How closely do financial markets really listen to central bank tone?

A high-frequency study on ECB press conferences

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Abstract

This thesis examines the effects of central bank tone on financial markets by conducting a textual analysis on 184 European Central Bank press conferences between April 2001 and December 2017. For this purpose, intraday data on euro area equity and bond markets is utilized. Overall, consistent with previous research, results confirm the positive (negative) relationship between ECB tone and equity (bond) returns. However, by further disentangling different financial market shocks, evidence shows that the effect on equity returns is weakened, canceled-out, or, in some cases, even reversed when central bankers use forward guidance. With regards to bonds, on the other hand, the relationship is amplified under the use of forward guidance. By studying different intraday event windows, it is suggested that bond markets systematically react faster and more clearly to central bank tone than equities. Finally, for both bonds and equities, neither volatility nor trading volume is systematically affected by changes in central bank tone.

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1 Introduction

Before the Governing Council of the European Central Bank (ECB) met to discuss monetary policy on 4 July 2013, financial markets expected that no changes in the ECB's key interest rates would be announced. At 13:45 Central European Time (CET) the official press release was published, confirming that indeed interest rates on the main refinancing operations, the marginal lending facility and the deposit facility will remain unchanged. No substantial movements on the financial markets were observed as a response. However, following president Draghi's introductory statement in the official press conference (starting at 14:30 CET) stating that the "the key ECB interest rates are to remain at present or lower levels for an extended period of time", stock prices sharply increased and bond yields fell immediately, reflecting a downward adjustment of expectations in interest rates (European Central Bank, 2014).

While prior the 1990s, central banks were characterized by low transparency and very cryptic statements informing the public only to the very minimum, the way they communicate has seen dramatic shifts in the last three decades. Direct control over key interest rates allows central banks to impact short-term interest rates quite directly. However, their mandate requires them also to influence asset prices and interest rates at longer maturities, because forward-looking agents typically condition their decision-making on expected real interest rates over long horizons. Consequently, it is now widely accepted that many aspects of modern monetary policy aim at managing inflation expectations (Hansen and McMahon, 2016). Communication has emerged to fill the void of strategically shaping market expectations and thus became an essential toolkit for central bankers to implement monetary policy (Woodford, 2005; de Haan et al., 2007).

Given the key role of central bank communication, both policymakers, as well as market participants, should be well aware of the intended and unintended effects words in public central bank statements have on financial assets. Using a dictionary developed by Loughran and McDonald (2015) (LM dictionary), this thesis strives to test and quantify, whether monetary policymakers can convey positive and negative sentiment through the choice and use of some specific words to affect expectations of financial market participants. Beyond general quantitative and qualitative information conveyed through the content of their communication, sentiment captures soft information in the tone of policymakers' communication (Hubert and Fabien, 2017). As central bank statements with positive (negative) tone are expected to be a reliable proxy for the degree of hawkishness (dovishness) of the central bank on economic and financial conditions, it

is further studied through which channels tone matters.

As surveyed by Blinder et al. (2008), the effect of central bank communication on financial markets is both theoretically as well as empirically an extensively researched domain. However, while a significant strand of literature examines market reactions to quantitative information such as rate changes, only few scholars explore the effects of "soft" information conveyed in the language of central bank communication. A benchmark paper for this thesis is the empirical study by Schmeling and Wagner (2015). Employing the LM dictionary to measure central bank tone, they report that daily stock prices and bond yields increase (decrease) as a result of positive (negative) tone changes in ECB press conferences. Jegadeesh and Wu (2017), as one of the few dictionary-based studies utilizing intraday stock returns, employ a Latent Dirichlet Allocation model to confirm that the tone of Federal Open Market Committee (FOMC) minutes affects stock and bond prices. Their findings indicate that directional effects are multidimensional and conditional on the topics addressed in the central bank statement [ibid.].

This thesis contributes to the existing literature in two main aspects. First, a theoretical framework is proposed to better understand the relationship between central bank tone and asset prices. Next to conventional monetary policy tools, central bank communication is considered to add two new tangible dimensions of information, namely forward guidance and the state of the economy (Hansen and McMahon, 2016). Moreover, while this cannot be modeled in terms of a specific topic, central bank communication may also affect perceived uncertainty and risk aversion of financial market participants. Consequently, it is argued that tone captures monetary, economic and risk-premium shocks with multidimensional effects on asset prices. By utilizing data on prices, volatility and trading volume of equities and bonds, the empirical analysis, studying 184 ECB press conferences between April 2001 and December 2017, thrives on shedding light on the different shocks through which central bank tone matters. Second, this paper utilizes intraday data to examine the effect of central bank communication on financial markets. There are several reasons why high-frequency data is more appropriate in this context than a lower-frequency (daily) study. The institutional features of the ECB allow separating between the monetary policy decision (announced at 13:45 CET) and the actual communication (starts around 14:30 CET). By employing narrow windows around ECB press conferences, it is possible to isolate the effects of communication on asset prices as intraday data surmount endogeneity problems that are inevitable with lower-frequency studies (Rosa, 2012). Additionally, in a narrow enough window, the likelihood of confounding effects and other news hitting the markets is kept to a minimum.

Thus, this thesis strives to answer *to what extent does central bank tone systematically affect financial markets?* In the empirical results, it is shown that generally equity and bond markets are significantly impacted by live press conferences held by the ECB. The relationship between ECB tone changes and financial market reactions, however, is less clearly visible in the reported results. Fundamentally, equity returns seem to co-move with central bank tone changes. In other words, when ECB tone becomes more positive (negative), stock returns will increase (decrease). However, while strong statistical significance is reported for daily stock returns, on an intraday level surrounding the time of the press conference no, at least statistically, meaningful estimates are found. Contrarily, for bonds, a negative correlation between ECB tone and returns is estimated. Put differently, when ECB tone improves (deteriorates), bond prices fall (rise). It is shown that ECB tone has a faster impact on bonds compared to equities, reflected in robust and significant estimates reported in the intraday windows surrounding the introductory statement of the ECB president. Finally, for both bonds and equities, neither volatility nor trading volume seems to change in response to ECB tone changes systematically. By including a specification for forward guidance, it is found that the positive relationship between tone and equity market returns is weakened, canceled-out, or, in some cases, even reversed. For bond markets, on the other hand, the relationship is stronger when central bankers use forward guidance in ECB press conferences compared to press conferences without forward guidance. All in all, it can be concluded that obtained results support theoretical suggestions, but further research is necessary to validate the findings.

The remainder of this thesis is organized as follows. The next section provides background information on the role of central bank communication in the field of monetary policy. Section 3 describes relevant theories the analysis is based upon. Section 4 is a review of the related empirical literature. Section 5 and 6 outline the methodology and describe the employed data sets. Section 7 presents the main findings. Section 8 summaries procedures for robustness checks. Finally, Section 9 discusses the obtained results, and Section 10 concludes.

2 Central bank communication

Central bank communication represents the public provision of information by central banks on topics of monetary policy, monetary policy strategy, the economic outlook, and future policy decisions (de Haan et al., 2007). Effectively, central banks are thereby "signaling" intentions behind specific monetary policy actions to prepare market participants. As a result, such signaling can substantially increase the effectiveness of a specific monetary policy (Issing, 2005). As this resembles a fundamental concept of this thesis, an extensive review of central bank communication is provided in the following section.

2.1 The development of central bank communication strategy

Prior to the 1990s, central bank communication was very different from today's standards and its importance in guiding the public was yet still to be discovered. Characterized by low transparency, central bank communication was very cryptic, and the public was only informed to the very minimum. Central bankers refrained from communicating their decisions and did not explain intuitions behind their strategies. Consequently, it was believed that effective monetary policy necessarily includes surprises for the financial markets (Kahveci and Odabaş, 2016). Fixed exchange rate strategies were considered to be a significant driver behind this closed central bank communication since slight indications of weakness could create a furor of self-fulfilling wagers among investors (Chant, 2003).

After this period characterized by mystery, secrecy, and opacity, the Reserve Bank of New Zealand inaugurated an era of transparency in central bank communication around 1990 (Kahveci and Odabaş, 2016; Vayid, 2013). Driven by inflation targeting policies and the corresponding link between expectations and rates, greater openness was considered to be critical for effective and efficient monetary policy (Blinder et al., 2008; Woodford, 2001). In turn, central bankers reacted by publicly providing more information about their monetary policy in the form of official statements and press conferences. Notably, the Federal Reserve only began publicly communicating changes in its federal funds rate in early 1994. The ECB, on the other hand, put great focus on transparency and hosted live press conferences ever since it started operations in 1998 (Blinder et al., 2008). Throughout time, as it became increasingly clear that managing expectations is an essential part of monetary policy, communication now represents a vital instrument for the majority of independent central banks around the world (Woodford, 2001; de Haan et al., 2007).

One of the latest milestones of central bank communication occurred after the global financial crisis 2007/08 when central banks struggled to guide the economy through traditional monetary policy tools at the zero-lower bound. While, on the one hand, non-traditional monetary tools, such as asset purchase programs were implemented, they also increasingly used forward guidance to direct expectations of the public. Realizing that the financial economy is greater than the sum of its parts, the need for transparency was stronger than ever (Vayid, 2013). Thus, financial markets should be better informed so that growing transparency harmonizes private sector expectations and reduces volatility (Kuttner, 2001). Practically, central banks increasingly introduced more sophisticated communication strategies, such as "extraordinary forward guidance", to provide more information on future rates (Kahveci and Odabaş, 2016).

Following the historical path in the general communication of central banks, the economy currently finds itself in an interesting state due to ongoing zero-interest rates set by the ECB and other central banks around the world. As outlined below, at the zero-lower bound, central bank communication becomes the true essence of monetary policy (Blinder et al., 2008).

2.2 Theoretical implications of central bank communication

Essentially, the higher a central bank's ability to drive market expectations on future overnight rates, the higher the impact on the economy. To understand this basic phenomenon, the scene is set by relating to the theory of the term structure. According to the standard economic frameworks presented in Blinder et al. (2008), central banks can only directly set today's overnight bank rate. Yields over longer maturities, however, are dependent on a series of future overnight rates. Accordingly, an economic model consisting of four equations is defined.

$$R_t = a_n + \frac{1}{n}(r_t + r^e_{t+1} + r^e_{t+2} + ... + r^e_{t+n-1}) + e_{1t} \tag{1}$$

In Equation 1, R_t represents the long-term rate and other financial-market prices, r_t is the current overnight rate and r^e_{t+1} is today's expectation of tomorrow's overnight rate. Lastly, a_n and e_{1t} are a term premium and an error term. Hence, Equation 1 shows that the long-term rate is mostly driven by expected future rates rather than the current overnight rate set by the central bank. An extreme case arises when overnight interest rates get close to the zero-lower bound. When central banks face this constraint of their conventional monetary policy instrument, alternative policy tools, such as communication about expected future rates, become the essence of central banking (Bernanke et al., 2004; Eggertsson et al., 2004).

Second, r_t is set as the short-term rate and R_t as the long-term rate. In a macroeconomic context, aggregate demand (y_t) then depends on r_t, R_t, expected inflation (π_t^e) and a set of other variables.[1]

$$y_t = D(r_t - \pi_t^e, R_t - \pi_t^e ...) + e_{2t} \tag{2}$$

Additionally, inflation depends on actual output (y_t) and potential real output (y_t^*). Thus, the aggregate supply relation is presented:

$$\pi_t = \beta E(\pi_{t+1}) + \gamma(y_t - y_t^*) + e_{3t} \tag{3}$$

Last, the Taylor rule is defined, namely the central bank reaction function with π_t^* being the central banks inflation target:

$$r_t = G(y_t - y_t^*, \pi_t, \pi_t^*, ...) + e_{4t} \tag{4}$$

Following this economic set-up, four factors make central bank communication significant: First, non-stationarity implies that Equations 1-3 can change over time. Second, learning is a side-effect of the economic surrounding. Third, non-rational expectations or asymmetric information exist between the public and the policymakers. Consequently, if one of these factors does hold, central bank communication, which is set as a vector of s_t for signaling, will in fact matter. The constant change in the economy suggests that learning about central banks' actions always continues. Additionally, any central bank usually has superior knowledge about monetary policies and economic outlook which triggers asymmetric information. Further, it is very rarely the case that a central bank does not change its policy for a long period (Bernanke and Reinhart, 2004).

It is important to fully understand that communication by central banks and the learning behavior of the public are closely connected. The process of learning creates contrasting behavior compared to rational expectations equilibrium (Blinder et al., 2008). Assuming that market participants learn, an increase in inflation can cause the public to adjust its long-run inflation estimate upwards and consequently real inflation increases. Hence, central banks should increase economic performance by publishing more information about long-term inflation (Bernanke et al., 2004). In line with that, the assumption of rational expectations is replaced by an

[1] Given the scope of this thesis it is not necessary to explain these factors in any more detail.

equation for interest rate expectations:

$$r^e_{t+j} = H_j(y_t, R_t, r_t, ..., s_t) + e_{5t} \tag{5}$$

Recall that s_t is a vector of central bank signals that can range from very specific (e.g., a numerical inflation target) to not specific at all (e.g., a set of words taken without detailed context) (Blinder et al., 2008). Derived from the economic model introduced above, central bank actions can be broken down into three distinct channels: First, the direct but considerably small impact of the overnight rate on demand. Second, the direct impact of the central banks' signaling on future short rates. Third, driven by signaling, the impact of short rate changes on expectations of the set of future rates, the resulting feedback on long-rates and hence demand. In essence, this again shows how central banks can impact the economy by providing information ('signal') on its long-run goals (Bernanke et al., 2004). As communication is so crucial, it has become the primary tool to drive expectations on long-term rates (Vayid, 2013). Concluding, the importance of expectations and central bank communication is probably best articulated by the following:

> *"Central banks have direct control only over a single interest rate, usually the overnight rate, while their success in achieving their mandate requires that they are able to influence asset prices and interest rates at all maturities."* (Ehrmann and Fratzscher, 2005)

2.3 Central bank communication at the ECB

Above, the historical development and theoretical foundations of central bank communication are described. The following section initially provides a brief overview of the ECB's background and organizational setup followed by a review on how central banks communicate in practice.

Established on 1 June 1998, the ECB represents the independent central bank for all of the 19 European Union countries that have introduced the euro as their currency. Currently led by Mario Draghi, the ECB's main task lies in maintaining price stability in the euro area and thereby ensuring the purchasing power of the Euro (European Central Bank, 2019a). Being the *Single Supervisory Mechanism* for the banking industry, it oversees all credit institutions in the euro area and participating non-euro area member states. In summary, the ECB intends to provide safety in the banking and the financial system within the European Union.

The heart of the ECB is represented by the Governing Council, which is set up as the ultimate decision-making body of the organization. It consists of six members in the Executive Board and governors from the national banks of all 19 euro area countries. The representatives of the Executive Board are the current president, the vice-president and four other members, who prepare the Governing Council meetings and manage the day-to-day operations of the ECB. Generally, the Governing Council formulates monetary policy decisions (e.g., key interest rates), finalizes propositions concerning the banking supervision and generally ensures the execution of supporting tasks related to its vital mission (price stability in the euro area). In order to do so, the Council comes together twice a month in Frankfurt, Germany. Moreover, every six weeks, it evaluates the latest economic developments and takes corresponding monetary policy decisions. With respect to the process behind each decision, the Governing Council employs a rotational system of voting rights. Recalling that the Council contains governors of all 19 member countries, rights are assigned based on economic and financial sector size. The five largest countries (Germany, France, Spain, Italy and the Netherlands) share four voting rights, while the remaining 14 countries share 11 voting rights. A monthly rotation then assigns voting authority to each governor. After agreeing, a press release about the latest monetary decisions is published right before a press conference, which is hosted by the president and the vice-president. These press conferences represent the ECB's most important communication vehicle (Berger et al., 2011), intended to put central banks and market participants on the same wavelength by decreasing asymmetric information. The basic set up of ECB press conferences is further outlined in Section 6.1.

Generally, central banks can align the level of information with the market if they can be held accountable for their actions, follow an effective communication strategy and find the right level of transparency (Vayid, 2013; Kahveci and Odabaş, 2016). These three principles are closely interlinked and central banks need to improve and coordinate them continuously (Vayid, 2013). Typically, central banks communicate four different topics, namely i) objectives and strategy, ii) motives behind policy decisions, iii) economic outlooks and iv) future policy decisions (Blinder et al., 2008).

First, when communicating about objectives and strategy, central banks should provide some kind of quantification. Numerical targets increase accountability and help to anchor expectations of the public. This quantification is especially important for inflation targeting since it removes an essential source of shocks. Nevertheless, significant practical differences among central banks are observed. As described in Section 2.4, the ECB, was set up without a clear

quantitative objective but chose one itself. In contrast, the Bank of England sets interest rates independently, its inflation goal, however, is announced by the Chancellor.[2]

Second, the majority of central banks provide detailed information regarding the policy decisions on the day of implementation. Some institutions do so by publishing minutes from the meetings, or host press conferences. While prompt and clear policy announcements do create news to the market, they also alleviate noise created by guessing of financial market participants. Considering the practices by the ECB, after a policy decision, the president of the ECB starts each press conference by repeating the latest decisions followed by the introductory statement.

Third, rather substantial differences exist on the extent of forward-looking information (economic outlook) that a central bank provides. Information with regards to the economic outlook includes the central bank's assessment of future inflation, economic growth, and its path of future monetary policy decisions. While inflation targeting central banks publish periodic reports including future expected inflation levels, non-inflation targeting central banks (e.g., the ECB) mostly do so through so-called "staff projections" (Blinder et al., 2008). These are essentially macroeconomic projections prepared by central bank staff in order to contribute to the monetary policy decision-making process.

Last, central banks follow forward guidance to express future policy rates to the public. Such forward guidance can vary from indirect signals (e.g., ECB using code words) over statements assessing future monetary policies (e.g., FOMC), to quantitative guidance of numerical paths of future policy rates (e.g., the central banks of Sweden and Iceland). To be protected from eventual pitfalls, most central banks emphasize that forward-looking assessments are conditional on current information and thus subject to change. Since July 2013, the ECB officially uses forward guidance. Included in the introductory statements, the ECB directly refers to future monetary intentions in order to shape commercial banks reactions and their corresponding rates on long-term loans. Note that the topic of forward guidance is described extensively in Section 5.4.3.

[2]The current inflation goal of the Bank of England is 2% (Bank of England, 2019).

2.4 Communication strategy for inflation-targeting

Below, actual practices used by central banks in the context of inflation targeting are reviewed to get a sense of real-life central bank communication. According to Bernanke and Boivin (2003), inflation targeting is characterized by the announcement of official target ranges for the level of inflation at one or more horizons. This includes an explicit overriding goal of low and stable inflation as well as increased communication with the public. Inflation targeting represents the most critical economic outlook published by central banks and, in line with Bernanke's definition, it serves as a demonstrative example for central bank communication. Following the economic model, inflation targeting is not about current conditions but is shaped by medium-term trends and goals. It is therefore crucial that market participants realize that impacts of policy decisions take time before they affect inflation (Kahveci and Odabaş, 2016). To achieve this, recall that central banks need to be accountable, follow an effective strategy and be transparent. Consequently, most central banks periodically publish inflation reports including the horizon of the target, their rationale behind it, and how it can be achieved (Mishkin, 2004).

Even though the ECB does not employ inflation-targeting in the traditional sense, it is used as an example to review its practices and get a real-life understanding of overall central bank communication. Generally, ECB communication uses indirect signals rather than being very explicit (Blinder et al., 2008). Even though the Maastricht Treaty did not assign the ECB a quantitative objective, it follows an inflation rate below, but close to, 2% (European Central Bank, 2019a). As discussed above, targeting an actual number makes the ECB very accountable since it is easy to track if its actions are successful. Regarding their communication strategy, the ECB states that it achieves its inflation goal by:

> *"(. . .) firmly anchoring inflation expectations. Monetary policy is considerably more effective if it firmly anchors inflation expectations. In this respect, it is crucial that the central bank specifies its goal, sticks to a consistent and systematic method for conducting monetary policy and communicates its decisions and actions clearly and openly."* (European Central Bank, 2019a)

In terms of communication vehicles, in contrast to e.g., the Federal Reserve, the ECB does not publish meeting minutes. Thus, aside from interviews and speeches, staff projections and ECB press conferences are their most important channel to talk about inflation. Note that the structural set-up of press conferences is reviewed in Section 6.1 and hence details are limited

to the background of inflation only.

First, staff projections are published four times a year (March, June, September, and December) and generally aim to understand the future state of the economy. Covered in an independent chapter of every staff projection document, the ECB reviews current inflation levels and future estimations. Second, during its regular press conferences, the current president of the ECB usually includes several passages about inflation and makes references to the latest staff projections. Besides the structural differences of press conferences among numerous ECB presidents, the introductory statements usually contain statements about the most recent inflation, the expected medium-term inflation and expected long-term inflation. Additionally, during the Q&A session, the president also answers on most of the inflation-related questions. The regularity of the introductory statements and the staff projections, as well as their level of detail, suggest a high level of transparency. Driven by the ECB's two communication vehicles focusing on inflation, clear inflation goals, and a detailed strategic rationale, it can be argued that the ECB follows the three principles for central bank communication outlined by Kahveci and Odabaş (2016).

2.5 Measuring the effectiveness of communication

After demonstrating the importance of central bank communication, it is helpful to understand how successful communication can be measured. Success in this context is the ability of policymakers to influence the public's expectations through their choice of language. In fact, central bank communication can be used to manage expectations both by "creating news" and "reducing noise." However, as central bank communication can take the form of regular announcements and reports or irregular speeches and interviews, the first challenge for researchers is to define what constitutes central bank communication. Additionally, the timing issue can lead to practical challenges as there may be lags between the announcement and its reporting in the media or even the media reporting on central banks actions before the official communication act.

Post-meeting statements are one of the most critical documents central banks use to communicate their policy actions, economic assessments, and future guidance. Practically, these statements can take the form of, e.g., meeting minutes or press conference transcripts and are usually carefully prepared by the policymakers. Accordingly, these documents are the closest representatives of central banks' actual communication and are hence widely used for analyt-

ical purposes. Finding only limited application in economics, text-mining techniques can be applied to assess the effectiveness of central bank communication by extracting the statements' information. This gives an idea of the type of information central banks are publishing and how they phrase specific topics to guide the public in their intent.

After highlighting the central bank's shared contents, the actual reaction of the public should be captured to measure the success of central bank communication. As extensively described in Section 4, most research suggests using financial markets rather than macroeconomic data as a dependent variable in this context (Issing, 2005; Blinder et al., 2008). The intuition behind this stems from timing differences behind the two economic relationships. It is established that central bank communication influences expectations of future short-term rates, and thus on long-term rates and other financial market prices. These market prices in turn influence inflation and output. However, there are two distinct differences between these causal relationships (Blinder et al., 2008): First, while central bank communication only gradually influences the economy, financial markets are expected to react much quicker to new information. Second, besides monetary policy, there are many more factors influencing macroeconomic variables such as inflation and output. True effects on financial markets, however, can be measured by studying short enough time intervals. Hence, it is easier to study the effect of central bank communication using high-frequency financial market data than low-frequency macroeconomic data (Blinder et al., 2008).

In summary, it seems promising to measure the effectiveness of central bank communication using text-mining techniques on published documents and high-frequency financial market data. Going forward, it is expected that if central bank communication can successfully influence expectations, financial markets should respond and policy decisions are better predictable.

3 Theoretical framework

This section outlines theoretical concepts of financial economics and sentiment analyses that help to understand results of the empirical analysis in the remainder of the thesis. Following, three interdependent theories are outlined, explaining if and how financial markets are expected to react to central bank communication. Subsequently, based on the theoretical suggestions, the thesis strives to answer *to what extent does central bank tone systematically affect financial markets?*

3.1 Efficient market hypothesis

Being one of the cornerstone theories in modern financial economics, the efficient market hypothesis states that security prices in liquid markets should reflect all available information at any time. According to Fama (1970), asset prices in efficient markets should only react to new information that was not expected before it became public. Moreover, they should do so in a rapid and unbiased fashion. Three different variations of the efficient market hypothesis exist: First, the weak form suggests that security prices reflect all *publicly available market information* implying that technical analysis of securities is not sufficient to generate excess returns. Second, the semi-strong form assumes that also *publicly available non-market information* is reflected in security prices. In other words, neither technical nor fundamental analysis techniques are reliable to earn excess returns. Finally, the efficient market hypothesis also exists in a strong form. Here, security prices reflect all *private and public information* available. Consequently, not even investors with insider information would be able to make a return on their superior knowledge. Closely related to the efficient market hypothesis, the random walk theory claims that changes in stock prices are unpredictable and random each day (Malkiel, 2003). In line with the efficient market hypothesis, news is instantly incorporated in stock prices and hence changes in stock prices tomorrow are only depending on the news that becomes available. In turn, when news is assumed to be unpredictable so are stock price changes and thereby random.

With regards to monetary policy, an announcement or statement by central banks can either meet market expectations or not. Consequently, financial markets should only react to announcements or statements containing information that was not previously expected by financial market participants. Since staff economists at central banks have access to a wide variety of confidential economic data, e.g., detailed records of inter-bank lending, it is likely that their information set is superior to that of other market participants. Empirical evidence

on whether and how financial markets respond to central bank communication is reviewed in Section 4.1.

