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Tweeting on Monetary Policy and Market Sentiments: The Central Bank Surprise Index

March 2020[♠]

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Abstract

This paper explores the relationship between central bank communication and market sentiment, and proposes a new measure. Market sentiment is proxied using a Twitter-based metric: the Central Bank Surprise Index. The empirical study covers three cases: the Federal Reserve, the European Central Bank and the Bank of England.

JEL Classifications: E44, E52, E58, G14, G15, G41

Keywords: monetary policy, central bank communication, financial market, social media, Twitter, Federal Reserve System, European Central Bank, Bank of England, Bank of Japan

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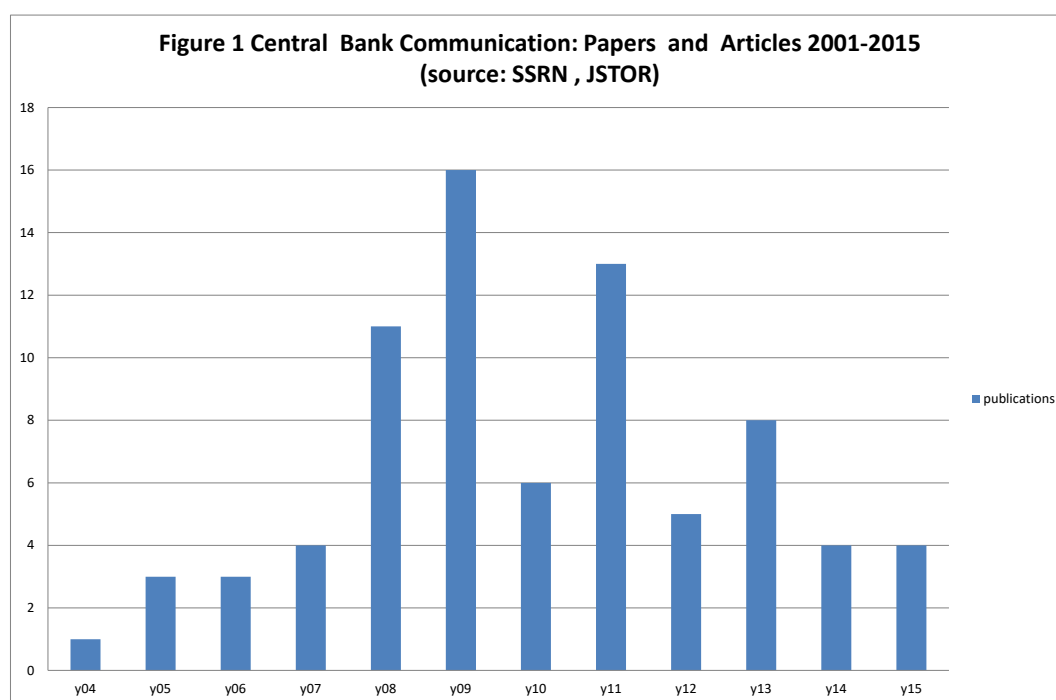
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1. Introduction

How are central banks' monetary policy announcements intertwined with market sentiments and macroeconomic outcomes? The Concluding Remarks that Paolo Baffi, Governor of the Bank of Italy, presented on 31 May 1979 highlighted the fact that *"the actions of central banks are no longer cloaked in silence, and perhaps never will be again. Whereas in the past silence was seen as a guarantee of independence, today this is achieved by giving an explicit account of one's actions."* The governor's words regarding the increasing influence of the link between monetary policy and central bank communication on the overall effectiveness of economic policy in modern economies are crystal clear. illuminating. However, the economic profession has only recently started to systematically recognise central bank communication as an autonomous policy area. In support of this claim, Figure 1 shows the evolution of the academic papers published between 2001 and 2015, with a title containing the term "central bank communication".



Notes: Figure 1 presents the evolution of the number of academic papers and research published with a title containing the words "Central Bank Communication", between 2004 and 2015. Data obtained from SSRN and JSTOR.

The aim of this paper is to explore the relationships among central bank communication and market sentiment. Market sentiment is proxied using a Twitter-based metric: the Central Bank Surprise Index. In our empirical study, we analyse three cases: the Federal Reserve, the European Central Bank (ECB) and the Bank of England. Notably, the link between tweeting on monetary policy and market sentiments has been studied recently in relation to US President Trump's tweets on US monetary policy (Camous and Matveev 2019, Bianchi et al. 2019).

The paper is organized as follows. A review of the most relevant extant literature is provided in sections two and three. A discussion of both the methodology and the data used in the analysis can be found in section four, while our conclusions are presented in section five.

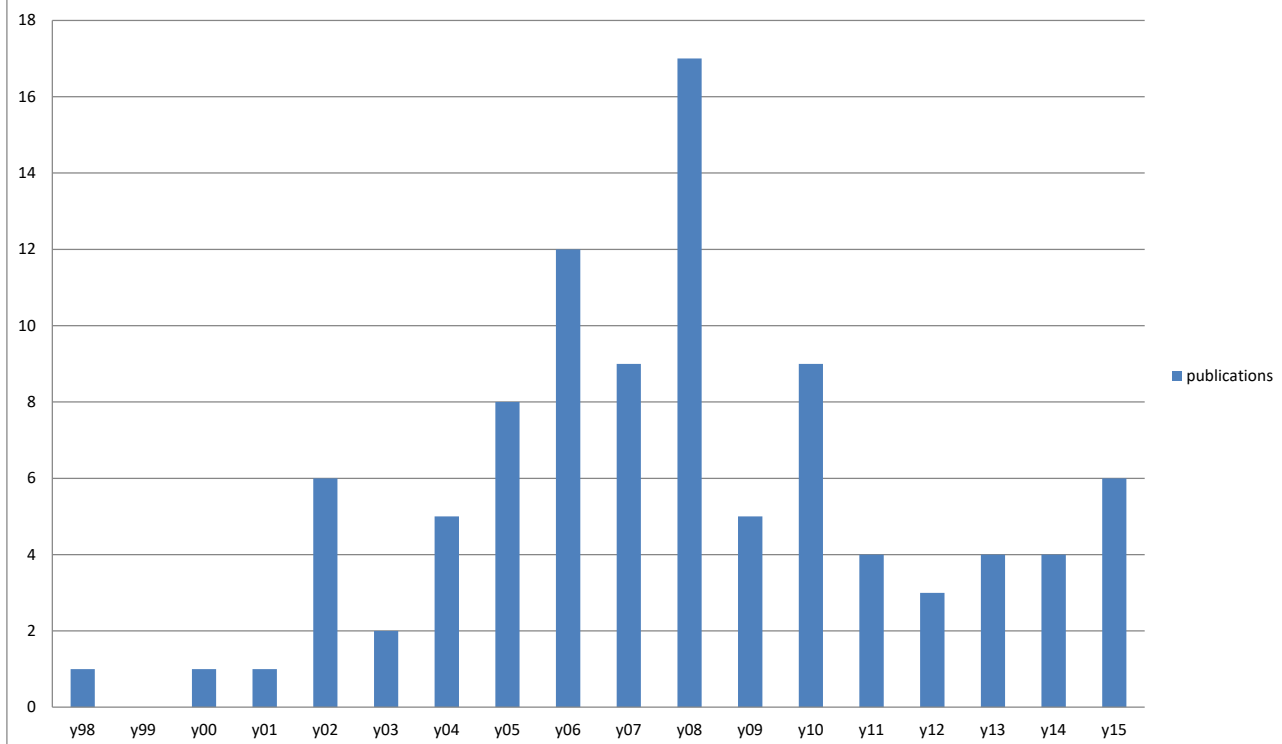
2. From Silent to Vocal: Monetary Policy, Transparency and Expectations

