Universidade de Brasília
Faculdade de Economia, Administração e Contabilidade
Departamento de Economia

Measuring Central Banks Communications with Machine Learning

Santiago Ravassi

Brasília
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Tese apresentada ao Programa de Doutorado em Economia da Universidade de Brasília como requisito à obtenção do título de Doutor em Ciências Econômicas.

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Agradecimentos

Agradeço primeiramente ao meu orientador, Professor Daniel Oliveira Cajueiro, pela paciência, disponibilidade e tempo, além de suas intervenções sempre contributivas.

À Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) pela bolsa concedida. Aos professores do Programa de Pós-Graduação em Economia por permitir acesso a uma excelente formação e ao pessoal do Departamento pela disponibilidade e ajuda indispensáveis.

Aos professores membros da banca examinadora de qualificação e da tese pelas contribuições fundamentais para a melhoria e aperfeiçoamento deste trabalho.

A mis dos amores:
Lívia y Martincito

Abstract

This thesis comprises three articles that use natural language processing and either unsupervised or supervised machine learning algorithms to get different measures of central banks announcements. In the first article, we quantify the optimism of the announcements from the European Central Bank and the Federal Reserve. We empirically show that more optimistic announcements affects the Brazils term structure of interest rates. In the second article, we analyze the evolution of minutes released by the Central Bank of Brazil under different presidencies. We score the discussion on the minutes in four different macroeconomic dimensions: inflation, economic growth, employment, and fiscal policy. We find inflation is the principal concern followed by employment, growth, and fiscal policy. We also find that the attention to inflation attains a historic maximum during the Goldfajn and Campos Netos presidency. In the third article, we develop a crisis dictionary with the aid of a supervised machine learning. With this dictionary, we create an index that measures the crisis sentiment of the Federal Reserve Federal Open Market Committee minutes. We empirically show the index predicts the interest rate level and volatility of the US treasuries. We also show that our index significantly outperforms the predictive power of indices created with the Correa, the Harvard-IV and the Loughran-McDonald dictionaries.

Keywords: Central banking, Monetary policy, Machine learning, Natural language processing, Dictionary, Spillover, Interest Rate

Resumo

A presente tese está constituída por três artigos que utilizam processamento de linguagem natural e aprendizagem de máquina, tanto não supervisionado como supervisionado, para obter diferentes medidas de anúncios de bancos centrais. No primeiro artigo, quantificamos o otimismo dos anúncios do Banco Central Europeu e da Reserva Federal (Fed). Mostramos, empiricamente, que anúncios mais otimistas têm um efeito na estrutura a termos da taxa de juros. No segundo artigo, analisamos a evolução das atas divulgadas pelo Banco Central do Brasil sob diferentes presidências. Marcamos a discussão da ata em quatro diferentes dimensões macroeconômicas: inflação, crescimento econômico, emprego e política fiscal. Constatamos que a inflação é a principal preocupação, seguida pelo emprego, crescimento e política fiscal. Também descobrimos que a atenção à inflação atinge um máximo histórico durante a presidência de Goldfajn e Campos Neto. No terceiro artigo, desenvolvemos um dicionário de crise com a ajuda de aprendizagem de máquina supervisionada. Com este dicionário, criamos um índice que mede o sentimento de crise das atas do Comitê Federal de Mercado Aberto da Reserva Federal. Mostramos, empiricamente, que o índice prevê o nível e a volatilidade das taxas de juros dos tesouros dos EUA. Mostramos também que o nosso índice supera significativamente o poder preditivo dos índices criados com os dicionários de Correa, Harvard-IV e Loughran-McDonald.

Palavras-chave: Banco central, Política monetária, Aprendizagem de máquina, Processamento de linguagem natural, Dicionário, Efeito transbordamento, Taxa de juros

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1 Introduction

This thesis comprises three articles that use natural language processing and both unsupervised and supervised machine learning algorithms to quantify the content of central banks announcements. In the first article, we show empirically the association between either the Federal Open Market Committee (FOMC) minutes and the European Central Bank (ECB) press conferences and the Brazilian term-structure of interest rates. To quantify the sentiment, we use the Harvard-IV dictionary in combination with the term frequency-inverse document frequency statistic. We find an association between either both central banks announcement affect the interest term structure in the same direction: an increase of the pessimism conveyed in the announcements, reduces the interest rate level. The FOMC minutes affect longer maturities and are economically more significant than the ECB press conferences. When we analyze the effect on the interest rate volatility, we find that an increase in the optimism of the announcements reduces the interest rate volatility on mid- and long-term maturities. Finally, we find that the release of the FOMC minutes has a significant reduction in the volatility, and on mid-term contracts. Also, optimistic minutes dominates this effect. These results show that Brazils interest rate trades monitor foreign central bank announcements and consider that the decisions of the Central Bank of Brazil (CBB) are based not only on the Brazilian economy but also on the monetary policy of foreign central banks.

In the second article, we create dictionaries to quantify the importance that different presidencies of the CBB place on each macroeconomic dimension: inflation, economic growth, employment, and fiscal policy. Rather than measuring the sentiment that announcements convey, we are interested in measuring the emphasis that the CBB expresses. We use the principal component analysis. We find inflation is the major concern followed by both employment and growth; fiscal policy is the least relevant topic except during Tombinis second mandate. Finally, we also find that During Neto and Goldfajn, the inflation score attains a historic maximum which shows a higher commitment to the inflation targeting policy.

In the last article, we use an elastic-net logistic regression classifier to develop a crisis sentiment dictionary. We use the dictionary to create a real-time crisis index of the FOMC minutes. We find that during the 2007-2008 financial crisis, up to 6% of the total number of words are crisis-related. We also show empirically that the index predicts the interest rate and the volatility of the US treasuries: an increment in the crisis sentiment predicts a reduction of the interest rate for intermediate-term maturities and an increase of the volatility for long-term maturities. Finally, our index significantly outperforms the predictive power of the indices created with the Correa, the Harvard-IV, and the Loughran-McDonald dictionaries.

2 International Central Bank Communications Spillovers to Brazilian Central Bank

Abstract

We empirically show that the European Central Bank (ECB) press conference and the Federal Open Market Committee (FOMC) minutes impact the Brazils interest rate structure. We use an automated procedure to quantify the optimism of the announcements and find more optimistic news drop interest rates. The FOMC minutes affect longer contracts and are economically more significant than the ECB press conferences. Market reaction is higher to the ECB press conference than to the introductory statement or the questions session. Regarding volatility, we also find economical and statistical significance for the mid- to long-term contracts. When either the FOMC minutes or the ECB press conference are more optimistic, they reduce volatility. Also, the release of either announcements reduce volatility, but this effect is statistically significant for the Fed minutes only.
Keywords: Central banking, Monetary policy, Machine learning, Text mining, Natural language processing, Dictionary, Spillover, Interest Rate

2.1 Introduction

With the adoption of inflation targeting in the 1990s central banks have increasingly become more transparent (MISHKIN, 2004). Central banks that use explicit inflation objective as part of their monetary policy framework consider transparency a crucial policy. Transparency not only implies defining the target interest rate regularly and explaining the rationale behind these decisions but also communicating the macroeconomic projections. This communication strategy is two-fold. On one hand, it allows for a more adequate transmission to the market, and consequently a faster reaction and more efficient achievement of the economic goals. On the other hand, since central banks regulate short-term interest rates and do not control any other interest rates, communication is an important monetary tool to regulate long-term rates. A good central bank communication, that also helps to develop market expectations regarding long-term interest rates, is a more efficient monetary policy (BERNANKE, 2004). After the 2008 crisis, forward guidance has became an even more important monetary tool for central banks from developed economies with short-term interest rate close to zero (CAMPBELL et al., 2012). In extreme cases, central bank communication can be the most important monetary tool of a central bank (BLINDER et al., 2008).

Our work tests the hypothesis that when a major foreign central bank releases a pessimistic announcement, there should be a rise in the interest rate futures of an emerging economy. Because a low and stable rate of prices is one of the main aims of central banks with a hierarchical or dual mandate, the tone of their announcements reflects inflation concerns. Variations in optimism conveyed by the central bank's announcement affect interest rates across different contract lengths for their respective state or monetary union; optimistic announcements signal the market that the bank will lower the interest rate. This change in market expectations will be reflected in a decrease in the interest rate of future contracts. Similarly, if a foreign country's monetary institution raises the target interest rate, then there will be more capital moving to that country. Countries affected by this foreign monetary policy will experience an outflow of capital to the foreign country, reducing their money supply. This flow of capital will exert upward pressure on their foreign interest rate.

We empirically show that traders in Brazil's market monitor foreign central bank announcements and consider the monetary policy of the Central Bank of Brazil (CBB) is based not only on the Brazilian economy but also on the decisions made by other central banks. An increase in the optimism of the ECB press conference and the Federal Open Market Committee (FOMC) minutes reduce the interest rates of the Brazilian futures. However, each announcement affects the structure of interest rates differently. The FOMC minutes affect longer contracts and are economically more significant than the ECB press conferences. An increase of one standard deviation of the optimistic factor of the ECB press conference reduces the interest rate level in about 1 and 1.5 basic points for contracts ranging from four months to four years. The same change in the FOMC minutes is of 2 basic points for two-year maturities or older. We also show that market reaction is more significant to changes in the ECB press conference than to its parts (the introductory statement or the question session). Volatility in future interest rates are also affected by both announcements. An increase of one standard deviation in the optimistic factor of either announcement reduces volatility by around ten percent. The effect is statistically significant for the ECB press conferences and the Fed minutes starting at two-year and three-year maturities, respectively. Also, the disclosure of either announcement reduces volatility in all contracts. However, the effect is only significant for optimistic Fed minutes, where their disclosure reduces the volatility for two-year contracts or longer.

To measure the level of optimism in the announcements, we use the term frequency-inverse document frequency (TFIDF) method on entries listed on the Harvard IV dictionary. TFIDF is a statistical method that evaluates the importance of a word in a collection of scripts. Loughran and McDonald (2011) used the TFIDF method for the first time in the economic literature to analyze the corporate 10-K reports.

We have chosen the effect of the ECB and the Fed on the Brazilian market for two reasons. First, measured by the power to buy or sell assets on a large scale with an inflation target, the ECB and the Fed are the two major banks.[1]

[1] The ECB and the Fed explicitly aim for 2 percent inflation over time (ECB, 2019) and (FED, 2015), but they are not inflation targeting banks since they do not follow a hierarchical mandate that makes price stability the primary aim for monetary policy (MEYER, 2001).

In terms of trade volume and reserve currency, the EUR is the second largest only to the USD. Second, Brazil is an emerging economy with a central bank with inflation targeting. The Brasil Bolsa Balcão (B3) is the third-largest interest rate futures market or options in the world and the largest among the emerging markets; in which 47% of the interest rates traders are non-residents.[2] [3]

The following literature is closely related to our work. Regarding the ECB, Picault and Renault (2017) quantify the content of the press conference using a term-weighting and contiguous sequence method and use it to both study the effect on stock market volatility and predict ECB decisions. Schmeling and Wagner (2019) use the Loughran and McDonald (2011) to study the effect of the press conferences on asset prices. Concerning the Fed, Lucca and Trebbi (2009) developed a method to measure central bank communications and used it to study the impact of FOMC statements on the Treasury yield curve. Hansen and McMahon (2016) classify FOMC communication into forward guidance or state of economic conditions and use Latent Dirichlet Allocation to analyze how their tone to study the effect on market and real variables. Sharpe, Sinha and Hollrah (2017) use TFIDF to study the predictive power in macroeconomics variables of the tonality of the Greenbook published by the Federal Reserve Board of Governors. As for the CBB, Carvalho, Cordeiro and Vargas (2013) use the method developed by Lucca and Trebbi (2009) to study the impact of statements on Brazil's future interest rates. Chague et al. (2015) study the impact of COPOM minutes on Brazil's future interest rates; they use principal component analysis to measure the level of optimism the minutes, a method proposed by Tetlock (2007). Our work is different because these articles examine the effects the ECB, Fed, and CBB announcements have on their respective overseeing territories, whereas we study the effect that the ECB and Fed have on Brazil's market.

