# Vague Talk in ECB Press Conference: News or Noise? *

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This Draft: March 25, 2019

**Abstract**

We answer the question by quantitatively measuring the amount of vague talk in the European Central Bank's press conferences and investigating its effect on the stock market performance of the Eurozone. Different than the results of current research, our study unveils the dual role vague talk plays in the market: It not only is considered as positive news that increases returns and lifts liquidity but also acts as a stabilizer that decreases realized and expected volatility. By decomposing the overall vagueness at the word- and sentence-levels, we find that the stock market only responds to the vague explanation of monetary policy strategies, but not the vague description of economic environments. An increase in the former type of vagueness helps investors develop a deeper understanding of the conduct of monetary policy, enhances the predictability of central bank's future policy actions, and thus contributes to a reduction of the volatility factor in the market. This paper presents the first piece of evidence that relates to the theoretical dispute on the social value of public information originating in Morris and Shin (2002).

*JEL classification:* G1, E4, E5
*Key words:* Central bank communication, stock returns, stock volatility, monetary policy shock, textual analysis

*We are particularly grateful to our supervisors, Maik Schmeling and Michael Binder, for their guidance and support. We also greatly appreciate the comments and suggestions by Michael Ehrmann, Alexander Hillert, Jan Pieter Krahnen, Michael McMahon, Emanuel Moench, Stefano Nardelli, and seminar participants at Goethe University Frankfurt.

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# 1 Introduction

Central bank statements are confirmed to have strong effects on the stock market (Rigobon and Sack, 2003; Bernanke and Kuttner, 2005; Lucca and Moench, 2015; Cieslak et al., 2019). Besides quantitative monetary policy decisions, the textual content of statements are also closely watched by market participants, in which policymakers evaluate economic developments and explain policy strategies in great detail. For instance, within a few minutes after the European Central Bank (ECB)'s press conference, Bloomberg publishes a side-by-side comparison that highlights the differences between the current and previous statements. This reflects the fact that the financial market can be sensitive to any tiny adjustment in the announcements. In fact, it has already been documented that the tightening/easing inclination (Ehrmann and Fratzscher, 2007), the optimistic/pessimistic attitude (Born et al., 2014), and the positive/negative tone (Schmeling and Wagner, 2019) contained in the policy statement can all significantly affect the performance of the stock market.

At the other end, policymakers are also becoming increasingly cautious about the framing of their statements. This trend has become particularly noticeable after the Great Recession, when conventional monetary policy tools became less effective than in the previous decade. Implied by theoretical studies on optimal communication design (Morris and Shin, 2002; Angeletos and Pavan, 2007; Amador and Weill, 2010), central banks are heading towards higher precision in their announcements, in the hope of reducing noise and anchoring expectations. However, there is no empirical evidence on whether such a policy change brings more benefits or harms to the financial market or the macroeconomy.

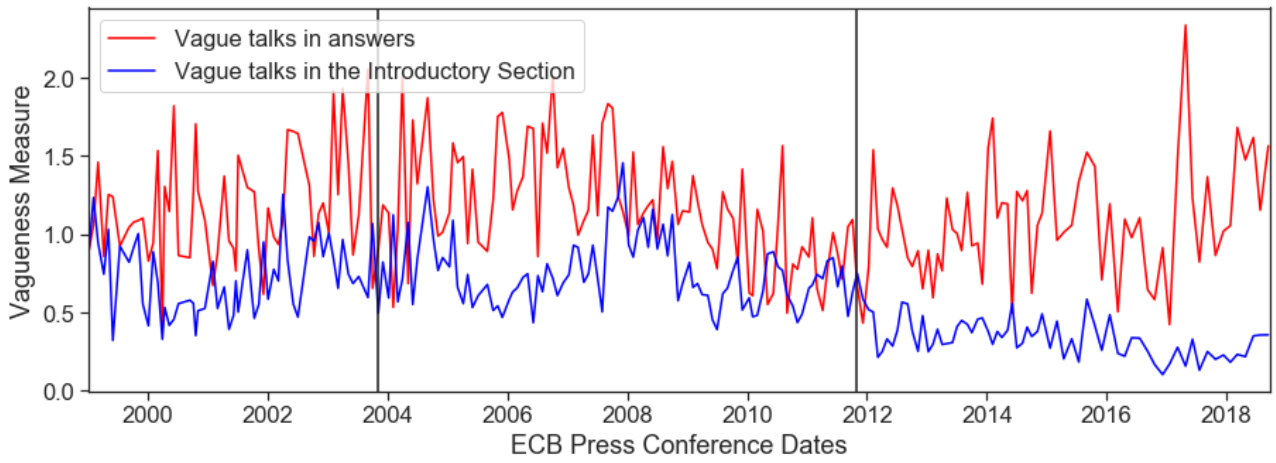
When the signal released by the central bank is imprecise, is it news or noise in the eyes of the market? In theoretical studies in finance, imprecise public information released by the private sector is usually regarded as noise, which is negatively correlated to returns and contributes to excess volatility in models (Epstein and Schneider, 2008; Illeditsch, 2011). Several firm-level empirical studies also showed that information communicated with ambiguous language is less informative and results in higher stock price volatility (Loughran and McDonald, 2013; Dzieliński et al., 2017). Accordingly, it is reasonable to expect that vague language spoken by policymakers is also a negative signal that induces lower return and larger volatility, or at least obscures the understanding of investors about central bank's monetary policy strategies.

Surprisingly, our analysis shows that vague talk from central banks is processed as positive news that leads to both higher returns and lower volatility in the stock market. Further exploration reveals that they help investors gain a deeper understanding of monetary policy actions taken by the central bank.

To elaborate this point, we measure the amount and classify the type of the vague talk in the press conferences of the ECB and examine the causal relationship between the vague tone

and the stock market performance of the Eurozone. To begin with, we use an automated dictionary method to quantify the vague talk in the answer section of each ECB press conference. The ECB is the first major central bank that holds press conferences to clarify its considerations after making the monetary policy decisions. Each press conference consists of an introductory statement and a Q&A session. We only focus on vague talks in answers of the Q&A session, because real-time answers are much less likely to be controlled in advance and thus contain more examples of vague expressions. In contrast, the introductory statement is meticulously prepared beforehand and thus is less qualified to represent any of the vague attitudes of the policymaker. Based on the quantification, we can observe an obvious downward tendency in the extent of vagueness in introductory statements after the Great Recession, whereas the vagueness in the answer sections fluctuates more violently during the same period and even peaks in the year 2017 (Figure 1).

Figure 1: Vagueness Measures in ECB Press Conference Transcripts




Sources: ECB, Authors' Calculations
Notes: This figure shows the time-series plots of the extent of vagueness in the introductory statement and the answer section of ECB press conference transcripts from 1999–2018. Two black vertical lines signify a change of ECB president.

Having quantified the vague talk, we then adopt an event-study approach to examine its influence on the EURO STOXX index, which is a benchmark representation of the stock market of the Eurozone. We choose to focus on returns and volatility of the index, as they both reflect the performance of the market. Besides, stock market volatility can be considered as a proxy for welfare (Gorodnichenko and Weber, 2016).

The key finding is that the vague talk is perceived as positive news that can increase market return, and it also acts as a stabilizer that can decrease market volatility. Specifically, within our scope of investigation from 1999–2018, on average a 1.0 percent unexpected increase in the vagueness measure raises the return of the EURO STOXX index by 58 basis points and reduces its volatility by 1.5 percent. This result is robust when we chose another stock market index, a different vagueness measure, or an alternative set of control variables in the regression. Furthermore, we show that more vague talk can significantly and robustly lower the expected market volatility, liquidity cost, and trading volumes of the stock market. It can

also lift the exchange rate for the Euro.

To explain these findings, we apply natural language processing tools to perform two levels of decomposition. First, we classify words with vague meanings into two groups: one group of words are used to describe ambiguous or uncertain circumstances the ECB faces, while the other group of words are related to imprecise or state-dependent explanation of monetary policy strategies taken by the ECB. Through this word-level decomposition, we isolate the vague description of economic environments from the vague explanation of policy considerations. The regression result suggests that only the second type of vagueness can significantly move the market.

To substantiate the claim, we additionally classify sentences containing vague words into two groups by their topics. One group of sentences focuses on policy actions and considerations, while the other group describes the current or future states of the economy. The regression based on this sentence-level decomposition reaffirms the above result, that is only vague talk on monetary policy strategies can lead to a higher return and lower volatility in the stock market.

We can explain this finding based on the *cheap talk* mechanism discussed in Kellner and Quement (2018): through vague talk, central banks can send more signals about their policy considerations with lower cost, and such signals can help market participants gain a better understanding of the underlying logic behind monetary policy decisions. Even if the ECB president does not attempt to send vague messages on purpose, the information contained in these messages do enhance the predictability of the central bank's future policy actions, and thus reduce the volatility factor in the market.

This implies that, for central banks, always seeking higher precision in policy statement as the sole goal is not the best strategy to take. Compared with sending highly precise messages that are known to the public, releasing more vague but also more informative signals on the conduct of monetary policy is likely to be more beneficial to the market. The reason is that no other market participant has superior knowledge than the policymakers themselves about this type of information.

The main contribution of this paper is that we show that the vague talk from policymakers can both create positive news and reduce noise in the market. More importantly, the reason is that through vague talk policymakers can send more signals about their policy considerations, which deepen investors' understanding of the rationales behind policy actions. As pointed out by Blinder et al. (2008), "asset prices should react, and policy decisions should become more predictable" after a successful communication. In this respect, vague policy explanations can be a successful communication strategy, as they both affect stock market price and increase the predictability of the central bank's future actions, even it might not be the policymaker's initial intention. This paper is also the first piece of empirical evidence related to the debate on the social value of public information that is initiated in Morris and

Shin (2002).

The rest of the paper is organized as follows. Section 2 introduces the related literature. Section 3 first quantifies the vague talk in ECB press conferences, and then describes the data and methodology. Section 4 starts with presenting a baseline analysis, then performs a robustness check and placebo test, and finally discusses some additional evidence. Section 5 explains the main result by decomposing the vagueness measure at the word and sentence levels. Section 6 discussed the policy implication in a simple theoretical framework. Section 7 concludes.

## 2 Related literature

Our research closely relates to the theoretical and empirical studies on the effect of ambiguity on the financial market. Theoretical models regard investors as ambiguity-averse (Ellsberg, 1961). Epstein and Schneider (2008) show that investors have the motivation to hedge ambiguity, inducing ambiguity premia that cross-sectionally depend on an idiosyncratic risk in fundamentals; a shock to increase ambiguity will have a persistent adverse effect on asset price. Comparably, Illeditsch (2011) also indicate that ambiguity leads to excess volatility. Specifically, linguistic ambiguity focuses on the text source and the relevant empirical studies document similar results as in theoretical works. Demers and Vega (2011) find that greater linguistic certainty in earnings announcements produces a stronger immediate response to earnings news and less drift. In particular, Loughran and McDonald (2011) create word dictionaries including uncertain terms (e.g., *approximate, contingency, uncertain, and indefinite*) and weak modal words (e.g., *might, possible, approximate, and contingent*) in a 10-K filing context and record higher stock return volatility when an increased number of these words are present. Loughran and McDonald (2013) apply the method in IPO prospectuses and conclude that a higher fraction of uncertain words enhances first-day IPO return and volatility. In 10-K fillings, Ertugrul et al. (2017) also document stricter loan contract terms and higher future stock price crash risk.

Our research is also tied to the literature on optimal communication strategy. There is no consistent theoretical conclusion yet to the question of whether central banks should talk vaguely or not. Some argue that when central bank statements are not clear enough, all agents may suffer from the same imperfect understanding, arousing common noise (Morris and Shin, 2002; Angeletos and Pavan, 2007). In the same vein, Allen et al. (2006) show that asset prices have an excess reliance on public information, thus common noise could lead to excess market volatility. However, some research show that ambiguity can be an optimal strategy chosen by policymakers. Namely, they might potentially decrease excess volatility. Stein (1989) claim that the meaningful yet imprecise talk of the Federal Reserve provides an opportunity for the Fed to manipulate expectation while maintaining flexibility.