In the 1970s and 1980s, central banks were shrouded in monetary mystique and secrecy (Goodfriend 1986). The rationale for the lack of monetary policy transparency and communication was the theory of ambiguity, credibility and inflation under discretion and asymmetrical information developed in the seminal article by Cukierman and Meltzer (1986). The bottom line was simple: when information between the public and the policymaker is asymmetrical, monetary policy ambiguity is likely to produce inflationary surprises and, consequently, short-run macroeconomic gains. The mix of a discretionary monetary policy with a short-sighted policymaker can justify ambiguity, as the negative spillover (under rational expectations) is likely to be in the form of higher and more variable inflation. Notably, under this approach, the effectiveness of monetary became linked with the role of market expectations, which are assumed to be rational across individuals.

In fact, the development of the modern theory of the monetary policy, which is based on the intertwined concepts of rules in policy making on the one hand and the policy maker's independence and accountability on the other hand, naturally produced a shift in communication from secrecy toward transparency (Eijffinger and Masciandaro 2014). Monetary policy discretion and ambiguity were abandoned in favour of explicitly announced and motivated monetary policy rules. Transparency became a key feature of central banks' policies and the increase in monetary policy transparency was a truly worldwide phenomenon (Blinder et al. 2008).

In parallel, the academic profession took note of central bank transparency as an interesting area of research. Again, a search of the economic literature for the terms "monetary policy transparency" (MPT) or "central bank transparency" in paper titles highlights this point (Figure 2).

Figure 2 Monetary Policy Transparency: Papers and Articles 1998-2015
(source: SSRN, JSTOR)

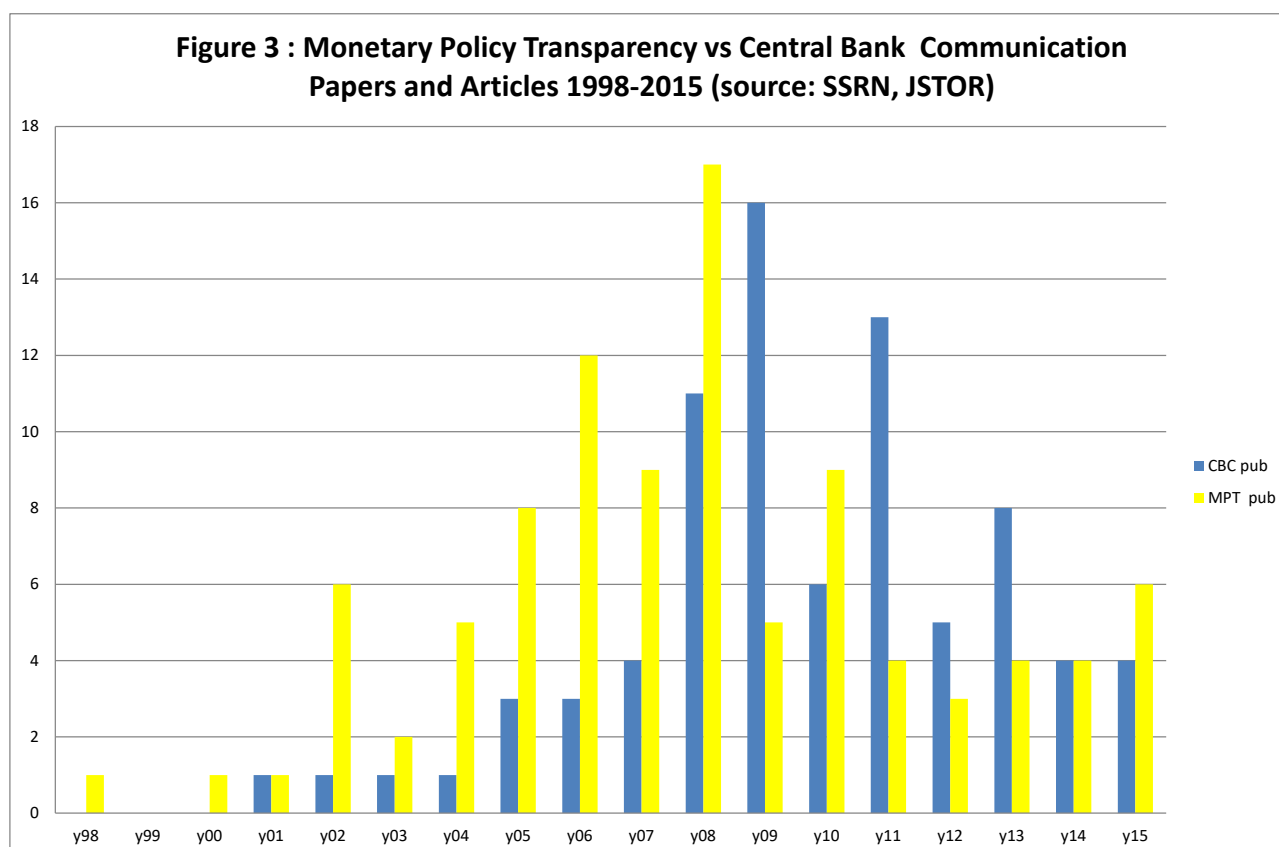


Notes: Figure 2 presents the evolution of the number of academic papers and research published with a title containing the words “Monetary Policy Transparency”, between 1998 and 2015. Data obtained from SSRN and JSTOR.

