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Federal Open Market Committee communication: a text mining analysis

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Federal Open Market Committee Communications: A Text Mining Analysis

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Abstract

The Federal Reserve Bank of the United States, the head of monetary policy in the country, primarily uses the Federal Open Market Committee, or FOMC, to make and communicate policy decisions. Since 1994 the FOMC has become ever more transparent. By releasing statements after each meeting they hold, releasing more detailed minutes of these meetings three weeks later, and releasing full transcripts of the meetings five years later, they are able to inform the public of their intentions and thoughts while withholding potentially volatile information for later release dates. These three documents reveal much about how the FOMC operates and what its members think. The goal of this research was to determine the sentiment in each of these documents from 2004 to 2012, to examine how the sentiment in each of these documents differs, to identify significant factors or themes, and to use treasury market data to characterize these themes. We found that there was a divergence in private and public sentiment output by the FOMC, we found that treasury markets are more receptive to policy related themes than sentiment, and we characterized three significant themes based on their interaction with treasury market data.

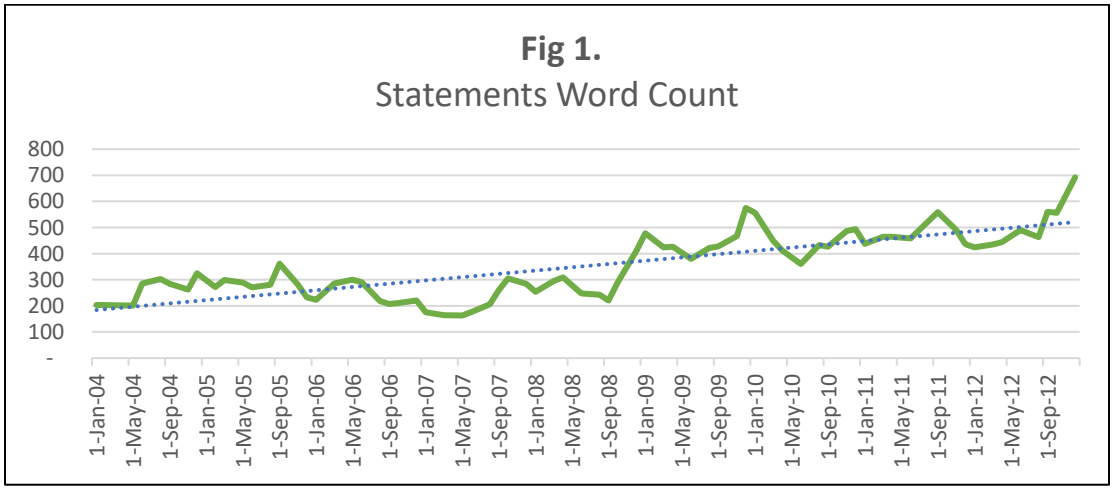
I. Introduction

This thesis seeks to answer four questions using sentiment analysis and regression techniques. First, what sentiment is reflected in statements, minutes, and transcripts released by the Federal Open Market Committee (FOMC). Second, to what extent do privately expressed sentiments and opinions (in meeting transcripts) diverge from those expressed to the public (in meeting statements). Third, what are the themes (or factors) expressed in these same documents during the time period. Finally, what is the financial market reactions to sentiment and themes found in these Federal Reserve communications.

The Federal Reserve serves many functions, from acting as a lender of last resort to banks short on liquidity, to setting monetary policy by adjusting interbank interest rates, or the federal funds rate, and acting as a supervisor of banking activities in the United States. The Federal Reserve has a dual mandate to maintain inflation at a target rate and to keep unemployment low. For many decades the Federal Reserve enacted policy largely in secret, sharing few details with the wider public. But with changing political and social climates the Fed released its first statement in 1994 following the February FOMC meeting. The FOMC is the committee comprised of (seven) Federal Reserve Governors and presidents of the twelve district Federal Reserve Bank presidents. The FOMC is the committee that sets monetary policy that the Federal Reserve enacts. It is led by a Chair, currently Jerome Powell, who serves a four-year renewable term. Statements released by the FOMC provide the public with information regarding monetary policy decisions and actions being taken by the Federal Reserve. These statements are released eight times a year immediately following FOMC meetings. In the two decades since the release of the first statement, the Fed has increased its communication with the public dramatically, from

holding press conferences following FOMC meetings, to releasing the minutes of their meetings (three weeks after a meeting) and indicating the voting pattern at each meeting.

The style of FOMC communication has changed over the years to reflect this trend towards greater communication and transparency. The chairman at the beginning of our sample period, Alan Greenspan, was notorious for his lack of clarity. He is known to have said "if I turn out to be particularly clear, you've probably misunderstood what I've said." (Norris,2002). His successor, Ben Bernanke, was a large proponent of the move to transparency, and this can be seen in how he affected the statement released after FOMC meetings. As seen in Fig. 1 the word count for statements increased over our period. It is difficult to say if Bernanke had the sole effect on this though as his leadership coincided with the Great Recession and the subsequent lengthening of statements in relation to new monetary policy actions, such as quantitative easing. Regardless there is a quantifiable move towards lengthier statements in the past 15 years.



In the words of the current FOMC Chair, Jerome Powell, there are three purposes to the FOMC communications. First is "to provide the transparency that enables the Congress and the

public to hold the Committee accountable for its decisions on monetary policy". Second is "to enhance the effectiveness of monetary policy", which results in a better-informed public who make economic decisions based on the FOMC's views, which in turn makes monetary policy more effective. Third is "to show the full range of FOMC participants views, even if doing so may sometimes make it difficult for the public to identify a consensus view" (Powell, 2016).

After each FOMC meeting three documents are released over the course of five years. The first and arguably most important document released is the FOMC statement. This includes the FOMC's economic outlook, the policy action that the Federal Reserve is taking, and forward guidance. Forward guidance, explicitly used for the first time in August of 2003, is the tool that the FOMC uses to influence expectations regarding future actions that they might take. The second document to be released is the minutes of the meeting. This is released three weeks after the FOMC meeting which represents another evolution in Federal Reserve Communication. These evolutions can be seen in greater detail in Table 1. This document contains a brief overview of what was discussed during the meeting. Finally, the transcript of the meeting, which contains the conversations had during the meetings verbatim, is released five years after the meeting.

Table 1		
Chairman	**Date**	**Change in Fed Communication**
Greenspan	Feb 1994 – May 1999	Began issuing statements at the end of FOMC meetings, but only if a change in policy occurred
	Since July 1995	Statement includes target for fed funds rate
	Since May 1999	Statement issued **after every FOMC meeting**
	Since Mar 2002	Statement includes **vote details** + explanation for dissents
	Since Aug 2003	First explicit **forward-guidance** language to the statement + the "considerable period" language
	Since Dec 2004	**Expedited release of FOMC minutes**, i.e. 3 weeks after FOMC meeting
Bernanke	Since Oct 2007	Summary of Economic Projections (**SEP**) provided with FOMC statement
	Since Sep 2010	Minutes have included paragraphs that reflect the views on monetary policy expressed by all meeting participants, not just those who vote on the policy decision.
	Since April 2011	Chair has held a quarterly **press conference** following the FOMC meetings
	Since Jan 2012	the federal funds rate projections, or "**dot plot**" added as an addendum to meeting minutes
	Since Jan 2012	Statement on Longer-Run Goals and Monetary Policy Strategy released after each FOMC meeting
		Greater frequency of speeches by key Fed officials
		Greater transparency + diversity of viewpoints
Source: Powell (2016) - The Modern Era		

Our analysis in this paper is over all scheduled FOMC meetings from January 2004 to December 2012 (ignoring conference calls), for a total sample of seventy-two meetings. We decided to begin our sample in 2004 since starting in "mid-2003, the statements have indeed become more informative and their final form had been settled." (Mazis and Tsekrekos, 2017). In addition to this, minutes began being released three weeks following meetings. We chose the end of our sample as 2012 since when we started this research we did not have access to all transcripts from 2013 meetings due to the five-year lag of release. Our sample is marked by the leadership of two Fed Chairman, Alan Greenspan and Ben Bernanke. Greenspan presided over the beginning of our sample until January 2006, or 17 meetings, while Bernanke was chair from February 2006 until the end of our sample, or 55 meetings.

