norway, Sweden, and Switzerland.

[4] Transcripts are publicly available on the ECB website, *https://www.ecb.europa.eu/press/pressconf/*.

transcripts to compute other text-based measures proposed by previous research to capture changes in the statements' wording, complexity, and lexical diversity. We discuss these textual characteristics in more detail in Appendix A.1 and will control for these characteristics throughout our empirical analysis of tone effects on asset prices.

We start by preparing the transcripts of the ECB press conferences for the subsequent textual analysis as follows: we (i) convert all words to lower case, (ii) remove numbers, (iii) remove punctuation, (iv) remove English stop words (e.g., for, very, and, of, are, etc.), and (v) strip whitespace as is common in the textual analysis literature. After preparing the text files, we construct a proxy for CB tone using the financial dictionary developed by Loughran and McDonald (2011, LM). More specifically, we use this dictionary to identify words that can be classified as *negative* in financial contexts.[5] In each transcript, we count the number of negative words (N) as well as the total number of words (T), and define CB tone (τ) as

$$\tau = 1 - N/T, \tag{1}$$

such that lower values reflect a more negative CB tone and higher values imply a less negative tone. Our empirical analysis focuses on *changes in tone*, $\Delta\tau$, measured as the first difference in τ between two subsequent press conference. Accordingly, we interpret increases in τ as tone becoming more positive and decreases in τ as tone becoming more negative.

Our choice to measure CB tone based on the LM dictionary is driven by the following considerations. First, by relying on this well-established dictionary we avoid the need for a subjective classification of words as being negative or not. Alternatively, we could build our own dictionary of CB language, either by labelling words as negative based on common sense or based on a statistical procedure that classifies certain words as negative based on the market's reaction to the occurrence of these words. However, defining such a list ourselves would essentially mean that we have control over the resulting time series of tone and, thus, the outcome of our empirical analysis later in the paper. Using a statistical procedure to

[5] We only use negative words because the usefulness of positive words for measuring tone is very limited, as discussed by Loughran and McDonald (2011) and also noted by others before. The main reason is that positive words are frequently negated. By contrast, negation of negative words is far less common.

generate a word list would either require to reserve some of data for training the model (which limits the sample available for the economic analysis) or to use the data twice, first to build the dictionary and subsequently to analyze the effect of tone on asset prices (which creates hindsight bias). As a robustness check, we implement such procedures based on Lasso regression and Naïve Bayes classifiers in Section 5. For the main analysis, we use the LM dictionary and thereby avoid the aforementioned concerns.

Second, the LM dictionary is explicitly designed to be informative for financial documents, in contrast to, e.g., the widely used Harvard Dictionary. The LM dictionary was originally designed for 10-K filings but has proven useful in other financial contexts as well; see, e.g., Gurun and Butler (2012), Hillert et al. (2014), and the survey of Loughran and McDonald (2016). While we cannot preclude that CB language differs from the typical language used in 10-K filings to a certain extent, any such misclassification should work against us in the empirical analysis and raise the hurdle to find a link between tone and asset prices.

Finally, we choose to measure tone by means of simple word counts rather than more elaborate techniques. Approaches such as term weighting or topic modelling use the full sample, which implies hindsight bias. Hence, to avoid all these potential biases, we choose simplicity and transparency over more elaborate alternatives in our main tests.[6]

The downside of our approach, as for any other method of textual analysis, is that there can be misclassifications, i.e., cases where a phrase is identified as being negative even though it is not. Below and in the Internet Appendix we use excerpts from PC statements to show which words and phrases drive our tone measure. In any case, misclassifications will only raise the bar for detecting a significant link between tone and asset prices. Our results reported below can thus be seen as a lower bound on the effect of tone on stock prices.

[6]For the same reason, we do not ask human readers to evaluate CB statements. For instance, while a potential advantage of that approach may be that human readers are better in processing certain nuances of texts, a disadvantage is that human judgement cannot be avoided in the scoring process, thereby neither guaranteeing an avoidance of misclassification nor 'reader-fixed effects' in tone measures (e.g., Ehrmann and Fratzscher, 2007). Moreover, it would be difficult to set up a generic out-of-sample analysis of how CB tone matters for asset prices, as multiple readers would have to be trained on a large body of statements.

3.2. Descriptive statistics for ECB tone

Table I presents some descriptives statistics for ECB press conferences. The first column shows that PCs take place regularly but not at equidistant intervals. The average PC cycle is around 23 trading days, with 10 and 50 days for the shortest and longest intervals, respectively. The second column summarizes statistics for the ratio of the number of negative words to the number of total words (N/T), which we use to compute the tone measure defined in Equation (1). The average N/T is around 2.6% and is associated with substantial variability within the range of 0.4% and 5.7%. The third column shows that tone changes ($\Delta\tau$) are close to zero on average and at the median but exhibit substantial variation in the range from -2.4% to $+2.0\%$ as well as significant first-order autocorrelation. Of the 208 ECB tone changes in our sample, we find that tone increases at 114 press conferences and decreases in 94 cases. Figure 2 plots the time series of ECB tone and changes in ECB tone. The grey vertical lines mark the dates of the ECB press conferences. Panel (a) shows that ECB tone reaches its minimum at the end of 2008/beginning of 2009 during the financial crisis and Panel (b) illustrates that the volatility of tone changes over time.

3.3. Which words drive ECB tone?

To provide evidence that tone indeed captures how the ECB frames macroeconomic fundamentals, we present summary statistics for the most frequently used negative words that drive our tone measure as well as for bigrams and trigrams (i.e., sequences of two and three adjacent words) in which they appear. Table II shows that the most frequently used negative words are "weak", "decline", and "imbalances".[7] The most common bigrams and trigrams involving negative words include, for instance, "global imbalances", "weaker (than) expected", "disorderly correction", "financial market volatility", and "high level (of) unemployment". This suggests that our simple, dictionary-based measure correctly captures negative phrases commonly used by the ECB. With this first evidence for tone picking up how the ECB interprets and judges economic developments, we provide several press conference excerpts, to

[7]These counts are based on aggregating words by their word-stem; for example, the 384 occurrences we summarize for "weak" are the sum of occurrences for "weak" (171), "weaken" (6), "weakened" (19), "weakening" (51), "weaker" (90), "weakness" (45), and "weaknesses" (2).

illustrate the broader context in which tone is measured.

Table III presents excerpts from the press conference held on January 15, 2009, which our measure identifies to exhibit the most negative tone during our sample period. In these excerpts, we highlight word sequences involving negative words that we have identified in multiple statements (in red italic font) and mark the negative words by asterisks (*). From this statement, the sentence having the largest impact on our tone measure is from the discussion of economic risks, stating that

> "They relate mainly to the potential for a stronger impact on the real economy of the **turmoil* in financial markets*, as well as to **concerns** about the emergence and intensification of protectionist pressures and to *possible *adverse* developments* in the world economy stemming from a **disorderly* *correction* of global *imbalances**."

In general, reading through these paragraphs, we find support for the view that our tone measure picks up the ECB's framing of economic and financial conditions as well as the economic outlook. To provide a broader picture of what our tone measure captures, we present additional excerpts in the Internet Appendix in Section IA.1. Notably, we only find few cases in which our simple tone measure incorrectly identifies negative words in ECB press conferences, as we also discuss in the Internet Appendix.

3.4. Tone changes and fundamentals

Before we show that central bank tone matters for asset prices in the next section, we present additional evidence consistent with the notion that ECB tone is related to current fundamentals as well as expectations about future economic and monetary policy developments.

We start by presenting results on the link between tone changes and changes in the term structure of government bond yields. The idea is that interest rates embody all relevant information about the future economy. Therefore, a standard approach to gauge the news revealed by central bank announcements and actions is to measure monetary policy shocks from changes in interest rates around monetary policy events. Using German government bond yields (with maturities from 1 to 20 years), Figure 3 presents results for the term

structure of yield changes on ECB press conference days.[8]

Panel (a) shows that, on average across all PC days (dashed blue line), yields of all maturities increase and more so for longer as compared to shorter maturities. When we separate PC days with positive (green) and negative (red) tone changes, we see a similar slope effect for both, but the level of yield changes is significantly different across all maturities: when ECB tone becomes more positive, all yields increase and more so for longer maturities. When ECB tone becomes more negative, yields of shorter maturities decrease whereas yields of longer maturities increase on average. Panel (b) shows estimates and confidence bands from regressions of yield changes on tone changes, suggesting a significant link for shorter maturities, which is consistent with the view that the central bank can manage the short end of the yield curve.

To better understand the dynamics and drivers of central bank tone, we explore the relation between the ECB's tone, its policy actions, its macroeconomic projections, and economic fundamentals. Section IA.2 in the Internet Appendix reports and discusses these results in detail. Our findings can be summarized as follows: First, we find (in Table IA.3) that tone changes are related to changes in policy rates, announcements of unconventional actions, and revisions in the real GDP projection. Notwithstanding these relations, the major share of variation in tone (around 80%) cannot be explained by these or other fundamentals, market variables, or past tone changes. Second, we provide evidence that tone changes are informative about future monetary policy: A more positive (negative) tone predicts future increases (decreases) in policy rates (see Table IA.4). Third, we provide some evidence for predictability of macroeconomic fundamentals, after controlling for policy actions and the ECB's economic projections (see Table IA.5). More specifically, we find that a more positive tone is associated with an increase in (real) industrial production growth and higher business confidence.

In summary, the above results suggest that the ECB uses its tone to frame its judgement about economic conditions and to adumbrate its future actions. Our finding that a large share of the variation in tone is left unexplained by fundamentals and policy actions suggests that central bank communication is a generic instrument of monetary policy.

[8]For details on the yield data see Internet Appendix IA.2.

4. Central Bank Tone and Asset Prices

In this section, we document a strong link between asset prices and the tone of ECB press conference statements. A more positive (negative) tone compared to the previous press conference is associated with higher (lower) equity market returns. In the cross section, stocks' responses to tone changes are commensurate with their exposure to systematic risk, which suggests a risk-based channel of central bank communication. Consistent with tone affecting risk premia embedded in asset prices through such a channel, we also find that a more positive tone is associated with lower volatility risk premia and lower credit spreads. All these results are robust to controlling for the ECB's policy actions, fundamentals, and interest rate-based measures of monetary policy shocks.

4.1. Data for asset prices and control variables

To study the the effect of changes in ECB tone on Eurozone asset prices, we rely on data from various sources, as we briefly discuss here and in more detail in Appendix A.2. In the Internet Appendix, Section IA.3 provides more details and presents descriptive statistics (in Tables IA.6 to IA.9) for all data used in the paper.

For equities, we obtain data for (i) the EuroStoxx 50, which covers the 50 largest firms in the Eurozone; (ii) the MSCI EMU Index, a broad Eurozone index; (iii) 18 EMU Stoxx industry sector indices; (iv) ten MSCI country indices, for EMU countries with data from 1999 through 2017 (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain); (v) individual stocks from the same ten countries from Compustat, which we use to construct portfolios based on firms' ex-ante betas. The data covers the period from the first to the last PC in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations, of which 208 are PC days (with tone changes) and 4,569 are non-PC days.

For this sample period, we also obtain data on the VSTOXX, a volatility index constructed from options on the Eurostoxx 50. We also collect data on the VSTOXX maturity-specific indices, with maturities ranging from one month to two years. Additionally, we obtain data on IBOXX credit indices to compute corporate yields spreads between BBB- and AAA-rated

firms, financial firms, and non-financial firms. The time-series for these data are somewhat shorter, starting in April 1999 for the overall and financial firms indices and in August 1999 for the index covering non-financial firms.

Finally, we collect data for the control variables that we use in our empirical analysis of tone effects on asset prices. First, we obtain data on the ECB's policy rate announcements and compute changes in the rate on main refinancing operations (MRO).[9] Second, we collect the ECB's projections on real GDP and inflation and compute revisions to these projections. With the first projections released on December 14, 2000 and subsequently updated at a quarterly frequency, we observe 67 revisions over our sample period. Third, we use the monetary policy shocks of Leombroni et al. (2018) which cover 161 PCs between February 2001 and December 2014. Our control variable for unconventional monetary policy (UMP_t) takes a value of one when a UMP event (according to Cieslak and Schrimpf, 2018) is announced during a press conference, and zero otherwise.

4.2. Equity returns around ECB press conferences

Akin to the literature that quantifies monetary policy shocks from changes in market prices in short windows around policy announcements, we study the impact of tone changes on asset prices in daily data. The intraday-results, shown above in in Figure 1, suggest that the effect of ECB tone changes on ESX50 prices over the full trading day is very similar to that arising during the press conference. Accordingly, we should find similar PC effects in daily data when we compute returns from the closing prices on the day preceding the PC and the day on which the PC is held.

Table IV provides such evidence for the ESX50 as well as the broad MSCI EMU index, 18 industry sector indices, and ten EMU country indices. In the left part of Table IV, we report results from regressions of daily returns on PC-day dummies and find that not a single coefficient is significantly different from zero. Hence, there is no general premium on PC days, unlike the FOMC premium for the US documented in Lucca and Moench (2015). The right part of the table presents results of regressing returns on separate dummies for PCs

[9]The MRO rate is the main policy rate but using the rates of the deposit facility or the marginal lending facility does not change the results as all three rates are highly correlated.

with positive tone changes and negative tone changes, respectively, and testing whether the estimated coefficients are equal. All dummies for positive tone changes carry a positive slope coefficient and the dummies for negative tone changes have a negative coefficient estimate for 29 of the 30 indices; many of the estimates for positive and/or negative tone change dummies are significantly different from zero. Moreover, we can reject equality of coefficients (based on an F-test) at the 5%-level for both EMU market indices, twelve of the 18 industries, and eight of the ten countries.

4.3. Regressions of equity returns on ECB tone changes

The above results suggest that there is no PC-day premium in EMU equity markets but that stocks react differently when the ECB's tone change is positive or negative. We now provide evidence that tone changes convey generic information for stock returns that is not subsumed by control variables that account for policy actions, revisions of economic forecasts, measures of monetary policy shocks, and other textual characteristics of the PC statements.

4.3.1 EMU stock market returns

Table V presents regression results for the ESX50. Specification (i) regresses PC day returns only on tone changes to provide a benchmark estimate. We find a significantly positive effect of tone changes on returns with a coefficient estimate of 0.34. In economic terms, a one standard deviation increase (decrease) in tone changes, where $\sigma(\Delta\tau) = 0.0076$, translates into a positive (negative) return of around 26 basis points on a PC day. With ten to twelve PCs per year, this translates into 2.5% to 3% *p.a.*, which seems sizeable given that the average annualized return of the ESX50 during our sample is of a similar magnitude.

Specification (ii) adds lagged tone changes (to control for autocorrelation in tone changes) and stock returns from the previous PC to the day before the current PC, to control for the possibility that the ECB might mechanically adjust its tone to recent market conditions (e.g., Cieslak and Vissing-Jorgensen, 2018, provide such evidence for the Federal Reserve). These controls hardly affect the estimate and significance of the coefficient on tone changes.

In specification (iii), we also control for other textual characteristics of PC statements,

discussed in more detail in Appendix A.1. First, we add a proxy for the distance (DIS_t) of statements, which captures how much the wording of a statement differs from that of the previous statement. DIS_t might matter for asset prices if changes in communication reflect changes in the monetary policy stance or economic environment (also see, e.g., Ehrmann and Talmi, 2017). Second, we add proxies for changes in readability, as measured by the FOG-index (ΔFOG_t), and lexical diversity, which we measure by the type-token ratio (ΔTTR_t). More complex and lexically diverse statements are potentially harder to interpret, might increase uncertainty and could thus matter for asset prices. However, these three additional characteristics turn out to be insignificant and they also do not affect the significance of tone changes. Hence, we can rule out that tone changes matter for stocks because they capture features of other textual characteristics.

Next we show in specification (iv) that policy actions taken by the ECB hardly affect the coefficient on tone changes, by controlling for changes in the actual policy rate (ΔMRO_t) and a dummy for unconventional monetary policy announcements (UMP_t).

In specification (v), we show that controlling for the latest changes in the ECB's macroeconomic projections on real GDP growth and HICP inflation has no impact on the significance of tone changes. Finally, we control for monetary policy shocks measured via high-frequency changes in short-term interest rates around PCs. Specifically, we use the estimates of Leombroni et al. (2018) for "target shocks" (short-term interest rate changes measured from 13:40 to 14:25 CET) and "communication shocks" (from 14:25 to 16:10), which are designed to separate the effects of the rate announcement and the ECB's PC communication. We find that the communication shocks have a significant effect on stock markets, but that tone changes remain significant as well.

These results show that changes in ECB tone convey generic information for EMU equity markets, which is not subsumed by changes in (expected) fundamentals or monetary policy shocks measured from high-frequency yield changes. Section IA.4 in the Internet Appendix summarizes additional regression results that corroborate our findings. Repeating the regressions with ESX50 intraday data confirms that this is only the case during the PC, i.e., in the time-window from 14:30 to 17:30 CET, as already suggested by Figure 1; for detailed intraday

results see Table IA.10 in the Internet Appendix. The results are also very similar for the broader MSCI EMU index (Table IA.11) as well as for country indices, where we find that Ireland is the only case in which equity returns are not significantly related to tone changes (see Table IA.12).

4.3.2 Cross-section of EMU stocks

When we repeat the regression analysis for industry sectors, the evidence is more mixed. Table VI shows that all estimates of the coefficient on tone changes are positive but there is variation in the degree of significance and in the regressions' adjusted-R^2s. These results suggest that tone changes are not equally important for all stocks.

To understand the heterogeneity in the industry results, we analyze whether cross-industry return differentials are commensurate with cross-industry differentials in systematic risk. To assess systematic risk, we conduct two exercises. First, we show that stocks' responses to tone changes are proportional to their market betas, i.e. high beta stocks earn higher (lower) returns than low beta stocks on PC days with positive (negative) tone changes.[10] Second, we show that stocks' market betas are positively correlated with their tone sensitivities, i.e. high beta stocks are more sensitive to tone changes than low beta stocks.

We estimate industries' market betas from regressing their returns on the returns of the broad MSCI EMU index and present the results in Figure 4. Panel A shows that market betas estimated from all days in our sample (x-axis) and betas estimated only from non-PC days or PC days (y-axis) are very similar. Hence, betas do not appear to systematically differ on PC and non-PC days. Using the betas estimated from all days in our sample, we compare realized to CAPM-implied returns on PC and non-PC days in Panel B. For non-PC days, we find that the relation between betas and realized returns is slightly inverse. On PC days the relation is somewhat positive, but the CAPM pricing errors appear large. However, Panel C shows that realized returns align with CAPM-implied returns quite well when we present

[10] If the CAPM worked well empirically, this could be considered a 'mechanic' result in that tone changes reflect systematic shocks that are captured by market returns and consequently transmitted to stock returns proportional to their betas. However, given the general evidence against the CAPM, this is an economically important finding in its own right.

them separately for PC days with positive and negative tone changes: On PC days with positive tone changes, which are associated with positive market returns on average, industry returns increase with betas, and vice versa for negative tone changes. Additionally, Panel D shows that there is a positive relation between industries' sensitivities to tone changes and their market betas, which shows that tone directly matters for stocks' systematic risk.

To sharpen our understanding of the link between stocks' sensitivities to tone changes and their systematic risk, we next turn to portfolios of individual stocks sorted by their ex-ante betas. The idea is to design portfolios that directly track stocks' exposures to systematic risk. We follow Frazzini and Pedersen (2014) and Fama and French (2017) in using the Compustat Global universe, but restrict ourselves to countries that have been EMU members since 1999. For each firm, we estimate its ex-ante beta as proposed by Frazzini and Pedersen (2014), who show that ex-ante betas predict subsequently realized exposures to systematic risk very well. At the end of each day, we sort stocks into decile portfolios based on their ex-ante betas and compute the portfolios' value-weighted returns.[11]

We present the main results in Figure 5. Panel A shows that (realized) market betas estimated from all days, PC-days, and non-PC days are very similar; in other words, ex-ante betas are good predictors for realized betas on PC and non-PC days. Panel B suggests that the CAPM may not provide a good representation of realized returns on, both, PC days and non-PC days, but Panel C reveals that realized returns are quite similar to CAPM-implied returns once we condition on the sign of tone changes. Finally, Panel D shows that there is a positive relation between the portfolios' regression coefficients on tone changes and their market betas. To confirm the statistical significance of these results, Table IA.13 in the Internet Appendix presents detailed regression evidence for the ten beta portfolios and the high-minus-low beta portfolio. Specifically, we find that the high-minus-low beta portfolio exhibits large differences in returns on PC days with positive compared to negative tone changes and that the regression coefficient on tone changes is highly significant (with and

[11]For details on the data and computation of ex-ante betas see Appendix A.2. We choose daily rebalancing such that portfolio compositions reflect the most recent information on any PC day (since we are not directly interested in trading these portfolios, we are not worried about turnover) and value-weighting of returns to mitigate the influence of small and illiquid stocks in accordance with the literature. For descriptive statistics for these portfolios see Internet Appendix IA.3.

without control variables).

The results for the beta portfolios are qualitatively the same but more clear-cut than for the industry indices. Our findings imply that stocks' responses to changes in central bank tone are commensurate with their systematic risk, similar to stocks' responses to monetary policy actions documented by Bernanke and Kuttner (2005). Our results also extend the findings of Savor and Wilson (2014), who show for the US that the CAPM works much better on scheduled FOMC announcement days than on days without announcements. Our findings reveal that the CAPM holds in EMU stock markets on ECB announcement days once we account for the ECB's communication tone. The role of tone for our CAPM results compared to those of Savor and Wilson (2014) is akin to the result documented above that there is no general announcement day effect in EMU markets (i.e., without conditioning on tone) whereas there is such an effect on FOMC announcement days in the US (Lucca and Moench, 2015).

Taken together, the results for the market and for the cross-section imply that ECB tone conveys twofold information about systematic risk, i.e. both for the risk factor and for the factor loadings. On the one hand, tone changes reflect systematic shocks that are captured by market returns. On the other hand, stocks' market betas are correlated with their tone sensitivities.[12] In the next section, we provide more evidence for such a risk-based channel.