When comparing the CBC publications to the MPT publications (Figure 3), we find that the MPT series is a bit older and that the total number of MPT publications is higher (94 versus 78). Moreover, the MPT peak is both slightly earlier (2008 versus 2009) and greater (17 versus 16 publications) than the CBC peak.

The increasing importance of transparency reflects the evolution of the monetary policy rationale. It has been widely stressed that the ability of central banks to affect the economy critically depends on their ability to influence market expectations regarding the *future path* of overnight interest rates – not just their current level. The provision of better information to market participants on the monetary policy ongoing activities and future intentions should enhance the degree to which central-bank policy decisions can actually affect expectations and, thereby, increase the effectiveness of monetary policy stabilization. Therefore, the public’s understanding of current and future policy is critical for policy effectiveness. As such, monetary policy has increasingly become the art of managing expectations (Woodford 2005).

As Woodford (2005) argues, the sole instrument traditionally available to central bankers was the overnight lending rate – a short-term interest rate. Nevertheless, all spending decisions ultimately rely on longer-term interest rates, such as mortgage rates and long-term treasury bonds, which in turn largely depend on private expectations regarding future central bank decisions. In other words, they depend on the future path of interest rates. As expectations provide the essential link between the two rates at different horizons, their management is of crucial importance. Under current conditions, nothing else seems to matter for monetary policy (Blinder et al. 2008).



Notes: Figure 3 presents a comparison of the evolution of the number of academic papers and research published with a title containing the words “Monetary Policy Transparency” versus those containing the words “Central Bank Communication”, between 1998 and 2015. Data obtained from SSRN and JSTOR.

Consequently, the transparency of central bank decision-making has increased rapidly since the early 1990s. The trend began with the adoption of inflation targeting by the Bank of England, the Bank of Canada, the Reserve Bank of New Zealand and Sweden’s Riksbank. Although the US Federal Reserve System does not officially engage in inflation targeting, it has gradually adopted this practice. From its beginning, the European Central Bank adopted from a “two-pillar strategy” with a monetary pillar focusing on monetary aggregates like M3, which it inherited from the Deutsche Bundesbank, and an economic pillar taking the drivers of inflationary expectations into account.

At the same time, the changing shape of the institutional setting motivated a shift in central banks’ behaviours in which more weight was put on communication with the public. In fact, an important trigger of increased transparency has been the demand for greater accountability of independent central banks. As central banks have become more independent over time, they have had to pay more attention to explaining what they do and the reasoning behind their decisions (Briault, Haldane and King 1996). More transparency and the increased use of communication are logical consequences of this development. As Woodford (2005) argues, to satisfy the requirements of democratic legitimacy associated with increased independence, central bankers have been forced to issue more and better information on their activities.

Even though central bank accountability justifies this trend towards more transparency, whether this transparency is beneficial from a general economic standpoint is less obvious. Therefore,

many theoretical studies attempt to analyse whether the trend towards transparency is justified. These studies vary not only with respect to the different aspects of central bank transparency, such as political, economic, procedural, policy and operational transparency, but also with regard to the structure of the economy determining the concrete monetary-transmission mechanism (Issing 2005). Several of these studies focus on how increased transparency could be effective in anchoring inflation expectations (Bianchi and Melosi 2018, Eusepi and Preston 2010, Campbell et al. 2017). This is a major concern for central bankers who have adopted a monetary policy framework of constrained discretion (i.e., the vast majority of central bankers), as inflation stability is deemphasized to accommodate short-sighted policies with potential benefits for output growth.

In addition to this theoretical research on the economic effects of central bank transparency, a wave of empirical studies uses institutional indices of central bank transparency. This literature can be divided into five areas of focus: political, economic, procedural, policy and operational transparency. Building on these five categories, the first comprehensive index for central bank transparency was constructed for the central banks of Australia, Canada, the Eurozone, Japan, New Zealand, Sweden, Switzerland, the United Kingdom and the United States (Eijffinger and Geraats 2006). Notably, other examples of the literature on the transparency indexes has been produced (Horvath and Vasko 2016). For example, Dincer and Eichengreen (2014) test their transparency index for more than 100 central banks between 1998 and 2010. They find little indication of these broad trends towards greater central bank independence and transparency being rethought or reversed as a result of the global financial crisis.

3. Voice as Policy: Central Bank Communication and Market Sentiments

In the overall issue of monetary policy transparency, the topic of central bank communication gained momentum when economic analyses acknowledged that the effectiveness of the central bank's strategy can depend on consistency in its communication policy. If we assume that the public has rational expectations, any systematic pattern in the way that policy is conducted should be correctly inferred from the central bank's rules for managing monetary policy action. Thus, when it comes to predicting the interest-rate policy, one can interpret (forecasts of) economic data in view of the central bank's policy rule. As such, there is no need for central bank communication.

Therefore, we can define central bank transparency as how easily the public can understand the central bank's strategy solely from "observables". One might say that a central bank can be fully transparent without any communication. However, the less monetary transparency is automatically guaranteed, the more the design and implementation of an effective communication policy become necessary (i.e., "discovering the observables").

Communication can enhance the effectiveness of monetary policy by either by creating genuine news that is complementary to policy actions or "reducing noise" and, thereby, uncertainty in the public's interpretation of policy actions (Blinder et al. 2008). The key lies in increasing the predictability and understanding of monetary policy, clarifying policy objectives and strategies to allow for more informed decisions by businesses and households, and enabling practitioners in financial markets to gain a better understanding of how policy is likely to respond to incoming information. This should be done in such way that asset prices and bond yields will tend to

respond to economic data in ways that further the central bank's policy objectives (Bernanke 2004).

Consequently, academics and central bankers (Bini Smaghi 2007) have zoomed in on communication policy (D'Amato et al. 2003, Woodford 2005, Blinder 2009, Neuenkirch 2011a, Ericsson 2016, Stekler and Symington 2016). Communication has become a key instrument in the central banker's toolbox in recent years. Virtually all central banks in advanced economies have taken major steps toward using communication as a key instrument in monetary policymaking. In fact, the communication strategy is usually associated with the decision-making process (Ehrmann and Fratzscher 2005a). Moreover, the communication policies of monetary authorities became even more important following the 2008 financial crisis and the subsequent adoption of unconventional monetary policy tools, such as forward guidance on the future path of interest rates and quantitative easing. These instruments had to be convincingly connected to the former monetary policy objectives (Yellen 2013). Moreover, these instruments are closely related to our previous reasoning on successfully steering expectations, as their effectiveness is completely dependent on success in this regard. Consequently, as argued by Blinder et al. (2016), "governors and academics agree that central bank communication has become more frequent since the crisis".