[2] (FIA, 2018)

[3] (B3, 2019)

The remainder of this paper is organized as follows. Section 2.2 describes the data we use for this study In Section 2.3 we explain how we use the TFIDF algorithm to measure the optimism of central banks communications and provides some interpretation of the optimism of the announcements and the expected inflation rate. In Section 2.4, we study the effect that the ECB press conference and the Fed minutes have on the Brazils interest rate level and volatility. Section 2.5 presents robustness analysis. Section 2.6 concludes.

2.2 Data

For future interest rates, we use daily returns from the B3 stock market webpage. We construct the interest rates term structure with the following maturities: two-month, four-month, six-month, one-year, two-year, four-year, six-year, eight-year, and ten-year maturities. [4] Contracts up to eight years are available from October 12, 2003, and contracts up to ten years are accessible from October September 16, 2005. We study the effect of ECB press conference on the maturities ranging from two months to eight years as the dependent variable and the one-month maturity as a control for surprises in the target interest rate decision. For the Fed minutes, we consider the contracts ranging from four months to ten years as dependent variables, and we do not use a control variable. For the ECB, we use 169 press conference from October 2003 to April 2019. For the Fed, we use 115 minutes from February 2005 to April 2019 for contracts up to eight years and 109 minutes from September 2005 to April 2019 for the ten-year contract.

[4]From October 12, 2003 to September 16, 2005, the B3 publishes contracts up to 2880 days and from October 16, 2005 discloses contracts up to 3660 days. For this reason, we get the eight-year contract from 2880 days (or seven years and ten months) and the ten-year contract from 3600 days (or nine years and ten months).

The ECB organizes the press conference immediately after disclosing the target rates announced in the monetary policy decisions, while the Fed releases meeting minutes three weeks after the disclosure of the target federal funds rate. Thus, with the ECB press conferences – and to differentiate between the effect of the announcement optimism and the disclosure of the new target rate – we need to control for interest rate surprises. For this purpose, we get the difference, in the current-month maturity interest rate of the Brazilian future, between the closing prices the day the announcement is released and the next trading day. We use the current-month difference as the interest rate surprise control variable to analyze the impact that the ECB press conferences have on the interest rate level. We use the square root the of the absolute value of the current-month difference when we study the effects of the ECB press conference on the interest rate volatility. This is the same variable used by Carvalho, Cordeiro and Vargas (2013) to control the impact that the COPOM statements of the CBB have on Brazil's interest rate future. Also, Lucca and Trebbi (2009) use the interest rate change of current-month federal funds futures to control the effect of Fed statements on treasury yields.

2.3 Measuring optimism

To quantify the optimism of the announcements we use an automated procedure similar to Tetlock (2007), Loughran and McDonald (2011), and Sharpe, Sinha and Hollrah (2017). We use the Harvard IV dictionary as Tetlock (2007) and the term weight method as Loughran and McDonald (2011), and the same dictionary and term weight method as Sharpe, Sinha and Hollrah (2017).

Our procedure starts by collecting all the announcements of either the ECB press conference or the Fed minute. Then, we classify each term in the collection according to the General Inquirer (GI) categories from the Harvard psychosocial dictionary. There are 77 categories, but we use 16, which are those that are the most obvious in transmitting an optimistic or a pessimistic sentiment to the market the same used by Chague et al. (2015). The categories with positive tone are: "active", "arousal", "complete", "fell", "persist", "pleasure", "positive", "strong", "virtue", and "work", and the categories with negative tone are: "fail", "negative", "pain", "passive", "weak", and "try".[5] Since the Harvard IV dictionary does not contain all the inflected forms of a term, we stem terms in both the dictionary and the document with the Porter algorithm.

To measure the level of optimism of the D announcements in the collection, we apply the TFIDF method to each document d. TFIDF is a term-weighting method that is the product of two parts. The first part is the term frequency that uses the raw frequency $f_{t,d}$ of term t in script d,

$$tf_{t,d} = \begin{cases} 1 + \log f_{t,d} & if \;\; f(t,d) > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{2.1}$$

The second part is the inverse document frequency, that considers the relation between the total number of documents and $df(t)$ the number of documents with the term t,

$$idf(t) = \log\left(\frac{N}{df(t)}\right). \tag{2.2}$$

Then, TFIDF weighting of the term t in the document d is the combination

[5]Chague et al. (2015) use 18 categories, but we decided not to include the categories "power" and "hostile". The category "hostile" is a subcategory of "ngvt", an early version of "negativ". The category "power" is a subcategory of "strong", and since we use "strong", including "power" does not affect the tone of the announcement, when used in the TFIDF algorithm. This difference might occur because we are using a newer version of the dictionary. Sharpe, Sinha and Hollrah (2017) also use the Harvard IV dictionary; or method and the method to analyze documents is similar to ours. However, they fined-tuned the dictionary by selecting entries that best fit for economic forecasting. To avoid subjective selection, we used Chague et al. (2015) categories as it is.

of the two parts:

$$\begin{aligned} tf\text{-}idf(t,d) &= tf(t,d)\cdot idf(t) \\ &= (1+\log f(t,d))\cdot \log\left(\frac{N}{df(t)}\right). \end{aligned} \tag{2.3}$$

To discriminate terms according to their tone, we sign or zero each term, listed in at least one of the sixteen GI categories, according to the semantic group of its category. [6]

$$cat(t) = \begin{cases} +1 & if \quad t \in \text{categories with positive tone} \\ -1 & if \quad t \in \text{categories with negative tone} \\ 0 & if \quad t \in \text{categories with both positive and negative tone.} \end{cases} \tag{2.4}$$

Finally, the optimist factor of the document d is the sign-weighted average of the terms that compose the document:

$$OF(d) = \sum_t cat(t)\cdot tf\text{-}idf(t,d). \tag{2.5}$$

Because entries with a positive tone enlarge the optimistic factor, we can associate higher optimistic factors with the perception of more optimistic announcements. For an easier interpretation of the results, we standardize the optimistic factors in the regressions and represent future interest rates in basic points.

2.4 Results

The following results show an association between the interest rate futures traded in the B3 stock exchange and the announcements of the ECB and the Fed. Since interest rate futures show the market's expectations regarding CBB's future monetary decisions, traders believe that the CBB's actions are partly connected to the future course of monetary policy of the ECB and the Fed.

[6] For example, the term "abolish" falls into the categories "negative" and "activate" and the term "abrasive" into "negative" and "strong", so we zeroed these two terms.

2.4.1 Effect of the ECB press conferences on interest rates

The Governing Council is the main decision-making organ of the ECB. It usually meets every two weeks, and, every six weeks, publishes the monetary policy decisions. The monetary policy decisions disclosures the interest rates of: the main refinancing operations, the marginal lending facility, and the deposit facility, which are the key interest rate for the euro area. The same day, after the disclosure of the target rates, a press conference is held. The press conference is approximately an hour long and has two parts. It starts with an introductory statement and then is followed by a questions session. The introductory statement is a manuscript speech in which the ECB explains the reasoning behind the decision on the most recent target interest rates. The introductory statement gives not only the expected inflation and economic performance but also clues about future decisions. The second part is the questions session in which the president and the vice president give unscripted answers to questions asked by the press from across the euro area and beyond.

To analyze how changes in the optimistic factor of the ECB press conference communication affect interest rates, we use the following model:

$$\Delta y_{t+1}^{m} = \beta_0 + \beta_1 IRS_{t+1} + \beta_2 \Delta OF_t^{IQ}, \tag{2.6}$$

where t is the day of the announcement; Δy_{t+1}^{m} is, for a maturity m, the interest rate difference between the following trading day $t+1$ and the day t and; and IRS_{t+1} is the interest rate surprise defined earlier. The communication surprise, ΔOF_t^{IQ} is the optimistic factor difference between the press conference of day t and the previous press conference.

Table 1 – **Effect of the ECB press conferences on interest rates**

This table presents regression estimates of future interest rates changes against variations in the optimistic factor of the press conference as set-out in Eq. 2.6. Columns show the dependent variable Δy^m, changes in yields at different maturities. Rows show the independent variables: interest rate surprise IRS and change in the optimistic factor of the press conference ΔOF^{IQ}; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are standardized to zero mean and one standard deviation. Each regression is based on 168 observations from October 2003 to April 2019. Robust standard errors in parentheses. *, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
IRS_l	0.341***	0.157***	0.118***	0.117***	0.104**	0.124***	0.113***	0.102***	0.080**
	(0.075)	(0.055)	(0.023)	(0.030)	(0.042)	(0.038)	(0.040)	(0.035)	(0.032)
ΔOF^{IQ}	0.475	-1.604**	-0.979***	-1.345***	-1.595***	-1.505**	-1.466**	-0.944	-0.775
	(0.599)	(0.684)	(0.363)	(0.433)	(0.587)	(0.619)	(0.682)	(0.749)	(0.881)
$Adj.R^2$	0.5785	0.1288	0.1320	0.0906	0.0478	0.0430	0.0297	0.0184	0.0037

Table 1 shows that future contracts respond to interest rate surprises in the same direction; in all cases, the coefficients are statistically significant. Also, except for the first contract, a positive shock in the optimistic factor reduces the interest rate level. The effect is statistically significant for maturities ranging from four months to three years. An increase of one standard deviation in the optimistic factor decreases the interest rate level by 1 basic point in the six-month contract and by 1.5 basic point in the four-month, one-year, two-year, three-year, and four-year contracts.

These results indicate that the content of the ECB announcements impacts the Brazilian market. An increase in the optimism of the press conference reduces interest rates levels; the effect of the shock is more significant in short- and mid-term maturities.

To analyze how different parts of the press conference affect the interest rate of futures, we use the following models:

$$\Delta y^m_{t+1} = \beta_0 + \beta_1 IRS_{t+1} + \beta_2 \Delta OF^I_t \tag{2.7}$$

$$\Delta y^m_{t+1} = \beta_0 + \beta_1 IRS_{t+1} + \beta_2 \Delta OF^Q_t \tag{2.8}$$

$$\Delta y^m_{t+1} = \beta_0 + \beta_1 IRS_{t+1} + \beta_2 \Delta OF^Q_t + \beta_3 \Delta OF^I_t , , \tag{2.9}$$

where ΔOF_t^I and ΔOF_t^Q are the optimistic factor difference for the introductory statement alone and the questions session with journalists alone, respectively.

Figure 1 – **Time-series of the press conferences length**
Lines in the chart show the number of Harvard IV steamed entries that are part of either the optimistic or pessimistic GI's categories. Gray and black lines represent the number of entries of the question session and the introductory statement, respectively. Dashed lines indicate the mean number of entries for each announcement.

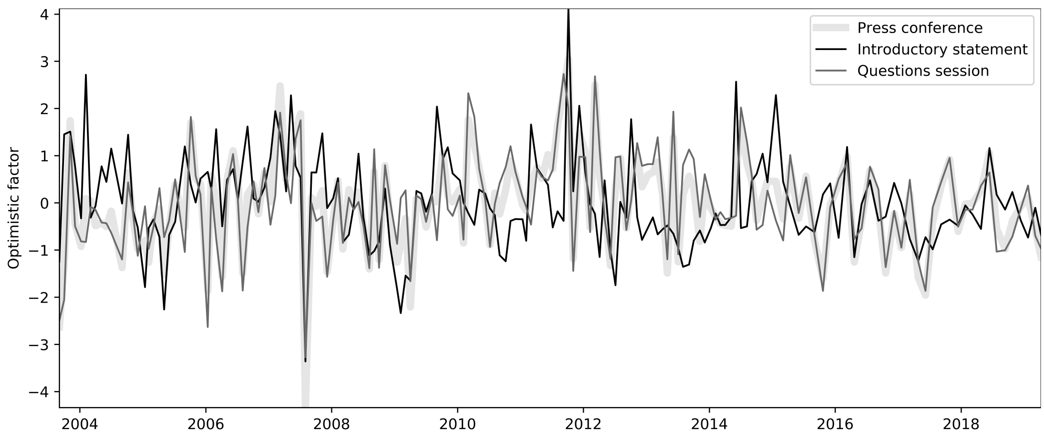


Figure 2 – **Time-series of the press conferences optimistic factor**
Lines in the chart represents the optimistic factor. The thick line represents the press conferences, and the gray and the black thin lines are the questions sessions and the introductory statements, respectively. The correlation between the optimistic factors of the press conferences and the introductory statements is 0.49; between the press conferences and the question sessions is 0.92, and between the introductory statements and the question sessions is 0.1.

