Let's Face It: Quantifying the Impact of Nonverbal Communication in FOMC Press Conferences ☆

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Abstract

We apply facial recognition analysis to FOMC press conference videos and quantify one of the most important aspects of nonverbal communication — facial expressions. Using minute-level data, we align our nonverbal communication measure with a set of financial assets to estimate the impact of the Fed Chairs' facial expressions on investor expectations. We find that investors adversely react to negative expressions revealed during the press conference, even when controlling for the verbal component of the press conference and additional explanatory variables. This work sets forth a new way of capturing soft information embedded in central bank communication.

Keywords: Central Bank Communication; Market Expectations; Facial Recognition; Video; Alternative Data

JEL Classification: E52, E58, F33, G12

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1. Introduction

"...In the 1920s, the Governor's "eyebrows" famously became one of the Banks means of communicating. The eyebrows were, in a way, a primitive form of emoji: sterling crisis – sad face.."

Speech by Andrew G. Haldane, 31 March 2017

The appreciation for central bank communication has increased dramatically in the past twenty years. We now know that central bank communication affects employment, income, and inflation (Kuttner and Posen (1999); Woodford (2001); Amato et al. (2002); Kohn and Sack (2003); Coibion et al. (2019)). In times when the standard monetary policy toolkit has limited impact, communication becomes one of the most important tools at the disposal of policymakers (Eggertsson and Woodford (2003); Bernanke (2004); Bernanke et al. (2004); Woodford (2005); Yellen (2013)). Nominal interest rates have been at the zero lower bound for the main part of the last ten years. Not surprisingly, attention to central bank communication during this period has been heightened.

Communication released by the Federal Reserve (henceforth, the Fed), and the Federal Open Market Committee (FOMC) in particular, gets a lot of attention from market participants. The FOMC has been shown to be an important mover of markets, with both equities and interest rates reacting when FOMC communication is released (Gürkaynak et al. (2005); Rosa (2013); Cieslak et al. (2019)). Arguably, the most important component of Fed communication is the post-FOMC policy decision announcement. In 2011, as part of the effort to further enhance the clarity of Fed communication, post-FOMC press conferences were introduced.

Boguth et al. (2019) show that the implementation of post FOMC press conferences skewed expectations of important monetary policy decisions towards meetings with press

conferences. The authors maintain that while press conferences attract investor attention, they convey little new information to the market. On the other hand, Gomez Cram and Grotteria (2020) document that messages communicated during press conferences do form investors expectations.

Our paper adds to the literature on central bank communication by providing a new way of quantifying central bank messages and estimating their impact. We leverage existing FOMC press conference videos to identify and quantify facial expressions exhibited by Fed Chairmen during the FOMC press conferences. We use facial recognition technology to create a composite score that summarizes these facial expressions quantitatively. By studying facial expressions exhibited during the press conference, we measure not only the sentiment of what was said, but also of how it was said.

To the best of our knowledge, our paper is the first to study the impact of emotions in central bank communication. A parallel complementary work by Gorodnichenko et al. (2021) utilizes a deep learning model to detect the tone of voice embedded in press conferences to examine its impact on financial markets. The authors find that the tone of voice in policy communication has a significant effect on the stock market. This emerging strand of literature sets forth a new way of identifying and capturing *soft* information embedded in central bank communication, and help policymakers utilize communication tools at their disposal to their fullest.

Further, our paper adds to the literature on the signaling channel of monetary policy. Our hypothesis is that market participants are impacted by information beyond that expressed verbally during the FOMC press conferences. We examine whether market participants notice and act upon nonverbal communication exhibited by Fed Chairmen during the FOMC press conferences. Specifically, we empirically document how market participants react to nonverbal communication signals in real time by relating the composite score based on intensity of certain facial expressions to minute-level market responses. In order to properly

capture market response, we use high frequency price and volume data for a set of financial asset classes, in the spirit of Gürkaynak et al. (2005) and Nakamura and Steinsson (2018), and use intensity of facial expressions as a proxy for how Chairs' expressed emotions are perceived by market participants.

Why should market participants be impacted by Chairs' facial expressions? It has been shown that facial expressions are a key channel through which emotional contagion occurs (Lundqvist and Dimberg (1995)). Emotional contagion is a situation where one persons emotions bring about a similar response in other people (Barsade (2002), Hareli and Rafaeli (2008), Van Kleef et al. (2004)). Observed emotions may be taken as cues of deeper motives, and interpreted as additional information by market participants. We reason that market participants not only pay attention to, but also act upon information derived from Chair's facial expressions.[1]

We focus on negative facial expressions in our analysis. It's been shown that adults display an asymmetry in the way they process negative versus positive information, a phenomenon called negativity bias. Specifically, adults tend to take disproportionate note of negative information (Rozin and Royzman (2001), and Vaish et al. (2008)). We hypothesize that market participants observing Chair's negative facial expressions during the FOMC press conference may associate similar negative feelings with the discussed topic. While we consider positive emotions in our robustness checks, the amount of positive facial expressions in our sample is extremely small.

We argue that given the presence of information asymmetry, market participants might interpret excessive intensity in negative facial expressions as a signal for worse economic outlook, beyond what is expressed verbally during the press conference. To formally examine

[1]Moreover, there is some anecdotal evidence that supports this reasoning. According to MarketWatch.com, there are certain hedge funds already studying Jerome Powells facial expressions in order to predict the direction of interest rates. See, for example: https://www.marketwatch.com/story/hedge-funds-are-studying-jerome-powells-facial-expressions-to-predict-interest-rates-2018-03-22

this assertion, we analyze price and volume changes of several financial asset classes over the course of the FOMC press conference. In our analysis, we control for content, general market conditions, meeting level characteristics, and other relevant controls described later in the paper. To account for potential announcement drift, we control for price changes in our set of assets from ten minutes prior to the press statement to the beginning of the press conference. We find that investors' adversely react to Chairs' negative facial expressions exhibited during the press conference. This effect is statistically significant across asset classes and specifications. Furthermore, we document that the impact of Chairs' negative facial expressions on the market is heightened when forward guidance is discussed during the press conference. We also note that Chairs' negative emotions lower trading volume in the subsequent three minute interval.

Finally, we show that the effect of negative emotions on the different market measures dissipates within five to ten minutes after the negative emotions are exhibited. Our results are robust to several alternative specifications of expressed emotions.

The economic significance of our findings is the following. For example, for every standard deviation increase in our negative emotions score, there is an associated decrease of 0.528 basis point in SPY index, during a given three minutes interval. This results applies to other asset classes, such as implied volatility index (increase of 3.73 basis points), and Euro to US Dollar exchange rate (decrease of 0.184 basis points).

The rest of the paper is organized as follows. We discuss relevant literature in Section 2, data in Section 3, and present our empirical results in Section 4. Section 5 presents our robustness checks, and Section 6 discusses policy implications and concludes.

2. Literature Review

2.1. FOMC Press Conferences

The FOMC Committee holds eight regularly scheduled meetings during a calendar year. During each meeting, there is a discussion of monetary policy actions at hand, as well as its likely future course. Policy decisions have been announced to the public via the post-FOMC statement releases starting in 1994, if the policy rate was changed. Since May 1999, the FOMC has issued a post-FOMC statement after every scheduled meeting. Starting June 1999, the statements began referring to specific target levels for the federal funds rate. Also in 1999, the FOMC Committee began to issue forward guidance in the form of an assessment of the perceived risks going forward.

The post-FOMC statements has been growing in both size and importance after the federal funds rate was lowered to its effective lower bound in December 2008. Given the increase in the level of complexity of Fed actions during that period, and in an effort to further increase transparency, the then Chairman Ben Bernanke began to hold press conferences following some, but not all, FOMC meetings. Starting 2019, all FOMC meetings have been followed by a press conference.

Market response to post-FOMC statements has changed since the introduction of press conferences. For example, Lucca and Moench (2015) show that there has been a large risk premium and stock price drift ahead of a post FOMC statement announcement (the so called pre-FOMC drift). Boguth et al. (2019) show that this price drift occurs only if the Federal Reserve Chair holds a press conference after the FOMC announcement. They show that markets have adjusted to expect more important decisions on days with press conferences, and so the media and investors concentrate most of their attention on those meetings. The authors argue that the press conference in itself carries little to no new information to the markets.

At the same time, Gomez Cram and Grotteria (2020) show a strong positive correlation

between price changes around the post FOMC statement releases and the subsequent press conferences. The only way this would be possible is if the information communicated via a press conference was new to at least some of the investors. The authors hypothesize that there is an ongoing learning process during the press conference, with journalists asking for clarifications and explanations. They show how the messages communicated during the post-FOMC press conference form investors expectations, and specifically document the importance of those moments in which the Fed Chairman answers questions related to the interpretation of the post-meeting statement.

In this paper, we argue that the aforementioned learning process is composed of both the verbal and nonverbal communication components. We hypothesize that market participants derive information from nonverbal communication expressed by Fed Chairmen to decipher verbal communication, and subsequently form expectations regarding the state of the economy. We disaggregate press conference information into verbal and nonverbal components by considering both the text and the images of each conference. We then estimate the impact of nonverbal communication on the markets, while controlling for the verbal component and other explanatory variables. As previously discussed, the expectations transmission channel of monetary policy has gained considerable importance during the recent decades. Therefore, factors that potentially impact investor expectations will impact the transmission of monetary policy. This paper ultimately links the reaction of market participants to Chairs' nonverbal communication with monetary policy transmission.

2.2. Nonverbal Communication in Finance

Nonverbal communication plays a large role in all human interactions (Birdwhistell (1970); Philpott (1983)). Impressions about other people, as well as interpretations of what they say, are largely based on factors other than the verbal content (Hecht and Ambady (1999); Leathers and Eaves (2015)). Facial expressions in particular play a significant role in con-

veying nonverbal communication (El Kaliouby and Robinson (2004)). Moreover, humans react to nonverbal communication based on a thin slice of behavioral evidence. Research in psychology indicates that humans routinely make rapid evaluations based on one-time interactions (Ambady et al. (2000)). This is consistent with rational inattention theory, where humans lack the ability to quickly absorb all available information, and base their decisions on select bits of data.

The existing literature in finance applies this theory of human behavior to analyze nonverbal communication and its impact on market outcomes. For example, Mayew and Venkatachalam (2012) examine response of capital market to managers nonverbal communication as expressed by the stress in the manage's voice during conference calls. They show that the stressed voice indicator is often a better predictor of future firm performance than is the content of manager's speech. Blankespoor et al. (2017) develop a composite measure of investor perception using 30-second video clips of initial public offering (IPO) roadshow presentations. They provide evidence that investors' perception of management is incorporated into their assessments of firm value. Hill et al. (2019) use third-party ratings of video samples to assess positive and negative communication signals expressed by chief executive officers (CEOs), as well as their overall perceived appeal.

There has been some research done specific to facial expressions. Breaban and Noussair (2018) analyze facial expressions of traders and link expressed fear to negative movements in a firms stock price, and positive emotional state with purchases and overpricing. Choudhury et al. (2018) use both the videos and the corresponding transcripts of interviews with emerging market CEOs to establish their communication styles. They synthesize the videos and transcripts and produce distinct communication styles that incorporate both verbal and nonverbal aspects of the conducted interviews. They then relate CEO communication styles to firms mergers and acquisitions outcomes. Akansu et al. (2017) show that if a CEO shows disgust or anger during a media interview, there is a subsequent increase in the firms profit

margin, sales growth, and return on assets, and when a CEO shows happiness in their face, there is a subsequent decrease in profit margin, return on equity, and return on assets. Momtaz (2019) examines how nonverbal communication expressed by CEOs impacts rm valuation in blockchain-based issuance of cryptocurrency tokens to raise growth capital. The paper shows that negative emotions expressed by CEOs are associated with lower absolute-value deviations from market's average underpricing level. Positive emotions, on the other hand, do not signicantly inuence underpricing behavior.

Overall, this strand of literature provides strong evidence that nonverbal communication by executives impacts firm outcomes. We provide an extension to this body of literature by considering a new context, and looking at nonverbal communication by the Federal Reserve Chairs and subsequent market responses.