4.4. A risk-taking channel?

Our empirical findings suggest that tone changes matter for stock markets through a risk-based channel, akin to Bernanke and Kuttner (2005), and there is ample evidence in the literature that monetary policy actions can affect risk premia (see the survey of Adrian and Liang, 2018). In what follows, we show that central bank communication matters for asset prices through such a risk-taking channel as well.

We follow Bekaert et al. (2013, 2017), who propose to measure time-variation in risk aversion via variance risk premia implied by equity options. Bekaert et al. (2013) show that monetary policy tightening shocks are associated with increases in variance risk premia that

[12] In our robustness checks, summarized in Section 5 and discussed in detail in Internet Appendix IA.4, we also document a significantly positive relation of market betas to tone sensitivities for individual stocks.

reflect heightened risk aversion. Similarly, we find that a more positive central bank tone is associated with a significant decrease in options-implied volatility and volatility risk premia.

Bekaert et al. (2017) also report that credit spreads are correlated with economic uncertainty, which complements earlier evidence that credit spreads predict future economic activity. Specifically, Gilchrist and Zakrajšek (2012) show that the link between credit spreads and economic activity is driven by the spreads' embedded risk premia, which also account for most of the spreads' variation. The economic mechanism is that heightened economic uncertainty leads to a reduction of credit supply and an increase of credit risk premia. Recent evidence shows that monetary policy directly affects credit risk premia through its impact on intermediaries' risk-taking (e.g., Chodorow-Reich, 2014; Dell'Ariccia et al., 2017; Drechsler et al., 2018; Adrian and Liang, 2018), and consistent with such a channel we also find that a more negative communication tone is associated with higher credit spreads.

4.4.1 Realized versus implied volatility and implications for risk aversion

Our findings above suggest that investors adjust their expectation for the market return, and thereby the market risk premium for pricing the cross-section of stocks, in response to changes in ECB tone. Conceptually, such adjustments may be driven by changes in the quantity of risk that investors face or the premium they require per unit of risk. To analyze these different dimensions, we assess the realized volatility of ESX50 returns, changes in index options-implied volatility, and the link between realized volatility and changes in implied volatility. Understanding the link between realized and implied volatility is particularly interesting, because this relation is driven by volatility risk premia which can be directly connected to investors' risk aversion (e.g., Bekaert et al., 2013, 2017).

Realized volatility We use high-frequency data to compute the realized volatility (RV) of the ESX50 for each trading day in our sample, following the approach of Bollerslev et al. (2018).[13] For each day, we also compute the realized volatility from 14:30 to 17:30 (RV_{PC}),

[13]For each day in our sample, we (i) compute five daily series of squared five-minute log returns, starting at the first five unique one-minute marks, respectively; (ii) compute the sum of squared returns for each of the five series; (iii) obtain that day's estimate of realized variance as the average of the five sums; (iv) take the square root to obtain our estimate of realized volatility. Bollerslev et al. (2018) provide a discussion that

which captures the time window of the PC on ECB announcement days. Using both estimates, we check whether realized volatility is different on PC and non-PC days and whether realized volatility is different on PC days with positive compared to negative tone changes.

Panel A in Table VII reports the results from regressing RV or RV_{PC} on PC- and PC tone change-dummies. We find that realized volatility is significantly higher on PC days compared to non-PC days, by about 13 basis points over the full trading day and by about 15 basis points in the time from 14:30 to 17:30. However, the sign of ECB tone changes does not appear to matter for realized volatility, as we are far from rejecting the null hypothesis of equal coefficients when we regress RV and RV_{PC} on separate dummies for PCs with positive and negative tone changes; the p-values of the F-tests are 0.38 for RV and 0.58 for RV_{PC}.

Options-implied volatility Next, we compute changes in index options-implied volatility, measured from the VSTOXX. The VSTOXX is a volatility index computed from options on the ESX50, similar to the VIX based on S&P 500 options in the US.[14] The VSTOXX can be interpreted as a price of volatility insurance, since $VSTOXX$ is the fixed leg in a volatility swap that pays the difference in implied volatility and future realized volatility of the ESX50. To analyze whether ECB tone matters for the pricing of insurance against future volatility, we compute log changes in VSTOXX from the close on the day before the PC to the close on the PC day, i.e., the timing is exactly the same as in our analysis of stocks.

The results in Panel A of Table VII show that implied volatility significantly decreases on PC days, by about one percent. However, once we distinguish between PCs with positive and negative tone changes, we find that implied volatility significantly decreases only on days with positive tone changes (by −1.85%) whereas it slightly increases on PC days with negative tone changes (by 0.12%); accordingly, we can reject the hypothesis of equal dummy coefficients with a p-value of 0.02. Hence, our results suggest that volatility insurance becomes cheaper when ECB tone becomes more positive.

this procedure provides an efficient estimate of realized volatility.

[14]The VSTOXX is designed to make pure volatility tradable and to be replicable by options portfolios that do not react to ESX50 price changes but only to volatility changes. The VSTOXX is computed from maturity-specific sub-indices, which themselves are computed from ESX50 options in predefined maturity buckets and across moneyness levels. For details see the STOXX (2018).

Volatility risk premia and risk aversion The above findings are intriguing, because they suggest that ECB tone matters for the volatility risk premium and hence for investors' risk aversion. Changes in implied volatility are due to changes in expected future volatility or changes in the volatility risk premium that investors are willing to pay on top of expected volatility. Given that realized volatility is not significantly different on PC days with positive and negative tone changes, it seems unlikely that ECB tone affects expectations about future realized volatility; and we provide more evidence for this view below. Instead, ECB tone appears to affect the VSTOXX through changes in volatility risk premia.

To assess changes in the volatility risk premium (VRP), we compute log changes in the VSTOXX relative to realized volatility, using both RV and RV_{PC}.[15] The results in Panel A of Table VII suggest that VRPs decrease on PC days, at moderate levels of significance (t-statistics of −2.39 and −2.00 for the VRP-proxies based on RV and RV_{PC}, respectively). Once we control for the sign of ECB tone changes, we find a significant decrease in VRPs when ECB tone becomes more positive, whereas VRPs tend to increase when the tone change is negative. As a result we can reject the null hypothesis of equal coefficients for the positive and negative tone change dummies with p-values of 0.01 or less for both VRP-proxies.

Regressions on ECB tone changes To provide further evidence for a link of implied volatility and volatility risk premia to ECB tone, we run regressions of changes in VSTOXX and VRPs on tone changes and the set of control variables that we have also used in our analysis of stock returns above. The results in Panel B of Table VII show that the coefficient estimate for tone changes is significantly negative in all specifications. Moreover, the (mostly significant) negative coefficients for UMP_t are in line with, e.g., Hattori et al. (2016), who show that unconventional monetary policy affects options-implied tail risk in equity markets. Additionally, we repeat the regression analysis for different VSTOXX-maturities, ranging from

[15] Our goal is to track changes in VRP at high frequency. Ideally, we would like to measure VRP from a one-day volatility swap that pays the difference between one-day $VSTOXX$ (fixed leg) and realized volatility over the PC day (floating leg), but unfortunately such contracts do not exist. Since we are not interested in precisely measuring VRP but only whether VRP increases or decreases, we compare the one-day change in the VSTOXX relative to realized volatility. To rule out the hypothetical case that tone changes may not affect RV and RV_{PC} but realized volatility going forward, we verify that there are no tone-related patterns in realized volatility over the next week, month, three months; see Section IA.4 in the Internet Appendix.

one month to two years. Figure 6 illustrates that the estimated coefficients are significantly negative and monotonically increase with maturity, except for a small twist at the one-year horizon. These results suggest that communication tone has a stronger impact on short-term compared to longer-term risk premia.

Hence, akin to the finding of Bekaert et al. (2013) that monetary easing decreases variance risk premia, we find that a more positive communication tone is associated with a significant decrease in volatility risk premia. Since we control for policy actions and fundamentals, our results suggests that changes in ECB tone affect investors' risk aversion as well.

4.4.2 Credit spreads

We use credit spreads to provide further evidence that ECB communication matters for asset prices through a risk-taking channel. Specifically, we explore the relation of changes in yield differentials of BBB- and AAA-rated corporate bonds to changes in tone.

Table VIII presents results for broad credit indices and for indices covering either financial or non-financial firms. Panel A shows that credit spreads tend to decrease on PC days, but the only (moderately) significant effect we find is for financial firms (−1.3 basis points, t-statistic of −1.9). When we test for differences in PC day-effects conditional on tone becoming more positive or negative, we find a significant difference for financial firms (p-value 0.03), where a more positive tone is associated with a spread decrease of −2.6 basis points. Using the same dummy regressions, we find weaker results for the credit spreads of all firms (p-value of 0.13) and no PC effects for non-financial firms (p-value of 0.35).

Turning to the regression analysis in Panel B, we obtain a similar picture but with more pronounced results. There is a negative relation between changes in credit spreads and changes in ECB tone, with the link being most significant for spreads of financial firms.[16] Among the control variables, we note that revisions of real GDP growth projections negatively affect credit spreads of financial firms, which appears consistent with a link between credit risk pre-

[16]Since the regression results suggest that lagged tone changes are also significant, we also run these regressions, as well as the regressions for equity market returns, implied volatility, and volatility risk premia, with five lags of tone changes. The results confirm that current tone changes are a significant driver of changes in asset prices, as we discuss in Section IA.4 in the Internet Appendix.

mia and economic activity as in Gilchrist and Zakrajšek (2012). Additionally, announcements of unconventional monetary policy actions (UMP_t) have a (mostly) significant negative effect on credit spreads, in line with the aforementioned references (e.g., Chodorow-Reich, 2014), and we also find that positive target shocks significantly reduces spreads of financial firms. Controlling for these and other effects, the coefficient estimate on tone changes are significantly negative in all specifications for financial firms (t-statistics between −3.12 and −3.46) and for the set of all firms (t-statistics around −2.5) but less for non-financial firms (t-statistics between −1.74 and −1.99).

Our findings are in line with previous research on how monetary policy actions matter for credit spreads (e.g., Gertler and Karadi, 2015) and suggest that central bank communication matters through a risk-taking channel as well. The stronger results for spreads of financial compared to non-financial firms further support this view.

5. Additional results and robustness tests

This section summarizes additional results and robustness checks, which we present detail in the Internet Appendix.

Robustness over subsample periods To show that our results are not driven by a particular period in our sample (e.g., the financial crisis), we repeat the empirical analysis for 14 five-year subsamples. As discussed in Section IA.5 in more detail, Figure IA.1 shows that there is a positive spread in stock market returns on days with positive compared to negative tone changes in each of the subsamples. In the cross-section of stocks, we find that that the difference in responses for positive versus negative tone changes for high compared to low beta stocks is always positive, in a range from 50 to 100 basis points across subsamples. Moreover, we find that changes in the VSTOXX and volatility risk premia are negatively related to tone changes in each subsample, as they are in the full sample. The inverse relation between tone changes and credit spreads of financial firms appears to exist since 2009, i.e., after the onset of the crisis when investors became particularly concerned with the health of financial institutions. Taken together, these results lend further support to the notion of a risk-taking

channel of central bank communication.

Tone changes and returns on individual stocks In the core of the paper, we report results for industry sector and beta-sorted portfolios to study the cross-sectional effects of ECB tone changes. In Internet Appendix IA.4, we discuss results for individual stocks. While, of course, there is substantial variation in firms' sensitivities to tone changes in monetary policy (as there also is for policy actions, see, e.g., Karolyi and McLaren, 2017, for an analysis of individual stocks in emerging markets following the Fed's taper episode), our analysis confirms a significantly positive relation between stocks' market betas and their sensitivity to ECB tone changes that is qualitatively the same as for industry and beta portfolios (Panels D in Figures 4 and 5). More specifically, in cross-sectional regressions of tone sensitivities on betas the slope coefficient estimate is 0.27, i.e., firms' tone sensitivities increase by 0.27 per unit of beta, as shown in Figure IA.2 in the Internet Appendix. This estimate is close to the tone sensitivity of the market, i.e., 0.32 for the MSCI EMU index (Table IA.11 in the Internet Appendix), and suggests that individual stocks' responses to ECB tone changes represent compensation for systematic risk.

Alternative methods of textual analysis Our paper uses a dictionary-based measure of central bank tone and throughout the empirical analysis we control for other textual measures aimed at capturing changes in wording, complexity and lexical diversity. In the Internet Appendix, we discuss alternative approaches to quantify central bank communication. In Section IA.6, we let the data speak for itself and use Lasso regressions and Naïve Bayes classifiers to identify words and n-grams that predict ESX50 returns on PC days. The main take-away is that more flexible methods can outperform the simpler dictionary-based approach to some extent but are hard to interpret economically. In Section IA.7, we additionally explore whether tone changes simply proxy for certain topics discussed at PCs. We follow Hansen and McMahon (2016) and estimate topics from the corpus of all 209 ECB statements in our sample based on latent dirichlet allocations (LDA) models by Blei et al. (2003). When we repeat the regressions of stock returns on tone changes and control for different topics identified by the algorithm, we still find that tone changes are significant. In other words,

tone changes are not simply a proxy for certain topics but convey independent information.

6. Conclusion

This paper shows that the *tone* of central bank communication matters for asset prices through a risk-based channel. We use a systematic approach to measure the tone of the ECB president in press conferences held after policy meetings and find that a more positive tone (compared to the previous press conference) is associated with higher equity market returns, cross-sectional stocks returns commensurate with systematic risk, lower volatility risk premia, and lower credit spreads. Our results suggest that central bank tone affects risk premia embedded in asset prices very similarly to the risk premium effects of policy actions transmitted through the risk-taking channel of monetary policy.

Our empirical analysis focuses on the ECB, which was the first central bank to hold press conferences after policy meetings and thus offers the longest history for our analysis, with 209 press conferences between 1999 and 2017. We first show that ECB tone captures how the ECB frames its policy decisions and its assessment of economic fundamentals. Next, we document a strong link between ECB tone and equity prices such that a more positive tone is associated with increasing stock prices and vice versa. Using high-frequency data, we show that all of this effect occurs after the start of the press conference and that none of the effect comes from the announcement of the policy rate decision (which is released 45 minutes before the start of the press conference). The link between tone changes and stock returns is statistically significant, economically large, and robust to controlling for policy actions, economic projections, interest rate-based measures of monetary policy shocks, and other textual characteristics (similarity, complexity, lexical diversity). In other words, central bank tone conveys generic information relevant for financial markets.

To substantiate our claim that tone affects asset prices through a risk-based channel, we show, first, that the tone-responses of stocks are proportional to their market betas and consistent with a transmission of systematic risk reflected in market returns. Second, we show that tone matters for options-implied volatility but not for realized volatility, and our results imply that a more positive tone is associated with cheaper volatility insurance due to lowered

volatility risk premia. Third, we find that a more positive tone is associated with lower yield differentials between BBB- and AAA-rated corporate bonds, in particular for financial institutions. All these results are reminiscent of the risk-taking effects arising from monetary policy actions (surveyed by Adrian and Liang, 2018). However, since we control for policy actions, our findings support the view that communication tone is an important, additional instrument of the monetary policy toolkit that allows central banks to affect the risk appetite of market participants.

In this paper, we have focused on the ECB, because it provides the longest history of press conferences to study tone effects. More recently, several other central banks (including the Fed) have started to hold press conferences very similar to those of the ECB to further their communication with the public. It will be interesting to see how their tone matters for asset prices and our results may serve as a benchmark to gauge such communication effects.

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Appendix

A.1. Other textual characteristics of ECB statements

Throughout our empirical analysis, we control for other textual characteristics of ECB press conference statements to rule out that tone changes matter for asset prices because they capture features of these other characteristics, which describe in more detail below.

First, we compute the "distance" (DIS_t) between two consecutive PC statements. DIS_t is based on the Euclidean distance between two vectors (one for each PC) where each vector counts the number of occurrences of each word (each word is represented by one row in the two vectors). Thus, larger values imply larger differences in the wording used in the two PCs.[17] We control for DIS_t because Bholat et al. (2015) and Ehrmann and Talmi (2017) suggest that CB communication might affect markets differently depending on how much it deviates from previous communication.

Second, we use the FOG-index to quantifiy the complexity/readability of ECB statements and measure changes in the index (ΔFOG_t) between consecutive PCs. The Fog-Index aims at measuring the number of years of education needed to understand a text on first reading and is computed from the text's average number of words per sentence and its percentage of complex words (defined as words with more than two syllables). For more details about the FOG-index, its application in financial research, and alternative readability measures (that in our application yield very similar results) see the survey of Loughran and McDonald (2016). Third, and somewhat related, we control for changes in the lexical diversity of ECB statements. Specifically, we compute the type-token ratio (TTR), i.e., the ratio of unique words (types) to total words (tokens) and its changes (ΔTTR_t) between consecutive PCs.

We control for ΔFOG_t and ΔTTR_t to account for the possibility that tone changes may be correlated with changes in complexity and lexical diversity. Complex and lexically diverse statements may have a worse 'signal-to-noise' ratio than simpler statements, which could

[17] We choose Euclidean distance for its simplicity. We have also experimented with alternative distance measures such as cosine similarity, which are immune to mechanical effects due to variation in text lengths across documents, and obtained similar results. Moreover, computing distance metrics based on bigrams (e.g. Tetlock, 2011; Amaya and Filbien, 2015) leads to very similar results.

impact on the effectiveness of central bank communication to markets (e.g. Woodford, 2005; Blinder et al., 2008). By controlling for ΔFOG_t and ΔTTR_t we can rule out that tone effects on asset prices may simply reflect that market participants respond differently to complex and lexically diverse compared to simple statements, because these are harder to interpret and lead to more uncertainty.

A.2. Data

Equity index data For equities, we obtain index data for (i) the EuroStoxx 50 directly from STOXX (https://www.stoxx.com/). We obtain MSCI index data from Datastream for (ii) the aggregate Euozone index MSCI EMU Index (mnemonic:). (iii) 18 EMU Stoxx industry sector indices (S2TEO2E, S2TEC2E, S2TEBAE, S2TES2E, S2TEIGE, S2TEA2E, S2TEFBE, S2TEHHE, S2TEH2E, S2TERTE, S2TEM2E, S2TER2E, S2TET2E, S2TEU2E, S2TEB2E, S2TEINE, S2TEFSE, and S2TEG2E). (iv) ten country indices: MSASTRL (Austria), MSBELGL (Belgium), MSFINDL (Finland), MSFRNCL (France), MSGERML (Germany), MSEIREL (Ireland), MSITALL (Italy), MSNETHL (Netherlands), MSPORDL (Portugal), MSSPANL (Spain). The data covers the period from the first to the last PC in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations, of which 208 are PC days (with data for tone *changes*) and 4,569 are non-PC days.

Individual stocks and ex-ante betas Our data on individual firms' stock returns are from the Compustat Global Securities Daily database as in Frazzini and Pedersen (2014) and Fama and French (2017), but we restrict the sample to countries that have been EMU members since the start of the euro in 1999: Austria, Belgium, Finland, France, Germany, Italy, Ireland, the Netherlands, Portugal, and Spain. We consider only common shares (TPCI equal to zero) and adjust returns for dividends and stock splits. The total number of stocks based on these criteria is 6,443. The frequency is daily and the sample period is January 1999 to September 2017.

We compute daily ex-ante betas as in Frazzini and Pedersen (2014). The ex-ante beta for firm i on day t is computed as $\widehat{\beta}_{i,t} = \widehat{\rho}_t(\widehat{\sigma}_{i,t}/\widehat{\sigma}_t^m)$, where $\widehat{\sigma}_{i,t}$ and $\widehat{\sigma}_t^m$ denote the stock and

market return standard deviation, respectively, computed over a backward-looking window of 252 trading days. $\widehat{\rho}_{i,t}$ is the correlation of firm i's stock return with the market return over the previous five years, based on three-day overlapping (log) returns to account for non-synchronous trading. We require at least six months (three years) of non-missing data to estimate volatilities (correlations) and we shrink betas towards one as suggested by Frazzini and Pedersen (2014) by weighting estimated betas with a factor of 0.6 and adding 0.4.

VSTOXX and credit spreads We obtain data for the VSTOXX and its maturity-specific sub-indices directly from STOXX (https://www.stoxx.com/), covering the same sample period as for equities. The corporate credit spreads are based on IBOXX credit indices obtained via Datastream: IBC3AAL (AAA firms) and IBC3BAL (BBB firms). Indices for financials and non-financials are based on mnemonics IBEFN3A and IBEFN3B (financials) as well as IBENF3A and IBENF3A (non-financials). The time-series for these data are somewhat shorter, starting in April 1999 for the overall and financial firms indices and in August 1999 for the index covering non-financial firms.

Other data We collect data on the ECB's policy rate announcements and projections on real GDP and inflation from the statistics section of the ECB website (https://www.ecb.europa.eu/stats/). With the first projections released on December 14, 2000 and subsequently updated at a quarterly frequency, we observe 67 revisions over our sample period. Our control variable for unconventional monetary policy (UMP_t) takes a value of one when the UMP events identified by Cieslak and Schrimpf (2018) are announced during a press conference, and zero otherwise. To control for monetary policy shocks, we use the target and communication shocks of Leombroni et al. (2018); their data covers 161 PCs between February 2001 and December 2014.

Table I: The Tone of ECB Press Conference Statements

This table reports descriptive statistics for the 209 ECB press conferences between January 7, 1999 and September 7, 2017. The first column reports the number of business days between press conferences (PCs). N/T reports the ratio of the number of negative words (N) divided by the total number of words (T) in the president's opening statement at the PC (in percentage points). $\Delta\tau$ measures the change in tone τ compared to the tone at the previous PC, where $\tau = 1-N/T$ as defined in Equation (1); reported numbers are the changes in percentage points. For the 208 realizations of $\Delta\tau$, we also report the coefficient of an AR(1) regression and the associated t-statistic. 'Obs $\Delta\tau > 0$' denotes the number of tone changes when tone becomes more positive and 'Obs $\Delta\tau < 0$' counts the observations when tone becomes more negative.