Overall, the sentiment, defined as positive, negative, or uncertain, of each of these three document types can be quantified and compared. The sentiment of these documents is important to study as it provides a quantifiable indication of what the FOMC was thinking in making each of its policy decisions. In addition, sentiment differences between documents can be calculated to see if the publicly expressed sentiments in the statements matches the sentiment expressed in private. This is important because it allows us to compare what was being said behind closed doors and what was purposefully being told to the public. Differences in private and public sentiment give us insight into if the FOMC was expressing a sentiment different than the one they held for potentially strategic purposes (though it cannot be definitively said if any difference in public and private sentiment was intentional or if it was simply by chance).

Sentiment is defined by the frequency of words belonging to each sentiment grouping, i.e. positive, negative, or uncertain. A document's sentiment is determined by which of the groupings has the highest frequency as a percent of total words. The sentiment varies over time

and across documents as different language is used to reflect different policy climates. Language may vary due to the changing opinions of FOMC members, or changes in the economy that require a different vocabulary to address, or deliberate word choices to evoke specific emotions from the readers of FOMC statements.

II. Literature Review

Because of this increase in communications and transparency increasingly research is being conducted into how exactly the Federal Reserve communicates and the impact that communications have on financial markets. A prime example of what is perhaps the earliest textual analysis of the FOMC can be found in Boukus and Rosenberg (2006). They utilized latent semantic analysis which is "a language processing technique that allows recognition of the textual associative patterns in documents" to determine how the content of FOMC minutes have changed and how they affect markets. They applied Latent semantic analysis to FOMC minutes from January 1987 to December 2005. It was found that treasury yield changes were dependent on the themes expressed in the minutes as well as the level of uncertainty expressed. They described these themes based on key words that appear within them but were never specifically named or characterized. Ultimately, they determined that this indicates that market watchers can fully understand the minutes and draw sophisticated conclusions based on the general themes. This research acts as the basis for all future FOMC textual analysis.

Mazis and Tsekrekos (2017) analyzed FOMC statements to find textual associative patterns and examine their impact on the treasury market in a similar way to the research conducted in this paper. They utilized latent semantic analysis and essentially found the themes, or groupings of statistically significant words based on use and effect, of the statements. They then compared these themes to treasury market reaction (specifically daily changes in treasury yields) through a time series regression. (This regression utilized these daily changes in treasury yields as the dependent variable and had the themes found in those documents as the independent variables.) They found that the themes had a statistically significant effect on the yield of treasury bonds. Different themes related to changes in different yield curves, such as Theme 1 relating to the

long end of the yield curve and the credit spread, while Theme 3 related to only the long end of the yield curve, and Theme 6 related to the short end of the yield curve. This indicated that different themes had different meanings that the public picked up on in reading FOMC statements.

Jubinski and Tomljanovich (2016) examined the effect of the release of FOMC statements and minutes on equity return and volatility series. When looking at the FOMC statements and minutes they only viewed release time and the immediate effects the releases had on the market. They did not view the content of the statement in depth and instead were comparing the severity of the change in stock price after the release of the statement to the severity of the change in stock price after the release of the minutes. Ultimately, they found that returns do not change much after releases, but conditional volatility rises. Also, they noted that high trading frequency firms responded much more to these FOMC statements and minutes than their lower frequency counterparts (though the study does not specify specific high and low trading intensity firms).

There is a strong correlation between the sentiment content of FOMC documents and the movement of interest rates. They determined this using max-entropy discrimination latent Dirichlet allocation models to show that FOMC documents affect short and long-term interest rates. This can be seen in Rohlfs et al (2016) where they found that applying the aforementioned Dirichlet model to FOMC statements they were able to predict what the Federal Funds Target Rate would be in the future with 93% accuracy.

This type of research is not limited to the Federal Reserve and the FOMC though, as research on the Brazilian Central Bank demonstrates (Montes and Nicolay, 2017). Their research examined the effect that clarity, defined as the “quality of information provided and the capacity of comprehension the public has reading what central bank communicates”, within central

banking had on perceived credibility. Credibility in this case is defined as the difference between expected inflation and the target inflation of the Brazilian Central Bank. They found that higher level of clarity increased credibility but only if the central bank and its leader are dedicated to inflation control as their primary objective, something that cannot be unequivocally said of the Federal Reserve as the dual mandate exists.

Kahveci and Odabas (2016) applied text mining and sentiment analysis the monetary policy texts from the Fed, ECB, and Central Bank of the Republic of Turkey from 2002 to 2015. Generally, they found that for the Fed, optimism declined over the period, while certainty increased. For the ECB they found that there was little change in tone over the period. For the Central Bank of the Republic of Turkey optimism has been increasing in recent years while certainty stayed relatively constant. The results regarding Fed optimism defied conventional wisdom, which dictates that more optimism in Fed communications would improve market expectations of the economy and future Fed actions. They found that market expectations actually declined as Fed optimism increased. Based on this finding the authors pose the question of whether the Fed could have mitigated some of the damage of the recession by using more optimistic language. Overall, they conclude that transparency and a decline in optimism from the Fed could have negatively impacted the US's recovery from the recession.

Overall, there is a rich literature on textual analysis of financial documents. Most researchers utilize advanced programming languages and incorporate textual analysis subroutines that can process an incredible amount of text in a very short time span. Shen (2018) conducts sentiment analysis of financial tweets and market data to study how financial tweets (specifically including mention of the company Apple) affect stock market changes. It contains a great bit of information on sentiment analysis, mainly that in performing sentiment analysis one

can either focus on a) words, which is based on frequency and sentiment value which comes from a dictionary, b) sentences, which focuses on sentences using the sentiment values of words to come up with a sentence score, or c) the whole documents. The author stresses that taking the whole document approach only works for analyzing short documents like tweets. For this reason, we apply a process which analyzes sentiment word by word. The study also includes information on sorting stock market data using a Python add on, called Python Data Analysis Library, which is a commonly used program for sorting data information according to the author. The findings of the study showed that there is a significant correlation between the sentiment expressed in financial tweets and stock market movements.

Ernst, Ekkehard and Merola (2018) covered how FOMC member's speeches matched the actions of the Federal Reserve. Their research examined speeches given by central bank members from the 1997 to 2016 to determine if the intensity, a scale from zero to one hundred based on the appearance of certain keywords, in the speeches is matched in the intensity of the banks' actions. To do this they developed a data mining routine in the R programming language. This routine analyzes the content of the speeches by searching for predefined words. It then determines intensity for five different areas, i.e. monetary conditions, financial stability, external competitiveness, labor and social conditions, and economic activity. They found that when speech intensity is matched in monetary policy decisions, such as the level of which to change interest rates there is less reliance on traditional monetary policy tools.

With all this research there is still a gap in the research, i.e. no one has combined the idea of analyzing the sentiment of FOMC statements, minutes, and transcripts and comparing that to immediate market reactions to determine if the disparity in sentiment correlates to these market reactions, and then also conducting a factor analysis to determine themes and their effect on

market data. Jubinski's and Tomljanovich (2016) merely examined the effects of the simple release of statements and minutes on treasury bonds. Mazis and Tsekrekos (2017) lay a strong foundation for the research detailed in this paper. Montes and Nicolay (2017) provided excellent information regarding the methods for analyzing communications, but their findings are limited to Brazil. Overall, there is a large literature in the field of Federal Reserve communications such as research on the importance of FOMC minutes (Nechio and Wilson, 2016), or research into how the public perceives Fed communications (Olson and Wessel, 2017), or regarding the need for transparency in Fed communications (Yellen, 2012). Despite this wealth of research there is still a gap regarding the comparison of the sentiment of transcript, minutes, and statements and their effect on asset markets, and the difference between private and public sentiment.