3. Data

Our data comes from three main sources. First, to proxy for changes in market responses, we look at minute-level changes in prices of several financial asset classes. Second, to measure nonverbal communication, we build a composite score that captures the intensity of negative facial expressions conveyed by the Fed Chairs during the FOMC press conferences. And third, to control for other aspects related to market environment and meeting characteristics, we include a set of additional control variables.

3.1. Market Responses

We proxy for changes in market expectations with high-frequency changes in asset volumes and prices. Nakamura and Steinsson (2018) show that this type of identification addresses both endogeneity issues and omitted variables bias. Using high frequency data and narrow time windows decreases the likelihood that other relevant information, such as relevant macroeconomic news, is released around policy announcements, thus impacting the market.

This approach removes the possibility that it is the monetary policy that is reacting to movements in asset prices, and not the other way around.

Monetary policy announcements impact prices of a wide range of financial assets. Because we look at very narrow time windows, we can assume changes in price are due to FOMC communication, and not due to a response to other events that occurred when markets are actively traded. We construct price changes around the statement release, and the subsequent press conference using a set of market instruments. Specifically, we use equity and futures prices, implied volatility, and Euro to US Dollar exchange rate to measure the market reaction to nonverbal component expressed during the press conference.

Detailed definitions of these variable are listed in Table 1.

[Insert Table 1 about here]

- SPDR S&P 500 (SPY): We use a historical dataset of SPY prices at one-minute frequency, spanning January 2011 to September 2020. We also use the SPY trading volume, measured in number of individual shares traded.

- CBOE Volatility Index (VIX): The Chicago Board Options Exchange Market Volatility Index (VIX) is an implied volatility index. We use the option-implied volatility of the S&P 500, as measured by the VIX index, to proxy for uncertainty associated with monetary policy. The time series spans January 2011 to September 2020.

- Euro-to-USD Exchange Rate (EURUSD): we use historical market data for deal-able interbank Euro-to-USD exchange rates for each minute. The time series spans January 2011 to September 2020. We also use the Euro-to-USD trading volume, measured in millions of base currency.

- 10-Year Treasury Note Futures (ZN10): historical market data for 10-Year Treasury Note traded on the Chicago Mercantile Exchange (CME). The time series spans January

2011 to September 2020. The continuous series is created by chaining together front-month contracts and rolling to the next month on the final day of the contract. We also use the ZN10 trading volume, measured in number of contracts.

We construct our main dependent variables based on the above data. We calculate percent changes within 3 minute intervals in SPY, VIX, FX, and ZN10 prices, all measured in basis points. We calculate the average trading volume within 3 minute intervals during the time of the press conference in SPY, FX, and ZN10. Table 2, Panel A reports the number of observations, mean value, standard deviation, and percentile distribution for the three minute interval price changes.

[Insert Table 2 about here]

The average price change for SPY over the course of 3 minutes is around zero, with a median of 0.4 basis points. The average price change for ZN10 is around 0.08 basis points, with a median of zero. The price changes for these instruments are of similar magnitude. The FX instrument fluctuates comparably to SPY during the press conference, with a mean of -0.17 basis points, and a median of 0.07 basis points. The average change for VIX over the course of 3 minutes is around -2 basis points, with a median of zero.

Trading volumes for SPY, FX and ZN10 during the FOMC press conferences are higher than on FOMC announcement days without the press conference, as documented by Gomez Cram and Grotteria (2020). In our sample there are, on a average, 447,000 SPY shares, 713 million of EURUSD base currency, and 4,619 ZN10 contracts traded per minute over the course of the conference.

3.2. Facial Expressions

The proliferation of machine learning methods in the last several years has made automatic recognition of facial expressions scalable. With precision greatly improved over the years,

these algorithms now perform essentially as accurately as human evaluators (Howard et al. (2017)). Besides scalability, accuracy, and speed, this method is easily reproducible, allowing for greater replication.

For our analysis, we use Microsoft Azure Cognitive Services Emotion API.[2] This API recognizes all seven basic emotions and a neutral face. The image recognition process involves taking an image as an input and transforming the image into a field of weighted pixels to code eight facial emotions (*Anger*, *Contempt*, *Disgust*, *Fear*, *Happiness*, *Neutral*, *Sadness*, and *Surprise*). The weights are generated by minimizing a loss function that compares the input image to images from a prior training set that have been coded for predetermined facial emotions. The API then returns emotion scores for the eight facial emotions, where each emotion receives a score between zero and one. These scores add up to 100%.[3]

Our sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 26^{th}, 2011 and September 16^{th}, 2020. On average, the duration of each press conference video is about 55 minutes long, where the first 10 minutes on average correspond to the opening statement made by the Fed Chair. The sample contains press conferences of the three Federal Reserve Chairs to serve between years 2011 and 2020: Ben Bernanke, Janet Yellen, and Jerome Powell. The structure of each press conference has stayed consistent throughout the years. Each press conference starts with the Chair reading an opening statement that provides more details on the current FOMC decision, and follows with a Q&A portion, with journalists asking the Chair questions ranging from the current state of the economy to the future direction of interest rates.

We decompose each of the 46 videos into a set of frames. Each frame is captured at the two second interval. We then use this set of frames as an input data for the API, and collect

[2]https://azure.microsoft.com/en-us/services/cognitive-services/face/

[3]Figure A1 in Appendix A provides an example of the scored frames for the three Chairs in our sample.

the output – estimated scores for each frame. Each score can be interpreted as an indicator of the intensity of the emotion expressed, relative to the other emotions that could have been expressed within that frame. In addition, for our analysis we consider frames that contain the face of the Chair only, and remove the journalist faces from the sample.

Once the set of the two second frames is scored, we aggregate these scores to a three minute level, in line with how we aggregate the market response variables described in the previous section. The interpretation for the aggregates here is the following. If we take the average score of $Fear$, for example, expressed during a specific three minute interval, we would get an extent to which the individual on camera expressed fear during those three minutes.

Using these intensity scores, we construct our main independent variable called *Negative Emotions*. *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over three minute intervals, scaled by the average intensity of negative emotions across all FOMC meetings presided by the Chair. The intensity scores of $Anger$, $Disgust$, and $Fear$ are considered as negative emotions.[4]

$$Negative\ Emotions_{i,k} = \frac{(Anger_{i,k} + Disgust_{i,k} + Fear_{i,k})}{(\overline{Anger_k} + \overline{Disgust_k} + \overline{Fear_k})} \tag{1}$$

In the above equation, $Anger_{i,k}$ for example, represents the average intensity of anger expressed during a given 3 minute interval i for Chair k. Correspondingly, $\overline{Anger_k}$ represents the average intensity of anger expressed across the sample by Chair k.

As discussed, we are focusing on negative emotions because we want to explore whether in the presence of information asymmetry market participants would interpret excessive intensity in negative facial expressions as a signal for worse economic outlook.

[4]In an unreported analysis (available upon request), we add *Sadness* as a negative emotion and our results are unchanged. We decided to not include *Sadness* as a negative emotion in our main measure of *Negative Emotions*, as it may not necessarily reflect a strong negative sentiment, as, for example, anger.

In an effort to provide further evidence to the effect of Chairs' emotions on market participants, we create several alternative measures of negative emotions. First, we build a measure that leverages all seven emotion scores by employing Principal Component Analyses (PCA), a dimensionality reduction technique. *Negative Emotions*$_{pca}$ score is created in the same fashion as our main measure in Equation 1, but uses the combination of all seven intensity scores (*Anger*, *Contempt*, *Disgust*, *Fear*, *Happiness*, *Sadness*, and *Surprise*) multiplied by their first principal component coefficients.[5] Next, we build a measure *Negative Emotions*$_{dmd}$, estimating negative emotions in an absolute way instead of a relative way, with respect to the Chairs' average intensity of emotions. Specifically, instead of taking the ratio of Chairs' negative emotions to their averages, we subtract them. This measure considers the difference between negative emotions expressed in a three minute interval and the Chairs' averages in the same manner across Chairs, regardless of Chairs' negative emotion averages. Lastly, *Negative Emotions*$_{std}$ measure is based on the standard deviation of negative emotions expressed in three minute intervals. This variable captures pronounced swings in expressed emotions. We report our results in Section 5 (Robustness Checks). Overall, our results hold under alternative specifications of our main explanatory variable.

Table 1 reports the variable definitions for *Negative Emotions* and its alternatives. Table 2, Panel B presents descriptive statistics for *Negative Emotions* and its alternatives. As previously defined, *Negative Emotions* accounts for each Chairs average intensity of negative emotions in three minute intervals, with higher numbers denoting more negative emotions.

Figure 1 shows the *Negative Emotions* average score, within a FOMC meeting, by each Chair. As can be seen, the *Negative Emotions* meeting average differs greatly across meetings and all Chairs' exhibit variation.

[5]Figure 3 visualizes the first two principal component scores. Higher values of the first principal component are associated with more negative emotions as *Fear*, *Disgust*, and *Anger* are the emotions with the largest positive coefficients and *Happiness* is the only sentiment with a negative coefficient. The figure also indirectly support our selection of emotions for the main measure of *Negative Emotions*.

3.3. Control Variables

To control for aspects related to the state of the economy, and to the environment surrounding each meeting, we include a set of additional control variables in our analysis. Table 1 presents definitions of these variables. Table 2, Panel C presents descriptive statistics.

First, we include a simple proxy of communication tone, *Negative Tone*. Using FOMC press conference transcripts, we extract the text of the discussion. We then break down the text into minute long intervals and apply a dictionary based method to calculate the sentiment expressed in the text. We follow a common practice in sentiment analysis and use the Loughran and McDonald (2011) finance specific dictionary. We calculate the number of finance specific negative words during each minute. We consider the negative sentiment category only. Tetlock (2015) and Loughran and McDonald (2011) find limited incremental value for other categories like positive words, and so we focus on the frequency of negative words relative to the total number of words only. *Negative Tone* captures the tone of each of the 3 minute long text excerpts.[6]

Second, we include the change in the Federal Funds Rate (FFR) for the current FOMC meeting, measured in basis points, ΔFFR, to control for the actual change in the key rate.

Then, we include a set of so called pre-drift variables. We include these variables to control for autocorrelation in prices changes. *SPY*, *VIX*, *EURUSD*, and *ZN10* pre drift variables measure the percent change in the relevant asset price within the 30 minutes preceding the start of an FOMC press conference, measured in basis points. We specifically control for these variable given that the reaction from the publication of the FOMC statements carries forward, as shown by Lucca and Moench (2015) and Gomez Cram and Grotteria (2020).

We also include a measure of monetary policy uncertainty, *MPU*, developed by Husted et al. (2020). *MPU* is an index that captures the degree of uncertainty the public hold

[6]In addition, we test alternative vocabularies, as well as z-standardizing our main variable *Negative Tone*, and find no significant impact on our results. This analysis is available upon request.

regarding the Federal Reserve policy actions and its consequences. This index tracks the frequency of newspaper articles related to monetary policy uncertainty in major news outlets.

The last control variable is *Market Conditions*, included to reflect current market conditions. This variable is based on the cumulative return of S&P 500, calculated across all trading days, starting from the Monday following a previous FOMC meeting and ending three days before the current FOMC meeting.

In investigating heterogeneity effects, we first include *Media Coverage* and *Press Statement Surprise* as interaction variables. Both variables measure the degree of attention each FOMC press conference receives. *Media Coverage* is based on the daily number of articles related to the Federal Reserve and published in Wall Street Journal and New York Times. This variable thus captures the ex-ante interest in the meeting.[7] *Press Statement Surprise* is derived from 30 Day Fed Fund Futures data, and is measured as the absolute change, in basis points, of 30 Day Fed Fund Futures occurring from 10 minutes prior to the FOMC announcement (1:50pm) and up until the start of the FOMC press conference (2:30pm). This variable captures the element of surprise the FOMC announcement delivered to the market.