Coenen et al. (2017) highlight the emergence of new challenges in recent unconventional times that increase the need to enhance monetary policy's predictability. These challenges relate to: higher economic uncertainty, which may weaken the public's ability to identify the information on which monetary actions are based; constrained policy instruments that may harm trust in a policy's effectiveness and disrupt the public's ability to predict the central bank's actions; and the introduction of new policy instruments that require additional central bank communication, as neither the set of potential instruments nor their effectiveness are known to the public. Moreover, in times of high uncertainty, central banks should consider the fact that volatility tends to increase due to the accumulation of "noise" in communication. Noise may be either "common" (when all agents suffer from the same imperfect interpretation of an announcement) or "private" (when interpretations differ across individuals). While the former can be avoided through the provision of more detailed information (Coenen et al. 2017, Sims 2002), the latter can be counteracted by communicating as precisely as possible in order to reduce the scope for private interpretations (Coenen et al. 2017).

The increased importance of communication for policy makers is mirrored in the rapid development of the academic literature on this topic. Researchers have highlighted at least three reasons why communication may prove useful for central banks. First, communication is a very direct and effective tool for influencing expectations (Eusepi and Preston 2007, Osterholm et al. 2008, Sturm and de Haan 2011, Drager et al. 2015). Therefore, it plays a seminal role in improving the effectiveness of monetary policy and, consequently, the economy's overall performance (Blinder et al. 2008).

Second, monetary policy communication can be a way to strengthen credibility and independence (Hayo and Neuenkirch 2014) as well as conservativeness (Eijffinger et al. 2004). In fact, communication may help the central bank demonstrate that its policies are consistent with its mandate.

Third, given the two above-mentioned intertwined channels, communication may greatly influence macroeconomic outcomes. The literature sheds light on the impact of central bank communication on macroeconomic variables, such as exchange rates (Fratzscher 2004, Jansen and De Haan 2004, Sager and Taylor 2004, Melvin et al. 2009, Conrad and Lamia 2010), interest rates (Guthrie and Wright 2000, Kohn and Sack 2004, Gurkaynak et al. 2005, Woodford 2005, Brand et al. 2006, Anderson et al. 2006a and 2006b, Hausman and Wongswan 2006, Anderson 2007, Ehrmann and Fratzscher 2007, Heinemann and Ullrich 2007, Rosa and Verga 2007, Lucca and Trebbi 2009, Hayo and Neuenkirch 2010, Rinaldo and Rossi 2010, Neuenkirch 2011b, Tang and Yu 2011, Beck et al. 2012, Smales 2012, Hendry 2012, Chirinko and Curran 2013, Egert and Kocenda 2013, Lamia and Sturm 2013, Kamada and Miura 2014, Carvalho et al. 2014, Hayo et al. 2014, Galardo and Guerrieri 2017, Hansen et al. 2020), stock prices (Rosa 2011, Kurov 2012), and general financial (Ehrmann and Talmi 2017, Jubinski 2017) and real variables (Hansen and McMahon 2016). Monetary policy news can also affect exchange rates via the interest-rate channel (Ferrari et al. 2017).

A more effective communication policy can lead to greater predictability of central banks' actions, which, in turn, reduces the uncertainty in financial markets. The ability of policy makers to influence macroeconomic outcomes and the predictability of policy decisions are not independent – communication that leads to high predictability may have a significant effect on the economic system as a whole. In other words, the more the market's reaction is not mechanically guaranteed, the more communication matters as a tool for increasing the likelihood that expectations, announcements and sentiments are consistent.

In modern monetary policy theory, the relevance of communication for the links among expectations, announcements and markets becomes even more evident if we adopt at least one of the following assumptions: non-rational expectations, asymmetrical information, or the absence of policy rules and reputation. If one or more of these conditions hold, then central bank communication may have an impact on financial markets (see De Haan, Eijffinger and Rybinski 2007). The intuition is straightforward – if monetary policy discretion becomes an unpalatable quality, then ambiguity is a central bank shortcoming that has to be eliminated via effective communication policies. Therefore, any kind of market imperfection reinforces the need for effective communication.

The three channels that motivate the relevance of central bank communication work as follows. First, the assumption that the public will perfectly understand monetary policy regardless of the efforts made to explain it may be unrealistic. King (2005) suggests that the public may follow simple (but possibly fairly robust) heuristics in making decisions instead of adopting optimising behaviour. He argues that, in this case, central-bank communication can play an important role in leading people to choose the right heuristics: “the more the central bank can do to behave in a way that makes it easy for the private sector to adopt a simple heuristic to guide expectations the better. A good heuristic from that point of view would be ‘expect inflation to be equal to target’” (King 2005, p. 12).

Furthermore, the literature focused on elaborating alternative frameworks to traditional DSGE modelling offers insights into possible cognitive distortions that might affect the understanding of the state of the economy and, thereby, the understanding of monetary policy. For example, Angeletos (2019) modulates these distortions by introducing high-order uncertainty and by arguing for the presence of exogenous sentiment waves across individuals. In so doing, the author

is able to explain the ambiguous effects of forward guidance in monetary policy where the effects (in terms of anchoring expectations) seem to be dulled with respect to a rational equilibrium benchmark. By accounting for forces more akin to animal spirits than fully rational beings, the benefits of forward guidance are attenuated, as individuals fail to coordinate a homogenous response to any exogenous shock. This, in turn, is the result of a failure to homogeneously interpret the forward guidance. In this case, the provision of more information does not necessarily enhance the effectiveness of monetary policy.

Nevertheless, by communicating to the public, the central bank may effectively help anchor expectations. Bernanke (2004) refers to the recent literature on adaptive learning when explaining why communication on these issues affects monetary policy effectiveness. When the public does not know the central bank's reaction function but instead must estimate it, there is no guarantee that the economy will converge to the optimal rational expectations equilibrium because the public's learning process *itself* affects the economy's behaviour. The effect of learning on the economy can lead to unstable or indeterminate outcomes. In such a setting, the central bank's communication may play a key role in improving economic performance.