A key component to performing any textual analysis is having a dictionary to run the software with. The dictionary defines the sentiment for a given list of words, such as positive, negative, or uncertain among many others. A great difficulty with performing a textual analysis is making sure that words have the correct sentiment associated with them within the dictionary. There are many different dictionaries available such as the Harvard IV-4, a very popular and heavily used dictionary. For the purposes of analyzing FOMC documents though one dictionary is best suited, the Loughran-McDonald dictionary. The Loughran – McDonald dictionary is discussed in Loughran and McDonald (2011). They did a study on the Harvard IV-4 dictionary and found that it lacked the context necessary to perform accurate analysis for finance, as a lot of words that were considered negative are either positive or neutral industry specific words in a finance context. They studied over fifty thousand 10-Ks and from their findings of how the Harvard IV-4 dictionary performed created their own sentiment dictionary. One inherent flaw in any textual analysis that they recognize is the fact that many words are polysemes, which means

they have multiple meanings. This makes the creation of a definitive categorization of a word challenging, as one meaning could be positive and one could be negative. Besides the positive and negative categories, Loughran and McDonald created categories for uncertainty, litigious, strong modal, and weak modal words. These categories have been shown to have a significant impact on the ability to gauge tone. The uncertainty dictionary focuses on words that denote imprecision. The litigious dictionary focuses on words that denote questions of legality or legal contest. The modal dictionaries are dictionaries that include other words for levels of confidences. Strong includes words such as ‘always’, ‘highest’, etc. Whereas weak includes words such as ‘could’, ‘depending’, etc.

Besides the issues of polysemes present in all dictionaries, the Loughran McDonald dictionary has difficulty with processing naturalistic language, or more common everyday language not particularly present in the more technical and professional 10-K’s that the Loughran-McDonald dictionary is based on. Such language includes words like ‘interesting’ or ‘insightful’ among others. Cannon (2015) noted in her research of how FOMC sentiment leads economic activity that the Loughran-McDonald dictionary misses some nuance of the speech patterns contained in FOMC transcripts, but that its financial specialization still makes it the best option.

Despite its flaws there is a general acceptance of the Loughran-McDonald dictionary. For instance, Mangee (2018) confirmed that the contextualized Loughran-McDonald dictionary is best suited to performing any sort of sentiment analysis on financial texts, especially when adding in market reactions to the mix. Mangee compared the Loughran McDonald dictionary to the Harvard IV-4 dictionary. He concluded through rigorous testing of both dictionaries on Wall

Street Journal articles and end of day summary reports that the context specific Loughran McDonald dictionary performed better at providing accurate analysis results.

Another prime instance of the dictionaries use is Kan Chen's research into FOMC statements. Chen's research examines FOMC statements using textual analysis. He decided to use the Loughran-McDonald dictionary using the positive, negative, and uncertain dictionaries. He claims that around the recession of 2008-2009, the FOMC used significantly more positive language as defined by the Loughran-McDonald dictionary in an attempt to boost market confidence. Similarly, negative words were used most frequently around 2008 when quantitative easing began and have slowly tapered off in use in recent years. Uncertainty peaked before the recession demonstrating that it might be a good indicator for bad economic situations. Also, Chen found a positive correlation between the sentiment and stock volatility indicators such as VIX, suggesting that stock markets are sensitive to negative sentiment (Chen, 2016).

Similarly, Kahveci and Odabas (2016) utilized two dictionaries from their software of choice, Diction 7. These two dictionaries were optimism and certainty. They defined optimism as "language endorsing some person, group, concept or event, or highlighting their positive entailments". They define certainty as language indicating resoluteness, inflexibility, and completeness and a tendency to speak ex cathedra. This use of a dictionary of positive words and a dictionary of certain (or uncertain) words matches well with the type of dictionaries created by Loughran and McDonald.

An important paper in this field that influenced how we thought about using dictionaries was Jegadeesh and Wu (2017). They combined the Loughran-McDonald and Harvard IV-4 dictionaries to run their sentiment analysis on FOMC minutes. This allows for both financially specific words to be accounted for as well as more naturalistic words. Similar to other studies in

this field they used a latent Dirichlet allocation algorithm to determine the topics discussed in each paragraph of the minutes in their sample. They combined these topics with sentiment data and examined the reaction of stock markets and interest rates. They found that positive statements regarding economic easing in minutes relate to positive trends in stock markets and interest rates going down. Overall, Jegadeesh and Wu contributed to the idea of combining sentiment dictionaries and using it to examine stock market reaction.

III. Methodology

The following sections detail the steps taken to run sentiment, factor, and regression analysis. These three analyses create the backbone of this study and allow for an in depth look into FOMC communications.

III.A. Sentiment Analysis

1. To begin the process of textual analysis the documents that were analyzed had to be collected and put into the correct format. All statements, minutes, and transcripts for our study are public information and can be found on the Federal Reserve's website. The documents had to be put into pdf form as the program of choice, Linguistic Inquiry and Word Count (LIWC), can only perform sentiment analysis on pdfs.
2. With the documents ready the next step needed for the sentiment analysis was the choice of a dictionary. As discussed previously, the best dictionary for the purpose of analyzing FOMC texts is a combination of the Loughran McDonald dictionary for its financial context and the Harvard IV-4 dictionary for its ability to analyze naturalistic speech. These dictionaries are all readily available online. For LIWC, the dictionaries had to all be combined into one single excel document and subsequently saved as a .dic file type, the standard dictionary file type.
3. Running the LIWC textual analysis software was simply a matter of uploading the combined Loughran McDonald and Harvard IV-4 dictionary file and running the textual analysis on every statement, minute, and transcript. The output, which will be discussed in greater detail in the results section, was then transferred to an excel spreadsheet from which calculations were performed, such as finding, mean sentiments, calculating the differences in sentiment

between statements, minutes, and transcripts, and graphing sentiment over years for each of the document types.

III.B. Factor Analysis

Factor analysis is a statistical process which groups variables together into statistically significant groups. This creates new variables or factors, which are the groupings of existing variables. In our case these factors are groupings of words that we call themes that can be characterized based on their appearance in statements and minutes and how they relate to changes in treasury yields.

1. To run factor analysis, we took the top 100 most frequently occurring words from the FOMC statements and added them to the existing dictionary (Loughran-McDonald and Harvard IV-4). This allowed for the factor analysis to capture words that may not have a predefined sentiment but were important monetary policy words for statements to include. These words included inflation, housing, mandate, employment, etc. Once added, the combined dictionary was reformatted to become self-referential. This newly formatted dictionary was run through LIWC. From there the top 100 most frequent words were selected and became its own dictionary. This was then run through LIWC one more time and the results were factor analyzed in the program SPSS.
2. Before the factor analysis could be run it had to be determined if the data set met two specific criteria, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and the Bartlett's test of sphericity. The KMO for the dictionary was found to be 0.8. A score of higher than 0.6 is considered optimal. Similarly, Bartlett's test of sphericity indicated that the data was significant and was therefore a good candidate for exploratory factor analysis.

3. Running an exploratory factor analysis with varimax and 7 groupings based on the elbow test, which is determining the number of factors to be used based on the inflection point of the scree plot of eigenvalues and factor numbers.
4. The seven factors were then put into a new dictionary. This dictionary was run through LIWC to determine how these factors varied over time.

III C. Regression Analysis

To determine what these factors mean and how they, as well as sentiment, relate to market data we had to perform a regression analysis. Our regression analysis was based on four different interest rate measures, i.e. the two-year treasury yield (T2Y), the ten-year treasury yield (T10Y), a measure of the slope of the treasury yield curve (T10Y2Y), and a measure of the credit spread (BAA10Y). The slope of the yield curve can be measured by the difference in long-term and short-term yields. We use the difference between the ten-year Treasury yield and two-year treasury yield (T10Y2Y). The credit spread is the difference between low quality bond yields and high-quality bond yields. We use the difference between BAA bond yields and 10-year Treasury yields (BAA10Y) to measure changes in the credit spread. All asset market data is from FRED.