	Days between PCs	N/T [in %]	$\Delta\tau$ [in %]
Mean	22.8	2.585	0.004
Std dev	6.2	0.999	0.762
Min	10.0	0.361	-2.409
Median	20.0	2.495	0.047
Max	50.0	5.651	2.015
AR(1)			-0.409
t-statistic			[-6.46]
Obs $\Delta\tau > 0$			114
Obs $\Delta\tau < 0$			94

Table II: Which Words Drive Tone?

This table presents descriptives statistics for the "negative" words (as classified by the dictionary of Loughran and McDonald, 2011) that are most prevalent in ECB press conference statements. The left panel, reports the 20 most frequently used negative words, ordered by the number of their occurrence across all ECB press conferences statements; these counts are based on aggregating words by their word-stem. The center and right panels show the context in which negative words are most frequently used by the ECB by presenting counts for bigrams and trigrams (i.e., sequences of two and three adjacent words), respectively. The analysis is based on 209 ECB press conference statements between January 7, 1999 and September 7, 2017.

Words	#	Bigrams	#	Trigrams	#
weak	384	global imbalances	86	correction global imbalances	38
decline	341	weaker expected	50	global imbalances regard	36
imbalances	226	fiscal imbalances	39	imbalances regard price	36
concerns	209	correction global	38	disorderly correction global	36
negative	179	imbalances regard	37	lagged relationship business	33
volatility	176	disorderly correction	36	reflect lagged relationship	29
unemployment	156	possibility disorderly	35	possibility disorderly correction	26
deficit	149	lagged relationship	33	pressures possibility disorderly	25
crucial	147	structural unemployment	31	prolonged period low	25
dampened	143	excessive deficit	30	continue reflect lagged	24
slow	139	prolonged period	29	financial market volatility	23
downward	117	reflect lagged	29	high level unemployment	22
challenges	107	level unemployment	28	financial market turmoil	21
adverse	84	disorderly developments	25	disorderly developments owing	20
correction	81	remain weak	25	owing global imbalances	20
lagging	76	excessive deficits	24	crucial social partners	18
disorderly	67	high unemployment	24	balance sheet restructuring	18
restructuring	67	market volatility	24	concerns remain relating	18
excessive	63	revised downwards	24	weaker expected domestic	17
turmoil	61	financial turmoil	22	sluggish pace implementation	17

Table III: Excerpts from the ECB President's Statement on January 15, 2009

This table presents excerpts of the the ECB president's introductory statement, given at the press conference on January 15, 2009. Our measure of central bank tone identifies this statement to exhibit the most negative tone of all statements in our sample. From this statement we present the three paragraphs that have the largest impact on our tone measure, i.e., the three paragraphs with the highest ratio of negative words to total words. Words highlighted in red italic font and marked by asterisks (*) are negative words identified by the dictionary we employ. Other words highlighted in red italic font are common word sequences involving negative words that we have identified in multiple statements.

- Looking further ahead, on the basis of our current analysis and assessment, we continue to see global *economic *weakness** and very **sluggish* domestic demand *persisting** in the coming quarters as the impact of the financial tensions on activity continues. At the same time, we expect the fall in commodity prices to support real disposable income in the period ahead. Furthermore, the euro area should over time reap the full benefit from the effects of policy measures announced over recent weeks.

- In the view of the Governing Council, this outlook for the economy remains surrounded by an exceptionally high degree of uncertainty. Overall, risks to economic growth remain clearly on the downside. They relate mainly to the potential for a stronger impact on the real economy of the **turmoil* in financial markets*, as well as to **concerns** about the emergence and intensification of protectionist pressures and to *possible *adverse* developments* in the world economy stemming from a **disorderly* *correction* of global *imbalances**.

- Risks to price stability over the medium term are broadly balanced. **Unexpected* further *declines** in commodity prices or a stronger than expected slowdown in the economy could put **downward* pressure* on inflation, while upside risks to price stability could materialise particularly if the recent fall in commodity prices were to reverse or if domestic price pressures turn out to be stronger than assumed. It is therefore **crucial** that price and wage-setters fully live up to their responsibilities.

Table IV: ECB Press Conferences, Tone Changes, and Equity Returns

This table presents results for the role of ECB press conferences (PCs) for daily equity returns of Eurozone market, industry, and country indices. In the left Panel, we report results from regressing returns on a constant and a dummy, $\mathbb{1}$(PC), that is one on days with PCs and zero otherwise. In the right panel, we report results from regressing returns on a constant and separate dummies for PC days with positive tone changes ($\Delta\tau > 0$) and negative tone changes ($\Delta\tau < 0$). Additionally, we report the p-value of an F-test that the coefficient estimates for both dummies are equal. The data covers the period from the first to the last PC in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes.

	PC days		PC days with positive vs negative tone changes			
	const	$\mathbb{1}$(PC)	const	$\mathbb{1}(\Delta\tau > 0)$	$\mathbb{1}(\Delta\tau < 0)$	p[F]
EMU market indices						
Eurostoxx 50	0.98	0.13	0.98	27.27	-32.77	0.01
	[0.52]	[0.01]	[0.52]	[1.67]	[-2.22]	
MSCI EMU	1.26	-1.14	1.26	23.56	-31.11	0.01
	[0.70]	[-0.11]	[0.70]	[1.56]	[-2.31]	
Industry sector indices						
Auto parts	3.34	3.28	3.34	33.97	-33.94	0.01
	[1.23]	[0.24]	[1.23]	[1.63]	[-2.08]	
Banks	-0.17	6.72	-0.17	35.10	-27.69	0.02
	[-0.06]	[0.47]	[-0.06]	[1.70]	[-1.46]	
Basic resources	2.97	-2.60	2.97	16.65	-25.94	0.14
	[1.12]	[-0.17]	[1.12]	[0.73]	[-1.49]	
Chemicals	4.33	-13.16	4.33	2.20	-31.79	0.10
	[2.18]	[-1.23]	[2.18]	[0.14]	[-2.29]	
Construction Materials	3.17	-6.58	3.17	18.75	-37.30	0.01
	[1.55]	[-0.57]	[1.55]	[1.06]	[-2.82]	
Financial Services	1.78	0.04	1.78	15.04	-18.15	0.08
	[0.92]	[0.00]	[0.92]	[1.08]	[-1.44]	
Food and beverages	3.19	-7.53	3.19	11.49	-30.61	0.01
	[2.17]	[-0.92]	[2.17]	[0.94]	[-3.10]	
Health care	3.04	-10.05	3.04	9.94	-34.30	0.01
	[1.85]	[-1.19]	[1.85]	[0.86]	[-2.97]	
Industrial goods	3.46	-2.76	3.46	19.84	-30.16	0.03
	[1.66]	[-0.23]	[1.66]	[1.20]	[-1.88]	
Insurance	0.95	-5.27	0.95	21.35	-37.55	0.03
	[0.37]	[-0.37]	[0.37]	[0.98]	[-2.31]	
Media	1.27	-11.63	1.27	11.25	-39.37	0.02
	[0.60]	[-1.07]	[0.60]	[0.80]	[-2.37]	
Oil and gas	2.03	-10.84	2.03	7.53	-33.13	0.08
	[0.99]	[-0.92]	[0.99]	[0.45]	[-2.09]	
Personal household goods	3.50	0.51	3.50	22.39	-26.04	0.02
	[1.88]	[0.05]	[1.88]	[1.55]	[-1.77]	
Retail	0.78	-8.48	0.78	9.24	-29.96	0.02
	[0.45]	[-0.94]	[0.45]	[0.76]	[-2.34]	
Technology	1.46	16.16	1.46	52.10	-27.42	0.01
	[0.55]	[1.02]	[0.55]	[2.46]	[-1.17]	
Telecom	-0.44	6.89	-0.44	30.94	-22.28	0.03
	[-0.20]	[0.55]	[-0.20]	[1.75]	[-1.29]	
Travel and leisure	1.67	10.44	1.67	14.51	5.51	0.63
	[0.82]	[1.09]	[0.82]	[1.03]	[0.44]	
Utilities	1.01	-12.04	1.01	3.21	-30.52	0.06
	[0.57]	[-1.31]	[0.57]	[0.24]	[-2.52]	
Country indices						
Austria	1.60	8.50	1.60	23.33	-9.49	0.11
	[0.73]	[0.81]	[0.73]	[1.61]	[-0.63]	
Belgium	0.59	5.91	0.59	31.46	-25.08	0.00
	[0.30]	[0.60]	[0.30]	[2.43]	[-1.78]	
Finland	1.58	19.36	1.58	51.01	-19.02	0.06
	[0.56]	[1.07]	[0.56]	[2.43]	[-0.63]	
France	1.86	-4.23	1.86	23.37	-37.71	0.00
	[1.04]	[-0.39]	[1.04]	[1.49]	[-2.69]	
Germany	2.08	-5.83	2.08	18.00	-34.74	0.02
	[1.03]	[-0.51]	[1.03]	[1.05]	[-2.53]	
Ireland	-0.78	7.27	-0.78	35.22	-26.62	0.01
	[-0.35]	[0.57]	[-0.35]	[1.84]	[-1.86]	
Italy	0.07	-3.58	0.07	22.24	-34.91	0.01
	[0.03]	[-0.31]	[0.03]	[1.34]	[-2.28]	
Netherlands	1.59	0.84	1.59	20.27	-22.73	0.02
	[0.86]	[0.09]	[0.86]	[1.44]	[-1.80]	
Portugal	-1.14	-0.44	-1.14	15.68	-19.98	0.03
	[-0.62]	[-0.05]	[-0.62]	[1.30]	[-1.70]	
Spain	1.14	5.02	1.14	28.83	-23.87	0.02
	[0.56]	[0.43]	[0.56]	[1.77]	[-1.50]	

Table V: Equity Market Returns and Changes in ECB Tone

This table presents results on the link between EuroStoxx 50 returns and changes in the ECB's communication tone. On each ECB press conference (PC) day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC and the equity return from the closing prices on the day preceding the PC and the day on which the PC is held. Our sample includes a total of 208 returns and tone changes, computed from the 209 PCs between January 7, 1999 and September 7, 2017. We regress returns on tone changes and the following control variables. To control for autocorrelation in tone changes we add lagged tone changes ($\Delta\tau_{t-1}$), and to control for other communication features we include the distance in the wording (DIS_t), change in complexity measured by the FOG-index (ΔFOG_t), and change in lexical diversity measured by the type-token-ratio (ΔTTR_t) of the current compared to the previous PC statement. To control for policy actions, ΔMRO_t denotes the change in the policy rate announced at the PC at time t and UMP_t is a dummy that takes the value one for PCs at which unconventional monetary policy actions are announced and zero otherwise. Expected $\Delta realGDP_t$ and Expected $\Delta HICP_t$ denote the latest revisions to the ECB's projections on real GDP and inflation, with the first projections released in December 2000. To control for monetary policy surprises, we use the target shocks and communication shocks of Leombroni et al. (2018), available for PCs between February 2001 and December 2014. Additionally, we control for the market return since the previous PC. We report coefficient estimates, t-statistics (based on White, 1980, standard errors), the regressions' adjusted-R^2, and the number of observations.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
const	0.00	0.00	-0.00	-0.00	-0.00	-0.01
	[0.09]	[0.06]	[-0.51]	[-0.58]	[-1.00]	[-1.30]
$\Delta\tau_t$	0.34	0.36	0.36	0.36	0.38	0.46
	[2.28]	[2.36]	[2.30]	[2.21]	[2.19]	[2.75]
$\Delta\tau_{t-1}$		0.04	0.03	0.10	0.23	0.21
		[0.20]	[0.18]	[0.58]	[1.22]	[1.35]
DIS_t			0.00	0.00	0.00	0.00
			[0.52]	[0.53]	[0.85]	[1.14]
ΔFOG_t			0.00	0.00	0.00	0.00
			[0.68]	[0.59]	[0.64]	[1.46]
ΔTTR_t			0.02	0.02	0.02	0.02
			[0.81]	[0.88]	[0.94]	[0.86]
ΔMRO_t				1.64	1.71	0.28
				[1.44]	[1.10]	[0.20]
UMP_t				0.01	0.01	0.01
				[1.42]	[1.57]	[1.40]
Expected $\Delta realGDP_t$					-0.02	0.03
					[-0.09]	[0.13]
Expected $\Delta HICP_t$					-0.10	0.47
					[-0.24]	[1.35]
Target shock						-0.01
						[-0.10]
Communication shock						0.10
						[2.59]
Lagged return		0.01	0.01	0.00	0.00	0.00
		[0.18]	[0.22]	[0.02]	[0.02]	[0.06]
adj R^2 (%)	2.11	1.25	0.25	2.55	1.77	6.33
obs	208	207	207	207	184	160

Table VI: Industry Sector Returns and Changes in ECB Tone

This table presents results on the link between industry returns and changes in the ECB's communication tone. On each ECB press conference (PC) day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC and the equity return from the closing prices on the day preceding the PC and the day on which the PC is held. Our sample includes a total of 208 returns and tone changes, computed from the 209 PCs between January 7, 1999 and September 7, 2017. We regress returns on tone changes and different sets of control variables: Specifications (iv), (v), and (vi) in the top row of this table refer to the specifications used in Table V, which use an expanding set of control variables (see Table V for details). We report coefficient estimates, t-statistics (based on White, 1980, standard errors), and the regressions' adjusted-R^2.

	Specification (iv)		Specification (v)		Specification (vi)	
	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)
Auto parts	0.38	0.08	0.42	-0.92	0.51	5.61
	[1.96]		[2.01]		[2.47]	
Banks	0.42	3.74	0.47	3.19	0.52	4.69
	[2.11]		[2.16]		[2.25]	
Basic resources	0.39	1.27	0.41	1.84	0.47	8.36
	[2.00]		[1.90]		[2.29]	
Chemicals	0.19	0.73	0.19	0.05	0.27	5.58
	[1.19]		[1.09]		[1.60]	
Construction Materials	0.34	3.05	0.37	2.48	0.46	5.69
	[2.42]		[2.38]		[2.81]	
Financial Services	0.19	-0.17	0.19	-1.88	0.28	3.00
	[1.46]		[1.32]		[2.06]	
Food and beverages	0.32	1.40	0.34	2.60	0.46	11.50
	[2.66]		[2.52]		[3.75]	
Health care	0.22	3.03	0.22	4.69	0.29	5.84
	[1.53]		[1.48]		[1.94]	
Industrial goods	0.38	1.47	0.32	0.29	0.42	5.56
	[2.20]		[1.97]		[2.53]	
Insurance	0.29	3.15	0.36	3.05	0.46	6.10
	[1.49]		[1.71]		[2.08]	
Media	0.31	0.84	0.27	3.28	0.31	5.14
	[1.97]		[1.89]		[2.06]	
Oil and gas	0.24	-0.11	0.25	0.10	0.33	4.23
	[1.48]		[1.44]		[1.98]	
Personal household goods	0.34	1.19	0.34	0.08	0.44	8.87
	[2.19]		[2.06]		[2.82]	
Retail	0.23	3.60	0.24	3.02	0.27	11.52
	[1.88]		[1.87]		[2.19]	
Technology	0.57	1.97	0.57	2.31	0.69	6.22
	[2.34]		[2.50]		[2.98]	
Telecom	0.31	0.72	0.30	0.27	0.40	0.72
	[1.67]		[1.76]		[2.43]	
Travel and leisure	0.15	-0.92	0.16	-1.97	0.25	2.51
	[1.33]		[1.26]		[1.92]	
Utilities	0.15	4.33	0.16	4.12	0.20	3.44
	[1.24]		[1.20]		[1.52]	

Table VII: Realized versus Implied Volatility and Changes in ECB Tone

This table presents results on the link between stock market volatility and changes in the ECB's communication tone. For each day in our sample, we measure the realized volatility of the Eurostoxx 50 from intraday data over the full day (RV) and over the time window from 14:30 to 17:30 (RV_{PC}). We measure changes in implied volatility as daily log changes in the VSTOXX, $\Delta log(VSTOXX)$. Finally, as a proxy for changes in the volatility risk premium, we compute the ratio of changes in implied volatility to realized volatility. On each ECB press conference (PC) day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC. The data covers the period from the first to the last PC in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes. Panel A reports results from using all days in our sample. On the left, we report results from regressing the volatility quantities on a constant and a dummy, $\mathbb{1}$(PC), that is one on days with PCs and zero otherwise. In the right part of Panel A, we report results for regressions on a constant and separate dummies for PC days with positive tone changes ($\Delta\tau > 0$) and negative tone changes ($\Delta\tau < 0$). Additionally, we report the p-value of an F-test that the coefficient estimates for both dummies are equal. Panel B reports results for PC day regressions of changes in implied volatility and changes in volatility risk premia on tone changes and a set of control variables; for detailed variable descriptions we refer to Table V.

Panel A. ECB Press Conferences and Tone Changes

	PC days		PC days with positive vs negative tone changes			
	const	$\mathbb{1}$(PC)	const	$\mathbb{1}(\Delta\tau > 0)$	$\mathbb{1}(\Delta\tau < 0)$	p[F]
Realized volatility						
Trading day (RV)	102.82	12.65	102.82	9.45	16.51	0.38
	[42.73]	[3.43]	[42.73]	[1.91]	[2.74]	
From 14:30 to 17:30 (RV_{PC})	65.01	15.33	65.01	13.82	17.15	0.58
	[41.78]	[5.45]	[41.78]	[3.54]	[3.96]	
Changes in implied volatility						
$\Delta log(VSTOXX)$	0.23	-95.72	0.23	-185.13	12.70	0.02
	[0.03]	[-2.13]	[0.03]	[-2.90]	[0.22]	
Proxies for volatility risk premia						
$\Delta log(VSTOXX)/RV$	-0.30	-1.05	-0.30	-2.02	0.11	0.01
	[-3.83]	[-2.39]	[-3.83]	[-3.07]	[0.22]	
$\Delta log(VSTOXX)/RV_{PC}$	-0.57	-1.36	-0.57	-3.00	0.60	0.00
	[-4.11]	[-2.00]	[-4.11]	[-3.04]	[0.72]	

Panel B. Regressions on ECB Tone Changes

	$\Delta log(VSTOXX)$			$\Delta log(VSTOXX)/RV$			$\Delta log(VSTOXX)/RV_{PC}$		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
const	0.00	0.01	0.02	1.47	1.83	2.79	1.85	2.49	4.18
	[0.15]	[0.20]	[0.66]	[0.52]	[0.61]	[0.77]	[0.42]	[0.53]	[0.72]
$\Delta\tau_t$	-1.17	-1.39	-1.55	-137.67	-156.65	-159.92	-214.18	-251.66	-253.91
	[-2.36]	[-2.52]	[-2.88]	[-2.77]	[-2.90]	[-2.91]	[-2.88]	[-3.13]	[-3.12]
$\Delta\tau_{t-1}$	-0.45	-0.62	-0.38	-30.59	-43.79	-34.22	-44.11	-70.92	-45.24
	[-0.68]	[-0.87]	[-0.59]	[-0.53]	[-0.71]	[-0.52]	[-0.51]	[-0.76]	[-0.45]
DIS_t	-0.00	-0.00	-0.00	-0.09	-0.09	-0.13	-0.12	-0.12	-0.17
	[-0.74]	[-0.60]	[-0.84]	[-1.46]	[-1.38]	[-1.47]	[-1.26]	[-1.18]	[-1.26]
ΔFOG_t	0.00	0.00	-0.00	0.16	0.26	0.02	0.49	0.66	0.42
	[0.43]	[0.60]	[-0.29]	[0.45]	[0.59]	[0.04]	[0.81]	[0.90]	[0.49]
ΔTTR_t	-0.06	-0.02	-0.01	-7.36	-5.89	-5.27	-8.12	-3.81	-2.70
	[-0.78]	[-0.21]	[-0.06]	[-1.02]	[-0.69]	[-0.53]	[-0.76]	[-0.29]	[-0.17]
ΔMRO_t	-4.40	-5.19	0.71	-191.83	-200.13	120.04	-240.49	-210.12	207.57
	[-1.43]	[-1.10]	[0.21]	[-0.92]	[-0.62]	[0.38]	[-0.74]	[-0.43]	[0.44]
UMP_t	-0.05	-0.05	-0.04	-2.46	-2.62	-2.66	-3.16	-3.38	-3.61
	[-2.44]	[-2.55]	[-2.22]	[-1.73]	[-1.83]	[-1.67]	[-1.77]	[-1.88]	[-1.83]
Expected $\Delta realGDP_t$		-0.02	-0.33		-40.48	-42.09		-50.78	-54.92
		[-0.02]	[-0.38]		[-0.50]	[-0.51]		[-0.43]	[-0.46]
Expected $\Delta HICP_t$		0.11	-2.33		-2.59	-150.94		-51.98	-247.14
		[0.07]	[-1.68]		[-0.02]	[-1.07]		[-0.26]	[-1.17]
Target shock			0.04			3.32			16.88
			[0.35]			[0.34]			[0.92]
Communication shock			-0.24			-5.98			-3.96
			[-1.61]			[-0.52]			[-0.22]
Lagged variance	0.01	0.00	-0.00	0.77	0.36	1.84	1.08	0.18	1.51
	[0.12]	[0.03]	[-0.08]	[0.24]	[0.11]	[0.56]	[0.22]	[0.03]	[0.29]
adj R^2 (%)	2.29	1.63	2.61	1.34	0.51	-0.00	0.72	-0.04	-0.78
obs	207	184	160	206	183	160	206	183	160

Table VIII: Corporate Credit Spreads and Changes in ECB Tone

This table presents results on the link between changes in corporate credit spreads and changes in the ECB's communication tone. For each day in our sample, we compute changes in credit spreads, defined as the yield differentials of BBB- and AAA-rated bonds of all corporates and separately for financials and non-financials. On each ECB press conference (PC) day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC. Daily data on credit spreads of corporates and financials is available from April 1999 and for non-financials from August 1999, providing us with 4,717 and 4,633 daily observations until September 2017. Over these sample periods, we observe 204 PCs and 200 PCs that reveal changes in ECB tone, respectively. Panel A reports results from using all days in our sample. On the left, we report results from regressing changes in credit spreads on a constant and a dummy, $\mathbb{1}(\text{PC})$, that is one on days with PCs and zero otherwise. In the right part of Panel A, we report results for regressions on a constant and separate dummies for PC days with positive tone changes ($\Delta\tau > 0$) and negative tone changes ($\Delta\tau < 0$). Additionally, we report the p-value of an F-test that the coefficient estimates for both dummies are equal. Panel B reports results for PC day regressions of changes in credit spreads on tone changes and a set of control variables; for detailed variable descriptions we refer to Table V.