Kellner and Quement (2018) found that vague communication strategies[1] can benefit both the information sender and ambiguity-averse receiver, by lowering the cost for a sender to influence the receiver, and benefits receiver by more information transmitted. Our research supports this argument by showing that central bank ambiguity has benefited central banks by decreasing market volatility and benefit the receiver by increasing market return.

Another strand of research aiming at measuring central bank communication through textual content in policy statements is also connected to our study. Since it directly quantifies the communication through the messages sent by central banks, it is less susceptible to simultaneity issues in the regression compared with quantifying the communication through financial market responses (e.g., Bernanke and Kuttner, 2005; Guerkaynak et al., 2005; Jarocinski and Karadi, 2018).

Earlier studies such as Romer and Romer (2004) code the overall content or potential intention of the central bank statement manually on the article base, while later works focus more on one or two specific dimensions of the communication. Ehrmann and Fratzscher (2007) studied the policy inclination in communications by committee members at three central banks, scaling the measure as a negative(positive) number when the statement is dovish(hawkish), and zero if neutral. Another more objective approach is textual analysis. Based on the content of FOMC minutes, Jegadeesh and Wu (2017) extract eight topics using the Latent Dirichlet Allocation (LDA) method and find that policy stance, inflation and employment topics are most informative to the financial market. Schmeling and Wagner (2019) use the dictionary method to measure the tone of the ECB press conference, suggesting that communication provides a channel through which monetary policy can influence risk premia embedded in market prices. Tobback et al. (2017) build up a Hawkish-Dovish indicator to measure the ECB's tone, based on the Support Vector Machine method. Hansen and McMahon (2016) combined the two dimensions to investigate whether the central bank is talking about the state of the economy (the topic), and then measure how they are talking about it (tone). We adopted a reversed version of Hansen and McMahon (2016), to find out the content (topic) behind vague talk (tone).

Finally, our paper is broadly related to the literature investigating the impact of central bank statements on the stock market. Kuttner (2001) creatively use Federal funds futures data to construct an aggregate measure of the monetary shock and form the basis for the following research. Regarding the equity market, Bernanke and Kuttner (2005) show that an unexpected 25-basis point cut in the federal funds target rate results in a 1 percent increase in the level of stock prices on average. Chen (2007) find a more substantial effect of monetary policy on stock returns in bear markets. Basistha and Kurov (2008) show that the size of the stock return reactions to monetary policy shock in recession years are twice as large as they are in good years. Lucca and Moench (2015) document excess return in the US equity market

[1]Their specification of vague language is that the communication strategy used by the speaker (i.e. how she attaches words to information sets) is unknown and not objectively describable

in the 24 hours before a Federal Open Market Committee (FOMC) announcement. Cieslak and Morse (2019) suggest that the FOMC announcement is the reason for the bi-weekly cycle of excess return in the stock market.

# 3 Data and Methodology

## 3.1 Measuring the Vague Talk

This section discusses how to measure the vague talk in the ECB's statements. In general, the ECB's communication policy includes all types of textual information published on its official website representing its opinions and views. It contains press releases (including monetary policy decisions), press conference transcripts, monetary policy accounts, speeches, interviews, explainers, as well as in-depth reports and analysis.

In this article, we mainly focus on the transcript of the ECB press conference for three reasons. First, the press conference usually takes place on the same day when the ECB announces its monetary policy decision; during which the president and vice-presidents provide a thorough explanation of the rationale behind the decision. Thus, the press conference of the ECB is the most direct and fundamental source of information for the public to understand ECB's policy strategies. Second, different from other communication channels such as speeches and interviews, the market has a clear and consistent expectation about the schedule, the speakers, and the structure of the press conference. Thus, market fluctuations on the day of the press conference will mostly reflect an unexpected change in content of the statement, in addition to any surprise in a monetary policy decision. Finally, compared with the press conferences of other central banks, which only started in recent years, the press conference of the ECB has been held regularly since its foundation, which provides us with a sufficient number of observations for empirical evaluation.

At each press conference, the president of the ECB first explains the decision in an introductory statement and then answers questions from journalists in a Q&A session. We restrict our discussion to the impact of vague talk only in the president's answers to the questions for the following reasons. First, while there are a great many of examples of vague talk in the answers, the extent of vagueness is strictly controlled in the well-prepared introductory section. Second, the vague talk in the introductory statement mostly refers to the ambiguous or uncertain situation of the economy, rather than signifying vague policy considerations, and we will show that the market is concerned more about the latter type of vagueness in the press conference transcript. In the placebo test, we will also examine the impacts of vague talk from the introductory statement and questions.

To quantify the extent of vague talk, we collected the ECB press conference transcripts from

their website[2], and applied a standard text-cleaning procedure to each transcript, which includes converting words to lowercase, lemmatizing words, removing numeric information and deleting stop words. The details are provided in Appendix A.

After finishing the procedure, we then apply an automated dictionary method to measure the vague talk in each transcript, by counting the reference of words from a pre-defined vague word list. This is a standard approach to extract certain textual features from the data and has been adopted in a number of studies that measure a central bank's tone from its policy statements (Hansen and McMahon, 2016; Jegadeesh and Wu, 2017; Schmeling and Wagner, 2019). Compared with manual coding, this automated approach is more objective and can be directly replicated and validated without resorting to human effort.

The word list we employ is the uncertainty word list provided by Loughran and McDonald (2011), which is specifically designed to quantify the amount of uncertain tone in financial and economic contexts. To obtain a vagueness measure for each press conference transcript, we identify the uncertainty words in answers of the Q&A section, count the total appearances of these words, and calculate its ratio to the total number of words in that press conference. Thus, for a press conference taking place at date $t$, the extent of vague talk, or the vagueness measure, or the vague tone is defined as

$$UncAnswer = \frac{\#(Uncertainty\ words\ in\ answers)}{\#(All\ words\ in\ press\ conference)} \tag{1}$$

Here we employ a relative measure (i.e., word ratio) rather than an absolute measure (i.e., number of words), so that we can isolate the effect from the length of the press conference transcript, which can be regarded as a proxy for the readability of the document. We will show in the robustness check that using an absolute measure does not change the main result. Besides this, we scale the number of uncertainty words with the total number of words in the whole transcript but not the total number of words in answers. The reason is that we will calculate the vague (and negative) tone in other sections of the press conference transcript and use these as control variables in the regression. Thus, using a same scaling parameter (i.e., $\#All\ words\ in\ press\ conference$) in these calculations will factor out the effect of the variation from this parameter. In the robustness check we will also show that the main conclusion remains unchanged when using a different scaling parameter (i.e., $\#All\ words\ in\ answers$).

At this stage we assign each word the same weight to prevent hindsight bias as emphasized by Schmeling and Wagner (2019), but choosing an alternative weighting scheme, e.g., the TF-IDF weighting, does not alter our conclusion.

One potential drawback of the dictionary method is that, since the uncertainty word list is pre-defined, it completely ignores the language style of the ECB, which could be vital for an

[2] https://www.ecb.europa.eu/press/pressconf

accurate understanding of its policy statements. Moreover, though all words from the uncertainty list can express a certain type of vagueness, their exact senses can be different. The following Table 1 displays three examples of sentences with uncertainty words. Obviously, the meanings of these words are not identical, and their usages are unalike.

Table 1: Examples of Sentences Including Words with Vague Meaning

| Speaker | Date | Subject | Sentence |
|---|---|---|---|
| Duisenberg | 4/3/2003 | Policy strategy | *... maybe that will be final, maybe we will need another discussion two weeks later ...* |
| Trichet | 8/7/2008 | Financial market | *... it's an ongoing, important market correction with episodes of turbulence and high levels of volatility ...* |
| Draghi | 7/6/2018 | Unconventional Policy | *... you have the uncertainty component in the term structure; this of course tends to be more variable and shifts with risk perceptions ...* |

Source: ECB.

To overcome these two limitations, in Section 5 we will represent each word by a numeric vector. The vector embeds the meaning of the corresponding word and can also reflect the language style of the ECB. Based on this vector representation, we will then be able to classify the uncertainty words into different subgroups that convey vague meanings on various dimensions, and we will explore how the stock market performance are affected by different types of vagueness in the transcript.

## 3.2 Textual Data

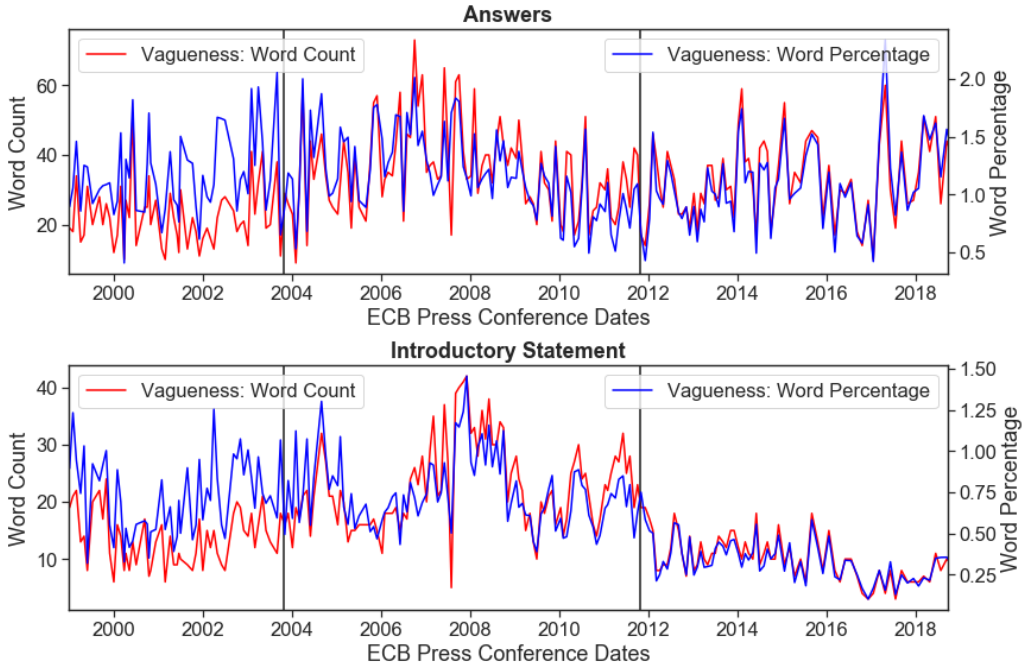
Our analysis focuses on the stock market returns and volatility around 217 scheduled ECB press conference meetings between January 1999 and September 2018, in a daily close-to-close window. From each transcript, we separate the introductory and Q&A sections, perform a standard text-cleaning procedure, and calculate the percentage of uncertainty words appearing in answers.

At the word level, there are on average 31.2 words expressing vague meanings in the answer section, accounting for approximately 1.15% of the total words in a press conference transcript. On the sentence level, on average 24.8 sentences contain at least one word with a vague meaning in the answer section, taking up to 9.6% of the sentences in a press conference transcript.

The time series plots of the absolute and relative measures of vagueness are displayed in Figure 2. From the second subplot, we can observe an obvious downward trend in the number and percentage of words with vague meanings used in the introductory section since the onset of the Great Recession, and there is even a drastic drop at the beginning of the Draghi period. This suggests that the ECB is aware of the importance of sending

out precise signals and has been intentionally controlling the vague tone in its statement, especially in an era when the conventional policy tools have become much less effective.

Figure 2: Uncertainty Word Count and Percentage in ECB Press Conference Transcripts




Sources: ECB, Authors Calculations
Notes: This figure shows the time-series plots of the vagueness in the introductory statement and the answer section of ECB press conference transcripts. Red lines are numbers of appearances of uncertainty words, and blue lines are appearances of uncertainty words divided by the total number of all words in a transcript. Two black vertical lines signify the change in ECB presidency.

However, we cannot spot a similar pattern in the appearance of words with vague meanings in answers over the same period: while the percentage of words has been kept below 0.5% after 2016 in the introductory statement, it peaked as high as 2% in the answer section in 2017. Compared with reading out a prepared statement, answering questions off-the-cuff is certainly more challenging. When the core message needs to be delivered in a limited time without mistake, it is more likely that speakers will limit the level of commitment and reduce the degree of certainty, thus resulting in a higher degree of vagueness in their statements.