Second, financial-market participants generally do not have as much information as monetary policymakers about a number of key inputs in policymaking, including the policymakers' objectives, their assessment of the economic situation and their policy strategy. If there is asymmetrical information (i.e., if the public and the central bank possess different information), it is perfectly rational for the public to adjust its expectations. For instance, the central bank may provide information about its reaction function. All else equal, this should lead to an increase in the private sector's ability to forecast the central bank's policy. In countries without explicit inflation targets, the central bank can provide information about its long-run inflation target.

Similarly, central banks could provide information on the relative weights that they place on their output and inflation objectives in their monetary rules. Furthermore, central banks may have better information on the economic outlook. Kohn and Sack (2004) argue that private agents may lend special credence to the economic pronouncements of the central bank, especially if the central bank has established credibility as an effective forecaster of the economy. However, even if the central bank has better information, an important issue that remains to be settled is the circumstances under which the release of that information may be beneficial (i.e., contribute to realizing the central bank's objectives).

Third, most central banks do not follow a fixed rule. For example, Bernanke (2004) stated that "specifying a complete and explicit policy rule, from which the central bank would never deviate under any circumstances, is impractical. The problem is that the number of contingencies to which policy might respond is effectively infinite (and, indeed, many are unforeseeable)". Consequently, "it is impossible to design a contract so complete that nothing ever happens to require its being rewritten" (Capie and Wood 2013). By commenting on recent or expected economic developments or by giving hints, the central bank may influence financial markets' expectations (Siklos and Strurm 2013).

However, what constitutes an optimal communication strategy remains unclear. Any communication strategy can produce intended and unintended effects. In other words, the consequences of the three channels described above – expectations, credibility and macroeconomic variables – can be positive or negative. Therefore, an approach of "more

information is always better” is neither sufficient nor correct. As Issing (2005) argues, full disclosure is idealistic, as it would quickly run into practical difficulties. Moreover, considering that data are not always self-explanatory and that they represent a wide spectrum of conditions, “even if a central bank wanted to, it would not be able to avoid the need to select information, qualify it, and comment on it” (Issing 2005).

Therefore, the communication policy adopted by each central bank must be carefully studied (Aidarova and Seyitov 2011, Garcia Herrero and Girardin 2013). In particular, at least three aspects should be highlighted: contents, procedures and timing. First, the contents of the communication must be distinguished. The contents can, for instance, be either quantitative (Hayo and Neuenkirch 2010) or qualitative, and the statements can be backward looking or forward looking. Furthermore, the topic of the communication is important (e.g., macroeconomic aspects, including inflation (Cihak et al. 2012, Ehrmann and Ullrich 2007), fiscal policies (Allard et al. 2012) or financial stability (Born et al. 2010 and 2014, Cihak 2006, Osterloo et al. 2011, Cihak et al. 2012, Correa et al. 2017)).

Second, the communication procedures must be considered (Ehrmann and Sondermann 2012). It can take such forms as a press release (Jansen and De Haan 2009, Lucca and Trebbi 2009, Fay and Gravelle 2010, Acosta and Meade 2015, Hansen and McMahon 2016, Ehrmann and Talmi 2017) or a press conference (Heinemann and Ullrich 2007, Ullrich 2008, Rosa and Verga 2007, Berger et al. 2010, Sturm and De Haan 2011). Other forms might depend on who is the communication sender (i.e., committees, Kohn and Sack 2004, Reeves and Sawicki 2006, Reinhart and Sack 2006, Andersson et al. 2006a and 2006b; individuals, Jansen and De Haan 2004, Ehrmann and Fratzscher 2007, Rozkrut 2008). For example, Reeves and Sawicki (2006) find that communication made on behalf of the entire policy-making committee is a particularly strong market mover relative to communication delivered on a personal basis.

Another aspect to be considered in relation to procedures is the consistency of communication. Jansen and de Haan (2010) test the extent to which the ECB uses consistent language in its communication. They find consistency overall, even though the ECB’s communication is flexible enough to adapt to changing circumstances. Acosta and Meade (2015) study the similarity of FOMC post-meeting statements and show that they have become more similar over time, especially since the global financial crisis. Nevertheless, FOMC statements have also become more complex since the onset of unconventional monetary policy, as shown by Hernández-Murillo and Shell (2014). Another matter of interest regarding consistency is how much importance the central bank attributes to the personal views of its committee members. This aspect differs across central banks. For example, the ECB and the Bank of England follow a collegial approach to communication and they exhibit a high degree of consistency. In contrast, communication from the Federal Reserve is significantly more dispersed (Ehrmann & Fratzscher 2005a).

The role of language is also crucial (Gerlach 2004, Heinemann and Ullrich 2007, Boukus and Rosemberg 2006, Rosa and Verga 2007, Bulir et al. 2008, Smidkova and Bulir 2008, Berger et al. 2010, Kawamura et al. 2016, Hansen and McMahon 2016). In measuring the content and the tone of central banks’ communication, two approaches have been used (Ehrmann and Talmi 2017): human coding and automated coding. In addition computational linguistic tools have been used to analyse monetary policy communication (Lucca and Trebbi 2009, Bailey and Schonhardt-Bailey 2008, Hendry and Madele 2010, Hendry 2012, Fligstein et al. 2014, Acosta 2015, Schonhardt-Bailey 2013, Hernandez-Murillo and Shell 2014, Hansen et al. 2014, Amaya and Filbien 2015,

Hansen and McMahon 2016, Schmeling and Wagner 2016, Hubert and Labondance 2017). Recently, social media, especially Twitter, has been explored as an information device for central bankers (Carretta et al. 2016) and markets (Guindy and Riordan 2017, Snow and Rasso 2017).

Third, the timing of communication must be investigated (Ehrmann and Fratzscher 2005b, Hu et al. 2015) from at least two points of view: in absolute terms by distinguishing periodical, institutional announcement, which is predictable, from announcements that are not; and in relative terms with respect to the functioning of financial markets (e.g., if the announcements are communicated when markets are closed or open) or the habits of investors (Guindy and Riordan 2017). With regard to institutional communication, the literature has emphasized the role of minutes and their timeliness (Reinhart and Sack 2006, Bank of England 2005).