3.2 Movement of stocks and bonds in response to shocks

Before empirically testing if and how central bank communication affects financial markets, it is worth reviewing what directional asset price changes are expected from different types of shocks that can be created through central banks. While stock returns and government bond yields, over the last two decades, have typically co-moved positively in response to economic activity and changes in investor's "risk appetite", a negative correlation is found with regards to monetary policy shocks. Put differently, a positive economic shock is expected to move yields and stock prices up, a positive monetary shock (tightening) moves yields up while stock prices decline, and, finally, a decline in risk appetite is associated with both lower yields and stock prices corresponding to "flight-to-safety" episodes.

3.2.1 Shock decomposition for stocks and yields

In order to understand how stocks and bonds respond to different types of shocks, this section discusses the economic intuition behind stock and yield changes.[3] First, following Campbell and Shiller (1988) and Cieslak and Schrimpf (2018) let r^s_{t+1} be the total log return of the aggregate stock market, pd_t represents the log price-dividend ratio and Δd_{t+1} the log dividend growth rate. Thus, the log-price dividend ratio is given by the following perpetuity:

$$pd_t = \frac{k_0}{1-k_1} + \sum_{j=1}^{\infty} k_1^{j-1} E_t(\Delta d_{t+j} - (ex^s_{t+j} + r_{t+j-1})) \tag{6}$$

Where k_0,k_1 are linearization constants, $ex^s_{t+j} = r^s_{t+1} - r_t$ represents the excess return. When log-linearizing the equation, it follows that $r^s_{t+1} \approx k_0 + k_1 pd_{t+1} + \Delta d_{t+1} - pd_t$, thus shocks to stock returns are caused by new information on future growth perspectives (dividend rate), the discount rate and finally the excess return (risk premia):

$$\tilde{r}^s_{t+1} := r^s_{t+1} - E_t(r^s_{t+1}) = u^s_{d,t+1} - u^s_{r,t+1} - u^s_{ex,t+1} \tag{7}$$

Turning to bond yields, i_t denotes the nominal short-term interest rate over one period, whereas π_{t+1} is the log change in price from time t to $t+1$. The real short-term interest rate is thus

[3] For an illustrative model of the shock decomposition, please refer to Cieslak and Schrimpf (2018).

the nominal rate less one-period expected inflation: $r_t = i_t - E_t[\pi_{t+1}]$. The nominal yield over n periods is linked to expectations about inflation, real rates, and bond returns:

$$y_t^{(n)} = \frac{1}{n}\sum_{i=1}^{n} E_t(\pi_{t+i}) + \frac{1}{n}\sum_{i=0}^{n-1} E_t(r_{t+i}) + \frac{1}{n}\sum_{i=1}^{n-2} E_t(ex_{t+i}^{(n-i+1)}) \tag{8}$$

Where $ex_{t+1}^{(n)} = -(n-1)y_{t+1}^{(n-1)} + ny_t^{(n)} - i_t$ denotes the excess return over one-period on a n period bond. Decomposed, it can be shown that yield curve shocks are caused by adjustments in expected inflation, real rates, and term premia:

$$\tilde{y}_{t+1}^{(n)} := y_{t+1}^{(n)} - E_t(y_{t+1}^{(n)}) = u_{\pi,t+1}^{(n)} + u_{r,t+1}^{(n)} + u_{tp,t+1}^{(n)} \tag{9}$$

So how can central banks, in theory, create these shocks to financial markets? The monetary transmission mechanism refers to the process by which asset prices and other economic conditions are affected by monetary policy actions (European Central Bank, 2019b). While central banks, fundamentally, operate by setting short-term interest rates, complementary communication may signal the future path of monetary policy and insider-knowledge on macroeconomic fundamentals. Such knowledge is superior to that of other market participants and thereby shapes market expectations. The following section addresses the main three channels through which central bank communication can create expectation shocks to financial markets.

3.2.2 Monetary policy shocks

Shocks to financial market participant's expectation about current and future actions of central banks are, in this thesis, considered as monetary policy shocks. While independent from their communication, central banks can create conventional monetary policy shocks by unexpectedly changing the real short-term interest rates, they have additional possibilities to explain their decisions or express their current view on the likely path of future monetary policy actions. In line with the decomposition of shocks, when a central bank communicates new information about a current or future monetary tightening (expansion), stock prices are expected to fall (rise) through an increase (decrease) of the expected risk-free component of the discount rate. Conversely, yields are expected to rise (fall). According to *Expectations Theory* on the interest rate term structure, the long-term represents a reflection of the expected future path of the short-term (Praet, 2013). As a result, forward guidance is expected to have a stronger effect on stock returns and long-term bond yields than conventional monetary policy decisions. Consistent with the theory, Hansen and McMahon (2016) find, when studying central bank

communication, that forward-looking statements about monetary policy are the main driver for financial market reactions.

3.2.3 Economic shocks

Following, economic shocks are referred to as adjustments in expectations with regards to current and future macroeconomic fundamentals. A large amount of research provides evidence that central banks communicate or at least signal information about the state of the economy to imperfectly informed market participants (Romer and Romer, 1998; Campbell et al., 2013). These shocks include but are not limited to new information on economic growth, inflation and unemployment. For equities specifically, positive economic shocks enhance the cash-flow prospective of stocks. With regards to bonds, it is argued that real interest rates (and thus government bond yields) increase as credit demand is likely to increase. If the real interest rate is not perfectly sensitive to the economic shock, the cash-flow effect dominates and stock returns are expected to increase (Gordon, 1962). To design and implement optimal policies, it is important for policymakers and financial market participants to understand the implications of this signaling channel. Ehrmann and Talmi (2017) report that the economic outlook in central bank speeches represents the most important driver for daily bond returns of up to ten years, with the most significant effect at a five-year horizon.

3.2.4 Risk-premium shocks

In line with Cieslak and Schrimpf (2018), shocks to financial risk premia that are uncorrelated with macroeconomic shocks in the economy are henceforth referred to as risk-premium shocks (higher risk aversion). While pricing and measurement of risk represent major issues in modern finance, with regards to monetary policy, it may concern asymmetric information on the mandate or objective of the central bank announcement, real-world complexities, and domestic and international economic developments (Kozicki and Vardy, 2017). Borio and Zhu (2012) provide evidence that expansionary monetary policy and the reduction of uncertainty surrounding central bank decisions decrease risk aversion of financial market participants. As government bonds typically become more valuable when premia on risky assets increase, it is expected that stock returns and yields move in the same direction in response to a risk-premium shock. Whereas some theoretical models have linked monetary policy actions and communication to risk-taking behavior in financial markets (Rajan, 2006; Adrian and Shin, 2008; Borio and Zhu, 2008), empirical research is limited to only a few studies (Bekaert et al., 2013; Schmeling and Wagner, 2015).

3.3 Sentiment of central bank communication

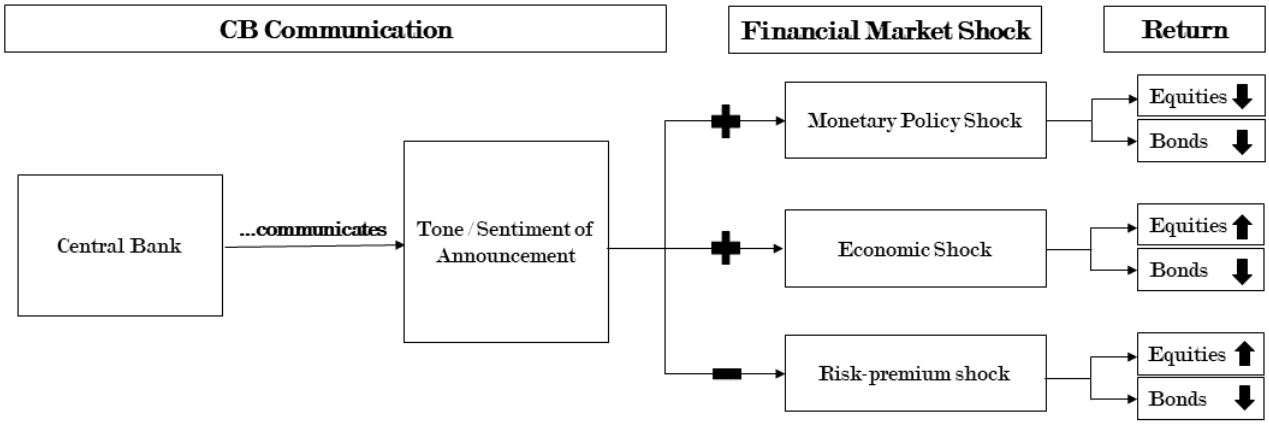
After having outlined the dynamics of stocks and bonds in response to external shocks, this section provides a theoretical foundation for the sentiment analysis and how it can be used to measure the shocks created by central bank communication.

Sentiment analysis refers to the task of identifying whether the valence or polarity of emotions, opinions or evaluations in a text can be considered as positive, negative or neutral. More generally, the sentiment of a specific piece of text represents one's attitude towards a topic (Wilson et al., 2005; Mohammad, 2015). Measuring the attitude, for example, means extracting whether an evaluative judgment by the communicator is considered as positive or negative. The idea of the analysis is, therefore, to present the sentiment information from text sources and reasonably summarize the findings (Pang and Lee, 2008). Accordingly, this thesis thrives on extracting the sentiment or tone of central bank communication in order to identify potential shocks created to financial markets.

In addition to conventional monetary policy tools, central bank communication is considered to add two new tangible dimensions of information, namely forward guidance and the state of the economy (Hansen and McMahon, 2016). Central bank statements with positive (negative) tone are expected to be a reliable proxy for the degree of hawkishness (dovishness) of the central bank on economic and financial conditions (Castillo et al., 2018). This relationship has several implications. First, as more restrictive monetary policies are typically implemented during economic upswings, it is expected that a more positive tone in central bank communication correlates with more restrictive forward-looking monetary policy announcements. Consequently, for monetary policy shocks specifically, stock and bond returns are expected to be more negative, when central bank tone is positive. Second, with regards to economic shocks, a more positive tone is expected to be associated with higher stock returns (through the cash-flow news channel) and lower bond returns (as yields typically increase in good economic environments). Finally, as outlined above, central bank communication may also affect perceived uncertainty and risk aversion of financial market participants. While this cannot be modeled in terms of a specific topic, the sentiment of central bank communication may capture this effect as well. A positive tone is typically associated with lower uncertainty and less implied risks. In turn, it is expected that a more positive tone is negatively correlated with risk-premium shocks, and thus associated with higher stock returns and lower bonds returns ("flight-to-safety").

Figure 1 summarizes the expected effects of central bank communication on equity and bond returns. In sum, stock and bond returns positively co-vary in response to monetary policy shocks, but negatively in response to economic and risk-premium shocks. The empirical analysis of this thesis tests whether the theoretical framework holds in practice. Moreover, findings are related to theoretical implications in order to understand whether central bank communication is effective and through which channels it may affect financial markets.

Figure 1: Proposed Relationship: Central bank tone and asset price reaction



4 Related literature

This section explores the economic literature on central bank communication to review how economists measure potential macroeconomic effects of speeches and other forms of communication by central banks. Further, a summary of the empirical work on textual analysis is provided which argues that it can further contribute to the discussion of central bank communication. For an extensive survey of the relevant literature in this domain, please refer to Blinder et al. (2008).

4.1 Central bank communication and financial markets

This thesis builds on the substantial literature studying the effect of central bank communication on asset markets. As noted previously, central bank communication is used through various channels and is sometimes difficult to measure. Consequently, this section focuses on relatively well-defined, high-frequency signals, such as announcements and speeches of central banks. In recent literature, it has become common practice to identify pre-scheduled, regular communications such as announcements of policy decisions by central banks as well as irregular statements through financial news reports. Two main challenges arise when studying central bank communication. First, it remains challenging to determine when precisely a communication event took place. Second, to assess whether central bank communication is effective, the intention or objective behind the policy statement needs to be extracted.

To approach these challenges, different methods are employed by several scholars. One line focuses on studying the effects of central bank communication events on the volatility of financial assets (Kohn and Sack, 2003; Connolly and Kohler, 2004; Reeves and Sawicki, 2007). By studying volatility, scholars do not attempt to divine the directional intent of announcements but instead examine the hypothesis that volatility of returns should be higher on days where the central bank communicates, as signals contain news. Besides avoiding to identify the direction of the policy effect, another potential drawback lies in not controlling for other factors, some of them unobservable, that may affect asset prices. A rise in volatility of asset prices may be due to shocks other than central bank communication that occurred in the period studied. Moreover, when studying central bank announcements, there may be a problem of endogeneity. A central bank may decide to communicate to the public in reaction to a sudden change in the economic outlook or some other news (Reeves and Sawicki, 2007). Asset prices are most likely more volatile in the observed period, but not necessarily due to the central bank announcement.

To avoid endogenous communication, scholars mostly focus on pre-scheduled central bank announcements that are known in advance.

Kohn and Sack (2003) find that variances of many financial variables increase significantly and by a large amount on days of FOMC statements and argue that this serves as evidence that central bank communication conveys relevant information to different participants in the market. Following a similar approach, Reeves and Sawicki (2007) show consistent results for effects of the Bank of England communication on financial markets. The release of Monetary Policy Committee minutes and inflation reports seem to move financial markets significantly. However, both papers do not find any evidence that live speeches of the respective central bank chairman move financial markets (Kohn and Sack, 2003; Reeves and Sawicki, 2007).

In order to gain further insights into the effects of central bank communication on asset prices in terms of magnitude and direction, many authors have subsequently attempted to quantify announcements on a numerical scale based on their content and/or intended effect. These studies assign negative (positive) values to statements that are perceived as dovish (hawkish) and zero to statements that appear to be neutral. While Jansen and De Haan (2005) and Ehrmann and Fratzscher (2009) restrict coding to the directional indication, Rosa and Verga (2007) and Musard-Gies (2006) code statements on a scale from -2 to +2 to also capture the magnitude of the indication. As mentioned previously, these approaches help to understand better whether communication by central banks shows the intended effect on the financial markets. However, manually coding statements based on their content and/or intended effect also yields a few drawbacks.

First, as humans have to classify statements manually, coding is inevitably subjective leading to the risk of misclassifications. Through the use of content analysis (Holsti, O., 1969) as in Berger et al. (2006) this risk can be reduced but never eliminated. Rosa and Verga (2007), for instance, disagree on 14 (22.58%) of the 62 ECB press conferences between 1999 and 2004. Second, when papers employ newswire reports to quantify central bank communication, several biases through the use of an intermediary may be introduced. For instance, news intermediaries could be selective in the content they report, misleading in their reporting or introduce a time lag between the actual communication and the reporting. Third, as communication is quantified ex-post, it may not accurately reflect how financial markets perceived the announcement at the time. This may further be affected by the expectations of the participants in the financial market about monetary policy. As noted in Section 3.1, an efficient market should only react

to the unexpected component of a statement.

From the strand of literature that quantifies central bank communication by constructing wording indicators, Ehrmann and Fratzscher (2009) suggest that central bank statements generally move financial markets in the intended direction: more hawkish statements lead to higher rates, while more dovish statements lead to lower interest rates. A particularly strong effect is shown for ECB talk referencing monetary policy inclinations with average interest rates moves of 1.5-2.5 basis points. Similar results for the ECB are provided by Musard-Gies (2006), although rates at the short end of the yield curve show to be more affected by central bank statements than interest rates at the long end. By constructing a hawkish/dovish indicator from statements, Lucca and Trebbi (2011) find that long-dated yields react significantly to changes in communication around central bank statements.

Subsequently, in order to alleviate the previously mentioned issues, authors have utilized indirect measures derived from financial market reactions. Gürkaynak et al. (2005) identify two common factors describing asset price movements around FOMC announcements by using a principal components method. The communication effect of the FOMC statement is defined by the factor that is orthogonal to the surprise of the Federal Funds' target rate. In this approach, the "path factor" that is related to the forward-looking part of the statement, affects interest rates across the entire yield curve, particularly dominant at the long end. Another approach by Brand et al. (2010) utilizes the fact that the ECB announces its monetary policy decision 45 minutes prior to the actual press conference. Thus, the forward-looking communication by the ECB can be distinguished from the actual release of the decision by using intraday asset price data. Similar to Gürkaynak et al. (2005), effects on interest rates appear to be dominant at the long end of the yield curve. Using intraday US equity returns, Rosa (2011a) finds that official FOMC statements yield much greater explanatory power to stock price reactions in response to monetary policy than the surprise component of monetary policy decisions.

Finally, a closer approach to manually classifying statements is a strand of literature that relies on dictionary-based and word-count methods. Jansen and De Haan (2005) quantify communication regarding risks to price stability by merely counting the word "vigilance" in ECB statements. Other authors (Tetlock, 2007; Sadique et al., 2013; Jegadeesh and Wu, 2017; Schmeling and Wagner, 2015), utilize a more standard approach by counting the number of positive and negative words in central bank communication based on a pre-defined dictionary such as the Harvard's General Inquirer or the LM dictionary. This method yields a particular

advantage compared to manually classifying statements. Subjectively defining a list of words essentially gives the authors control over the resulting tone and the outcome of the empirical analysis leading to hindsight bias. This caveat is alleviated by using word counts or standard dictionaries.

With regards to equities specifically, Sadique et al. (2013) provide evidence that the Federal Reserve Beige Book tone drives volatility and trading volume in the stock market. Only a few studies use the LM financial dictionary to measure central bank tone. Schmeling and Wagner (2015) find that stock prices and bond yields increase (decrease) as a result of a positive (negative) tone change in ECB press conferences. Further, as they do not find evidence that tone aggregates information about the economic outlook, it is concluded that ECB tone moves assets through risk premia required by market participants (ibid.). Moreover, Amaya et al. (2015) observe that pessimistic speeches amplify the overreaction of stock markets proving that ECB announcements have been effective at facilitating stock markets to learn from monetary policy. As one of the few dictionary-based studies utilizing intraday stock returns, Jegadeesh and Wu (2017) employ the Latent Dirichlet Allocation model to confirm that the tone of FOMC minutes affects stock market returns and volatility.

This thesis builds on literature studying the relationship between central bank tone and financial market reactions, utilizing asset price data at the intraday level. To get a better understanding on how a sentiment or tone can be measured in this specific context, the next section holistically outlines the textual analysis literature.

4.2 Textual analysis literature

The following section reviews the most influential literature on textual analysis, primarily focusing on sentiment measures in a financial context. Since textual analysis serves as the fundamental technique behind this thesis, recent trends and latest developments should be known and understood.

As already introduced in Section 3.3, textual analysis intentionally converts qualitative into quantitative information (Loughran and Mcdonald, 2011). Including applications in Biblical translations around 1300, validations of Shakespeare's work in 1901 or interpretations of political speeches during World War II, textual analysis faces a history of several hundreds of years (Loughran and McDonald, 2015). Its relevance in the financial context is a more recent

phenomenon driven by the introduction of computers and the rising importance of financial markets. Antweiler and Frank (2004) and Das and Chen (2007) are among the first who report results that show effects between qualitative content and equity valuations. Following Kearney and Liu (2013), corporations, the media, and the internet provide the three natural input factors for textual analysis in finance and accounting. Additionally, the burgeoning research on central bank press conferences to measure tone shows how wide the scope of accessible sources for textual analysis is. Press articles, company filings, chat room transcripts or central bank minutes hold critical information that affects real market variables, making textual analysis a popular vehicle to study the underlying relationships.

Following Loughran and McDonald (2015), textual analysis extracts distinct features of text components: First, it can help to assess the text's extent of readability, as in the study by Loughran and McDonald (2009) about the use of plain English in 10-K filings. Measuring the level of plain English in 10-K reports with the Flesch Score and the Fog index, they find that simple English has significant announcement effects on a company's stock.[4] Second, textual analysis can measure similarity among different documents: Measuring boilerplate disclosure and cosine similarity, Lang and Stice-Lawrence (2015) compare annual reports of non-US companies to review their semantic similarity and understand improvements in financial reporting.[5] Third, textual analysis can highlight a general topic or theme among text groups. The most common methods to do so are Latent Semantic Analysis and Latent Dirichlet Allocation. Huang et al. (2014), for example, use Latent Dirichlet Allocation to show that analysts play an essential role in finding information beyond corporate disclosures. The most popular field of textual analysis, however, is represented by sentiment analysis, namely measuring the contextual meaning of texts (Loughran and McDonald, 2015). Due to its popularity, the existing literature on sentiment analysis is reviewed in a detailed manner.

In sentiment analysis, there are two general concepts of analyzing text, namely manual content analysis, and computational linguistics (Apel and Blix-Grimaldi, 2012). In the former approach, researchers read a piece of text and classify it on a customized numerical scale based on its content. In his study on the ECB's interest-rate setting behavior, Rosa (2011a) resembles an example of manual content analysis, where texts are ranked from -2 to +2. Inevitably, since the

[4]The Fog measure is a linear combination of average sentence length and proportion of complex words whose scale provides an estimate of grade level. Based on the same components, Flesch uses an explicit count of syllables rather than the binary classification of complex words (Loughran and McDonald, 2009).

[5]Cosine similarity is a textual measure identifying similar texts by comparing the relative word frequencies across documents.

researcher has to judge every piece of text personally, manual content analysis is time-consuming and mostly suitable for small data sets. Alternatively, computational linguistics automatically determine, e.g., the frequency of specific words in a text. Within computational linguistics, researchers either apply machine learning or the bag-of-words method. Machine learning techniques usually consist of thousands of rules constructed from a training set that evaluate the content of a document (Loughran and McDonald, 2015). Such rules are essentially statistical algorithms, called 'classifiers', which scan a document's content and classify it. Among the most well-known classifiers are Naïve Bayes, support vector machines and N-grams. A classifier's training set is an excerpt of the complete text body where each word has to be classified into a sentiment dimension (e.g., positive, negative) and is then used to train the classifiers (Kearney and Liu, 2013). Even though machine learning tends to make very few errors when operated correctly, the complexity of the underlying rules makes it extremely tedious to apply and replicate (Loughran and McDonald, 2015). Due to its simplicity, the bag-of-words method has become the preferred alternative for most researchers that employ computer linguistics. Following the bag-of-words approach, a piece of text is scanned, compared to a pre-defined word list and then classified based on frequencies (e.g., a high number of negative words can classify the text body as being negative) (Apel and Blix-Grimaldi, 2012; Das and Chen, 2001). Consequently, the accuracy of a bag-of-words method is heavily dependent on the researcher's choice of word list, namely the dictionary.

4.2.1 Dictionaries in the financial context

Following the popularity of the bag-of-words approach in measuring the tone and its reliance on a well-functioning word-lists, the subsequent section focuses on the empirical development of dictionaries used in sentiment analysis. Generally speaking, dictionaries that frequently appear in sentiment analysis literature are, e.g., WordNet, LIWC or VADER. Due to their broad applicability and limited functionality in a financial context however, such generalist dictionaries are not considered any further in the following review. In finance and accounting, Henry (2008), Harvard's General Inquirer (HGI) (Stone et al., 1966), Diction (Hart, 2000) and LM have become the most popular dictionaries. In a more particular context of central bank communication, two alternatives have emerged: The word lists by Apel and Blix-Grimaldi (2012) and Picault and Renault (2017).

Developed by Philip Stone in 1966, the Harvard's General Inquirer (HGI) represents an external word list, which is based on the Harvard-IV-4 dictionary. It includes numerous tag categories,

including positive, negative, active and passive ones. The General Inquirer is the quantitative content analysis tool which estimates the frequency in each category. Since it is publicly available, HGI is among the most widely used textual analysis dictionaries within business related studies. In a financial context, HGI is criticized due to its misclassification of many words (Loughran and Mcdonald, 2011). Led by Tetlock (2007) and Tetlock et al. (2008), there is a yet a vast amount of literature using HGI to study textual tone. Tetlock uses the dictionary's most favored word list, namely the negative one, to show that pessimism in financial press has significant downward pressure on market prices. He measures the daily variation in the Wall Street Journal and its impact on the daily returns of the Dow Jones Industrial Average.

Similarly, DICTION is another publicly available dictionary which contains several different subcategories. Developed by Hart (2000) it is used to interpret mostly narrative texts, like political speeches, speeches by Federal Reserve policymakers but also corporate annual reports (Davis et al., 2006; Short and Palmer, 2008). Analogous to HGI, Loughran and Mcdonald (2011) argue that DICTION misclassifies several financial terms and phrases. Further, apart from its applicability in business communications, DICTION is incapable of evaluating tone concerning its context (Davis et al., 2006). Nevertheless, researchers like Davis et al. (2006) use DICTION to study the impact of optimism and pessimism in earnings releases on future performance. They find that optimistic language in a company's earnings releases successfully predicts positive future performance and vice versa.

Introduced in 2008, Henry's dictionary is the first one that targets explicitly financial texts. It is constructed from earnings press releases and thus holds a database of words that is strictly comparable to real financial documents. Nevertheless, the dictionary only contains a small number of words which limits its explanatory power (Loughran and McDonald, 2015). Research by Price et al. (2011) follows Henry's dictionary, to show that the sentiment in conference calls is connected to stock returns.

The latest and most widely used dictionary in financial research is an extension of the popular HGI, namely the LM dictionary. It overcomes several of the shortcomings in previously mentioned dictionaries. First, as briefly introduced, other dictionaries tend to misclassify or ignore specific words in a financial context. Classified as strict negative words in HGI, words like tax, cost or capital are examples that might have a non-negative context in finance and accounting. Consequently, Loughran and Mcdonald (2011) construct word lists which are adjusted for such terms (e.g., LM extends the HGI negative word list by 2,000 words). Second, LM is

constructed based on financial communication only, and hence all words in the dictionary are actual terms in financial documents. These improvements and their public availability make LM the predominant word list in the most recent studies on financial tone (Kearney and Liu, 2013). Chouliaras (2016), for example, employs LM to find that pessimism in 10-K earnings reports has a negative impact on stock returns. Further, as reported in Section 4.1, Schmeling and Wagner (2015) show that improving central bank tone has a positive effect on equity returns.