Finally, we label each sentence in the press conference transcript as either one discussing the status of the economy, forward guidance, or other. Specifically, for each three minute interval, we create three dummy variables taking the value of one if either the status of the economy (*Status of Economy*), forward guidance (*Forward Guidance*) or other topics (*Other*) are discussed for the majority of the time, and zero otherwise. Table 2, Panel C shows that, on average, status of the economy is discussed for about 12% of the total conference time, and topics related to forward guidance are discussed for about 17% of the total conference time.[8]

[7] We follow Boguth et al. (2019) to construct the relevant search query.

[8] Appendix B provides examples of how transcript excerpts are assigned into these three categories.

3.4. Variable Correlations

Table 3 describes variable correlations. Panel A reports correlations between our set of market responses and our main measure of negative sentiment, *Negative Emotions*. Panel B reports correlations between negative emotions variables and the variable that measures the tone of the verbal component, *Negative Tone*.

[Insert Table 3 about here]

Panel A reports correlations between our dependent variables *SPY*, *EURUSD*, *VIX*, *ZN10*, and our key explanatory variable, *Negative Emotions*. The correlations between these variables are as expected: negative, and of similar magnitude for *SPY*, *EURUSD*, and *ZN10*, and positive for *VIX*. For *SPY*, *EURUSD*, and *ZN10* the correlations are at -0.047, -0.040, and -0.044, respectively. The correlation is at 0.028 for *VIX*. We also note that the relation between the *Negative Emotions* and the asset price changes is significant, with the exception of *VIX*.

Panel B reports correlations between our set of negative emotions variables and the variable that measures the tone of the verbal component, *Negative Tone*. The correlations between our set of explanatory variables and the written sentiment are weakly positive and of similar magnitude, with the exception of *Negative Emotions*$_{std}$, that measures volatility in expressed negative emotions. For example, the correlation between *Negative Emotions* and *Negative Tone* is at 0.012, a weak positive correlation. For *Negative Emotions*$_{pca}$ and *Negative Emotions*$_{dmd}$, the correlations are at 0.038 and 0.025, respectively. For *Negative Emotions*$_{std}$, the correlation is at -0.047. Overall, this is gives us confidence that there are no multicollinearity issues between our verbal and nonverbal components.

The next section lays out our main results.

4. Regression Results

4.1. Market Reaction

In order to examine whether Chairs' negative emotions are related to the changes in the stock, currency, and treasury markets we next employ multivariate regressions that enables us to control for confounding effects. We estimate the following main specification for each of our dependent variables:

$$\%\Delta Market_{t,me} = \alpha_{fe} + \beta_1 Negative\ Emotions_{t-1} + \beta_k Ctrls_{t-1} + \epsilon_{t,me,fe} \tag{2}$$

where t indexes the minutes, me indexes the FOMC meeting, and fe indexes either the Chair or FOMC meeting. $\%\Delta Market$ is the percent change in price, in the following three minutes, for one of our four market measures: *SPY*, *VIX*, *EURUSD*, and *ZN10*. *Negative Emotions* variable represents Chair's intensity of negative emotions averaged in the prior three minutes, and divided by the average intensity of negative emotions across all FOMC meetings presided by the same Chair. $Ctrls$ represents a vector of control variables described in Section 3.3. α_{fe} represents either Chair or FOMC meeting fixed effects, which absorbs potentially different levels of markets' percent changes and negative emotions at the Chair or FOMC meeting levels. We cluster standard errors at the Chair level to account for within-Chair correlation of the error terms. Table 4 presents the results of our main specification under different fixed effect schemes.

[Insert Table 4 about here]

Table 4, Panel A, examines the impact of Chairs' negative emotions on percent changes in SPY and VIX. Column (1) starts with a pooled regression specification with no fixed effects. The coefficient on *Negative Emotions* is negative and statistically significant at the 1% level. Columns (2)-(3) further suggest that the negative association in Column (1) is robust to

the introduction of either Chair or FOMC meeting fixed effects. Based on the specification in Column (3), with meeting fixed effects, a one standard deviation increase in *Negative Emotions* is associated with a -0.528 basis point change in SPY ($= 1.060 * (-0.499)$) for a three minutes interval. Columns (4)-(6) show that the coefficient on *Negative Emotions* is positive and statistically significant at the 10% level for the two specifications with fixed effect and close to statistically significant for the one without fixed effect, suggesting that more intense negative emotions increase stock market volatility, as captured by VIX. Based on the specification in Column (6), with meeting fixed effects, a one standard deviation increase in *Negative Emotions* is associated with a 3.730 basis point increase in VIX ($= 1.060 * 3.519$) for a three minutes interval.

Table 4, Panel B, examines the impact of Chairs' negative emotions on percent changes in EURUSD exchange rate and ZN10. Columns (1)-(3) show that the coefficient on *Negative Emotions* is negative and statistically significant at the 5% level, suggesting that more intense negative emotions impact the change in EUR-to-USD exchange rate negatively. Columns (2)-(3) further suggest that the negative association in Column (1) is robust to the introduction of either Chair or FOMC Meeting fixed effect. Based on the specification in Column (3), with meeting fixed effects, a one standard deviation increase in *Negative Emotions* is associated with a -0.184 basis point change in EURUSD ($= 1.060 * (-0.174)$) for an interval of three minutes. Columns (4)-(6) show that the relation between *Negative Emotions* and the 10-Year T-Note Price change is negative, but not significant at conventional levels. While potentially surprising that no statistically significant relation is found between *Negative Emotions* and ZN10, several studies in the academic literature have shown that ZN10 is less impacted by the FOMC Press Conference with respect to the other asset classes we investigate.

Overall, our results indicate that certain facial expressions, as captured by the variable *Negative Emotions*, adversely impact the markets. In the next section we investigate whether *Negative Emotions* variable impacts trading volumes.

4.2. Trading Volumes

A growing body of literature documents that both trading volume and market depth increase during FOMC announcement days and, in particular, those minutes surrounding the statement release (Fleming and Piazzesi (2005)) or those surrounding the press conference (Gomez Cram and Grotteria (2020)). Overall, trading volume spikes at the beginning of the statement release and decreases afterwards. Kim and Verrecchia (1991) and Shalen (1993) theoretical frameworks predict that new information may generate trading by changing the extent of disagreement between market participants. Specifically, those frameworks predict that an increased disagreement among agents on new information would lead to an increase in trading volume. Conversely, a decrease in trading volume should reflect a convergence in agents belief about new information.

To investigate the relation between trading volumes and *Negative Emotions* we perform a multivariate regression analysis in the spirit of Eq. (2), with dependent variables being the average trading volumes evaluated in the three minutes following the measurement of the independent variables. Table 5 presents the results.

[Insert Table 5 about here]

Column (1) shows that the there is a statistically significant negative relation between SPY trading volume and Chair's *Negative Emotions*. In Columns (2)-(3) the estimated coefficient sign remains negative, but shows no statistically significant relationship between *Negative Emotions* and EURUSD and ZN10 trading volumes. Based on the specification in Column (1), a one standard deviation increase in *Negative Emotions* is associated with a trading decrease of 12,702 shares per minute ($= 1.060 * (-0.012) * 1,000,000$), which represent a 2.85% decrease with respect to the unconditional SPY trading volume mean. Overall, our results suggest that *Negative Tone* significantly reduces trading volumes across all the three asset classes, while *Negative Emotions* reduces trading volume only for SPY.

4.3. Media Attention and Press Statement Surprise

To examine whether increased attention exacerbates the reaction of market participants to negative emotions expressed by the Chair, we include two measures of market attention in our analysis.

Table 6, Panel A summarizes our findings with respect to the amount of media coverage of an upcoming FOMC meeting using *Media Coverage* variable. Column (1) shows that increased media attention provides an amplification effect to nonverbal communication for SPY, which is unsurprising.

Columns (1) and (3) show that there is a statistically significant effect of increased media attention on the reaction of market participants to negative emotions expressed during the press conference. While there is no statistical significance for columns (2) and (4), the coefficient sign remains positive for *VIX* and negative for *ZN*.

[Insert Table 6 about here]

Table 6, Panel B presents results related to an alternative measure of attention, *Press Statement Surprise*. This measure captures the reaction of market expectations relating to future interest rates, based on the arrival of new information following the post FOMC press statement. We construct it by calculating the absolute change in the 30 Day Fed Fund Futures prices, occurring from 10 minutes before the FOMC Press Statement (1:50pm) and the beginning of the FOMC Press Conference (2:30pm).

Columns (1) and (2) show that there is a statistically significant effect of FOMC announcement surprise on the reaction of market participants to negative emotions expressed during the press conference. Column (3) shows a statistically significant response as well, albeit with a positive coefficient sign.

4.4. Written Tone and Discussion Theme

In this section, we examine the interaction between the negative emotions expressed by the Chair with the tone and topic of the verbal component.

The tone here is the overall level of negative sentiment in the press conference, captured by *Negative Tone* variable. We capture the text sentiment in order to control for the content of the message, and we use it as an interaction term in our estimation in order to see whether there is an amplification effect between the verbal and nonverbal communication instances.

The topic of the verbal component also controls for the content of the message, but it specifically captures whether the discussion was geared towards forward guidance or economic conditions. We create discussion theme dummies, *Status of Economy* and *Forward Guidance*, by manually labeling the press conference transcripts. We examine the interaction between the topics of the discussion and the negative emotions expressed in order to capture any interplay between the two variables.

Table 7, Panel A summarizes our findings with respect to the overall level of negative sentiment, captured by *Negative Tone*. Column (1) shows that coefficient on the interaction term is positive and significant, while it is negative and significant in Column (4). The adverse effect of *Negative Emotions* on stock market is diminished if the tone of the conference takes a more negative turn. Market participants seem to focus on the content of the message, and disregard facial expressions when the tone of the message becomes more negative. However, this results does not hold for treasuries, where it seems to create an opposite effect.

[Insert Table 7 about here]

Table 7, Panel B considers interactions with our labeled discussion theme dummies, *Status of Economy* and *Forward Guidance*, while controlling for the *Negative Tone* variable.

Results in Column (1) show that the adverse effect of *Negative Emotions* on markets is amplified if forward guidance is discussed during the conference. This means that market

participants consider negative facial expressions in the context of what is being discussed. At the same time, when status of the economy is discuss, the amplification effect is not significant. This might signal that any discussion of current economic activity is already priced in, and the markets are reacting only to forward looking information, as signified by the *Forward Guidance* indicator.

5. Robustness Checks

5.1. The Impact of Negative Emotions Through Time

In this section we investigate how long the impact of Chairs' negative emotions lasts on the markets. Our main specification relies on a three minute time window to measure the changes in the stock, currency, and treasury markets. We use a three minute time frame because we consider it to be long enough for the markets to react in response to any given communication instance, and short enough to be able to identify the impact of Chairs' negative emotions in a clean manner.

[Insert Figure 2 about here]

Figure 2 provides a comprehensive picture of how Chairs' negative emotions impact the markets using different estimation windows. Specifically, Figure 2 presents coefficients and 90% confidence intervals from OLS regressions of price changes in the stock, currency and treasury markets on Chairs' *Negative Emotions* and control variables. The estimated coefficients presented in the panel graphs reflect our original specification with meeting Fixed Effects and varying estimation windows, from one to fifteen minutes, for the dependent variables.

[Insert Table 8 about here]

Table 7, Panel A presents our estimation results for the stock market measures, *SPY* and *VIX*. Columns (1) and (2) show that the impact of Chairs' negative emotions is still

statistically significant when considering windows that are five and ten minutes long for *SPY*. Coefficients in Columns (3) and (4) are of expected sign and decreasing magnitude, but not significant. Table 7 Panel B presents our estimation results for *EURUSD* and *ZN10*. In these cases our results suggest that the impact of Chairs negative emotions dissipates more quickly, as the coefficients in Columns (1) through (4) are not statistically significant for both the five minute and ten minute window alternatives.

The results in this section show that the impact of Chairs' negative emotions tends to dissipate, depending on the instrument, within five to ten minute interval.