Figure 1 shows the time-series of the length of both the introductory statements and the press conferences. The length is the number of steamed words that belong to the entries of the sixteen semantic categories. The mean length for the questions session is 642 and the introductory statement is 278, and the length of either announcement remains stable throughout the series. Figure 2 shows this size difference which affects the correlations of the optimistic factors which are: 0.49 between the press conferences and the introductory statements and 0.92 between press conferences and question session.

Panels A, B, and C from Table 2 display the impact that individual parts of the press conference have on the interest rate level. Panels A and B show the individual effect of the press conference when the optimistic factor difference is from the introductory statement (Equation (2.7)) and the questions session with journalists (Equation (2.8)), respectively. Panel C indicates the two individual effects combined (Equation (2.9)).

The three panels show that an increase in the optimism of the introductory statement or the question session reduces the interest rates level; also, interest rate surprises have the expected effect and are significant. The comparison of Table 1 with Panels A and B explains which part of the annoncements leads the effect. The effect of the press conference is more statistical and economic significant than either the introductory statement or the questions session –except for the introductory statement of the eight-year maturity at the 10% significance level. This indicates that changes in the press conference optimistic factor have a higher impact on the interest rates level than the individual changes in the optimistic factor of either the introductory statement or the questions sessions.

Panel C shows the p-values of the null hypothesis which states that neither of the optimistic factors affects interest rates. If we compare them with the p-values of the optimistic factor estimates from Table 1, we see that the estimates in Panel C are less significant for all contracts –except for the two-month and eight-year maturities although their p-values are statistically insignificant. Hence, changes in the optimistic factor of the press conference have a more significant effect on interest rates than the sum of the individual changes of both the introductory statement and the question session.

Table 2 – **Effect of ECB introductory statements and questions sessions on interest rates**

This table presents regression estimates of future interest rates changes against variations in the optimistic factor of the introductory statement or question sessions as set-out in Eq. 2.7, 2.8 and 2.9. Columns show the dependent variable Δy^m, changes in yields at different maturities. Each horizontal panel displays the results of a different regression equation. Rows represent the independent variables: IRS is the interest rate surprise control, and ΔOF^I and ΔOF^Q is the change in the optimistic factor for the introductory statement and the questions session, respectively; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are standardized to zero mean and one standard deviation. Each regression is based on 168 observations from October 2003 to April 2019. Robust standard errors in parentheses.[a] p-val of $H_0 : \Delta OF^I = \Delta OF^Q = 0$.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
Panel A	Introductory statement								
IRS	0.343***	0.159***	0.120***	0.118***	0.104***	0.125***	0.111***	0.103***	0.093***
	(0.077)	(0.052)	(0.021)	(0.026)	(0.038)	(0.037)	(0.038)	(0.034)	(0.036)
ΔOF^I	0.066	-1.358**	-0.951*	-1.086*	-1.194	-1.271	-0.905	-0.847	-2.172**
	(0.643)	(0.668)	(0.501)	(0.643)	(0.848)	(0.819)	(0.863)	(0.896)	(1.082)
$Adj.R^2$	0.5749	0.1124	0.1251	0.0745	0.0320	0.0346	0.0183	0.0159	0.0252
Panel B	Questions session								
IRS	0.342***	0.152***	0.114***	0.113***	0.098**	0.118***	0.107***	0.098***	0.075**
	(0.076)	(0.052)	(0.020)	(0.026)	(0.038)	(0.036)	(0.038)	(0.033)	(0.031)
ΔOF^Q	0.410	-1.341**	-0.690**	-0.978**	-1.140**	-0.972	-0.964	-0.442	0.124
	(0.499)	(0.639)	(0.338)	(0.417)	(0.564)	(0.600)	(0.666)	(0.729)	(0.890)
$Adj.R^2$	0.5776	0.1176	0.1178	0.0750	0.0339	0.0316	0.0205	0.0128	-0.0003
Panel C	Introductory statement and questions session								
IRS	0.343***	0.161***	0.121***	0.120***	0.106**	0.127***	0.113***	0.104***	0.092***
	(0.076)	(0.055)	(0.024)	(0.030)	(0.042)	(0.039)	(0.040)	(0.035)	(0.035)
DOF^I	-0.011	-1.139*	-0.845*	-0.928	-1.008	-1.120	-0.745	-0.786	-2.258**
	(0.599)	(0.684)	(0.511)	(0.639)	(0.835)	(0.809)	(0.860)	(0.893)	(1.104)
DOF^Q	0.411	-1.172*	-0.565	-0.841**	-0.990*	-0.806	-0.854	-0.326	0.459
	(0.467)	(0.656)	(0.358)	(0.417)	(0.556)	(0.583)	(0.661)	(0.711)	(0.860)
$Adj.R^2$	0.5750	0.1277	0.1293	0.0821	0.0372	0.0343	0.0179	0.0107	0.0207
p-val[a]	0.380	0.076	0.116	0.046	0.077	0.169	0.198	0.647	0.590

Regarding the level of interest rates, the conclusions from Tables 1 and 2 are: (a) the press conferences affect Brazilian market expectations; an increase in one standard deviation of the optimistic factor reduces from 1 to 1.5 basic points the interest rate of contracts from four months to six years; (b) the press conference has a greater economic and statistical significance than the individual introductory statement or questions sessions; moreover, market reaction is more significant to the optimism conveyed by the introductory statement intertwined with the question sessions than to the sum of their individual optimism.

2.4.2 Effect of minutes on interest rates

The FOMC has eight regularly scheduled meetings a year and has additional meetings as needed. Immediately after each meeting, the FOMC publishes a statement with the target range for the federal funds rate. The statement is the principal tool the Fed has to communicate its monetary policy but is not the only one. After each statement, the FOMC issues the minutes to provide a general insight into the discussion at the meeting. Before 2004, minutes were released two days after the Committee's subsequent meeting, and, after 2004, they are released three weeks later. The decision to bring forward the release of the minutes is to increase the usefulness of the content. Statements inform about the monetary decisions. Minutes provide insight regarding the monetary policy decisions by giving a more complete explanation of the discussions at the meeting.

To analyze the effect of the FOMC minutes on Brazil's interest rates level, we use the following model:

$$\Delta y_{t+1}^{m} = \beta_0 + \beta_1 \ \Delta OF_t^M \tag{2.10}$$

where Δy^m is the same variable as is in the ECB analysis, and ΔOF_t^M is the optimism factor difference between the FOMC minute release in day t and the previous one. Since the minutes are published days after the target interest, we do not use the interest rate surprise control variable.

Table 3 – **Effect of Fed minutes on interest rates**

This table presents regression estimates of the future interest rates changes against variations in the optimistic factor of the FOMC minutes as set-out in Eq. 2.10. Columns show the dependent variable Δy^m, changes in yields at different maturities. The row shows the independent variable ΔOF change in the optimistic factor; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are normalized to one. Each regression is based on 114 observations from February 2005 to April 2019, except for the 10-year contract that starts in September 2005 and contains 109 observations. Robust standard errors in parentheses.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year	10-year
ΔOF^I	-0.193	0.187	-0.983	-1.669**	-2.477***	-2.174**	-2.225***	-2.158***	-1.448*
	(0.487)	(0.537)	(0.691)	(0.836)	(0.906)	(0.909)	(0.760)	(0.798)	(0.755)
$Adj.R^2$	-0.0081	-0.0076	0.0118	0.0255	0.0479	0.0314	0.0406	0.0350	0.0085

Table 3 shows the results of Equation (2.10). The estimates indicate that a positive shock in the optimistic factor produces a statistically significant reduction on the interest rate level of contracts longer than two years. An increase of one standard deviation in the optimistic factor reduces the interest level in 2 basic points with a significance level of 1% for the three-, six-, and eight-year contracts and 5% for the two- and four-year contracts.

2.4.3 Effect of announcements interest rates volatility

We test how announcements affect interest rate volatility. We measure the volatility of the maturity m in a time window of five working days as

$$Vol_{t+1}^{m} = \sqrt{\frac{1}{5}\sum_{i=1}^{5}(\Delta y_{t+i}^{m})^2}, \tag{2.11}$$

where Δy_s^m is the interest rate difference between day s and $s-1$ for maturity m. To understand how the ECB press conferences and the Fed minutes affect the interest rate volatility, we use the following equations:

$$Vol_{t+1}^{m} = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t \tag{2.12}$$

$$Vol_{t+1}^{m} = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ Pessimism_t \tag{2.13}$$

$$\log(Vol_{t+1}^{m}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ OF_t \tag{2.14}$$

$$\log(Vol_{t+1}^{m}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ OF_t + \theta\ OF_t \cdot Pessimism_t \tag{2.15}$$

where t is the day of the announcement is released; OF_t is the optimistic factor of the announcement; the dummy variable $Release_t$ takes a value of one when the announcement is released and zero otherwise; the dummy variable $Pessimism_t$ is equal to one when OF_t is negative and zero otherwise; and IRS_{t+1} is the interest rate surprise control variable –we used it to study the ECB press conferences.

We use equation 2.12 to study the effect when announcements are released, regardless of their optimism. To analyze the effect of the quality of the announcements we employ Equation (2.13), and to assess the effect of the magnitude of the optimism we use Equation (2.14). Equation (2.15) tests whether the qualitative content of the announcement has an asymmetric effect on volatility. These four equations were also present in Chague et al. (2015) to analyze the volatility of the Brazilian interest rate futures. However, there are some differences since. First, they study the effect of the Central Bank of Brazil, whereas we study the effect of foreign central banks.Second, when we analyze the effect of the ECB press conferences, we add the IRS control variable.

Table 4 reports the effect of the ECB press conference on volatility. We see that the IRS control variable is positive and statistically significant. Panel A and B show that the release of the press conference (regardless of whether the content is negative or positive) does not have a statically significant effect. However, the magnitude of the shock has a statistically significant effect on contracts between two and eight years. Panel C shows that an increase of one standard deviation in the optimistic factor reduces volatility by 8% in the two-year contract and the effect increases monotonically to 17% for the eight-year contracts. From Panel D we cannot conclude that shocks from pessimistic or optimistic press conferences have different impacts on future volatility.

Table 5 presents the effect of the FOMC minutes on interest rates volatility. Panel A shows that the release of the minutes reduces volatility. There is a statistically significant reduction of 1.2, 1.7, and 1.2 basic points for the six-, eight-, and ten-year contracts, respectively; however, from Panel B, we cannot conclude that the reduction in the volatility is driven by either optimistic or pessimistic minutes. Panel C shows that an increase of one standard deviation in the optimism has a statistically significant impact on the reduction of the volatility of 11%, 12%, 12%, and 14% for three-, four-, six-, and eight-year contracts, respectively. Panel D shows that this volatility reduction is not driven by either pessimistic or optimistic shocks.

From the results on Tables 4 and 5, we conclude that changes in the tone, measured as the optimistic factor, of the ECB press conference and FOMC minutes affect the volatility of the Brazilian future interest rates. Except for the effect of the ECB press conference on the four-month contract, the release of either announcement reduces volatility, but the effect is statistically significant for the Fed minutes only. Moreover, if we consider the tone of the Fed minutes, optimistic minutes drive the effect and also have a statistically significant effect on two-, three-, and four-year contracts. Regarding how the magnitude of optimism affects volatility, the announcements of both banks reduce it by around 1 basic point on mid- and long-term contracts.

2.5 Robustness

To check the robustness of our results, we run the previous econometric models by modifying either the dates of the future interest rates or the measuring method of the content of the announcements. In the former test, we shift forward to an earlier day the dates of the dependent variable and, in the case of the ECB announcements, the date of the control variable too. Because future interest rates volatility is a time window of five working days, we only test the interest rates level.