4. Tweets on Monetary Policy as Market Sentiment Metrics: Methodology and Data

Our objective is to transform daily tweets about the monetary policy decisions of the Bank of England, the European Central Bank and the Federal Reserve Bank into a numerical measure of similarity that reflects the distance between market expectations and the information provided in central bank transcripts. In this section, we describe our methodology for constructing the similarity measure.

4.1 Data Collection

We focus on official communication about monetary policy committee decisions from the three most important central banks: the Bank of England, the European Central Bank and the Federal Reserve. From their official websites, we retrieved transcripts of meetings in which a monetary policy decision was announced. Our sample comprised:

- 1) 143 transcripts of Bank of England meetings from 2006 to December 2018,
- 2) 230 transcripts of European Central Bank meetings from 1998 to December 2018 and
- 3) 54 transcripts of Federal Reserve meetings from 2012 to December 2018.

Even though we can only match these communications with tweets as of 2011, we included older transcripts, as a larger set of documents improves the accuracy of the algorithm that we use for the natural language processing (NLP) analysis.

In the first step of our analysis, we collected all Twitter messages related to monetary policy decisions. Specifically, we collected tweets that: (a) mentioned the official Twitter account of the bank (e.g., @bankofengland); (b) contain a number sign followed by the bank's acronym (e.g., #ecb); (c) contained a number sign followed by the governor's surname (e.g., #draghi) or (d) contained the hashtag #interestrates. Using the "Get Old Tweets" module in Python, we collected all Twitter messages with these characteristics published in the period from seven days prior to the focal central bank's monetary policy announcement until two days after that announcement.

In the following Table we show the keywords used for each bank together with the number of codified Twitter messages and the period of analysis.

Bank	Keywords	Number of tweets	Timeframe
Bank of England ¹	@bankofengland, #bankofengland, #boe, #interestrates	325,462	Since 2011
European Central Bank	@ecb, #draghi, #ecb, #interestrates	609,447	Since 2011
Federal Reserve	@federalreserve, #Yellen, #fed, #interestrates	952,806	Since 2011

We manually checked several random selected tweets to ensure that we only retrieved tweets related to reactions to central banks' announcements. We found that unrelated tweets typically contained one of the acronyms indicated in the Table (e.g., #ecb) but were in a language other than English. To avoid the inclusion of irrelevant tweets in our sample, we eliminated tweets not in English. Eliminating these tweets had an additional advantage, as some of the pre-processing steps that we describe below relied on pre-existing dictionaries that were developed only for the English language. The final sample of tweets is reported in the Table.

4.2 Metrics: Building the Central Bank Surprise Index

Text pre-processing

We pre-processed the text in both the central bank transcripts and the Twitter messages by lower-casing all words. For tweets, we also removed all URLs and mentions of other Twitter users. For central bank transcripts, we removed standard introductions to speakers. We then broke streams of text into single words called "tokens". Thereafter, we eliminated "stop words" – words that occur frequently in our corpus but have little meaning. For this purpose, we used the stop words dictionary in NLTK. We also removed all tokens that consisted only of non-alphanumeric characters. Moreover, we removed emoticons as well as the symbols @ and # from tweets.

Next, we lemmatized the words using WordNetLemmatizer from the Python module NLTK. Lemmatization entails reducing words to a common root form, called a "lemma", to limit the presence of synonyms. Then we performed stemming, which implies conflating the various forms of a word into a common representation known as the "stem". For instance, as a result of this process, the words "ate" and "eating" are both reduced to the common stem "eat". Stemming and lemmatization rely on pre-existing dictionaries for the English language, which explains why we eliminated non-English tweets from our corpus. We relied on Porter Stemmer in the Python module NLTK for our stemming. Finally, we introduced collocation – the combination of two words that have higher probabilities of co-occurring together than separately. For instance, the tokens "new" and "york" have higher chances of co-occurring as "New York" than separately. In this case, collocations transform the two separate tokens into just one: "new_york".

Our corpus comprises two types of documents: bank transcripts and tweets. As we are interested in how the similarity between bank conference calls and the market's response after the call influences interest rates, we gathered the tweets published in the interval between 48 hours

¹ The number sign with the governor's surname was not used for this bank because it is a common last name with different meanings, so it would be found in numerous irrelevant tweets.

before and 48 hours after a speech. The tweets were split into 12-hour segments around the speech. The intervals are illustrated in the following Table. Thus, we have eight groups of tweets to measure against the content of the speeches.

Tweet Intervals (delta hours from the speech)		
[-48, -36)	a_lag_4836	48 to 36 hours before the speech
[-36, -24)	b_lag_3624	36 to 24 hours before the speech
[-24, -12)	c_lag_2412	24 to 12 hours before the speech
[-12, 0)	d_lag_1200	Up to 12 hours before the speech
[0, +12)	e_fwd_0012	Up to 12 hours after the speech
[+12, +24)	f_fwd_1224	12 to 24 hours after the speech
[+24, +36)	g_fwd_2436	24 to 36 hours after the speech
[+36, +48)	h_fwd_3648	36 to 48 hours after the speech

Vector representation: doc2vec

Our approach consists of using neural networks to compute vector representations of words, including their context, through embedding. To perform this task, Mikolov et al. (2013) propose using word2vec, which learns word embeddings and aims to predict the occurrence of a word given the surrounding words (context). In this model, every word is mapped to a unique vector, which is represented by a column in weight matrix W . The algorithm constructs a vocabulary from the input corpus and then learns word representations by training a neural network language model. The model is trained using stochastic gradient descent with back propagation. When the model converges, it represents words as word embeddings – meaningful, real-value vectors of configurable dimensions (usually 150-500 dimensions). The neural network learns a word's embedding based on its contexts in different sentences. As a result, the words that occur in similar contexts are mapped onto close vectors.

As an extension of word2vec, Le and Mikolov (2014) introduced doc2vec to learn embeddings of sentences and documents (or sentence embeddings). Doc2vec is an extension of word2vec that learns to capture entire sentences and paragraphs. By treating each document as a word token, the word2vec methodology is used to learn document embeddings (Bhatia, Han Lau and Baldwin 2016). As with word2vec, training occurs through back propagation. This type of document embedding allows for texts to be represented as dense, fixed-length feature vectors that take their semantic and syntactic structure into account.