5.2. Alternative Specifications of Negative Emotions

In this section, we re-estimate Equation 2 using a set of alternative measures for our main explanatory variable, *Negative Emotions*. Specifically, we consider three alternatives: *Negative Emotions*$_{pca}$, *Negative Emotions*$_{dmd}$, and *Negative Emotions*$_{std}$. *Negative Emotions*$_{pca}$ is a measure that leverages all seven intensity scores (*Anger*, *Contempt*, *Disgust*, *Fear*, *Happiness*, *Sadness*, and *Surprise*) and is derived using principal component analysis. To construct the measure, the intensity scores of each emotion are multiplied by the first principal component coefficients estimated using 75,540 frames at the two-seconds level from the 46 the FOMC meetings analyzed in this study. As can be seen on the x-axis of Figure 3, negative emotions are associated with a positive principal component coefficient, while *happiness* is associated with a negative principal component coefficient, keeping the same interpretation as our main measure. *Negative Emotions*$_{dmd}$ estimates negative emotions in an absolute way instead of a relative way, with respect to the Chairs' average intensity of emotions. Specifically, to construct the measure we subtract the Chairs' averages from the Chairs' negative emotion in the prior three minutes instead of dividing the Chairs' negative emotions by their averages. Finally, to investigate whether changes in emotions also have an effects on the markets, we construct *Negative Emotions*$_{std}$ a measure based on the standard

deviation of negative emotions expressed in the prior three minutes, or ninety frames.

[Insert Figure 3 about here]

[Insert Table 9 about here]

Table 9, Panel A considers these alternative measures of negative emotions and their impact on *SPY* and *VIX*. Columns (1) through (3) show that the coefficients of all three measures have same sign and similar statistical significance with respect to our main explanatory variable, *Negative Emotions*. The coefficients in Columns (4)-(6) are of expected sign and statistically significant at the 10% (or very close to that). Table 9, Panel B considers the alternative measures of negative emotions and their impact on *EURUSD* and *ZN*. Columns (1) through (3) show that the coefficients of all three alternative measures are of predicted sign and statistically significant. Columns (4) through (6) show that the coefficients for the negative emotions variables are of expected sign, but not statistically significant, as per our main specification.

Overall, Table 9 results show that the adverse effect of Chairs' negative emotions on the markets, as documented in our main specification, is not a function of how we construct the emotion based measure, and is robust to: 1) estimating Chairs' negative emotions considering all the emotions identified by the Microsoft Emotion API instead of considering only the negative ones; 2) estimating Chairs' negative emotions in an absolute manner instead of relative manner, with respect to the Chairs' negative emotions average, and; 3) estimating Chair's negative emotions using a measure that captures the variability of emotions within the three minute interval.

6. Conclusion

With this paper, we establish a new strand of literature. Given the ever-increasing reliance of central banks on communication-based tools, this emerging line of work can help policy-

makers improve the effectiveness of these tools.

In this paper, we capture and quantify the nonverbal part of policy communication. We start with a premise that nonverbal communication reveals information about the state and trajectory of the economy to market participants. We confirm this premise empirically, and show that nonverbal communication plays a role in influencing investors' beliefs.

We first apply facial recognition methods to FOMC press conference videos to capture and quantify the facial expressions. We construct a nonverbal communication measure using these expressions. Using minute-level data, we align our nonverbal communication measure with a set of financial assets to estimate the impact of facial expressions on investor expectations. We find a significant adverse relation between Chairs' negative emotions expressed during the press conference and reaction of investors, even when controlling for the content of the conference and additional explanatory variables. Furthermore, we observe that the adverse impact of the Chairs negative emotions on the markets is heightened when forward guidance is discussed during the press conference.

Nakamura and Steinsson (2018) underscore the "information effect" of monetary policy communication, forward guidance among them. Discussions featuring forward guidance provide direct information on the probable future state of monetary policy. The purpose of forward guidance is to influence expectations.

The common understanding among market participants is that forward guidance is either a form of commitment ("Odyssean"), or a way of conveying information to the public ("Delphic") (Campbell et al. (2012)). Given the issue of asymmetrical information that divides market participants and policymakers, communication related to forward guidance might be, at any given time, perceived as an indicator of deterioration in macroeconomic fundamentals, and result in Delphic pessimism among market participants. When it comes to communication, there needs to be an effective strategy that prevents Delphic information effect.

Our paper shows that certain facial expressions exhibited during the press conference could, in fact, exacerbate the Delphic effect. We provide evidence that certain aspects of press conference discourse have a potential to cause market under-reaction or overreaction. With this insight in mind, it seems that shaping expectations becomes even more of an intricate game than previously thought. When Fed Chairmen speak, the market not only listens, but also watches.

References

Akansu, A., Cicon, J., Ferris, S. P., and Sun, Y. (2017). Firm performance in the face of fear: How ceo moods affect firm performance. *Journal of Behavioral Finance*, 18(4):373–389.

Amato, J. D., Morris, S., and Shin, H. S. (2002). Communication and monetary policy. *Oxford Review of Economic Policy*, 18(4):495–503.

Ambady, N., Bernieri, F. J., and Richeson, J. A. (2000). Toward a histology of social behavior: Judgmental accuracy from thin slices of the behavioral stream. *Advances in Experimental Social Psychology*, 32:201–271.

Barsade, S. G. (2002). The ripple effect: Emotional contagion and its influence on group behavior. *Administrative Science Quarterly*, 47(4):644–675.

Bernanke, B. (2004). The great moderation. *Board of Governors of the Federal Reserve System*.

Bernanke, B., Reinhart, V., and Sack, B. (2004). Monetary policy alternatives at the zero bound: An empirical assessment. *Brookings Papers on Economic Activity*, 2:1–100.

Birdwhistell, R. (1970). Kinesics and context. *Essays on Body-Motion Communication*.

Blankespoor, E., Hendricks, B. E., and Miller, G. S. (2017). Perceptions and price: Evidence from ceo presentations at ipo roadshows. *Journal of Accounting Research*, 55(2):275–327.

Boguth, O., Grégoire, V., and Martineau, C. (2019). Shaping expectations and coordinating attention: The unintended consequences of fomc press conferences. *Journal of Financial and Quantitative Analysis*, 54(6):2327–2353.

Breaban, A. and Noussair, C. N. (2018). Emotional state and market behavior. *Review of Finance*, 22(1):279–309.

Campbell, J. R., Fisher, J. D., Justiniano, A., and Melosi, L. (2012). Forward guidance and macroeconomic outcomes since the financial crisis. *NBER Macroeconomics Annual*, 31(1):283–357.

Choudhury, P., Wang, D., Carlson, N. A., and Khanna, T. (2018). Machine learning approaches to facial and text analysis: An application to ceo oral communication. *Harvard Business School*.

Cieslak, A., Morse, A., and Vissing-Jorgensen, A. (2019). Stock returns over the fomc cycle. *The Journal of Finance*, 74(5):2201–2248.

Coibion, O., Gorodnichenko, Y., and Weber, M. (2019). Monetary policy communications and their effects on household inflation expectations. *Working Paper*.

Eggertsson, G. B. and Woodford, M. (2003). Optimal monetary policy in a liquidity trap. *National Bureau of Economic Researchs*, w9968.

El Kaliouby, R. and Robinson, P. (2004). Real-time inference of complex mental states from facial expressions and head gestures. *Conference on Computer Vision and Pattern Recognition Workshop*.

Fleming, M. J. and Piazzesi, M. (2005). Monetary policy tick-by-tick. *Working Paper*.

Gomez Cram, R. and Grotteria, M. (2020). Real-time price discovery via verbal communication: Method and application to fedspeak. *Working Paper*.

Gorodnichenko, Y., Pham, T., and Talavera, O. (2021). The voice of monetary policy. *Working Paper*.

Gürkaynak, R. S., Sack, B., and Swanson, E. (2005). The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American Economic Review*, 95(1):425–436.

Hareli, S. and Rafaeli, A. (2008). Emotion cycles: On the social influence of emotion in organizations. *Research in Organizational Behavior*, 28:35–59.

Hecht, M. A. and Ambady, N. (1999). Nonverbal communication and psychology: Past and future. *Atlantic Journal of Communication*, 7(2):156–170.

Hill, A. D., Petrenko, O. V., Ridge, J. W., and Aime, F. (2019). Videometric measurement of individual characteristics in difficult to access subject pools: Demonstrating with ceos. *Research Methodology in Strategy and Management*, 11:36–61.

Howard, A., Zhang, C., and Horvitz, E. (2017). Addressing bias in machine learning algorithms: A pilot study on emotion recognition for intelligent systems. *IEEE Workshop on Advanced Robotics and its Social Impacts*, 2(1):1–7.

Husted, L., Rogers, J., and Sun, B. (2020). Monetary policy uncertainty. *Journal of Monetary Economics*, 115:20–36.

Kim, O. and Verrecchia, R. E. (1991). Trading volume and price reactions to public announcements. *Journal of Accounting Research*, 29(2):302–321.

Kohn, D. L. and Sack, B. (2003). Central bank talk: does it matter and why? *Finance and Economics Discussion Series*.

Kuttner, K. N. and Posen, A. S. (1999). Does talk matter after all?: Inflation targeting and central bank behavior. *Institute for International Economics Working Paper*.

Leathers, D. G. and Eaves, M. (2015). *Successful nonverbal communication: Principles and applications*. Routledge.

Loughran, T. and McDonald, B. (2011). When is a liability not a liability? textual analysis, dictionaries, and 10ks. *The Journal of Finance*, 66(1):35–65.

Lucca, D. O. and Moench, E. (2015). The prefomc announcement drift. *The Journal of Finance*, 70(1):329–371.

Lundqvist, L. O. and Dimberg, U. (1995). Facial expressions are contagious. *Journal of Psychophysiology*, 9:203–203.

Mayew, W. J. and Venkatachalam, M. (2012). The power of voice: Managerial affective states and future firm performance. *The Journal of Finance*, 67(1):1–43.

Momtaz, P. P. (2019). Ceo emotions and underpricing in initial coin offerings. *Working Paper*.

Nakamura, E. and Steinsson, J. (2018). Identification in macroeconomics. *Journal of Economic Perspectives*, 32(3):59–86.

Philpott, J. S. (1983). The relative contribution to meaning of verbal and nonverbal channels of communication: A meta-analysis. *Working Paper*.

Rosa, C. (2013). The financial market effect of fomc minutes. *Economic Policy Review*, 19(2).

Rozin, P. and Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review*, 5(4):296–320.

Shalen, C. (1993). Volume, volatility, and the dispersion of beliefs. *The Review of Financial Studies*, 6(2):405–434.

Tetlock, P. C. (2015). Giving content to investor sentiment: The role of media in the stock market. *The Journal of Finance*, 70(1):329–371.

Vaish, A., Grossmann, T., and Woodward, A. (2008). Not all emotions are created equal: the negativity bias in social-emotional development. *Psychological Bulletin*, 134(4):383.

Van Kleef, G. A., De Dreu, C. K., and Manstead, A. S. (2004). The interpersonal effects of anger and happiness in negotiations. *Journal of Personality and Social Psychology*, 86(1):57.

Woodford, M. (2001). Monetary policy in the information economy. *National Bureau of Economic Research*, w8674.

Woodford, M. (2005). Central bank communication and policy effectiveness. *National Bureau of Economic Research*, w11898.

Yellen, J. (2013). Interconnectedness and systemic risk: Lessons from the financial crisis and policy implications. *Board of Governors of the Federal Reserve System*.