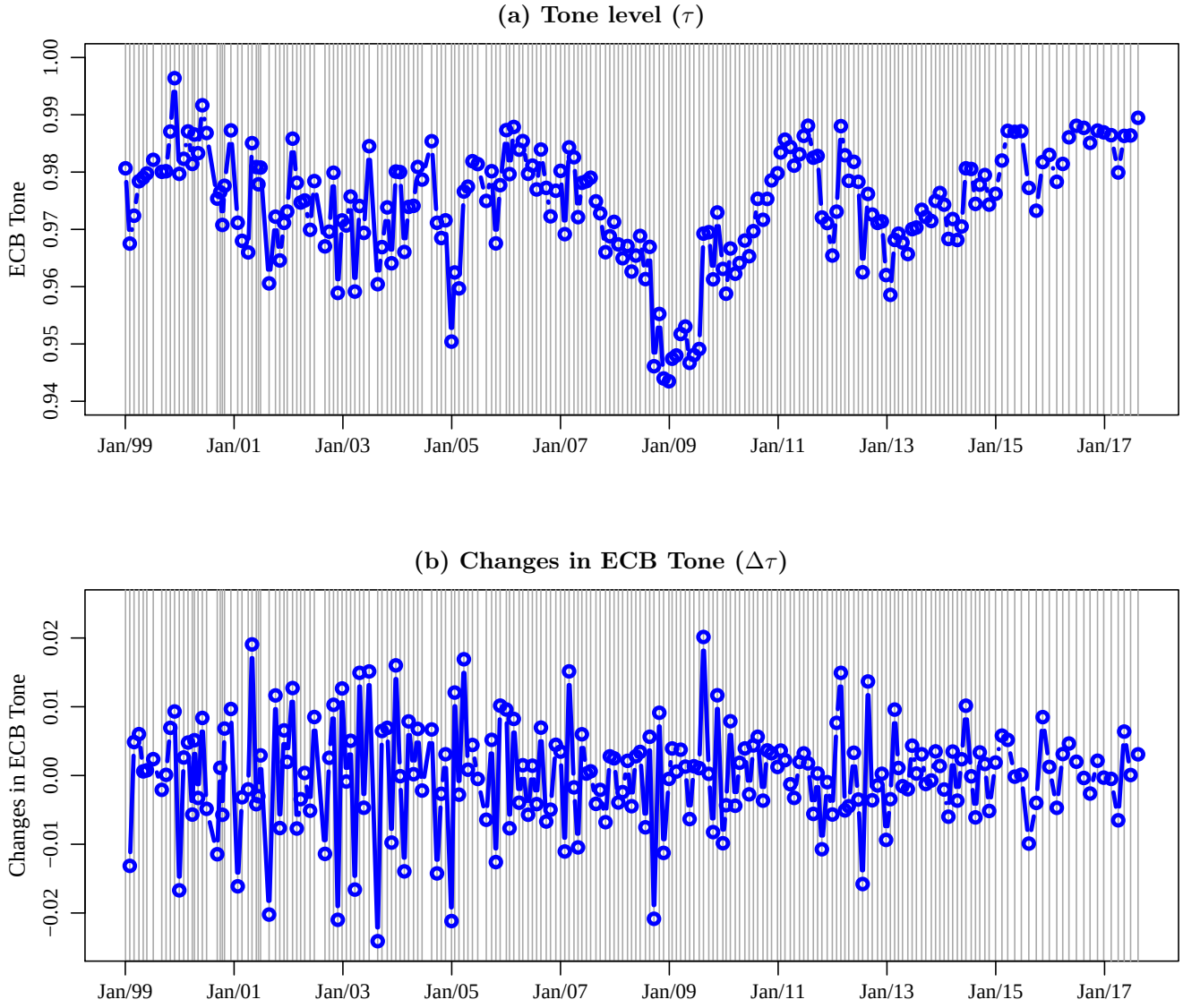
Panel A. ECB Press Conferences and Tone Changes

	PC days		PC days with positive vs negative tone changes			
	const	$\mathbb{1}(\text{PC})$	const	$\mathbb{1}(\Delta\tau > 0)$	$\mathbb{1}(\Delta\tau < 0)$	p[F]
All corporates	0.02	-0.61	0.02	-1.16	0.05	0.13
	[0.25]	[-1.45]	[0.25]	[-1.58]	[0.19]	
Financials	0.07	-1.29	0.07	-2.55	0.24	0.03
	[0.27]	[-1.90]	[0.27]	[-2.30]	[0.36]	
Non-financials	0.00	-0.26	0.00	-0.66	0.22	0.35
	[0.02]	[-0.51]	[0.02]	[-0.74]	[0.78]	

Panel B. Regressions on ECB Tone Changes

	All corporates			Financials			Non-financials		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
const	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.00
	[-1.13]	[-1.00]	[-0.78]	[-0.30]	[-0.12]	[0.25]	[-1.21]	[-1.05]	[-1.00]
$\Delta\tau_t$	-0.01	-0.01	-0.01	-0.03	-0.03	-0.03	-0.01	-0.01	-0.01
	[-2.54]	[-2.50]	[-2.51]	[-3.20]	[-3.12]	[-3.46]	[-1.99]	[-1.74]	[-1.79]
$\Delta\tau_{t-1}$	-0.01	-0.01	-0.01	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01
	[-2.39]	[-2.28]	[-2.11]	[-2.28]	[-2.02]	[-2.00]	[-2.59]	[-2.48]	[-2.00]
DIS_t	0.00	0.00	0.00	0.00	-0.00	-0.00	0.00	0.00	0.00
	[1.08]	[0.96]	[0.76]	[0.01]	[-0.03]	[-0.35]	[1.33]	[1.11]	[1.05]
ΔFOG_t	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
	[0.62]	[0.71]	[0.22]	[1.30]	[0.93]	[0.01]	[-1.18]	[-0.75]	[-1.11]
ΔTTR_t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[1.69]	[1.30]	[1.17]	[1.14]	[1.01]	[0.77]	[0.88]	[0.98]	[1.20]
ΔMRO_t	0.06	0.07	0.11	0.07	0.11	0.25	-0.00	-0.02	-0.01
	[0.95]	[0.92]	[1.15]	[0.75]	[0.97]	[2.39]	[-0.23]	[-0.74]	[-0.24]
UMP_t	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-1.75]	[-2.03]	[-1.37]	[-2.12]	[-2.28]	[-1.64]	[-2.70]	[-2.67]	[-2.11]
Expected $\Delta realGDP_t$		-0.01	-0.00		-0.03	-0.04		0.00	0.00
		[-0.41]	[-0.30]		[-1.64]	[-1.75]		[0.39]	[0.29]
Expected $\Delta HICP_t$		0.01	0.00		-0.00	-0.03		0.00	0.00
		[0.71]	[0.35]		[-0.12]	[-0.98]		[0.40]	[0.08]
Target shock			-0.00			-0.01			0.00
			[-1.25]			[-2.09]			[1.11]
Communication shock			-0.00			-0.00			-0.00
			[-0.48]			[-0.68]			[-0.65]
Lagged spread changes	-0.01	-0.01	-0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03
	[-0.74]	[-0.77]	[-0.21]	[-1.14]	[-1.23]	[-1.12]	[-1.06]	[-1.05]	[-1.17]
adj R^2 (%)	2.71	1.48	1.16	8.03	9.73	15.73	1.24	-0.92	-2.34
obs	204	184	160	204	184	160	200	184	160

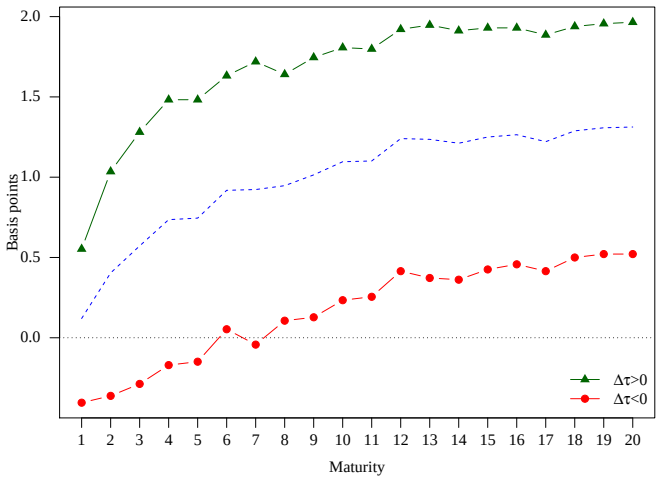
Figure 2: The Tone of ECB Press Conference Statements



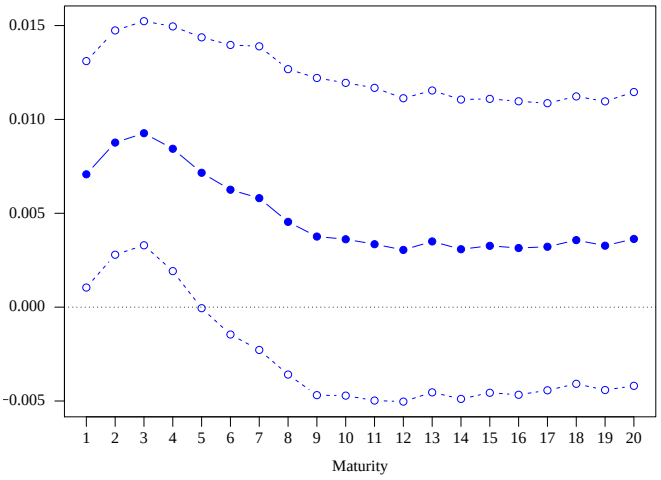
This figure plots the time-series of ECB tone, τ, and changes in ECB tone, $\Delta\tau$, in Panels (a) and (b), respectively. Tone is defined as $\tau = 1 - N/T$, see Equation (1), where N and T denote the number of negative words and the total number of words in a press conference statement. $\Delta\tau$ is measured as the difference in τ between two consecutively held press conferences. Tone is measured form the ECB president's opening statements at the 209 ECB press conferences between January 7, 1999 and September 7, 2017. The vertical lines mark these 209 press conferences.

Figure 3: Government Yield Changes on ECB Press Conference Days

(a) Positive versus negative tone changes on PC days

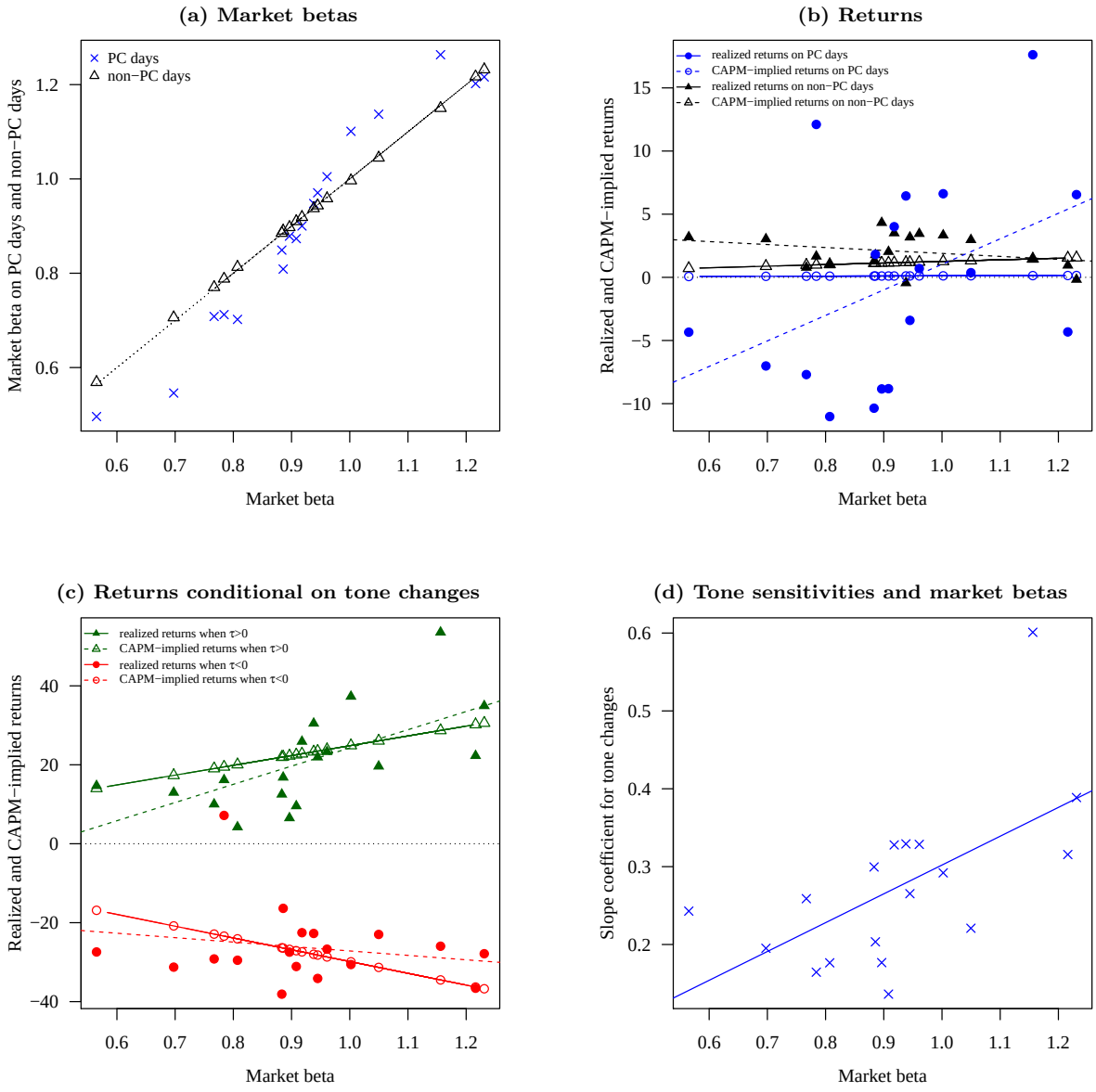


(b) Regressions of PC day yield changes on tone changes



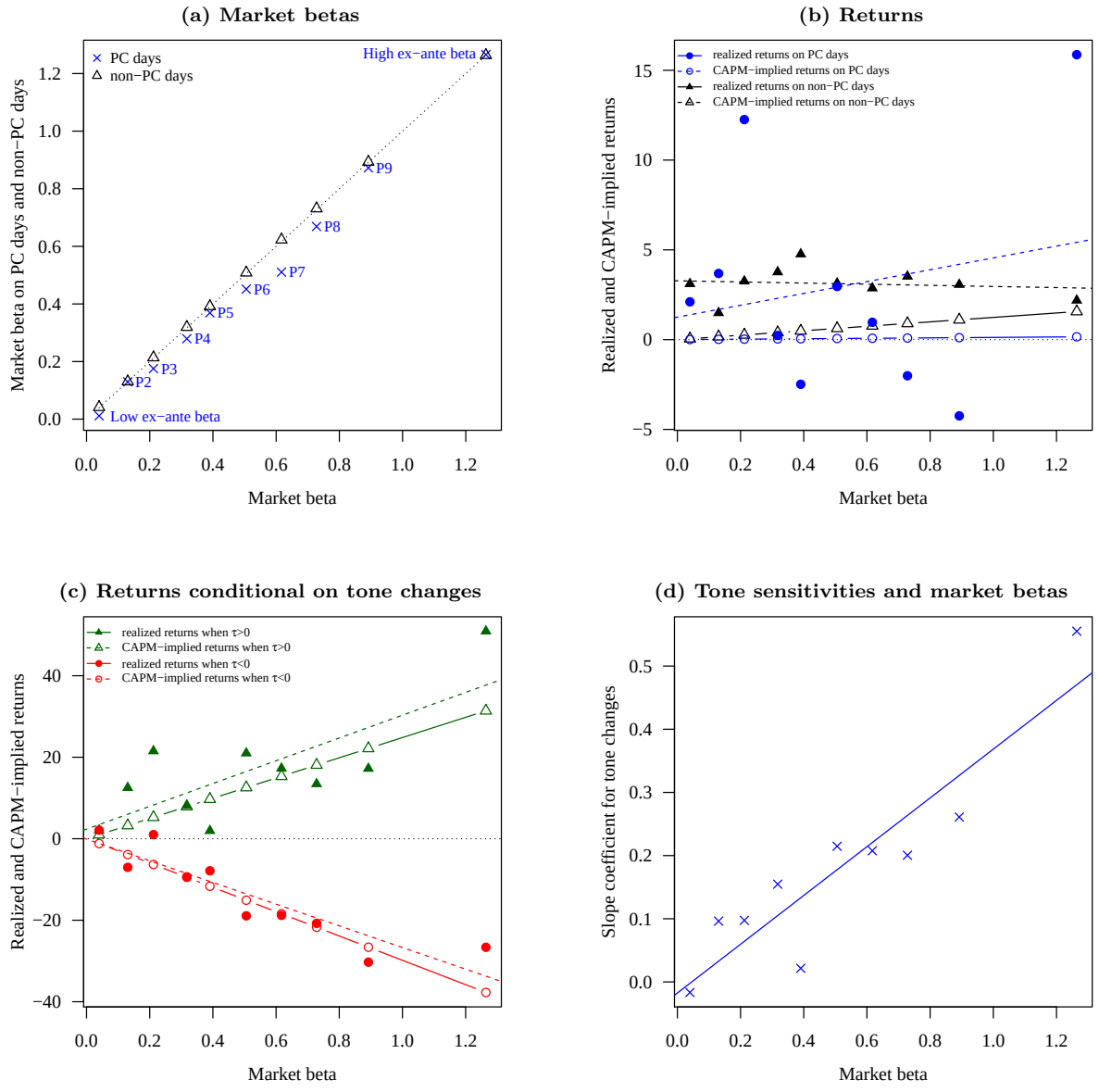
This figure presents results on changes in the German government bond yield curve (for maturities ranging from one to 20 years, x-axis) in response to changes in ECB tone. Panel (a) presents average PC-day yield changes conditional on the tone changes at the most recent PC having been positive (green triangles) or negative (red bullets). Panel (b) plots the slope coefficients from regressing PC-day yield changes (of individual maturities) on changes in ECB tone ($\Delta\tau$), along with 95% confidence bands (based on White (1980) standard errors). The sample spans a total of 208 tone changes from 209 ECB press conferences between January 1999 and September 2017.

Figure 4: Industry Sector Indices



This figure summarizes the link between the returns, market betas, and tone sensitivities of industry sector indices. The data covers the period from the first to the last ECB press conference (PC) in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes. Panel A shows a scatter plot of industries' market betas estimated from all days in our sample (on the x-axis) and betas estimated only using returns on PC days or on non-PC days (on the y-axis). Panel B illustrates the relation of average realized returns and CAPM-implied returns (y-axis) to market betas (x-axis) on PC and non-PC days. Panel C presents the relation between returns and betas on PC days separately for PC days with positive and negative tone changes in ECB tone. Panel D shows a scatter plot of the indices' market betas (x-axis) and their tone sensitivities estimated from regressing index returns on changes in ECB tone (y-axis).

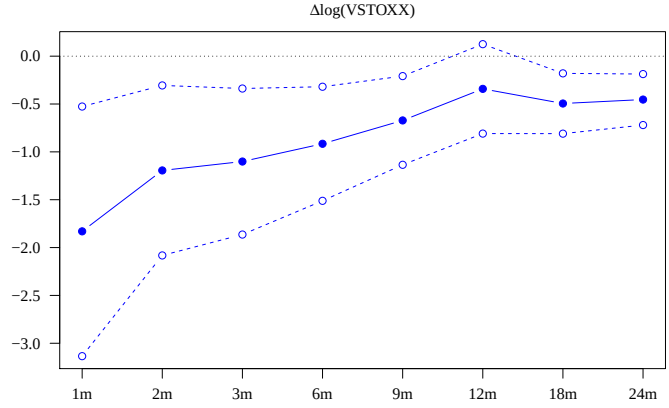
Figure 5: Portfolios Sorted by Ex-Ante Beta



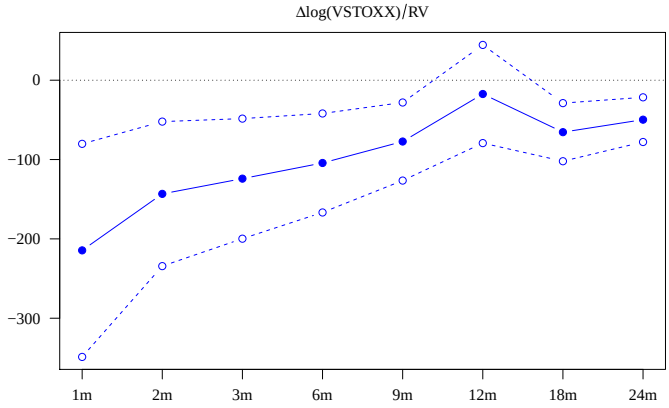
This figure summarizes the link between the returns, market betas, and tone sensitivities of portfolios sorted by ex-ante betas. Each day in our sample, we sort stocks into decile portfolios according to their ex-ante beta and compute the value-weighted returns of the portfolios. The data covers the period from the first to the last ECB press conference (PC) in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes. Panel A shows a scatter plot of the portfolios' market betas estimated from all days in our sample (on the x-axis) and betas estimated only using returns on PC days or on non-PC days (on the y-axis). Panel B illustrates the relation of average realized returns and CAPM-implied returns (y-axis) to market betas (x-axis) on PC and non-PC days. Panel C presents the relation between returns and betas on PC days separately for PC days with positive and negative tone changes in ECB tone. Panel D shows a scatter plot of the portfolios' market betas (x-axis) and their tone sensitivities estimated from regressing portfolio returns on changes in ECB tone (y-axis).