These interest rate metrics were chosen to help shed light on the nature of the themes embedded in FOMC documents. The 3 month and two-year treasuries are shorter term and are very sensitive to FOMC actions. The ten-year treasury is longer term and is sensitive to inflation expectations and global economic conditions. The credit spread tends to widen in recessionary (or weak economic) times and narrow in expansionary (or strong economic) times.

We ran four different types of regressions. First was a regression of the changes in yields on the factors identified in our factor analysis. This model took the following form:

1. $\Delta y_t = \alpha + \beta_1 F_{1t} + \cdots + \beta_N F_{Nt} + \gamma_t X_t' + \varepsilon_t$

where Δy_t is the difference in end of day yields between the day before and day of release of FOMC statements. α is the regression constant. $F_{1t} \ldots F_{Nt}$ are factors one through seven and the β's are their coefficients. X_t' is vector of control variables for the pre- and post-crisis (ie. Pre-Dec.2007 and post-Dec.2007), quantitative easing periods (i.e. December 2008 to March 2010, November 2010 to June 2011, and September 2012 to the end of the sample) and FOMC meetings at which a policy change occurred (i.e. raising or lowering rates, which occurred at 27 meetings between the beginning of the sample to December 2008, the beginning of QE). These controls were coded as dummy variables of 0 for pre-crisis, and 1 for post crisis; 0 for non-quantitative easing, and 1 for quantitative easing; and, 0 for no policy change (i.e. a raising or lowering of federal funds rate), and 1 for a policy change.

The second was a regression of the changes in treasury yields on the factors identified in our factor analysis, but instead of being on the difference in yields based on statement releases it is based on minutes release dates. It took the same form as (1).

The third was a regression of the changes in treasury yields on positive, negative, and uncertain sentiment of statements. It took the form:

2. $\Delta y_t = \alpha + \beta_1 S^+ + \beta_2 S^- + \beta_3 S^U + \gamma_t X_t' + \varepsilon_t$

where all variables are the same as previously defined, except S^+, S^-, S^U are the sentiments expressed in each FOMC statement.

The final regression was of the absolute difference of sentiment between minutes and statements. This is done to determine how the difference in sentiment between the carefully crafted statement and the more detailed minutes affect the treasury markets. It took the form:

3. $$\Delta y_t = \alpha + \beta_1 |M - S|^+ + \beta_2 |M - S|^- + \beta_3 |M - S|^u + \gamma_t X_t' + \varepsilon_t$$

with $|M - S|^+, |M - S|^-, |M - S|^u$ being the absolute difference in positive, negative and uncertain sentiment, and the change in yield being centered around the minutes release date.

These models were run through SPSS using stepwise regressions with backwards elimination. The regression coefficients obtained from this process were then used to characterize the factors obtained through the factor analysis process, which is discussed in greater depth in the results and conclusion sections.

IV. Empirical Results

The following sections provides the results from each of the previously described analyses, sentiment analysis, factor analysis, and regression analysis. These take the form of sections detailing sentiment analysis results, the difference between private and public sentiment, and factor analysis results.

IV A. Sentiment Analysis Results

The first set of results comes from the sentiment analysis of statements, minutes, and transcripts. It can be seen in Fig. 2 that negative sentiment peaked during the beginning of the recession and then decreased over the courrse of the remainder of the recession. Conversely, positive sentiment increased during the recession. This makes sense as economic conditions improved so too would the sentiment in statements similar to the findings of Cannon (2015). An important note is how uncertainty decreases over the sample period. This agrees with the findings of Kahveci and Odabas (2016). This could potentially be attributed to changes in chairman style. Unfortunately we cannot definitively say that as the recession in the middle of the sample limits our ability to make solid conclusions about chairman style, but it is still an important element of the results. Regardless, the decrease in uncertainty means that the FOMC was more clearly positive or negative following the recession and conveyed their sentiment more effectively.

Fig. 2
Statement Results

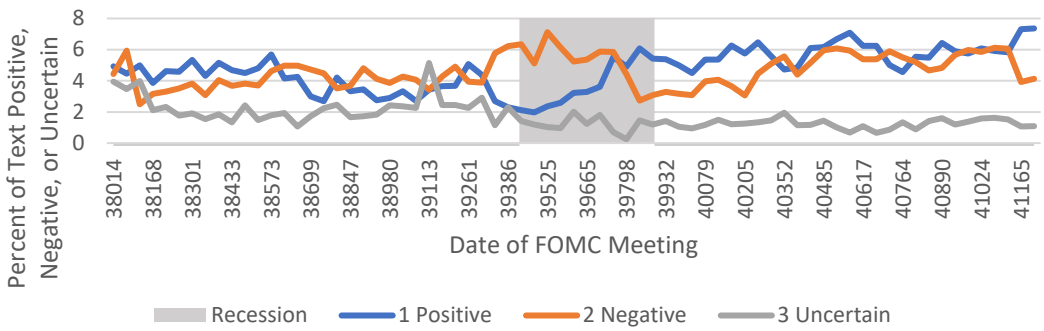


Fig. 3
Minutes Results

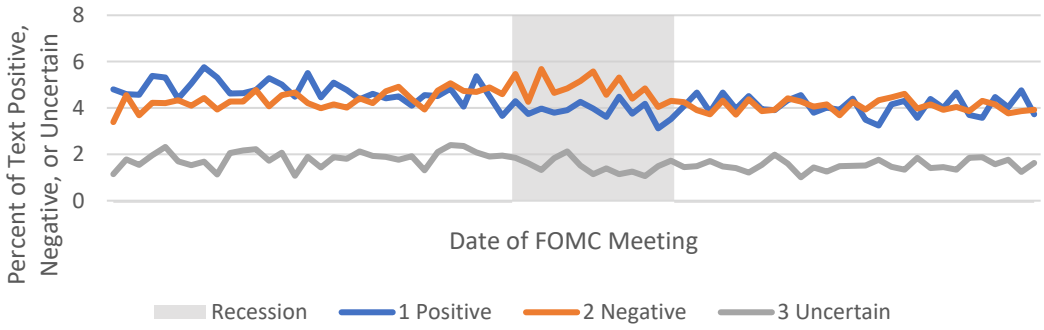
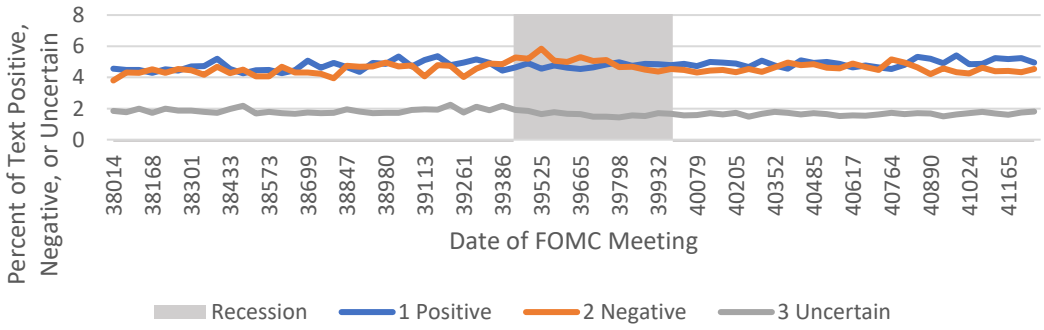


Fig. 4
Transcript Results



The results from minutes and transcripts in Figs. 3 and 4 tell a similar story. Perhaps of more interest is the correlation between the sentiments of the document types as seen in Tables 2, 3, and 4. We would generally expect a positive correlation between all documents for a given meeting if they are conveying the same sentiment. Table 2 shows us that on average for the whole period the sentiment in statements, minutes, and transcripts was positive correlated. Table 3 and 4 break this down by pre-crisis and post-crisis. Of most note in Table 3 is the correlation between positive sentiment between statements and transcripts pre-2007 and the correlation between uncertain sentiment between statements and minutes pre-2007 (the highlighted cells in Table 3). What the negative correlation between the statement and transcript prior to the crisis could suggest is that there is a divergence between the privately expressed sentiment (in statements) and the publicly expressed sentiment (in transcripts). In particular, we find that the Fed was more positive in private in the pre-crisis period, and less positive in private in the post-crisis period relative to the sentiment expressed in public statements. Table 4 shows that there was only positive correlation between the sentiment of each document type indicating that the divergence was limited to pre-crisis.