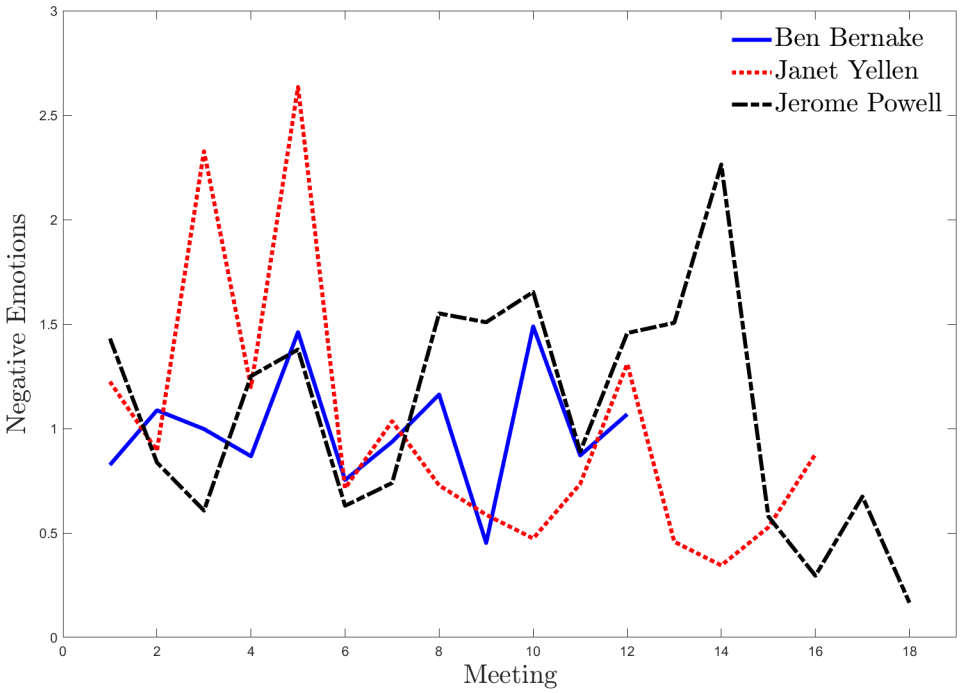


Figure 1: **Negative Emotions and FOMC Meetings**
This figure presents the relation between the equally averaged *Negative Emotions* score and the meetings presided by each of the Chairs of the Federal Reserve System. The sample comprises 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020.

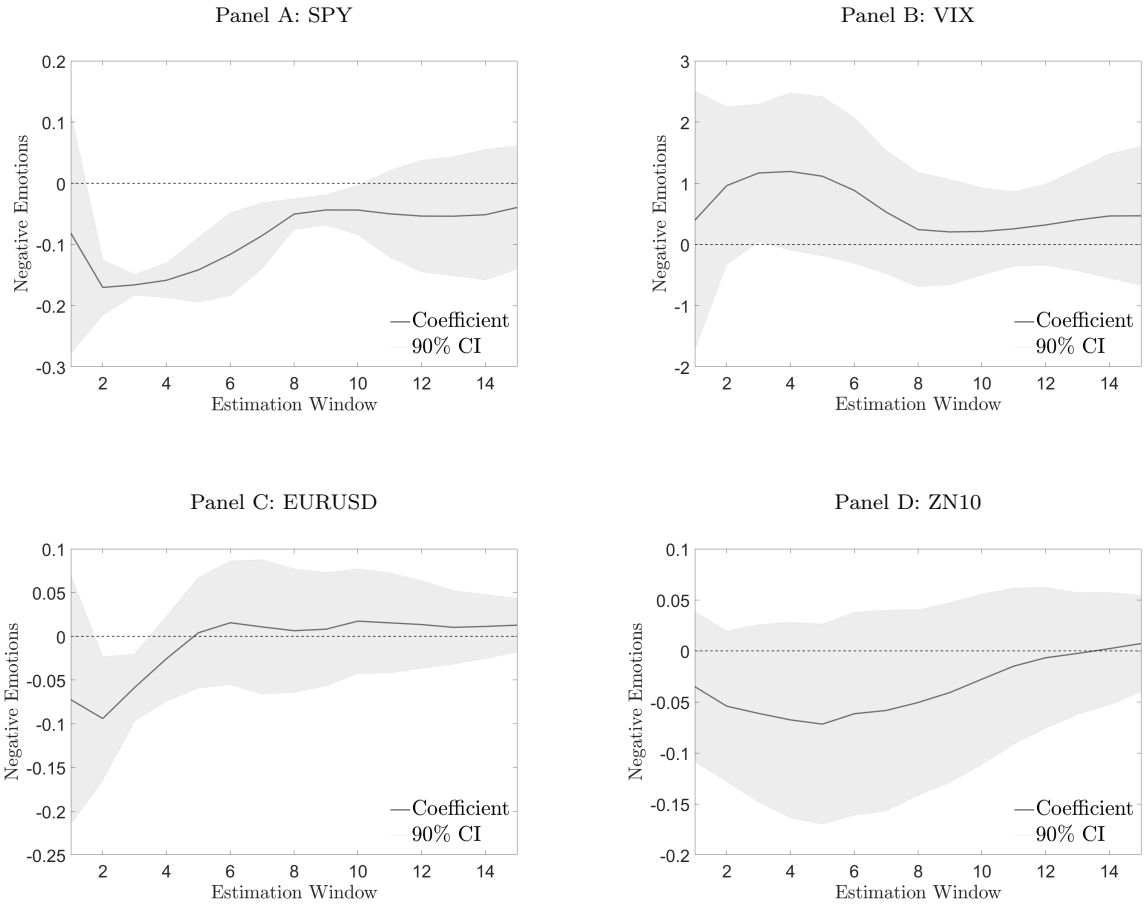


Figure 2: **The Impact of Negative Emotions Trough Time**
This figure presents coefficients and 90% confidence intervals from OLS regressions of changes in the stock, currency and treasury markets on Chairs' *Negative Emotions* and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. Specifically, the coefficient estimates presented in the graphs reflect the specification with meeting Fixed Effects and varying estimation windows, from 1 to 15 minutes, for the changes in the stock, currency, and treasury markets.

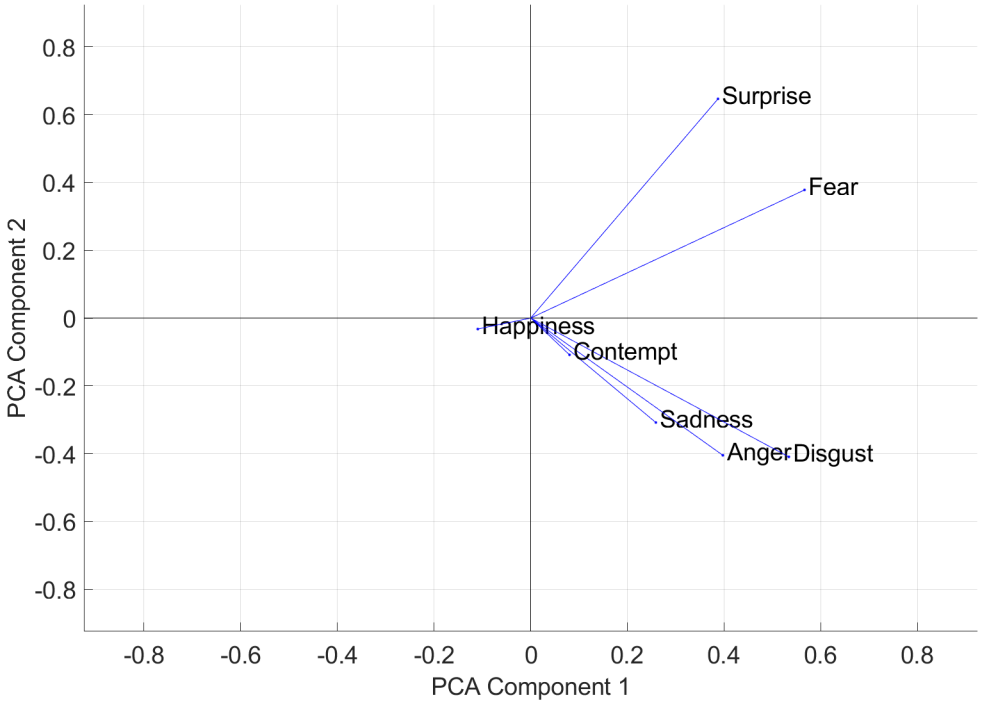


Figure 3: **Emotion Intensity Scores and Principal Component Analysis**
This figure presents the first two principal components of the emotion intensity scores as captured by the Microsoft Azure Cognitive Services Emotion API. The estimation sample includes 75,540 frames at the two-seconds level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020.

Table 1: **Variable Definitions**
This table presents definitions of dependent variables, key independent variables, meeting characteristics variables, and other variables.

Dependent Variables	
%Δ SPY	The percent change in SPY (SPDR S&P 500), measured in basis points.
%Δ VIX	The percent change in VIX (Cboe Volatility Index), measured in basis points.
%Δ EURUSD	The percent change in EURUSD (EUR-to-USD) exchange rate, measured in basis points.
%Δ ZN10	The percent change in ZN10 (10-Year T-Note Price), measured in basis points.
SPY Volume	The SPY trading volume, measured in number of individual shares traded divided by one million.
EURUSD Volume	The EURUSD trading volume, measured in millions of base currency divided by one thousand.
ZN10 Volume	The ZN10 trading volume, measured in number of contracts divided by one thousand.
Key Independent Variables	
Negative Emotions	The Chair's intensity of negative emotions averaged in the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. The *negative emotions* intensity is the sum of anger, disgust, and fear intensities as captured by the Microsoft Azure Cognitive Services Emotion API.
Negative Emotions$_{pca}$	The Chair's intensity of negative emotions averaged in the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. The *negative emotions*$_{pca}$ intensity is the combination of the seven intensities (anger, contempt, disgust, fear, happiness, sadness, and surprise) as captured by the Microsoft Azure Cognitive Services Emotion API multiplied by the first principal component coefficients.
Negative Emotions$_{std}$	The standard deviation of the Chair's intensity of negative emotions averaged in the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. The *negative emotions* intensity is the sum of anger, disgust, and fear intensities as captured by the Microsoft Azure Cognitive Services Emotion API.
Negative Emotions$_{dmd}$	The Chair's intensity of negative emotions averaged in the prior three minutes subtracted by the average intensity of negative emotions across all FOMC meetings presided by the Chair. The *negative emotions* intensity is the sum of anger, disgust, and fear intensities as captured by the Microsoft Azure Cognitive Services Emotion API.

Table Continued...

Meeting Characteristics and Other Variables	
Negative Tone	Negative Tone measures the tone of the words expressed by the Chairs in the prior three minutes, by relying on the NRC Emotion Lexicon to capture the sentiment of each word, as well as valence shifters (amplifiers/negators). A positive value is associated with positive words and viceversa.
Δ FFR	The change in the Federal Fund Rate (FFR) of the FOMC meeting, measured in basis points.
SPY Pre Drift	The *SPY* percent change in the 30 minutes proceeding the beginning of the FOMC press conference, measured in basis points.
VIX Pre Drift	The *VIX* percent change in the 30 minutes proceeding the beginning of the FOMC press conference, measured in basis points.
EURUSD Pre Drift	The *EURUSD* percent change in the 30 minutes proceeding the beginning of the FOMC press conference, measured in basis points.
ZN10 Pre Drift	The *ZN10* percent change in the 30 minutes proceeding the beginning of the FOMC press conference, measured in basis points.
MPU	The value of the Monetary Policy Uncertainty (MPU) index measured prior to the FOMC meeting as per Husted et al. (2020)
Market Conditions	The *SPY* percent change in the period between the Monday following the prior FOMC meeting and the Friday before the FOMC meeting of interest, measured in percentage points.
Media Coverage	The number of articles about the FOMC meeting appeared in the Wall Street Journal and New York Times the day before the FOMC meeting.
Press Statement Surprise	The absolute change in ZQ (30 Day Fed Fund Futures) occurred from 10 minutes before the FOMC Press Statement (1:50pm) and the beginning of the FOMC Press Conference (2:30pm), measured in basis points.
Status of Economy	An indicator variable equal to 1 if the Chair's has discussed the status of the economy for the majority of the time interval when *Negative Emotions* are estimated, 0 otherwise.
Forward Guidance	An indicator variable equal to 1 if the Chair's has discussed the forward guidance for the majority of the time interval when *Negative Emotions* are estimated, 0 otherwise.

Table 2: **Descriptive Statistics**

This table presents descriptive statistics. The sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. Panel A reports descriptive statistics on the dependent variables. Panel B reports descriptive statistics on the key independent variables. Meeting characteristics and other variables are reported in Panel C. Variable definitions are reported in Table 1.