4.2.2 Central bank specific dictionaries

While LM represents the current state-of-the-art dictionary in general financial content, latest research has criticized its functioning in the economic studies, especially in the context of central bank communication (Picault and Renault, 2017; Kearney and Liu, 2013; Kahveci and Odabaş, 2016). Consequently, the two most recent dictionaries that have been constructed for this specific context are reviewed.

In order to overcome the shortcomings of traditional dictionaries for monetary policy situations, Apel and Blix-Grimaldi (ABG) introduce a 'hawkish' and 'dovish' word list in 2012. Following their list, a central bank is considered to be dovish when it implements monetary stimulation in bad economic health. A hawkish central bank, on the other hand, does not implement such stimulation in bad economic health. In contrast to general finance word list, e.g., LM, ABG has two distinct differences: First, it uses the frequency of two-word combinations rather than a single word. Second, it simultaneously classifies phrases in terms of hawkishness and dovishness (Dossani, 2018). Despite ABG's exceptional functionality in central bank contexts, the dictionary tends to fail measuring the negative tone following crises in monetary policy situations (Picault and Renault, 2017). Additionally, ABG does not capture the full content of an announcement (Dossani, 2018). Yet, existing literature proofs that researchers still employ ABG to study central bank communication. Hansen and McMahon (2016), for example, follow ABG to study the impact of FOMC statement information on market and real economic variables.

Following the development trend of field-specific dictionaries, Picault and Renault (2017) construct a more advanced word-list to measure both the stance of the ECB and the state of the Eurozone economy at the same time. While LM and ABG follow equally-weighted word lists, the Picault and Renault dictionary relies on term-weighting and continuous sequence of words. Their approach tends to outperform LM and ABG when explaining future ECB decisions and

market volatility. Nevertheless, Picault and Renault (2017) manually categorize sentences in the ECB introductory statements, which raises concerns of subjectivity and coding errors. Further, the dictionary is relatively new to this specific field of research. Hence, it misses a solid proof of its functionality as there is no extensive body of research employing it.

5 Methodology

Essentially, the following section consists of three main components. First, Subsections 5.1 and 5.2 concentrate on the independent variables. There is a thorough description of the variable's relevance in the context of this thesis as well as the theoretical and practical approach of manipulating the data. Second, Subsection 5.3 and 5.4 focus on the dependent variables, by identifying appropriate time windows and elaborating on three computed variables at hand. Third, the econometric set-up is introduced in Subsection 5.5, which includes the justification of the chosen statistical model and its underlying regressions.

5.1 The tone of central bank communication

Central bank tone retrieved from monetary policy statements is selected as the independent variable of this thesis. Throughout this subsection, three general questions are addressed: *First, why is there a need to study central bank tone in general? Second, what makes ECB press conferences the most appropriate source to do that? And last, how is the actual tone extracted from an ECB press conference?*

While the content of policy statements can be digested by markets right away, tone presents soft information that is captured by the sentiment (Hubert and Fabien, 2017). This sentiment can, for example, be reflected by positive or negative words, which shapes the subjective perception of the statement's audience. Recalling Section 2.2., namely that central banks can only directly set short-term rates, but that the long-term depends on market expectations about future rates, this subjective market perception appears to be essential for long-term rates. Practically speaking, the chosen central bank tone is argued to be associated with three different financial market shocks, which drive asset returns (see Section 3.3). Consequently, in order to shape the markets' opinion about the future, central banks need to reach market participants through their respective channels of communication. Every piece of information that is communicated to the public is therefore well prepared and agreed on by teams of central bankers. Overall, it therefore appears that assets do not only react to any specific policy decision, but also to the tone in a respective policy statement. Hence, central bank tone represents an essential component in the understanding of policymakers' influence on long-term interest rates and asset returns.

In this thesis, transcripts of introductory statements from ECB press conferences serve as the

sole source to extract sentiment from central bank communication. The selection for these transcripts builds on four distinct reasons: First, recall from Section 2.3 that the introductory statement is considered to be the main channel of ECB communication. In line with that, market respondents perceive the communication by the ECB president as being very precise (Gertler and Horvath, 2017). Second, several structural features of the ECB press conference provide empirical attractiveness:

1. The institutional features of the ECB allow separating between the monetary policy decision (announced at 13:45 CET) and the actual communication (starts around 14:30 CET) of a press conference day (PC day). Thus, market participants receive information from a press conference isolated from conventional monetary policy news.

2. Unlike the Federal Reserve or the Bank of England, the ECB does not provide actual meeting minutes and hence no information on individual voting records in the Governing Council. The main argument for doing so is to present decisions as one closed unit and avoid publishing any internal deliberations (Blinder et al., 2008). In turn, it can be assumed that every decision represents the Governing Council's unified opinion limiting volatility and doubts among market participants.

3. ECB press conferences are broadcasted live and thus do not contain a time lag. In contrast, most other central banks have an extensive sanitizing process to express the committee's decisions in the best possible way (Goodhart and Hofmann, 2005). Additionally, through its live broadcast, the ECB can reach a much broader audience, and market participants follow decisions all over the world.

Third, the ECB was the first monetary institution that made transcripts available to the public. It thus represents the largest applicable database of central bank communication documents. All other central banks have either just recently started publishing their meetings or do not host press conferences as the ECB does. Lastly, in contrast to the Federal Reserve, the ECB's textual tone is relatively stable over time without any major fluctuations facilitating that no significant tone-disruptions are disrupting the underlying study (Kahveci and Odabaş, 2016).

As an alternative to ECB press conferences transcripts, minutes by the FOMC or the Bank of England could be used as well. However, these minutes are not available in real-time and are edited before publication. Decision statements provided by central banks also do not serve as an appropriate substitute to measure tone since they are typically very short and contain less

information (ibid).

After having established that central bank tone can provide several insights and that ECB introductory statements serve as a suitable source to provide these insights, it is now described how textual tone can be extracted from each document. In general, the document modification for textual analysis relies on two steps, namely pre-processing and the use of a dictionary. Both these steps are executed using RStudio and a number of relevant software packages.[6] In line with previous textual analysis literature, first, transcripts are prepared in the following way:

1. *Html tags are removed*
2. *All words are converted to lower case*
3. *All numbers are removed*
4. *Punctuation is removed*
5. *English stop words are removed*
6. *Whitespace is stripped*

The applicable list of English stop words contains a total of 121 words, i.e. "and", "before", "from", "there" and "when".[7] This step intends to eliminate any textual content that does not add any significant value to the overall measurement of tone. Figure A1 in the Appendix exemplary shows lines of press conference text after the pre-processing step. Second, to rely on computational linguistics rather than manual content analysis, a proxy for central bank tone is constructed by using a financial dictionary. This facilitates the practical implementation and limits personal subjectivity. In the case at hand, the LM dictionary is considered to be most suitable, and among a total of seven word lists that are part of this dictionary, the negative word list only is employed to measure tone.

The initial choice of LM as the employed dictionary is based on several reasons, which appear when reviewing potential alternatives: First, one could set up a new statistical dictionary or manually classify tone of individual press conferences. Both approaches are, however, very likely to face risks of subjectivity and are relatively time-consuming. Second, among dictionaries that consist of positive and negative word lists (e.g., HGI), LM represents the latest and

[6] Used packages include *quanteda* and *Sentiment Analysis* (Benoit et al., 2018).

[7] For an exhaustive list, please find: https://sraf.nd.edu/textual-analysis/resources/LM%20Sentiment%20Word%20Lists

most widely used candidate in this field of research. Third, tone could also be measured by studying hawkish and dovish, rather than positive and negative expressions. However, the most applicable dictionary in this context (e.g., ABG) does not represent a better alternative, due to its shortcomings in crisis times (e.g., sovereign debt crisis) and during the presence of forward guidance (Picault and Renault, 2017). To complete the discussion, it should be noted that the LM dictionary was originally constructed for the use of 10-K filings and therefore might lack explanatory power in a monetary policy context. However, as of today, alternatives with a monetary policy focus as, e.g., the dictionary by Picault and Renault (2017) are still very new, and their practicality is not widely confirmed yet. Finally, solely the negative LM word list is selected to quantify the corresponding ECB tone. As stated by Loughran and Mcdonald (2011) themselves, the usefulness of positive words for measuring tone is limited in a context like this. This stems from the fact that positive words are often negated. In contrast, the negation of negative words is not as common.

It is justified why the negative word list of the LM dictionary is chosen for the remainder of this thesis. Next, the attention is directed to the actual application of the list. Analog to Schmeling and Wagner (2015), a sentiment score is computed by counting the number of negative words (N) and dividing it by the total number of words (T) in each introductory statement. Consequently, central bank tone (τ) in terms of negativity is defined as:

$$\tau = 1 - N/T \tag{10}$$

Based on Equation 10, lower values are considered as more negative central bank tone, whereas higher values imply the opposite (a more positive tone). Eventually, this unitary approach of classifying each press conference allows comparing introductory statements in terms of its negative tone. In the following empirical analysis, however, the first difference between two subsequent press conferences is used as an independent variable, defined as the change in tone $\Delta\tau$. The reason to do so stems from the process of how central banks set up their statements. Mostly, the previous communication transcript is used as a starting point, and then texts are modified when needed (Ehrmann and Talmi, 2017). This practice has significantly impacted the financial news industry in the way they report about policy releases: e.g., Bloomberg publishes side-by-side comparisons of the current to the previous ones just 1.5 minutes after the press release (ibid.).

The step-by-step approach above describes how ECB press conferences are manipulated in order

to extract and quantify its tone (sentiment score), allowing comparisons among different events.

5.2 Forward guidance in central bank statements

To further explore through which channels central bank tone may affect financial markets, additional control for forward guidance in ECB introductory statements is derived. Before describing the process of the dummy variable construction, there will be a brief review of forward guidance at the ECB.

In July 2013, the ECB officially used forward guidance for the first time. Ever since, it formulates the Governing Council's intentions about future monetary decisions, e.g., on key interest rates. Practically, the ECB president makes a statement about the future monetary path with the intention that commercial banks react by adjusting their interest rates on long-term loans. Subsequently, businesses and individuals are expected to align their future spending and inflation adjusts accordingly. Even though 4 July 2013 is considered to be the start date for forward guidance, the ECB has given indications about future actions before.

In order to extract information on forward guidance, qualitative content analysis is applied (Krippendorff, 1980; Mayring, 2004). On events where either the press claims that the ECB signaled on upcoming interest rates or a clear statement in the transcript is found, the press conference is classified as a *forward guidance PC*. In practice, this dummy construction consists of four steps:

1. Two business newspapers with daily reporting, namely Reuters and Handelsblatt, are used as the primary source for the content analysis. In line with similar studies (Bohl et al., 2008), Reuters is selected due to its regular and reliable consultation and publishing of economists' opinions on potential outcomes of ECB decisions. Additionally, Handelsblatt represents one of the leading German business newspapers with a daily reach of 200,000 copies. The fact that it is published in German requires the use of additional non-English keywords in the search process.

2. News articles for the exact day as well as the following day of the press conferences are searched and then filtered through the following English and German keywords: "ECB" (EZB), "monetary policy" (Geldpolitik), "key interest rates" (Leitzins), "forward guidance" (Forward Guidance) or the surname of the current ECB president. Usually, the name of the ECB president or "ECB" itself is enough to provide a list of well-matching

articles over the selected time window.

3. After collecting relevant news articles using the keyword search, each press conference needs to be classified into *forward guidance press conference* or not. An exemplary list of news articles and quotes is provided in the Appendix, Table A1. Mostly, press articles clearly state what the future signals of the ECB presidents are, which can then be cross-examined in the press conference transcript. A typical example of such a match includes:

   Retrieved from Reuters article (6 February 2014): *The ECB is wary of inflation getting stuck in what Draghi has called a danger zone' below 1 percent and vowed again to keep rates at present or lower levels for an extended period.*

   Retrieved from transcript (6 February 2014): *"We firmly reiterate our forward guidance. We continue to expect the key ECB interest rates to remain at present or lower levels for an extended period of time."*

4. If neither the press nor the transcript gives a clear indication, the press conference is classified as *not containing forward guidance*.

5.3 Time windows for market reaction

Following the definition of the independent variables, the next section focuses on the side of the dependent variable, namely financial market reactions. Consequently, first, the general characteristics of the event study are outlined. Second, the nature of the financial market data at hand is reviewed. Lastly, in line with empirical research, appropriate time windows are defined.

In general, the empirical analysis of this thesis is set up as an event study, with ECB press conferences classifying as the events of interest. Other than the event definition, the study requires constructing an event window over which market reactions are measured (Campbell and Shiller, 1988). Setting the right length for the event window is therefore a crucial step since it narrows down the period of interest that tracks the ultimate effect of the event (Kliger and Gurevich, 2014). Inaccurately defining the time span of an event window could yield risks of including too much or too little market response. Since this study employs intraday data to measure financial market reactions to central bank tone, it allows constructing event windows on a minute base, which provides several incremental advantages:

First, using data on an intraday base, each PC day can be divided to measure temporal responses and carve out the true effect of tone. In practice, the conventional monetary policy announcements can be separated from the actual speech (e.g., introductory statement). Recalling that this thesis aims to measure the tone from press conferences, this is the most critical advantage of high-frequency data. With daily observations, in contrast, it shows to be more tedious to differentiate whether asset reactions are triggered by interest rate announcement or central bank tone. Second, intraday data also allows controlling for non-event related effects, such as macroeconomic announcements. Given the short event windows, it can be ensured that only central bank-related news hit the market. Consequently, residual regression errors are smaller and point estimates are much more precise. This is especially relevant during times of high volatility (e.g., the global financial crisis). Third, high-frequency data strengthens the statistical models as endogeneity issues created by reverse causality can be alleviated. If daily asset returns are used, the borders between dependent and independent variables become blurred. There is no certainty if either asset prices react to central bank tone or if central bankers have adjusted their communication tone based on previous movements on the financial markets.

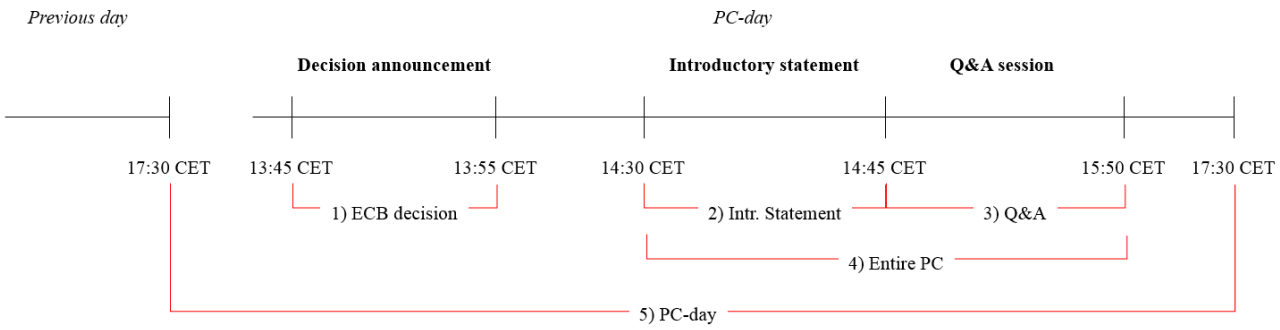
For the sake of completeness, it should be noted that intraday data also provides two disadvantages to the research approach. First, not all securities are traded every minute, which requires data adjustments to end up with an asset price for every minute (see Section 6.2). Second, the exact length of asset return effects is hard to estimate. Constructing appropriate intraday event windows requires to determine how long a specific effect lasts.

Given that the nature of the data allows the construction of intraday event windows, it makes sense to first review the schedule of a typical PC day, before setting up the actual windows: Every six weeks, the ECB hosts a press conference regarding the latest monetary policy decisions. Following a fixed schedule, each press conference takes place on a Thursday, starting with a press release on the latest interest rate decisions at 13:45 CET. Approximately at 14:30 CET, the current president and vice-president of the ECB read their introductory statements. These statements usually follow a similar pattern with the president welcoming the audience and informing about the attendance at the Governing Council meeting. After the formalities, the decision on the interest rates is repeated, and topics regarding the real economy, exchange rates, and price stability are discussed. Around 14:45 CET, the Q&A session represents the last part of each press conference, giving the audience the change to raise questions. Ehrmann and Talmi (2017) provide an overview of the length for each press conference part: On average, the entire press conference lasts for 44 minutes, with the introductory statement and the Q&A

session respectively accounting for 12 and 32 minutes.[8]

In line with previous research, the corresponding event windows are defined below, taking into account the schedule of a PC day. Similar to Ehrmann and Fratzscher (2009), four intraday windows are used to capture the market responses of each different press conference component. Besides, a daily event window is introduced to compare the intraday findings to previous daily studies, e.g., Schmeling and Wagner (2015). Given the fact that these windows increase in length, it can be demonstrated which component of the ECB's meeting-day communication is most relevant to the markets. Figure 2 provides a graphical representation of the chosen event windows.

Figure 2: Employed event windows over PC days



ECB decision. First, mostly for reasons of statistical control, the ECB decision window is defined throughout 13:45-13:55 CET to directly capture the effect of the monetary policy announcement on financial markets. It can be argued that information from the decision becomes public already before the actual announcement due to internal information leakage. However, empirical studies only find limited evidence in this context and higher market activity before the announcement is rather due to dealers minimizing their exposures (Sager and Taylor, 2004). The choice of length for the ECB decision window above relies on previous findings of market reactions, proving that financial markets take less than 10 minutes to adjust to an ECB's announcement (Brand et al., 2010).

Introductory statement. Second, setting up an interval around the reading of the introductory statement from 14:30-14:45 CET, allows to measure the direct market response on the

[8]Due to limited data availability, the stated time frame relies on Ehrmann and Talmi (2017). Note that their study tracks the average lengths of the individual components over a sample of 53 press conferences.

ECB president's choice of words. It is most likely that effects during this window are mainly due to words from the introductory statement since it is short enough not to be influenced by other macroeconomic effects (Jegadeesh and Wu, 2013). Nevertheless, it should be noted that US jobless claims are published every Thursday at 14:30 CET.

Q&A. Third, a Q&A-window (14:45-15:50 CET) is constructed to capture valuable information of the ECB president's answers on questions raised by the press. Based on Ehrmann and Fratzscher (2009), the length of the Q&A sessions varies from a minimum of 16 minutes to 54 minutes and can be used to evaluate information from the introductory statement further. Based on these time differences, the Q&A-window at hand is set over an extended interval.

Entire PC. Fourth, in order to measure the market response over the entire press conference, a window is set up over 14:30-15:50 CET. It should be noted, that the interval excludes the ECB decision announcement at 13:45 CET.

PC day. Last, a fifth event window is constructed to evaluate if intra-daily market effects result in different conclusions than daily findings. Consequently, the daily interval spans from 17:30 CET of the previous day until 17:30 CET of the PC day. Accordingly, all remaining results can be validated and comparisons to previous studies exclusively relying on daily data are drawn (Schmeling and Wagner, 2015).

5.4 Market response variables

Next, three dependent variables are defined. Correspondingly, asset returns, market volatility, and trading volume are introduced as market response variables individually.

Asset returns serve as the primary dependent variable in this thesis mainly because of two reasons: First, asset returns allow judgments about the direction that either press conferences in general or their tone have on the financial markets. Second, asset returns can be used to evaluate the central bank's ability to influence financial markets (Blinder, 1998). Since long-term effects on the economy are very difficult to estimate, empirical research typically uses short term variables such as asset prices. According to Strong (1992), logarithmic returns are both theoretically and empirically more attractive than discrete returns. In line with that, returns for every event window are calculated in logs in order to account for continuous compounding. The log-return is then computed by using the closing price of the 1-minute interval prior to

the event window and the last 1-minute interval of the event window. Due to the nature of stock index data, normal rather than abnormal returns are used. Consequently, asset returns are computed as follows:

$$R_t = 100 \cdot log\left(\frac{P_t}{P_{t-1}}\right) \tag{11}$$

Next, in line with previous research (Blinder, 1998), the effect of PC days on the volatility of financial variables is measured. Setting volatility as the dependent variable avoids making judgments about the direction of a particular statement, which can be both an advantage and a disadvantage. It provides a convenient way of estimating if central banks are able to create news through communication events (Ross, 1989). Nevertheless, the researcher cannot determine whether or not the central bank's communication drives markets in the intended direction. Similar to Andersson (2010), intraday volatility is computed, using closing prices of the 1-minute interval before the event window and the last 1-minute interval of the event window. Shown in Formula 12, volatility is practically the absolute log return of each window:

$$V_t = abs\left(100 \cdot log\left(\frac{P_t}{P_{t-1}}\right)\right) \tag{12}$$

Finally, average trading volume per minute serves as the third dependent variable to gain further insights on the market activity on PC days. Similar to measurements of volatility, trading volume shows the overall impact a press conference has on market respondents. Market microstructure models imply that volumes increase with the precision of the announcement information and decrease with the precision of the information known prior to the announcement (Kim and Verrecchia, 1991). In this context, higher activity would thus imply that ECB press conferences provide more precise information than previously available to the market. In order to adjust for the differing length of the event windows, this measure was computed on a per-minute (n) basis as follows:

$$Volume = \frac{1}{n}\sum_{i=1}^{n} Volume_{t+i} \tag{13}$$

5.5 Econometric setup

To estimate how financial assets respond to central bank tone, the following analysis relies on Ordinary Least Square (OLS) estimations. OLS represents the most common linear regression method to test financial market responses to textual sentiment (Kearney and Liu, 2013). More specifically, the closest previous research to this thesis also employs OLS estimators, partially

due to its practicality with high-frequency data (Ehrmann and Fratzscher, 2009; Jegadeesh and Wu, 2013). By definition, coefficients in OLS models are set by the objective to minimize the dependent variable's residual from the best-fitted line. The OLS model relies on three underlying assumptions, in order to be the best linear unbiased estimator (Wooldridge, 2012). First, the explanatory variable and the error term should be independent. Second, the error is serially uncorrelated and homoskedastic with mean 0 and variance of σ^2. Third, the explanatory variables are linearly independent. As an additional fourth assumption, the error term is normally distributed.

However, the OLS might face some limitations in the real-life application to the context of this study: First, it might suffer from *omitted variable bias*, occurring when a disregarded variable correlates with one of the independent variables or if it is a determinant of the dependent variable Stock and Watson (2012). In the case at hand, this could stem from potential macroeconomic events that are out of the scope of this study since they might still partially explain asset returns. Nevertheless, based on the short duration of the constructed windows, the risk of other major influences on asset prices is minimized. Second, *reverse causality* might provide another problem, which is present when communication is endogenous to financial market developments (Blinder et al., 2008). From time to time, a central bank might communicate in response to a particular economic change. In response, asset prices will most likely be more volatile these days, which might not be solely triggered because of the statement (Reeves and Sawicki, 2007). Due to the pre-announced schedule of ECB press conferences, this problem however only provides a limited threat to the analysis. Third, an OLS model could suffer from *inaccurate standard errors*. In the following models, however, it is ensured that standard errors are robust to heteroskedasticity by relying on White-Huber standard errors, as suggested by Freedman (2006).

5.5.1 Relevance for financial markets

First, the general relevance of ECB press conferences for financial markets is estimated. Consequently, a dummy regression is defined around each of the respective event windows. The specific dummy variable is constructed by considering every Thursday during the applicable sample period, and checking whether (PC day) or not (non-PC Thursdays) a press conference took place on that day.

$$y_{it} = a + b \cdot D^{PC} + u_{it} \tag{14}$$

Where y_{it} either represents the continuously compounded return, volatility or trading volume

over the respective event window. The constant a provides the mean estimate on non-PC Thursdays. The dummy D^{PC} takes the value of "1" on PC days and "0" otherwise. The coefficient b represents the difference in mean return, volatility and trading volume for event windows on PC days compared to non-PC Thursdays. The error term is represented by u_{it}. Based on the fact that press conferences usually take place on Thursdays, there is a sole focus on this weekday and thus eight press conferences occurring on other weekdays are excluded.

5.5.2 Central bank tone

The change in tone of two subsequent press conferences can either be positive or negative. The following regression estimates if there are systematic differences in market response variables between press conferences where tone improves compared to when it deteriorates.

$$y_{it} = a + b \cdot D^{\Delta\tau<0} + u_{it} \tag{15}$$

Where y_{it} either represents the continuously compounded return, volatility or trading volume. The constant is again captured by a, estimating the mean financial market variables on event windows when there is a positive tone change. The dummy variable $D^{\Delta\tau<0}$ takes a value of "1" when the change in tone from one press conference to the following one turns negative and "0" otherwise. The coefficient b captures the difference in mean market response variables during event windows when central bank tone worsens compared to an improvement in tone.
The second regression of this section intends to test whether or not, the magnitude of tone changes matter. Thus, each event window return is regressed on tone changes, using the following regression equation:

$$y_{it} = a + b \cdot \Delta\tau_{t-1,t} + u_{it} \tag{16}$$

Where y_{it} either represents the continuously compounded return, volatility or trading volume. $\Delta\tau_{t-1,t}$ resembles the change in central bank tone. Correspondingly, b captures the average response of financial markets to a one standard deviation tone change. For both formulas above, u_{it} represents the error term.