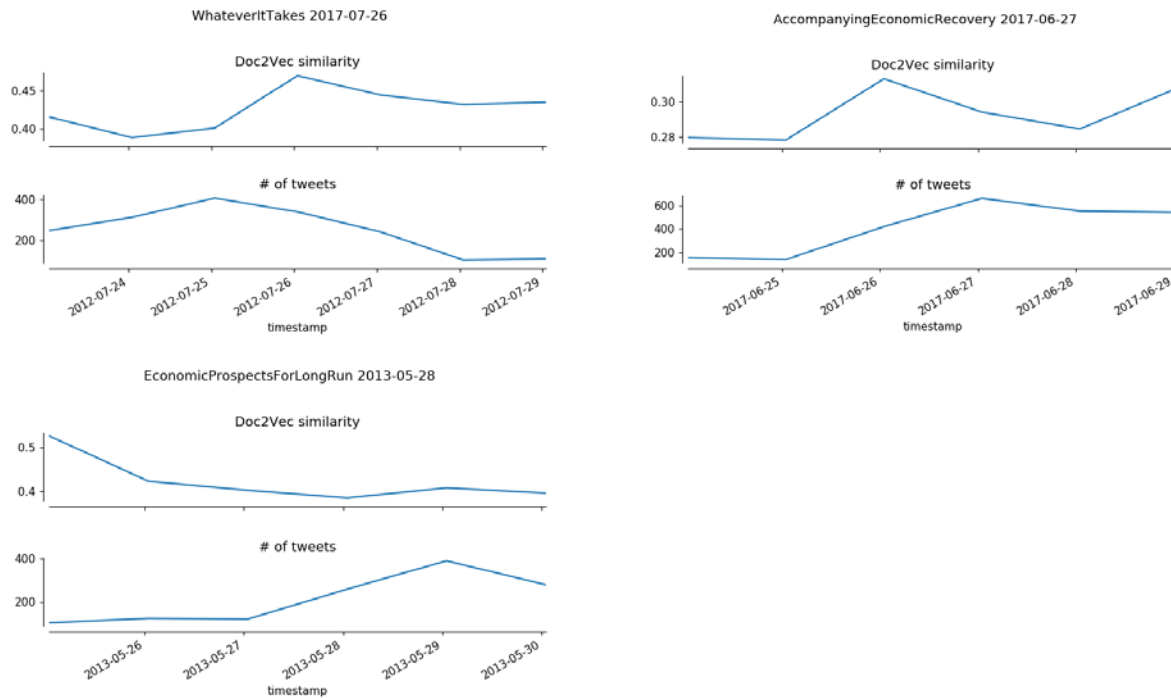
We used a freely available implementation of the doc2vec algorithm included in the GENSIM Python module. We asked for 300-dimensional vectors.

Twitter similarity metrics: The Central Bank Surprise Index

Both methods allow us to represent our documents as vectors. We then measure similarity between documents as the cosine of the angle between the two corresponding vectors (i.e., the normalized inner product of the two vectors).

We tested the validity of our two similarity measures by looking at three famous announcements: a) Mario Draghi's conference call on July 26, 2012; b) Mario Draghi's conference call on June 27,

2017; and c) the “Economic Prospects for the Long Run” speech held by Ben S. Bernanke on May 18, 2013.



The first two cases are known for being largely misinterpreted by the market. Hence, we should observe very low similarity scores between the documents related to events a) and b) and the Twitter document containing relevant tweets after the calls. The data support our contention. In the third case, the markets correctly interpreted Ben Bernanke’s message and, hence, we expect to observe a high similarity score.

We believe it is useful to present a few descriptive statistics regarding our measure of similarity. First, Figure 4 presents the evolution of the similarity measures for each of the three central banks. We observe a rather stable similarity index in the case of the Federal Reserve Bank over the period 2012-2017. On the other hand, a slight decrease can be observed for the Bank of England and the European Central Bank.² One possible explanation of the latter might be the increasing number of Twitter users and/or messages concerned with monetary policy decisions, which could naturally lead to increased variability in opinions. The increased level of noise that might come from a rise in the number of uninformed Twitter users appears to distance the policy announcements from market perceptions.

² If we narrow our analysis to the post-2012 period for the ECB and the Bank of England, we find a more stable index.