We display several examples of the sentences containing uncertainty words in Table 5. We also present an exhaustive list of the sentences containing uncertainty words in ECB press conference transcripts in the online Appendix B.

In addition to the core vagueness measure *UncAnswer*, we also obtain (1) the vague tone in the introductory statement (*UncIntro*), (2) the vague tone in the questions of the Q&A session (*UncQuestion*), (3) the negative tone in the introductory statement (*NegIntro*), and (4) the negative tone in the answers (*NegAnswer*). They are treated either as control variables in the regression or as independent variables in the placebo test. Here the negativity tone is calculated as the number of negative words from Loughran and McDonald (2011) divided by the total number of words in a press conference transcript.

So far, we have measured the vague and negative tones based on a constant scaling factor, which is the total word count in the whole press conference transcript. In the robustness check, we take two alternative vagueness measures into account. The first is the absolute measure without a scaling factor. The second is a relative measure with a variable scaling factor, which is the total word count in the each respective section only. For example, $UncAnswer = \#(Uncertainty\ words\ in\ answers)/\#(All\ words\ in\ answers)$ in this scenario.

Finally, we calculate the total number of words ($TotalWords$) and the total length of the string ($TotalLength$) for each press conference transcript as proxies for the readability of the press conference transcript.

### 3.3 Financial and Economic Data

Our baseline analysis focuses on the performance of the EURO STOXX index. As one of the benchmark indices in the Eurozone, the EURO STOXX index represents the stock prices of approximately 300 large, medium, and small companies in the area. In the robustness check, we also examine the return and volatility of the following indices on the day of each of the press conferences: SMALL STOXX 200, MEDIUM STOXX 200, LARGE STOXX 200, MSCI, MSCI VALUE, and MSCI GROWTH. These indices represent a wide spectrum of the stock market performance of the Eurozone.

To comprehensively evaluate the effect of the vague tone, we additionally explore how the vague tone influences the excess return, the expected volatility, the liquidity cost, as well as the trading volume of the stock market. These variables are calculated based on the MSCI EMU Index, EURO STOXX 50 Volatility Index (VSTOXX), EURO STOXX 50 Turnover, as well as the stock market indices mentioned above. To substantiate our main conclusion, we also explore the effect of vague tone on the foreign exchange market, where the dependent variable is the EUR/USD Exchange Rate.

We collect the Three-Month Overnight Index Swap (OIS) Rate and the Two-Year German Government Bond Yield to compute market-based monetary policy shocks (Guerkaynak et al., 2005) as control variables. We also collect the Economic Policy Uncertainty (EPU) Index as another control variable in the regression. All the time series listed above are obtained from the Datastream (Thomson Reuters) at a daily frequency, except the EPU index, which is computed monthly.

In order to control for the impact of monetary policy decisions and economic projections, we download the following series from the ECB website: the rate on marginal refinancing operations (ECB's key interest rate), the rate on the deposit facility (ECB's key interest rate), the forward guidance statements, the amount of securities purchased in the asset purchase programme (APP), and the ECB staff macroeconomic projections. These variables will be treated as controls either in the baseline regression or in the robustness check.

Table 6 provides summary statistics for the main variables used in our analysis.

### 3.4 Estimation strategy

As noted above, the question we want to address is whether there exists a causal relationship between the vague tone and stock market performance. To answer this question, we apply an event-study approach, that is, we only concentrate on the response of stock prices on press conference days. Unlike macroeconomic variables, stock prices can respond promptly to adjustments in monetary policies and central bank communication. Kontonikas et al. (2013) point out that the endogeneity of monetary policy on stock price is less likely to be a problem in regression by taking an event-study approach.

Identifying the unanticipated tone change as an exogenous shock is fundamental for our analysis. One approach is to identify aggregate monetary policy surprises from the perspective of information receivers, that is, through variations in high-frequency asset prices (Bernanke and Kuttner, 2005; Guerkaynak et al., 2005; Jarocinski and Karadi, 2018; Nakamura and Steinsson, 2018). However, even though the prices of some financial contracts (e.g., the Federal Funds Futures) are tightly linked to changes in key policy rates (e.g., the Federal Funds Rate), they are still endogenously determined by market transactions and might suffer from a severe simultaneity issue. Besides, such a measure cannot isolate the effect of central bank communication from the effect of quantitative policy decisions.

Instead, we identify the tone change as an exogenous monetary policy shock from the perspective of the information sender, that is, through the press conference of the ECB. It allows us to accurately capture the vagueness dimension of the central bank communication effect. Moreover, since the answers from ECB presidents cannot be affected by the stock market behavior within the same day, the likelihood of the reverse causality is almost non-existent in a daily window.

The regression equation takes the form

$$y_t = \beta_0 + \beta_1 \Delta UncAnswer_t + \boldsymbol{\gamma}' \boldsymbol{x}_t + \varepsilon_t, \tag{2}$$

where $y_t$ is the variable of primary interest, which can be the return or realized volatility (the squared return) of the EURO STOXX index in the baseline analysis. In further analysis it can also be the liquidity cost, trading volume, expected volatility, or exchange rate.

$\Delta UncAnswer$ is the change in the vague tone from the previous to current press conference. We build our analysis based on the efficient market hypothesis, namely the asset prices will only react to unexpected information. As is discussed, the signals sent by the ECB through a press conference are much stronger than the signals sent through a speech or interview, and even a slightest change can trigger a non-negligible reaction in the market. It is thus more

meaningful to examine how the market responds to the vague tone in first differences. The same strategy is adopted by Schmeling and Wagner (2019). In the robustness test, we will also consider the case when the market responds to the vague tone in levels.

Though a reverse causality is unlikely to be present, forces that affect both the vague tone and stock market performance may still exist in a daily window. To isolate the influence of vague talk from other effects, we run the regression with $\boldsymbol{x}_t$, a vector of control variables.

First, we control for the textual features of the press conference transcript. To exclude the impact of some mechanisms that might influence the use of words with vague meanings both in the introductory and answer sections, we control for (1) $\Delta UncIntro$, the change in the vague tone in the introductory statement. To exclude the impacts from the positive/negative attitude of the speaker (Ehrmann and Talmi, 2017; Schmeling and Wagner, 2019), we control for (2) $\Delta NegAnswer$ and $\Delta NegIntro$, which measure changes in negative tone in each of the two sections of the press conference. Finally, to exclude the impact of the readability of the transcript (Coenen et al., 2017), we control for (3) $\Delta total\_words$, the change in the total number of words in a transcript.

Second, to separate the effects of policy announcements from policy actions, we control for monetary policy decisions announced on the press conference day. These controls include (1) changes in the marginal refinancing operations ($\Delta MRO$), which is the middle one of the three official interest rates set by the ECB[3]; (2) a dummy variable that equals one when there is a forward guidance statement in the introductory statement, and zero otherwise ($UMP\_dummy$), which is used to represent unconventional monetary policy enacted by the ECB. In addition, we include (3) market-based measures of monetary policy surprises on the short-term ($Level\_shock$) and mid-term level ($Path\_shock$). Following Guerkaynak et al. (2005), we define the level shock in the Euro Area as the change of three-month OIS rates from the previous trading day, and the path shock as the change in two-year government bond yields minus the change in three-month OIS rates. These two shocks can represent how the market interprets ECB's statements.

We also control for changes in the projections of the rate of inflation ($\Delta HICP\_next$) and real GDP growth ($\Delta GDP\_next$) of the Euro Area, to rule out the case when the vague tone is only a manifestation of future economic expectations. Furthermore, to make sure that the information is disseminated from the ECB press conference to media reports but not the opposite direction, we control for changes in the economic uncertainty index ($EPU$). This index is constructed in Baker et al. (2016), and it reflects the policy-related economic uncertainty discussed in ten influential newspapers published in Europe.

We additionally control for the return and volatility in the previous trading day ($Lagged\_ret$

[3]Note that the change of the official interest rate in the market usually takes place several days after the announcement. However, having anticipated the change, investors will respond promptly on the stock market, days before the new policy rate is implemented.

and *Lagged_vol*), to exclude the possibility that the vague tone is only a representation of the financial market performance in the past. Finally, we introduce two dummy variables to control for the style of speech of the three presidents of the ECB (*p=Draghi* and *p=Duisenberg*).

When reporting the estimation result, the Newey–West variance estimator is used to produce consistent standard errors in the presence of heteroskedasticity and auto-correlation (Newey and West, 1987).

# 4 Empirical Results

In this section, we first discuss the main empirical result, namely the responses of close-to-close daily event returns and realized volatility (squared returns) of the EURO STOXX index to the vagueness tone on days with a scheduled ECB press conference. Then we perform the robustness check and a placebo test. Finally, we provide several supporting pieces of evidence from both the stock market and the foreign exchange market on the impact of vague talk.

## 4.1 Baseline

Table 7 presents the baseline estimation result, where we regress daily event return and squared return on the difference of vagueness measures compared to the last event. We use Newey–West standard errors to account for autocorrelation across time and report them in the parentheses.

Column 1 of Panel (a) shows that vagueness change has a large positive effect on daily STOXX return, significant at the level of 1%. A 1% increase of the vagueness tone can lead to a rise in the return by 58 basis points. Column 2 of Panel (a) presents that the vagueness change also has a large negative effect on the realized volatility of the EURO STOXX index at a significant level of 5%. A 1% increase of the vagueness tone can reduce the volatility by 1.480%.

The response of event daily return and squared return to vagueness change in press conference Q&A sections is fairly robust. In the first two columns of Panels (b) and (c), we compare the estimation results before and after controlling for outliers.[4] Panel (b) robustly shows the positive effect of ECB vagueness on return. Column 3 and 4 in Panel (b) use excess return as the dependent variable, defined as the difference of STOXX return and the EMU benchmark ten-year government bond return. We restrict our sample in columns 5– 6 to observations before 2007 to control for the impact of the financial crisis and the zero lower bound. The

[4]We use a standard DFITS method to detect outliers by jackknife as described in Bollen and Jackman (1990).

effect of the vague tone on the return is statistical significance in both pre-2007 and post-2007 sample. Panel (c) displays the effect of the vague tone on volatility. To decrease the influence of outliers, in column 3 and 4 we use an alternative measure of volatility, the absolute return, which reflects a similar effect as the squared return. Finally, both in return and volatility cases, the influence of the vague tone in the post-2007 period seems to outweigh that of pre-2007.

## 4.2 Additional Controls

Though the simple framework in the baseline regression has shown clear effects of the vagueness change in press conference Q&A sections on event daily return and squared return, some potential factors might exist to drive both the change of vague tone and the stock market. In Table 8, we include a variety of control variables to disentangle the effect of the vague talk from these potential factors.

We repeat the baseline regression in the first column. As suggested by Figure 2, the ECB might have intentionally controlled for the language used in the press conference. In specifications 2–5, we include other textual features in the Introductory and Q&A section ($\Delta UncAnswer$, $\Delta UncIntro$, $\Delta NegAnswer$, $\Delta NegIntro$) to control for such effects. The effect of $\Delta UncAnswer$ on the return is not altered. The monetary policy decisions announced prior to the press conference can have both effect on the stock market and vague tone of the president. Thus, we additionally controlled for conventional and unconventional monetary policy (column 7). The term structure effect of monetary policy is captured by level and path shock (column 8). With these controls, the effect of vague talk remains statistically significant.

One might also argue that vague talk simply reflect certain macroeconomic environments. When we control for economic policy uncertainty and ECB projection adjustments on GDP and HICP (column 9), the effect is not changed. Controlling for the lagged return and realized volatility (column 10) show that the effect of vague talk is not the residual influence of the day before the press conference event. To mitigate concern about the speaking styles of presidents, we include two dummy variables signify different presidencies (column 11). The main effect we are interested in remains unchanged and keeps statistical significance at a 1% level. Among the control variables, the slope coefficient of $\Delta NegIntro$ is negative on returns, suggesting that the more the negative words in the introductory statement, the less the stock market return on press conference day. Besides this, a positive adjustment of GDP projection could also significantly enhance return.