5.5.3 The role of forward guidance

As an extension to the baseline regressions introduced in the previous section, a dummy variable is added accounting for the use of forward guidance during central bank press conferences. The rationale of introducing this specification lies in testing whether, as suggested by Section 3.3, the effect of central bank tone on financial markets systematically differs when central bankers

make forward-looking monetary policy statements.

$$y_{it} = a + b \cdot \Delta\tau_{t-1,t} + c \cdot D^{FG} + d \cdot (\Delta\tau_{t-1,t} \cdot D^{FG}) + u_{it} \tag{17}$$

Where y_{it} either represents the continuously compounded return, volatility or trading volume. The dummy D^{FG} takes the value of "1" on press conference when forward guidance is used and "0" otherwise. The coefficient b reports the average response of financial markets to a one standard deviation tone change when no forward guidance is used. Next, coefficient c represents the difference in mean return, volatility and trading volume for event windows when forward guidance is used compared to when no forward guidance is used. Finally, coefficient d estimates the mean difference in financial market reactions to tone changes on *forward guidance press conferences* compared to *non-forward guidance press conferences*.

6 Data

This section describes the employed data in the analysis studying the relationship between central bank meeting day communication and financial market reactions. Both types of data are provided by Marc Steffen Rapp (Philipps-Universität Marburg) and Kai Henseler (Stern Stewart & Co GmbH).

6.1 ECB introductory statements

The following section provides the full picture of the independent data sample, namely transcripts of introductory statements. It includes a step-by-step review of the statement's typical content and structure as well as a statistical and graphical overview of the processed sample.

Representing the practical implementation of the theoretical process described in Section 5.2, central bank tone is extracted from 184 introductory statements over a period from 11 April 2001 to 14 December 2017. Lasting for around 15 minutes, recall that the introductory statement is held by the ECB president and intends to clarify the latest policy decisions and to provide an outlook and summary of the economy. Throughout the sample period at hand, the statements were presented by three representatives, namely Wim Duisenberg, Jean-Claude Trichet and Mario Draghi. These presidents were accompanied by Christian Noyer, Lucas Papademos, Vitor Constancio, and Luis de Guindos, all serving as vice-presidents (European Central Bank, 2019c).

Even though three different ECB presidents have presented the introductory statement for over 16 years, the basic setup and its main characteristics has not changed significantly. On the contrary, they show major similarities and even identical paragraphs, which eases comparisons among different documents. Initially, the president always welcomes the audience and informs about who else is present aside from the vice-president. These introductions usually appear in style like:

> *Ladies and gentlemen, the Vice-President and I are very pleased to welcome you to our press conference today. We will now report on the outcome of today's meeting of the Governing Council, which was also attended by ...*

Next, the ECB president always repeats the latest monetary announcements that have been published shortly before the introductory statement around 13:45 CET. These are namely the

decisions about key interest rates and unconventional monetary policy measures (e.g., asset purchase programs). It should be noted, that the latter is just found in more recent introductory statements since these unconventional policies have only been introduced in response to the global financial crisis. As highlighted in Section 5.5.3, statements from July 2013 onwards additionally contain a reference to forward guidance in most cases.

In general, the main body of the transcript, following the standard sections above, is then more distinct for each situation and usually includes detailed explanations behind the monetary policy decisions. Nevertheless, each introductory statement usually refers to the ECB's "two pillars" approach. When the Governing Council organizes, evaluates and cross-checks information used to assess the price instability risk, it relies on two areas of analyses: First, economic analyses concentrate on the short to medium-term components of price developments (e.g., overall output, demand and labor market conditions). Second, monetary analyses rather focus on a longer-term link between money and prices. Assessing the implications for inflation and economic growth, monetary analysis observes current monetary and credit developments (e.g., growth rates of M1, M2, M3). To finally confirm all relevant information, both types of analyses are always cross-checked with each other. Exemplary for these two-pillar approach references, there are quotes from the introductory statements presented by Mario Draghi on 22 October 2015 provided below:

> *"Let me now explain our assessment of the available information in greater detail, starting with the* ***economic analysis****. Euro area real GDP increased by 0.4%, quarter on quarter, in the second quarter of 2015, following a rise of 0.5% in the previous quarter. The outcome for the second quarter reflected positive contributions from both domestic demand and net exports. The most recent survey indicators point to a broadly similar pace of real GDP growth in the third quarter of the year. Overall, we expect the economic recovery to continue, albeit dampened, in particular, by weaker than expected foreign demand."*
>
> *"Turning to the* ***monetary analysis****, recent data confirm solid growth in broad money (M3), notwithstanding a decline in the annual growth rate of M3 to 4.8% in August 2015 from 5.3% in July. Annual growth in M3 continues to be mainly supported by its most liquid components, with the narrow monetary aggregate M1 growing at an annual rate of 11.4% in August, after 12.2% in July."*
>
> *"To sum up, a* ***cross-check*** *of the outcome of the economic analysis with the signals coming from the monetary analysis indicates the need to firmly implement the*

Governing Council's monetary policy decisions and to monitor closely all relevant incoming information as concerns their impact on the medium-term outlook for price stability."

Towards the end of each introductory statement, the ECB presidents mostly talk about structural reforms and fiscal policies. Intended to ensure the economy's growth potential, structural reforms are measures that modify the fabric of an economy, the institutional and regulatory framework in a business environment (European Central Bank, 2019d). Statements by the president about current fiscal policies or fiscal consolidation usually directly address member countries of the euro area, in order to give political impulses and guidance. After these final discussions, the ECB president finishes his monolog, and the stage is opened for the audience to ask questions.

To get a statistical understanding of the introductory statements at hand, Table 1 presents the key descriptive statistics of the independent data sample.

Table 1: Descriptive statistics of press conference analysis

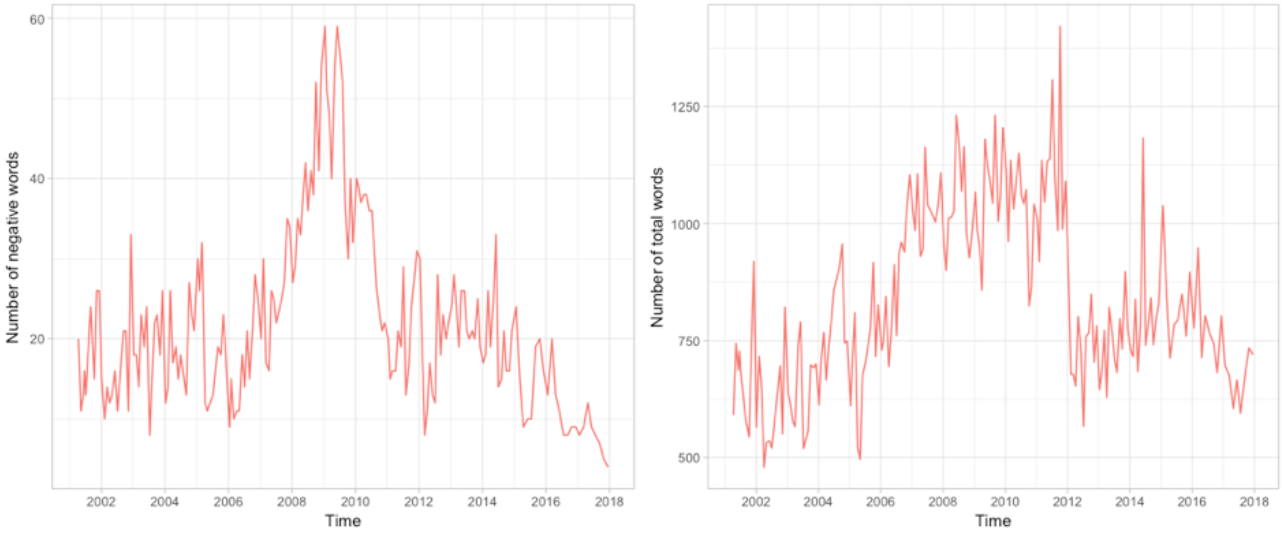
Statistic	N	Mean	St. Dev.	Min	Median	Max
negative	184	22.3750	11.2067	4	20	59
length	184	840.8043	189.6359	480	798	1,421
N/T	184	0.0261	0.0101	0.0056	0.0254	0.0553
t	184	0.9739	0.0101	0.9447	0.9746	0.9944
$\Delta\tau_{t-1,t}$	184	0.0002	0.0077	−0.0240	0.0005	0.0198
D^{FG}	184	0.4620	0.4999	0	0	1

From the first two rows, it is observed that both the number of negative words and the total number of words of the processed introductory statements varies vigorously around the means. While, on average, processed transcripts contain 841 words, the standard deviation is around 190 words. The most extensive introductory statement (1,421 words) took place on 6 October 2011, when Jens Weidmann (President of the Deutsche Bundesbank) opened the press conferences to farewell President Trichet at the end of this legislative period. The shortest introductory statement (480 words) on 4 April 2002, did not have any specific incidents that justify its length. The third row reports statistics for the ratio of the number of negative words

in relation to the number of total words, which is used to compute the ECB tone defined in Equation 10 and summarized in the fourth row. While on average the number of negative words in the transcripts presents around 2.6% of the total words, the range lies between approximately 0.6% and 5.6%. The fifth row reports the properties of tone changes, which are measured as the difference between two subsequent introductory statements. On average, tone changes are close to zero but show a wide interval between -2.4% and +1.9% over the sample period. Out of all 184 introductory statements in the sample, in 101 tone is improving compared to 83 where tone is deteriorating. Finally, the last row represents the forward guidance dummy. In the underlying sample, 77 press conferences are containing forward guidance and 107 do not.

Figure 3 graphically presents the amount of negative and total words per press conference over the selected sample period.

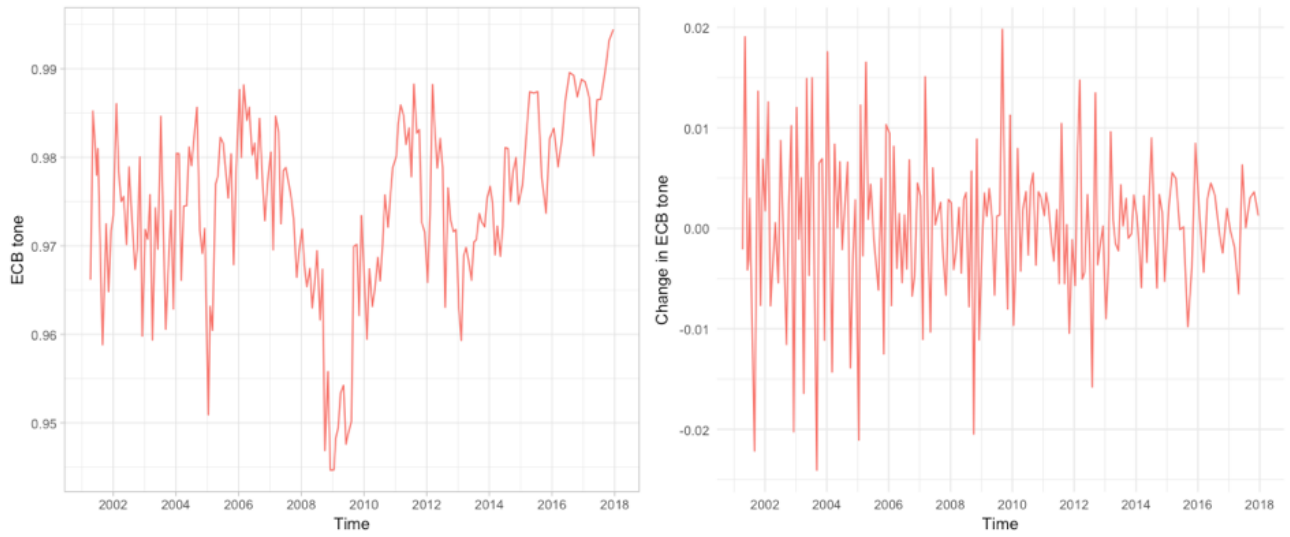
Figure 3: Number of negative words (left) and number of total words (right)



Analog to the description above, the shortest and the longest press conference are found in the right graph of Figure 3. It is further observed that the number of words per press conference starts to increase from 2007 onwards, peaks in late 2011 and then drops around the designation of Mario Draghi in the very end of 2011. The number of negative words follows a similar shape, which indicates that the negative word share overall runs in linear relation to the total length per statement.

With respect to the change in tone, Figure 4 plots the time series of ECB tone, t, and changes in ECB tone, $\Delta\tau_{t-1,t}$, over the sample period.

Figure 4: ECB tone (left) and changes in ECB tone (right)



The left panel shows that ECB tone reaches, as expected, a minimum at the end of 2008/ beginning of 2009 in the middle of the global financial crisis. Notably, ECB tone has steadily improved since the beginning of 2013 reaching a high at the end of the sample period. The right panel depicts the volatility of tone changes over time. A first observation reveals that while at the beginning of the sample the volatility of ECB tone is substantial, it has deteriorated over time.

6.2 Market reaction data

Since the tone of ECB introductory statements represents the independent variable, the closest dependent variable, namely European financial market data is chosen. Clearly, the European financial markets will be impacted most by any statements made by the ECB. Accordingly, the EuroStoxx50 (denoted as "Market") and the EuroStoxx Bank (denoted as "Banks") indices, as well as the 10-year German government bond (denoted as "Bund"), are used. All securities are available as futures of the underlying asset. Provided by Portata CQG, the financial data on all assets is reported by the minute and in Euro. The trading volume is based on the EUREX, with trading time expressed in Central European Time (CET). Table 2 below, provides an overview of the three asset classes.

Table 2: Overview of unadjusted market data

Market description	CQG Symbol	Type	Intraday start	Intraday end
EuroStoxx 50	DSX	Future	30 June 1998	19 March 2018
EuroStoxx Bank	ESB	Future	19 March 2001	28 December 2017
Bund	DB	Future	16 December 1992	13 March 2018

Equities. On the equity's side, the *Market* index is a major stock indicator for the Eurozone (Brechmann et al., 2013). It represents the most extensive blue-chip index in Europe, covering stocks from 11 Eurozone countries based on their market capitalization. The raw data set covers a range from 30 June 1998 until 19 March 2018 with current trading hours from 09:00 to 18:00 CET. Consisting of the 30 largest banks in the European Union, the *Bank* index is the main representative of the banking sector in Europe and namely the second representative of the stock market (Acharya et al., 2016). Covering a slightly shorter period, the *Bank* index starts on 19 March 2001 and runs until 28 December 2017. Trading hours for the *Bank* index are equivalent to the *Market* index.

Bonds. With regards to the fixed income asset, running with a maturity of 10 years, the *Bund* represents a notional long-term debt instrument issued by the German government (London Stock Exchange, 2019). As previous research finds that policy shocks from central bank communication mainly affect interest rates at intermediate maturities and long maturities, the choice of the long-term government bond seems justified (Brand et al., 2010; Leombroni et al., 2018). The unadjusted sample covers a range from 16 December 1992 until 13 March 2018. In line with all German government bonds, current trading hours of the *Bund* starts with the pre-market at 07:30-08:00 CET and regular trading on 08:00-19:00 CET.

In order to properly work with the market response data, several steps of processing are undertaken: First, the raw dataset of asset prices is provided on irregular intervals, and hence there is not a price for every single minute. Accordingly, asset prices are adjusted to regularly spaced 1-minute intervals, using methods of Previous Tick Aggregation (Boudt et al., 2013). Figure A2 in the Appendix illustrates the asset closing prices before and after the transformation. Second, based on their irregular trading patterns, all weekend days and overnight quotes are excluded. As trading hours of the equity and bond futures vary throughout the sample period, only timestamps with trading activity over the entire period are used in the sample. Consequently, in line with Andersson (2010), the utilized trading hours for equity and bond markets

are 10:15 to 17:30 CET, and 08:00 to 19:00 CET respectively. Finally, to ensure sufficient comparability across the asset classes and match data with ECB transcripts, the processed sample only regards the period between 11 April 2001 and 14 December 2017.

Based on the windows that are defined in Section 5.3 of this study, Tables 3-5 provide the most important descriptive statistics of both equities and bonds.

Table 3: Descriptive statistics of Market index returns

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	−0.050	0.466	−2.874	−0.033	2.614
Intr. Statement	184	−0.105	0.589	−3.763	−0.030	1.239
Q & A	184	−0.078	0.788	−3.012	−0.046	2.437
Entire PC	184	−0.183	0.887	−3.938	−0.099	2.801
PC-day	184	−0.113	2.512	−10.398	0.069	10.357

Table 4: Descriptive statistics of Bank index returns

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	0.062	0.559	−2.253	0.000	3.502
Intr. Statement	184	−0.149	0.882	−7.690	0.000	2.400
Q & A	184	−0.113	1.044	−5.064	0.000	4.256
Entire PC	184	−0.261	1.353	−9.663	0.000	3.690
PC-day	184	0.173	2.889	−11.041	0.446	11.310

Table 5: Descriptive statistics of Bund returns

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	−0.007	0.181	−0.707	0.000	0.466
Intr. Statement	184	−0.006	0.181	−0.705	0.000	0.468
Q & A	184	0.021	0.252	−0.786	0.035	1.107
Entire PC	184	0.014	0.308	−1.227	0.026	1.149
PC-day	184	0.006	0.588	−1.896	0.069	1.549

Among all ECB press conferences, the mean event window return of all assets is slightly negative except for the daily- and the decision-window of the banking stocks. For descriptive statistics of both volatility and trading volume per minute for each asset class, please find Table A2 – Table A7 in the Appendix.

7 The effect of ECB press conferences

The result section of this thesis is divided into empirical findings on equity and bond markets. The two subsections consider the general relevance of ECB press conferences for financial markets, the impact of central bank tone as well as further specifications to gain insights on empirical findings based on theoretical suggestions. Practically, the graphs either plot market response variables (return, volatility, trading volume) for PC days versus non-PC Thursdays or compare press conferences with negative versus positive tone changes. The corresponding statistical tests are presented to support visual observations.

7.1 Equity market results

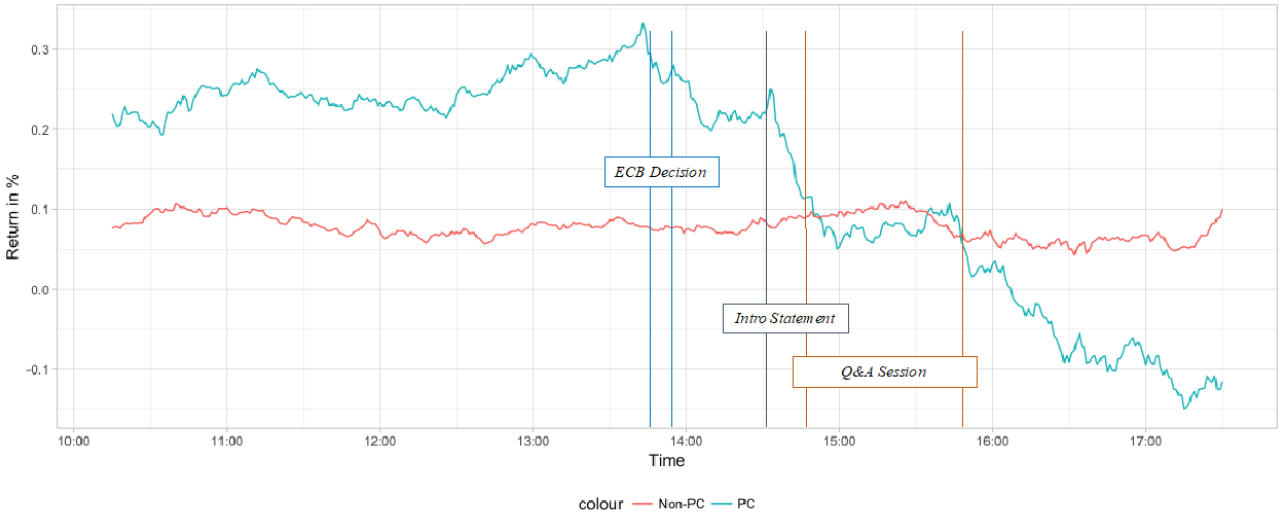
As outlined in the theoretical framework, equities should react to information leading to an adjustment in expectations about the cash-flow, interest rate and risk-premium component of stocks. Initially, it is tested whether stock returns are systematically different during event windows on PC days compared to non-PC Thursdays. Secondly, the effect of the ECB tone is studied on equity returns. Third, forward guidance serves as an addition to extend the equity results on ECB tone. All corresponding graphs are plotted by the minute from 10:15 to 17:30 CET.

7.1.1 Relevance for financial markets

To start, the fundamental relevance of ECB press conferences is estimated by comparing equity market developments during event windows on PC days compared to non-PC Thursday (see Section 5.5.1). Figure 5 presents the average cumulative return of the *Market* index by the minute for PC days and non-PC Thursdays over the sample period.[9] The endpoints of both lines resemble the average magnitude of daily equity returns.

[9]Over the sample under consideration, the trading hours of the EuroStoxx 50 futures have not remained constant. The intraday equity returns in Figure 5 are therefore plotted to employ only hours which have been traded over the entire sample.

Figure 5: Intraday Overview: Relevance of PC days for equity returns



Overall, it can be observed that cumulative returns on PC days substantially differ on an intraday basis compared to returns on non-PC Thursdays. Returns on PC days are negative while returns for non-PC Thursdays are slightly positive on a daily level. Initially, it is discovered that cumulative returns on PC days start at a much higher level compared to non-PC Thursdays. These first returns are calculated using the closing price of the previous day and the first 1-minute interval closing price of the current day. This suggests that overnight returns before PC days are higher than on non-PC Thursdays, indicating that PC days, in general, create more market volatility even ahead of the actual monetary policy decisions. Other than differences in the overnight returns, similar to findings by Lucca and Moench (2015) on FOMC meetings, a pre-announcement effect (up until 13:45 CET) is observed. Just after 13:45 CET, cumulative returns on PC days decrease for some time and then stabilize until the start of the introductory statement at 14:30 CET. After an initial jump around the start of the introductory statement, returns continue falling until 15:00 CET after which they stabilize for some time.

Previous research suggests that the Q&A session is used to confirm, reevaluate or reject the information provided in the introductory statement (Ehrmann and Fratzscher, 2009). The graph resembles this suggestion, as financial markets do not react immediately but seem to await additional information. This tendency accelerates when there is macroeconomic uncertainty. Put differently, when market participants are unsure about the future monetary decisions, they tend to wait for the Q&A session to get some more clarification and market prices fluctuate

further (ibid.). From around 15:45 CET onwards, returns on PC days then continue to fall until the markets close at 17:30 CET. There are two possible explanations to this sustained negative trend throughout and after the press conference ends: First, market respondents react to contents retrieved from ECB press conferences with a time lag. In essence, triggered by the flood of relevant material, markets only digest information after it went through a "filtering process" by other parties rather than immediately after it becomes available (Hayo et al., 2008). Secondly, non-ECB related news, that is not captured by this study, could be driving PC day returns.

Table 6 reports the most important statistical tests comparing average returns for *Market* and *Banks* indices across the previously specified event windows on PC days and non-PC Thursdays (see Section 5.2). The average returns during non-PC Thursdays are represented by the constants. The coefficients of the dummy intercept report the average difference between PC event windows and non-PC control windows during the selected sample period.

Table 6: Equity returns on ECB press conference days

Results are based on the estimation of Equation 14, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Equity returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
D_s^{PC}	−0.048	0.059	−0.110**	−0.128*	−0.046	−0.123	−0.155**	−0.252**	−0.225	0.054
	(0.036)	(0.044)	(0.047)	(0.069)	(0.064)	(0.085)	(0.072)	(0.109)	(0.207)	(0.237)
Constant	−0.002	0.004	0.004	−0.016	−0.032	−0.001	−0.028	−0.017	0.100	0.123
	(0.007)	(0.012)	(0.014)	(0.015)	(0.022)	(0.030)	(0.024)	(0.034)	(0.083)	(0.095)
Observations	875	875	875	875	875	875	875	875	875	875
R^2	0.005	0.004	0.010	0.009	0.001	0.003	0.008	0.010	0.002	0.0001
Adjusted R^2	0.004	0.003	0.009	0.008	−0.0003	0.002	0.007	0.009	0.0005	−0.001

Note: *p<0.1; **p<0.05; ***p<0.01

In line with the visual observations, Table 6 supports the negative return trend for PC days

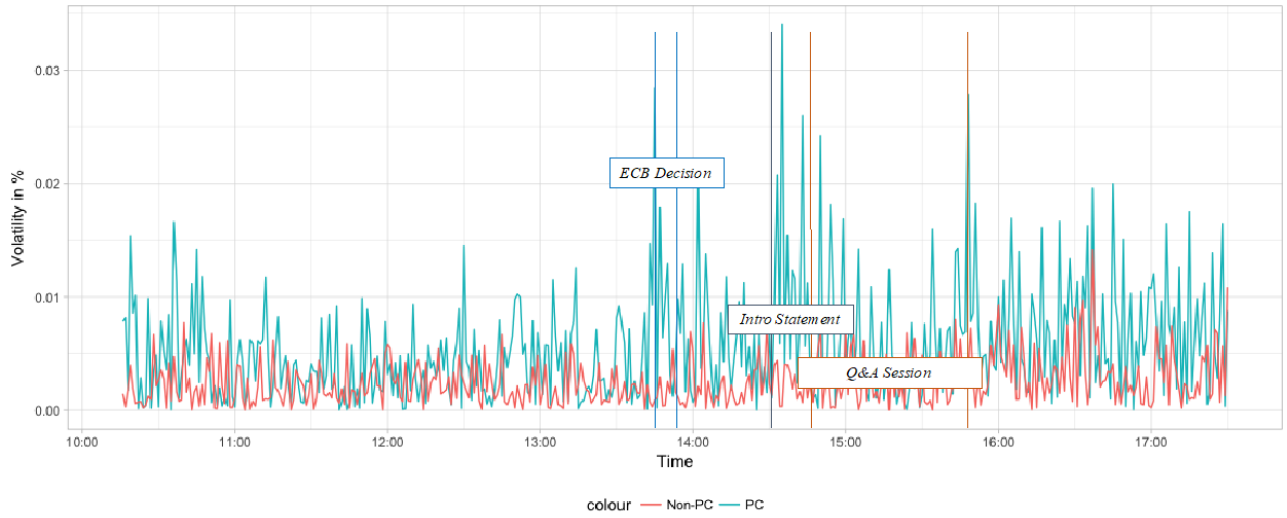
throughout all event windows. The estimated constants suggest that *Market* returns on non-PC event windows are not statistically different from zero. Thus, in line with previous research (Ehrmann and Fratzscher, 2009), US jobless claims do not seem to have an apparent directional effect on returns. Significant results are found during the event windows set around the introductory statement and the entire press conference: One can observe that mean *Market* returns during the introductory statement and the entire press conference are -0.11 percentage points and -0.18 percentage points respectively. Both these figures are significant at the 95% level. Thus, findings yield a different conclusion than what is found by Schmeling and Wagner (2015). Even though it is also found that daily average returns on PC days are not statistically different from non-PC days, on an intraday perspective, average returns differ during the introductory statement and throughout the entire press conference. Another important stylized fact is that the *Market* reaction to the entire press conference is substantially higher than for the announcement of monetary policy decisions. On average, the *Market* reaction to the entire press conference is more than three times stronger than the reaction to the announcement of the policy decision. This is consistent with results obtained by Ehrmann and Fratzscher (2009), who find that intraday absolute return reactions of 3-month EURIBOR futures are on average three times stronger on PC event windows compared to non-PC control windows. In line, Lucca and Moench (2015) report substantial average excess returns for US equities in anticipation of monetary policy announcements by the FOMC.