Table 2

Average Sentiment Scores 2004-2012; N=72			
	Positive	Negative	Uncertain
Statements	4.74	4.62	1.68
Minutes	4.34	4.34	1.65
Transcripts	4.8	4.59	1.74
Correlation between raw sentiment scores			
	SM	ST	MT
Positive Sentiment	-0.16	0.30	-0.09
Negative Sentiment	0.28	0.50	0.59
Uncertain Sentiment	0.26	0.59	0.58

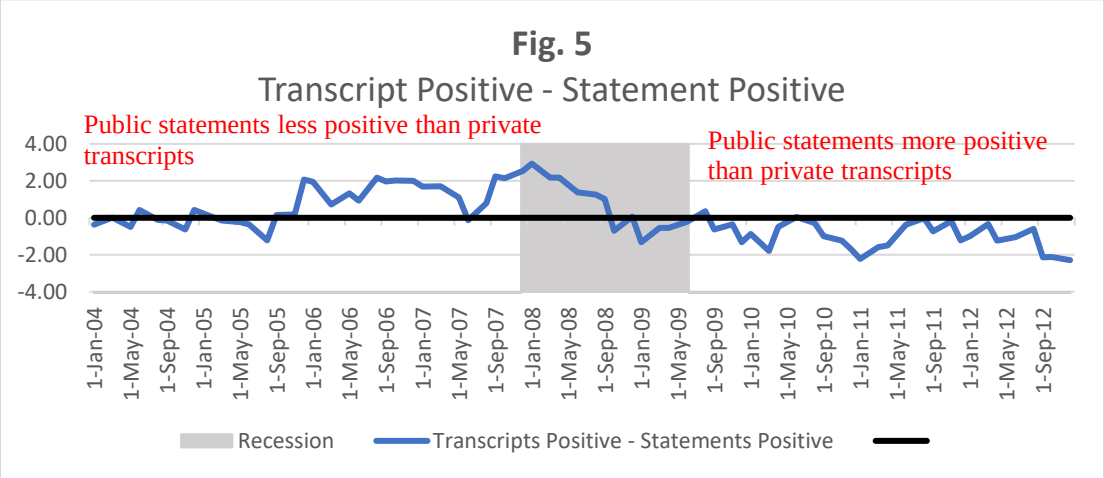
Table 3			
Average Sentiment Scores Pre 12/07			
	Positive	Negative	Uncertain
Statements	4.00	4.18	2.26
Minutes	4.75	4.36	1.83
Transcripts	4.71	4.45	1.86
Correlation between raw sentiment scores			
	SM	ST	MT
Positive Sentiment	0.41	-0.22	0.08
Negative Sentiment	0.40	0.31	0.48
Uncertain Sentiment	-0.23	0.29	0.33

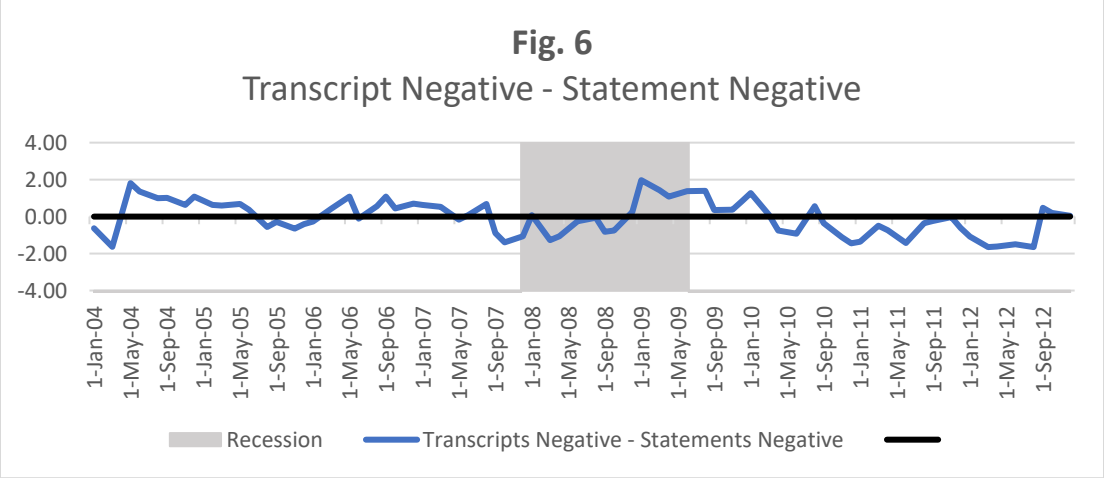
Table 4			
Average Sentiment Scores Post 12/07			
	Positive	Negative	Uncertain
Statements	5.30	4.96	1.23
Minutes	4.03	4.33	1.51
Transcripts	4.87	4.69	1.65
Correlation between raw sentiment scores			
	SM	ST	MT
Positive Sentiment	0.12	0.51	0.20
Negative Sentiment	0.23	0.46	0.71
Uncertain Sentiment	0.37	0.46	0.53

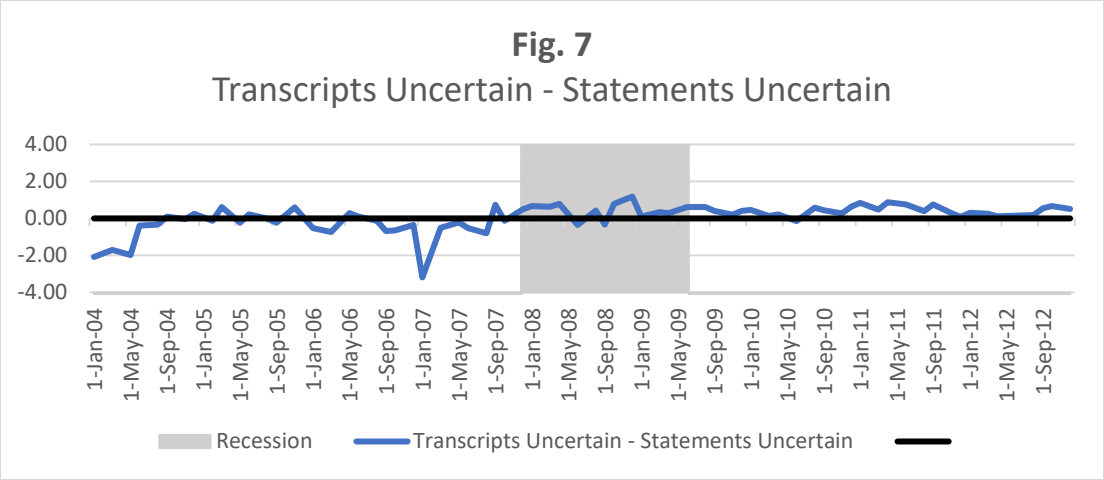
IV B. Public versus Private Sentiment

Fig. 5 highlights the difference in sentiment between the transcripts and statements in our sample. A positive difference in Fig. 5 (any value above the solid black line) indicates that the public statement is less positive than the private transcript and any negative value (any value below the black line) indicates that the public statements is more positive than the private transcript. This would suggest that over the recession the FOMC wanted to put out a positive outlook by using positive words, while internally they were less positive and more negative (as seen in Fig. 6). This means that the FOMC deliberately expressed a different sentiment to the

public than they personally felt. Finally, we note that transcripts transitioned to being more uncertain than statements over the period. This corroborates the results seen earlier that uncertainty in statements declined over the period. This means that the FOMC wanted to be more clearly positive or negative in their public statements.