The effects of the vague talk model on volatility are shown in Table 9. Using the same controls as shown in Table 8, we also find a robust effect of ECB vagueness in decreasing market volatility, statistically significant at the 1% level. Among the control variables, $\Delta NegAnswer$ shows a significant increase in volatility. On the contrary, volatility will be reduced followed

by a rise in the GDP projection.

### 4.3 Robustness Check and Placebo Test

Empirically, we find a robustly significant effect of the ECB press conference vagueness change on stock market return and volatility. The effect survives a series of robustness checks. Firstly, our conclusion is robust when using the return and volatility of other stock market indices as the dependent variable, including SMALL STOXX 200, MEDIUM STOXX 200, LARGE STOXX 200, MSCI, MSCI VALUE, and MSCI GROWTH. Table 10 presents the responses of these indices' return and volatility to ECB press conference vagueness changes. STOXX Large and MSCI Value react more strongly compared to STOXX small and MSCI Growth, in terms of both returns and volatilities. Our result also remains unchanged when changing the control variables into alternative measures.

In Table 11, we reverse the policy rate measure from MRO to DF/MLF and keep all other controls included in column 1. Similarly, we change the unconventional policy measure from the forward guidance announcement dummy variable to the number of assets purchased in quantitative easing in column 2, the textual complexity measure from the total number of words to the total length of the document in column 3, and the economic projection measure from the forecasts to nowcasts in column 4. The Return result reported in Panel a and volatility in Panel b show that the effect of ECB vagueness is still positively significant in terms of return and negatively significant in volatility.

To exclude the possibility that the effect is significant only under a specific choice of the vagueness measure, we also check the result for alternative vagueness measures. In our main analysis, we have used the percentage vagueness and negativity measure for the ECB answer and introductory sections. To keep consistent scaling for all measures, the corresponding scores are scaled to the number of total words in the whole press conference. To check the robustness, we employ score measures directly and also percentage measures scaled to total words in corresponding answer or introductory sections. Table 12 displays the result for the score measure in Panel a, and the percentage measure with section scaling in Panel b. Such a change in measures has not altered our finding substantially: the change of vague tone in ECB press conference answer section has a significant positive effect on stock market return and negative influence on volatility.

We also conduct placebo tests to confirm that the vague tone in the introductory statement or questions cannot significantly move the market. Table 13 shows that the vagueness measures in introductory statement and questions do not have a significant effect on market return and volatility. However, the directions of the coefficients for vagueness measures in the introductory statement are the same as the ones for answer section, indicating that such an effect might also exist in introductory statement, but is too weak to be significant.

## 4.4 Further Evidence

To obtain a broader view of how ECB vagueness in press conference works on the financial market, we further studied the response of VSTOXX, EURO STOXX bid-ask spreads, EURO STOXX 50 Turnover and EUR/USD Exchange Rate to ECB Press Conference's Vagueness. The results are displayed in Table 14. The results further suggest that vague talk is regarded as positive news and a stabilizer: an increase in the vagueness measure increases EUR/USD Exchange Rate and decreases the VSTOXX (implied volatility), bid-ask spreads (liquidity cost) and EURO STOXX 50 Turnover.

In Panels a and b, column 1 shows the effect of ECB vagueness on the percentage change of VSTOXX, European volatility benchmark VSTOXX index. As the European counterpart of VIX, VSTOXX measures risk-neutral volatility. The result suggests that ECB vagueness in the PCs answer section significantly decreases risk-neutral volatility as well, at a 1% level.

The independent variable of column 2 is estimated bid-ask spread, a measure of liquidity cost. Following Abdi and Ranaldo (2017), we estimate the aggregate bid-ask spreads for STOXX index using daily close, high, and low prices. In the regression, we use the difference change in bid-ask spread. The bid-ask spread provides a measure of the distance between the demand and supply in trading, thus a higher bid-ask spread means larger liquidity cost, namely higher illiquidity. The result in column 2 indicates that increased ECB vagueness results in lower liquidity cost and more liquidity.

Column 3 and 4 depicts the response of turnover to increased ECB vagueness. STOXX turnover indicates the percentage change of turnover on EURO STOXX index. **?**, investigated the role of turnover in the financial market, concluding that turnover is a proxy for uncertainty, with higher turnover indicating enhanced aggregate volatility risk. Our results show that ECB vagueness significantly decreases the two turnover measures used at a 1% level, which suggest ECB vagueness in the answer section could mitigate market uncertainty.

Finally, column 5 describes the response of the EUR/USD exchange rate, showing that ECB vagueness in the answer section leads to Euro appreciation, namely the increased positivity of the markets is also reflected in the exchange rate.

To conclude, we show that ECB vagueness in the press conference answer section has two inviting roles in the financial market: one as authentic positive news that raises return, lifts liquidity and pushes up the Euro, and another as a stabilizer that declines volatility, implied volatility, and potential uncertainty.

# 5 Decomposing the Vague Talk

## 5.1 Identifying Different Types of Vagueness

As described in Loughran and McDonald (2011), words from the uncertainty word list "denot[e] uncertainty, with emphasis on the general notion of imprecision." Although these words all express a certain degree of vagueness, the exact meaning of each word can be different.[5] To fully understand why vague talk leads to higher returns and lower volatility, it is thus essential to identify the meaning of each word. Based on this, we can then identify different types of vagueness by classifying words into different sub-groups and examining which type of vagueness is the driving force behind the market reaction.

Instead of manually classifying these words, we adopt the cutting-edge technique in natural language processing to quantify the senses of each word with a numeric vector (the *word vector*, or *word embeddings*). A non-technical introduction to the word vector can be found in Appendix C. These word vectors are generated based on a wide variety of textual information that the ECB has published on its website, which includes not only press conference transcripts but also press releases, policy accounts, speeches, interviews, as well as various reports and analyses. In total, we generate 38,509 unique word vectors from 338,967 sentences in 4,714 documents. As a result, each word vector can accurately represent the semantic and syntactic meanings of the corresponding word. Also, since these vectors are obtained based on ECB statements only, they reflect the unique writing and speaking styles of the policymakers from the ECB.

One of the important features of the word vectors is that the similarity between the meanings of two words can be quantified by the cosine distance between the corresponding word vectors. Therefore, to classify words into subgroups by their meanings, it is equivalent to classifying word vectors into clusters by their cosine distances. We apply the K-Means clustering algorithm to perform such a classification, through minimizing the error sum of squares within each cluster.

To begin with, we select the first 20 (out of 109) most-mentioned words with vague meanings and classify them into two subgroups. We focus only on these 20 words for two reasons. First, these top 20 words already take up to 85% of the uncertainty word count. Second, given the complexity of word vectors (i.e., the subtlety of word meanings), the K-Means method will be less likely to yield consistent word groups when we choose to classify many more words into subgroups. The full list of the first 20 most-mentioned words with examples is displayed in Table 5. The two word groups generated by the K-Means method are shown in Table 2.

[5] For instance, the word "risk" is often used to picture a certain situation involving danger, while the word "depend" can be used to describe a determinant relationship without involving any undesirable outcome.

Table 2: Word Clusters for 20 Most Mentioned Words with Vague Meanings

| Name | Percentage | Word |
|---|---|---|
| *Risk* | 27.7% | risk, uncertainty, volatility, turbulence |
| *Could* | 56.6% | could, may, believe, might, possible, perhaps, seem, depend, probably, assumption, possibility, suggest |

We name each cluster by the most-mentioned word in that cluster. There is a clear distinction between the meanings of the words in two different groups. The words from the Cluster 'Risk' account for 27.7% of the total count of words with vague meanings, and they are referred to uncertain, ambiguous, and in particular unfavorable situations the ECB faces. The words from the Cluster 'Could' account for 56.6% of the vague word appearances, and they mostly used by the ECB presidents to provide a vague explanation of the monetary policy strategies, especially those that are dependent on unrealized states beyond the control of the ECB.

We can visualize the word vectors and two word clusters in Figure 3. Each word is originally represented by a high dimensional numeric vector of size 100. To visualize the vectors, we adopt the Principal Component Analysis (PCA) algorithm to reduce the dimensionality to two. Words in the Cluster 'Risk' are surrounded by a red circle, whereas word in the Cluster 'Could' are surrounded by a blue circle.

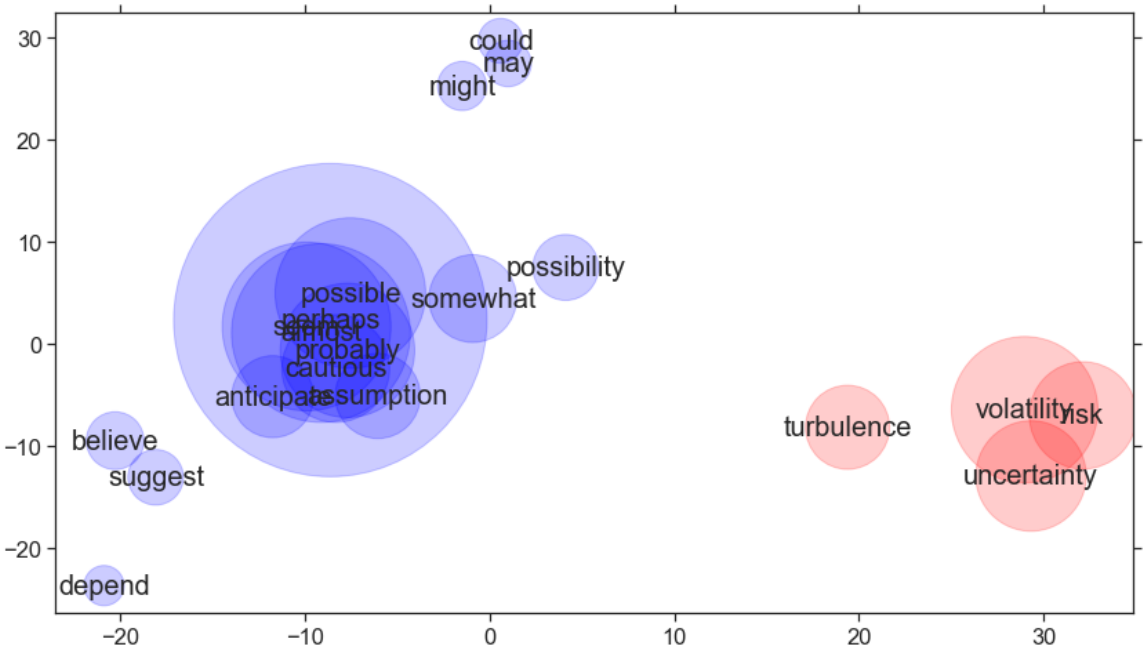
Obviously, the distance between any two words from different clusters are much larger than the distance between any two words within a same cluster. The size of the circle signifies the distance from each word vector to its corresponding cluster center, which can be regarded as the average meaning of all words in that cluster. If the circle of a word is larger, then its word vector is closer to the cluster center, and thus the meaning of the word is more similar to the average meaning of its cluster. The average meaning of the Cluster 'Risk' is a combination of the meanings of words *risk*, *uncertainty* and *volatility*, while the meaning of the word *turbulence* is somewhat more distant from the other three words. In contrast, the five words that are most representative to the average meaning of the Cluster 'Could' are *seems*, *perhaps*, *seems*, *almost*, *probably*, and *cautious*.

Accordingly, we identify the vague tone built on the Cluster 'Risk' as signifying vague economic and financial environments, while the vague tone built on the Cluster 'Could' as indicating an imprecise, and sometimes state-dependent description of monetary policy strategies.

## 5.2 Regression Based on Word Clusters

We first run a regression on the vagueness measure built on the 20 most-mentioned words with vague meanings to ensure that they indeed explain a major fraction of the effect. The

Figure 3: Representing Word Vectors and Clusters in a Two-Dimensional Diagram




Notes: This Figure shows the first twenty most-mentioned uncertainty word vectors in a two-dimensional space. The length of the original word vectors is 100, and we use the PCA method to reduce their dimension to two. Words in the Cluster 'Risk' are surrounded by red circles, and words in the Cluster 'Could' are surrounded by blue circles. The size of the circle signifies the distance from each word to its corresponding cluster center, which can be regarded as the average meaning of all words in that cluster. If the circle of a word is larger, then its word vector is closer to the cluster center, and hence the meaning of the word is more similar to the average meaning of the corresponding cluster.

first column of Table 15 confirms that the slope coefficients are statistically significant for changes in the vague tone, and their magnitudes are close to the ones in the baseline analysis.