The effect on price changes, especially during the introductory statement and the entire press conference, are stronger for *Banks* (significant at the 90% and 95% level) than for other equities. As banks are directly dependent on decisions about overnight lending rates and unconventional monetary policies, this should not come as a surprise. Strong *Bank* stock reactions are most visible during introductory statements, which usually contain most explanations about, e.g., unconventional monetary policies.

From the statistical and graphical results, four substantial observations on the return comparison between PC days and non-PC Thursdays can be made. First, PC day returns start at a much higher initial level, suggesting higher overnight returns. Second, ECB press conferences tend to create market volatility, as one can observe from a pre-announcement comparison. Third, overall returns on PC days are negative, especially during and after the ECB press conference. Fourth, the return effects from press conferences are most substantial for the *Bank* index.

Next, Figure 6 plots the average market volatility of the *Market* index by the minute on PC days and non-PC Thursdays. Similar to return data, market volatility on PC days visually varies from non-PC Thursdays.

Figure 6: Intraday Overview: Relevance of PC days for equity volatility



Throughout the whole ECB press conference day, volatility is much higher than volatility on non-PC Thursdays. As found by previous research, it seems that press conferences are of incremental importance for market participants (Andersson, 2010; Hussain, 2011). Consistent with results reported by Andersson (2010), especially interest rate changes are found to have a strong impact on intraday volatility. One can observe the largest spikes during the announcement at 13:45 CET and during the introductory statement. The graph further demonstrates that PC day-volatility stays on a high level for an extended period. This is most likely related to the explanation given earlier about Q&A sessions serving as an additional source to reevaluate information.

Table 7 reports the estimated results for comparing average volatility for the *Market* and the *Bank* index across specified event windows on ECB press conference days and benchmark Thursdays without press conferences. The average volatility during non-PC Thursdays is represented by the constant. The coefficients of the dummy intercept report the average difference between volatilities on PC day event windows and non-PC control windows during the selected sample period.

Table 7: Equity volatility on ECB press conference days

Results are based on the estimation of Equation 14, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

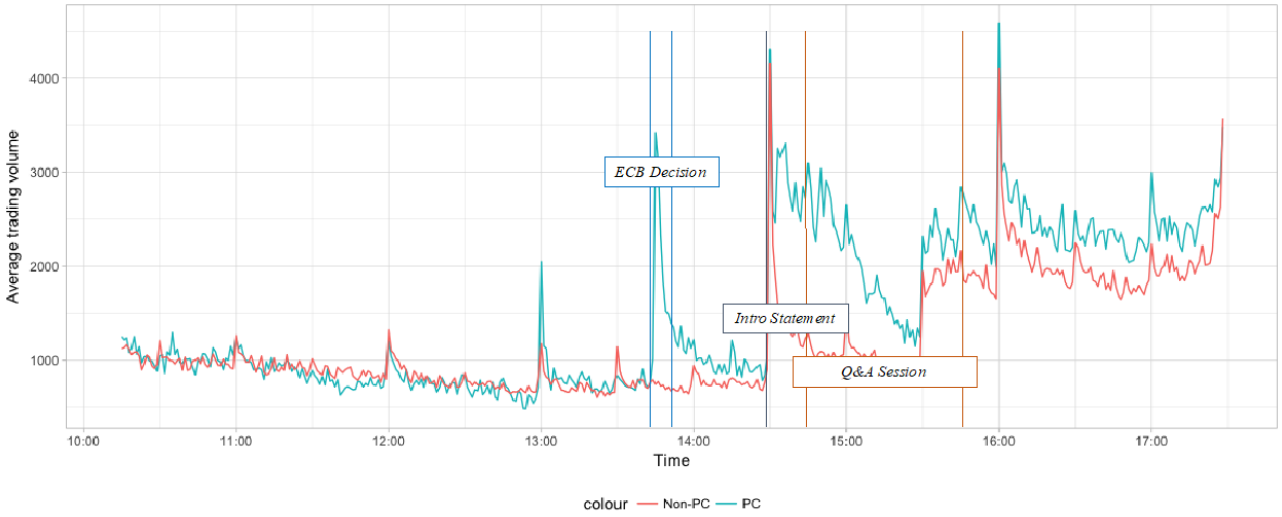
	Volatility:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
D_s^{PC}	0.136***	0.103**	0.145***	0.217***	0.179***	0.180***	0.216***	0.251***	0.284*	0.359**
	(0.031)	(0.042)	(0.037)	(0.062)	(0.047)	(0.069)	(0.054)	(0.092)	(0.153)	(0.169)
Constant	0.112***	0.098***	0.229***	0.202***	0.372***	0.457***	0.408***	0.533***	1.441***	1.684***
	(0.005)	(0.011)	(0.011)	(0.013)	(0.018)	(0.025)	(0.018)	(0.027)	(0.062)	(0.071)
Observations	875	875	875	875	875	875	875	875	875	875
R^2	0.058	0.014	0.028	0.032	0.021	0.011	0.027	0.015	0.005	0.006
Adjusted R^2	0.057	0.012	0.027	0.031	0.020	0.010	0.026	0.013	0.003	0.004

Note: *p<0.1; **p<0.05; ***p<0.01

Throughout all event windows, market volatility substantially increases on PC days compared to non-PC Thursdays, indicating that both, the ECB decision as well as the whole press conference, are deemed to be highly informative to equity markets. The majority of these volatilities are significant at the 99% level. Results further suggest that on PC days, among all press conference components, the actual announcement creates the least volatility on the markets. It seems that the information flow to market participants is thus, on average, relatively small compared to the rest of the press conference. Most likely, this stems from the fact that markets are only surprised when interest rate changes do not correspond to their expectations, i.e., unexpected interest rate cut. The Q&A session, on the other hand, is less predictable and every specific question could contain new information, corresponding in increased volatility. Overall, the results are consistent with previous research showing that central bank communication substantially increases daily and intraday equity market volatility (Fleming and Piazzesi, 2005; Andersson, 2010; Lucca and Moench, 2015; Jegadeesh and Wu, 2013).

Finally, concerning trading volume, findings are aligned with return and market volatility: On an intraday level, average volume on PC days is different, as illustrated by Figure 7.

Figure 7: Intraday Overview: Relevance of PC days for equity trading volume



Average trading volume on both PC days and non-PC Thursdays increases towards the afternoon. This is in line with the opening of the US markets since higher market activity on 14:30 CET is triggered by weekly announcements on the US jobless claims.[10] Further, around 16:00 CET there are usually a number of major US macroeconomic releases, e.g., Index of Leading Indicators, ISM-Index Manufacturing, House Price Index, Consumer Confidence. In fact, it is shown that about 28% of the ECB monetary policy announcement dates coincide with US macroeconomic releases at 16:00 CET (Hussain, 2011). On PC days, the impact from the ECB announcement on 13:45 CET as well as the introductory statement and US jobless claims on 14:30 CET are visible. Just after the ECB makes announcements about monetary policies, market activity spikes and then diminishes until it is almost back to normal right before the start of the introductory statement. Despite high market activity for both samples, at 14:30 CET market activity on PC days remains on a higher level for some time during the ECB press conference. Considering the procedure of the press conference, this behavior seems intuitive: The ECB president's introductory statement does not immediately start 14:30 CET with relevant facts for market respondents but rather with a general welcome, some formalities and sometimes with a slight delay. Similar to the explanations given before, the introductory statement and the Q&A session then release further information, which is absorbed over an extended period. In contrast to that, on non-PC Thursdays, US jobless claims are published

[10]NYSE opening times start with a pre-opening session on 6:30 am ET (11:30 CET), followed by the core trading session at 9:30am-4:00 pm ET (14:30-21:00 CET) (New York Stock Exchange, 2019).

at 14:30 CET sharp, and markets react and adjust expectations based on the new information immediately.

Table 8 reports the outcome of comparing average volume traded per minute for the *Market* index and the *Bank* index across specified event windows on PC days and non-PC Thursdays. The average trading volume per minute during non-PC Thursdays is represented by the constants. The coefficients of the dummy intercept report the average difference between average trading volume per minute on PC event windows and non-PC control windows during the selected sample period.

Table 8: Equity volume traded per minute on ECB press conference days

Results are based on the estimation of Equation 14, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Average volume traded per minute:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
D_s^{PC}	1,219.6***	50.7	1,511.0***	61.1**	863.0***	304.9**	961.0***	48.7**	343.1***	7.3
	(239.9)	(32.6)	(258.1)	(25.3)	(137.5)	(124.7)	(149.8)	(19.4)	(82.0)	(11.3)
Constant	765.8***	88.6***	1,654.6***	92.3***	1,287.8***	568.8***	1,341.1***	87.5***	1,205.4***	84.9***
	(39.5)	(9.1)	(62.1)	(7.7)	(38.9)	(40.0)	(40.4)	(6.1)	(31.6)	(4.9)
Observations	875	875	875	875	875	875	875	875	875	875
R^2	0.1	0.01	0.1	0.01	0.1	0.01	0.1	0.01	0.02	0.001
Adjusted R^2	0.1	0.004	0.1	0.01	0.1	0.01	0.1	0.01	0.02	−0.001

Note: *p<0.1; **p<0.05; ***p<0.01

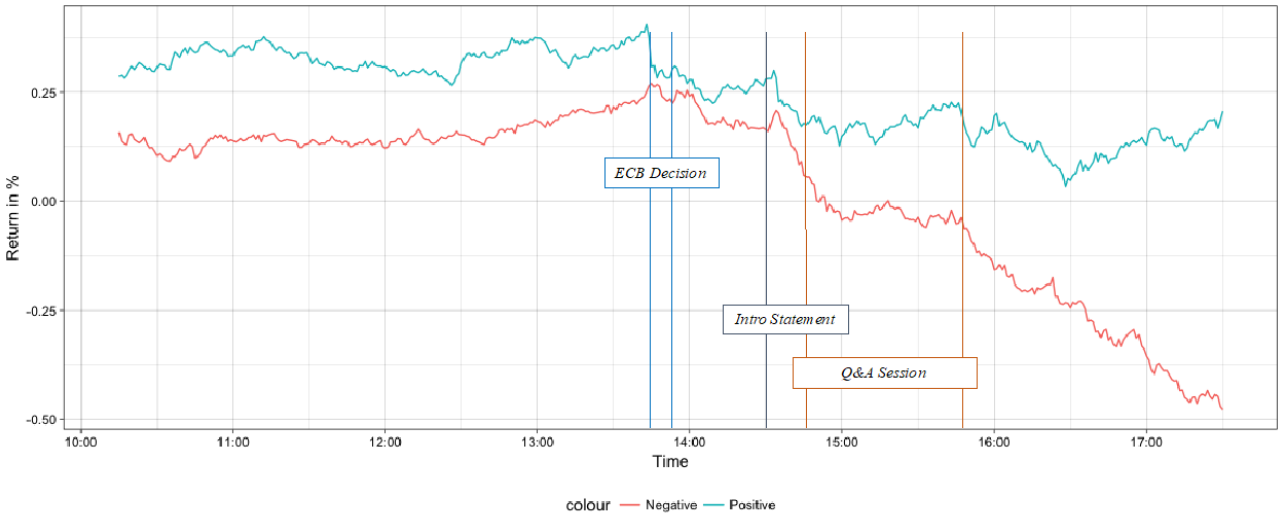
Throughout all event windows, it can be observed that the average trading volume is substantially higher on PC days compared to non-PC Thursdays. The majority of coefficients indicate that the difference during event windows on PC days and on-PC Thursdays is significant at the 99% level, which further supports the relevance of ECB press conferences to the financial markets. Further, one can observe that the highest trading activity for the *Market* index takes place during the introductory statement, while bank stocks are mostly traded during the Q&A session. Although with lower magnitude and statistical significance, this also applies to *Banks*

during the event windows of the press conferences. With respect to the daily window as well as during the ECB decision announcement, there are no statistically significant differences.

7.1.2 Central bank tone

Following, it is assessed whether and how ECB tone plays a role in explaining the equity market reaction to central bank communication. Figure 8 plots the equity *Market* index on PC days for positive and negative tone changes, illustrated by the green and red lines respectively. As outlined in Section 5.1, tone change is defined as the difference between the calculated tone from two subsequent press conferences.

Figure 8: Intraday Overview: Negative vs. positive ECB tone on PC day equity returns



Following the presentation by Figure 8, two main findings appear: First, on a daily level, cumulative returns are positive on events when the ECB tone becomes positive and negative when it is more negative. Second, while both returns are very similar around the announcement at 13:45 CET, they start to diverge during the introductory statement (14:30-14:45 CET). The second observation suggests that the large return difference of positive and negative press conferences is probably not simply driven by the announcement. Rather, information during the introductory statement is likely to be a trigger for the return difference. Regarding the time after the press conference, similar to the explanations given above, the return development might either be due to confounding macroeconomic effects or delays in adjusting market expectations. In Section 9, these and other phenomena are discussed in more detail.

Table 9 reports the outcome of a few statistical tests comparing average returns for the *Market* and the *Bank* index across specified event windows on ECB press conference days separately for 101 (83) observations at which ECB tone becomes more positive (negative) compared to the previous press conference. The average returns during event windows on PC days where tone improves are represented by the constant. The coefficients of the dummy intercept report the average difference in returns between press conference event windows when tone improves and press conference event windows when tone deteriorates.

Table 9: Equity returns with positive vs. negative ECB tone

Results are based on the estimation of Equation 15, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. The dummy $D_t^{\Delta\tau<0}$ takes a value of "1" when the change in tone from one press conference to the following turns negative and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$D_t^{\Delta\tau<0}$	0.035	0.091	−0.008	−0.103	−0.103	−0.186	−0.111	−0.290	−0.730**	−0.447
	(0.070)	(0.084)	(0.087)	(0.136)	(0.117)	(0.156)	(0.132)	(0.206)	(0.351)	(0.415)
Constant	−0.066	0.021	−0.101*	−0.102	−0.032	−0.028	−0.133	−0.131	0.248	0.374
	(0.042)	(0.051)	(0.060)	(0.066)	(0.075)	(0.094)	(0.084)	(0.109)	(0.283)	(0.317)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.001	0.007	0.00005	0.003	0.004	0.008	0.004	0.011	0.021	0.006
Adjusted R^2	−0.004	0.001	−0.005	−0.002	−0.001	0.002	−0.002	0.006	0.016	0.0005

Note: *p<0.1; **p<0.05; ***p<0.01

To gain first insights into whether changes in central bank tone and conventional policy actions correlate, the ECB decision (Column 1-2) window is tested. As expected, no economically meaningful and statistically significant differences of stock returns as a reaction to central bank tone changes are found in this window. Further controls in that respect will be provided in Section 8.

Turning to the main results, it is found that, consistent with previous research (Schmeling and

Wagner, 2015), on a daily level (Column 9-10), equity returns are significantly different when ECB tone becomes more negative compared to when tone improves. Daily *Market* returns are, on average, -0.482 percentage points when there is a negative tone change compared to a mean of 0.248 percentage points when the tone becomes more positive. Reported estimates are consequently in line with findings by Rosa (2011b) who reports that an unanticipated hawkish statement by the FOMC is associated with, on average, 0.6 percentage points lower equity returns. However, in line with the visual representation, throughout all intraday event windows, no statistically significant return differences between the two groups are found. Nevertheless, the signs of the coefficients indicate that during the press conferences a negative tone change is associated, on average, with more negative stock returns compared to when tone improves. These stock reactions are consistent with the theoretical suggestions of the economic and the risk-premium shocks caused by central bank communication (see Section 3.3).

However, due to the nature of this dummy regression, all positive and negative tone changes are treated equally, coefficients thus only represent averages (constant) and differences in average (dummy) within and across the two groups. Consequently, no conclusions with regards to different central bank transmission channels can be made yet.

As the next step in this empirical analysis, stock returns are regressed on tone changes to take the magnitude of effects into account. Table 10, reports the outcome of a few statistical tests for the average returns of the *Market* index and the *Bank* index across specified event windows based on a change in ECB tone. The constants, in this case, report the mean return for all 184 press conferences throughout event windows. The coefficients of the tone change variable report the average equity return response to a one standard deviation change in tone. As shown in Section 6.1, recall that the standard deviation of tone changes is around 0.008.

Table 10: Equity returns and ECB tone

Results are based on the estimation of Equation 16, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. $\Delta\tau_{t-1,t}$ resembles the change in central bank tone. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.021	−0.005	0.006	0.058	0.090	0.150**	0.095	0.208	0.308	0.154
	(0.044)	(0.042)	(0.051)	(0.094)	(0.061)	(0.071)	(0.076)	(0.129)	(0.192)	(0.206)
Constant	−0.050	0.062	−0.105**	−0.149**	−0.078	−0.113	−0.183***	−0.261***	−0.113	0.173
	(0.034)	(0.041)	(0.043)	(0.065)	(0.058)	(0.076)	(0.065)	(0.098)	(0.183)	(0.212)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.002	0.0001	0.0001	0.004	0.013	0.021	0.012	0.024	0.015	0.003
Adjusted R^2	−0.004	−0.005	−0.005	−0.001	0.008	0.015	0.006	0.018	0.010	−0.003

Note: *p<0.1; **p<0.05; ***p<0.01

While most coefficients estimating the equity market reaction to tone changes are not significant, economically they do support the findings from the previous test. As seen before, an improvement in tone is, throughout all event windows surrounding the press conferences, associated with increasing stock returns. The only significant estimate (95% level) is reported during the Q&A session, where a change in tone by one standard deviation, is associated with, on average, 0.15 percentage points higher *Bank* stock returns. The results are in line with previous research providing evidence that ECB tone has a stronger influence on banks and that markets wait for the Q&A to confirm what was said in the introductory statement (Schmeling and Wagner, 2015; Picault and Renault, 2017). For the US currency regime, Jegadeesh and Wu (2013) disentangle central bank communication into various topics and subsequently compute and regress tone on equity returns. Their findings show that effects are multi-dimensional and conditional on the topics used (ibid.). While a similar approach extends the scope of this thesis, the next section provides further specifications on this issue.

To explore whether there is a relationship between central bank tone and informativeness of communication to the market, the same regressions as above are tested for equity volatility

and trading volume per minute. If for example, press conferences with a positive tone change are seen as more informative, it is expected that volatility is systematically higher during these windows. Interestingly, no significant reactions of volatility and trading volume for a given change in ECB tone are found, indicating that uncertainty and risk-aversion among financial market participants are not substantially affected by central bank tone. Statistical outputs for these two tests is provided in the Appendix, Table A8 and A9. In line with these findings, Jegadeesh and Wu (2013) find, for the US equity markets, that central bank tone is not perceived useful by markets, as neither positive nor negative tone in FOMC statements is associated with higher market volatility. However, it should be noted that when the authors disentangle FOMC statements into topics, they find evidence that market reactions to different topics are based on informational value, and can hence run into opposite directions (ibid.). While conducting a similar approach here would be valuable as well, it exceeds the scope of this thesis. Thus, studying this question remains open for future research.

7.1.3 The role of forward guidance

While the previous two subsections show that equity returns fundamentally co-move with changes in central bank tone, results obtained, particularly during the intraday event windows, are not systematically strong and statistically significant. This raises further questions about what exactly the tone changes of central bank communication are capturing.

Referring to the theoretical framework introduced in Section 3, three shocks potentially result from central bank communication, namely monetary policy shocks, economic shocks, and risk-premium shocks. According to the framework, a more positive tone is associated with positive monetary policy shocks (tightening), economic shocks (better growth perspective) and negative risk premium shocks (lower risk-aversion). While the latter two are expected to increase equity returns, tightening monetary policy announced by forward guidance is typically associated with lower stock returns. No evidence for central bank tone affecting equities through risk-premium shocks is found as volatility, and trading volume does not systematically differ when the tone changes. Accordingly, this section thrives on disentangling the opposing effects central bank tone has on equity returns through monetary policy and economic shocks.

As introduced in Section 5.5.3, equity returns are, as above, regressed on tone changes but with the specification of including a forward guidance dummy. Table 11, reports the outcome for the average returns of the *Market* index and the *Bank* index across specified event windows based

on a change in ECB tone. The constants report the mean equity return during event windows on days where press conferences did not contain any forward-looking statements on the path of monetary policy actions. For these occurrences specifically, the coefficients of the tone change variable report the average equity return response to a one standard deviation change in tone. Moreover, the coefficient of the dummy variable represents the average return difference during event windows on PC days where forward-looking statements were made compared to PC days where no forward guidance was used. Finally, the interaction is an estimate of the average difference in the market reaction to a one standard deviation change in tone comparing PC days where forward guidance was used and PC days where it was not used. As shown in section 6.1, recall that the standard deviation of tone changes is around 0.008.

Table 11: Equity returns and ECB tone with forward guidance

Results are based on the estimation of Equation 17, using EuroStoxx 50 (*Market*) and EuroStoxx Bank (*Bank*) indices. $\Delta\tau_{t-1,t}$ resembles the change in central bank tone. The dummy D^{FG} takes the value of "1" on press conference when forward guidance is used and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.060	−0.036	0.032	0.121	0.118	0.204**	0.151	0.325*	0.546**	0.332
	(0.056)	(0.037)	(0.062)	(0.130)	(0.083)	(0.094)	(0.098)	(0.176)	(0.231)	(0.270)
FG	0.130*	0.180**	0.093	0.148	0.051	0.039	0.144	0.187	0.156	0.537
	(0.067)	(0.085)	(0.089)	(0.129)	(0.115)	(0.152)	(0.130)	(0.195)	(0.349)	(0.407)
$\Delta\tau_{t-1,t} * FG$	−0.125*	0.115	−0.083	−0.201	−0.093	−0.181	−0.176	−0.382*	−0.769**	−0.563
	(0.075)	(0.116)	(0.110)	(0.156)	(0.103)	(0.129)	(0.143)	(0.213)	(0.336)	(0.365)
Constant	−0.112**	−0.019	−0.149***	−0.220**	−0.104	−0.134	−0.253***	−0.354**	−0.167	−0.085
	(0.046)	(0.044)	(0.057)	(0.102)	(0.085)	(0.105)	(0.093)	(0.149)	(0.291)	(0.343)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.037	0.034	0.011	0.023	0.017	0.027	0.027	0.045	0.037	0.020
Adjusted R^2	0.021	0.018	−0.006	0.006	0.001	0.011	0.010	0.029	0.021	0.003

Note: *p<0.1; **p<0.05; ***p<0.01

Confirming previous findings, throughout all event windows surrounding press conferences with no forward guidance, a change in tone is associated with higher equity returns. Most notably, daily *Market* returns increase, on average, by 0.546 percentage points in response to a one standard deviation change in central bank tone. More interestingly, however, are the coefficients of

the interaction term. All estimated figures are negative, indicating that when forward guidance is employed by the central bankers, a positive tone change is associated with a less strong equity market reaction. In other words, the positive relationship between tone and equity market returns is weakened, canceled-out, or, in some cases, even reversed. For instance, daily *Market* returns on average fall by around 0.223 percentage points (0.546-0.769) in response to a one standard deviation change when forward guidance is employed (as compared to a 0.546 percentage point increase).

A similar pattern can also be observed for the *Bank* index. Throughout all event windows surrounding press conferences without forward guidance, positive tone changes are associated with higher equity returns. Statistical significance is found around the Q&A and the entire-PC with, on average, 0.204 and 0.325 percentage point increases in equity returns as a response to a one standard deviation change in tone respectively. In line with the *Market* index, the interaction term for *Banks* shows negative coefficients throughout all event windows surrounding the press conferences. During the event window surrounding the entire-PC, for example, the previously found positive equity return response completely cancels out when forward guidance is used (0.325-0.382).