Panel A: Dependent Variables

	N	Mean	Std	P25	P50	P75
%Δ SPY	2,518	0.006	10.764	-4.116	0.401	5.081
%Δ VIX	2,518	-2.093	105.124	-39.841	0.000	29.455
%Δ EURUSD	2,518	-0.174	6.159	-3.147	0.077	3.052
%Δ ZN10	2,518	0.085	4.058	-1.388	0.000	2.489
SPY Volume	2,518	0.447	0.361	0.212	0.338	0.559
EURUSD Volume	2,518	0.713	0.507	0.299	0.625	1.008
ZN10 Volume	2,518	4.619	4.881	1.776	3.303	6.068

Panel B: Key Independent Variables

	N	Mean	Std	P25	P50	P75
Negative Emotions	2,518	0.944	1.060	0.225	0.533	1.196
Negative Emotions$_{pca}$	2,518	1.007	1.043	0.416	0.937	1.559
Negative Emotions$_{std}$	2,518	0.028	0.032	0.004	0.016	0.040
Negative Emotions$_{dmd}$	2,518	-0.000	0.014	-0.010	-0.002	0.002

Panel C: Meeting Characteristics and Other Variables

	N	Mean	Std	P25	P50	P75
Negative Tone	2,518	0.018	0.010	0.011	0.017	0.024
Δ FFR	2,518	1.122	19.066	0.000	0.000	0.000
SPY Pre Drift	2,518	10.975	41.414	-15.542	6.669	31.390
VIX Pre Drift	2,518	-122.330	385.964	-202.247	-91.093	31.990
EURUSD Pre Drift	2,518	3.479	37.110	-17.749	1.670	21.753
ZN10 Pre Drift	2,518	5.489	27.639	-8.054	4.797	15.308
MPU	2,518	1.395	0.767	0.919	1.095	1.562
Market Conditions	2,518	0.190	0.369	0.006	0.123	0.379
Media Coverage	2,518	15.111	5.509	12.000	14.000	18.000
Press Statement Surprise	2,518	35.663	64.168	0.000	0.000	25.000
Status of Economy	2,518	0.124	0.330	0.000	0.000	0.000
Forward Guidance	2,518	0.174	0.379	0.000	0.000	0.000

Table 3: **Variable Correlations**

This table presents variable correlations. The sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. Panel A reports correlation between different dependent variables and our main measure of negative sentiment. Panel B reports correlations between different negative emotions measures and the sentiment measure. Variable definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Dependent Variables and Negative Emotions Correlation

	%Δ SPY	%Δ VIX	%Δ EURUSD	%Δ ZN10	Negative Emotions
%Δ SPY	1.000				
%Δ VIX	-0.746	1.000			
	(0.000)				
%Δ EURUSD	0.275	-0.197	1.000		
	(0.000)	(0.000)			
%Δ ZN10	0.039	-0.070	0.405	1.000	
	(0.050)	(0.000)	(0.000)		
Negative Emotions	-0.047	0.028	-0.040	-0.044	1.000
	(0.018)	(0.155)	(0.044)	(0.029)	

Panel B: Negative Emotions and Sentiment Variables Correlation

	Negative Emotions	Negative Emotions$_{pca}$	Negative Emotions$_{std}$	Negative Emotions$_{dmd}$	Negative Tone
Negative Emotions	1.000				
Negative Emotions$_{pca}$	0.416	1.000			
	(0.000)				
Negative Emotions$_{std}$	0.805	0.306	1.000		
	(0.000)	(0.000)			
Negative Emotions$_{dmd}$	0.875	0.364	0.850	1.000	
	(0.000)	(0.000)	(0.000)		
Negative Tone	0.012	0.038	-0.047	0.025	1.000
	(0.554)	(0.055)	(0.019)	(0.208)	

Table 4: **Market Reactions and Negative Emotions**

This table reports coefficients from OLS regressions of changes in the stock, currency and treasury markets on Chairs' negative emotions and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. *%Δ SPY*, *%Δ VIX*, *%Δ EURUSD*, and *%Δ ZN10* are the percent changes evaluated in the three minutes following the measurement of the independent variables for *SPY*, *VIX*, *EURUSD*, and *ZN10*, respectively. *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. Δ *FFR* is the FOMC meeting change in the Federal Funds Rate (FFR). *SPY Pre Drift*, *VIX Pre Drift*, *EURUSD Pre Drift*, and *ZN10 Pre Drift* capture the percent changes in the 30 minutes proceeding the beginning of the FOMC press conference for the *SPY*, *VIX*, *EURUSD*, and *ZN10*, respectively. *MPU* is the value of the Monetary Policy Uncertainty (MPU) index measured prior to the FOMC meeting as per Husted et al. (2020). *Market Conditions* is the *SPY* percent change in the period between the Monday following the prior FOMC meeting and the Friday before the FOMC meeting of interest. Panel A reports regressions using measures from the stock market. Panel B reports regression from the FX and Treasury markets. Specifications in column (2) and (5) include Chair fixed effects. Specifications in column (3) and (6) include meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Stock Market Reaction

	(1) %Δ SPY	(2) %Δ SPY	(3) %Δ SPY	(4) %Δ VIX	(5) %Δ VIX	(6) %Δ VIX
Negative Emotions	−0.459***	−0.493***	−0.499***	3.203	3.330*	3.519*
	(0.000)	(0.000)	(0.000)	(0.106)	(0.083)	(0.088)
Negative Tone	13.557	16.754	21.568	83.497	49.513	−56.846
	(0.577)	(0.522)	(0.543)	(0.542)	(0.770)	(0.852)
Δ FFR	−0.032***	−0.039***		0.224	0.269	
	(0.000)	(0.000)		(0.205)	(0.250)	
SPY Pre Drift	0.023***	0.022***				
	(0.005)	(0.002)				
VIX Pre Drift				0.006	0.005	
				(0.126)	(0.155)	
MPU	−0.488***	0.102		1.568	0.105	
	(0.000)	(0.782)		(0.668)	(0.988)	
Market Conditions	−0.495	0.276		4.928	2.189	
	(0.701)	(0.819)		(0.575)	(0.811)	
Chair FE	No	Yes	No	No	Yes	No
Meeting FE	No	No	Yes	No	No	Yes
N	2,518	2,518	2,518	2,518	2,518	2,518
Adj R^2	0.012	0.017	0.051	0.001	0.001	0.021

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Panel B: FX and Treasury Market Reactions

	(1) %Δ EURUSD	(2) %Δ EURUSD	(3) %Δ EURUSD	(4) %Δ ZN10	(5) %Δ ZN10	(6) %Δ ZN10
Negative Emotions	−0.265**	−0.257**	−0.174**	−0.167	−0.158	−0.183
	(0.017)	(0.015)	(0.011)	(0.273)	(0.317)	(0.247)
Negative Tone	−25.115***	−26.585***	−28.034	−3.363	−4.129	−5.748
	(0.010)	(0.004)	(0.114)	(0.713)	(0.632)	(0.463)
Δ FFR	0.008*	0.010***		0.007***	0.008**	
	(0.078)	(0.004)		(0.000)	(0.031)	
EURUSD Pre Drift	0.009***	0.010***				
	(0.001)	(0.000)				
ZN10 Pre Drift				0.020**	0.020**	
				(0.022)	(0.012)	
MPU	0.266**	0.195		0.164	0.048	
	(0.031)	(0.334)		(0.176)	(0.829)	
Market Conditions	0.266	0.132		−0.088	−0.235	
	(0.667)	(0.864)		(0.571)	(0.328)	
Chair FE	No	Yes	No	No	Yes	No
Meeting FE	No	No	Yes	No	No	Yes
N	2,518	2,518	2,518	2,518	2,518	2,518
Adj R^2	0.006	0.006	0.040	0.019	0.020	0.066

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Table 5: **Trading Volumes and Negative Emotions**
This table reports coefficients from OLS regressions of changes in the trading volume of the stock, currency and treasury markets on Chairs' negative emotions and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. *SPY Volume*, *EURUSD Volume*, and *ZN10 Volume* are the percent changes in average trading volumes evaluated in the three minutes following the measurement of the independent variables for *SPY*, *EURUSD*, and *ZN10*, respectively. *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. All specifications include Meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

	(1) SPY Volume	(2) EURUSD Volume	(3) ZN10 Volume
Negative Emotions	-0.012^{**}	-0.006	-0.004
	(0.020)	(0.256)	(0.960)
Negative Tone	-2.147^{***}	-1.410^{**}	-17.985^{***}
	(0.000)	(0.016)	(0.006)
Meeting FE	Yes	Yes	Yes
N	2,518	2,518	2,518
Adj R^2	0.569	0.615	0.422

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6: **Meeting Attention, Press Statement Surprise and Negative Emotions**
This table reports coefficients from OLS regressions of changes in the stock, currency and treasury markets on Chairs' negative emotions, meeting attention measures and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. *%Δ SPY*, *%Δ VIX*, *%Δ EURUSD*, and *%Δ ZN10* are the percent changes evaluated in the three minutes following the measurement of the independent variables for *SPY*, *VIX*, *EURUSD*, and *ZN10*, respectively. *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. *Media Coverage* represents the number of articles about the FOMC meeting appeared in the Wall Street Journal and New York Times the day before the FOMC meeting.*Press Statement Surprise* is the absolute change in ZQ (30 Day Fed Fund Futures) occurred from 10 minutes before the FOMC Press Statement (1:50pm) and the beginning of the FOMC Press Conference (2:30pm). Panel A presents results on *Negative Emotions* interactions with the *Media Coverage* measure. Panel B presents results on *Negative Emotions* interactions with the *Press Statement Surprise* measure. All specifications include meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Media Attention

	(1) %Δ SPY	(2) %Δ VIX	(3) %Δ EURUSD	(4) %Δ ZN10
Negative Emotions	0.881**	−2.706	0.491*	0.043
	(0.012)	(0.602)	(0.075)	(0.733)
Media Coverage * Negative Emotions	−0.088***	0.399	−0.043**	−0.015
	(0.000)	(0.384)	(0.036)	(0.430)
Negative Tone	21.029	−54.415	−28.293*	−5.837
	(0.555)	(0.857)	(0.099)	(0.437)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518
Adj R^2	0.053	0.021	0.041	0.066

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Panel B: Press Statement Surprise

	(1) %Δ SPY	(2) %Δ VIX	(3) %Δ EURUSD	(4) %Δ ZN10
Negative Emotions	−0.078	−2.274	−0.200*	−0.285**
	(0.843)	(0.587)	(0.069)	(0.024)
Press Statement Surprise * Negative Emotions	−0.015**	0.201**	0.001	0.004***
	(0.041)	(0.031)	(0.484)	(0.001)
Negative Tone	21.682	−58.417	−28.041	−5.776
	(0.486)	(0.811)	(0.111)	(0.474)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518
Adj R^2	0.057	0.033	0.039	0.068

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Table 7: **Written Tone, Discussion Theme, and Negative Emotions**
This table reports coefficients from OLS regressions of changes in the stock, currency and treasury markets on Chairs' negative emotions, meeting attention measures and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. *%Δ SPY*, *%Δ VIX*, *%Δ EURUSD*, and *%Δ ZN10* are the percent changes evaluated in the three minutes following the measurement of the independent variables for *SPY*, *VIX*, *EURUSD*, and *ZN10*, respectively. *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. *Status of Economy* is an indicator variable equal to 1 if the Chair's has discussed the status of the economy for the majority of the time interval when *Negative Emotions* are estimated, 0 otherwise. *Forward Guidance* is an indicator variable equal to 1 if the Chair's has discussed the forward guidance for the majority of the time interval when *Negative Emotions* are estimated, 0 otherwise. Panel A presents results on *Negative Emotions* interactions with the *Negative Tone* measure. Panel B presents results on *Negative Emotions* interactions with discussion theme measures. All specifications include meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Written Tone