Table 4 – **Effect of ECB press conferences on interest rates volatility**

This table presents regression estimates of future interest rates changes against variations in the optimistic factor of the press conference as set-out in Eq. 2.6. Columns show the dependent variable Δy^m, changes in yields at different maturities. Rows show the independent variables: interest rate surprise IRS and change in the optimistic factor of the press conference ΔOF^{IQ}; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are standardized to zero mean and one standard deviation. Each regression is based on 168 observations from October 2003 to April 2019. Robust standard errors in parentheses. *, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
Panel A	$Vol^m_{t+1} = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t$								
IRS	0.684***	0.311***	0.163***	0.122***	0.144***	0.167***	0.156***	0.206***	0.374***
	(0.050)	(0.026)	(0.023)	(0.031)	(0.039)	(0.042)	(0.042)	(0.044)	(0.063)
Release	-0.433	0.399	-0.318	-0.112	-0.291	-0.287	-0.359	-0.326	-0.508
	(0.863)	(0.505)	(0.459)	(0.578)	(0.760)	(0.857)	(0.862)	(0.860)	(1.034)
$Adj.R^2$	0.0501	0.0380	0.0135	0.0039	0.0034	0.0040	0.0034	0.0056	0.0101
Panel B	$Vol^m_{t+1} = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ Pessimism_t$								
IRS	0.681***	0.311***	0.162***	0.122***	0.143***	0.164***	0.155***	0.203***	0.370***
	(0.050)	(0.026)	(0.023)	(0.030)	(0.039)	(0.041)	(0.042)	(0.044)	(0.063)
Release	-1.116	0.699	-0.357	0.187	0.091	0.138	-0.112	-0.396	-0.698
	(1.255)	(0.746)	(0.790)	(1.023)	(1.336)	(1.518)	(1.533)	(1.458)	(1.643)
Pessimism	1.163	-0.620	-0.038	-0.711	-0.800	-0.901	-0.515	-0.101	-0.173
	(1.679)	(1.001)	(0.903)	(1.140)	(1.513)	(1.710)	(1.723)	(1.682)	(1.923)
$Adj.R^2$	0.0500	0.0379	0.0132	0.0038	0.0032	0.0038	0.0031	0.0054	0.0099
Panel C	$\log(Vol^m_{t+1}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ OF^{IQ}_t$								
IRS	0.021***	0.026***	0.021***	0.013***	0.013***	0.013***	0.011***	0.014***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Release	-0.010	0.034	-0.058	-0.010	-0.032	-0.044	-0.044	-0.032	-0.020
	(0.029)	(0.037)	(0.045)	(0.044)	(0.047)	(0.049)	(0.048)	(0.048)	(0.052)
$OF^{IQ}F$	-0.044*	-0.020	-0.066	-0.054	-0.079**	-0.098**	-0.112***	-0.138***	-0.165***
	(0.027)	(0.032)	(0.044)	(0.044)	(0.038)	(0.041)	(0.040)	(0.042)	(0.047)
$Adj.R^2$	0.0424	0.0405	0.0198	0.0068	0.0069	0.0075	0.0060	0.0086	0.0132
Panel D	$\log(Vol^m_{t+1}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ OF^{IQ}_t + \theta\ OF^{IQ}_t \cdot Pessimism_t$								
IRS	0.021***	0.026***	0.021***	0.013***	0.013***	0.013***	0.011***	0.014***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Release	-0.008	0.028	-0.039	0.012	-0.043	-0.060	-0.069	-0.060	-0.030
	(0.035)	(0.044)	(0.056)	(0.053)	(0.059)	(0.062)	(0.061)	(0.063)	(0.066)
OF^{IQ}	-0.045	-0.003	-0.095	-0.088	-0.049	-0.058	-0.055	-0.073	-0.135*
	(0.049)	(0.052)	(0.070)	(0.078)	(0.071)	(0.079)	(0.082)	(0.081)	(0.078)
$OF^{IQ}\cdot$	0.016	-0.018	0.086	0.096	-0.034	-0.051	-0.091	-0.089	-0.013
Pessimism	(0.065)	(0.079)	(0.102)	(0.101)	(0.098)	(0.109)	(0.109)	(0.114)	(0.112)
$Adj.R^2$	0.0419	0.0402	0.0195	0.0066	0.0064	0.0069	0.0056	0.0079	0.0122

Table 5 – **Effect of Fed minutes on interest rates volatility**

This table presents regression estimates of the future rates volatility against variations in the optimistic factor of the FOMC minutes as set-out in Eq. 2.12, 2.13 2.14 and 2.15. Each horizontal panel displays the results of a different regression equation. Columns show the dependent variable five-workday volatility at different maturities. Rows represent the independent variables: the dummy variable *Release* indicates when the Fed minute is published, *OF* is the optimistic factor of the minute, and the dummy *Pessimism* indicates when *OF* is negative; the intercept is not reported. The period from February 2005 to April 2019, regressions are run with 3540 observations for Panels A and C and 3533 observations for Panels B and D. *Release* is nonzero in 115 observations for Panels A and C and 114 observations for Panels B and D, and *Pessimism* is nonzero in 56 observations. Changes in interest rates are expressed in basis points and the optimistic factor is standardized to zero mean and one standard deviation. Robust standard errors in parentheses.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year	10-year
Panel A	$Vol^m_{t+1} = \alpha + \gamma\ Release_t$								
Release	-0.419	-0.499	-0.560	-0.904*	-0.664	-0.738	-1.209**	-1.636***	1.208*
	(0.500)	(0.336)	(0.376)	(0.487)	(0.538)	(0.584)	(0.570)	(0.627)	(0.660)
Adj.R^2	-0.0001	0.0001	0.0000	0.0002	-0.0000	-0.0000	0.0004	0.0006	0.0003
Panel B	$Vol^m_{t+1} = \alpha + \gamma\ Release_t + \delta\ Pessimism_t$								
Release	-0.287	-0.468	-0.750*	-1.637***	-1.584***	-1.846***	-2.162***	-2.262***	1.473*
	(0.671)	(0.353)	(0.399)	(0.522)	(0.564)	(0.585)	(0.660)	(0.778)	(0.867)
Pessimism	-0.455	-0.146	0.317	1.392	1.798*	2.183*	1.883*	1.230	0.538
	(0.982)	(0.658)	(0.733)	(0.945)	(1.046)	(1.137)	(1.107)	(1.225)	(1.299)
Adj.R^2	-0.0002	-0.0001	-0.0002	0.0002	0.0001	0.0003	0.0005	0.0005	0.0000
Panel C	$\log(Vol^m_{t+1}) = \alpha + \gamma\ Release_t + \delta\ OF_t$								
Release	-0.041	-0.054	-0.025	-0.064	-0.027	-0.044	-0.073	-0.097*	-0.073*
	(0.046)	(0.048)	(0.045)	(0.052)	(0.049)	(0.051)	(0.052)	(0.055)	(0.057)
OF	-0.084	-0.079*	-0.012	-0.074	-0.108**	-0.124**	-0.120**	-0.141**	-0.113*
	(0.052)	(0.044)	(0.035)	(0.045)	(0.044)	(0.049)	(0.055)	(0.060)	(0.066)
Adj.R^2	0.0007	0.0005	-0.0005	0.0004	0.0007	0.0011	0.0013	0.0019	0.0010
Panel D	$\log(Vol^m_{t+1}) = \alpha + \gamma\ Release_t + \delta\ OF_t + \theta\ OF_t \cdot Pessimism_t$								
Release	-0.067	-0.079	-0.052	-0.101*	-0.058	-0.083	-0.102*	-0.133**	-0.078
	(0.044)	(0.049)	(0.048)	(0.054)	(0.052)	(0.052)	(0.054)	(0.059)	(0.062)
OF	-0.046	-0.040	0.029	-0.016	-0.058	-0.062	-0.074	-0.084	-0.096
	(0.061)	(0.049)	(0.034)	(0.049)	(0.049)	(0.054)	(0.064)	(0.076)	(0.082)
OF·	-0.110	-0.110	-0.122	-0.184	-0.166	-0.210*	-0.157	-0.200	-0.031
Pessimism	(0.121)	(0.104)	(0.104)	(0.119)	(0.111)	(0.127)	(0.139)	(0.145)	(0.174)
Adj.R^2	0.0006	0.0003	-0.0005	0.0006	0.0008	0.0015	0.0013	0.0021	0.0006

In the latter test, we randomly assign a positive, negative, or neutral tone to each GI category, so the factors created by this random dictionary are false. This dictionary lets us assess: a) whether an arbitrary classification of the categories affects the interest rate structure; b) whether we have properly selected and classified the categories in the dictionary. For example, in the random dictionary the category "feel" is neutral; "ovrst" is negative; "positive" is positive; and "weak" is positive.[7] We use this test in both interest rates level and volatility.

We present the results of the robustness analysis on the interest rates level in Tables 6 to 9. To analyze the effect of the ECB announcements we used Equations (2.6) to (2.9); Tables 6 and 7 show the results of running these equations with the lagged interest rates and the random dictionary, respectively. To study the impact of the Fed minutes, we used Equation (2.10); the outcome of running this equation with lagged interest rates and random dictionary are in Tables 8 and 9, respectively.

Regarding the control variable, te sign in Table 6 is the same as in the original run; however, since shifted dates (in both control and dependent variables) are no longer absorbing the shock of the ECB monetary policy, their estimates are statistically and economically less significant than in the original run. By contrast, Table 7 shows that both the economic and statistical significance of the estimates are larger than in Table 6 and coincide with the original run. As expected, Table 7 indicates the interest rate shock absorption by both the control and the dependent variable is not affected by the random factor.

The optimistic factor difference from Tables 6 and 8 and the random factor difference from Tables 7 and 9 are statistically insignificant at the 10% level. The exceptions are the press conference optimistic factor difference coefficients for the four-month contract in Panel A of Table 6 and the four- and six-month contracts in Table 8, which are only significant at the 10% level.

[7]The category "ovrst" indicates overstatement, often reflecting the presence or lack of emotional expressiveness.

Table 6 – **Effect of ECB introductory statements and questions sessions on lagged interest rates**

Columns show the dependent variable changes in yields at different maturities with a lag (shifted forward to an earlier day). Each horizontal panel displays the results of a different regression equation. Rows represent the independent variables: IRS_l is the lagged interest rate surprise control, ΔOF^{IQ}, ΔOF^{I} and ΔOF^{Q} represent the change in the optimistic factor for the press conference, introductory statement and the questions sessions, respectively; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are standardized to zero mean and one standard deviation. Each regression is based on 168 observations from October 2003 to April 2019. Robust standard errors in parentheses.[a] p-val of $H_0 : \Delta OF^I = \Delta OF^Q = 0$.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
Panel A				Press conference					
IRS_l	0.094***	0.035**	0.057***	0.050**	0.049*	0.071**	0.055	0.056	0.040
	(0.022)	(0.015)	(0.018)	(0.022)	(0.028)	(0.034)	(0.035)	(0.043)	(0.057)
ΔRF^{IQ}	-0.299	-0.760*	-0.133	0.241	0.344	0.153	0.022	-0.118	-0.520
	(0.463)	(0.432)	(0.469)	(0.530)	(0.643)	(0.657)	(0.681)	(0.682)	(0.760)
$Adj.R^2$	0.1218	0.0325	0.0549	0.0197	0.0071	0.0231	0.0096	0.0099	0.0002
Panel B				Introductory statement					
IRS_l	0.098***	0.038**	0.061***	0.052**	0.049*	0.072**	0.056	0.057	0.043
	(0.022)	(0.016)	(0.018)	(0.022)	(0.028)	(0.034)	(0.035)	(0.043)	(0.058)
ΔOF^I	0.143	-0.297	0.418	0.502	0.416	0.162	0.075	0.036	-0.118
	(0.511)	(0.491)	(0.471)	(0.553)	(0.716)	(0.737)	(0.719)	(0.731)	(0.801)
$Adj.R^2$	0.1201	0.0179	0.0589	0.0229	0.0074	0.0231	0.0096	0.0097	-0.0021
Panel C				Questions session					
IRS_l	0.095***	0.037**	0.057***	0.049**	0.048*	0.071**	0.055	0.056	0.041
	(0.022)	(0.015)	(0.018)	(0.022)	(0.028)	(0.034)	(0.034)	(0.042)	(0.055)
ΔOF^Q	-0.301	-0.632	-0.175	0.227	0.400	0.207	0.048	-0.098	-0.508
	(0.457)	(0.443)	(0.457)	(0.544)	(0.678)	(0.725)	(0.761)	(0.782)	(0.856)
$Adj.R^2$	0.1219	0.0276	0.0553	0.0196	0.0077	0.0233	0.0096	0.0098	0.0001
Panel D				Introductory statement and questions session					
IRS_l	0.096***	0.036**	0.060***	0.053**	0.050*	0.072**	0.056	0.057	0.041
	(0.022)	(0.016)	(0.018)	(0.022)	(0.029)	(0.034)	(0.035)	(0.044)	(0.058)
DOF^I	0.201	-0.191	0.459	0.474	0.355	0.129	0.068	0.055	-0.030
	(0.512)	(0.505)	(0.476)	(0.573)	(0.746)	(0.778)	(0.764)	(0.786)	(0.860)
DOF^Q	-0.329	-0.606	-0.238	0.162	0.351	0.190	0.038	-0.106	-0.504
	(0.466)	(0.461)	(0.459)	(0.559)	(0.701)	(0.758)	(0.798)	(0.826)	(0.902)
$Adj.R^2$	0.1173	0.0226	0.0550	0.0175	0.0030	0.0175	0.0036	0.0038	-0.0060
p-val[a]	0.481	0.191	0.605	0.772	0.617	0.808	0.962	0.898	0.577