Second, we run two independent regressions based on the vagueness measures derived from the two clusters. The result are displayed in the second and third columns of Table 15. When we measure the vague talk by the word appearance from the Cluster 'Could', the change significantly affects the asset returns and volatility. Moreover, the magnitudes of the effect are even higher than that based on the entire uncertainty word list. On the contrary, when we measure the vague talk by the word appearance from the Cluster 'Risk', its difference does not influence the market return or volatility at a significance level lower than or equal to 10%.

The critical implication from the above analysis is that the response of the stock market is due to the unexpected change in policymakers' vague description of monetary policy strategies. Although ECB is apparently making an effort to control its vague tone in the introductory statement, it is more difficult to provide a precise answer to unprepared questions from journalists. This often happens when policymakers need to explain the monetary policy strategies that are not fully clear at the moment, or possibly dependent on unrealized events beyond the control of the ECB. These are precisely the cases we are measuring using the words from the Cluster 'Could'. From a linguistic perspective, these words are related to

the concept of hedging language, which is employed by speakers to limit their commitment to a proposition.

## 5.3 Regression Based on Extended Word Clusters

To further substantiate this view, we include more words with similar meanings in the word clusters, and run regressions based on extended word clusters. For each uncertainty word in a cluster, we can find out its closest synonym by calculating the cosine similarities between it and other words. We can then extend the two word-clusters by including these synonyms.

Four synonyms are added to the Cluster 'Risk', *threat*, *uncertain*, *fluctuation*, and *turmoil*. These words are still used to describe uncertain circumstances. Twelve new words are added to the Cluster 'Could': *think*, *necessary*, *maybe*, *appear*, *hinge*, *judgement*, *option*, *indicate*, *careful*, *slightly*, *nearly*, and *predict*. These words also express similar meanings to the original ones in the Cluster 'Could'. The two word groups including synonyms are presented in Table 3.

Table 3: Extended Word Clusters (including Synonyms)

| Name | Word |
|---|---|
| *Risk* (with synonyms) | risk, uncertainty, volatility, turbulence, threat, uncertain, fluctuation, turmoil |
| *Could* (with synonyms) | could, may, believe, might, possible, perhaps, seem, depend, probably, assumption, possibility, suggest, think, necessary, appear, hinge, judgement, option, indicate, careful, slightly, nearly, predict |

If investors concentrate more on the words reflecting speaker's vague attitude rather than vague situation, then the result obtained by running regressions based on the two extended clusters will be in line with the results obtained above. Indeed, from the third and fifth columns of Table 15, the effect of changes in the vague tone that we built on the extended Cluster 'Could' remain both statistically and economically significant on the return and volatility of the stock market. On the contrary, the impact of vague talk that is built on the extended Cluster 'Risk' is not significant on any acceptable confidence level.

## 5.4 Regression Based on Sentence Clusters

The above result suggests that the market reacts most to the vague talk on policy considerations. To further examine the cause, we perform a sentence-level classification to categorize sentences into sub-groups by their topics and to examine the vagueness of which topic has the biggest impact on the stock market.

To begin with, we express each sentence in the press conference transcript as a sparse sentence vector. The details for generating sentence vectors can be found in Appendix D. Having obtained the sentence vectors, we can apply the K-Means method a second time to detect

two main topics (clusters) from all sentences appearing in press conference transcripts.[6]. The main feature of each word cluster can be characterized by the first ten words closest to the cluster center, which are listed in Table 4.

Table 4: Sentence Clusters

| Cluster | First ten words closest to the cluster center |
|---|---|
| *Policy* | growth, market, area, policy, time, interest, decision, bank, country, measure |
| *State* | price, inflation, stability, medium, term, risk, expectation, oil, development, outlook |

We name each cluster by the meanings of its most distinctive words. Apparently, the words closest to the center of Cluster 'Policy' cover a wider range of topics. More importantly, it includes words *policy*, *decision*, and *measure*, which are frequently used to explain monetary policy strategies. In contrast, we find the words closest to the center of the Cluster 'States' appear in sentences depicting the current (*price*, *inflation*) and future (*development*, *outlook*) states of the economy.

Next, we measure the vagueness of each cluster as the number of sentences containing at least one uncertainty word in answers to the number of sentences in a press conference. The regression results based on these two vagueness measures are shown in the sixth and seventh columns of Table 15. An unexpected increase in the vagueness from the Cluster Policy leads to both a rise in return and a drop in volatility with a level of significance lower than or at least 1%, while changes in the vagueness from the Cluster State do not impose any significant effect on the performance of the stock market.

# 6 Policy Implication

Based on word-level and sentence-level decomposition, we find that the stock market only reacts to vague talk of ECB presidents when describing monetary policy strategies rather than the uncertain circumstances of the economy.

The economic reasoning behind this finding is based on the *cheap talk* mechanism, which was initialized in Crawford and Sobel (1982), applied on central bank communication in Stein (1989), and further developed in Kellner and Quement (2018): Through vague talk, central banks can send more signals about their policy considerations at a lower cost, and these signals can help market participants gain a better understanding of the underlying logic behind monetary policy decisions. Therefore, the information delivered through vague messages do enhance the predictability of the central bank's future policy actions, and reduce the volatility factor in the market.

[6] Alternatively we can detect the topic of the sentences by applying a probabilistic model, such as the Latent Dirichlet Analysis adopted in Hansen et al. (2017) and Jegadeesh and Wu (2017) We did not follow this approach because for a low number of clusters there will not be much difference between the classification result obtained by K-Means and the result obtained by LDA.

Recall that we observe an evident downward tendency in the time series of vague talks in the introductory statement. This implies that the ECB has been moving towards higher precision in its announcement on purpose. However, this might not always be the best strategy to take.

To illustrative this point, consider a simplified variation of Morris and Shin (2002), with only one representative agent and a central bank. The objective of the agent is to minimize the squared distance between the true state of the economy $\theta$, and its action $a$.

$$\max_a U(a) = -(\theta - a)^2.$$

This agent has no prior knowledge on $\theta$, but can receive both a private signal ($x$) and a public signal ($y$) about $\theta$

$$\begin{aligned} x &= \theta + \varepsilon_x, \quad \varepsilon_x \sim N(0, \sigma_x^2), \\ y &= \theta + \varepsilon_y, \quad \varepsilon_y \sim N(0, \sigma_y^2), \end{aligned}$$

where $\varepsilon_x$ and $\varepsilon_y$ are the noise in the signals that is independent of $\theta$. The Bayes' theorem implies that the agent's posterior belief on $\theta$, which is also its optimal action, should be

$$a = E(\theta|x,y) = \frac{\alpha x + \beta y}{\alpha + \beta} = \theta + \frac{\alpha \varepsilon_x + \beta \varepsilon_y}{\alpha + \beta},$$

where $\alpha = 1/\sigma_x^2$ and $\beta = 1/\sigma_y^2$ are the precision of the private and public signals. Taking this solution back into the objective function and rearranging terms we obtain the expected pay-off $E(U)$

$$E(U|x,y) = -\frac{1}{\alpha + \beta},$$

which simply suggests that the ex-ante welfare increases with the precision of the signals.

To fit the model into our empirical analysis, it is worth noting that the market only responds to imprecise signals on monetary policy strategies but not on states of the economy. Since the public has considerably less information regarding the decision-making process of the central bank, the precision of private signal, $\alpha$, should be arbitrarily small compared with the precision of public signal, $\beta$. Thus, for a large positive $k$, we can express $\beta = k\alpha$ and the expected pay-off as

$$E(U|x,y) = -\frac{1}{(1+k)\alpha}.$$

The critical question here is which element the central bank can control in the above expression. The welfare will undoubtedly increase if the policymaker can raise $k$, the relative

precision of the public signal. However, if the nature of the monetary policy strategy is imprecise, as it might depend on unrealized and complicated circumstances beyond central bank's knowledge, then the only choice the policymaker can make is whether or not releasing this vague signal. In this case, announcing an imprecise message make the agent better off compared with keeping silent

$$\Delta E(U) = -\frac{1}{(1+k)\alpha} - [-\frac{1}{(1+0)\alpha}] = \frac{k}{1+k}\alpha > 0.$$

Even though this public signal might not be extremely precise, the agent will still gain from receiving it, as the policymaker always knows more on the conduct of monetary policy than the public (i.e., $k$ is still a positive large number).

In other words, the signal on the conduct of monetary policy sent by the central bank should be as precise as possible (i.e., if $k$ can be chosen then it must be set to the possible highest value), but if the policy strategy is uncertain by its nature (i.e., the value of $k$ cannot be chosen), then such vague message should still be delivered. Here the real dilemma faced by the central bank is that whether it should only send high precise signals that might not convey new information, or it should also send less precise but more informative signals to the market on its policy considerations. Our analysis suggests the latter choice.

Even if the policymaker does not intentionally send vague messages about the monetary policy strategy, such information does deepen investors' understanding of the rationales behind central bank's policy actions, because no other market participant has superior knowledge on this than policymakers themselves. Vague as these signals are, they make central banks' future policy actions more predictable and diminish the volatility factor in the market.

# 7 Conclusion

Is vague talk in ECB's press conference news or noise to the stock market of the Eurozone? We answer this question by quantifying the extent of vagueness in answers provided by ECB presidents on press conference, and showing that such vagueness can robustly increase the return and decrease the volatility of the stock market of the Eurozone.

To further explore the cause, we decompose the overall vagueness into two sub-components at the word level and sentence level using natural language processing and machine learning tools. The result suggests that the market only responds to vague talk on monetary policy strategies. The reason is that policymakers can send more signals about their policy considerations through vague talk. Though this might not be the initial intention of policymakers, the information delivered through the vague talk does enhance the predictability of

the monetary policy and reduce the volatility factor in the stock market.

As the next step, we will examine the response of the stock market in different countries in the Euro Area, and the response of the prices of stocks in different industries to vague talks. In addition, we will investigate how the S&P 500 index reacts to the vague tone contained in the press conference held by the Federal Reserve since 2011.

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# Appendix

## A Data preparation

We apply the following text cleaning procedure to prepare the textual data.

- Decompose each press conference transcript into three sub-components: the introductory statements, questions, and answers
- Apply the Stanford's CoreNLP package to detect named entities and part-of-speeches
- Convert all words into lowercase
- Lemmatize all words to their base form, so that all nouns are reduced to their singular forms, and all verbs are reduced to the present tense form
- Identify words from the uncertainty word list in Loughran and McDonald (2011)
- Remove the uncertainty word possible, if it appears in the expressions *as ... as possible*. This step deletes expressions such as (1) *as soon as possible*, (2) *as clearly as possible*, etc.
- Remove the uncertainty word, if it is after a negative word, including *no, not, never, nothing, nobody, nowhere, few, little, less, without, any*. This step deletes expressions such as (1) *no risk*, (2) *little uncertainty*, (3) *without a doubt*, etc.
- Remove several types of named entities identified by CoreNLP, which includes *date, duration, money, number, ordinal number, percent, time, URL address,* and *E-Mail address*. This step deletes expressions such as (1) *the beginning of 2014*, (2) *the next few month*, (3) *$ 60 billion*, (4) *five o'clock*, (5) *https://www.ecb.europa.eu*, etc.
- Remove symbols, punctuations, possessive endings, and foreign words
- Remove several types of part-of-speeches identified by CoreNLP, including

  1. determiners (e.g., *a*, *the*)
  2. predeterminers (e.g., *all*, *such*)
  3. Wh-determiners (e.g., *which*, *what*)
  4. the existential (*there*)
  5. personal pronouns (e.g., *you*, *we*)
  6. possessive pronouns (e.g., *yours*, *its*)
  7. Wh-pronouns (e.g., *what*, *who*)
  8. the possessive wh-pronoun (*whose*)
  9. interjections (e.g., *yes*, *ok*)
  10. prepositions (e.g., *of*, *in*)
  11. particles (e.g., *up*, *out*)

12. Wh-adverbs (e.g., *when*, *where*)

- Remove stop words *to*, *do*, *have*, *be*, and single letter words

# B Annotated ECB Press Conference Transcripts

To find out more examples of sentences including words with vague meanings please visit the following webpage

https://zexisun.github.io/ecb_annotation

On this page we annotated the uncertainty words in each press conference transcript published by the ECB from 1999-2018. In addition, we grouped all sentences containing at least one uncertainty words in the answer section by date and by word appearance.