Figure 6: Changes in ECB Tone and Term Structures of Volatility Changes

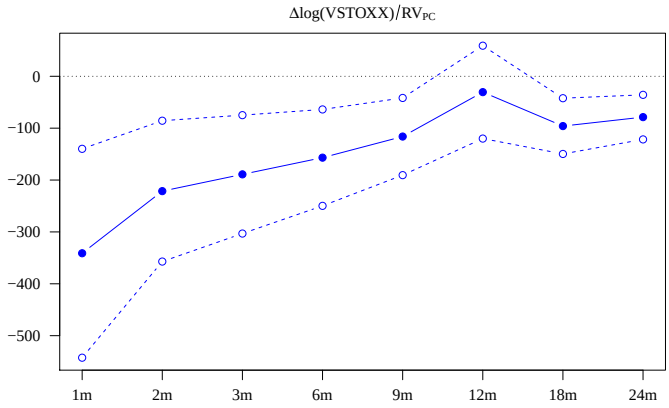
(a) Tone sensitivities of changes in implied volatility (VSTOXX)



(b) Tone sensitivities of changes in volatility risk premia (ΔVRP)



(b) Tone sensitivities of changes in volatility risk premia (ΔVRP_{PC})



This figure shows the slope coefficient estimates from regressions of changes in implied volatility and proxies for volatility risk risk premia on changes in ECB tone. Our sample covers the 209 press conferences (PCs) held by the ECB between January 7, 1999 to September 7, 2017, from which we compute 208 changes in ECB tone. On each PC day, we measure the change in implied volatility as the daily log change in the VSTOXX, $\Delta log(VSTOXX)$, from the closing values of the day preceding the PC and the day on which the PC is held. As proxies for changes in volatility risk premia, we scale changes in implied volatility by the realized volatility, computed from high frequency data either over the full PC day (ΔVRP) or over the time window from 14:30 to 17:30 (ΔVRP_{PC}). We compute changes in implied volatility and volatility risk premia using VSTOXX indices with maturities between one month and 24 months and present coefficient estimates (solid line with bullets) along with 95% confidence bands (dashed lines).

Internet Appendix for

Does Central Bank Tone Move Asset Prices?

(not for publication)

This Internet Appendix reports and discusses additional results and robustness checks.

IA.1. Excerpts from ECB press conference statements

In the main part of the paper, we present excerpts from the press conference in January 2009, which is the PC that our tone measure identifies as the most negative PC in our sample; see Table III. To provide a broader picture of what our tone measure captures, we now present additional excerpts. Table IA.1 presents excerpts from the press conference in February 2010, which has the highest count of commonly used phrases involving negative words across all statements in our sample. Table IA.2 presents excerpts from the press conference in January 2005, which according to our tone measure is the most negative PC in a pre-crisis subsample from January 1999 to June 2007.

While we find that our tone measure leads to only very few misclassifications, i.e., cases in which our procedure incorrectly treats a word or statement negative, in the ECB press conference transcripts, one example is the first sentence of the first excerpt in Table IA.2: "Downside risks to the economic outlook stemming from oil price developments have diminished somewhat over recent weeks." The dictionary identifies 'diminished' as a negative word whereas the overall sentence is obviously not negative. Nonetheless, these excerpts provide further support for the view that our tone measure generally captures the ECB's framing of economic and financial conditions.

IA.2. ECB tone, policy actions, and fundamentals

Our results in Section 3.3 in the main paper suggest that tone is related to the framing of fundamentals. We now present additional evidence for such a relation between tone and fundamentals. At the outset, we describe the additional data required for these exercises and subsequently we present results on the link between tone changes and policy actions, economic fundamentals, as well as future policy actions and future macro fundamentals.

IA.2.1. Macro and yield curve data

In addition to the data discussed in Section 4.1 of the paper, we collect the following data. First, we obtain data for Eurozone fundamentals from Datastream (DS). The DS mnemonics are EMRETTOTG (Retail Sales), EMUNPTOTO (Unemployment), EKIPTOT.G (Industrial Production), EMCPCOR5F (Harmonised Index of Consumer Prices), EMCNFCONQ (Consumer Confidence), EKCNFBUSQ (Business Confidence), and EMGDP...D (GDP).

Second, we obtain data for the term structure of German government bond yields (available from the Bundesbank). This data is available over our full sample period, whereas European yield data available from the ECB only start in 2004. Over the joint sample period, the German yield curve is highly correlated ($> 90\%$) with the ECB AAA yield curve. We therefore use daily data of German government bond yields with maturities ranging from one to 20 years provided by Deutsche Bundesbank from January 1999 to September 2017.[18]

IA.2.2. Policy actions and economic projections

We start by exploring the link between changes in the ECB tone revealed at a press conference and the ECB's policy actions, its revision of macroeconomic projections, and current fundamentals. Table IA.3 presents the results, in Panel A for the subset of PCs that coincide with releases of macroeconomic projections and in Panel B for all PCs in our sample.

Panel A presents results for regressions of tone changes on changes in policy rates (ΔMRO_t), a dummy for unconventional monetary policy announcements (UMP_t), changes in the ECB's macroeconomic projections for real GDP growth and inflation, proxies for current economic conditions (the latest real GDP growth and changes in inflation rates). In the last specifica-

[18]Maturities for the term structure of German government bonds range from 1 to 20 years and are provided by Deutsche Bundesbank. These series can be downloaded from here. The tickers of the series we use are:

BBK01.WT3211, BBK01.WT3213, BBK01.WT3215, BBK01.WT3217, BBK01.WT3219, BBK01.WT3221, BBK01.WT3223, BBK01.WT3225, BBK01.WT3227, BBK01.WT3229, BBK01.WT3431, BBK01.WT3433, BBK01.WT3435, BBK01.WT3437, BBK01.WT3439, BBK01.WT3441, BBK01.WT3443, BBK01.WT3445, BBK01.WT3447, BBK01.WT3449.

tion, we also include lagged tone changes. The main take-aways are that tone changes are positively correlated with changes in policy rates, however, the coefficient estimate becomes insignificant when accounting for revisions of economic projections. In all specifications, we find a significantly positive relation between tone changes and forecast revisions for real GDP growth. These results suggest that the ECB adjusts its tone consistent with its policy actions and judgment of economic conditions, yet the explanatory power of fundamentals for tone changes is relatively low with an adjusted-R^2 of 14% (which increases to 26% when including lagged tone changes).

Panel B presents results for the sample of all PCs, i.e., the sample we use in our main analysis to assess the link between ECB tone and asset prices. In these regressions (which are at a monthly high frequency), we control for additional fundamental variables available at a monthly frequency, i.e., changes in current industrial production, retail sales, and unemployment. To account for autocorrelation in tone changes, we add up to five lags for tone changes. To account for other communication features, we control for the distance as well as changes in complexity and lexical diversity of a PC statement relative to the previous PC statement. Finally, we control for the equity market return accumulated since the previous PC.

The results can be summarized (across specifications) as follows. First, there is a positive link between tone changes and changes in the policy rate (with a varying degree of significance). This relation is less affected by controlling for revisions to real GDP projections compared to Panel A, presumably because such forecast revisions occur less frequently (once a quarter) than announcements of policy rates (on average once a month). In line with this argument, we also find that the link between tone changes and revisions of real GDP forecasts is again positive but not always significant. Revisions to inflation forecasts and changes in current economic fundamentals do not exhibit a significant relation to tone changes. Lagged tone changes entail significant predictive ability for current tone changes, with the generic information being concentrated in the most recent lag, whereas other lags do not contain independent information. Additionally, the positive link between tone changes and equity returns

(since the previous PC) and the negative estimate of the dummy for UMP announcements are more or less significant depending on the particular regression specification.

Overall, these results are economically intuitive. A more positive tone is associated (on average, but not always significantly) with increases in the policy rate, upward revisions of real GDP growth, and a higher recent return of the stock market, and vice versa. UMP announcements are typically associated with the ECB choosing a more negative tone compared to the previous PC. These results lend further credence to the view that tone captures how the ECB frames its policy decisions and its judgement of economic conditions. Nonetheless, policy actions, fundamentals and the other variables cannot fully explain tone changes, and given that we control for the tone drivers identified here throughout our empirical analysis in Section 4 of the paper, this further corroborates our conclusion that tone conveys generic information for market participants.

IA.2.3. Central bank tone and future policy rates

We now complement the results on the relation between ECB tone and interest rates by showing that changes in tone predict future changes in policy rates (ΔMRO). Table IA.4 reports results for regressions of the form

$$\Delta MRO_{t,t+k} = a + \beta \Delta MRO_{t-h} + \gamma \Delta \tau_{t-h} + \epsilon_{t,t+k}, \tag{IA.2.1}$$

where k is the forecast horizon (in terms of future policy meetings) and h is the lag of the predictive variable. With one policy meeting per month on average, these horizons roughly translate into months. We include lagged MRO changes in this regression as it is well-known that central banks often adjust interest rates only gradually (i.e., engage in "interest rate smoothing"). We run these regressions with individual lags of the predictive variables (Panel A) and with multi-period changes in predictive variables (Panels B and C).

We find that lagged tone changes have predictive power for future policy rate changes over

and above the information contained in lagged MRO changes. These results suggests that central bank tone is related to the future stance of monetary policy, which is also consistent with the positive relation between tone changes in yield changes illustrated in Figure 3 in the main text (see Section 3.4).

IA.2.4. Forecasting macro fundamentals

Table IA.5 reports results for regressions of future growth rates of key Eurozone macro fundamentals on lagged ECB tone changes. We consider log changes in price levels ($\Delta HICP$), industrial production (ΔIP), real industrial production ($\Delta RealIP$), retail sales ($\Delta RetSales$), and unemployment ($\Delta Unemp$), as well as changes in consumer confidence ($\Delta ConsConf$) and business confidence ($\Delta BusConf$) as dependent variables and report the predictive slope coefficients and adjusted R^2s. The left part of the table shows results for univariate predictive regressions of fundamentals on tone changes, the right part shows predictive slopes for lagged tone changes when additionally controlling for the most recent change in the policy rate (ΔMRO), a dummy for unconventional monetary policy announcements, and the most recent revisions in the ECB's projection for future inflation and real GDP growth.

The signs of all estimated coefficients support the economic intuition that a more positive tone means higher expected (real) growth. The lack of statistical significance for most of the estimates is unsurprising, given that it is notoriously difficult to forecast realized fundamentals. We do find some degree of significance (with t-statistics around two) for the growth in industrial production (ΔIP and $\Delta RealIP$) and, somewhat more pronounced, for business confidence at several horizons. These results are consistent with the idea that a more positive central bank tone points towards higher growth.

IA.3. Descriptive statistics

This appendix presents summary statistics for all data used in the empirical analysis in Section 4. We report the number of daily observations (Obs), averages (Avg), medians (Med), and standard deviations (Std) for the full sample, non-PC days, and PC days.

Equity indices and portfolios Table IA.6 reports descriptive statistics for aggregate market indices (Eurostoxx 50 and MSCI EMU), 18 industry sector indices, and country indices (MSCI country indices). Table IA.7 reports the same descriptive statistics for the decile portfolios sorted by stocks' ex-ante betas. We note that the portfolios' average returns do not monotonically increase in ex-ante betas and that this lack of a positive relation is in line with previous evidence (e.g., Frazzini and Pedersen, 2014). In the paper, we show in Panel (c) of Figure 5 that a positive link between betas and returns (as predicted by the CAPM) emerges once we condition on changes in ECB tone.

Volatility and credit spreads Table IA.8 reports descriptive statistics for the volatility quantities used in Section 4.4.1 and the credit spreads used in Section 4.4.2. Panel A presents summary statistics for realized volatility, log changes in the VSTOXX, and a proxy for changes in the volatility risk premium, computed as the ratio of the log change in the VSTOXX to the realized volatility. Panel B presents summary statistics for the credit spread of EMU firms, financial firms, and non-financial firms.

Tone changes and control variables Table IA.9 presents descriptive statistics for ECB tone changes and other potential drivers of returns on ECB press conference days that we control for in our regression analysis. We report summary statistics for tone changes ($\Delta\tau_t$) as well as the other textual characteristics discussed in more detail in Appendix A.1, i.e., distance (DIS_t) to proxy the difference in wording between consecutive PCs, changes in readability measured by the FOG-index (ΔFOG_t) and lexical diversity measured by the type-token ratio

(ΔTTR_t). Additionally, we present summary statistics for revisions of the ECB's projections on future GDP growth (Expected $\Delta realGDP_t$) and consumer price inflation (Expected $\Delta HICP_t$), as well as for the monetary policy shocks (Target shocks and Communication shocks) estimated by Leombroni et al. (2018).

IA.4. Additional regression results

Eurostoxx 50 intraday results Table IA.10 reports results for regressions of intraday Eurostoxx 50 returns on tone changes and other control variables for three different time windows: from 9:00 – 13:44, from 13:45 – 14:29, and from 14:30 – 17:30. The first time windows captures returns from the start of the day until the minute before the policy rate decision, the second window captures the time from the policy rate decision to one minute before the start of the press conference, and the third window captures the time of the press conference until the end of the trading day. In all three cases, the dependent variable is the return over the respective time window, computed from data sampled at the minute frequency. For each window, we present results for regressions of returns on tone changes and a regression that additionally includes control variables that account for ECB policy actions, revisions of its economic forecasts, measures of monetary policy shocks, and other textual characteristics of the PC statements, i.e., the regressions correspond to specifications (i) and (vi) of Table V (which uses daily data). The results show that tone changes do not matter for stock returns before the start of the press conference and that the effect of tone changes on returns is not crowded out by the other control variables.

MSCI EMU index Table IA.11 replicates the analysis from Table V using the broader MSCI EMU index instead of the Eurostoxx50. The results are very similar.

Country indices Table IA.12 summarizes the results of repeating the regression analysis for EMU country indices. More specifically, we report estimated coefficients for tone changes

in regressions that additionally include lagged tone changes and other textual characteristics of PCs and ECB policy actions, which corresponds to specification (iv) from Table V, additionally controls for revisions in the ECB's projections (v), and measures of policy shocks (vi). We find that the coefficients for tone changes are significantly positive in all specifications for all countries, except for Ireland.

Portfolios sorted by ex-ante betas Table IA.13 reports additional results for the decile portfolios sorted by stocks' ex-ante betas used in Figure 5 of the paper. The general takeaway is that high-beta stocks are more sensitive to tone changes than low beta stocks. Panel A shows this by repeating the dummy regressions from Table IV in the paper, with the high-minus-low beta portfolio generating an average return of 50 basis points on PC days with a positive tone change and −28 basis points when the tone change is negative. Panel B reports results from regressing portfolios returns on changes in ECB tone using specifications (iv), (v), and (vi) of Table V in the paper. These results show that the high-minus-low beta portfolio's significantly positive tone coefficient estimate is robust to controlling for policy actions, policy shocks, and fundamentals.

Individual stocks Figure IA.2 summarizes results on the relation between equity returns and ECB tone changes at the individual stock level. Panel A plots densities of the estimated slope coefficient of individual firms' stock returns on tone changes on PC days. We report results for three sets of stocks: (i) those with available data on all PC days, (ii) those with data on at least 80% of all PC days and (iii) those with data for at least 60% of all PC days; all samples are winsorized at the top and bottom one percent to eliminate outliers. We find a positive response of stock returns to tone changes on average (and for the median stock) and a fairly symmetric distribution, which suggests that our main result is not simply driven by a few large stocks. Panel B of Figure IA.2 shows scatter plots, for the same three sets of stocks, for the slope coefficient of returns on tone chances (y-axis) and market betas (x-axis). We find a consistently positive relation between market betas and sensitivities to tone changes

which is in line with our results in Panel D in Figures 4 and 5.

Realized volatility on beyond PC days Table IA.14 extends the finding that tone changes do not matter for realized volatility during the PC and over the full PC day, by showing that there are also no tone effects in realized volatility measured over the next five, 22, and 66 days. Hence, our finding that the VSTOXX responds to changes in tone is unlikely to be driven by changes in expected volatility and mostly reflects changes in risk premia.

Regressions with more lags for tone changes We extend the regressions for Eurostoxx 50 returns (from Table V), changes in options-implied volatility (VSTOXX) and volatility risk premia (from Table VII), and changes in credit spreads (from Table VIII) by adding more lags for tone changes. The results in Tables IA.15, IA.16, and IA.17 show that the link between changes in asset prices and tone changes is robust to including additional lags.

IA.5. Robustness over subsamples

To better understand the effect of tone changes on asset prices, we report results for subsample estimations in Figure IA.1. These figures plot the average returns / asset price changes on PC days with a positive tone change, PC days with a negative tone change, and all PC days for rolling (overlapping) 5-year windows from January 1999 to September 2017.

The upper two panels (Eurostoxx 50 and MSCI EMU) show that there is a positive and sizeable return spread between PC days with positive versus negative tone changes in all subsample periods. Similarly, we find a consistently positive spread for high versus low beta stocks (middle left panel), which shows that the link between stocks' tone sensitivities and systematic risk is robust over time. For credit spreads of financial firms (middle right panel), we find a large negative spread for the period since the global financial crisis in 2007/2008 whereas there is no evidence for tone effects before the crisis. Finally, the lower two panels show that changes in implied volatility and volatility risk premia are inversely related to tone

changes in all subsample periods.

Hence, our main results are stable over time and not driven by a particular subsample period, which corroborates our conclusion that tone conveys genuine information that matters for asset prices through a risk-based channel. It also suggests that the informational value of tone has not decreased over time, e.g., due to more sophisticated information processing.

IA.6. Alternatives approaches for analyzing ECB statements

We have chosen a deliberately simple approach to measure the tone of central bank communication based on an existing financial dictionary. An interesting question is whether more sophisticated approaches can generate an even stronger link between stock returns and press conference statements.

We investigate this question in two ways. First, we use Lasso regressions of PC-day returns for the Eurostoxx 50 on all words (or all bi-, tri-grams, ...; n-grams) in a PC statement and let the data decide which words (or n-grams) to use for predicting returns. Second, we apply a Naïve Bayes (NB) classifier to all words (or n-grams) of a PC statement to generate directional predictions for ESX50 returns.

To avoid the risk of overfitting, we execute these exercises in an out-of-sample setup as follows: We use the first three years of PC statements to estimate a Lasso regression in which we regress returns on the words (or n-grams) in the respective statements, i.e., our estimation window is $\{1, 2, ..., k\}$, where initially $k = 36$ (since there is approximately one PC each month). At $k + 1$ we observe the next PC statement and use it to compute the Lasso-based return prediction $\widehat{r}_{k+1}$. We re-estimate the Lasso regression using the updated window $\{1, 2, ..., k + 1\}$ and subsequently use the statement at $k + 2$ to compute $\widehat{r}_{k+2}$. Repeating this procedure until we reach the last PC in our sample generates an out-of-sample sequence of return predictions. We follow the same setup to generate out-of-sample series of positive vs negative return predictions based on the NB classifier. Finally, to use our tone measure as a

benchmark in a comparable way, we use the same out-of-sample setup to generate tone-based return and directional predictions.

To evaluate the Lasso- versus tone-based return predictions, we compute root mean square errors (RMSEs) of the predicted relative to the realized returns. The first row in Table IA.18 shows that RSME of tone changes is 2.0% whereas the Lasso prediction RMSEs are typically smaller (between 1.70 and 1.92%) except for bigrams (RSME of 2.04%).

To evaluate the directional NB- versus tone-based predictions, we compute hit ratios to measure the forecasts' directional accuracy for realized returns. The second row in Table IA.18 reports that the tone-based predictions achieve a hit ratio of 0.53 and that the NB-based predictions generate hit-ratios between 0.51 and 0.56.

Overall, we find that our dictionary-based method is not necessarily optimal if the goal is to simply maximize the explanatory (or predictive) ability of communication for returns. However, at least for the two alternative methods employed here, we find that the gain in explanatory power seems relatively small and not all specifications yield superior results. Moreover, there are several instances of words (or n-grams) selected by the algorithms that are hard to interpret in economic terms (e.g., we find that Lasso selects words such as "outcome", "survey", and "March") whereas we show in Tables II and III in the main text that the results from our dictionary-based method are generally easier to interpret.

IA.7. Statement 'topics' and the link between tone and returns

We also provide evidence that tone changes do not simply proxy for certain topics discussed at press conferences. What we have in mind is to account for scenarios as in the following, hypothetical example: if tone changes were predominantly negative in ECB statements that mainly discuss economic growth but mostly positive in statements that mainly discuss inflation, then tone changes would proxy for the topics but not contain independent information.

To explore this possibility, we follow Hansen and McMahon (2016) and Jegadeesh and Wu

(2017) and use latent dirichlet allocation (LDA) models to estimate 'topics' from the corpus of all 209 ECB statements in our sample. LDA essentially is an algorithm that groups words into a predefined number of groups based on the co-occurrence of words across statements (see Blei et al., 2003, for more details). It is then up to the researchers to assign appropriate topic labels to the word groups provided by the LDA algorithm, which typically requires some freedom in interpretation and subjective judgement. Since, we are only interested in whether tone conveys generic information, i.e., remains significant in regressions after controlling for topics, we do not need to label the word groups that result from the LDA.[19] Additionally, the LDA quantifies the likelihood of each topic for each statement.

We estimate LDAs with 2,3, ..., 8 topics to allow for a plausible number of topics while being agnostic about the exact number. For each topic, we create a dummy variable that equals one on PC days on which the LDA suggest that this topic dominates the statement and zero otherwise. We then run regressions of Eurostoxx 50 returns on tone changes, our most comprehensive set of control variables as in specification (vi) of Table V, and the topic dummies. Table IA.19 reports the slope coefficient estimates for tone changes and the topic dummies for topics 2, 3. ..., 8 (we exclude the dummy for topic 1 to avoid collinearity with the intercept). We find that the coefficient estimate for tone changes is significantly positive in all specifications, hence it seems unlikely that tone is simply a proxy for a particular topic.