Table 7 – **Effect of random ECB introductory statements and questions sessions on interest rates**

Columns show the dependent variable Δy^m, changes in yields at different maturities. Each horizontal panel displays the results of a different regression equation. Rows represent the independent variables: IRS is the interest rate surprise control, ΔRF^{IQ}, ΔRF^{I} and ΔRF^{Q} represent the change in the random factor for the press conference, introductory statement and the questions sessions, respectively; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the random factor are standardized to zero mean and one standard deviation. Each regression is based on 168 observations from October 2003 to April 2019. Robust standard errors in parentheses.[a] p-val of $H_0 : \Delta RF^I = \Delta RF^Q = 0$.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
Panel A	Press conference								
IRS	0.344***	0.150***	0.111***	0.109***	0.094***	0.114***	0.101***	0.093***	0.075**
	(0.077)	(0.049)	(0.018)	(0.023)	(0.035)	(0.035)	(0.037)	(0.032)	(0.031)
ΔRF^{IQ}	-0.006	-0.835	0.090	0.092	-0.028	0.247	0.727	1.033	0.192
	(0.430)	(0.709)	(0.465)	(0.591)	(0.789)	(0.993)	(1.114)	(1.003)	(1.143)
$Adj.R^2$	0.5748	0.0989	0.1035	0.0568	0.0189	0.0236	0.0167	0.0186	-0.0002
Panel B	Introductory statement								
IRS	0.344***	0.147***	0.111***	0.108***	0.093***	0.113***	0.103***	0.096***	0.076**
	(0.077)	(0.049)	(0.018)	(0.023)	(0.035)	(0.036)	(0.037)	(0.032)	(0.031)
ΔRF^{IQ}	-0.102	-0.771	-0.619	-0.884	-1.459	-1.254	-1.011	-0.437	0.560
	(0.560)	(0.847)	(0.525)	(0.707)	(0.926)	(1.030)	(1.120)	(1.087)	(1.328)
$Adj.R^2$	0.5750	0.0970	0.1125	0.0685	0.0383	0.0342	0.0195	0.0124	0.0013
Panel C	Questions session								
IRS_l	0.344***	0.150***	0.111***	0.108***	0.093***	0.112***	0.099***	0.091***	0.074**
	(0.078)	(0.049)	(0.018)	(0.023)	(0.036)	(0.036)	(0.038)	(0.034)	(0.032)
ΔOF^{I}	-0.039	-0.766	0.200	0.331	0.391	0.698	1.201	1.291	0.260
	(0.391)	(0.608)	(0.425)	(0.551)	(0.726)	(0.894)	(1.004)	(0.922)	(1.099)
$Adj.R^2$	0.5749	0.0982	0.1044	0.0587	0.0205	0.0272	0.0237	0.0241	0.0000
Panel D	Introductory statement and questions session								
IRS	0.344***	0.149***	0.110***	0.107***	0.091**	0.110***	0.098***	0.091***	0.075**
	(0.078)	(0.049)	(0.018)	(0.024)	(0.036)	(0.036)	(0.038)	(0.034)	(0.032)
δRF^{I}	-0.099	-0.706	-0.642	-0.921	-1.505	-1.327	-1.129	-0.559	0.540
	(0.556)	(0.826)	(0.527)	(0.713)	(0.934)	(1.029)	(1.119)	(1.097)	(1.358)
δRF^{Q}	-0.031	-0.712	0.249	0.402	0.507	0.800	1.288	1.335	0.219
	(0.386)	(0.590)	(0.421)	(0.548)	(0.713)	(0.887)	(1.001)	(0.928)	(1.118)
$Adj.R^2$	0.5724	0.0988	0.1089	0.0657	0.0352	0.0336	0.0256	0.0202	-0.0045

Table 8 – **Effect of Fed minutes on lagged interest rates**

Columns show the dependent variable changes in yields at different maturities shifted forward to an earlier day. The row shows the independent variable ΔOF, change in the optimistic factor; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the optimistic factor are normalized to one. Each regression is based on 114 observations from February 2005 to April 2019, except for the 10-year contract that starts in September 2005 and contains 109 observations. Robust standard errors in parentheses. *, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year	10-year
ΔRF	2.188*	1.230*	0.523	0.423	0.439	0.254	0.693	0.924	-0.285
	(1.218)	(0.631)	(0.580)	(0.641)	(0.908)	(1.078)	(1.145)	(1.249)	(1.119)
$Adj.R^2$	0.0727	0.0570	0.0019	-0.0052	-0.0063	-0.0082	-0.0048	-0.0021	-0.0087

Table 9 – **Effect of random Fed minutes on interest rates**

Columns show the dependent variable Δy^m, changes in yields at different maturities. The row shows the independent variables ΔRF, change in the random factor; the intercept is not reported. Changes in interest rates are expressed in basis points and the standard deviations of the random factor are normalized to one. Each regression is based on 114 observations from February 2005 to April 2019, except for the 10-year contract that starts in September 2005 and contains 109 observations. Robust standard errors in parentheses. *, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year	10-year
ΔRF	-0.027	0.093	0.541	0.975	1.394	1.127	1.104	1.543	1.425
	(0.643)	(0.559)	(0.721)	(0.952)	(1.085)	(1.172)	(1.055)	(1.015)	(1.058)
$Adj.R^2$	-0.0089	-0.0086	-0.0028	0.0025	0.0085	0.0016	0.0029	0.0128	0.0172

Tables 6 to 9 show that when we either change the dates of disclosure or use a random dictionary, the association between the optimism of the announcements and the interest rates level is no longer significant.

The results of the robustness test on the interest rates volatility are in Table 10, for the ECB press conferences, and in Table 11, for the Fed minutes. Except for the *Release* dummy variable and the IRS control variable, in the ECB press conference regression, the value of the variables differ from the original run. We fabricated the random factor RF sing a random dictionary, the $RPessimism$ dummy takes the value of one to indicate when RF is negative.

Compared to the original run, the coefficients of the surprise control variable in Table 10 preserve the sign and significance, as expected. The remaining coefficients are mainly insignificant at the 10% level, with few exceptions. The random factor in Panel B is significant in the two- and six-month maturities at the %10 and 5% levels, respectively, and the pessimistic random factor of the one-year maturity in Panel C is significant at the 5% level.

Panel A and B from Table 11 shows that the *Release* estimates are affected by the random factor; they have the same sign but are less significant than the original run. The remaining coefficients, which are a function of the random dictionary, are mostly statistically insignificant at the 10% level. The exceptions are *RPessimism* in Panel A and *RF* in Panel B, which are significant at the 10% level. From Tables 11 and 10 we see that, when the content is analyzed with the random dictionary, there is not a significant relationship between the interest rates volatility and either the ECB press conference or the Fed minutes.

The results of the robustness analysis show that the interest rates level does not respond to shocks of arbitrary announcements. They also show that the relation between the optimistic factor of either bank and the interest rates is not spurious, and the optimistic factor is likely to be correctly synthesizing the information of the announcements that traders use when trading future interest rates.

2.6 Conclusion

This paper analyzes the relationship between the optimism of the ECB press conference and the Fed minutes on the interest rate level and volatility of future contracts traded in the Brazil stock exchange.

Table 10 – **Effect of random ECB press conferences on interest rates volatility**

Each horizontal panel displays the results of a different regression equation. Columns show the dependent variable five-workday volatility at different maturities. Rows represent the independent variables: IRS is the interest rate surprise control, the dummy variable *Release* indicates when the ECB press conference is published, RF^{IQ} is the optimistic random factor of the press conference, and the dummy *RPessimism* indicates when RF^{IQ} is negative; the intercept is not reported. The IRS and the *Release* variables have the same values as in Table 4; the remaining variables are fabricated with the random dictionary. The period from October 2003 to April 2019, regressions are run with 3875 observations for Panels A and C and 3864 observations for Panels B and D. *Release* is nonzero in 169 observations for Panels A and C and 168 observations for Panels B and D, and *RPessimism* is nonzero in 83 observations. Changes in interest rates are expressed in basis points, and the random factor is standardized to zero mean and one standard deviation. Robust standard errors in parentheses.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	2-month	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year
Panel A	$Vol^m_{t+1} = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ RPessimism_t$								
IRS	0.681***	0.310***	0.162***	0.122***	0.142***	0.164***	0.154***	0.203***	0.369***
	(0.050)	(0.026)	(0.023)	(0.030)	(0.039)	(0.041)	(0.042)	(0.044)	(0.063)
Release	0.286	0.836	0.000	0.295	0.263	0.363	0.312	0.088	0.074
	(1.186)	(0.822)	(0.813)	(1.024)	(1.326)	(1.507)	(1.528)	(1.447)	(1.653)
RPessimism	-1.629	-0.901	-0.752	-0.936	-1.154	-1.362	-1.368	-1.071	-1.719
	(1.675)	(0.999)	(0.896)	(1.131)	(1.502)	(1.697)	(1.709)	(1.671)	(1.908)
$Adj.R^2$	0.0501	0.0380	0.0134	0.0039	0.0033	0.0039	0.0033	0.0055	0.0100
Panel B	$\log(Vol^m_{t+1}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ RF^{IQ}_t$								
IRS	0.021***	0.026***	0.021***	0.013***	0.013***	0.013***	0.011***	0.014***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Release	-0.010	0.034	-0.058	-0.010	-0.032	-0.044	-0.044	-0.032	-0.020
	(0.029)	(0.037)	(0.044)	(0.044)	(0.047)	(0.049)	(0.049)	(0.049)	(0.053)
OF	-0.053*	-0.056	-0.089**	-0.045	-0.043	-0.026	-0.024	-0.026	-0.048
	(0.030)	(0.038)	(0.044)	(0.043)	(0.047)	(0.047)	(0.049)	(0.049)	(0.056)
$Adj.R^2$	0.0426	0.0410	0.0203	0.0067	0.0064	0.0065	0.0046	0.0065	0.0109
Panel C	$\log(Vol^m_{t+1}) = \alpha + \beta\ IRS_{t+1} + \gamma\ Release_t + \delta\ RF^{IQ}_t + \theta\ RF^{IQ}_t \cdot RPessimism_t$								
IRS	0.021***	0.026***	0.021***	0.013***	0.013***	0.013***	0.011***	0.014***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Release	-0.011	0.008	-0.092*	-0.069	-0.054	-0.054	-0.045	-0.048	-0.034
	(0.031)	(0.044)	(0.051)	(0.053)	(0.055)	(0.057)	(0.057)	(0.058)	(0.063)
RF	-0.054	-0.004	-0.025	0.071	0.001	-0.010	-0.024	0.001	-0.028
	(0.056)	(0.069)	(0.080)	(0.068)	(0.068)	(0.069)	(0.073)	(0.075)	(0.085)
RF·	0.006	-0.092	-0.110	-0.205**	-0.074	-0.023	0.006	-0.039	-0.023
RPessimism	(0.069)	(0.093)	(0.101)	(0.098)	(0.107)	(0.108)	(0.114)	(0.115)	(0.133)
$Adj.R^2$	0.0422	0.0410	0.0203	0.0074	0.0061	0.0061	0.0043	0.0062	0.0106

Table 11 – **Effect of random Fed minutes on interest rates volatility**

Each horizontal panel displays the results of a different regression equation. Columns show the dependent variable five-workday volatility at different maturities. Rows represent the independent variables: the dummy variable *Release* indicates when the Fed minute is published, *RF* is the random optimistic factor of the minute, and the dummy *Pessimism* indicates when *RF* is negative; the intercept is not reported. The *Release* variable has the same values as in Table 5; the remaining variables are fabricated with the random dictionary. For contacts up to 8 years, the period is from February 2005 to April 2019, and regressions are run with 3540 observations for Panels A and C and 3533 for Panels B and D. For the 10-year contract, the period is from September 2005 to April 2019, and regressions are run with 3358 observations for Panels A and C and 3340 for Panels B and D. Changes in interest rates are expressed in basis points and the random factor is standardized to zero mean and one standard deviation. Robust standard errors in parentheses.*, **, *** denote statistical significance at 10%, 5% and 1% levels.