# C Word vector

Vector representation of word is introduced in Mikolov et al. (2013). The word vectors embed the semantic and syntatic pattern of the word, and are generated from a neural network.

In machine learning terminologies, these word vectors are obtained by training an unsupervised neural network model on textual data. From a computational economics point of view, training a neural network is similar to finding the solution of a nonlinear function starting from a random initial guess: We first represent each word as a randomized vector, and then repeatedly update these vector representations until they converge or until we stop at the end of the loop.

In each iteration, we update the word vectors according to the distributional hypothesis, which states that words appearing in the same contexts tend to have similar meanings (Harris, 1954). In practice, it amounts to updating word vectors, so that the inner products of two nearby words' vectors will be maximized compared with that of two distant words' vectors.

After a sufficient number of iterations, each vector will be able to capture the semantic and syntactic patterns of the corresponding word.

A direct approach to evaluate the performance of the word vectors derived from the above method is to find out verbal analogies. Denote $\mathbf{u}_X$ as the vector for the word $X$. If the relationship between the words $A$ and $B$ is similar to the relationship between the words $P$ and $Q$, then the vector $\mathbf{u}_Q$ must have the largest cosine similarity to the vector $\mathbf{u}_A - \mathbf{u}_B + \mathbf{u}_P$ among all the word vectors. Indeed, using the word vectors we can verify the equivalence of following relationships (recall that all words are converted to lowercase):

*germany* to *bundesbank* = *us* to *fed*
*inflation* to *inflationary* = *uncertainty* to *uncertain*
*france* to *french* = *ireland* to *irish*
*us* to *dollar* = *china* to *renminbi*

For word vector representation, it has a nice feature that the cosine distance between two words vector is higher when the two corresponding words share more similar meanings. Therefore, grouping words that are close to each other together is equivalent to grouping words with similar meanings.

# D Sentence vector

Different from the method we applied to generate word vectors, we adopt the bag-of-words approach to obtain vector representations for all sentences in ECB press conference. For each sentence vector, its length is equal to the total number of unique words in all sentences, where the value of its entry is equal to the number of appearances of the corresponding word in that sentence. As an example, consider the following three sentences:

*ECB is a central bank*
*Fed is a central bank*
*ECB is in Frankfurt*

To code the three sentences into numeric vectors, we can first establish a mapping between each word (in lowercase) and their locations in sentence vector. Suppose the order of the word locations is as follows

*is, a, in, ecb, fed, central, bank, frankfurt*

Then the three sentences vectors are

$\{1, 1, 0, 1, 0, 1, 1, 0\}$, $\{1, 1, 0, 0, 1, 1, 1, 0\}$, and $\{1, 0, 1, 1, 0, 0, 0, 1\}$.

Similarly, we can translate each of the 52,177 sentences in ECB's press conference transcripts into a numeric vector. Note that the length of the vector equals the number of unique words in all sentences. To decrease the dimensionality, we keep only the nouns in each sentence, as the topic of text is more likely to be described by nouns rather than verbs, adjective, or adverbs. In addition, we only keep nouns appearing at least ten times in all sentences. Through the pre-processing steps, we reduce the size of the sentence vector from 7,900 to 1,315. Thus, each sentence in the press conference transcript can be expressedd by a vector of the length 1315.

Having obtained the sentence vector, we can apply the K-Means method again to obtain sentence clusters, which can be considered as topics of the sentences.

Table 5: Uncertainty Words List

| Uncertainty word | Appearances in answers | Cumulative percentage | Example sentence |
|---|---|---|---|
| Risk | 1338 | 19.7% | It is clear that we see these upside risks to price stability augmenting. |
| Could | 747 | 30.8% | No, it could be a signal that markets have to listen more to me than to others. |
| May | 473 | 37.8% | But the bottom line of this is that there may be complexities. |
| Believe | 355 | 43.0% | We believe that all countries must always be ahead of the curve. |
| Might | 338 | 48.0% | There might be a shock, at least in the statistical series, and we must, of course, be prepared to deal with it. |
| Possible | 306 | 52.5% | But I should stress the possible, because we are still at a very early stage. |
| Perhaps | 294 | 56.8% | It 's shared by other people ; I wouldn't say 'widely shared': it would be too ambitious, perhaps. |
| Uncertainty | 262 | 67.0% | There are many uncertainties, but the risks have moved, let me say, in an upward direction. |
| Seem | 235 | 64.2% | Without giving details, what I have seen until now seems to me to be going in the right direction. |
| Depend | 203 | 67.2% | We are also very much depending on the global evolution. |
| Volatility | 198 | 70.1% | So basically, we are watching, monitoring this volatility. |
| Probably | 177 | 72.7% | That is one of the differences, and I think it is probably the most important. |
| Assumption | 149 | 74.9% | That's the working assumption of the Governing Council, which trusts the signature of the 17 heads. |
| Possibility | 119 | 76.7% | And so, the possibility of having imbalances was always being looked at and considered. |
| Suggest | 114 | 78.3% | The influence of an increase of oil prices goes in the two directions you have suggested. |
| Cautious | 108 | 79.9% | But as far as we are concerned, we are very prudent and cautious. |
| Somewhat | 95 | 81.3% | The transmission mechanism as such is somewhat in the dark, I admit. |
| Almost | 76 | 82.5% | I am almost inclined to say: we continuously ask ourselves the same question. |
| Turbulence | 74 | 83.6% | This is part of the overall financial turbulence that we have to cope with. |
| Anticipate | 62 | 84.5% | We anticipate that, subject to incoming data confirming our medium-term inflation outlook, we will then end net purchases. |

Source: ECB.

Table 6: Summary Statistics

| | Mean | St.Dev | Min | Max | No.Obs |
|---|---|---|---|---|---|
| *UncAnswer* | 0.012 | 0.0036 | 0.0041 | 0.023 | 217 |
| *UncIntro* | 0.0061 | 0.0027 | 0.0010 | 0.014 | 217 |
| *NegAnswer* | 0.018 | 0.0058 | 0.0056 | 0.038 | 217 |
| *NegIntro* | 0.0084 | 0.0042 | 0.0013 | 0.024 | 217 |
| STOXX | 309.22 | 65.62 | 173.05 | 459.28 | 216 |
| MSCI | 181.74 | 38.94 | 100.98 | 270.66 | 216 |
| VSTOXX | 24.11 | 9.17 | 11.44 | 60.71 | 216 |
| Bid-ask Spread | 0.009 | 0.008 | 0.00049 | 0.042 | 100 |
| STOXX Turnover | 878998 | 325322 | 375806 | 2414737 | 135 |
| DAX Turnover | 4122.61 | 1581.33 | 1743.84 | 11753.35 | 216 |
| EUR/USD | 0.84 | 0.13 | 0.63 | 1.19 | 216 |
| Total Words | 2977.47 | 731.0926 | 1076 | 4387 | 217 |
| MRO | 2.44 | 1.78 | 0 | 4.25 | 216 |
| *Level_shock* | 1.81 | 1.66 | -0.359 | 5.055 | 216 |
| *Path_shock* | 0.43 | 0.61 | -0.92 | 2.34 | 216 |
| GDP Projection | 1.58 | 0.73 | -0.51 | 3.12 | 196 |
| HICP Projection | 1.643 | 0.399 | 0.71 | 2.60 | 196 |
| EPU | 140.77 | 64.53 | 47.69 | 433.27 | 216 |

Sources: ECB, Datastream, Authors Calculations.

Table 7: Stock Market Response to the Vague Tone in ECB Press Conference

(a) Euro STOXX Return and Volatility (Squared Return)

| | Return | Volatility |
|---|---|---|
| | (1) | (2) |
| $\Delta UncAnswer$ | 0.581*** | -1.480** |
| | (3.09) | (-2.48) |
| Const | 0.021 | 2.207*** |
| | (0.20) | (5.36) |
| #Observation | 215 | 215 |
| Adj $R^2$ (%) | 2.6 | 1.9 |

(b) Variation for STOXX Return

| | Baseline | | Excess return | | Pre-2007 | | Post-2007 | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\Delta UncAnswer$ | 0.581*** | 0.383*** | 0.555*** | 0.401** | 0.522* | 0.303* | 0.648** | 0.581** |
| | (2.83) | (2.81) | (2.60) | (2.38) | (1.79) | (1.84) | (2.20) | (2.44) |
| Const | 0.021 | 0.139* | 0.055 | 0.171* | 0.042 | 0.147 | 0.007 | 0.102 |
| | (0.23) | (1.75) | (0.52) | (1.92) | (0.34) | (1.36) | (0.05) | (0.89) |
| Remove outliers | No | Yes | No | Yes | No | Yes | No | Yes |
| #Observation | 215 | 188 | 215 | 188 | 91 | 77 | 124 | 109 |
| Adj $R^2$ (%) | 2.6 | 2.1 | 1.8 | 1.7 | 2.6 | 1.0 | 2.0 | 3.6 |

(c) Variation for STOXX Volatility

| | Baseline | | Absolute return | | Pre-2007 | | Post-2007 | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\Delta UncAnswer$ | -1.480** | -0.884*** | -0.347*** | -0.338*** | -0.903** | -0.489** | -2.135* | -0.995** |
| | (-2.48) | (-3.24) | (-2.65) | (-2.91) | (-2.54) | (-2.51) | (-1.83) | (-2.05) |
| Const | 2.207*** | 1.540*** | 1.075*** | 0.908*** | 1.871*** | 1.167*** | 2.450*** | 1.696*** |
| | (5.36) | (7.84) | (11.56) | (17.56) | (4.01) | (5.72) | (4.12) | (6.33) |
| Remove outliers | No | Yes | No | Yes | No | Yes | No | Yes |
| #Observation | 215 | 200 | 215 | 192 | 91 | 81 | 124 | 117 |
| Adj $R^2$ (%) | 1.9 | 2.3 | 1.8 | 3.2 | 1.3 | 0.9 | 2.1 | 1.6 |

*Notes*: This table reports the result of regression percentage returns and squared percentage returns (volatilities) on changes in ECB vagueness measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. $\Delta UncAnswer$ is the percentage vagueness measure in PC answer section (in Q&A) based on Loughran and McDonald (2013) . Panel a represents both the market returns and squared percentage returns (volatilities) based on EURO STOXX index and MSCI Europe index, from date t-1 close to the date t close. Panel b provides further specifications on return. Excess return is defined as the difference of STOXX return and EMU benchmark 10 years government bond return. Panel c provides further specifications on volatility. The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 8: Response of the EURO STOXX Return to the Vague Tone in ECB Press Conference