IV C. Factor Analysis

The process of factor analysis yielded seven factors of varying length seen in Table 5. These factors were analyzed in the context of statements, minutes, and transcripts over our sample. These results can be seen in Fig. 8, 9, and 10. These represent the total percentage of words from the statements, minutes, and transcripts that are part of each of the factors. From this we can see that factor one makes up a significant portion of the words in the statements, with a peak of twenty-six percent of words in the May 2007. Factor one obviously accounts for more of each document type than any other factor due to its large size, with thirty-four words compared to factor seven's three. What is more meaningful is how the appearance of each factor over time relates to market data.

Table 5						
Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
vice	consistent	markets	maintain	point	prices	downside
fomc	mandate	financial	underlying	basis	energy	may
inflation	holdings	credit	support	period	board	activity
target	recovery	promote	stability	approved	increase	
voting	unemployment	conditions	year	action	needed	
moderate	levels	reserve	low	percent	risk	
keep	securities	economic	price		sustainable	
today	employment	lower	continues			
decided	run	developments	pace			
pressures	since	remain				
funds	help	time				
chairman	investment	purchases				
policy	longer-term	spending				
information	committee					
utilization	range					
likely	over					
resource	continue					
monetary	agency					
growth	appropriate					
open	expectations					
quarters						
housing						
outlook						
could						
federal						
risks						
ongoing						
remains						
elevated						
real						
market						
rate						
recent						
although						

Fig. 8

Factors in Statements over Time

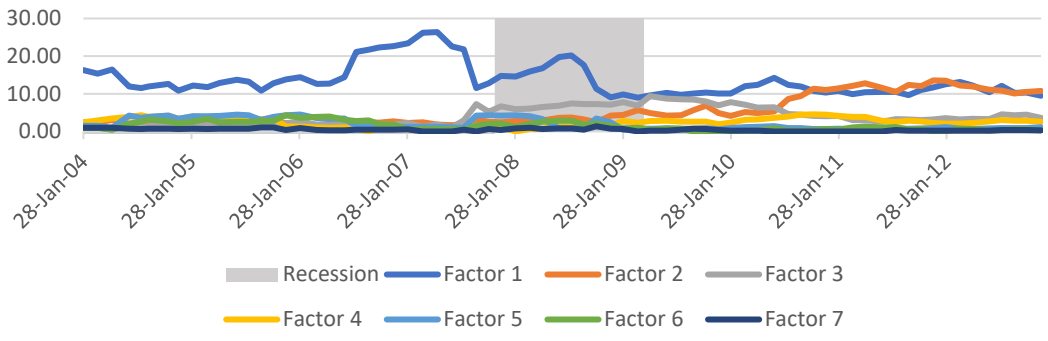


Fig. 9

Factors in Minutes over Time

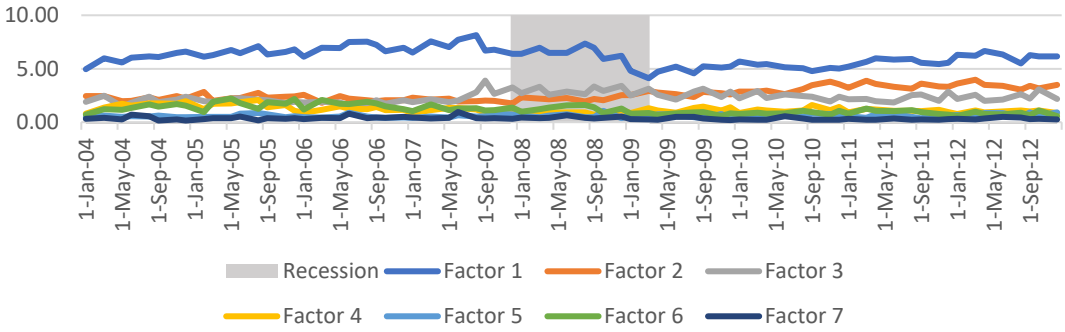
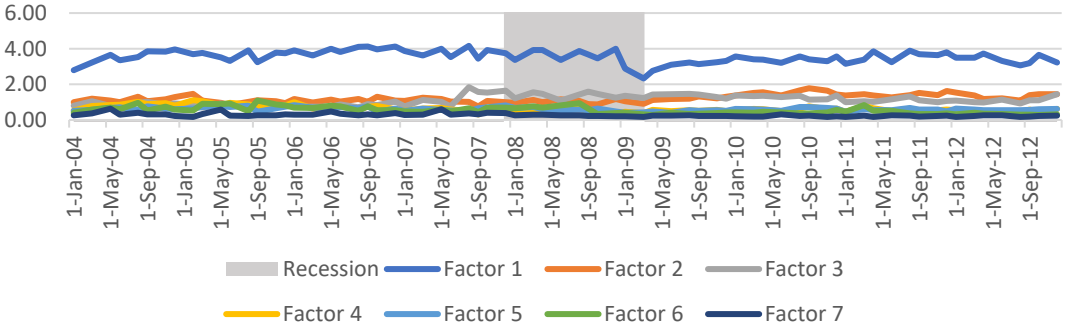