Maturity	4-month	6-month	1-year	2-year	3-year	4-year	6-year	8-year	10-year
Panel A	$Vol^m_{t+1} = \alpha + \gamma\ Release_{t+1} + \delta\ RPessimism_t$								
Release	-0.518	-0.540	-0.517	-0.598	-0.200	-0.189	-0.448	-0.802	-0.193
	(0.621)	(0.500)	(0.559)	(0.764)	(0.835)	(0.916)	(0.891)	(0.994)	(1.078)
RPessimism	0.009	-0.003	-0.159	-0.738	-1.045	-1.217	-1.661	-1.817	-2.195*
	(0.998)	(0.649)	(0.724)	(0.928)	(1.032)	(1.123)	(1.084)	(1.185)	(1.229)
$Adj.R^2$	-0.0003	-0.0001	-0.0002	0.0000	-0.0002	-0.0001	0.0004	0.0006	0.0005
Panel B	$\log(Vol^m_{t+1}) = \alpha + \gamma\ Release_{t+1} + \delta\ RF_t$								
Release	-0.041	-0.054	-0.025	-0.064	-0.027	-0.044	-0.073	-0.097*	-0.079
	(0.045)	(0.049)	(0.045)	(0.052)	(0.050)	(0.053)	(0.053)	(0.057)	(0.057)
RF	0.079*	0.012	0.059	-0.004	-0.005	-0.040	-0.025	-0.028	0.011
	(0.041)	(0.047)	(0.045)	(0.061)	(0.060)	(0.062)	(0.061)	(0.059)	(0.060)
$Adj.R^2$	0.0006	-0.0002	-0.0001	-0.0002	-0.0005	-0.0002	-0.0000	0.0003	0.0000
Panel C	$\log(Vol^m_{t+1}) = \alpha + \gamma\ Release_{t+1} + \delta\ RF_t + \theta\ RF_t \cdot RPessimism_t$								
Release	-0.028	-0.045	0.001	-0.055	-0.027	-0.056	-0.091	-0.108	-0.110
	(0.048)	(0.049)	(0.047)	(0.057)	(0.058)	(0.063)	(0.065)	(0.068)	(0.068)
RF	0.041	-0.013	-0.002	-0.028	-0.008	-0.018	0.010	-0.007	0.066
	(0.055)	(0.076)	(0.075)	(0.113)	(0.110)	(0.117)	(0.118)	(0.113)	(0.113)
RF·	0.083	0.057	0.124	0.052	0.011	-0.038	-0.065	-0.038	-0.144
RPessimism	(0.085)	(0.095)	(0.097)	(0.140)	(0.143)	(0.150)	(0.150)	(0.145)	(0.148)
$Adj.R^2$	0.0007	-0.0004	-0.0000	-0.0004	-0.0008	-0.0005	-0.0002	0.0000	-0.0001

We show that while both announcements reduce the interest rates level and volatility, their effect differs. Regarding interest rates level, Fed minutes affect longer contracts and their impact is economically more significant. Concerning interest rates volatility, an increase in the optimism of either announcement reduces it in mid- and long-term contracts. However, only the disclosure of the Fed minutes significantly reduces uncertainty expressed for longer contracts. Also, the release of optimistic minutes is the leading cause of this reduction and affects mid-term contracts.

The term structure of Brazil's interest rate reflects investors' expectations regarding the future monetary policy of the CBB. These results show that traders in Brazil's market closely monitor foreign central bank announcements and consider that the CBB monetary policy is based not only on the Brazilian economy but also on the decisions made by other central banks.

3 A Quantitative Assessment of the Evolution of Central Bank of Brazil Communications

Abstract

We analyze the evolution of minutes released by the Central Bank of Brazil under different presidencies. We text mine the documents and use natural language processing exploring an unsupervised learning algorithm to score the discussion on the minutes in four different macroeconomic dimensions: inflation, economic growth, employment, and fiscal policy. Results of the study indicate the emphasis of the Central Bank of Brazil on the control of prices of goods and services, perhaps reflecting concerns of the negative and long-lasting impacts of past hyperinflation in the country.
Keywords: Central bank communications, Inflation targeting, Text mining, Natural language processing, Unsupervised learning algorithm

3.1 Introduction

We analyze the Central Bank of Brazil (CBB) minutes under different institutional chair mandates. After the adoption of the targeting inflation regime in July/1999, the minutes of the Monetary Policy Committee (COPOM) meeting represent the most important monetary tool of the CBB for the long-term interest rate. We study the announcements released between 2000 and 2019 on four macroeconomic dimensions: inflation, economic growth, employment, and fiscal policy.

For each dimension, we count the terms that appear in an ad hoc dictionary and perform a principal component analysis (PCA) to get the macroeconomic scores. The scores indicate how much stress a document place on different macroeconomic variables. The central question of our work is: How does the focus on these variables change with different chairs of the CBB?

Regarding the size of the minutes, we observe that there are two restructurings in the analyzed period. These reorganizations take place at the end of Tombini's first term, and at the beginning of Goldfajn's presidency. In both cases, there is a drop in the length of the minutes. Also, over time, the variation of the length of the document reduces.

Throughout the twenty years of analysis, we find that inflation is the main concern, followed by both employment and growth. This result may reflect the Brazilian historical economic context, as inflation has been especially worrisome. During the 1980 and 1990 the country hyperinflation strongly impacted the economy, reaching over 2,700% in 1993.

The results of the study show that fiscal policy is the least relevant topic; however, during the second half of Tombini's presidency, there is a peak in the score of fiscal policy reaching the same level of importance as the employment and growth scores. During Goldfajn and Campos Neto's tenure, the gap between the score of inflation and the scores of economic growth, employment, and fiscal policy becomes larger. This result also coincides with the lack of correlation between the macroeconomic scores and the macroeconomic indicators, which shows that during their tenures there is a stronger adherence to the inflation targeting regime.

Textual content in finance have been studied in various context. For instance, Cookson and Niessner (2019) analyze tweets to identify disagreement among investors and Rybinski (2019) use natural language processing (NLP) techniques to predict economic variables from sell-side research reports. Documents and transcripts of Central Banks' meetings have been used in other studies. For instance, Vayid (2013) describes the history and discusses the effectiveness of the communications of central banks, during the 2007 economic crisis, whereas Montes and Scarpari (2014) examine the influence of communication policies of the central bank on bank risk-taking. Amaya and Filbien (2015) investigate potential impacts of the communication of the European Central Bank on the financial market.

More closely related to our work are the studies from Cannon (2015) and Hansen, McMahon and Prat (2018). Cannon (2015) analyzes the tone difference among bank presidents, governors, and federal reserve staff from transcripts of the Federal Open Market Committee (FOMC) announcements of the US Federal Reserve System. Hansen, McMahon and Prat (2018) investigate how transparency affects the deliberation of monetary policymakers on the FOMC.

In the Brazilian context, the following literature uses text mining in CBB's announcements. Filho and Rocha (2010) study how the publication of minutes affects the term structure of interest rates. Regarding the content of the announcements, Carvalho, Cordeiro and Vargas (2013) and Chague et al. (2015) show that the information conveyed in statements and minutes, respectively, affect the interest rate structure. Our work differs from the former studies, as it analyzes the evolution of these minutes under different presidencies and focus on economic dimensions related to inflation, economic growth, employment, and fiscal policy. We use specific dictionaries and explore natural language processing with an unsupervised learning algorithm.

3.2 Data

The sample of the CBB's minutes comprises 185 documents released from January 2000 to November 2019. Our study spans the tenures of Fraga Neto, Meirelles, Tombini, Goldfajn , and Campos Neto as presidents of the CBB.[1] The explicit target for inflation rate was announced in July 1999, which means all the minutes in the sample are published under inflation targeting regime in Brazil.

Table 12 – **Minutes analyzed**

President of the CBB				President of Brazil	
Name	From	To	Scripts	Name	Scripts
Armínio Fraga Neto	2000-01-24	2002-12-31	38	Fernando Henrique Cardoso (2nd term)	38
Henrique Meirelles	2003-01-01	2010-12-31	75	Luiz Inácio Lula da Silva (1st term)	44
				Luiz Inácio Lula da Silva (2nd term)	31
Alexandre Tombini	2011-01-01	2016-06-08	45	Dilma Rousseff (1st term)	32
				Dilma Rousseff (2nd term)	11
				Dilma Rousseff (suspended)	2
Ilan Goldfajn	2016-06-09	2019-02-27	20	Michel Temer	20
Roberto Campos Neto	2019-02-28	2019-11-05	7	Jair Bolsonaro	7

We gather all the macroeconomic indicators from the Institute of Applied Economic Research of Brazil (IPEA) webpage. The growth rate is published by the Brazilian Institute of Geography and Statistics (IBGE) and represents the variation of the real GDP at market prices from the previous year. The unemployment rate is from the State System Foundation for Data Analysis (SEADE). This index considers the São Paulo metropolitan area and was discontinued in June 2019.[2] For the inflation index, we use the Extended National Consumer Price Index (IPCA) determined by the IBGE. We also use the fiscal policy index estimated by the CBB, which represents the percentage of the public sector net financial liabilities regarding the GDP.

[1] Our sample starts in January 2000 since this is the first year that English transcripts are available on the webpage of the CBB.

[2] The IBGE published a more comprehensive study covering the six most populated metropolitan regions, but it was interrupted in February 2016.

3.3 Methodology

We are interested in measuring the emphasis that minutes place on different macroeconomic categories: fiscal policy, economic growth, employment, and inflation. To measure each economic category m we use an NLP mechanism that explores an unsupervised learning algorithm based on PCA, which was first used in the economic literature by Tetlock (2007). However, our approach differs since Tetlock (2007) counts terms present in the Harvard dictionary to measure sentiment, while we count the terms in each of the m ad hoc dictionaries to measure the emphasis put in each economic dimension. We have chosen the PCA method as it eliminates the redundant categories of each dictionary.

To get the quantitative measures from the minutes content we proceed in the following way. First, we define a dictionary for each macroeconomic dimension; we list the dictionaries in Tables 13 to 16 for inflation, economic growth, employment, and fiscal score, respectively. The dictionaries have multiple groups semantically related, and each group has one or multiple semantically similar terms. For example, the dictionary we used to measure inflation (Table 13) has eight groups semantically related to inflation. The third group, associated with the Consumer price index (FGV), contains terms such as ipc-10 and ipc-m that are semantically similar (both measure the same basket of goods and services but differ in the collection period). For each group that does not contain anachronisms, we remove the inflected form of words with Porter's algorithm (PORTER, 1980), so we can increase the match between terms.

Second, we find the principal component of each economic dimension. For each of the 185 minutes, we count the number of entries that falls into each of the G_m macroeconomic groups of a macroeconomic variable m. Then, we normalize each frequency by the length of the corresponding minute and collapse the 185 vectors into a matrix A_m of dimension $(G_m \times 185)$. On A_m, we apply PCA on covariance; select the eigenvector with the highest eigenvalue; and set the eigenvector's component to a positive sign. The resulting vector is the basis vectors v_m that summarizes the information of its corresponding matrix A_m. We listed the weight of the components in the last column of Tables 13 and 16.