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $\Delta UncAnswer$ | 0.3834*** | 0.3827*** | 0.3597*** | 0.3053*** | 0.3526*** | 0.3490*** |
| | (3.77) | (3.49) | (3.79) | (2.91) | (2.83) | (3.00) |
| $\Delta UncIntro$ | | -0.0086 | | | | 0.6544*** |
| | | (-0.03) | | | | (2.66) |
| $\Delta NegAnswer$ | | | 0.1429 | | | 0.0757 |
| | | | (1.36) | | | (0.72) |
| $\Delta NegIntro$ | | | | -0.8119*** | | -0.9675*** |
| | | | | (-4.43) | | (-4.40) |
| $\Delta total\_words$ | | | | | 0.0001 | -0.0001 |
| | | | | | (0.59) | (-0.47) |
| Const | 0.1393 | 0.1394 | 0.1368 | 0.1416* | 0.1404 | 0.1368 |
| | (1.57) | (1.58) | (1.52) | (1.69) | (1.59) | (1.64) |
| Remove outliers | Yes | Yes | Yes | Yes | Yes | Yes |
| #Observation | 188 | 188 | 188 | 188 | 188 | 188 |
| Adj $R^2$ (%) | 2.1 | 1.5 | 2.3 | 9.9 | 1.8 | 10.1 |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| $\Delta UncAnswer$ | 0.3543*** | 0.3781*** | 0.4099*** | 0.3772*** | 0.3835*** | 0.3812*** |
| | (3.21) | (3.76) | (4.13) | (3.70) | (3.79) | (3.24) |
| $\Delta UncIntro$ | | | | | | 0.4933 |
| | | | | | | (1.61) |
| $\Delta NegAnswer$ | | | | | | 0.0459 |
| | | | | | | (0.47) |
| $\Delta NegIntro$ | | | | | | -0.8344*** |
| | | | | | | (-3.97) |
| $\Delta total\_words$ | | | | | | -0.0001 |
| | | | | | | (-0.56) |
| $\Delta MRO$ | 1.7004*** | | | | | 1.2156** |
| | (5.34) | | | | | (2.45) |
| $UMP\_dummy$ | 0.2166 | | | | | 0.0006 |
| | (1.53) | | | | | (0.00) |
| $Level\_shock$ | | -0.0677 | | | | -0.1410 |
| | | (-1.43) | | | | (-1.20) |
| $Path\_shock$ | | 0.0172 | | | | -0.2576 |
| | | (0.15) | | | | (-1.08) |
| $\Delta GDP\_next$ | | | 0.4799*** | | | 0.3359** |
| | | | (4.51) | | | (2.18) |
| $\Delta HICP\_next$ | | | 0.0733 | | | -0.1144 |
| | | | (0.37) | | | (-0.65) |
| $EPU$ | | | 0.0012 | | | 0.0005 |
| | | | (0.68) | | | (0.38) |
| $Lagged\_ret$ | | | | 0.0563 | | 0.0847 |
| | | | | (0.66) | | (1.25) |
| $Lagged\_vol$ | | | | 0.0323 | | 0.0356 |
| | | | | (0.81) | | (0.86) |
| $p{=}Draghi$ | | | | | 0.2016 | -0.2193 |
| | | | | | (0.86) | (-0.48) |
| $p{=}Duisenberg$ | | | | | 0.1404 | -0.0364 |
| | | | | | (0.74) | (-0.22) |
| Const | 1.6196*** | 1.6466*** | 1.5671*** | 1.2612*** | 1.3140*** | 1.5491 |
| | (8.20) | (4.35) | (6.77) | (6.57) | (5.43) | (1.63) |
| Remove outliers | Yes | Yes | Yes | Yes | Yes | Yes |
| #Observation | 200 | 200 | 181 | 200 | 200 | 181 |
| Adj $R^2$ (%) | 4.8 | 2.3 | 6.0 | 2.3 | 1.8 | 12.8 |

*Notes*: This table reports the result of regression EURO STOXX percentage returns on ECB vagueness change measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. $\Delta UncAnswer$ is the percentage vagueness measure in PC answer section (in Q&A) based on Loughran and McDonald (2011) . Independent variable is percentage return based on EURO STOXX index, from date t-1 close to the date t close. Specification (1)- (6) show the results after controlling for other linguisitc characteristics. $\Delta UncIntro$ is the percentage vagueness measure in PC introductory section. $\Delta NegAnswer$ is the percentage negative measure in PC answer section (in Q&A), and $\Delta NegIntro$ is the percentage negative measure in PC introductory section. All of these linguistic measures are following Loughran and McDonald (2011). $\Delta total\_words$ is the number of words in answers. (7) present the results after controlling for monetary policy changes. (8) controlis for the monetary shocks. We use the change in the 3-month OIS rate (Level shock) and the change in the spread between the two-year (German) government yield and the 3-month OIS rate (Path shock). (9) controlls the change of ECB economic projections on GDP and HICP for next year. (10) includes both lagged return and lagged realized volatility. (11) gives the result after controlling for presidents dummy. The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 9: Response of EURO STOXX Volatility (Squared Return) to the Vague Tone in ECB Press Conference

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $\Delta UncAnswer$ | -0.8836*** | -0.8911*** | -0.9535*** | -0.8775*** | -0.8844*** | -0.9190*** |
| | (-3.24) | (-3.32) | (-3.58) | (-3.32) | (-3.67) | (-3.88) |
| $\Delta UncIntro$ | | -0.1042 | | | | 0.0341 |
| | | (-0.21) | | | | (0.06) |
| $\Delta NegAnswer$ | | | 0.3593*** | | | 0.4012*** |
| | | | (2.61) | | | (2.69) |
| $\Delta NegIntro$ | | | | 0.0545 | | 0.1768 |
| | | | | (0.18) | | (0.56) |
| $\Delta totalwords$ | | | | | 0.0000 | -0.0001 |
| | | | | | (0.01) | (-0.19) |
| Const | 1.5402*** | 1.5403*** | 1.5357*** | 1.5402*** | 1.5402*** | 1.5351*** |
| | (7.84) | (7.82) | (7.93) | (7.82) | (7.81) | (7.87) |
| Remove outliers | Yes | Yes | Yes | Yes | Yes | Yes |
| #Observation | 200 | 200 | 200 | 200 | 200 | 200 |
| Adj $R^2$ (%) | 2.3 | 1.8 | 2.8 | 1.8 | 1.8 | 1.4 |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| $\Delta UncAnswer$ | -0.8596*** | -0.8843*** | -0.7633*** | -0.9234*** | -0.8908*** | -0.8357*** |
| | (-3.14) | (-3.24) | (-3.31) | (-3.22) | (-3.41) | (-3.23) |
| $\Delta UncIntro$ | | | | | | -0.5447 |
| | | | | | | (-0.86) |
| $\Delta NegAnswer$ | | | | | | 0.2753** |
| | | | | | | (2.03) |
| $\Delta NegIntro$ | | | | | | -0.0033 |
| | | | | | | (-0.01) |
| $\Delta totalwords$ | | | | | | -0.0001 |
| | | | | | | (-0.32) |
| $\Delta MRO$ | -0.1003 | | | | | 0.4189 |
| | (-0.08) | | | | | (0.26) |
| $UMP\_dummy$ | -1.0170*** | | | | | -1.6713*** |
| | (-4.77) | | | | | (-4.74) |
| $Level\_shock$ | | -0.0716 | | | | -0.1752 |
| | | (-0.70) | | | | (-0.71) |
| $Path\_shock$ | | 0.0483 | | | | -0.0063 |
| | | (0.19) | | | | (-0.01) |
| $\Delta GDPnext$ | | | -0.8463** | | | -0.9411*** |
| | | | (-2.04) | | | (-3.03) |
| $\Delta HICPnext$ | | | 0.3208 | | | 0.5395 |
| | | | (0.57) | | | (0.73) |
| $\Delta EPU$ | | | -0.0003 | | | -0.0018 |
| | | | (-0.11) | | | (-0.48) |
| $Lagged\_ret$ | | | | -0.0886 | | -0.1142 |
| | | | | (-0.66) | | (-0.68) |
| $Lagged\_vol$ | | | | 0.2030*** | | 0.1343** |
| | | | | (2.84) | | (2.01) |
| $p$=$Draghi$ | | | | | 0.4279 | 0.5603 |
| | | | | | (1.00) | (0.51) |
| $p$=$Duisenberg$ | | | | | 0.3801 | 0.5937** |
| | | | | | (1.14) | (2.30) |
| Const | 0.0002*** | 0.0002*** | 0.0002*** | 0.0001*** | 0.0001*** | 0.0002 |
| | (8.19) | (4.34) | (6.77) | (6.56) | (5.43) | (1.62) |
| Remove outliers | Yes | Yes | Yes | Yes | Yes | Yes |
| #Observation | 200 | 200 | 181 | 200 | 200 | 181 |
| Adj $R^2$ (%) | 2.9 | 1.7 | 4.0 | 8.3 | 2.2 | 7.5 |

*Notes*: This table reports the result of regression squared returns (volatilities) on ECB vagueness change measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. $\Delta UncAnswer$ is the percentage vagueness measure in PC answer section (in Q&A) based on Loughran and McDonald (2011) . Independent variable is squared percentage return based on EURO STOXX index, from date t-1 close to the date t close. Specification (1)- (6) show the results after controlling for other linguistic characteristics. $\Delta UncIntro$ is the percentage vagueness measure in PC introductory section. $\Delta NegAnswer$ is the percentage negative measure in PC answer section (in Q&A), and $\Delta NegIntro$ is the percentage negative measure in PC introductory section. All of these linguistic measures are following Loughran and McDonald (2011). $\Delta total\_words$ is the number of words in answers. (7) present the results after controlling for monetary policy changes. (8) controlls for the monetary shocks. We use the change in the 3-month OIS rate (Level shock) and the change in the spread between the two-year (German) government yield and the 3-month OIS rate (Path shock). (9) controlls the change of ECB economic projections on GDP and HICP for next year. (10) includes both lagged return and lagged realized volatility. (11) gives the result after controlling for presidents dummy. (12) includes all controlls. The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 10: Stock Market Responses to ECB Press Conference Vagueness

(a) Return Reaction of Various Indice

| | (1) STOXX | (2) STOXX | (3) STOXX Large | (4) STOXX Median | (5) STOXX Small | (6) MSCI | (7) MSCI Growth | (8) MSCI Value |
|---|---|---|---|---|---|---|---|---|
| $\Delta UncAnswer$ | 0.3812** | 0.4645** | 0.4556** | 0.4020** | 0.3961** | 0.4646** | 0.3769* | 0.5366** |
| | (3.24) | (2.22) | (2.34) | (2.30) | (2.56) | (2.21) | (1.83) | (2.39) |
| Remove outliers | Yes | No | No | No | No | No | No | No |
| Controlls | All | All | All | All | All | All | All | All |
| #Observation | 169 | 192 | 192 | 192 | 192 | 192 | 192 | 192 |
| Adj $R^2$ (%) | 12.8 | 6.5 | 5.0 | 9.2 | 10.9 | 6.4 | 6.6 | 6.1 |

(b) Volatilities Reaction of Various Indice

| | (1) STOXX | (2) STOXX | (3) STOXX Large | (4) STOXX Median | (5) STOXX Small | (6) MSCI | (7) MSCI Growth | (8) MSCI Value |
|---|---|---|---|---|---|---|---|---|
| $\Delta UncAnswer$ | -0.8357*** | -1.3982** | -1.0652* | -0.9530** | -0.7952* | -1.3994** | -1.1217** | -1.6609** |
| | (-3.23) | (-2.09) | (-1.94) | (-2.06) | (-1.85) | (-2.11) | (-2.30) | (-1.99) |
| Remove outliers | Yes | No | No | No | No | No | No | No |
| Controlls | All | All | All | All | All | All | All | All |
| #Observation | 181 | 192 | 192 | 192 | 192 | 192 | 192 | 192 |
| Adj $R^2$ (%) | 7.5 | 20.4 | 17.3 | 18.8 | 16.0 | 20.4 | 18.4 | 21.4 |

*Notes*: This table reports the result of regression percentage returns and squared percentage returns (volatilities) of a series of indice on changes in ECB vagueness measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. $\Delta UncAnswer$ is the percentage vagueness measure in PC answer section (in Q&A) based on Loughran and McDonald (2013) . The indice series include EURO STOXX, STOXX Large 200, STOXX Median 200, STOXX Small 200, MSCI Europe, MSCI Europe Growth and MSCI Europe Value. Panel a represents market returns and Panel b represents market volatility based on the indice, from date t-1 close to the date t close. Both Panels include all controlls in Table 8 (12) and Table 9 (12). The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 11: Stock Market Response to ECB Press Conference Vagueness with Alternative Controls

(a) Return Response with Alternative Controls

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\Delta UncAnswer$ | 0.3549*** | 0.3822*** | 0.3857*** | 0.4057*** |
| | (3.12) | (3.23) | (3.28) | (3.16) |
| DF/MLF | 0.0048 | | | |
| | (1.41) | | | |
| QE | | 0.0000 | | |
| | | (0.77) | | |
| $\Delta\%TotalLength$ | | | -0.0000 | |
| | | | (-0.73) | |
| $\Delta\%GDPnowcast$ | | | | 0.0017** |
| | | | | (2.31) |
| $\Delta\%HICPnowcast$ | | | | -0.0021 |
| | | | | (-1.29) |
| Remove outliers | Yes | Yes | Yes | Yes |
| Controlls | All | All | All | All |
| #Observation | 169 | 169 | 169 | 169 |
| Adj $R^2$ (%) | 12.9 | 13.0 | 12.9 | 12.4 |