[19] A common challenge with LDA is that the topics extracted from a corpus are not mutually exclusive. For example estimating an LDA with two topics for our corpus, we find "inflation", "euro", and "monetary" among the most common words for topic one and "price", "euro", "stability" for topic two; it would be difficult to pin down precise (exclusive) labels for these two topics, and it becomes even more difficult with a bigger number of topics. Hansen and McMahon (2016) deal with this by manually combining topics extracted from the LDA into different aggregate topics. Since the goal of our approach is only to control for the effect of certain topics on the link between tone changes and stock returns, there is no need to assign specific labels.

Table IA.1: Excerpts from the ECB President's Statement on February 4, 2010

This table presents excerpts of the the ECB president's introductory statement, given at the press conference on February 4, 2010. Our textual analysis identifies this statement to contain the highest count of commonly used phrases involving negative words of all statements in our sample. From this statement we present the three paragraphs that have the largest impact on our tone measure, i.e., the three paragraphs with the highest ratio of negative words to total words. Words highlighted in red italic font and marked by asterisks (*) are negative words identified by the dictionary we employ. Other words highlighted in red italic font are common word sequences involving negative words that we have identified in multiple statements.

- The Governing Council continues to view the risks to this outlook as broadly balanced. On the upside, confidence may improve more than expected, and both the global economy and foreign trade may recover more strongly than projected. Furthermore, there may be stronger than anticipated effects stemming from the extensive macroeconomic stimulus being provided and from other policy measures taken. On the downside, **concerns* remain* relating to a *stronger or more *protracted* than expected *negative* feedback loop* between the real economy and the financial sector, renewed increases in oil and other commodity prices, the intensification of protectionist pressures and the *possibility of a *disorderly* *correction* of global *imbalances**.

- As regards fiscal policies, many euro area countries are faced with large, **sharply* rising fiscal *imbalances**, leading to less favourable medium and long-term interest rates and lower levels of private investment. Moreover, high levels of *public *deficit* and debt* place an additional **burden** on monetary policy and **undermine** the Stability and Growth Pact as a key pillar of Economic and Monetary Union. Against this background, it is of paramount importance that the stability programme of each euro area country clearly defines the fiscal exit and consolidation strategies for the period ahead. Countries will be required to meet their commitments under the *excessive *deficit* procedures*. Consolidation of public finances should start in 2011 at the latest and will have to exceed substantially the annual adjustment of 0.5% of GDP set as a minimum requirement by the Stability and Growth Pact. A strong focus on expenditure reforms is needed.

- The *key *challenge** in order to reinforce sustainable growth and job creation is to accelerate structural reforms, as the *financial *crisis* has *negatively* affected* the productive capacity of our economies. In the case of product markets, policies that enhance competition and innovation are urgently needed to *speed up *restructuring** and investment and to create new business opportunities. In labour markets, moderate wage-setting, effective incentives to work and sufficient labour market flexibility are required in order to avoid significantly *higher structural *unemployment** over the coming years. Finally, an *appropriate *restructuring** of the banking sector should play an important role. Sound balance sheets, effective risk management and transparent, robust business models are key to strengthening banks' resilience to shocks, thereby laying the foundations for sustainable growth and financial stability.

Table IA.2: Excerpts from the ECB President's Statement on January 13, 2005

This table presents excerpts of the the ECB president's introductory statement, given at the press conference on January 13, 2005. Our measure of central bank tone identifies this statement to exhibit the most negative tone of all statements in a subsample from 1999/01 – 2007/06 (i.e., the pre-crisis period). From this statement we present the three paragraphs that have the largest impact on our tone measure, i.e., the three paragraphs with the highest ratio of negative words to total words. Words highlighted in red italic font and marked by asterisks (*) are negative words identified by the dictionary we employ. Other words highlighted in red italic font are common word sequences involving negative words that we have identified in multiple statements.

- Downside risks to the economic outlook stemming from oil price developments have **diminished** somewhat over recent weeks. As regards exchange rates, we confirm our position, expressed when the euro rose **sharply**, that such moves are **unwelcome** and **undesirable** for economic growth.

- With regard to both fiscal policies and structural reforms, the governments and institutions of the European Union will have to **confront** many important **challenges** in the course of 2005.

- Foremost among these **challenges** is the need to strengthen public finances by **correcting** **excessive** **deficits** swiftly and returning to a path of vigorous fiscal consolidation. Moreover, throughout the European Union there is a need to address the considerable **challenges** that population ageing **poses** to existing pension and social security systems.

Table IA.3: ECB Tone, Policy Rates, and Fundamentals

This table presents results on the relation between ECB tone, ECB policy actions, and fundamentals. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 PC days with tone changes. Panel A presents results for the subset of 67 ECB press conference (PC) days on which the ECB also releases macroeconomic projections. We report estimates from regressing tone changes on changes in policy rates announced on the day of the press conference at time t (ΔMRO_t), a dummy for the announcement of unconventional monetary policy measures (UMP_t), changes in macroeconomic projections released by the ECB (Expected $\Delta realGDP_t$ and Expected $\Delta HICP_t$), and the current growth in real GDP and inflation. Additionally, we control for lagged tone changes ($\Delta\tau_{t-1}$). Panel B presents similar regression results using all 208 PCs in our sample and adds further control variables: current changes in industrial production, retail sales, and unemployment; additional lags of tone changes; other textual characteristics of PC statements, i.e., the distance in the wording (DIS_t), change in complexity measured by the FOG-index (ΔFOG_t), and change in lexical diversity measured by the type-token-ratio (ΔTTR_t) of the current compared to the previous PC statement; and the return of the Eurostoxx 50 since the previous PC (ESX50 return).

Panel A. Press Conferences with Macroeconomic Projection Releases

	(i)	(ii)	(iii)	(iv)	(v)
const	0.00	0.00	0.00	0.00	0.00
	[0.67]	[0.42]	[0.64]	[0.13]	[0.36]
ΔMRO_t	1.34		0.50	0.28	0.42
	[2.31]		[0.95]	[0.50]	[0.80]
UMP_t	-0.00		-0.00	-0.00	-0.00
	[-0.81]		[-0.46]	[-0.13]	[-0.13]
Expected $\Delta realGDP_t$		0.78	0.72	0.78	0.77
		[3.64]	[3.22]	[3.48]	[4.26]
Expected $\Delta HICP_t$		0.32	0.23	0.22	0.11
		[0.94]	[0.58]	[0.56]	[0.28]
Current $\Delta realGDP_t$				0.11	0.16
				[0.80]	[1.44]
Current $\Delta HICP_t$				0.07	0.10
				[0.57]	[1.05]
$\Delta\tau_{t-1}$					-0.35
					[-3.95]
adj R^2 (%)	4.08	17.59	15.76	14.01	26.39
Obs	67	67	67	67	66

Panel B. All Press Conferences

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)
const	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[0.71]	[0.99]	[0.79]	[-0.93]	[-1.30]	[-1.35]	[-1.21]	[-1.35]	[-0.74]	[-0.80]	[-0.58]	[-1.01]
ΔMRO_t	0.86	1.08	1.10	0.59	1.04	1.13	0.97	1.06	0.51	0.49	0.51	0.71
	[2.37]	[2.25]	[2.05]	[1.41]	[1.95]	[2.12]	[1.83]	[1.99]	[1.28]	[1.23]	[1.73]	[2.10]
UMP_t	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-1.06]	[-0.74]	[-0.70]	[-1.90]	[-1.01]	[-0.95]	[-0.95]	[-0.98]	[-1.43]	[-1.50]	[-2.23]	[-1.94]
Expected $\Delta realGDP_t$		0.08	0.08	0.19	0.09	0.10	0.11	0.10	0.35	0.34		0.19
		[0.82]	[0.67]	[1.48]	[0.79]	[0.93]	[0.94]	[0.93]	[3.27]	[3.20]		[1.68]
Expected $\Delta HICP_t$		-0.28	-0.27	-0.28	-0.26	-0.27	-0.25	-0.26	-0.26	-0.27		-0.28
		[-1.48]	[-1.32]	[-1.30]	[-1.34]	[-1.37]	[-1.20]	[-1.34]	[-1.26]	[-1.35]		[-1.47]
Current $\Delta realGDP_t$			0.03	0.06	0.02	0.02	0.02	0.02	0.10	0.11		
			[0.35]	[0.87]	[0.26]	[0.21]	[0.31]	[0.30]	[1.46]	[1.61]		
Current $\Delta HICP_t$			0.03	0.05	0.02	0.02	0.02	0.01	0.01	0.01		
			[0.24]	[0.51]	[0.16]	[0.14]	[0.15]	[0.06]	[0.16]	[0.15]		
Current $\Delta RealIP_t$			-0.00	0.04	0.00	0.00	0.00	0.00	0.05	0.05		
			[-0.01]	[0.65]	[0.06]	[0.04]	[0.02]	[0.03]	[0.90]	[1.01]		
Current $\Delta RetSales_t$			-0.01	0.00	-0.02	-0.03	-0.02	-0.02	0.02	0.00		
			[-0.09]	[0.03]	[-0.27]	[-0.31]	[-0.19]	[-0.29]	[0.33]	[0.07]		
Current $\Delta Unemp_t$			0.02	0.03	0.01	0.00	-0.00	0.01	-0.01	0.00		
			[0.37]	[0.49]	[0.12]	[0.06]	[-0.00]	[0.12]	[-0.12]	[0.02]		
$\Delta\tau_{t-1}$				-0.43					-0.61	-0.62	-0.41	-0.44
				[-8.08]					[-9.06]	[-8.78]	[-7.89]	[-8.05]
$\Delta\tau_{t-2}$					0.04				-0.34	-0.34		
					[0.51]				[-3.74]	[-3.72]		
$\Delta\tau_{t-3}$						-0.06			-0.28	-0.28		
						[-0.59]			[-3.15]	[-3.21]		
$\Delta\tau_{t-4}$							-0.06		-0.28	-0.28		
							[-0.52]		[-3.41]	[-3.41]		
$\Delta\tau_{t-5}$								-0.02	-0.20	-0.21		
								[-0.20]	[-3.04]	[-3.19]		
DIS_t				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				[1.06]	[1.40]	[1.45]	[1.31]	[1.46]	[0.94]	[1.01]	[0.80]	[1.19]
ΔFOG_t				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				[1.05]	[1.00]	[1.05]	[0.85]	[0.97]	[0.99]	[0.95]	[0.77]	[0.99]
ΔTTR_t				-0.00	-0.01	-0.01	-0.00	-0.00	0.00	0.01	-0.01	-0.00
				[-0.15]	[-0.36]	[-0.40]	[-0.30]	[-0.33]	[0.43]	[0.50]	[-0.64]	[-0.15]
ESX50 return										0.01	0.01	0.01
										[1.63]	[1.94]	[1.48]
adj R^2 (%)	1.93	2.24	-0.43	18.51	-0.58	-0.38	-0.34	-0.72	26.85	27.23	18.30	20.68
Obs	208	184	184	184	184	184	184	184	184	184	207	184

Table IA.4: Forecasting Future Policy Rates

This table reports results for regressions of changes in policy rates (marginal refinancing operation, ΔMRO), on lagged MRO changes and lagged changes in ECB tone ($\Delta\tau$). We consider forecast horizons of $1, 3$, and 12 policy meetings (which corresponds approximately to the same number of months) using lagged MRO changes and tone changes from the past three or twelve policy meetings. Panel A presents regression results using the latest three MRO changes and tone changes as predictors. The results in Panel B are also based on the last three policy meeting but uses cumulative MRO and tone changes (rather than using each individual lag as predictor). Panel C repeats the analysis using the MRO and tone changes accumulated over the previous twelve policy meetings. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 days with MRO and tone changes.

Panel A. Predicting MRO changes with the latest three MRO and tone changes

	$\Delta MRO_{t,t+1}$		$\Delta MRO_{t,t+3}$		$\Delta MRO_{t,t+12}$	
	(i)	(ii)	(i)	(ii)	(i)	(ii)
const	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-0.74]	[-0.54]	[-0.63]	[-0.60]	[-0.76]	[-0.81]
ΔMRO_{t-1}	0.15	0.16	0.59	0.57	0.95	0.90
	[1.18]	[1.34]	[3.42]	[3.84]	[3.12]	[2.76]
ΔMRO_{t-2}	0.12	0.13	0.45	0.42	0.63	0.58
	[2.13]	[2.26]	[4.46]	[4.13]	[1.81]	[1.58]
ΔMRO_{t-3}	0.24	0.20	0.27	0.27	0.29	0.26
	[2.86]	[2.63]	[1.70]	[1.84]	[0.83]	[0.82]
$\Delta\tau_{t-1}$		-0.01		0.05		0.13
		[-0.84]		[1.49]		[1.83]
$\Delta\tau_{t-2}$		0.03		0.07		0.21
		[1.62]		[1.90]		[2.29]
$\Delta\tau_{t-3}$		0.04		0.05		0.15
		[3.31]		[1.74]		[2.30]
adj R^2 (%)	12.10	18.03	19.13	21.25	4.52	6.24

Panel B. Predicting MRO changes with cumulative MRO and tone changes from the latest three policy meetings

	$\Delta MRO_{t,t+1}$		$\Delta MRO_{t,t+3}$		$\Delta MRO_{t,t+12}$	
	(i)	(ii)	(i)	(ii)	(i)	(ii)
const	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-0.75]	[-0.54]	[-0.61]	[-0.58]	[-1.14]	[-1.20]
$\Delta MRO_{t-3;t-1}$	0.17	0.17	0.44	0.42	0.62	0.58
	[4.46]	[4.54]	[5.24]	[5.42]	[2.58]	[2.43]
$\Delta\tau_{t-3;t-1}$		0.02		0.05		0.15
		[1.68]		[1.75]		[2.34]
adj R^2 (%)	12.33	14.17	18.97	21.58	4.94	7.31

Panel C. Predicting MRO changes with cumulative MRO and tone changes from the latest twelve policy meetings

	$\Delta MRO_{t,t+1}$		$\Delta MRO_{t,t+3}$		$\Delta MRO_{t,t+12}$	
	(i)	(ii)	(i)	(ii)	(i)	(ii)
const	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-0.78]	[-1.05]	[-0.87]	[-1.11]	[-1.62]	[-1.96]
$\Delta MRO_{t-12;t-1}$	0.04	0.04	0.09	0.08	0.10	0.07
	[3.11]	[2.98]	[2.32]	[2.11]	[1.03]	[0.65]
$\Delta\tau_{t-12;t-1}$		0.02		0.09		0.26
		[2.40]		[2.67]		[3.46]
adj R^2 (%)	4.92	8.33	6.21	18.07	0.63	16.83

Table IA.5: Forecasting future macro fundamentals

This table reports results for regressions of changes in macro fundamentals on lagged changes in ECB tone. We consider log changes in price levels ($\Delta HICP$), industrial production (ΔIP), real IP ($\Delta RealIP$), retail sales ($\Delta RetSales$), and unemployment ($\Delta Unemp$), as well as changes in consumer confidence ($\Delta ConsConf$) and business confidence ($\Delta BusConf$) as dependent variables. Using forecast horizons in the range from three months to three years, we report the predictive slope coefficients and adjusted R^2s for two sets of regression specifications. The left part of the table shows results for univariate predictive regressions of fundamentals on tone changes, the right part shows predictive slopes for lagged tone changes when additionally controlling for the most recent change in the policy rate (ΔMRO), a dummy for unconventional monetary policy announcements, and the most recent revisions in the ECB's projection for future inflation and real GDP growth. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 days with tone changes.

	Regresions on tone changes					Regresions on tone changes and controls				
	3m	6m	12m	24m	36m	3m	6m	12m	24m	36m
$\Delta HICP$	0.05	-0.04	-0.01	0.01	0.02	0.08	-0.02	-0.01	-0.00	0.01
	[0.95]	[-1.24]	[-0.35]	[0.48]	[0.68]	[1.31]	[-0.69]	[-0.47]	[-0.14]	[0.26]
adj R^2 (%)	-0.26	-0.02	-0.51	-0.52	-0.54	5.05	5.56	5.81	8.24	6.65
ΔIP	0.24	0.36	0.56	0.45	0.36	0.14	0.32	0.53	0.92	0.96
	[1.16]	[1.34]	[2.00]	[1.50]	[1.45]	[0.72]	[1.21]	[1.67]	[1.98]	[2.07]
adj R^2 (%)	0.34	0.17	0.13	-0.29	-0.39	9.00	3.00	3.16	3.90	10.92
$\Delta RealIP$	0.18	0.40	0.57	0.44	0.35	0.06	0.34	0.54	0.93	0.96
	[0.95]	[1.51]	[2.01]	[1.49]	[1.44]	[0.31]	[1.33]	[1.68]	[1.93]	[2.01]
adj R^2 (%)	-0.06	0.31	0.12	-0.31	-0.41	11.03	4.63	3.73	4.79	11.45
$\Delta RetSales$	0.08	0.12	0.09	0.17	0.00	0.10	0.15	0.20	0.45	0.32
	[1.26]	[1.59]	[0.89]	[1.15]	[0.00]	[1.52]	[1.83]	[1.50]	[1.61]	[1.07]
adj R^2 (%)	-0.04	-0.05	-0.41	-0.41	-0.57	1.79	0.37	1.31	4.98	6.14
$\Delta Unemp$	-0.33	-0.55	-0.85	-1.03	-0.75	-0.20	-0.22	-0.44	-1.03	-1.12
	[-1.53]	[-1.74]	[-1.83]	[-1.48]	[-1.05]	[-0.98]	[-0.77]	[-1.06]	[-1.46]	[-1.11]
adj R^2 (%)	0.44	0.27	0.07	-0.19	-0.44	19.72	13.18	8.72	4.51	1.71
$\Delta ConsConf$	0.21	0.15	0.14	-0.22	-0.19	0.18	0.29	0.47	0.53	0.28
	[1.08]	[0.66]	[0.46]	[-0.52]	[-0.56]	[0.82]	[0.90]	[1.10]	[0.84]	[0.69]
adj R^2 (%)	-0.27	-0.46	-0.49	-0.51	-0.54	0.26	5.61	4.83	12.35	12.62
$\Delta BusConf$	0.76	0.89	1.03	0.04	0.02	0.79	0.99	1.56	1.67	1.31
	[2.58]	[2.15]	[2.05]	[0.09]	[0.06]	[2.45]	[2.19]	[2.41]	[1.71]	[2.02]
adj R^2 (%)	1.31	0.27	-0.10	-0.53	-0.56	3.93	5.10	7.12	18.60	26.06

Table IA.6: Descriptive Statistics for Equity Index Returns

This table reports descriptive statistics for the returns (measured in basis points) of various equity indices. We report results for two aggregate market indices in the EMU (Eurostoxx 50 and MSCI EMU), 18 industries (STOXX industry sector indices), as well as ten country indices (MSCI country indices). For all indices, we report the number of daily observations (Obs), the average return (Avg), the median return (Med), and the standard deviation of returns (Std). We report these statistics for all days in our sample, for all days that are not ECB press conference days (Non-PC days), and for ECB press conference days (PC days). The sample is daily from January 1999 to September 2017.

	All days				Non-PC days				PC days			
	Obs	Avg	Med	Std	Obs	Avg	Med	Std	Obs	Avg	Med	Std
EMU market indices												
Eurostoxx 50	4777	0.98	2.42	147.64	4569	0.98	2.19	146.89	208	1.11	8.30	163.54
MSCI EMU	4777	1.21	4.17	135.11	4569	1.26	4.06	134.40	208	0.12	8.08	150.27
Industry sector indices												
Auto parts	4777	3.48	3.02	205.19	4569	3.34	2.15	205.51	208	6.62	23.84	198.40
Banks	4777	0.12	2.01	190.19	4569	-0.17	1.55	189.42	208	6.55	20.46	206.77
Basic resources	4777	2.86	4.97	185.53	4569	2.97	4.97	184.12	208	0.37	5.06	214.72
Chemicals	4777	3.75	6.72	144.89	4569	4.33	6.80	144.48	208	-8.83	4.95	153.53
Construction Materials	4777	2.89	6.37	147.97	4569	3.17	6.29	147.13	208	-3.41	11.38	165.63
Financial Services	4777	1.78	5.78	137.97	4569	1.78	5.97	137.96	208	1.82	3.13	138.45
Food and beverages	4777	2.86	4.38	108.28	4569	3.19	4.55	107.85	208	-4.34	-1.44	117.32
Health care	4777	2.60	5.41	129.44	4569	3.04	6.33	129.87	208	-7.01	-3.38	119.43
Industrial goods	4777	3.34	6.47	146.29	4569	3.46	6.25	145.20	208	0.70	16.10	168.85
Insurance	4777	0.72	4.07	183.50	4569	0.95	3.61	182.50	208	-4.32	13.95	204.50
Media	4777	0.76	2.97	146.06	4569	1.27	3.40	145.54	208	-10.36	-7.05	157.10
Oil and gas	4777	1.56	4.70	154.61	4569	2.03	4.11	153.97	208	-8.81	7.31	168.05
Personal household goods	4777	3.53	6.48	140.23	4569	3.50	6.39	139.74	208	4.01	9.34	151.01
Retail	4777	0.41	0.99	124.22	4569	0.78	1.18	124.06	208	-7.70	-3.77	127.83
Technology	4777	2.17	5.99	192.10	4569	1.46	5.82	190.17	208	17.63	14.26	230.60
Telecom	4777	-0.14	-0.49	155.56	4569	-0.44	-0.49	154.30	208	6.45	-1.01	181.24
Travel and leisure	4777	2.12	5.20	135.78	4569	1.67	4.51	135.69	208	12.11	27.37	137.70
Utilities	4777	0.49	2.21	131.99	4569	1.01	2.24	132.00	208	-11.02	0.05	131.55
Country indices												
Austria	4777	1.97	2.27	152.11	4569	1.60	1.95	152.17	208	10.10	19.06	151.11
Belgium	4777	0.85	3.92	134.41	4569	0.59	3.54	134.21	208	6.50	12.34	138.98
Finland	4777	2.42	0.78	208.79	4569	1.58	0.86	206.21	208	20.94	0.27	259.06
France	4777	1.67	3.44	141.96	4569	1.86	3.40	141.26	208	-2.38	5.90	156.85
Germany	4777	1.82	6.66	147.88	4569	2.08	6.42	147.12	208	-3.76	8.05	163.98
Ireland	4777	-0.46	1.00	164.10	4569	-0.78	0.76	163.43	208	6.50	5.54	178.38
Italy	4777	-0.09	2.37	149.51	4569	0.07	1.91	148.67	208	-3.52	9.66	167.28
Netherlands	4777	1.63	3.39	136.98	4569	1.59	3.16	136.87	208	2.43	12.23	139.69
Portugal	4777	-1.16	0.31	122.30	4569	-1.14	0.13	122.29	208	-1.58	2.61	122.82
Spain	4777	1.36	4.35	152.52	4569	1.14	3.98	151.85	208	6.16	17.40	166.84

Table IA.7: Descriptive Statistics for Stock Portfolios Sorted by Ex-Ante Beta

This table reports descriptive statistics for the returns (measured in basis points) of ten portfolios sorted on ex-ante betas (computed as in Frazzini and Pedersen, 2014) as well as the return of a portfolio that goes long in portfolio "High beta" and short in portfolio "Low beta" (High minus low beta). For all portfolios, we report the number of daily observations (Obs), the average return (Avg), the median return (Med), and the standard deviation of returns (Std). We report these statistics for all days in our sample, for all days that are not ECB press conference days (Non-PC days), and for ECB press conference days (PC days). The sample is daily from January 1999 to September 2017.