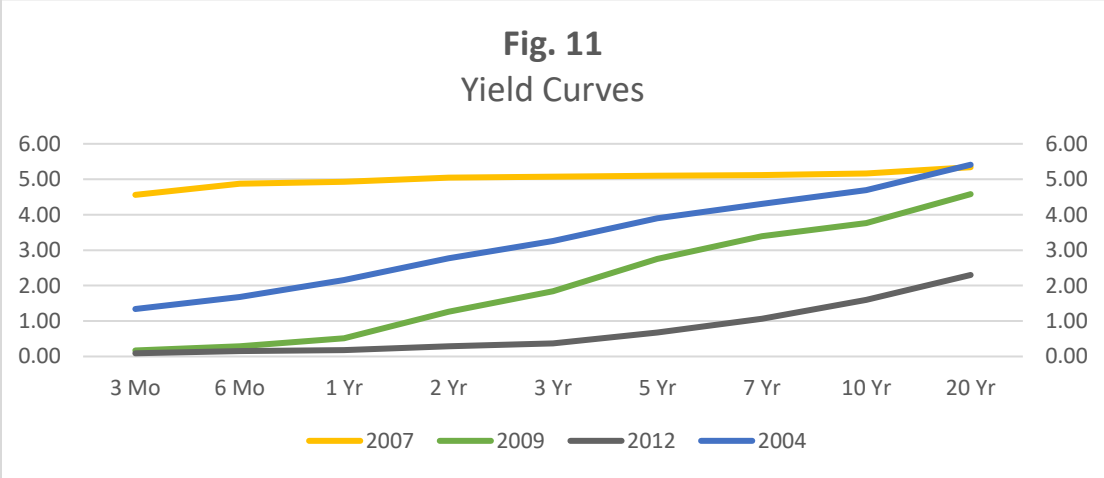
Fig. 10

Factors in Transcripts over Time

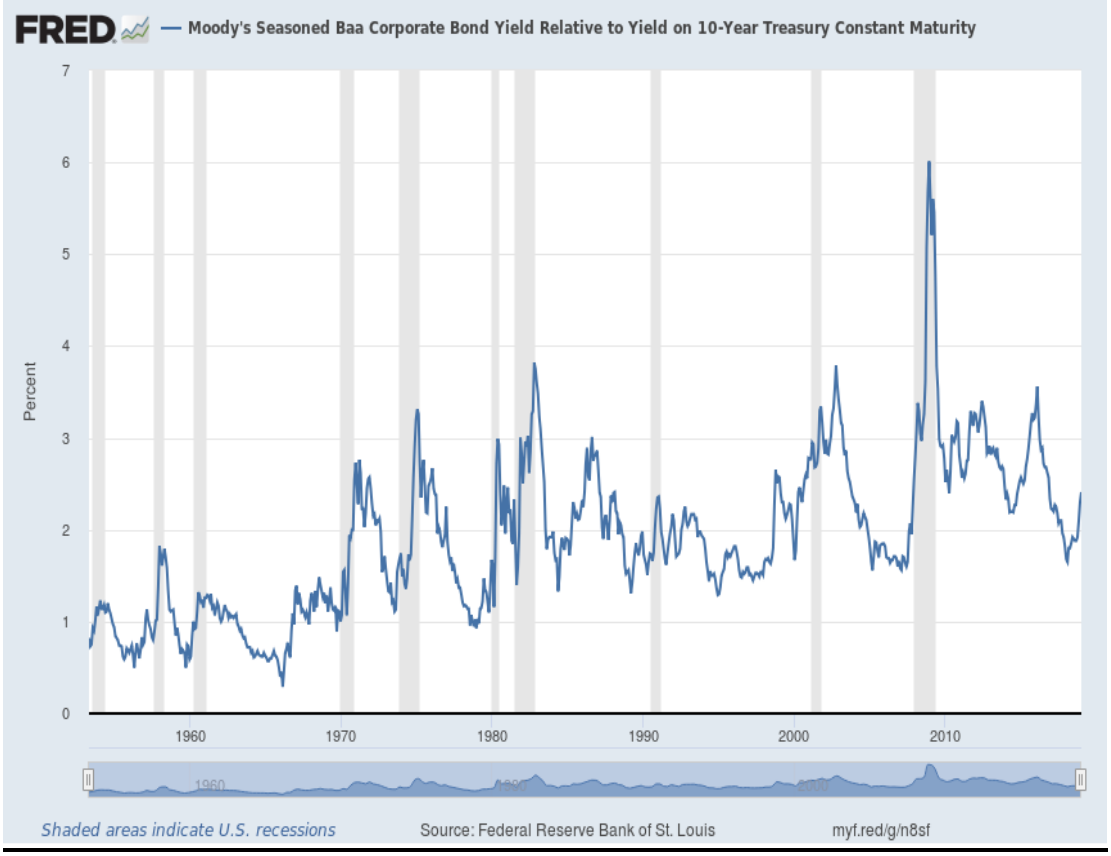


Regression analysis was run on four different yields, the change in the two-year treasury (T2Y), the change in the ten-year treasury (T10Y), the change in the yield curve (T10Y2Y), and the change in the credit spread (BAA10Y). The yield curve shows the relationship between short- and long-term interest rates. Short rates (T2Y) are very sensitive to FOMC actions, while long rates (T10Y) are sensitive to inflation expectations and global economic conditions.

A sample of Treasury yield curves on June 15th of 2004, 2007, 2009 and 2012 can be seen in Fig. 11. These curves demonstrate what can be gleaned from yield curves. The flatter yield curve for 2007 portends a recession, whereas the steeper yield curve for 2009 appears to predict the emergence from a recession.



The credit spread (BAA10Y) is another important factor we used for our regression analysis. In Fig. 12, the credit spread shows the relationship between low- and high-quality debt. The spread widens in recessions (indicated by grey bars) and narrows in expansions.



With this understood, the results seen in Table 6 show us the results from running model 1 on statements. These results indicate that Factor 1 has a positive effect on the slope of the yield curve (T10Y2Y). The results also show us that Factor 2 has a positive effect on the slope of the yield curve (T10Y2Y). This would indicate that Factor 1 and Factor 2 are related to improving economic conditions as a steepening yield curve is associated with improved economic conditions as discussed earlier. Also, we can see that Factor 3 has a positive effect on the short-term yield (T2Y) as well as a positive effect on the yield curve change (T10Y2Y). This would suggest that Factor 3 steepens the yield curve and deals with increasing short-term yields, meaning factor 3 most probably relates to Fed interest rate policy changes.

Table 6				
Model 1 based on Statements				
Coefficient	ΔT2Y	ΔT10Y	ΔT10Y2Y	ΔBAA10Y
Intercept	0.012	0.253	-0.264**	0.099
(Standard Error)	0.126	0.165	0.113	0.086
Factor 1	0.000	0.008	0.008**	-0.003
(Standard Error)	0.004	0.006	0.004	0.003
Factor 2	0.005	0.006	0.010*	-0.002
(Standard Error)	0.006	0.008	0.005	0.004
Factor 3	0.014*	0.002	0.016**	0.000
(Standard Error)	0.008	0.011	0.008	0.006
Factor 4	0.003	0.013	0.010	-0.001
(Standard Error)	0.011	0.014	0.010	0.007
Factor 5	0.009	0.013	0.003	-0.006
(Standard Error)	0.019	0.024	0.017	0.013
Factor 6	0.004	0.000	-0.004	0.003
(Standard Error)	0.014	0.018	0.013	0.010
Factor 7	0.039	0.070	0.031	0.038***
(Standard Error)	0.035	0.046	0.032	0.024
Crisis	0.067	0.007	-0.060	-0.010
(Standard Error)	0.052	0.068	0.047	0.036
QE	0.001	0.042	0.041	-0.005
(Standard Error)	0.030	0.040	0.027	0.021
Policy Change	0.035	0.004	0.031	-0.011
(Standard Error)	0.058	0.076	0.052	0.040
*** significant at 1% ** significant at 5% * significant at 10%				

Table 7 shows us the results from running model 1 on minutes. From these results we can see that Factor 1 again has a positive effect on the yield curve slope (T10Y2Y). This would indicate that Factor 1 steepens the yield curve like Factor 3 but does not affect the short-term yield curve meaning it relates more to economic conditions than Fed policy. Factor 1 has a significant positive effect on the slope of the yield curve for both the release of statements as well as the release of minutes, unlike Factor 2 which only has a statistically significant effect on the slope of the yield curve for the release of statements. This might suggest that Factor 1 still deals with economic conditions, but perhaps with greater specificity which the minutes would

allow. It should be noted that these results are significant despite the positive effect of quantitative easing on the slope of the yield curve.

Table 7

Model 1 based on Minutes

Coefficient	T2Y	T10Y	T10Y2Y	BAA10Y
Intercept	0.035	0.138	-0.172	-0.070
(Standard Error)	0.108	0.121	0.088	0.061
Factor 1	0.009	0.018	0.027**	0.004
(Standard Error)	0.013	0.014	0.010	0.007
Factor 2	0.011	0.028	0.017	-0.002
(Standard Error)	0.019	0.022	0.016	0.011
Factor 3	0.014	0.003	0.011	0.018
(Standard Error)	0.021	0.024	0.017	0.012
Factor 4	0.021	0.029	-0.009	-0.004
(Standard Error)	0.032	0.035	0.026	0.018
Factor 5	0.039	0.063	-0.025	0.038
(Standard Error)	0.052	0.058	0.042	0.029
Factor 6	0.034	0.013	-0.021	0.023
(Standard Error)	0.033	0.036	0.026	0.018
Factor 7	0.055	0.043	-0.012	-0.044
(Standard Error)	0.053	0.059	0.043	0.029
Crisis	0.013	0.017	-0.029	-0.009
(Standard Error)	0.032	0.036	0.026	0.018
QE	0.013	0.047	0.035***	0.020
(Standard Error)	0.018	0.021	0.015	0.010
Policy Change	0.003	0.002	-0.001	-0.021
(Standard Error)	0.019	0.022	0.016	0.011

*** significant at 1% ** significant at 5% * significant at 10%

Tables 8 and 9 show the results from running models 3 and 4. Nothing was found to be significant within these regressions meaning sentiment does not have any effect on treasury markets.