(b) Volatility Response with Alternative Controls

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\Delta UncAnswer$ | -0.8310*** | -0.8745*** | -0.8395*** | -0.9193*** |
| | (-3.38) | (-3.53) | (-3.26) | (-3.26) |
| DF/MLF | -0.3901 | | | |
| | (-0.51) | | | |
| QE | | -0.0202** | | |
| | | (-2.11) | | |
| $\Delta\%TotalLength$ | | | -0.0000 | |
| | | | (-0.27) | |
| $\Delta\%GDPnowcast$ | | | | 0.0773 |
| | | | | (0.27) |
| $\Delta\%HICPnowcast$ | | | | 0.5822* |
| | | | | (1.81) |
| Remove outliers | Yes | Yes | Yes | Yes |
| Controlls | All | All | All | All |
| #Observation | 181 | 181 | 181 | 181 |
| Adj $R^2$ (%) | 7.7 | 6.4 | 7.5 | 5.0 |

*Notes*: This table reports the result of regression percentage returns and squared percentage returns (volatilities) on changes in ECB vagueness measure in PC answer section (in Q&A), with alternative controls compared with Table 8 (12) and Table 9 (12), from date t-1 close to the date t close. In specificaion (1), keeping other controls unchanged, policy rate control is changed from MRO to DF/MLF, which is a dummy that measures whether ECB has negative policy rate. In (2), unconventional policy measure is changed from forward guidance dummy to QE, the amount of assets purchased in quantitative easing. In (3), textual complexity measure is changed from total number of words to total length of document. In (4), economic projection measures is replaced from the forecasts to nowcasts. The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 12: Stock Market Response to Various ECB Press Conference vagueness measure

(a) vagueness measured by Absolute Score

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Panel A: Return | | | | |
| $\Delta UncAnswer$ | 0.0114* | 0.0196*** | 0.0096*** | 0.0081** |
| | (1.75) | (3.29) | (3.40) | (2.04) |
| Remove outliers | No | No | Yes | Yes |
| Controlls | No | All | No | All |
| #Observation | 215 | 192 | 181 | 162 |
| Adj $R^2$ (%) | 0.8 | 6.6 | 1.4 | 8.7 |
| Panel B: Volatility | | | | |
| $\Delta UncAnswer$ | -0.0379** | -0.0506* | -0.0161 | -0.0189** |
| | (-2.04) | (-1.96) | (-1.62) | (-2.11) |
| Remove outliers | No | No | Yes | Yes |
| Controlls | No | All | No | All |
| #Observation | 215 | 192 | 205 | 185 |
| Adj $R^2$ (%) | 1.3 | 22.5 | 0.5 | 8.1 |

(b) vagueness measure Scaled by Total Count in Answer

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Panel A: Return | | | | |
| $\Delta UncAnswer$ | 0.2925** | 0.2175** | 0.1459** | 0.1728*** |
| | (2.44) | (2.00) | (2.18) | (2.77) |
| Remove outliers | No | No | Yes | Yes |
| Controlls | No | All | No | All |
| #Observation | 215 | 192 | 187 | 168 |
| Adj $R^2$ (%) | 2.2 | 5.4 | 0.7 | 5.5 |
| Panel B: Volatility | | | | |
| $\Delta UncAnswer$ | -0.8952** | -0.6073** | -0.5185*** | -0.4112** |
| | (-2.56) | (-2.01) | (-3.22) | (-2.17) |
| Remove outliers | NO | NO | Yes | Yes |
| Controlls | No | All | No | All |
| #Observation | 215 | 192 | 200 | 180 |
| Adj $R^2$ (%) | 2.5 | 21.7 | 2.8 | 6.3 |

*Notes*: This table reports the result of regression percentage returns and squared percentage returns (volatilities) on changes in ECB vagueness measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. In Panel a, $\Delta UncAnswer$ is the score vagueness measure, namely the number of uncertainty words based on Loughran and McDonald (2013), in PC answer section (in Q&A) . In controls, $\Delta UncIntro$, $\Delta NegAnswer$ and $\Delta NegAnswer$ are also changed into score measure correspondingly. Panel a represents both the market returns and squared percentage returns (volatilities) based on EURO STOXX index, from date t-1 close to the date t close. In Panel b, $\Delta UncAnswer$ is the percentage vagueness measure, calculated by number of uncertainty words scaled to total number of words in answer section. In controls, $\Delta UncIntro$, $\Delta NegAnswer$ and $\Delta NegAnswer$ are also scaled into total number of words in correspondingly sections.e. All controls means regression include all the controls in Table 8 (12) and Table 9 (12). The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 13: Placebo Test on vagueness measure in ECB Press Conference Introductory Statement and Questions

(a) Effect of Vagueness in Introductory Statement

| | Return | | Volatility | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\Delta UncIntro$ | 0.1752 | 0.6114 | -1.7879 | -2.5431 |
| | (0.32) | (1.09) | (-0.80) | (-1.11) |
| Controlls | No | All | No | All |
| Remove outliers | No | No | No | No |
| #Observation | 215 | 192 | 215 | 192 |
| Adj $R^2$ (%) | -0.4 | 4.7 | 0.4 | 20.4 |

(b) Effect of Vagueness in Questions

| | Return | | Volatility | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\Delta UncrQuestion$ | -0.2350 | -0.3266 | -0.8147* | -0.6550 |
| | (-0.93) | (-1.14) | (-1.69) | (-0.98) |
| Controlls | No | All | No | All |
| Remove outliers | No | No | No | No |
| #Observation | 215 | 192 | 215 | 192 |
| Adj $R^2$ (%) | -0.2 | 4.7 | -0.0 | 21.5 |

*Notes*: This table reports the result of regression percentage returns and squared percentage returns (volatilities) on changes in ECB vagueness measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. In Panel a $\Delta UncIntro$ is the percentage vagueness measure in PC Introductory statement section. In Panel b $\Delta UncrQuestion$ is the percentage vagueness measure in PC Question section(in Q&A) based on Loughran and McDonald (2013). Both the market returns and squared percentage returns (volatilities) are calculated based on EURO STOXX index, from date t-1 close to the date t close. All controls means regression include all the controls in Table 8 (12) and Table 9 (12). The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses.***Significant at 1%, **significant at 5%, *significant at 10%.

Table 14: Response of the VSTOXX, Liquidity Cost, EURO STOXX 50 Turnover, German DAX Turnover, and EUR/USD Exchange Rate to the Vague Tone in ECB Press Conference

(a) Baseline

| | (1) VSTOXX | (2) Liquidity Cost | (3) STOXX Turnover | (4) EUR/USD Exchange Rate |
|---|---|---|---|---|
| $\Delta UncAnswer$ | -1.554*** | -0.004** | -12.523*** | 0.207*** |
| | (-2.87) | (-7.13) | (-4.02) | (2.81) |
| Const | -1.312** | 0.002*** | 11.063*** | 0.057* |
| | (-2.58) | (3.98) | (7.07) | (1.82) |
| Remove outliers | Yes | Yes | Yes | Yes |
| Controlls | No | No | No | No |
| #Observation | 183 | 26 | 112 | 188 |
| Adj $R^2$ (%) | 1.5 | 14.5 | 5.5 | 1.8 |

(b) Include All Controlls

| | (5) VSTOXX | (6) Liquidity Cost | (7) STOXX Turnover | (8) EUR/USD Exchange Rate |
|---|---|---|---|---|
| $\Delta UncAnswer$ | -1.617** | -0.005*** | -13.276*** | 0.233*** |
| | (-2.61) | (-3.50) | (-3.68) | (2.66) |
| Remove outliers | Yes | Yes | Yes | Yes |
| Controlls | All | All | All | All |
| #Observation | 163 | 24 | 112 | 167 |
| Adj $R^2$ (%) | 11.9 | 16.1 | 6.7 | 0.4 |

*Notes*: This table reports the result of regression VSTOXX, Liquidity Cost, EURO STOXX 50 Turnover, and EUR/USD Exchange Rate percentage changes on ECB vagueness change measure in PC answer section (in Q&A), in a close-to-close window around the PC announcement. $\Delta UncAnswer$ is the percentage vagueness measure in PC answer section (in Q&A) based on Loughran and McDonald (2011) . As dependent variables, VSTOXX present the percentage change of European volatility benchmark VSTOXX index; Liquidity Cost is the difference change of esmated bid-ask spread follow Abdi and Ranaldo (2017); STOXX turnover is percentage change of aggregate turnover of Euro STOXX 50 index; EUR/USD Exchange Rate is the percentage change of eur/usd exchange rate. All changes are calculated from date t-1 close to the date t close. Results in Panel a include no controlls, and in Panel b include all controlls in Table 8 (12) and Table 9 (12). The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 15: Response of STOXX Return and Volatility to ECB Press Conference vagueness measured Based on Variation of Word Lists

(a) Return

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Top 20 | 0.3675*** | | | | | | |
| | (3.34) | | | | | | |
| Cluster *could* | | 0.5175** | | | | | |
| | | (2.34) | | | | | |
| Cluster *could* Synonym | | | 0.2827** | | | | |
| | | | (2.01) | | | | |
| Cluster *risk* | | | | 0.2020 | | | |
| | | | | (1.01) | | | |
| Cluster *risk* Synonym | | | | | 0.1565 | | |
| | | | | | (0.78) | | |
| Cluster *Policy* | | | | | | 0.0584*** | |
| | | | | | | (3.12) | |
| Cluster *State* | | | | | | | -0.0473 |
| | | | | | | | (-0.89) |
| #Observation | 169 | 169 | 169 | 169 | 169 | 169 | 169 |
| Adj $R^2$ (%) | 12.4 | 10.6 | 10.5 | 12.4 | 11.3 | 13.3 | 10.6 |

(b) Volatility

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Top 20 | -0.0078*** | | | | | | |
| | (-3.13) | | | | | | |
| Cluster *could* | | -0.0098* | | | | | |
| | | (-1.88) | | | | | |
| Cluster *could* Synonym | | | -0.0068** | | | | |
| | | | (-2.44) | | | | |
| Cluster *risk* | | | | -0.0056 | | | |
| | | | | (-0.85) | | | |
| Cluster *risk* Synonym | | | | | -0.0054 | | |
| | | | | | (-0.82) | | |
| Cluster *Policy* | | | | | | -0.0012*** | |
| | | | | | | (-3.01) | |
| Cluster *State* | | | | | | | -0.0000 |
| | | | | | | | (-0.07) |
| #Observation | 181 | 181 | 181 | 181 | 181 | 181 | 181 |
| Adj $R^2$ (%) | 7.1 | 5.6 | 5.5 | 6.6 | 6.2 | 7.7 | 5.0 |

*Notes*: This table reports the result of regression return and Volatility to ECB Press Conference Vagueness, while the vagueness measures are based on variations of Loughran and McDonald (2011) uncertainty word list. Top 20 represents the vagueness measure calculated based on the top 20 uncertainty words, accounting for about 85% of all uncertainty word count in ECB Press Conference texts. Cluster *could* is the the vagueness measure calculated based on cluster led by *could* in top 20 uncertainty words. Cluster *risk* is the the vagueness measure calculated based on cluster led by *risk* in top 20 uncertainty words. Cluster *could* list and Cluster *risk* list together make up the whole Top 20 word list. Cluster *could* Synonym measures vagueness based on Cluster *could* words' synonym, identified using word vector trainning in a conclusive ECB published texts set. We derive Cluster *risk* Synonym similarly as Cluster *could* Synonym. Results in Panel a and b both include all controlls in Table 8 (12) and Table 9 (12). The sample period is from January 7, 1999 to September 13, 2018. We adjust for any potential time-series autocorrelation by using Newey-West (1987) standard errors with 20 lags autocorrelation. t-statistics are displayed in parentheses. ***Significant at 1%, **significant at 5%, *significant at 10%.