Table 13 – **Groups used to measure inflation**

Group	Description	Terms	Weight
I	Inflation related terms†	deflat, deflation, deflationari, disinfl, disinflationari, infla, inflat, inflation, inflation-index, inflation-link, inflation-persist, inflation-target, inflationari	0.998
II	Retail prices (IBGE)	ipca, ipca-15, ipca-ex, ipcaex	0.041
III	Consumer price index (FGV)	ipc, ipc-10, ipc-br, ipc-cor, ipc-di, ipc-m, ipc-s	0.031
IV	General price index (FGV)	igp, igp-10, igp-di, igp-m	0.029
V	Wholesale price index (FGV)	ipa, ipa-10, ipa-di, ipa-m	0.023
VI	National construction cost index (FGV)	incc, incc-10, incc-di, incc-m	0.016
VII	Producer price index (IBGE)	ipp	0.014
VIII	Brazilian inflation linked bonds (National Treasury)	ntn, ntn-b, ntn-c	0.013

† Stemmed terms with Porter's algorithm.

Table 14 – **Groups used to measure economic growth**

Group	Term	Weight
I	product	0.994
II	output	0.120
III	gdp	0.104

All terms are stemmed with Porter's algorithm.

Finally, we get each macroeconomic measure, and construct m time series of length 185 from the product between A_m and v_m. Since the components of each basis vector have a positive sign, the greater the score of a document in the time series, the higher the document's attention to the macroeconomic category m.

Table 15 – **Groups used to measure employment**

Group	Terms	Weight
I	job, jobless, employ, unemploy	0.956
II	labor	0.292
II	wage, salari	0.006

All terms are stemmed with Porter's algorithm.

Table 16 – **Groups used to measure fiscal policy**

Group	Terms	Weight
I	fiscal	0.993
II	debt, debtor, creditor, oblig	0.079
III	budget, budgetari	0.063
IV	tax, taxat	0.057
V	spend, spending	0.016
VI	levi	0.006
VII	receipt	0.002

All terms are stemmed with Porter's algorithm.

3.4 Results and Discussion

Figure 3 displays the length of the minutes after removing stop words [3]. During Meirelles' tenure, there was a change in the frequency of the COPOM meetings. Until 2005, CBB published one COPOM minute per month, so the CBB released twelve minutes per year. In 2006, the CBB reduced the frequency of the COPOM meetings to six weeks or eight minutes per year.

[3]We use the `stop.words` list from the `nltk.corpus` python package.

We can see that when meetings were held less frequently, the minutes got larger. From Fraga Neto to Meirelles, minutes grew from a mean size of 2,500 words to 4,500 words. In the first half of Tombini's tenure, the mean length remained unchanged, but then, in March 2014, the size plunged to a mean size of 2,200 words. In October 2016, with the transition from Tombini to Goldfajn, there was a second reduction to a mean size of 1,400 words. These two size cuts showed a restructuring of the minutes. During Goldfajn's and Campos Neto's term, the mean length remained unchanged. Also, over time, the variation of the length reduced. During Fraga Neto's tenure, the variation was the largest; with Meirelles and Tombini, decreased; and, with Goldfajn and Campos Neto, attained its minimum.

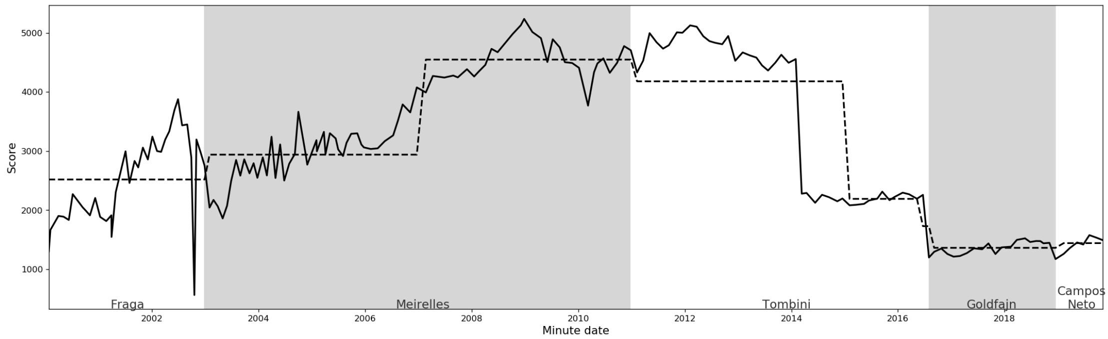


Figure 3 – **Time-series of the COPOM minutes length.**
The black line represents minutes' length after removing stop words, and the dashed line indicates the mean length by the presidential term of Brazil. Alternate background colors correspond to CBB's presidencies. The series shows 185 minutes from January 24, 2000 to November the 5, 2019.

Figure 4 shows the four macroeconomic scores for each dimension: inflation, economic growth, employment, and fiscal policy. As expected, when we compared the scores, the most important topic in each presidency is inflation. Its relevance is low with Fraga Neto, increases with Meirelles, and, in the first half of Tombini's presidency, gradually declines. However, in the second half of his term, inflation arrives at a historical maximum; rises again when Goldfajn assumes the presidency; and remains high with Campos Neto. Employment and economic growth are the second most important scores. Employment is more relevant than economic growth until the first half of Meirelles presidency, but this relation reverts afterward. Fiscal policy is the less important subject throughout the series, except for two occasions in which it remains close to economic growth and employment: at the end of Tombini's term when fiscal policy peaks, and with Campos Neto when growth and employment reach their historical minimum. Finally, the second restructuring not only places more relevance to inflation but also reduces the attention in economic growth, employment, and fiscal policy. Hence, during Campos Neto and Goldfajn, inflation becomes the sole macroeconomic concern.

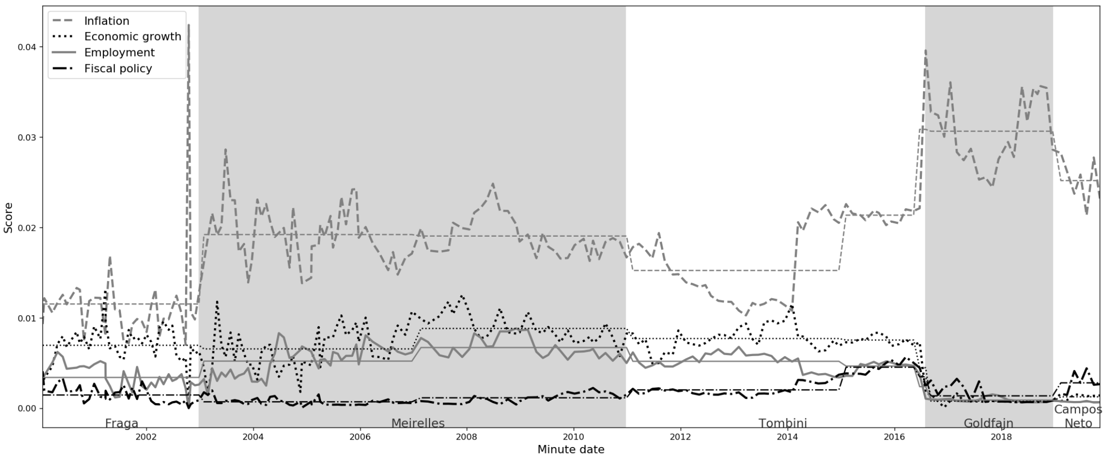


Figure 4 – **Macroeconomic scores.**
Thick lines represent the macroeconomic scores, and the thin lines are their corresponding mean score for each president Brazil. Alternate background colors correspond to BCB's presidencies. The series shows 185 scores corresponding to the minutes release between January 2000 and November 2019.

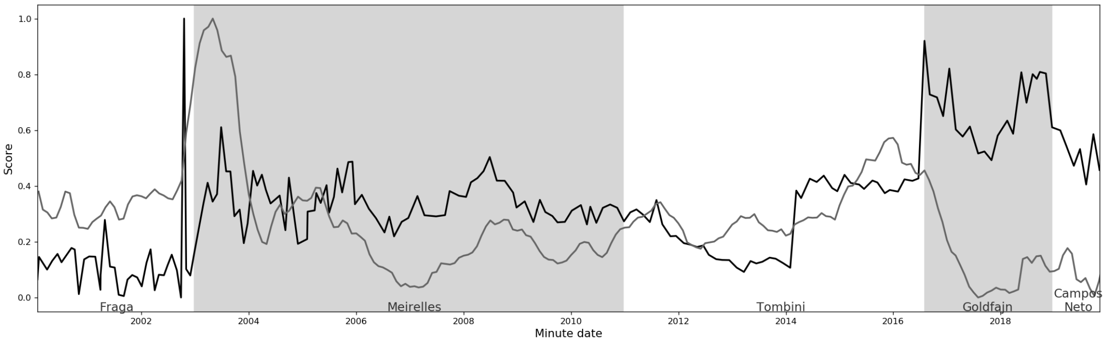
Figure 5 shows the time-series of the factors separated in four frames along with their corresponding macroeconomic indicators. The content of each frame is: (a) the inflation scores and rates, (b) economic growth scores and rates, (c) employment scores and unemployment rates, and, (d) fiscal policy scores and debt. We smooth out the inflation, economic growth, and unemployment indicators with a simple moving average of the twelve past observations. That is, the window of the moving average is one year for inflation and unemployment and three years for growth. To ease the comparison between each score with its corresponding economic indicator, we scale the range in $[0, 1]$ using min-max normalization.

With each presidential term, the scores become less volatile, except for the fiscal score during the beginning of Goldfajn's and Campos Neto's mandates. Frames (a) and (d) show that until Tombini, the inflation score and fiscal policy are correlated with their respective economic indicators. Frame (a) also displays that Goldfajn's and Campos Neto's presidencies have both low inflation rates and high inflation scores. Frame (d) shows the opposite as the fiscal score is relatively low while debt is in a historic high. Frames (b) and (c) show that economic growth and employment are uncorrelated with the economic growth and unemployment indicators throughout the series; also, the scores remain to a historic low.

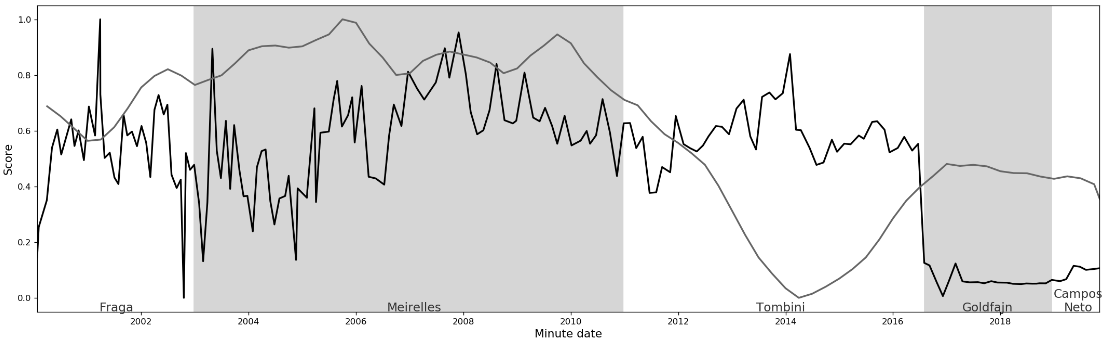
In conclusion, the second restructuring, which takes place with Godlfajn, impacts on the macroeconomic scores. Inflation achieves a historical maximum, while cuts down not only economic growth and employment to a historical minimum but also reduces fiscal policy. These results indicate that after the second restructuring, the CBB shows a tighter adherence to the inflation targeting regime.

3.5 Conclusion

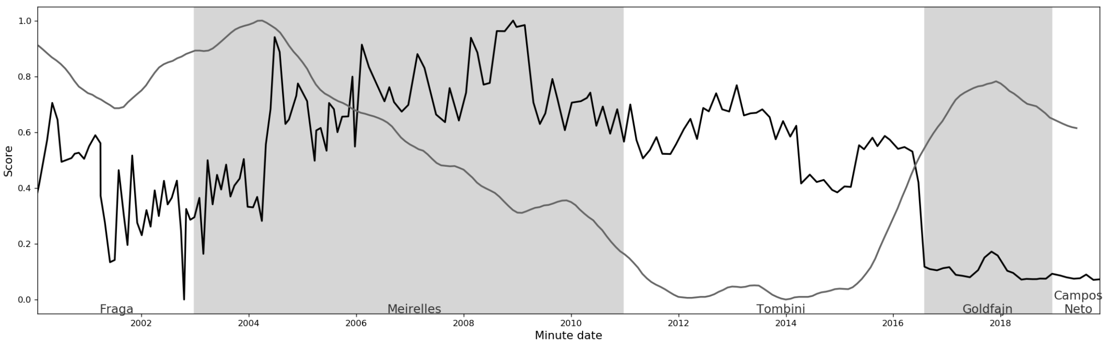
Our study contributes to the understanding of communications of central banks, by focusing on an emerging country, with high volatile economic and political environments.