	All days				Non-PC days				PC days			
	Obs	Avg	Med	Std	Obs	Avg	Med	Std	Obs	Avg	Med	Std
Low beta	4777	3.07	3.85	40.53	4569	3.12	3.84	40.88	208	2.11	5.03	32.17
P2	4777	1.57	4.02	110.02	4569	1.48	4.00	112.02	208	3.68	4.83	48.30
P3	4777	3.66	5.86	67.66	4569	3.26	5.83	67.95	208	12.25	7.45	60.52
P4	4777	3.68	5.39	79.07	4569	3.84	5.39	79.35	208	0.23	4.09	72.74
P5	4777	4.47	5.09	136.43	4569	4.79	5.02	138.41	208	-2.49	6.32	81.42
P6	4777	3.11	7.69	89.99	4569	3.12	7.92	89.83	208	2.96	-3.14	93.76
P7	4777	2.80	6.84	100.93	4569	2.88	6.86	101.30	208	0.97	5.07	92.45
P8	4777	3.29	7.04	112.30	4569	3.53	7.20	112.32	208	-2.01	4.02	111.99
P9	4777	2.82	6.28	134.64	4569	3.14	6.18	134.28	208	-4.25	7.03	142.38
High beta	4777	2.60	5.52	184.91	4569	2.00	4.68	183.99	208	15.87	36.73	204.12
High minus low beta	4777	-0.47	0.31	184.81	4569	-1.11	-0.80	183.80	208	13.77	26.64	205.65

Table IA.8: Descriptive Statistics for Realized Volatility, Implied Volatility, and Credit Spreads

This table reports descriptive statistics for the volatility quantities and credit spreads used in the paper. In Panel A, we report summary statistics for the realized volatility of the Eurostoxx 50, measured from intraday data over the full day (RV) and over the time window from 14:30 to 17:30 (RV_{PC}); for changes in implied volatility, measured as daily log changes in the VSTOXX, $\Delta log(VSTOXX)$; and for proxies of changes in volatility risk premia, computed the ratios of changes in implied volatility to realized volatility. In Panel B, we report summary statistics for changes in credit spreads, defined as the yield differentials of BBB- and AAA-rated bonds of all corporates and separately for financials and non-financials. In both panels, we report the number of daily observations (Obs), the average return (Avg), the median return (Med), and the standard deviation of returns (Std). We report these statistics for all days in our sample, for all days that are not ECB press conference days (Non-PC days), and for ECB press conference days (PC days). The sample is daily from January 1999 to September 2017 for the volatility quantities, April 1999 to September 2017 for the credit spreads of all corporates and financials, and August 1999 to September 2017 for the credit spreads of non-financials.

Panel A. Realized versus Implied Volatility

	All days				Non-PC days				PC days			
	Obs	Avg	Med	Std	Obs	Avg	Med	Std	Obs	Avg	Med	Std
Realized volatility												
Trading day RV	4739	103.37	88.49	60.22	4532	102.82	88.13	60.27	207	115.47	101.61	57.97
From 14:30 to 17:30 RV_{PC}	4739	65.68	55.49	40.35	4532	65.01	54.68	40.09	207	80.34	67.89	43.23
Changes in implied volatility												
$\Delta log(VSTOXX)$	4727	-3.99	-42.81	582.28	4519	0.23	-39.10	579.55	208	-95.50	-149.55	633.29
Proxies for volatility risk premia												
$\Delta log(VSTOXX)/RV$	4707	-0.35	-0.45	6.47	4500	-0.30	-0.42	6.48	207	-1.35	-1.37	6.13
$\Delta log(VSTOXX)/RV_{PC}$	4707	-0.63	-0.70	11.11	4500	-0.57	-0.66	11.17	207	-1.93	-1.96	9.44

Panel B. Credit Spreads

	All days				Non-PC days				PC days			
	Obs	Avg	Med	Std	Obs	Avg	Med	Std	Obs	Avg	Med	Std
All corporates	4717	-0.01	-0.10	4.27	4511	0.02	-0.10	4.17	206	-0.59	-0.30	6.15
Financials	4717	0.01	-0.10	12.42	4511	0.07	-0.10	12.51	206	-1.22	-0.40	10.10
Non-financials	4633	-0.01	-0.00	3.83	4431	0.00	-0.00	3.61	202	-0.25	0.00	7.10

Table IA.9: Descriptive Statistics for Control Variables

This table reports descriptive statistics for tone changes ($\Delta\tau_t$) and the control variables used in our regressions of returns on tone changes. These include the distance in the wording (DIS_t), change in complexity measured by the FOG-index (ΔFOG_t), and change in lexical diversity measured by the type-token-ratio (ΔTTR_t) of the current compared to the previous PC statement. ΔMRO_t denotes the change in the policy rate announced at the PC at time t and UMP_t is a dummy that takes the value one for PCs at which unconventional monetary policy actions are announced and zero otherwise. Expected $\Delta realGDP_t$ and Expected $\Delta HICP_t$ denote the latest revisions to the ECB's projections on real GDP and inflation, with the first projections released in December 2000. We also make use of the target shocks and communication shocks constructed by Leombroni et al. (2018), available for PCs between February 2001 and December 2014. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 PC days with tone changes.

	Obs	Avg	Std	Min	Q5%	Med	Q95%	Max
$\Delta\tau_t$	208	0.0000	0.0076	-0.0241	-0.0137	0.0005	0.0125	0.0201
DIS_t	208	34.2385	7.5574	20.0000	23.5550	33.9189	48.0270	64.4826
ΔFOG_t	208	0.0023	0.9254	-3.6745	-1.3845	-0.0109	1.5177	2.6180
ΔTTR_t	208	0.0001	0.0467	-0.2767	-0.0636	-0.0036	0.0662	0.2569
ΔMRO_t	208	-0.0001	0.0014	-0.0075	-0.0025	0.0000	0.0025	0.0050
Expected $\Delta realGDP_t$	67	-0.0002	0.0049	-0.0170	-0.0074	0.0000	0.0080	0.0130
Expected $\Delta HICP_t$	67	-0.0002	0.0030	-0.0120	-0.0040	0.0000	0.0033	0.0065
Target shock	161	0.0001	0.0218	-0.1852	-0.0135	0.0003	0.0193	0.0727
Communication shock	161	-0.0011	0.0351	-0.1444	-0.0499	-0.0001	0.0435	0.1791

Table IA.10: Equity Market Returns and Changes in ECB Tone: Intraday Results

This table reports results for regressing Eurostoxx 50 intraday returns on changes in ECB tone and control variables. On days with ECB press conferences (PCs), we use index data sampled at the one-minute frequency to compute the returns over three, non-overlapping time windows: the return from 9:00-13.44 (i.e., from the trading start to just before the policy rate announcement), the return from 13:45 to 14:29 (i.e., from the rate announcement to just before the start of the press conference), and from 14:30 to 17:30 (i.e., from the start of the press conference to the end of the trading day). Otherwise, the setup is identical to Table V in the main paper. The sample period is from January 1999 to September 2017; for more details about the regression specifications and variable descriptions, see Table V.

	Return from 9:00 to 13:44		Return from 13:45 to 14:29		Return from 14:30 to 17:30	
	(i)	(vi)	(i)	(vi)	(i)	(vi)
const	0.00	-0.00	-0.00	0.00	-0.00	-0.01
	[3.35]	[-0.60]	[-1.59]	[0.05]	[-2.29]	[-1.86]
$\Delta\tau_t$	-0.02	-0.00	0.01	0.02	0.26	0.29
	[-0.19]	[-0.00]	[0.14]	[0.49]	[2.34]	[2.45]
$\Delta\tau_{t-1}$		0.03		0.05		0.08
		[0.37]		[1.42]		[0.74]
DIS_t		0.00		-0.00		0.00
		[0.99]		[-0.59]		[1.29]
ΔFOG_t		-0.00		0.00		0.00
		[-0.85]		[1.04]		[1.82]
ΔTTR_t		0.01		-0.01		0.03
		[0.34]		[-1.74]		[1.50]
ΔMRO_t		-0.83		0.77		0.67
		[-1.19]		[1.76]		[0.79]
UMP_t		0.01		0.00		0.00
		[2.16]		[1.89]		[0.38]
Expected $\Delta realGDP_t$		-0.04		0.11		-0.12
		[-0.29]		[1.40]		[-0.69]
Expected $\Delta HICP_t$		0.17		0.08		-0.20
		[0.77]		[0.65]		[-0.76]
Target shock		-0.05		-0.05		0.04
		[-1.18]		[-2.68]		[1.12]
Communication shock		0.04		0.01		0.04
		[2.25]		[1.28]		[1.16]
adj R^2 (%)	-0.46	7.34	-0.47	11.82	2.53	4.96
obs	207	160	207	160	207	160

Table IA.11: Equity Market Returns and Changes in ECB Tone: MSCI EMU

This table reports results for regressions of MSCI EMU index returns on changes in ECB tone and control variables. The setup is identical to Table V in the main paper, which conducts the same analysis for the Eurostoxx 50. The sample period is from January 1999 to September 2017; for more details about the regression specifications and variable descriptions, see Table V.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
const	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01
	[-0.00]	[-0.04]	[-0.44]	[-0.49]	[-0.97]	[-1.24]
$\Delta\tau_t$	0.32	0.34	0.34	0.34	0.35	0.43
	[2.31]	[2.43]	[2.36]	[2.28]	[2.23]	[2.80]
$\Delta\tau_{t-1}$		0.05	0.05	0.12	0.23	0.20
		[0.31]	[0.30]	[0.70]	[1.31]	[1.45]
DIS_t			0.00	0.00	0.00	0.00
			[0.42]	[0.41]	[0.80]	[1.06]
ΔFOG_t			0.00	0.00	0.00	0.00
			[0.70]	[0.61]	[0.70]	[1.55]
ΔTTR_t			0.01	0.01	0.01	0.02
			[0.46]	[0.56]	[0.70]	[0.71]
ΔMRO_t				1.49	1.57	0.14
				[1.40]	[1.07]	[0.12]
UMP_t				0.01	0.01	0.01
				[1.44]	[1.58]	[1.40]
Expected $\Delta realGDP_t$					-0.03	0.02
					[-0.15]	[0.09]
Expected $\Delta HICP_t$					-0.13	0.43
					[-0.33]	[1.34]
Target shock						-0.00
						[-0.05]
Communication shock						0.09
						[2.67]
Lagged return		0.01	0.01	0.00	0.00	0.00
		[0.32]	[0.35]	[0.17]	[0.15]	[0.16]
adj R^2 (%)	2.14	1.40	0.22	2.54	1.71	6.64
obs	208	207	207	207	184	160

Table IA.12: ECB Tone and EMU Country Indices

This table reports results for regressions of MSCI country index returns on changes in ECB tone and control variables. The setup is identical to Table V in the main paper, which conducts the same analysis for the Eurostoxx 50. The sample period is from January 1999 to September 2017; for more details about the regression specifications and variable descriptions, see Table V.

	Specification (iv)		Specification (v)		Specification (vi)	
	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)
Austria	0.37	3.06	0.43	2.79	0.47	7.43
	[2.65]		[2.74]		[3.10]	
Belgium	0.29	1.39	0.29	1.11	0.36	5.22
	[2.02]		[2.04]		[2.45]	
Finland	0.71	0.88	0.58	2.66	0.71	9.90
	[2.70]		[2.72]		[3.21]	
France	0.34	2.32	0.33	1.72	0.42	6.73
	[2.16]		[2.04]		[2.65]	
Germany	0.29	1.34	0.32	0.54	0.41	5.31
	[1.84]		[1.90]		[2.47]	
Ireland	0.25	5.19	0.21	5.80	0.28	4.67
	[1.30]		[0.99]		[1.26]	
Italy	0.35	5.58	0.39	4.79	0.43	7.63
	[2.30]		[2.37]		[2.63]	
Netherlands	0.27	1.24	0.30	0.18	0.37	6.57
	[1.88]		[1.94]		[2.53]	
Portugal	0.33	4.32	0.31	4.48	0.34	5.22
	[2.92]		[2.57]		[2.80]	
Spain	0.36	3.17	0.41	2.21	0.48	2.65
	[2.11]		[2.18]		[2.43]	

Table IA.13: ECB Tone Changes and Returns of Portfolios Sorted by Ex-Ante Betas

This table presents results on the link between the returns of portfolios sorted by stocks' ex-ante betas and changes in the ECB's communication tone. Each day in our sample, we sort stocks into decile portfolios according to their ex-ante beta and compute the value-weighted returns of the portfolios. Additionally, we compute the return a high-minus-low beta portfolio, that goes long in high and short in low beta stocks. The data covers the period from the first to the last ECB press conference (PC) in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes. On each PC day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC. Panel A reports results from using all days in our sample. On the left, we report results from regressing portfolio returns on a constant and a dummy, $\mathbb{1}$(PC), that is one on days with PCs and zero otherwise. In the right part of Panel A, we report results for regressions on a constant and separate dummies for PC days with positive tone changes ($\Delta\tau > 0$) and negative tone changes ($\Delta\tau < 0$). Additionally, we report the p-value of an F-test that the coefficient estimates for both dummies are equal. Panel B reports results for PC day regressions of portfolio returns on tone changes and a set of control variables; for detailed variable descriptions we refer to Table V.

Panel A. ECB Press Conferences and Tone Changes

	PC days		PC days with positive vs negative tone changes			
	const	$\mathbb{1}$(PC)	const	$\mathbb{1}(\Delta\tau > 0)$	$\mathbb{1}(\Delta\tau < 0)$	p[F]
Low beta	3.12	-1.01	3.12	-1.01	-1.00	1.00
	[5.23]	[-0.43]	[5.23]	[-0.34]	[-0.28]	
P2	1.48	2.21	1.48	11.03	-8.50	0.00
	[0.88]	[0.60]	[0.88]	[2.35]	[-1.68]	
P3	3.26	8.99	3.26	18.26	-2.25	0.01
	[3.11]	[2.13]	[3.11]	[3.30]	[-0.36]	
P4	3.84	-3.60	3.84	4.29	-13.18	0.07
	[3.06]	[-0.71]	[3.06]	[0.57]	[-2.10]	
P5	4.79	-7.27	4.79	-2.84	-12.65	0.38
	[2.01]	[-1.20]	[2.01]	[-0.35]	[-1.49]	
P6	3.12	-0.16	3.12	17.87	-22.03	0.00
	[2.30]	[-0.02]	[2.30]	[1.81]	[-2.94]	
P7	2.88	-1.91	2.88	14.39	-21.69	0.00
	[1.92]	[-0.30]	[1.92]	[1.62]	[-2.45]	
P8	3.53	-5.54	3.53	9.91	-24.29	0.02
	[2.21]	[-0.71]	[2.21]	[0.87]	[-2.45]	
P9	3.14	-7.39	3.14	14.08	-33.43	0.01
	[1.62]	[-0.75]	[1.62]	[0.97]	[-2.69]	
High beta	2.00	13.87	2.00	48.92	-28.64	0.00
	[0.78]	[0.98]	[0.78]	[2.34]	[-1.65]	
High minus low beta	-1.11	14.88	-1.11	49.94	-27.63	0.00
	[-0.45]	[1.04]	[-0.45]	[2.35]	[-1.59]	

Panel B. Regressions on ECB Tone Changes

	Specification (iv)		Specification (v)		Specification (vi)	
	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)	$\Delta\tau_t$	adj R^2 (%)
Low beta	-0.00	1.10	0.01	1.30	0.02	4.53
	[-0.01]		[0.26]		[0.55]	
P2	0.11	1.14	0.14	0.55	0.13	0.18
	[2.59]		[2.84]		[2.65]	
P3	0.10	1.22	0.10	1.96	0.11	1.16
	[1.86]		[1.74]		[1.81]	
P4	0.19	3.45	0.19	6.22	0.22	12.35
	[3.03]		[2.96]		[3.24]	
P5	0.06	-1.30	0.07	-2.60	0.13	0.34
	[0.80]		[0.89]		[1.69]	
P6	0.24	2.85	0.22	1.80	0.25	7.94
	[2.65]		[2.34]		[2.46]	
P7	0.25	2.45	0.26	1.16	0.33	8.84
	[2.79]		[2.82]		[3.68]	
P8	0.21	3.45	0.22	2.39	0.26	6.46
	[1.89]		[1.71]		[2.13]	
P9	0.30	0.90	0.33	1.64	0.40	7.74
	[2.24]		[2.22]		[2.76]	
High beta	0.57	3.44	0.64	3.22	0.74	7.53
	[2.93]		[3.08]		[3.31]	
High minus low beta	0.57	4.23	0.64	4.10	0.72	7.54
	[3.01]		[3.08]		[3.26]	

Table IA.14: Realized volatility

This table extends the analysis of the relationship between tone changes and realized volatility of the Eurostoxx 50 presented in Panel A of Table VII in the main paper. On each day in our sample, we measure the realized volatility of the Eurostoxx 50 from intraday data over the time window from 14:30 to 17:30 (RV_{PC}); the full trading day (RV); a period of five days, including the current day plus the next four trading days, (RV_{5d}); 22 trading days (RV_{22d}); and 66 trading days (RV_{66d}). On each ECB press conference (PC) day, we compute the change in tone ($\Delta\tau_t$) compared to the previous PC. The data covers the period from the first to the last PC in our sample, i.e., January 7, 1999 to September 7, 2017, with 4,777 daily observations including 209 PCs, i.e., we have 208 PC days with tone changes. Panel A reports results from using all days in our sample. On the left, we report results from regressing the realized volatility on a constant and a dummy, $\mathbb{1}$(PC), that is one on days with PCs and zero otherwise. In the right part of Panel A, we report results for regressions on a constant and separate dummies for PC days with positive tone changes ($\Delta\tau > 0$) and negative tone changes ($\Delta\tau < 0$). Additionally, we report the p-value of an F-test that the coefficient estimates for both dummies are equal.

	PC days		PC days with positive vs negative tone changes			
	const	$\mathbb{1}$(PC)	const	$\mathbb{1}(\Delta\tau > 0)$	$\mathbb{1}(\Delta\tau < 0)$	p[F]
Realized volatility 14:30-17:30 (RV_{PC})	65.01	15.33	65.01	13.82	17.15	0.58
	[41.78]	[5.45]	[41.78]	[3.54]	[3.96]	
Realized volatility (RV)	102.82	12.65	102.82	9.45	16.51	0.38
	[42.73]	[3.43]	[42.73]	[1.91]	[2.74]	
Realized volatility 5 days (RV_{5d})	234.89	6.30	234.89	4.06	9.02	0.77
	[43.09]	[0.88]	[43.09]	[0.39]	[0.74]	
Realized volatility 22 days (RV_{22d})	500.72	7.43	500.72	5.54	9.72	0.91
	[45.05]	[0.55]	[45.05]	[0.28]	[0.40]	
Realized volatility 66 days (RV_{66d})	882.55	5.07	882.55	12.42	-3.76	0.77
	[48.95]	[0.24]	[48.95]	[0.38]	[-0.10]	

Table IA.15: Equity Market Returns and Changes in ECB Tone: Controlling for additional lags of tone

This table reports results for regressions of Eurostoxx 50 returns on changes in ECB tone and control variables. The setup is identical to Table V in the main paper but additionally controls for more lags in tone changes by adding $\Delta\tau_{t-2}$, $\Delta\tau_{t-3}$, $\Delta\tau_{t-4}$, and $\Delta\tau_{t-5}$. For more details about the regression specifications, data sample, and variable descriptions, see Table V.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
const	0.00	0.00	-0.00	-0.00	-0.00	-0.01
	[0.09]	[0.01]	[-0.60]	[-0.60]	[-1.00]	[-1.31]
$\Delta\tau_t$	0.34	0.37	0.38	0.36	0.41	0.45
	[2.28]	[2.39]	[2.38]	[2.08]	[2.34]	[2.66]
$\Delta\tau_{t-1}$		0.06	0.06	0.10	0.29	0.21
		[0.31]	[0.30]	[0.52]	[1.41]	[1.24]
$\Delta\tau_{t-2}$		0.00	0.01	-0.05	0.09	0.00
		[0.02]	[0.04]	[-0.26]	[0.50]	[0.00]
$\Delta\tau_{t-3}$		0.27	0.27	0.18	0.14	0.00
		[1.49]	[1.48]	[1.07]	[0.74]	[0.00]
$\Delta\tau_{t-4}$		0.07	0.07	0.05	-0.01	-0.16
		[0.41]	[0.44]	[0.33]	[-0.03]	[-0.90]
$\Delta\tau_{t-5}$		0.10	0.10	0.07	0.13	0.07
		[0.55]	[0.54]	[0.40]	[0.73]	[0.37]
DIS_t			0.00	0.00	0.00	0.00
			[0.60]	[0.53]	[0.84]	[1.14]
ΔFOG_t			0.00	0.00	0.00	0.00
			[0.36]	[0.35]	[0.48]	[1.26]
ΔTTR_t			0.02	0.02	0.02	0.03
			[0.76]	[0.76]	[0.91]	[0.97]
ΔMRO_t				1.57	1.48	0.11
				[1.30]	[0.95]	[0.09]
UMP_t				0.01	0.01	0.01
				[1.41]	[1.52]	[1.41]
Expected $\Delta realGDP_t$					-0.06	0.06
					[-0.26]	[0.23]
Expected $\Delta HICP_t$					-0.09	0.51
					[-0.22]	[1.48]
Target shock						-0.01
						[-0.19]
Communication shock						0.10
						[2.53]
Lagged return		0.00	0.00	-0.00	-0.00	0.00
		[0.07]	[0.11]	[-0.08]	[-0.04]	[0.01]
adj R^2 (%)	2.11	0.66	-0.50	1.39	0.20	4.83
obs	208	203	203	203	184	160

Table IA.16: Realized versus Implied Volatility and Changes in ECB Tone: Controlling for additional lags of tone

This table reports results for regressions of realized volatility, changes in implied volatility, and changes in volatility risk premia on changes in ECB tone and control variables. The setup is identical to Table VII in the main paper but additionally controls for more lags in tone changes by adding $\Delta\tau_{t-2}$, $\Delta\tau_{t-3}$, $\Delta\tau_{t-4}$, and $\Delta\tau_{t-5}$. For more details about the regression specifications, data sample, and variable descriptions, see Table VII.