	(1) %Δ SPY	(2) %Δ VIX	(3) %Δ EURUSD	(4) %Δ ZN10
Negative Emotions	−0.789***	7.339**	0.391	0.068
	(0.000)	(0.048)	(0.235)	(0.730)
Negative Tone	8.075	120.891	−1.777	5.944
	(0.841)	(0.688)	(0.756)	(0.181)
Negative Tone * Negative Emotions	15.654**	−206.216	−30.465	−13.565***
	(0.025)	(0.115)	(0.179)	(0.000)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518
Adj R^2	0.051	0.021	0.041	0.067

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Panel B: Discussion Theme

	(1) %Δ SPY	(2) %Δ VIX	(3) %Δ EURUSD	(4) %Δ ZN10
Negative Emotions	−0.083	0.735	−0.013	−0.106
	(0.145)	(0.829)	(0.852)	(0.552)
Negative Tone	11.554	33.539	−28.769	−6.517
	(0.750)	(0.903)	(0.129)	(0.457)
Status of Economy	1.343	−8.243	−0.128	0.032
	(0.196)	(0.130)	(0.775)	(0.963)
Status of Economy * Negative Emotions	−0.505	2.916	−0.430	−0.388
	(0.127)	(0.686)	(0.182)	(0.172)
Forward Guidance	0.956	−0.901	0.314	−0.027
	(0.287)	(0.885)	(0.609)	(0.934)
Forward Guidance * Negative Emotions	−1.892***	13.275*	−0.721**	−0.259
	(0.005)	(0.067)	(0.012)	(0.238)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518
Adj R^2	0.057	0.025	0.041	0.067

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 8: **The Dissipation of the Impact of Negative Emotions**

This table reports coefficients from OLS regressions of changes in the stock, currency and treasury markets on Chairs' negative emotions and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. $\%\Delta^n$ *SPY*, $\%\Delta^n$ *VIX*, $\%\Delta^n$ *EURUSD*, and $\%\Delta^n$ *ZN10* are the percent changes for *SPY*, *VIX*, *EURUSD*, and *ZN10* respectively. In column (1) and (3) the percent changes are measured over the five minutes following the measurement of the independent variables. In column (2) and (4) the percent changes are measured over the ten minutes following the measurement of the independent variables *Negative Emotions* measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. Panel A reports regressions using measures from the stock market. Panel B reports regression from the FX and Treasury markets. All specifications include meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Stock Market Reaction

	(1) $\%\Delta^5$ SPY	(2) $\%\Delta^{10}$ SPY	(3) $\%\Delta^5$ VIX	(4) $\%\Delta^{10}$ VIX
Negative Emotions	-0.711^{***}	-0.438^{*}	5.611	2.158
	(0.000)	(0.067)	(0.157)	(0.620)
Negative Tone	27.456	−57.185	−351.812	500.885
	(0.641)	(0.554)	(0.599)	(0.491)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518
Adj R^2	0.092	0.177	0.049	0.098

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Panel B: FX and Treasury Market Reactions

	(1) $\%\Delta^5$ EURUSD	(2) $\%\Delta^{10}$ EURUSD	(3) $\%\Delta^5$ ZN10	(4) $\%\Delta^{10}$ ZN10
Negative Emotions	0.023	0.177	−0.358	−0.276
	(0.906)	(0.624)	(0.230)	(0.585)
Negative Tone	−26.194	−39.274	−5.410	0.915
	(0.312)	(0.428)	(0.679)	(0.949)
Meeting FE	Yes	Yes	Yes	Yes
N	2,518	2,518	2,516	2,516
Adj R^2	0.076	0.173	0.120	0.226

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 9: **Alternative Measures of Negative Emotions**

This table reports coefficients from OLS regressions of changes in the stock, currency and treasury markets on Chairs' negative emotions and control variables. The estimation sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020. *%Δ SPY*, *%Δ VIX*, *%Δ EURUSD*, and *%Δ ZN10* are the percent changes evaluated in the three minutes following the measurement of the independent variables for *SPY*, *VIX*, *EURUSD*, and *ZN10*, respectively. *Negative Emotions*$_{pca}$ measures the Chairs' intensity of negative emotions averaged over the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair using all seven emotions, captured by the Microsoft Azure Cognitive Services Emotion API, multiplied by the coefficient of the principal component. *Negative Emotions*$_{std}$ measures standard deviation of the Chair's intensity of negative emotions averaged in the prior three minutes divided by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Emotions*$_{dmd}$ measures the intensity of negative emotions averaged in the prior three minutes subtracted by the average intensity of negative emotions across all FOMC meetings presided by the Chair. *Negative Tone* measures the tone of the words expressed by the Chairs in the prior three minutes. Panel A reports regressions using measures from the stock market. Panel B reports regression from the FX and Treasury markets. All specifications include meeting fixed effects. Standard errors are clustered at the Chair level. Variables definitions are reported in Table 1. p-values are presented in parentheses.

Panel A: Stock Market Reaction

	(1) %Δ SPY	(2) %Δ SPY	(3) %Δ SPY	(4) %Δ VIX	(5) %Δ VIX	(6) %Δ VIX
Negative Emotions$_{pca}$	−0.585**			4.392		
	(0.014)			(0.133)		
Negative Emotions$_{std}$		−15.098**			72.853**	
		(0.032)			(0.033)	
Negative Emotions$_{dmd}$			−33.742***			276.120
			(0.000)			(0.127)
Negative Tone	21.444	21.774	22.066	−55.781	−58.516	−60.581
	(0.569)	(0.547)	(0.535)	(0.862)	(0.850)	(0.844)
Meeting FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518	2,518	2,518
Adj R^2	0.052	0.051	0.051	0.022	0.021	0.021

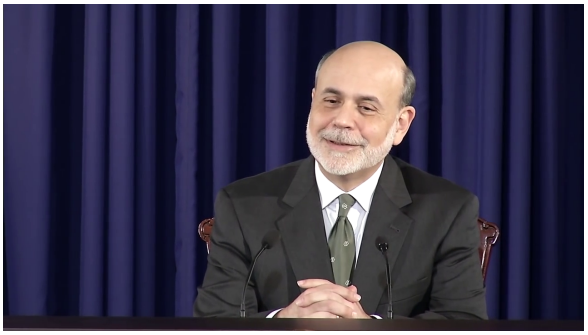
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Panel B: FX and Treasury Market Reactions

	(1) %Δ EURUSD	(2) %Δ EURUSD	(3) %Δ EURUSD	(4) %Δ ZN10	(5) %Δ ZN10	(6) %Δ ZN10
Negative Emotions$_{pca}$	−0.202			−0.086		
	(0.112)			(0.231)		
Negative Emotions$_{std}$		−10.632***			−5.370	
		(0.000)			(0.258)	
Negative Emotions$_{dmd}$			−19.399***			−8.745
			(0.000)			(0.460)
Negative Tone	−28.076*	−27.997	−27.817	−5.699	−5.671	−5.586
	(0.099)	(0.110)	(0.117)	(0.469)	(0.477)	(0.486)
Meeting FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2,518	2,518	2,518	2,518	2,518	2,518
Adj R^2	0.040	0.041	0.040	0.065	0.065	0.065

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Appendix A: Emotion Intensity Scores



Panel A: Ben Bernanke, March 20th 2013

Emotion	Intensity Score
Anger	0.00
Contempt	0.00
Disgust	0.00
Fear	0.00
Happiness	1.00
Neutral	0.00
Sadness	0.00
Surprise	0.00

Panel B: Janet Yellen, December 14th 2016

Emotion	Intensity Score
Anger	0.02
Contempt	0.00
Disgust	0.00
Fear	0.00
Happiness	0.00
Neutral	0.98
Sadness	0.00
Surprise	0.00

Panel C: Jerome Powell, January 30th 2019

Emotion	Intensity Score
Anger	0.00
Contempt	0.05
Disgust	0.00
Fear	0.00
Happiness	0.00
Neutral	0.04
Sadness	0.91
Surprise	0.00

Figure A1: **Emotion Intensity Scores**
This figure presents emotion intensity scores as captured by the Microsoft Azure Cognitive Services Emotion API. Panel A shows Ben Bernanke during the FOMC press conference held on March 20th, 2013, Panel B shows Janet Yellen during the FOMC press conference held on December 14th, 2016, and Panel C shows Jerome Powell during the FOMC press conference held on January 30th, 2019.

Appendix B: Statement Excerpts

In this appendix we provide examples of three categories of statements tagged in different ways. Each excerpts is tagged either as *Status of Economy*, *Forward Guidance* or *Other*.

1. Status of Economy

1.1. April 11th 2011

5 minutes, 41 seconds into the press conference, part of the opening statement:

"I turn now to the Committees economic outlook. As indicated in todays policy statement, the Committee sees the economic recovery as proceeding at a moderate pace. Household spending and investment in equipment and software continue to expand, supporting the recovery, but nonresidential investment is still weak and the housing sector is depressed. In the labor market, overall conditions continue to improve gradually. For example, the unemployment rate moved down a bit further and payroll employment increased in March; new claims for unemployment insurance and indicators of hiring plans are also consistent with continued improvement."

1.2. September 17th 2015

15 minutes, 42 seconds into the press conference, journalist question:

"Mr. Chairman, first, thanks for doing this. This is a tremendous development. There are critics who say that Fed policy has driven down the value of the dollar, and a lower value to the dollar reduces Americans standard of living. How do you respond to the criticism that, essentially, Fed policy has reduced Americans standard of living?"

1.3. June 13th 2018

22 minutes, 27 seconds into the press conference, journalist question:

"Hi, Chair Powell. Heather Long from the Washington Post. Can you give us an update on what the FOMC thinks about wages? Are we finally going to see that wage growth pickup this year? I know youre forecasting a little bit more inflation, but is that going to translate through to wage growth?"

24 minutes, 08 seconds into the press conference, Chair's answer:

"You know, wages have been gradually moving up. Earlier in the recovery, they werethere are many different wage measures, of course, butso justbut just to generalize, wages were running roughly around 2 percent and theyve moved gradually up into between 2 to 3 percent as the labor market has become stronger and stronger. I think its fair to say that some of usand I certainly would have expected wages to react more to the very significant reduction in unemployment that weve had, as I mentioned, from 10 percent to 3.8 percent. Part of that can be explained by low productivity, which is something weve talked about at the Committee and elsewhere. But, nonetheless, I think we had anticipated, and many people have anticipated, that wagesthat in a world where were hearing lots and lots about labor shortageseverywhere we go now, we hear about labor shortagesbut where is the wage reaction? So its a bit of a puzzle. I wouldn't say its a mystery, but its a bit of a puzzle. And, frankly, I do think

theres a lot to like about low unemployment. And one of the things isyou will seepretty much people who want to get jobsnot everybodybut people who want to get jobs, many of them will be able to get jobs. You will see wages go up. Youll see people at the, sort of, the margins of the labor force having an opportunity to get back in work. They benefit from that. Society benefits from that. So there are a lot of things to really like, including higher wages, as you asked. Our role, though, is also to, you know, to make sure thatthat maximum employment happens in a context of price stability and financial stability, which is why were gradually raising rates."

2. Forward Guidance

2.1. June 22nd 2011

8 minutes, 28 seconds into the press conference, journalist question:

"Jon Hilsenrath from the Wall Street Journal. Mr. Chairman, the FOMC says that it will maintain short-term interest rates at an exceptionally low level for an extended period. Does that policy or, does that guidance also apply for the Feds securities holdings? In other words, will they be maintained at a very high level for an extended period?"

8 minutes, 58 seconds into the press conference, Chair's answer:

"We havent made any such commitment. Its true that when we begin to allow the portfolio to run off rather than reinvesting, that would be a first step in a process of exiting from our currently highly accommodative policies. But weve not yet chosen to make any particular commitment about the time frame. But well be looking at the outlook and trying to assess when the appropriate time is to take that step."

2.2. December 16th 2015

26 minutes, 6 seconds into the press conference, journalist question:

"Chair Yellen, Jon Hilsenrath from the Wall Street Journal. In the sentence in your statement about gradual increases, in that section, the Committee says that it will carefully monitor progressactual and expected progress on inflation. Thats going to read like some kind of code to a lot of people on Wall Street. Can you describewhat do you mean when you say carefully monitor? And, specifically, with regard to what you do next, do you need to see inflation actually rise at this point in order to raise interest rates again?"