All in all, findings can be summarized as follows: First, no evidence is found that tone matters for risk-premium shocks as volatility and trading volume do not systematically differ when central bank tone changes. Second, as suggested by the theoretical framework, a positive tone change is associated with higher equity returns, mainly when no forward guidance is used by central bankers. Third, in the few cases when forward guidance is used, the response of equity prices is less robust, canceled-out or, in some cases, even negative. In the subsequent section, findings are complemented by studying bonds to draw a complete picture of the relationship between central bank tone and financial markets.

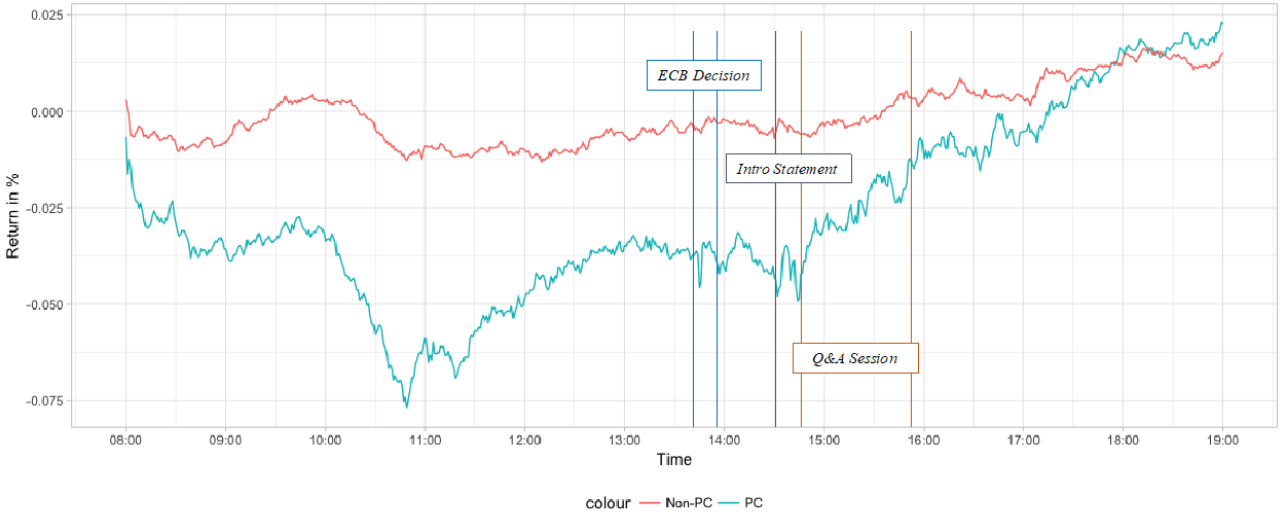
7.2 Bond market results

Equivalently to the results on equity market presented above, bond prices reactions are estimated next in order to complete the understanding of ECB press conferences' effect on financial markets. Analog to the previous section, first, the general relevance of press conferences for bond markets is determined. Second, the specific impact of tone used by the ECB on bond reactions is measured. Third, the role of forward guidance is examined to shed further light on previous findings.

7.2.1 Relevance for financial markets

In order to estimate the overall impact of ECB press conferences, the following section compares bond returns during PC days and non-PC Thursdays. Average cumulative return of the *Bund* for each minute from 08:00 to 19:00 CET on PC days and non-PC Thursdays over the sample period are displayed in Figure 9.[11] The endpoints of both lines resemble the average magnitude of daily *Bund* returns.

Figure 9: Intraday Overview: Relevance of PC days for bond returns



Even though returns in both cases are slightly positive on a daily basis, the figure shows that cumulative returns on PC days are fairly different, compared to non-PC Thursdays on an intraday level. It is observed that returns on non-PC Thursdays start at a higher level than PC day returns. Initial returns are estimated using the closing price of the previous day and the first 1-minute interval closing price of the current day. This suggests that overnight returns before non-PC Thursdays are, on average, larger than on PC days. Throughout the day, returns on PC days are slightly more positive than for non-PC Thursdays. However, both returns follow a similar daily shape, except that PC days contain more extreme movements. Following a quick drop shortly after the market opening, both returns rise on average to a local peak at 9:45 CET. Subsequently, both returns fall until around 10:50 CET to a daily low, with the effect

[11] Over the sample under consideration, the trading hours of the 10-year German government bond future have not remained constant. The intraday bond returns in Figure 9 are therefore plotted employing only hours which have been traded over the entire sample.

being much stronger on PC days. Finally, both returns increase until the end of the trading day.

Differences among both return lines are found on 14:30 CET and during 14:45-15:50 CET. Corresponding to the start of the introductory statement and announcements on US jobless claims, PC day returns spike around 14:30 CET. Further, during the Q&A session (14:45-15:50 CET), PC day returns show a stronger increase than returns in the control group. In comparison to non-PC Thursdays, this return development could be triggered by the explanatory power the QA session traditionally has (Ehrmann and Fratzscher, 2009). With respect to the ECB decision announcement, it can be observed that returns on PC days show only a small jump at 13:45 CET. This suggests that the actual decision has only a minor influence on bond trader's market behavior.

In terms of quantitative estimates, Table 12 reports the most important statistical tests comparing average returns across the previously specified event windows on PC days and non-PC Thursdays. Average returns during non-PC Thursdays are represented by the constants. The coefficients of the dummy intercept report the average difference between PC event windows and non-PC control windows during the selected sample period.

Table 12: Bond returns on ECB press conference days

Results are based on the estimation of Equation 14, using the 10-year German Government Bond (*Bund*). The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Bond returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
D_s^{PC}	−0.002	−0.007	0.019	0.013	0.007
	(0.009)	(0.014)	(0.019)	(0.024)	(0.047)
Constant	0.003*	0.001	0.011**	0.012**	0.016
	(0.002)	(0.004)	(0.005)	(0.006)	(0.017)
Observations	875	875	875	875	875
R^2	0.0002	0.001	0.002	0.001	0.00003
Adjusted R^2	−0.001	−0.001	0.001	−0.001	−0.001
Note:					*p<0.1; **p<0.05; ***p<0.01

As suggested by the graphical display, Table 12 supports the overall positive trend for PC days and non-PC Thursdays. Except for the PC day and the introductory statement, the estimated constants among all event windows on non-PC Thursdays are positive, small in magnitude and statistically different from zero, resembling the falling interest rates in the employed sample period. Nevertheless, differences among *Bund* returns for PC days and non-PC Thursdays are not significant for any given event window. In contrast to Schmeling and Wagner (2015), the estimates above thus suggest that there is no specific PC day effect for bonds.[12] The basis for these contradicting findings might stem from the different set-up of the two studies: While Schmeling and Wagner (2015) divide their data set into PC days and non-PC days, this thesis differentiates among PC days and non-PC Thursdays which is by nature a stronger control.

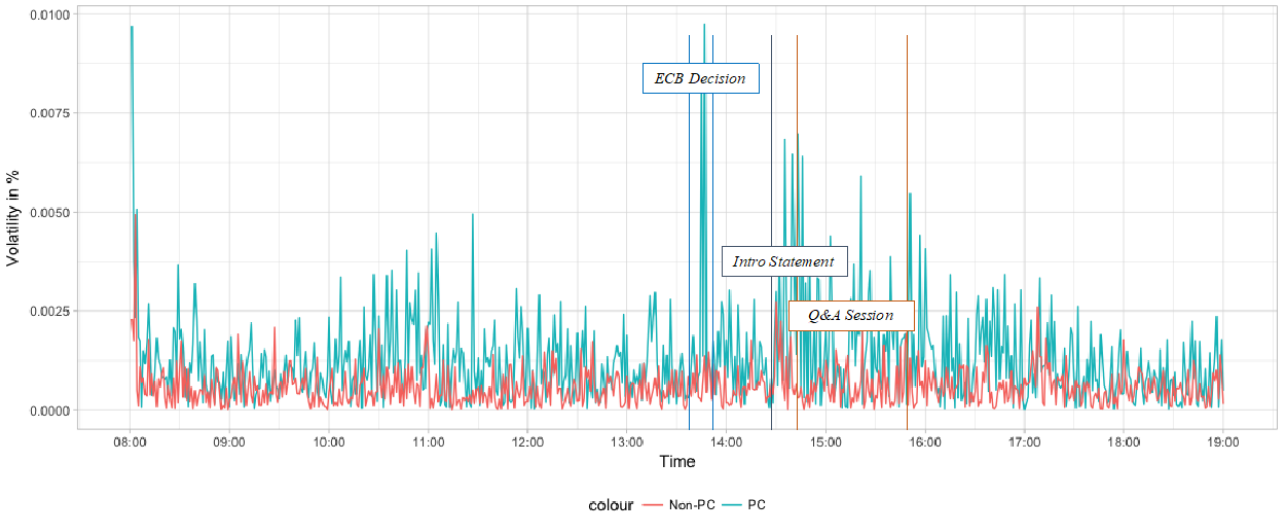
In summary, three main statements can be made about bond returns and ECB press conferences. First, average returns from both PC days and non-PC Thursdays follow a similar daily development path, with PC days showing more extreme movements. Second, bond returns on

[12] Schmeling and Wagner (2015) find that PC days are associated with higher yields. The effect is considered to be stronger for longer than for shorter maturities.

PC days and non-PC Thursdays are significantly different from zero throughout most event windows. Third, no significant differences among bond returns on PC days and non-PC Thursdays are found. Consequently, a systematic effect of press conferences does not seem to be present.

Next, the average market volatility for the *Bund* by the minute from 08:00 to 19:00 CET on PC days and non-PC Thursdays is depicted in Figure 10. As highlighted by the graph, market volatility differs substantially for PC days and non-PC Thursdays.

Figure 10: Intraday Overview: Relevance of PC days for bond volatility



Overall, market volatility is higher during the entire ECB press conference day compared to non-PC Thursdays. Right after the market opening, *Bund* volatility on PC days already increases compared to non-PC Thursdays. Central bank press conferences and corresponding interest rate changes are of fundamental value to market participants (Andersson, 2010; Lucca and Trebbi, 2011), which at least partially explains the higher market volatility on PC days. It is further observed that the largest spikes on PC days occur at the ECB decision, the introductory statement and the Q&A session. Especially throughout the Q&A session, market volatility has several peaks, which supports the previous idea that it serves as a source to reevaluate previously published information (Ehrmann and Fratzscher, 2009).

The estimated results for the average *Bund* volatility across many event windows on PC days and non-PC Thursdays are reported in Table 13. The constants represent the average volatility

for the benchmark sample of non-PC Thursdays. Each dummy coefficient resembles the average difference on PC days against its benchmark sample.

Table 13: Bond volatility on ECB press conference days

Results are based on the estimation of Equation 14, using the 10-year German Government Bond (*Bund*). The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

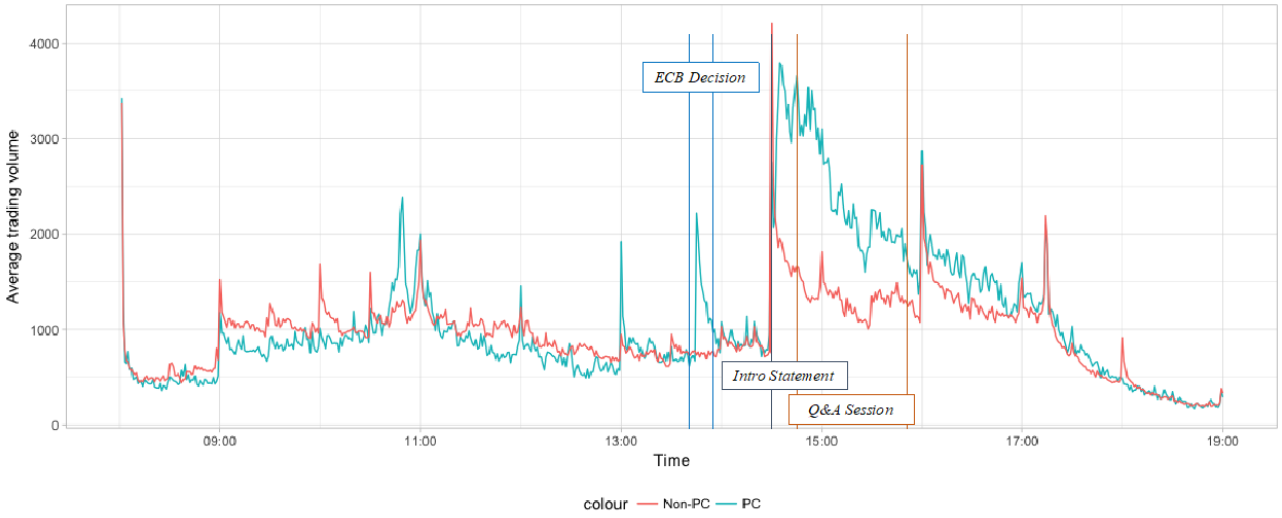
	Bond volatility:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
D_s^{PC}	0.033***	0.069***	0.081***	0.098***	0.114***
	(0.007)	(0.009)	(0.013)	(0.016)	(0.029)
Constant	0.031***	0.070***	0.104***	0.122***	0.343***
	(0.001)	(0.003)	(0.004)	(0.004)	(0.011)
Observations	875	875	875	875	875
R^2	0.065	0.106	0.075	0.075	0.021
Adjusted R^2	0.064	0.105	0.073	0.074	0.020
Note:					*p<0.1; **p<0.05; ***p<0.01

The results support the visual observations from Figure 10, as estimates report higher market volatility on PC days compared to non-PC Thursdays. All these results are statistically significant at the 99% level. Table 13 further confirm that, among all press conference components, the monetary policy decision by the ECB causes the least volatility in the bond markets, while the Q&A session creates most. Given an unexpected monetary decision, markets are only surprised at the exact moment of the ECB announcements. In contrast, the Q&A session is least certain, and traders might react to every question/answer that is raised. Observations are consistent to results reported by Leombroni et al. (2018), who find that bond volatility of communication shocks is almost twice as large as target shocks.[13]

[13]The authors differentiate, similar to this thesis, between news related to the ECB policy interest rate (target rate shocks), and news related to the future path of monetary policy or the economy more generally (communication shocks).

Following, Figure 11 completes the picture of intra-day differences on PC days compared to non-PC Thursdays by plotting the average trading volume per minute.

Figure 11: Intraday Overview: Relevance of PC days for bond trading volume



Overall, both samples follow similar shapes throughout the day. Towards the afternoon, average *Bund* trading volume is highest for both PC days and non-PC Thursdays. Further, market activity on both days is highest around 14:30 CET due to the opening of the US markets as well as the weekly announcements on US jobless claims[14]. Both lines also spike at 16:00 CET, triggered by the release of several macroeconomic indices (e.g., Index of Leading Indicators) (Hussain, 2011; Andersson, 2010). In contrast to non-PC Thursdays, there is a spike in market activity on PC days during the ECB announcement at 13:45 CET. Even though trading volume increases during the introductory statement and the Q&A session on PC days, the line does not spike right at the beginning of the introductory statement (14:30 CET). Again, this stems from the fact that ECB press conferences usually do not start at 14:30 CET sharp, but rather with a slight delay. The difference in market activity throughout the rest of the ECB press conference then corresponds to the introductory statement and the Q&A session.

Statistical tests for the intraday average trading volume per minute on PC days and non-PC Thursdays across specified windows are reported in Table 14. The constants resemble the

[14]NYSE opening times start with a pre-opening session on 6:30 am ET (11:30 CET), followed by the core trading session at 9:30am-4:00 pm ET (14:30-21:00 CET) (New York Stock Exchange, 2019).

average *Bund* trading volume per minute on non-PC Thursdays, while the dummy coefficients report the average difference on PC days and non-PC Thursdays.

Table 14: Bond trading volume per minute on ECB press conference days

Results are based on the estimation of Equation 14, using the 10-year German Government Bond (*Bund*). The dummy D^{PC} takes the value of "1" on press conference days and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

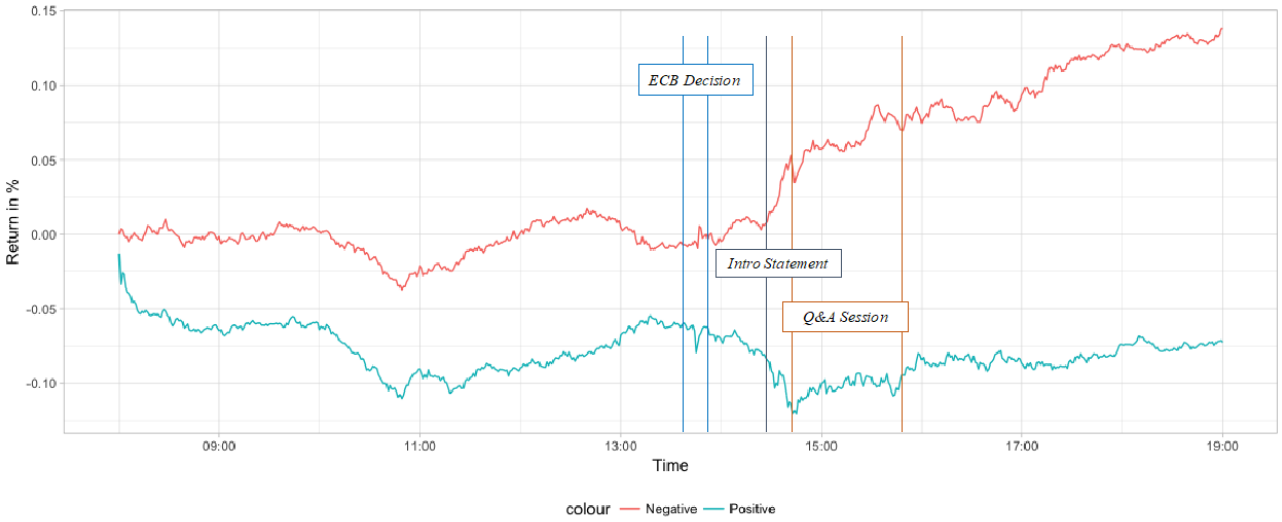
	Bond trading volume per minute:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
D_s^{PC}	713.299***	1,287.788***	1,083.789***	1,097.491***	219.064**
	(146.555)	(222.349)	(144.872)	(150.206)	(89.983)
Constant	799.107***	2,074.732***	1,316.640***	1,438.391***	1,407.005***
	(34.340)	(81.810)	(41.856)	(46.701)	(39.224)
Observations	875	875	875	875	875
R^2	0.056	0.048	0.102	0.091	0.007
Adjusted R^2	0.055	0.047	0.101	0.090	0.006
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 14 support the visual findings from Figure 11, as it is observed that average trading volume is substantially higher on PC days than on non-PC Thursdays. Since all coefficients are significantly different at the 99% level, there is reasonable evidence that the ECB press conference is of incremental importance for the bond markets. Further, the highest bond trading activity takes place during the introductory statement, which is most likely due to the explanatory power it has for market participants.

7.2.2 Central bank tone

In order to understand if ECB tone significantly influences bond market reactions, Figure 12 displays *Bund* returns on PC days for positive and negative tone changes. As described before, a change in tone is defined as the difference between the computed tone from two subsequent press conferences (see Section 5.1).

Figure 12: Intraday Overview: Negative vs. positive ECB tone on PC day bond returns



From a daily perspective, Figure 12 indicates that cumulative returns are positive for negative tone changes and negative for positive tone changes. Considering the intraday event windows, it appears that both returns follow similar patterns until around 12:45 CET, noting that the line of positive tone changes takes a steeper dip shortly after the markets open (08:00 CET). Again, it is observed that the ECB announcement (13:45 CET) does not seem to have a major impact on the bond market. Following the introductory statement, however, returns of positive (negative) tone changes are decreasing (increasing) for a sustained period. Especially for *Bund* returns on PC days with negative tone changes, this effect holds on until the market closes at 19:00 CET, indicating that either markets are not perfectly efficient or confounding effects contribute to traders adjusting their expectations throughout the day.

Table 15 reports the outcome of a few statistical tests comparing average *Bund* returns across specified windows on ECB press conferences at which tone becomes more positive (negative). The constants represent the average returns during event windows on PC days where tone improves. Average differences in returns between PC event windows where the tone improves and where it deteriorates are reported by the dummy coefficients.

Table 15: Bond returns with positive vs. negative ECB tone

Results are based on the estimation of Equation 15, using the 10-year German government bond (*Bund*). The dummy $D_t^{\Delta\tau<0}$ takes a value of "1" when the change in tone from one press conference to the following turns negative and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Bond returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$D_t^{\Delta\tau<0}$	0.006	0.046*	−0.002	0.044	0.188**
	(0.017)	(0.026)	(0.037)	(0.045)	(0.084)
Constant	−0.002	−0.028	0.022	−0.006	−0.078
	(0.010)	(0.019)	(0.026)	(0.032)	(0.062)
Observations	184	184	184	184	184
R^2	0.001	0.016	0.00002	0.005	0.025
Adjusted R^2	−0.005	0.011	−0.005	−0.0003	0.020
Note:					*p<0.1; **p<0.05; ***p<0.01

To initially understand whether changes in central bank tone and conventional policy actions correlate, the ECB decision (Column 1) window is tested. In line with expectations, Table 15 does not report any statistically significant difference of *Bund* returns as a reaction to central bank tone change at the monetary policy press release.

Turning to the main results provided in Table 15, findings are aligned with related studies on a daily perspective (Schmeling and Wagner, 2015), namely that negative tone changes are associated with positive bond returns. In numbers, daily *Bund* returns are, on average, 0.11 percentage points when there is a negative tone change compared to a mean of -0.078 percentage point when the tone becomes positive. The difference is significant at the 95% level. With respect to the intra-daily event windows, significant differences (90% level) between the two groups are only found in the introductory statement. In line with visual observations from Figure 12, average returns throughout the introductory statement are 0.018 percentage points during negative tone changes compared to a mean of -0.028 percentage points during positive tone changes. More generally, the signs of the coefficients further suggest that negative tone

changes are associated, on average, with higher *Bund* returns compared to when central bank tone improves. Consequently, it can be assumed that bond reactions are in line with the theoretical implications of monetary policy shocks and economic shocks caused by central bank communication (see Section 3.3). Based on the nature of this dummy regression, one should note, however, that all positive and negative tone changes are considered uniformly, with coefficients just resembling averages (constants) and differences in averages (dummies) within and across groups. Therefore, judgments about the different central bank mechanisms at hand should be made with caution.

In the following, *Bund* returns are regressed on tone changes in order to estimate by how much bond prices move in response to a change in tone. Table 16 reports the statistical outcome of average *Bund* returns across specified event windows for a given change in ECB tone. Throughout all event windows, the mean return for all 184 press conferences is represented by the constants. Coefficients of the tone change variable resemble the average *Bund* returns in response to a one standard deviation change in tone. Recall, that the standard deviation of tone change is around 0.008 (see Section 6.1).

Table 16: Bond returns and ECB tone

Results are based on the estimation of Equation 16, using the 10-year German government bond (*Bund*). $\Delta\tau_{t-1,t}$ resembles the change in central bank tone. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Bond returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	0.007	−0.030**	−0.008	−0.039*	−0.099**
	(0.009)	(0.013)	(0.016)	(0.021)	(0.040)
Constant	0.0004	−0.007	0.021	0.014	0.006
	(0.008)	(0.013)	(0.019)	(0.022)	(0.043)
Observations	184	184	184	184	184
R^2	0.003	0.028	0.001	0.016	0.028
Adjusted R^2	−0.002	0.023	−0.004	0.010	0.023

Note: *p<0.1; **p<0.05; ***p<0.01

On a daily level, results support the previous findings from Table 15, namely that tone change in fact matters. It is observed that a tone improvement by one standard deviation, is associated with, on average, -0.099 percentage points lower daily *Bund* returns. This estimate is significant at the 95% level. On an intraday level, significances are found during the introductory statement (95% level) and throughout the entire press conference (90% level). Given the improvement in tone by one standard deviation, the estimates suggest that *Bund* returns are lower during both, introductory statement (-0.030 percentage points) and the entire press conference (-0.039). These results provide two exciting insights: First, the negative bond returns for an improvement in tone further support the theoretical implications of monetary policy and economic shocks, which was already indicated by Table 15. Secondly, the significance during the introductory statement suggests that bond traders actively listen during the ECB press conferences and quickly react correspondingly. Potentially triggered by a higher level of professionals in fixed income markets, bond traders seem to adjust their trading behavior already when the ECB president reads out the introductory statement (Sercu, 2009). Consistently, Hubert and Fabien (2017) report that positive sentiment shocks in central bank communication increase yields, and thus lower bond returns, across all maturities.

Additionally, neither market volatility nor trading volume presents any significant results for a given change in ECB tone. This suggests that tone change does not systematically determine the informativeness of communication to bond market traders. The corresponding statistical output tables can be found in the Appendix, Table A10 and A11.

7.2.3 The role of forward guidance

Derived from the theoretical framework in Section 3.3, three shocks might stem from central bank communication, namely monetary policy shocks, economic shocks, and risk-premium shocks. Recalling Section 3.3, namely that a positive tone change could theoretically decrease bond returns either through a monetary policy shock or an economic shock. Given previous results, it is found that there is, in fact, a negative association between a positive tone change and bond returns. Consequently, the following section aims to separate these two parallel effects, to get a better understanding of which shocks predominately determine bond market behavior.