	$\Delta log(VSTOXX)$			$\Delta log(VSTOXX)/RV$			$\Delta log(VSTOXX)/RV_{PC}$		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
const	-0.00	0.01	0.02	1.14	1.74	2.51	1.14	2.33	3.72
	[-0.01]	[0.16]	[0.55]	[0.41]	[0.58]	[0.70]	[0.26]	[0.50]	[0.65]
$\Delta\tau_t$	-1.02	-1.16	-1.11	-138.70	-143.70	-122.98	-200.01	-214.81	-180.25
	[-1.96]	[-2.03]	[-2.03]	[-2.69]	[-2.54]	[-2.22]	[-2.50]	[-2.42]	[-2.09]
$\Delta\tau_{t-1}$	-0.09	-0.18	0.41	-19.85	-18.02	33.01	-1.88	-4.35	85.23
	[-0.12]	[-0.20]	[0.46]	[-0.29]	[-0.23]	[0.39]	[-0.02]	[-0.03]	[0.60]
$\Delta\tau_{t-2}$	0.66	0.70	1.12	16.48	37.85	94.68	72.87	103.41	186.62
	[0.87]	[0.78]	[1.22]	[0.25]	[0.47]	[1.15]	[0.63]	[0.73]	[1.29]
$\Delta\tau_{t-3}$	0.04	0.48	0.92	-28.18	26.31	75.00	11.94	100.69	166.65
	[0.05]	[0.45]	[0.86]	[-0.39]	[0.33]	[0.94]	[0.08]	[0.63]	[1.06]
$\Delta\tau_{t-4}$	0.03	0.32	1.07	-25.18	13.78	85.19	5.44	65.92	181.20
	[0.04]	[0.36]	[1.11]	[-0.34]	[0.17]	[0.94]	[0.04]	[0.48]	[1.19]
$\Delta\tau_{t-5}$	0.65	0.46	1.03	54.29	40.71	87.59	108.34	87.26	167.39
	[0.85]	[0.56]	[1.18]	[0.81]	[0.56]	[1.14]	[0.92]	[0.69]	[1.26]
DIS_t	-0.00	-0.00	-0.00	-0.09	-0.09	-0.12	-0.12	-0.12	-0.17
	[-0.66]	[-0.57]	[-0.76]	[-1.45]	[-1.35]	[-1.43]	[-1.21]	[-1.14]	[-1.21]
ΔFOG_t	0.00	0.00	-0.00	0.18	0.23	0.00	0.53	0.62	0.38
	[0.52]	[0.59]	[-0.34]	[0.49]	[0.54]	[0.00]	[0.87]	[0.88]	[0.48]
ΔTTR_t	-0.07	-0.03	-0.03	-8.26	-6.49	-6.88	-9.77	-5.12	-5.96
	[-0.81]	[-0.28]	[-0.27]	[-1.08]	[-0.73]	[-0.68]	[-0.86]	[-0.38]	[-0.39]
ΔMRO_t	-4.75	-5.69	0.18	-157.84	-234.79	73.81	-250.63	-313.63	106.20
	[-1.39]	[-1.18]	[0.05]	[-0.68]	[-0.69]	[0.23]	[-0.65]	[-0.59]	[0.21]
UMP_t	-0.05	-0.05	-0.05	-2.47	-2.66	-2.79	-3.20	-3.47	-3.91
	[-2.45]	[-2.59]	[-2.35]	[-1.70]	[-1.86]	[-1.78]	[-1.78]	[-1.96]	[-2.00]
Expected $\Delta realGDP_t$		-0.36	-1.02		-58.60	-99.20		-105.84	-170.75
		[-0.33]	[-0.96]		[-0.62]	[-1.02]		[-0.72]	[-1.13]
Expected $\Delta HICP_t$		0.08	-2.62		-4.79	-173.77		-59.91	-294.56
		[0.05]	[-1.84]		[-0.03]	[-1.21]		[-0.29]	[-1.37]
Target shock			0.11			8.49			26.66
			[0.75]			[0.68]			[1.23]
Communication shock			-0.24			-6.42			-5.08
			[-1.73]			[-0.58]			[-0.30]
Lagged variance	0.01	0.00	-0.00	1.39	0.43	2.05	2.18	0.23	1.83
	[0.28]	[0.06]	[-0.02]	[0.43]	[0.13]	[0.62]	[0.44]	[0.04]	[0.35]
adj R^2 (%)	1.24	-0.17	2.02	0.11	-1.55	-1.24	-0.43	-1.72	-1.06
obs	203	184	160	202	183	160	202	183	160

Table IA.17: Corporate Credit Spreads and Changes in ECB Tone: Controlling for additional lags of tone

This table reports results for regressions of changes in corporate credit spreads on changes in ECB tone and control variables. The setup is identical to Table VIII in the main paper but additionally controls for more lags in tone changes by adding $\Delta\tau_{t-2}$, $\Delta\tau_{t-3}$, $\Delta\tau_{t-4}$, and $\Delta\tau_{t-5}$. For more details about the regression specifications, data sample, and variable descriptions, see Table VIII.

	All corporates			Financials			Non-financials		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
const	-0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
	[-1.14]	[-1.08]	[-0.85]	[0.25]	[0.06]	[0.43]	[-1.18]	[-0.98]	[-0.95]
$\Delta\tau_t$	-0.01	-0.01	-0.01	-0.03	-0.02	-0.03	-0.01	-0.01	-0.01
	[-2.43]	[-2.02]	[-2.21]	[-2.87]	[-2.50]	[-2.79]	[-2.12]	[-1.79]	[-1.67]
$\Delta\tau_{t-1}$	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.02	-0.02
	[-1.36]	[-0.83]	[-0.88]	[-1.44]	[-0.97]	[-0.71]	[-2.07]	[-1.91]	[-1.60]
$\Delta\tau_{t-2}$	-0.00	-0.00	0.00	-0.00	0.00	0.01	-0.00	-0.01	-0.01
	[-0.48]	[-0.02]	[0.15]	[-0.47]	[0.20]	[0.52]	[-1.16]	[-1.28]	[-1.10]
$\Delta\tau_{t-3}$	0.00	0.01	0.01	-0.01	-0.00	0.00	0.00	0.00	0.00
	[0.86]	[1.16]	[1.31]	[-1.19]	[-0.40]	[0.09]	[0.31]	[0.40]	[0.25]
$\Delta\tau_{t-4}$	0.00	0.01	0.00	0.00	0.01	0.00	-0.00	-0.00	-0.00
	[0.77]	[1.14]	[0.63]	[0.46]	[0.90]	[0.32]	[-0.23]	[-0.33]	[-0.39]
$\Delta\tau_{t-5}$	0.01	0.01	0.00	0.02	0.02	0.01	-0.01	-0.01	-0.01
	[0.54]	[0.65]	[0.42]	[1.32]	[1.39]	[0.93]	[-0.70]	[-0.75]	[-0.70]
DIS_t	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
	[1.08]	[1.04]	[0.84]	[-0.53]	[-0.21]	[-0.50]	[1.30]	[1.04]	[1.00]
ΔFOG_t	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
	[0.74]	[0.86]	[0.10]	[1.61]	[1.29]	[0.08]	[-1.28]	[-0.86]	[-1.12]
ΔTTR_t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.85]	[0.28]	[0.67]	[0.62]	[0.29]	[0.55]	[0.64]	[0.69]	[0.95]
ΔMRO_t	0.08	0.09	0.11	0.18	0.22	0.32	-0.00	-0.02	-0.01
	[1.36]	[1.30]	[1.35]	[1.82]	[1.88]	[2.74]	[-0.01]	[-0.98]	[-0.49]
UMP_t	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	[-1.56]	[-1.83]	[-1.37]	[-1.15]	[-1.44]	[-0.82]	[-2.47]	[-2.39]	[-1.88]
Expected $\Delta realGDP_t$		-0.00	-0.00		-0.02	-0.03		0.01	0.01
		[-0.30]	[-0.20]		[-1.12]	[-1.20]		[1.17]	[0.97]
Expected $\Delta HICP_t$		0.01	0.00		0.02	-0.00		0.00	0.00
		[0.77]	[0.48]		[0.58]	[-0.06]		[0.59]	[0.39]
Target shock			-0.00			-0.01			0.00
			[-1.69]			[-1.95]			[0.32]
Communication shock			-0.00			-0.00			-0.00
			[-0.64]			[-0.53]			[-0.68]
Lagged spread changes	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
	[2.39]	[2.63]	[2.16]	[1.23]	[1.26]	[1.15]	[1.84]	[2.05]	[1.15]
adj R^2 (%)	4.07	3.66	2.44	14.54	15.43	20.48	0.12	-1.94	-4.75
obs	203	184	160	203	184	160	201	184	160

Table IA.18: Comparing tone changes to other methods

This table reports root mean squared errors (RMSE) and hit ratios for forecasts of Eurostoxx 50 returns on days of ECB press conferences (PCs). Returns are measured from the closing prices on the day preceding the PC and the day on which the PC is held. We use Lasso regressions to generate point forecasts and Naïve Bayes (NB) classifiers to generate directional forecasts (positive versus negative return). In both cases, we evaluate the performance of using tone changes as a predictor to predictors based on all words in a PC statement ("Words"), all bigrams ("2"), trigrams ("3") or longer sequences of words (n-grams, with n up to 12). We use an initial window of 36 months for estimating Lasso regressions and training of the NB classifiers and use the resulting model to forecast the return on the next PC day. Subsequently, we update regressions/classifiers recursively to generate a sequence of out-of-sample predictions. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 days with tone changes.

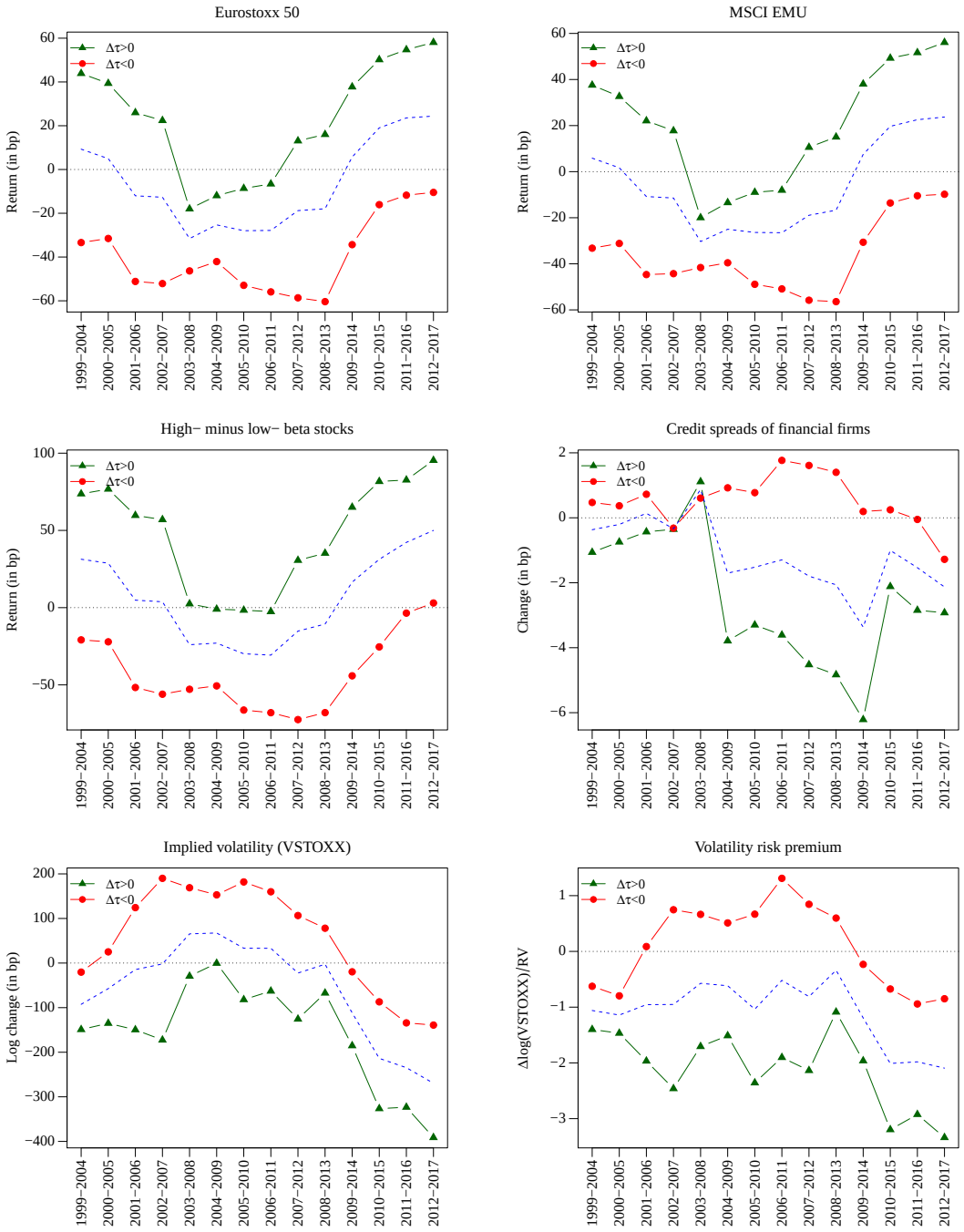
	$\Delta\tau$	Words	n-grams						
			n=2	n=3	n=4	n=6	n=8	n=10	n=12
Lasso: RMSE	2.00	1.70	2.04	1.92	1.83	1.72	1.71	1.70	1.70
Naïve Bayes: Hit ratio	0.53	0.56	0.55	0.53	0.51	0.52	0.54	0.55	0.52

Table IA.19: Tone Changes and Topics in ECB press conference statements

This table reports results for regressions of Eurostoxx 50 returns on changes in ECB tone, our standard set of control variables, and topic dummies. Our sample covers all 209 ECB press conferences in the period from January 7, 1999 to September 7, 2017, i.e., we have 208 days with tone changes. Additionally, we use the PC statements to estimate 'topics' using a topic model based on latent dirichlet allocation (LDA). The model requires to specify the number of topics to identify, and we present results for estimations with 2,3, ..., 8 topics in specifications (i) through (vii), respectively. More specifically, we repeat the regression with the largest set of control variables from Table V, i.e., specification (vi) in that table, but additionally include dummies that take on the value one for PCs in which a topic identified by the LDA occurs and zero otherwise. We always exclude the dummy for topic 1 to avoid collinearity with the regression intercept. For more details about the regression specifications and variable descriptions, see Table V.

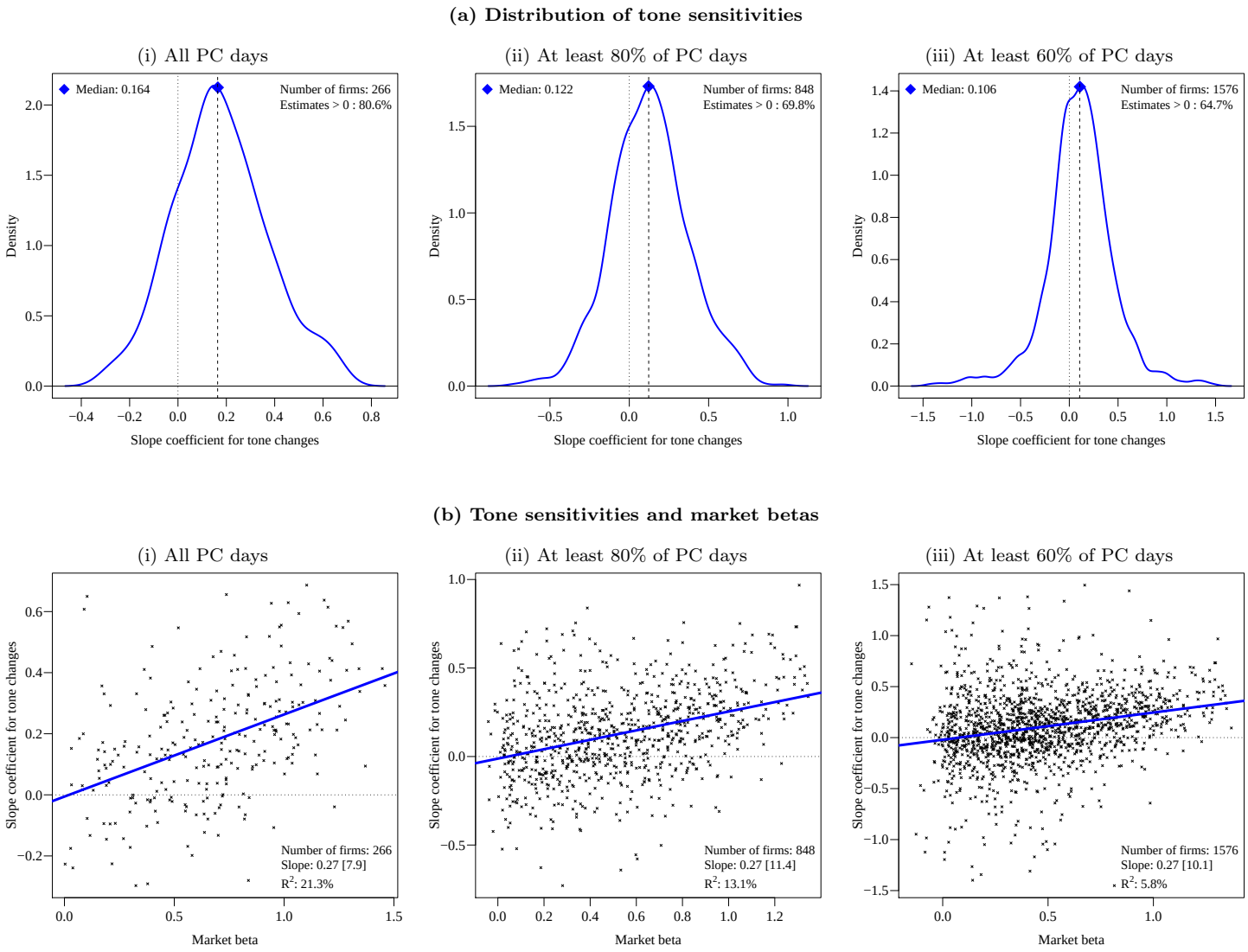
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
$\Delta\tau_t$	0.49	0.50	0.48	0.50	0.48	0.47	0.44
	[2.73]	[2.80]	[2.70]	[2.80]	[2.59]	[2.51]	[2.37]
Topic 2	0.18	0.00	-0.25	-0.41	-0.85	-0.20	2.50
	[0.75]	[-0.01]	[-0.83]	[-0.77]	[-1.19]	[-0.48]	[1.21]
Topic 3		0.16	-0.14	-0.13	-0.35	-0.11	-0.02
		[0.42]	[-0.28]	[-0.38]	[-1.20]	[-0.25]	[-0.06]
Topic 4			-0.09	-0.86	0.25	0.04	-1.10
			[-0.25]	[-1.19]	[0.63]	[0.08]	[-1.12]
Topic 5				-0.02	0.01	-0.12	0.01
				[-0.04]	[0.02]	[-0.30]	[0.02]
Topic 6					-0.20	-1.51	-0.24
					[-0.60]	[-1.49]	[-0.65]
Topic 7						-0.50	-0.43
						[-1.21]	[-0.89]
Topic 8							-0.26
							[-0.57]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj. R^2 (%)	7.18	6.47	6.01	6.66	6.31	6.50	6.06

Figure IA.1: Robustness over Subsamples



This figure presents results on changes in asset prices in response to changes in ECB tone revealed at press conferences over 14 five-year subsamples (x-axis). The green lines (with triangles) represent averages across subsample's press conferences with positive tone changes, the red lines (with bullets) for negative tone changes. We report results for the press conference day returns of (i) the Eurostoxx 50, (ii) the MSCI EMU index, and (iii) a portfolio that goes long stocks with high and short stocks with low ex-ante betas. Additional we report results for (iv) changes in credit spreads (BBB–AAA) of financial firms, (v) log changes in the VSTOXX, and (vi) a proxy for changes in the volatility risk premium, computed as the ratio of the log change in the VSTOXX to the realized volatility on a press conference day.

Figure IA.2: ECB Tone Changes and the Returns on Individual Stocks



This figure presents results from regressing individual stocks' returns on days of ECB press conferences on changes in ECB tone. Panel A illustrates the distribution of coefficient estimates across firms. Panel B presents a scatter plot of firms' market betas and tone coefficient estimates. In each panel, we present results when we restrict the sample to firms for which we have observations for all ECB press conferences (left), at least 80% of the press conferences ((middle), or at least 60% of the press conferences (right). In all cases, we winsorize the data at the top and bottom 1% to reduce the influence of outliers. In Panel B, we also report results from a cross-sectional regression of tone sensitivities on market betas and report the regression slope and its associated t-statistic based on bootstrapped standard errors.