Table 8				
Model 2				
Coefficient	T2Y	T10Y	T10Y2Y	BAA10Y
Intercept	0.171	0.222	-0.052	0.106
(Standard Error)	0.093	0.120	0.086	0.063
Positive	0.013	0.012	-0.001	-0.005
(Standard Error)	0.009	0.011	0.008	0.006
Negative	0.008	0.020	0.013	-0.009
(Standard Error)	0.010	0.013	0.009	0.007
Uncertain	0.029	0.029	0.000	-0.012
(Standard Error)	0.019	0.024	0.017	0.013
Crisis	0.019	0.003	-0.016	-0.005
(Standard Error)	0.036	0.046	0.033	0.024
QE	0.012	0.030	0.042	0.003
(Standard Error)	0.029	0.037	0.026	0.019
Policy Change	0.039	0.035	-0.004	-0.028
(Standard Error)	0.030	0.039	0.028	0.021
*** significant at 1% ** significant at 5% * significant at 10%				

Table 9				
Model 3				
Coefficient	T2Y	T10Y	T10Y2Y	BAA10Y
Intercept	0.013	0.005	0.008	0.016
(Standard Error)	0.020	0.023	0.017	0.012
Positive	0.000	0.009	0.009	0.000
(Standard Error)	0.010	0.011	0.008	0.005
Negative	0.007	0.009	-0.016	-0.007
(Standard Error)	0.012	0.013	0.010	0.007
Uncertain	0.003	0.007	0.004	0.000
(Standard Error)	0.011	0.012	0.009	0.006
Crisis	0.005	0.008	-0.014	0.002
(Standard Error)	0.019	0.021	0.016	0.011
QE	0.011	0.023	0.011	0.025**
(Standard Error)	0.018	0.020	0.015	0.010
Policy Change	0.004	0.001	-0.004	-0.008
(Standard Error)	0.017	0.019	0.014	0.009
*** significant at 1% ** significant at 5% * significant at 10%				

Overall, the regression analysis has shown that out of the seven factors developed during the factor analysis three of them, factors 1,2 and 3 can be characterized by their relationship to changes in treasury yields around the release of FOMC statements and minutes. These characterizations are summarized in the Table 10. Ultimately, these characterizations, coupled with the zero effect of sentiment on treasury yields, would suggest that markets are more focused on the significant policy related words (factors) than the overall sentiment created by the word choice.

Table 10	
Factor Characterizations	
Factor 1	Improving Economic Conditions with greater specificity
Factor 2	Improving Economic Conditions
Factor 3	Easing of Monetary Policy

V. Conclusions, Limitations, and Continuations

Overall, we conclude that sentiment varied over the sample period. Uncertainty decreased, perhaps as a result of change in leadership style, but at the very least as a result of the move to transparency. We conclude that over the course of the recession the FOMC began publicly expressing a more positive sentiment than they were privately expressing during meetings. And we conclude that sentiment holds no effect on changes in treasury yields, but that factors, specifically factors 1,2, ad 3, do and therefore can be characterized by their effect.

Despite these conclusions there are still limitations to this study. First is the dictionary that was used. Though a combination of dictionaries allowed us to get more accurate results than simply using one there are still words not being categorized and slipping through the sentiment analysis procedure. Finally, there could be other variables influencing the change in treasury yields besides the factors we analyzed.

There are a number of extensions that could stem from this study. One of those would be the creation of a specific sentiment dictionary for monetary policy. Just as Loughran and McDonald created a finance specific dictionary, a monetary policy specific dictionary would contribute immensely to the field. Another extension would be analyzing the effect of leadership style, such as Alan Greenspan's vagueness and Ben Bernanke's transparency. Another extension would be to take the divergence of private and public sentiments found in this study and determine if this was done for strategic purposes or not. Finally, another extension would be to look into how voting patterns correlate with sentiment changes between meetings, an issue we do not consider in this paper.

Overall despite its flaws, this research contributes to the literature in novel ways. First by analyzing sentiment in all document types. Second by comparing the sentiment of statements and

transcripts to understand how sentiment varies between public and private documents. Finally, by creating significant factors and characterizing them based on how they relate to the change in treasury yields around statement and minute releases.

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Appendix

January 28, 2004 Statement

For immediate release

The Federal Open Market Committee decided today to keep its target for the federal funds rate at 1 percent.

The Committee continues to believe that an accommodative stance of monetary policy, coupled with robust underlying growth in productivity, is providing important ongoing support to economic activity. The evidence accumulated over the intermeeting period confirms that output is expanding briskly. Although new hiring remains subdued, other indicators suggest an improvement in the labor market. Increases in core consumer prices are muted and expected to remain low.

The Committee perceives that the upside and downside risks to the attainment of sustainable growth for the next few quarters are roughly equal. The probability of an unwelcome fall in inflation has diminished in recent months and now appears almost equal to that of a rise in inflation. With inflation quite low and resource use slack, the Committee believes that it can be patient in removing its policy accommodation.

Voting for the FOMC monetary policy action were: Alan Greenspan, Chairman; Timothy F. Geithner, Vice Chairman; Ben S. Bernanke; Susan S. Bies; Roger W. Ferguson, Jr.; Edward M. Gramlich; Thomas M. Hoenig; Donald L. Kohn; Cathy E. Minehan; Mark W. Olson; Sandra Pianalto; and William Poole.

December 12, 2012 Statement

For Immediate Release

Information received since the Federal Open Market Committee met in October suggests that economic activity and employment have continued to expand at a moderate pace in recent months, apart from weather-related disruptions. Although the unemployment rate has declined somewhat since the summer, it remains elevated. Household spending has continued to advance, and the housing sector has shown further signs of improvement, but growth in business fixed investment has slowed. Inflation has been running somewhat below the Committee's longer-run objective, apart from temporary variations that largely reflect fluctuations in energy prices. Longer-term inflation expectations have remained stable.

Consistent with its statutory mandate, the Committee seeks to foster maximum employment and price stability. The Committee remains concerned that, without sufficient policy accommodation, economic growth might not be strong enough to generate sustained improvement in labor market conditions. Furthermore, strains in global financial markets continue to pose significant downside risks to the economic outlook. The Committee also anticipates that inflation over the medium term likely will run at or below its 2 percent objective.

To support a stronger economic recovery and to help ensure that inflation, over time, is at the rate most consistent with its dual mandate, the Committee will continue purchasing additional agency mortgage-backed securities at a pace of $40 billion per month. The Committee also will purchase longer-term Treasury securities after its program to extend the average maturity of its holdings of Treasury securities is completed at the end of the year, initially at a pace of $45 billion per month. The Committee is maintaining its existing policy of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency

mortgage-backed securities and, in January, will resume rolling over maturing Treasury securities at auction. Taken together, these actions should maintain downward pressure on longer-term interest rates, support mortgage markets, and help to make broader financial conditions more accommodative.

The Committee will closely monitor incoming information on economic and financial developments in coming months. If the outlook for the labor market does not improve substantially, the Committee will continue its purchases of Treasury and agency mortgage-backed securities, and employ its other policy tools as appropriate, until such improvement is achieved in a context of price stability. In determining the size, pace, and composition of its asset purchases, the Committee will, as always, take appropriate account of the likely efficacy and costs of such purchases.

To support continued progress toward maximum employment and price stability, the Committee expects that a highly accommodative stance of monetary policy will remain appropriate for a considerable time after the asset purchase program ends and the economic recovery strengthens. In particular, the Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal, and longer-term inflation expectations continue to be well anchored. The Committee views these thresholds as consistent with its earlier date-based guidance. In determining how long to maintain a highly accommodative stance of monetary policy, the Committee will also consider other information, including additional measures of labor market conditions, indicators of inflation pressures and inflation expectations, and readings

on financial developments. When the Committee decides to begin to remove policy accommodation, it will take a balanced approach consistent with its longer-run goals of maximum employment and inflation of 2 percent.

Voting for the FOMC monetary policy action were: Ben S. Bernanke, Chairman; William C. Dudley, Vice Chairman; Elizabeth A. Duke; Dennis P. Lockhart; Sandra Pianalto; Jerome H. Powell; Sarah Bloom Raskin; Jeremy C. Stein; Daniel K. Tarullo; John C. Williams; and Janet L. Yellen. Voting against the action was Jeffrey M. Lacker, who opposed the asset purchase program and the characterization of the conditions under which an exceptionally low range for the federal funds rate will be appropriate.

Sample of Minutes

January 28, 2004:

https://www.federalreserve.gov/fomc/minutes/20040128.htm

December 12, 2012:

https://www.federalreserve.gov/monetarypolicy/fomcminutes20121212.htm

Sample of Transcripts

January 28, 2004:

https://www.federalreserve.gov/monetarypolicy/files/FOMC20040128meeting.pdf

December 12, 2012:

https://www.federalreserve.gov/monetarypolicy/files/FOMC20121212meeting.pdf