Similar to outputs presented in Table 16, *Bund* returns are regressed on tone changes in order to measure the magnitude effect of a given tone change. However, as reported in Table 17, a dummy variable is introduced to capture the presence of forward guidance. The corresponding outcomes for the average returns across specified event windows based on a given change in tone are presented below. First, the constants capture the mean *Bund* return across the event windows on PC days not containing any forward-looking statements on future monetary policy actions. Second, for these circumstances specifically, the coefficients of the tone change variable then resemble the average *Bund* returns' response to a one standard deviation change in tone. Third, the dummy variable coefficients represent the average return difference during event windows on PC days containing forward-looking statements compared to PC days when no forward guidance was used. Lastly, the interaction term estimates the average difference in the market reaction to a one standard deviation change in tone comparing PC days with forward guidance and PC days when it was not used. Recall that the standard deviation of tone changes is around 0.008.

Table 17: Bond returns and ECB tone with forward guidance

Results are based on the estimation of Equation 17, using the 10-year German government bond (*Bund*). $\Delta\tau_{t-1,t}$ resembles the change in central bank tone. The dummy D^{FG} takes the value of "1" on press conference when forward guidance is used and "0" otherwise. Heteroskedasticity-robust standard errors are reported in parenthesis (Freedman, 2006).

	Bond Returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	0.009	−0.030**	0.003	−0.026	−0.127***
	(0.012)	(0.015)	(0.017)	(0.023)	(0.048)
FG	0.025	−0.033	0.004	−0.029	−0.021
	(0.017)	(0.027)	(0.038)	(0.046)	(0.084)
$\Delta\tau_{t-1,t} * FG$	−0.008	−0.003	−0.039	−0.042	0.094
	(0.016)	(0.028)	(0.035)	(0.050)	(0.086)
Constant	−0.011	0.008	0.018	0.027	0.019
	(0.012)	(0.018)	(0.023)	(0.029)	(0.063)
Observations	184	184	184	184	184
R^2	0.017	0.036	0.006	0.022	0.034
Adjusted R^2	0.001	0.020	−0.010	0.005	0.018
Note:					*p<0.1; **p<0.05; ***p<0.01

In line with previous findings, among most event windows on PC days with no forward guidance, a change in tone is associated with lower bond returns. On a daily perspective, returns fall significantly, on average, by -0.127 percentage points following a one standard deviation change in ECB tone. Considering the intraday event windows, there is further significant evidence for the fast market reaction by bond traders during the introductory statement. However, indicated by insignificance of the interaction term, forward guidance does not seem to play a substantial role. This suggests that economic rather than monetary policy shocks dominate for the relationship between central bank tone and bond market reactions. Findings are in line with Ehrmann and Fratzscher (2009) who find that ECB speeches regarding the economic outlook impact daily bond return up to ten years, with the most significant effect at a five-year horizon. However, news concerning the course of monetary policy, only show effects on a few three-month, one-, two- and five- year maturities, where likely interest rate hikes drive the yield up and vice versa. Nevertheless, the direction of the interactions' coefficients suggests that on press conferences

that contain forward guidance, a positive tone change intensifies the association with negative bond returns. This is generally consistent with the theoretical framework at hand, namely that a tone change negatively impacts bond returns.

Based on the result section above, four distinct findings are summarized regarding the impact of ECB press conferences on bond markets: First, even though trading activity and market volatility are generally higher during ECB press conference, bond returns are not significantly different on PC days compared to non-PC Thursdays. Correspondingly, press conferences do not seem to affect bond markets in a systematic one-directional fashion. Second, aligned with the theoretical framework, a negative association between tone change and bond prices is found. In essence, an improvement of central bank tone is associated with negative bond returns. Third, it is found that ECB tone not only matters for bond traders on a daily but also on an intra-daily level. More specifically, it appears that bond markets actively listen to the content of ECB press conferences indicated by significant market reactions during the introductory statement. Fourth, findings on forward guidance suggest that central bank tone affects bond returns predominantly through economic shocks.

8 Robustness checks

The following section summarizes results of additional empirical exercises, in order to eliminate any noise in the results and strengthen the output of this study's baseline regressions. The idea is to test if the sentiment measure still significantly predicts the dependent variable after controlling for a vector of key variables and previous market activities. Consequently, the robustness check can help to limit the omitted variable bias. Following a test of asymmetries (Bernanke and Kuttner, 2005), a list of dummy variables is defined to control for monetary policy decisions, the corresponding surprise factor, and time-related differences.

8.1 Monetary policy decisions

Since the ECB's interest rate announcement resembles a core topic of each press conference, as a first step, it is estimated if the effects of central bank tone on asset returns vary for different key interest rate decisions. As defined by the ECB, there are effectively three key interest rates which the Governing Council sets in accordance with each other (European Central Bank, 2019e):

1. The interest rate on the *main refinancing operations* provides a bulk of liquidity to the banking system.

2. The rate on the *deposit facility* is used by banks to make overnight deposits with the Eurosystem.

3. The rate of the *marginal lending facility* offers overnight credit to banks from the Eurosystem.

In line with previous research, this study introduces a dummy variable for the respective decision on the key interest rates (Rosa, 2011b). Rather than simply adjusting for general rate changes, the regression contains three dummy variables (interest rate "continuation", "reduction" and "increase") which all take a value of "0" or "1". Using historical data on key interest rates, published by the ECB, as well as the base sample of transcripts, decisions for every press conference are classified. Throughout the data sample, 153 continuations, 21 reductions and 10 increases of the ECB's key interest rates are found. Table A12 and A13 in the Appendix report the outcome of a few statistical tests comparing average equity and bond returns across different event windows for given interest rate changes. Similar to related studies, rate reductions, increases and, continuations significantly drive asset prices in different directions (Rosa, 2011b).

Nevertheless, it is essentially observed that the impact of tone changes on asset returns is not significantly different for disparate interest rate decisions. Consequently, including interest rate decisions in the econometric model, serves as a confirmation to the previous findings.

8.2 Monetary policy surprises

Further, a control variable for the impact of market surprises is introduced. In line with Kuttner (2001), forward-looking markets will only react to surprises about monetary policy decisions, as suggested by the efficient market theory (see Section 3.1). Equivalently to changes in the key interest rates, the magnitude of market responses could depend on the surprise of these decisions (Bernanke and Kuttner, 2005). Similar to the procedure of identifying forward guidance, qualitative content analysis is applied to estimate whether or not a given monetary policy was a surprise. If the press claims that the ECB's decision was unexpected, the monetary policy decision is classified as a surprise ($MPAS$). In a subsequent step, two dummy variables are constructed to define if the surprise was either more expansionary ($MPAS^e$) or restrictive ($MPAS^r$) than expected.

In practice, the qualitative content analysis behind the dummy construction builds on five components:

1. For the same reasoning as in Section 5.2, articles are extracted from Factiva using Reuters and Handelsblatt as news sources.

2. In order to see whether or not the ECB's interest rate decision was a surprise, news articles from 24h before (pre-articles) and after the announcement (post-articles) are screened. The general idea is to understand what the press was expecting shortly before the announcement and whether or not these expectations were met afterwards. Hence, a number of pre- and post-announcement articles are extracted and used for the subsequent steps.

3. The same English and German keywords as in Section 5.2 are used to filter news articles.

4. Once left with a collection of relevant articles, each interest rate announcement needs to be classified as a surprise or not. In some cases, there is a clear word-indication in the articles published within 24h after the announcement. These include expressions related to "as expected" (wie erwartet), "unexpected" (unerwartet) or "surprisingly" (überraschend) and precisely separate *surprises* from *non-surprises*. If there is not such

a clear indication in the post-articles, one would need to compare the expectations 24h before the announcement and the officially stated decision. The news sources usually provide market expectations just before the ECB press conference, which can then be matched with the official decision.

5. Following these steps for each press conference, 14 interest decisions are classified as *surprises* while 170 are considered to be in line with expectations (*non-surprises*). Concerning the underlying study, a monetary surprise would occur during the ECB announcements of the key interest rates. For a given surprise, it would then be very likely that there is a corresponding explanation during the introductory statement and some related questions during the Q&A session. The surprise factor, therefore, measures if a tone change has a different effect on asset returns, once the policy decision was not expected by the markets.

6. Once the sample is divided into *surprises* and *non-surprises*, the former category is further disentangled in terms of the surprise direction. In this regard, a monetary policy surprise can either be more expansionary ($MPAS^e$) or restrictive ($MPAS^r$) than expected. Correspondingly, the respective dummy variables of $MPAS^e$ and $MPAS^r$ can take a value of "1" and "0" otherwise. In case there is no surprise, both dummies take the value of "0". Based on this classification, the underlying sample consists of 6 expansionary surprises and 8 restriction surprises. An exemplary list of articles and their classifications are provided in Appendix Table A14.

Indicated by Table A15 and A16 in the Appendix, there are no general differences observed for the $MPAS$ interaction terms. Nevertheless, some significances are found during the introductory statements of equity returns as well as for the ECB announcement and the Q&A of bond returns. These findings could provide a base for future research to further investigate.

8.3 Time-related differences

With respect to temporal influences on the relationship between central bank tone and asset returns, periods of economic turmoil or differing central bank officials might show significant differences. Consequently, two time-related dummy variables are introduced as controls in the following section.

Global financial crisis 2007/08. First, generally speaking, crisis times have significant influences on central banks operations. While monetary easing typically triggers an increase in stock prices during normal economic states, the same action might decrease returns in times

of crisis (Kontonikas et al., 2013; Hosono et al., 2014). Additionally, the ECB introduced unconventional monetary policies early in the global financial crisis 2007/08 and even used both, conventional and unconventional policies, simultaneously for some time (Haitsma et al., 2016). This suggests that the impact of central bank tone on asset returns may be affected, which is why the data set of ECB press conferences is separated into pre- and post-crisis dates (Vayid, 2013; Kahveci and Odabaş, 2016). Based on a Markov-switching vector autoregression model, Nowak et al. (2011) identify 5 June 2007 as the starting point of the global financial crisis in 2007/08. Indicated by the higher implied volatility of equity options on financial institutions and the depreciation of the US dollar, the starting point relies on the initial rises of uncertainty about asset prices and risk aversion. Consequently, every date after 5 June 2007 takes a dummy variable of "1" (post-crisis) while the remainder is coded with "0" (pre-crisis). 114 press conferences are classified as post-crisis and 70 as being pre-crisis. Table A17 and A18 in the Appendix report the outcome of a few statistical tests comparing average equity and bond returns across different event windows regressed tone changes before and after the financial crisis 2007/08. Interestingly, the results indicate that the impact of tone change on asset returns is not significantly different pre- and post-crisis. Thus, the dummy regression confirms the previous baseline results which further eliminates some underlying noise.

ECB presidents. Following Rosa and Verga (2007), there are no variations among the tone of different presidents. In Section 3, however, it has been described how central bank communication has developed over time towards more transparency and more interaction with other market participants. Given the fact that a total of three presidents have served as heads of the ECB, it can be argued that differences might exist among their impact on the financial markets. Previous research has already considered the tone effects of various speakers at the FOMC (Presidents, Governors or Federal Reserve Staff) on economic activity (Cannon and Sandra, 2015). Yet, this is the first attempt to construct dummy variables for the three respective ECB presidents to examine if the effects of central bank tone on financial markets systematically differ. Similar to findings on the impact of the financial crisis 2007/08 on asset prices, Table A19 and A20 present statistical results for all ECB presidents. Again, neither bonds nor equity returns suggest that there are significant differences in the central bank tone among ECB presidents. It seems that market respondents focus on the press conference content itself, rather than individual noise by the presenter. Given the statement's strict structural setup and the fact that each statement is prepared collectively by the whole Governing Council, this should not come as a surprise. In the end, the ECB president *only* reads out the introductory statement.

Beyond the scope of this thesis, there might be other controls that can be employed to question the previous results. Future research is therefore encouraged to look for e.g., unknown macroeconomic announcements or additional temporal influences that could further decrease any remaining noise in the results. Nevertheless, based on the chosen robustness measures above, it can be summarized that there is no evidence that key interest rate decisions, monetary policy surprises or time-related differences affect the relationship of central bank tone and asset returns. Consequently, the robustness check strengthens the previous results and thereby confirms the baseline findings of the underlying study.

9 Discussion

In this section, combined results from the equity and bond market are interpreted, put into context, and related to the theoretical framework. Additionally, practical implications to policymakers as well as financial market participants are discussed.

In market-oriented economies, many central banks aim to achieve medium-term monetary stability in their currency zone to ensure sustainable levels of output, employment, and inflation (European Central Bank, 2019a). Using monetary policy instruments, central banks can influence aggregate demand and thereby indirectly impact the overall price level. While central banks have direct control over key interest rates to impact short-term interest rates quite directly, their mandate requires them to also influence asset prices and interest rates at longer maturities. As the public's expectations drive asset prices and longer-term interest rates, communication is an essential tool for central banks to implement effective monetary policies in a respective currency regime. In this context, success is defined as the ability of policymakers to influence the public's expectations through their choice of language. To credibly do so, central banks should be held accountable for their actions, follow an effective communication strategy and find the right level of transparency (Vayid, 2013; Kahveci and Odabaş, 2016).

Given the key role of central bank communication, both policymakers, as well as market participants, should be aware of the intended and unintended effects words in public central bank statements have on financial assets. By utilizing press conference transcripts of the ECB, this thesis studies whether and how central banks can steer market expectations by their choice of words. The following discussion is guided by three research questions that can, at least partially, be answered with empirical findings:

Do live press conferences of central banks have an effect on financial markets as a result of market participants adjusting expectations? If yes, how and through what channels?

In the empirical results, it is shown that equity and bond markets are significantly impacted by live press conferences held by the ECB. Several interesting observations are made: First, equity returns tend to be significantly negatively impacted during the time of the introductory statement of the ECB president. While the direction of this effect is confirmed during the Q&A and on a daily-level, no statistical significance is found. Put differently, markets sharply react to the

words of the ECB president in a negative fashion, but the effect fades away over time during the day. Second, bond returns, on the other hand, do not seem to be systematically affected by ECB press conferences. However, throughout most windows, the absolute magnitude of returns is positive and economically meaningful. Third, both equity and bond markets show economically substantial and significantly higher volatility and trading volume during ECB press conferences.

As equity and bond returns move in different directions, results suggest, that press conferences do not drive stock prices via the yield, which makes a simple discount rate effect unlikely. More likely is, consistent with the theoretical framework, that ECB communication during the time of the sample period predominantly triggers either negative economic or positive risk-premium shocks (higher risk aversion) or both. A potential explanation could lie in the features of the utilized sample period. Between 2001 and 2017 several crises - the dot-com bubble, the global financial crisis, and the sovereign-debt crisis - have shaken financial markets and created substantial uncertainty also for central bankers. Substantially increased market volatility and trading volume of both asset classes reconfirm the hypothesis of a risk-premium shock. With regards to volatility specifically, a large set of asset pricing models suggest that realized volatility is proportional to the amount of information flow received by market participants during the time of the announcement (Ross, 1989). In terms of trading volume, on the other hand, market microstructure models imply that volumes increase with the precision of the announcement information and decrease with the precision of the information known prior to the announcement (Kim and Verrecchia, 1991).

In sum, it is confirmed that press conferences of central banks do have a substantial effect on financial markets as market participants adjust expectations based on new or more precise information received. Nevertheless, measuring tone of the ECB press conference yields further insights into these findings.

Does the tone of press conferences affect financial markets? If yes, how and through what channels?

Contrary to the previous question, the relationship between ECB tone changes and financial market reactions are less clearly visible in the reported results. Generally, equity returns seem to co-move with central bank tone changes. In other words, when ECB tone becomes more positive (negative), stock returns will increase (decrease). However, while strong statistical significance is reported for daily stock returns, on an intraday level surrounding the time of the press conference no, at least statistically, meaningful estimates are found. Contrarily, for

bonds, a negative correlation between ECB tone and returns is found. Put differently, when ECB tone improves (deteriorates), bond prices fall (rise). It is shown that ECB tone has at least a faster impact on bonds compared to equities, as there are strong and significant estimates reported in the intraday windows surrounding the introductory statement of the ECB president. Daily returns confirm these findings. Finally, for both bonds and equities, neither volatility nor trading volume seems to change in response to ECB tone changes systematically.

Potential explanations for the reported results may be found in the characteristics of financial market shocks, market efficiency, and confounding effects. First, as central bank tone is, on average, positively correlated with stock returns and negatively correlated with bond returns, results suggest that tone predominantly creates economic shocks to financial markets. However, a potential explanation for why there is a less strong response in equity returns could be that, as suggested by the theoretical framework, positive (negative) central bank tone is correlated with restrictive (expansionary) forward-looking monetary policy statements (forward guidance). As these statements will typically push bond returns down (up), they may increase (decrease) the expected risk-free component of the discount rate and thereby depress (stimulate) stock prices. The opposing effects of shocks created by central bank tone may consequently lower the directional change in equity prices, explaining the non-significant estimates. Further analysis is provided in the next question of this discussion.

Second, with regards to timing, bond prices react faster and more clearly to central bank tone than equities. This suggests that, at least for equity traders, financial news is not necessarily incorporated directly at the time when the information becomes available to the public. Prior research shows that markets use information from the Q&A session to either confirm, reinforce or reconsider earlier market moves (Ehrmann and Fratzscher, 2009). Reported results for the window surrounding the Q&A session suggest this "confirmation phenomena" as the signs of coefficients are, in all cases, consistent with the returns found during the introductory statement. Comparing press conferences with improving tone to deteriorating tone, there are different trends for stock returns after the press conference has ended. This implies that equity markets seem to further adjust expectations post the Q&A session. Hayo et al. (2008) find a similar pattern for FOMC speeches and the US markets and refer to it as a "media filtering process". The underlying hypothesis is that individual news recipients, in this case equity traders, rely on information filters (e.g., media outlets) to deal with the information flow of the central bank. Thus, in line with Hayo et al. (2008), viewing equity markets as "automatic information processing entities" does not seem to be realistic in this case. This is quite a remarkable

observation as EU financial markets are typically considered to be very efficient (see Section 3.1). In contrast to equities, bond markets predominantly consist of professional traders – an explanation of why bond prices respond in a more efficiently to the words of central bankers (Sercu, 2009).

Finally, a potential driver for why daily financial market returns show stronger effects compared to intraday observations might be the impact of confounding effects that are not directly related to central bank tone. On a fundamental level, the longer an event window, the higher the likelihood of including non-event related shocks that may bias the results. This may also be the case for the daily returns reported in this thesis. According to Hussain (2011), around 28% of the US macroeconomic releases at 16:00 CET coincide with ECB press conference days.[15] Since staff economists at central banks have access to a wide variety of confidential economic data, e.g., detailed records of inter-bank lending, it is likely that their information set is superior to that of other market participants. While they are not directly disclosing this confidential information during press conferences, their choice of words in statements may be endogenous to the new information received by market participants at the US macroeconomic releases. Interestingly, particularly equity but also bond returns, show clear continued trends from 16:00 CET onwards depending on whether ECB tone improves or deteriorates. The higher sensitivity to global macroeconomic conditions may be an explanation for the pronounced trend in equity returns.

Concluding, it is partly confirmed that central bank tone effects financial markets. However several open questions, with regards to financial shocks, market efficiency, and confounding effects, remain for future research.

Is it possible to further distinguish between different shocks to market expectations that are triggered by central bank tone?

So far, results have indicated that ECB tone predominantly affects both equity and bond markets through economic shocks. The theoretical foundation of this hypothesis is twofold. First, volatility and trading volume of both asset classes do not systematically differ when central bank tone changes, indicating that tone is not creating risk-premium shocks. Second, stock and bond returns negatively co-vary in response to tone changes, an inconsistent reaction to

[15] Hussain (2011) selects nine US macroeconomic releases at 16:00 CET: Index of Leading Indicators; ISM-Index Manufacturing; ISM-Index Services; House Price Index; Existing Home Sales; New Home Sales; Factory Orders; Consumer Confidence; Business Inventories.

monetary policy shocks. However, as particularly intraday equity returns are not estimated to be strong and statistically significant, it is further tested whether monetary policy shocks may be an explanation for the weak estimates found. Indeed, by including a specification for forward guidance, it is found that the positive relationship between tone and equity market returns is weakened, canceled-out, or, in some cases, even reversed when forward guidance is used. While this effect is observable for all event windows, again only daily returns show significant estimates. For bond markets, on the other hand, the relationship is stronger when forward guidance is used in ECB press conferences compared to press conferences without forward guidance. However, no statistically significant estimates are found. As economic and monetary shocks create opposing effects on equity prices and allied effects to bonds, these results are, at least for equities, consistent with the theoretical suggestions.

On an initial note, it should be stated that perfectly disentangling monetary and economic shocks is empirically a difficult challenge. The current model is based, consistent with Hansen and McMahon (2016), on the assumption that only forward guidance in press conferences creates monetary policy shocks that affect financial markets. In practice, however, central bankers do comment on current monetary policies that potentially contain new information to the market as well and thereby change expectations of market participants. Nevertheless, for equities specifically, it can be shown that when forward guidance is used in press conferences, monetary policy shocks seem to dominate economic shocks. This finding is important as the positive relationship between tone and equity returns seems to only exist under specific circumstances. During the period between April 2013 and December 2017, all press conferences contained forward-looking statements with regards to the future monetary policy. Consequently, it is not reliable to predict that more positive central bank tone will drive equity prices up in the future. With regards to bond markets, no apparent forward guidance effect is observable indicating that economic shocks dominate the negative relationship of central bank tone and bond prices.

All in all, it is quantified whether monetary policymakers can convey positive and negative signals through the choice and use of some specific words to consequently affect expectations of financial market participants. Beyond conventional quantitative and qualitative information conveyed through the content of their communication, sentiment captures soft information conveyed through the tone of policymakers' communication (Hubert and Fabien, 2017). Obtained results may give central bankers some further insights on how financial markets interpret and react to the tone conveyed by their communication. This should be understood as signals beyond policy decisions and standard forms of communication. As a result of the findings, central

bankers are encouraged to evaluate their choice of words in central bank statements conditional on the topic they are referring to. For instance, when communicating their view on the economic outlook to the public, it is expected that a more positive tone results in a more positive (negative) stock (bond) price reaction. However, when referring to the future monetary policy path, the same words may have opposed effects to markets. Second, particularly for equity traders, it may be lucrative to closely listen to the words of the ECB president during the time the introductory statement is made. As intraday findings indicate, markets tend to react relatively slowly to changes in central bank tone.

10 Conclusion

The goal of this thesis is to enhance the understanding of how the choice of words in central bank communication affects financial markets. Consequently, by using the LM dictionary, it is quantified and tested whether monetary policymakers can convey positive and negative sentiments to affect expectations of financial market participants. The empirical analysis covers 184 ECB press conferences between April 2001 and December 2017.

In contrast to existing literature, a theoretical framework is proposed to better understand the relationship between central bank tone and asset prices. Within the limits of the empirical model, it is shown that generally equity and bond markets are significantly impacted by live press conferences held by the ECB. With regards to central bank tone specifically, results suggest that effects are multidimensional and conditional on the information shocks that are created. Fundamentally, equity (bond) prices are positively (negatively) reacting to improvements in central bank tone. However, when further differentiating between monetary policy and economic shocks, evidence is found that the effect on equity returns is weakened, canceled-out, or, in some cases, even reversed when forward guidance is used. With regards to bonds, on the other hand, the relationship is stronger when forward guidance is used in ECB press conferences compared to press conferences without forward guidance. As economic and monetary shocks create opposing effects to equity prices and allied effects to bonds these results are consistent to the theoretical suggestions.

A second contribution stems from the use of intraday financial data, which allows measuring the effects of central bank communication and asset prices more precisely. Results show that bond prices react faster and more clearly to central bank tone than equities. Two explanations are proposed for this phenomenon. First, it is suggested that, at least for equity traders, financial news are not necessarily created or incorporated directly at the time when the information becomes available to the public. It could be that individual equity traders rely on information filters (e.g., media outlets) to deal with the information flow of the central bank. Bond markets, on the other hand, predominantly consist of professional traders – an explanation of why bond prices respond more efficiently to the words of central bankers. Second, a potential driver for why daily equity market returns show stronger effects compared to intraday observations might be the impact of confounding effects that are not directly related to central bank tone.

This thesis should be seen as a starting point for further discussions and empirical testing rather than a final answer to the research questions. While Schmeling and Wagner (2015) show evidence that central bank tone does matter for daily equity returns and bond yields, this study shows that effects are not as straight-forward as previously depicted. Consequently, both policymakers, as well as financial market participants, can draw several important implications from the findings. First, central bankers are encouraged to evaluate their choice of words in central bank statements conditional on the topic they are referring to. For example, when communicating their view on the future state of the economy to the public, it is expected that a more positive tone results in a more positive (negative) stock (bond) price reaction. However, when referring to the future monetary policy path, the same words may have diametrical effects to markets. Second, particularly for equity traders, it may be lucrative to carefully listen to words of the ECB president during the introductory statement. As intraday findings indicate, markets tend to react quite slowly to changes in central bank tone.

However, as noted throughout the paper, the reported results should be viewed with caution due to several practical challenges: First, disentangling different shocks that are created through the choice of words in press conferences. Second, identifying why equity markets react relatively inefficient to central bank tone. Third, controlling for confounding effects that may have an impact on the relationship between central bank tone and asset prices. To better disentangle different shocks, future research is encouraged to study the relationship between central bank tone and asset prices with more sophisticated proxies for financial market participant's risk aversion and macroeconomic uncertainty (Ehrmann and Fratzscher, 2009; Schmeling and Wagner, 2015). Moreover, while this thesis has shown that results apply to long-term bonds and equity indices, it would be valuable to study how bonds across different maturities and equities across other sectors behave. Similar to Hansen and McMahon (2016), it also remains interesting to extract specific phrases within central bank statements and classify them into pre-determined topics to more precisely measure the multidimensional effects of central bank communication on asset prices. Finally, due to the nature of the sample, these empirical findings are currently only valid for the ECB, it would be insightful for future research to examine whether similar dynamics hold in other currency regimes.