Figure 4. Evolution of the Central Bank Surprise Index Over Time

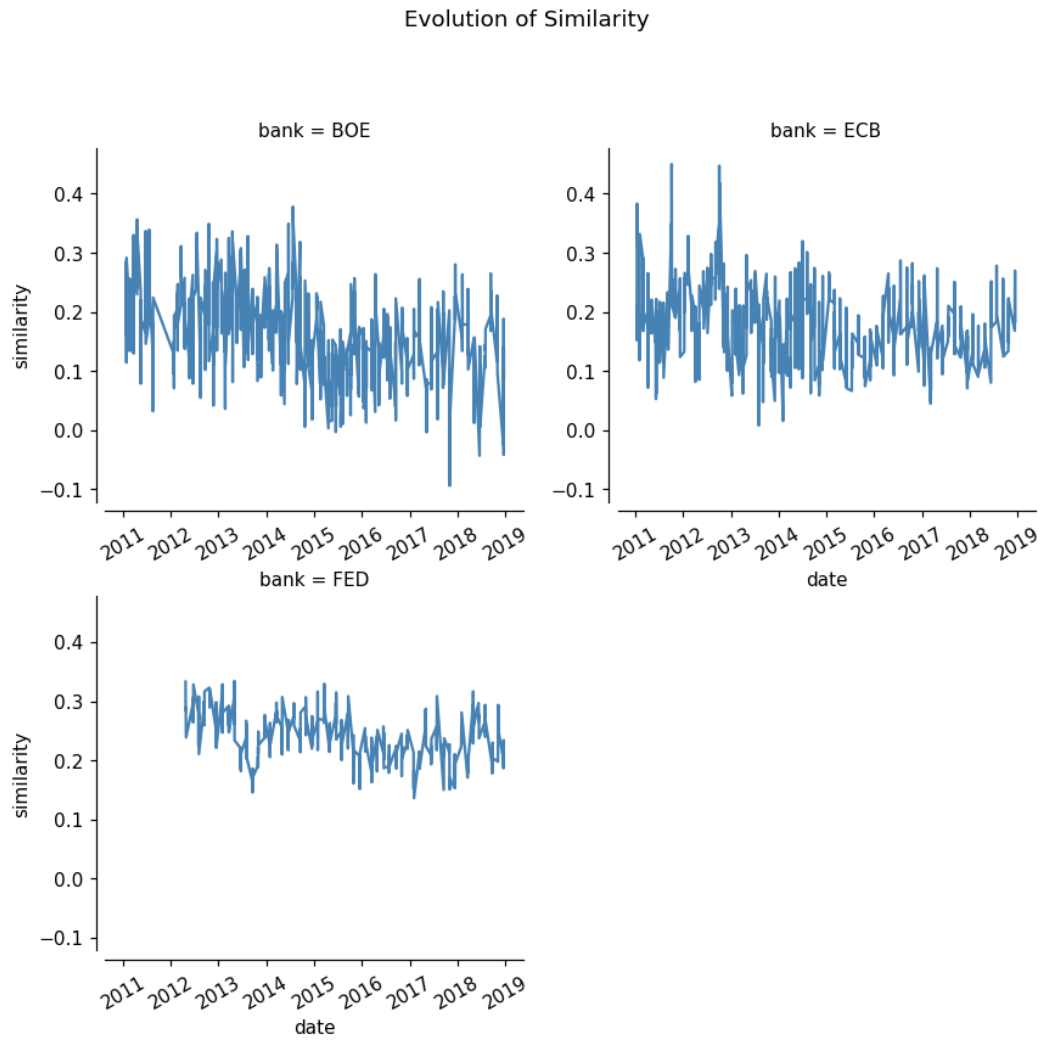


Figure 5. Evolution of the Similarity Index around the Monetary Policy Announcements

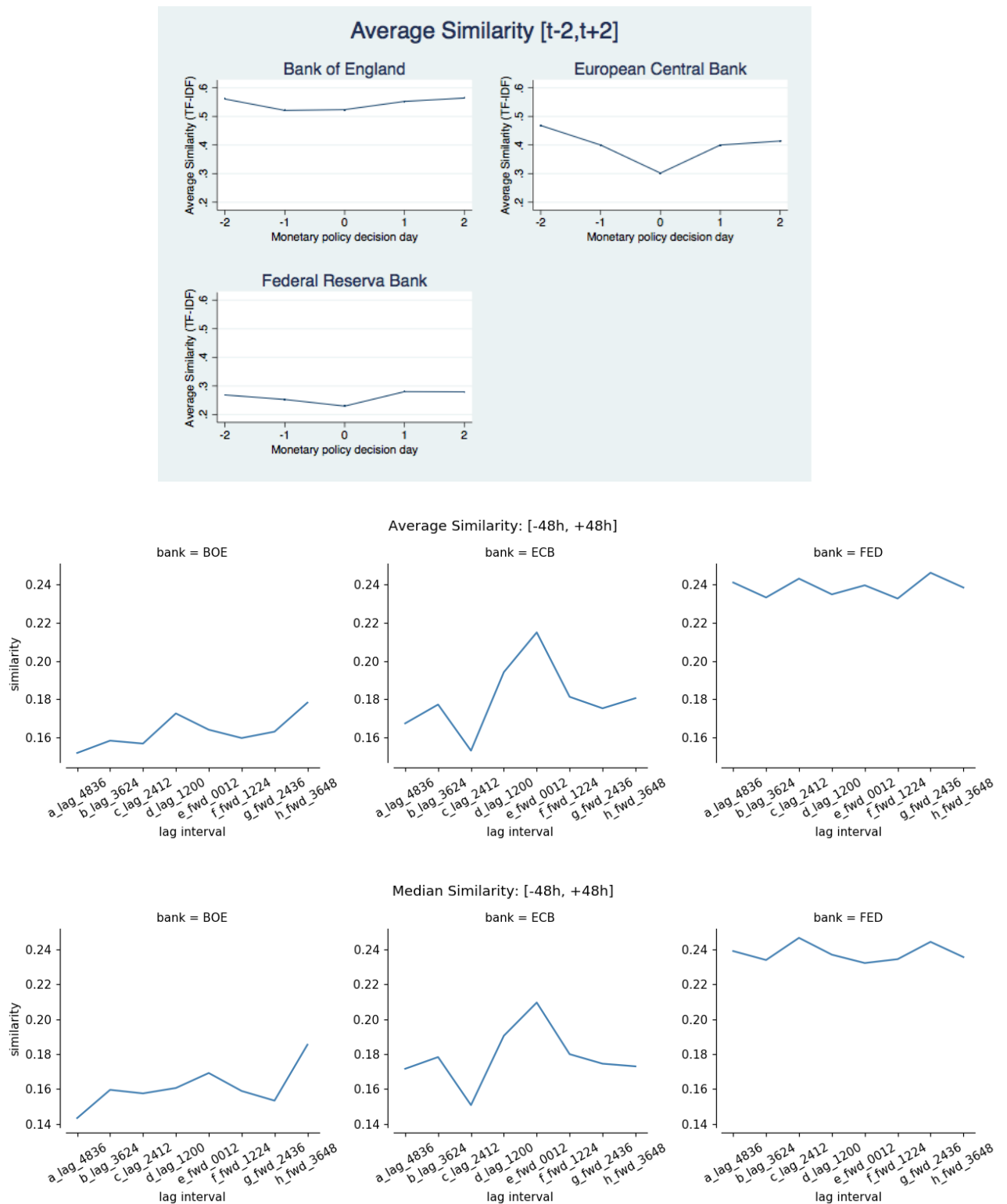


Figure 5 shows the average and median values of the Similarity Index during the period $[t-2;t+2]$, around the monetary policy announcements. The absolute values of the measure of similarity appear to be quite different for the Bank of England, the Federal Reserve Bank and the ECB. This might indicate a difference in the pool of Twitter users who tweet about monetary policy and/or the presence of different communication approaches adopted by the three central banks.

In the case of the ECB, in particular, we note a sharp drop in the similarity index in the days before a meeting and an increase in the days after a meeting. This suggests that although markets find it more difficult to forecast the ECB's policy directions prior to the announcement, especially on the day of the announcement, a closer consensus is reached afterwards. The pattern is similar for the Bank of England, although the differences before and after the announcement are not as stark as in the case of the ECB. Finally, little difference is observed for the Federal Reserve.

5. Conclusion

This paper aimed to take the first step in exploring the relationship between central bank communication and market sentiment by proposing a new measure. Market sentiments are proxied using a Twitter-based metric: the Central Bank Surprise Index. We translated daily tweets about the monetary policy decisions of the Bank of England, the European Central Bank and the Federal Reserve Bank into a numerical measure of similarity that reflects the distance between market expectations and the information provided in central banks' transcripts.

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