28 minutes, 9 seconds into the press conference, Chair's answer:

"Well, we recognize that inflation is well below our 2 percent goal. The entire Committee is committed to achieving our 2 percent inflation objective over the medium term, just as we want to make sure that inflation doesnt persist at levels above our 2 percent objective. The Committee is equally committedthis is a symmetric goaland the Committee is equally committed to not allowing inflation to persist below our 2 percent objective. Now, Ive tried to explainand many of my colleagues have as wellwhy we have reasonable confidence that inflation will move up over time, and the Committee declared it had reasonable confidence. Nevertheless, that is a forecast, and we really need to monitor over time actual inflation performance to make sure that it is conforming, it is evolving, in the manner that we expect. So it doesnt mean that we need to see inflation reach 2 percent before moving again, but

we have expectations for how inflation will behave. And were we to find that the underlying theory is not bearing out, that it is not behaving in the manner that we expect, and that it doesnt look like the shortfall is transitory and disappearing with tighter labor markets, that would certainly give us pause. And we have indicated that were reasonably closenot quite there, but reasonably closeto achieving our maximum employment objective, but we have a significant shortfall on inflation. And so were calling attention to the importance of verifying ourthat things evolve in line with our forecasts."

2.3. March 21st 2018

16 minutes, 50 seconds into the press conference, journalist question:

"Adam Shapiro with the Fox Business Network. You brought up the fiscal stimulus and the impact its having, and I was curious, how is the change in the federal budget deficitbecause the stimulus is coming with great debthas it changed your approach to how many securities youre going to allow to roll off the balance sheet, and is there a level of Treasury supply at which the Fed would consider adjusting its balance sheet roll-off, given how much the U.S. governments going to have to borrow going forward? And, then a second question, things beyond your controlthe President is expected to announce new tariffs against China, and does the Committee discuss what potential impacts that could have in regards to inflation? And do you have a timeline as to how you would respond to that?"

17 minutes, 17 seconds into the press conference, Chair's answer:

"So, in terms of the balance sheet, weve said that, you know, we carefully developed this plan. We carefully socialized it in a series of meetings last year. We announced it, and we said we wouldnt change it, really, unless there were a significant downturn that required, you know, meaningful reductions in interest rates. And I have no inclination to revisit that. Were going to use monetary policy as the principle tool of adjusting, you know, our policy."

3. Other

3.1. January 25th 2012

0 minutes, 43 seconds into the press conference, part of opening statement:

"In my opening remarks I will briefly review todays policy decision by the Federal Open Market Committee. And then Ill discuss next the consensus statement that has been distributed to you regarding the Committees longer-run policy goals and strategy. And finally, Ill place todays policy decision in the context of our economic projections and our assessments of the appropriate path of monetary policy. And Ill then, of course, be glad to take your questions."

3.2. January 25th 2012

27 minutes, 35 seconds into the press conference, journalist question:

"Greg Robb, MarketWatch. Mr. Chairman, thank you. You havent had a very good time in all the Republican presidential debates, and I was wondering if I could have your comment on what youve heard. And some of the analysts I talked to said that one of the reasons for this hostility, perhaps, is that a lot of the Republican primary voters are on fixed incomes

and have an inability to invest and make money with their funds. So could you talk to them as well? And one more thing, if Republicans take back the White House in November and ask you to resign, would you?"

28 minutes, 01 seconds into the press conference, Chair's answer:

"So Im not going to get involved in political rhetoric. Im just going to stay completely away from that. I have a job to do, and as long as Im here, I will do everything I can to help the Federal Reserve achieve its dual mandate of price stability and maximum employment. Thats my answer to the last part as well. Im not going to be thinking about hypothetical situations in the future."

3.3. March 21st 2018

32 minutes, 58 seconds into the press conference, journalist question:

"Hi. Victoria Guida with Politico. More on the regulatory side, you know, the Fed might soon be getting more power to decide exactly which regulationswhich stricter regulations to apply to banks with between 100 and 250 billion in assets. And so I had a couple of questions about that. So, for CCAR, those stress tests, since thats based around, you know, having a punitive penalty of potentially being able to restrict dividend payouts or stock buybacks, is there any kind of logistical challenge that could be posed if you dont have CCAR every year for certain banks? Is it possible to have CCAR not on an annual basis? And then, my other question is, you know, youve talked a lot about how size isnt the only thing that causes banks to pose systemic risk, and I was wondering, what other factors do you think would cause a bank to potentially pose a systemic risk?"

34 minutes, 01 seconds into the press conference, Chair's answer:

"Okay. So, this is a matter that Congress has under consideration. Its not somethingso Congress is looking at raising the threshold for applying enhanced financial standards tofrom 50 billion to 250 billion, while leaving us with the ability to reach below 250 billion and apply those standards where we think its appropriate. And, you know, we havent been shy about doing that, because, of course, one of the eight SIFIs is below 250 already. So we are fully prepared to do that. But this is a decision thats in the hands of Congress. Its not something thats beenbeen taken. The version of the bill, I think, that passed the Senate did havedid give us the ability to do supervisory stress tests periodically, as opposed to annually, is the language. We havent made any decision about that at all. We would want to think very carefully about that, and, you know, we wouldwhatever we do decide to do, wed put that out for comment. Is it, you know, logistically possible? I would think it would be, but its certainly not something that weve decided to do. And the second question you had was?"

Appendix C: FOMC Meetings

Table C1: **List of Scored FOMC Meetings**
This table presents the average scores of *Negative Emotions*, *Negative Tone*, Δ *FFR* for each meeting in our sample as well as the meeting type. The sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 27^{th}, 2011 and September 16^{th}, 2020.

Date	Chair	Δ FFR	Negative Emotions	Negative Tone	Type
April 27, 2011	Ben Bernanke	0	0.73	0.0192	Scheduled
June 22, 2011	Ben Bernanke	0	1.07	0.0214	Scheduled
November 2nd, 2011	Ben Bernanke	0	0.99	0.0193	Scheduled
January 25, 2012	Ben Bernanke	0	0.82	0.0166	Scheduled
April 25, 2012	Ben Bernanke	0	0.74	0.0263	Scheduled
June 20, 2012	Ben Bernanke	0	0.71	0.0181	Scheduled
September 13, 2012	Ben Bernanke	0	0.71	0.0194	Scheduled
December 12, 2012	Ben Bernanke	0	0.79	0.0203	Scheduled
March 20, 2013	Ben Bernanke	0	0.45	0.0286	Scheduled
June 19, 2013	Ben Bernanke	0	1.18	0.0161	Scheduled
September 18, 2013	Ben Bernanke	0	0.71	0.0198	Scheduled
December 18, 2013	Ben Bernanke	0	0.93	0.0218	Scheduled
March 19, 2014	Janet Yellen	0	1.21	0.0213	Scheduled
June 18, 2014	Janet Yellen	0	0.91	0.0205	Scheduled
September 17, 2014	Janet Yellen	0	2.34	0.0164	Scheduled
December 17, 2014	Janet Yellen	0	1.17	0.0129	Scheduled
March 18, 2015	Janet Yellen	0	2.54	0.0165	Scheduled
June 17, 2015	Janet Yellen	0	0.69	0.0158	Scheduled
September 17, 2015	Janet Yellen	25	1.01	0.0233	Scheduled
December 16, 2015	Janet Yellen	0	0.73	0.0191	Scheduled
March 16, 2016	Janet Yellen	0	0.59	0.0163	Scheduled
June 15, 2016	Janet Yellen	0	0.47	0.0157	Scheduled
September 21, 2016	Janet Yellen	0	0.74	0.0159	Scheduled
December 14, 2016	Janet Yellen	25	1.30	0.0173	Scheduled
March 15, 2017	Janet Yellen	25	0.44	0.0125	Scheduled
June 14, 2017	Janet Yellen	25	0.35	0.0138	Scheduled
September 20, 2017	Janet Yellen	0	0.52	0.0197	Scheduled
December 13, 2017	Janet Yellen	25	0.88	0.0141	Scheduled
March 21, 2018	Jerome Powell	25	1.51	0.0218	Scheduled
June 13, 2018	Jerome Powell	25	0.82	0.0148	Scheduled
September 26, 2018	Jerome Powell	25	0.61	0.0187	Scheduled
December 19, 2018	Jerome Powell	25	1.30	0.0125	Scheduled
January 30, 2019	Jerome Powell	0	1.33	0.0164	Scheduled
March 20, 2019	Jerome Powell	0	0.64	0.0204	Scheduled
May 01, 2019	Jerome Powell	0	0.75	0.0178	Scheduled
June 19, 2019	Jerome Powell	0	1.53	0.0195	Scheduled
July 31, 2019	Jerome Powell	-25	1.53	0.0199	Scheduled
September 18, 2019	Jerome Powell	-25	1.64	0.0173	Scheduled
October 30, 2019	Jerome Powell	-25	0.87	0.0136	Scheduled
December 11, 2019	Jerome Powell	0	1.53	0.0144	Scheduled
January 29, 2020	Jerome Powell	0	1.28	0.0137	Scheduled
March 03, 2020	Jerome Powell	-50	2.49	0.0162	Unscheduled
April 29, 2020	Jerome Powell	0	0.58	0.0239	Scheduled
June 10, 2020	Jerome Powell	0	0.29	0.0214	Scheduled
July 29, 2020	Jerome Powell	0	0.66	0.0198	Scheduled
September 16, 2020	Jerome Powell	0	0.17	0.0175	Scheduled

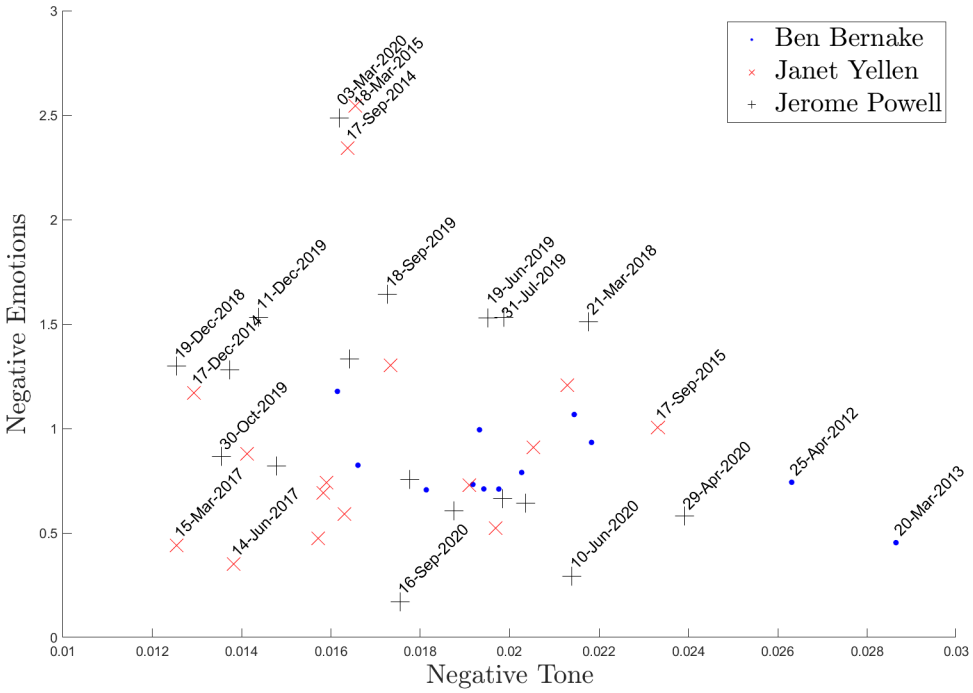


Figure D1: **Meetings' Negative Emotions and Tone**
This figure presents the average negative emotions and average negative tone for each meeting in our sample. The sample includes 2,518 observations at the minute level from 46 FOMC meetings chaired by Ben Bernake (12), Janet Yellen (16), and Jerome Powell (18) between April 26^{th}, 2011 and September 16^{th}, 2020.