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Appendix

Section 5: Methodology

Figure A1: Exemplary lines of processed press conference

```
## [1] "ladies gentlemen vicepresident pleased welcome press conference based regular"
## [2] "economic monetary analyses line forward guidance decided keep key ecb interest"
## [3] "rates unchanged regards nonstandard monetary policy measures march started"
## [4] "purchasing eurodenominated public sector securities part expanded asset"
## [5] "purchase programme also comprises purchases assetbacked securities covered"
## [6] "bonds purchases intended run end september case see sustained adjustment path"
```

Table A1: Exemplary list of newspaper articles and quotes to identify forward guidance

Date	Forward guidance	Article title	Article content
06 May 2014	Yes	Draghi comments at ECB news conference	"We firmly reiterate our forward guidance. We continue to expect the key ECB **interest rates to remain at present or lower levels for an extended period of time."**
06 Feb 2014	Yes	ECB holds rates at record low, puts focus on March	The ECB is wary of inflation getting stuck in what Draghi has called a "danger zone" below 1 percent and vowed again **to keep rates at present or lower levels for an "extended period".**
05 Dec 2013	Yes	Draghi comments at ECB news conference	The (ECB) **confirmed its forward guidance** that it continues to expect the key ECB interest rates to remain at present or lower levels for an extended period of time. This expectation continues to be based on an overall subdued outlook for inflation extending...
07 Nov 2013	Yes	Draghi comments at ECB news conference	"Following today's rate cut, the Governing Council reviewed the forward guidance provided in July and confirmed that it **continues to expect the key ECB interest rates to remain at present or lower levels for an extended period of time."**
10 Jul 2003	Yes	ECB leaves rates steady, sees no change for a time.	The European Central Bank left interest rates steady on Thursday and said it expected to keep its policy stance unchanged for a considerable time as the worst of the economic downturn may be over. ECB President Wim Duisenberg sounded more optimistic than a month ago that the euro zone economy ....would gradually start picking up by year end, noting that economic sentiment may be bottoming out. In a strong sign the ECB thinks it has done enough to boost sluggish euro zone growth, Duisenberg said interest rates were appropriate and **could well remain so for some time to come.**

Section 6: Data

Figure A2: Closing prices before vs. after processing

Closing prices before processing:

```
##                         V1
## 1998-06-30 10:12:00 2780
## 1998-06-30 10:15:00 2779
## 1998-06-30 10:23:00 2770
## 1998-06-30 10:24:00 2769
## 1998-06-30 10:30:00 2761
## 1998-06-30 10:39:00 2759
```

Closing prices after processing:

```
##                         ts
## 1998-06-30 10:13:00 2780
## 1998-06-30 10:14:00 2780
## 1998-06-30 10:15:00 2779
## 1998-06-30 10:16:00 2779
## 1998-06-30 10:17:00 2779
## 1998-06-30 10:18:00 2779
```

Table A2: Descriptive statistics of Market index volatility

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	0.245	0.399	0.000	0.117	2.874
Intr. Statement	184	0.370	0.470	0.000	0.222	3.763
Q & A	184	0.543	0.575	0.000	0.342	3.012
Entire PC	184	0.610	0.669	0.000	0.377	3.938
PC-day	184	1.722	1.828	0.000	1.177	10.398

Table A3: Descriptive statistics of Bank index volatility

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	0.202	0.525	0.000	0.000	3.502
Intr. Statement	184	0.414	0.792	0.000	0.076	7.690
Q & A	184	0.626	0.841	0.000	0.342	5.064
Entire PC	184	0.762	1.147	0.000	0.352	9.663
PC-day	184	2.048	2.039	0.000	1.425	11.310

Table A4: Descriptive statistics of Bund volatility

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	0.062	0.093	0.000	0.033	0.813
Intr. Statement	184	0.137	0.118	0.000	0.103	0.707
Q & A	184	0.189	0.167	0.000	0.151	1.107
Entire PC	184	0.223	0.213	0.000	0.168	1.227
PC-day	184	0.463	0.362	0.013	0.390	1.896

Table A5: Descriptive statistics of Market index trading volume per minute

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	1,972.691	3,109.616	0.000	999.800	23,798.700
Intr. Statement	184	3,125.666	3,299.962	0.000	2,173.367	20,157.530
Q & A	184	2,129.085	1,733.689	0.000	1,806.454	8,957.600
Entire PC	184	2,278.157	1,897.193	0.000	1,954.200	9,902.400
PC-day	184	1,548.705	1,001.042	0.000	1,468.230	5,309.421

Table A6: Descriptive statistics of Bank index trading volume per minute

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	135.526	407.962	0.000	23.750	3,663.800
Intr. Statement	184	149.882	314.271	0.000	26.667	2,399.467
Q & A	184	855.126	1,541.945	0.000	229.500	9,302.400
Entire PC	184	133.230	240.296	0.000	35.362	1,599.925
PC-day	184	91.351	133.082	0.000	36.338	952.575

Table A7: Descriptive statistics of Bund trading volume per minute

Statistic	N	Mean	St. Dev.	Min	Median	Max
ECB decision	184	1,481.520	1,861.213	0.000	975.300	9,929.000
Intr. Statement	184	3,342.582	2,736.059	0.000	3,273.133	10,683.730
Q & A	184	2,431.668	1,869.991	0.000	2,452.654	9,577.831
Entire PC	184	2,558.393	1,916.559	0.000	2,652.713	9,483.175
PC-day	184	1,640.137	1,077.448	0.000	1,819.229	4,290.970

Section 7: The effect of ECB press conferences

Table A8: Equity volatility and ECB tone

	Volatility:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	−0.012	−0.001	−0.042	−0.075	−0.076	−0.047	−0.070	−0.140	0.147	0.123
	(0.037)	(0.041)	(0.043)	(0.091)	(0.048)	(0.064)	(0.064)	(0.119)	(0.136)	(0.152)
Constant	0.245***	0.202***	0.370***	0.414***	0.543***	0.626***	0.610***	0.762***	1.722***	2.048***
	(0.029)	(0.039)	(0.034)	(0.058)	(0.042)	(0.062)	(0.049)	(0.084)	(0.134)	(0.150)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.001	0.00000	0.008	0.009	0.018	0.003	0.011	0.015	0.006	0.004
Adjusted R^2	−0.005	−0.005	0.002	0.003	0.012	−0.002	0.006	0.009	0.001	−0.002

Note: *p<0.1; **p<0.05; ***p<0.01

Table A9: Equity volume traded per minute and ECB tone

	Average volume traded per minute:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	−149.4	6.9	−146.2	4.5	11.2	−11.6	−17.5	−0.6	2.0	1.4
	(171.3)	(19.1)	(293.0)	(17.3)	(134.9)	(84.7)	(156.3)	(13.2)	(81.2)	(8.0)
Constant	1,972.7***	135.5***	3,125.7***	149.9***	2,129.1***	855.1***	2,278.2***	133.2***	1,548.7***	91.4***
	(228.4)	(30.0)	(242.4)	(23.1)	(127.5)	(113.4)	(139.5)	(17.7)	(73.6)	(9.8)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Adjusted R^2	−0.003	−0.01	−0.004	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01

Note: *p<0.1; **p<0.05; ***p<0.01

Table A10: Bond volatility and ECB tone

	Bond volatility:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	−0.006	0.00000	0.009	0.009	−0.005
	(0.007)	(0.008)	(0.009)	(0.016)	(0.025)
Constant	0.062***	0.137***	0.189***	0.223***	0.463***
	(0.007)	(0.009)	(0.012)	(0.016)	(0.027)
Observations	184	184	184	184	184
R^2	0.004	0.000	0.003	0.002	0.0002
Adjusted R^2	−0.002	−0.005	−0.003	−0.004	−0.005

Note: *p<0.1; **p<0.05; ***p<0.01

Table A11: Bond trading volume per minute and ECB tone

	Bond trading volume per minute:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	−71.122	65.577	115.956	102.449	28.110
	(113.720)	(230.370)	(154.467)	(162.212)	(94.116)
Constant	1,481.520***	3,342.582***	2,431.668***	2,558.393***	1,640.137***
	(136.737)	(201.098)	(137.218)	(140.705)	(79.187)
Observations	184	184	184	184	184
R^2	0.001	0.001	0.004	0.003	0.001
Adjusted R^2	−0.004	−0.005	−0.002	−0.003	−0.005

Note: *p<0.1; **p<0.05; ***p<0.01

Section 8: Robustness Check

Table A12: Equity returns and ECB tone with interest rate changes

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.014	0.055	0.016	0.099	0.086*	0.095	0.102	0.194	0.299	0.225
	(0.028)	(0.043)	(0.055)	(0.119)	(0.049)	(0.071)	(0.075)	(0.157)	(0.198)	(0.239)
Rate reduc.	0.160	0.541***	−0.277	−0.145	−0.275	−1.063***	−0.552*	−1.208***	−1.103	−0.631
	(0.282)	(0.204)	(0.274)	(0.320)	(0.290)	(0.339)	(0.310)	(0.376)	(1.096)	(1.158)
Rate incr.	0.112***	0.042	−0.008	0.121	0.315***	0.155	0.307**	0.276**	−0.550	0.068
	(0.039)	(0.049)	(0.096)	(0.079)	(0.120)	(0.132)	(0.142)	(0.128)	(0.579)	(0.458)
$\Delta\tau_{t-1,t} * Ratereduc.$	0.070	−0.221	−0.093	−0.251	−0.002	0.159	−0.096	−0.093	−0.190	−0.595
	(0.230)	(0.152)	(0.204)	(0.210)	(0.265)	(0.267)	(0.288)	(0.305)	(0.773)	(0.739)
$\Delta\tau_{t-1,t} * Rateincr.$	−0.025	−0.091*	−0.063	−0.071	−0.173*	−0.180	−0.236*	−0.251	0.367	0.212
	(0.039)	(0.050)	(0.084)	(0.123)	(0.104)	(0.121)	(0.135)	(0.172)	(0.568)	(0.434)
Constant	−0.071***	−0.008	−0.075*	−0.146**	−0.062	0.008	−0.137**	−0.138	0.063	0.219
	(0.021)	(0.034)	(0.040)	(0.068)	(0.053)	(0.070)	(0.063)	(0.103)	(0.168)	(0.211)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.017	0.133	0.023	0.017	0.035	0.140	0.059	0.107	0.037	0.012
Adjusted R^2	−0.011	0.109	−0.005	−0.010	0.008	0.116	0.032	0.081	0.009	−0.015

Note: *p<0.1; **p<0.05; ***p<0.01

Table A13: Bond returns and ECB tone with interest rate changes

	Bond Returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	−0.005	−0.022	−0.011	−0.033	−0.110**
	(0.005)	(0.014)	(0.017)	(0.024)	(0.046)
Rate reduc.	0.031	−0.027	−0.070	−0.097	−0.067
	(0.053)	(0.066)	(0.079)	(0.091)	(0.216)
Rate incr.	0.006	−0.100***	0.002	−0.098	−0.055
	(0.020)	(0.029)	(0.058)	(0.073)	(0.152)
$\Delta\tau_{t-1,t} * Ratereduc.$	0.072**	−0.051	−0.009	−0.060	0.037
	(0.036)	(0.052)	(0.043)	(0.063)	(0.128)
$\Delta\tau_{t-1,t} * Rateincr.$	0.002	0.017	0.037	0.054	0.066
	(0.020)	(0.032)	(0.054)	(0.070)	(0.137)
Constant	−0.001	−0.00004	0.028	0.028	0.019
	(0.006)	(0.013)	(0.019)	(0.024)	(0.043)
Observations	184	184	184	184	184
R^2	0.061	0.053	0.010	0.033	0.031
Adjusted R^2	0.035	0.027	−0.018	0.006	0.004

Note: *p<0.1; **p<0.05; ***p<0.01

Table A14: Exemplary list of newspaper articles and quotes to identify interest rate changes and surprises

Date	Interest rate adjustment	Article title	Article content	Surprise indicator
07 Jul 2011	Interest rate increase	"Euro, Bunds little changed after ECB raises rates"	The euro and German Bund futures were little changed on Thursday after the European Central Bank raised benchmark interest rates by 25 basis points, as widely expected. The euro traded around $1.4275 versus the dollar, down around 0.3 percent for the day. German Bund futures were barely moved at 126.39, down 13 ticks on the day. Attention shifts to ECB President Jean-Claude Trichet's press conference at 1230 GMT for hints on timing of further rate rises and comment on Greece's debt crisis.	No
03 Jun 2004	Interest rate continuity	"Euro debt-Futures steady after ECB keeps rates on hold"	The Bund future and Euribor interest rate futures were little changed on Thursday after the European Central Bank left interest rates steady at 2.0 percent, as expected. Attention was on the ECB's news conference at 1230 GMT, with investors keen to see what the ECB will say about the impact of high oil prices on inflation and the economy. The news conference could see Jean-Claude Trichet adopt a hawkish stance as inflation expectations rise, analysts say. "Trichet may be forced to raise rates by a quarter point by year end if the inflation forecast gets raised today."	No
09 Jan 2003	Interest rate continuity	"ECB holds key rate at 2.75 percent as expected"	The European Central Bank met market expectations and held interest rates steady on Thursday in the hope that a struggling economy is on the mend. The bank said it left the minimum bid rate at its weekly refinancing auctions unchanged at 2.75 percent. The rates for the marginal lending and the deposit facilities also stayed flat at 3.75 percent and 1.75 percent respectively. The bank made no immediate further statement but a news conference with President Wim Duisenberg is due at 1330 GMT. Almost all economists in a Reuters poll last week had said they expected the ECB to stay put this week.	No
11 Oct2001	Interest rate continuity	"Euro debt-Short-dated yields rise on ECB unchanged decision"	Yields on interest rate-sensitive two-year German Schatz notes rose to one-week high on Thursday after the European Central Bank's decision to leave interest rates unchanged dissapointed some investors in the market. In a Reuters survey carried out last week, 28 out of 46 economists expected a quarter percentage point cut in the ECB's minimum bid refi rate to 3.50 percent. But some doubts about a rate cut had begun to emerge after recent rhetoric, especially from the ECB chief Wim Duisenberg over the weekend. "The ECB wants confirmation that things are slowing down. Although confidence is down, the ECB will argue it addressed that already with a 50 basis piint rate cut (in September)," said Adam Chester, economist, Halifax Group Treasury. The ECB last cut rates by 50 basis points - to 3.75 percent - in a concerted move led by the Federal Reserve on September 17, in the wake of...Over the weekend, ECB President Duisenberg voiced his confidence that growth in the euro zone would start to recover by year-end. Duisenberg also said the bank's first responsibility was to maintain price stability in the euro zone. Ahead of the ECB decision, economic data confirming subdued inflationary pressures in the euro zone'e largest economy had little impact on the bond market. Similiarly, data showing euro zone Gross Domestic... The 10-year Bund yield spread over Treasuries narrowed to zero from two basis points as Bunds outperformed after the ECB rate decision. The 10-year euro swap spread was two basis points narrower at 30.	Yes
07 Jun 2001	Interest rate continuity	"ECB keeps interest rates unchanged as expected"	The European Central Bank on Thursday left its interest rates unchanged as expected in the face of mixed signals of rising inflation and cooling economic growth in the euro zone. The ECB said in a brief statement it had left its key minimum bid rate unchanged at 4.50 percent. It made no further comment but ECB President Wim Duisenberg will explain the decision at a news conference at 1230 GMT. Economists polled by Reuters on average saw a 75 percent likelihood the ECB would keep its rate unchanged. Most analysts, however, expect a cut later this summer. On May 10, the ECB surprised markets by cutting rates by a quarter point after defending for weeks its wait-and-see stance citing lingering inflation risks.	No

Table A15: Equity returns and ECB tone with interest rate surprise

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.01	−0.02	0.04	0.09	0.08	0.14*	0.12	0.24*	0.39**	0.22
	(0.04)	(0.03)	(0.05)	(0.10)	(0.07)	(0.08)	(0.08)	(0.14)	(0.19)	(0.22)
$MPAS^e$	1.13***	1.10**	0.18*	0.52**	−0.32	−0.52	−0.14	−0.005	1.13	2.15***
	(0.38)	(0.55)	(0.10)	(0.23)	(0.24)	(0.55)	(0.26)	(0.46)	(0.75)	(0.56)
$MPAS^r$	−0.06	0.005	−0.47	−0.57	−0.03	0.02	−0.49*	−0.55	−0.53	−0.31
	(0.10)	(0.19)	(0.33)	(0.36)	(0.14)	(0.12)	(0.27)	(0.40)	(0.60)	(0.49)
$\Delta\tau_{t-1,t} * MPAS^e$	0.24	−0.32	−0.12*	−0.29*	0.11	0.04	−0.01	−0.24	0.12	−0.18
	(0.18)	(0.27)	(0.06)	(0.15)	(0.13)	(0.27)	(0.16)	(0.26)	(0.52)	(0.36)
$\Delta\tau_{t-1,t} * MPAS^r$	−0.02	0.65	−0.28	−0.16	0.05	0.05	−0.23	−0.10	−1.53	−0.94
	(0.10)	(0.51)	(0.45)	(0.35)	(0.13)	(0.18)	(0.44)	(0.42)	(1.11)	(1.05)
Constant	−0.08***	0.01	−0.08**	−0.14**	−0.07	−0.10	−0.15**	−0.23**	−0.06	0.14
	(0.03)	(0.03)	(0.04)	(0.06)	(0.06)	(0.08)	(0.07)	(0.10)	(0.19)	(0.22)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.20	0.20	0.06	0.04	0.02	0.03	0.03	0.03	0.05	0.03
Adjusted R^2	0.18	0.17	0.03	0.02	−0.01	0.002	0.01	0.01	0.02	0.001

Note: *p<0.1; **p<0.05; ***p<0.01

Table A16: Bond returns and ECB tone with interest rate surprise

	Bond Returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	0.003	−0.029**	0.0003	−0.029	−0.109***
	(0.009)	(0.012)	(0.016)	(0.021)	(0.041)
$MPAS^e$	0.191***	0.055	−0.170**	−0.115	−0.118
	(0.044)	(0.056)	(0.079)	(0.074)	(0.156)
$MPAS^r$	0.011	−0.154***	−0.069	−0.223**	−0.451**
	(0.048)	(0.058)	(0.074)	(0.109)	(0.198)
$\Delta\tau_{t-1,t} * MPAS^e$	0.018	0.045	−0.010	0.036	0.210**
	(0.023)	(0.037)	(0.040)	(0.045)	(0.084)
$\Delta\tau_{t-1,t} * MPAS^r$	0.052*	0.023	−0.135**	−0.111	0.268
	(0.027)	(0.074)	(0.066)	(0.125)	(0.222)
Constant	−0.008	−0.002	0.033*	0.031	0.025
	(0.008)	(0.013)	(0.019)	(0.023)	(0.043)
Observations	184	184	184	184	184
R^2	0.106	0.060	0.037	0.060	0.051
Adjusted R^2	0.081	0.033	0.010	0.034	0.024

Note: *p<0.1; **p<0.05; ***p<0.01

Table A17: Equity returns and ECB tone with crisis dummy

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.056	0.058	0.027	0.001	0.104	0.051	0.131*	0.052	0.358	0.119
	(0.052)	(0.050)	(0.040)	(0.024)	(0.077)	(0.039)	(0.070)	(0.047)	(0.227)	(0.163)
Crisis	0.007	−0.004	−0.038	−0.159	0.051	−0.119	0.014	−0.279*	0.015	0.045
	(0.067)	(0.076)	(0.079)	(0.111)	(0.108)	(0.125)	(0.121)	(0.165)	(0.369)	(0.380)
$\Delta\tau_{t-1,t} * Crisis$	−0.099	−0.176*	−0.058	0.161	−0.042	0.277	−0.100	0.439	−0.124	0.098
	(0.093)	(0.092)	(0.129)	(0.255)	(0.126)	(0.183)	(0.185)	(0.336)	(0.407)	(0.518)
Constant	−0.054	0.065	−0.081*	−0.051	−0.110	−0.040	−0.191**	−0.091	−0.090	0.144
	(0.047)	(0.049)	(0.046)	(0.045)	(0.070)	(0.039)	(0.075)	(0.064)	(0.284)	(0.209)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.012	0.023	0.003	0.020	0.015	0.040	0.015	0.058	0.016	0.003
Adjusted R^2	−0.004	0.007	−0.013	0.003	−0.002	0.024	−0.002	0.042	−0.00002	−0.013

Note: *p<0.1; **p<0.05; ***p<0.01

Table A18: Bond returns and ECB tone with crisis dummy

	Bond Returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	0.009	−0.031**	−0.018	−0.049**	−0.076*
	(0.007)	(0.014)	(0.018)	(0.023)	(0.045)
Crisis	−0.011	0.013	−0.004	0.009	0.033
	(0.015)	(0.025)	(0.035)	(0.043)	(0.084)
$\Delta\tau_{t-1,t} * Crisis$	−0.007	0.002	0.026	0.028	−0.063
	(0.022)	(0.030)	(0.035)	(0.049)	(0.089)
Constant	0.007	−0.015	0.023	0.009	−0.012
	(0.009)	(0.018)	(0.022)	(0.029)	(0.061)
Observations	184	184	184	184	184
R^2	0.006	0.029	0.004	0.018	0.032
Adjusted R^2	−0.010	0.013	−0.013	0.001	0.015

Note: *p<0.1; **p<0.05; ***p<0.01

Table A19: Equity returns and ECB tone with president dummies

	Equity Returns:									
	ECB decision		**Intr. Statement**		**Q & A**		**Entire PC**		**PC-day**	
	Market	Banks	Market	Banks	Market	Banks	Market	Banks	Market	Banks
$\Delta\tau_{t-1,t}$	0.132	0.096	0.050	−0.003	0.183	0.109*	0.233**	0.106	0.405	0.151
	(0.091)	(0.091)	(0.071)	(0.047)	(0.132)	(0.064)	(0.114)	(0.079)	(0.385)	(0.278)
Trichet	0.015	−0.143	0.052	0.078	0.236	−0.065	0.288*	0.013	0.057	−0.123
	(0.112)	(0.122)	(0.111)	(0.117)	(0.153)	(0.121)	(0.156)	(0.178)	(0.668)	(0.541)
Draghi	0.216*	0.005	−0.051	−0.163	0.238	−0.022	0.187	−0.185	0.647	0.667
	(0.119)	(0.145)	(0.141)	(0.196)	(0.163)	(0.194)	(0.186)	(0.271)	(0.653)	(0.568)
$\Delta\tau_{t-1,t} * Trichet$	−0.143	−0.129	−0.113	−0.038	−0.190	−0.056	−0.303**	−0.094	−0.274	−0.391
	(0.102)	(0.100)	(0.079)	(0.066)	(0.146)	(0.111)	(0.135)	(0.131)	(0.440)	(0.360)
$\Delta\tau_{t-1,t} * Draghi$	−0.248**	−0.224	0.060	0.470	−0.013	0.406	0.047	0.876	0.248	1.148
	(0.121)	(0.146)	(0.240)	(0.484)	(0.184)	(0.275)	(0.308)	(0.578)	(0.581)	(0.738)
Constant	−0.130	0.133	−0.114	−0.133	−0.277**	−0.072	−0.391***	−0.205	−0.328	0.012
	(0.104)	(0.115)	(0.102)	(0.106)	(0.130)	(0.084)	(0.134)	(0.147)	(0.614)	(0.447)
Observations	184	184	184	184	184	184	184	184	184	184
R^2	0.082	0.038	0.020	0.064	0.039	0.047	0.057	0.096	0.035	0.054
Adjusted R^2	0.057	0.011	−0.007	0.037	0.012	0.020	0.031	0.070	0.008	0.028

Note: *p<0.1; **p<0.05; ***p<0.01

Table A20: Bond returns and ECB tone with president dummies

	Bond Returns:				
	ECB decision	**Intr. Statement**	**Q & A**	**Entire PC**	**PC-day**
$\Delta\tau_{t-1,t}$	0.017	−0.029	−0.042**	−0.071***	−0.098
	(0.012)	(0.020)	(0.021)	(0.028)	(0.069)
Trichet	−0.029	−0.015	0.063	0.048	0.046
	(0.023)	(0.037)	(0.041)	(0.056)	(0.133)
Draghi	−0.017	−0.021	0.045	0.023	−0.020
	(0.024)	(0.041)	(0.051)	(0.065)	(0.137)
$\Delta\tau_{t-1,t} * Trichet$	−0.013	0.009	0.046	0.054	0.030
	(0.019)	(0.026)	(0.030)	(0.040)	(0.086)
$\Delta\tau_{t-1,t} * Draghi$	−0.022	−0.031	0.067	0.036	−0.090
	(0.021)	(0.046)	(0.053)	(0.083)	(0.135)
Constant	0.021	0.008	−0.026	−0.018	−0.008
	(0.020)	(0.032)	(0.033)	(0.048)	(0.119)
Observations	184	184	184	184	184
R^2	0.017	0.035	0.019	0.025	0.036
Adjusted R^2	−0.011	0.008	−0.009	−0.002	0.009

Note: *p<0.1; **p<0.05; ***p<0.01