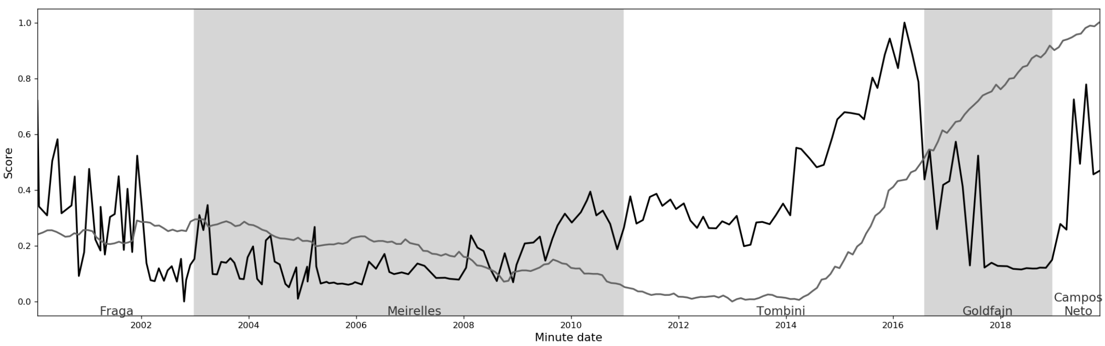
(a) Inflation



(b) Economic growth



(c) Employment



(d) Fiscal policy

Figure 5 – **Macroeconomic scores of the COPOM minutes.**

Black and gray lines represent the macroeconomic scores and indicators, respectively. Alternate backgrounds colors correspond to BCB's presidencies. Series (a) shows the inflation scores and the IPCA inflation rates. Series (b) shows the economic growth scores and the real GDP growth rates. Series (c) shows the employment scores and the unemployment rates. Series (d) shows the fiscal policy scores and the government debt as a percentage of the GDP. We smooth out the inflation, economic growth, and unemployment indicators with a simple moving average of twelve observations. Both the scores and economic indicators are min-max normalized to scale the range in $[0, 1]$. Except for the unemployment rate, which spans until July 2019, each series shows the macroeconomic score and index from January 2000 to November 2019. Each series (a), (b), (c), and (d) displays 239 inflation, 78 GDP, 233 unemployment, and 238 debt indicators, respectively.

The COPOM meeting minutes provide a record of what were the concerns that the CBB under different presidencies. From Fraga Neto to Meirelles, the size of the minutes got larger and remained unchanged until the end of Tombini's first presidency, in which there is a plunge of their size. When Goldfajn assumes the presidency, there is a second restructuring, which also reduces the size of minutes to its current level.

We used an unsupervised learning algorithm to score the emphasis that minutes place on inflation, economic growth, employment, and fiscal policy. We find that inflation is the major concern, followed by both economic growth and employment. The fiscal policy is the least important topic; however, before the first restructuring its concern attains the attention of growth and employment.

The second restructuring shows that the inflation score attains a historic maximum, whereas economic growth, employment and fiscal policy remain low. Moreover, the lack of correlation between the macroeconomic scores and the macroeconomic variables reflects that inflation is the main monetary policy aim of Goldfajn and Campos Neto.

The communications of the CBB may suggest that hyperinflation during the 1990s, with enduring effects in the economy, may still influence monetary policy in Brazil, favoring control of prices of goods and services over growth, employment and fiscal policies.

4 A Measure of the Economic and Financial Crisis Sentiment in Central Bank Communications

Abstract

We build a dictionary to measure the crisis sentiment of central bank announcements using a machine learning classifier trained with terms that come from monetary policy or economic/financial crisis books. We use the dictionary to create a crisis index of the Federal Open Market Committee minutes. The index predicts the interest rate and volatility of the U.S. treasuries. Our index outperforms the indices created with the Correa, the Harvard-IV, or the Loughran-McDonald dictionaries.
Keywords: Central bank communications, Text mining, Natural language processing, Supervised learning algorithm, Crisis sentiment, Interest Rate

4.1 Introduction

The main reason Central bank communication has become more transparent is for economic reasons (GERAATS, 2002). More transparency helps predict central bank actions, and, by lowering market uncertainty, reduces the volatility in financial markets (BLINDER et al., 2008). Since the financial crisis of 2007-2009, many central banks from developed economies have set the short-term nominal interest rate close to zero; thus, forward guidance has gained even more importance (CAMPBELL et al., 2012). However, there is little knowledge regarding the economic crisis sentiment conveyed on central banks forward guidance.

Our article seeks to fill this gap by analyzing the crisis sentiment of central bank announcements. Our contributions to the literature are threefold: i) we create a crisis sentiment dictionary with the aid of a supervised classifier; to our knowledge, it is the first time a supervised machine learning classifier is used in the economic literature to develop a lexicon; ii) we provide a real-time index that measures the sentiment crisis of the Federal Open Market Committee (FOMC) minutes; during the 2007-2008 financial crisis, our index shows that up to 6% of the total number of words are crisis-related; iii) we show empirically that the crisis index from the FOMC minutes significantly predicts the interest rate and the volatility of the US treasuries. An increment (decline) in the crisis sentiment predicts a reduction (increase) of the interest rate level for the intermediate-term maturities and an increase (reduction) of the volatility for the long-term maturities. We also show that our index is robust to macroeconomic information available at the time the FOMC minute is released. We also measure alternative sentiments with the Correa, the Harvard-IV, and the Loughran-McDonald dictionaries. We find that our index significantly outperforms those indices.

To create the dictionary, we train a penalized logistic regression with monetary policy books classified as either crisis or general theory. The model identifies the terms that associated with a crisis. From this subset, we focus our effort on identifying manually the entries that will compose our lexicon.

Our method has several advantages. First, the use of a machine learning approach greatly reduces the lexicographic effort. Correa et al. (2017) and Picault and Renault (2017) have to analyze manually 7388 words and 7333 sentences, respectively. Since we let the algorithm filter out irrelevant terms, we only have to analyze 809 terms; in comparison, this is a reduction of nearly 90% on the time needed in the create our dictionary. On the other hand, Apel and Grimaldi (2012) created an ad hoc list of twenty-one nouns and adjectives to measure the sentiment of central bank announcements; however, the dictionary fails to predict the monetary stance of the ECB introductory statement.

Second, since supervised learning classifiers are simple to scale, the dictionary is easy to update. Each time Picault and Renault (2017) needs to update the dictionary with a recent announcement, it has to both analyze new sentences and recalculate the weight of the lexicon. Our method only requires adding new books to the algorithm and then analyze those novel terms that the model highlights.

Third, since the lexicon is from books of general monetary policy theory, the dictionary is independent of the monetary institution; moreover, we designed the dictionary ready for the creation of real-time indices.

Picault and Renault (2017) use the ECB introductory statements to create dictionaries that measure the stance of the monetary policy and the state of the Eurozone economy; when they use these dictionaries for real-time prediction, their predictive power is not significant to explain stock market volatility. By design, our method is robust to any look-ahead bias and can be used to different central bank announcements without further adjustments. Contrary to the assertion of Picault and Renault (2017), we show empirically that equal-weighted single word dictionaries are powerful tools to create meaningful quantitative indicators.

Our paper is organized as follows. In Section 4.2, we review the literature associated with textual analysis in the area of finance and central banks. In Section 4.3, we describe the data to train the classifier; the announcements to create the crisis index; and the macroeconomic variables and the US treasuries to perform the regressions. In Section 4.4, we explain the supervised machine learning model we use to create the dictionary and to measure the crisis sentiment. In Section 4.5, we describe the method and empirical findings. In Section, 4.6 we check if the crisis index conveys relevant information relative to different macroeconomic indicators and test alternative measures. Our paper concludes in Section 4.7.

4.2 Literature Review

Our work is related to the literature that studies central bank communications. We quantify the crisis sentiment of FOMC minutes and its prediction power on the interest rate level and volatility of the US treasuries.

On a general level, the following works use textual analysis to study the effect on asset prices. Tetlock (2007) uses Principal Component Analysis with the Harvard-IV dictionary to measure the effect of news media on stock markets; Loughran and McDonald (2011) use term frequency-inverse document frequency to create the financial dictionary; and Shapiro, Sudhof and Wilson (2017) combine different dictionaries to estimate how sentiment in news articles affect macroeconomic indicators.

Closer to our work is the research on textual analysis and central banking. Boukus and Rosenberg (2006) use latent Dirichlet allocation to assess the effect of the Fed communications on the market and Hansen, McMahon and Prat (2018) use the same statistical model to study how transparency affect deliberation within the FOMC. Apel and Grimaldi (2012), use bigrams of words to quantify the information of the Swedish Central Bank minutes to predict policy decisions; Lucca and Trebbi (2009) develop a method to estimate the economic stance of the FOMC statements and the effect on Treasury yields; Picault and Renault (2017) create weighted dictionaries to measure ECB communications and to predict futures bank's decisions. Shapiro and Wilson (2019) measure the sentiment of the Fed's policymakers with the Loughran and McDonald (2011) dictionary to estimate the bank's objective. Schmeling and Wagner (2019) also use the Loughran and McDonald (2011) dictionary to study the effect of the ECB press conferences on asset prices.

Related to our crisis dictionary is the financial stability dictionary created by Correa et al. (2017) used to extract the sentiment from the financial stability reports. The major differences with our work are i) we measure a different textual dimension; in economics, crisis and stability are not complementary antonyms; [1] ii) we build our dictionary with the aid of a machine learning approach, whereas Correa analyzes individually each word; and iii) crisis concerns the public, while financial stability interests policymakers.

4.3 Data

We develop a crisis sentiment index of the FOMC minutes from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019. To build the index, we develop a crisis dictionary with the aid of a machine learning classifier we trained with monetary policy or financial/economic crisis books. We list these books on Tables 17 and 18.

[1] For example, the word crisis does not convey sentiment in the financial stability report Correa et al. (2017).

Table 17 – **Books used for extracting the crisis features**

The table shows .

Author/Editor	Year	Title
Arestis, Philip; Sawyer, Malcolm	2012	The Euro Crisis
Barth, James R.; Trimbath, Susanne; Yago, Glenn; Barth, James R.; Yago, Glenn	2004	The Savings and Loan Crisis: Lessons from a Regulatory Failure
Botsiou, Konstantina E.	2011	The global economic crisis and the case of Greece
Celi, Giuseppe; Ginzburg, Andrea; Guarascio, Dario; Simonazzi, Annamaria	2017	Crisis in the European Monetary Union: A Core-Periphery Perspective
Claessens, Stijn; Kose, Ayhan; Laeven, Luc; Valencia, Fabian	2014	Financial Crises : Causes, Consequences, and Policy Responses
Han, Miao	2016	Central Bank Regulation and the Financial Crisis
Johnson, Simon; James, Kwak	2011	13 Bankers: The Wall Street Takeover and the Next Financial Meltdown
Karasavvoglou, Anastasios; Polychronidou, Persefoni	2014	Economic Crisis in Europe and the Balkans
Lo, Andrew W.	2012	Reading About the Financial Crisis: A Twenty-One-Book Review
Macdonald, Roderick	2018	Eurocritical
Moro, Beniamino; Beker, Victor A.	2016	Modern Financial Crises
Reinhart, Carmen M.; Rogoff, Kenneth S.	2009	This time is different: eight centuries of financial folly
Thomas, Lloyd B.	2013	The Financial Crisis and Federal Reserve Policy
UNCTAD	2009	The global economic crisis: systemic failures and multilateral remedies

Table 18 – **Books used for extracting the theory features**

The table shows .

Author/Editor	Year	Title
Bain, K.; Howells, P. G. A.	2003	Monetary economics: policy and its theoretical basis
Bofinger, Peter; Reischle, Julian; Schächter, Andrea	2001	Monetary policy: goals, institutions, strategies, and instruments
Fleming, Miles	1972	Monetary Theory
Friedman, Milton; Heller, Walter Wolfgang	1969	Monetary vs. fiscal policy
Fuhrer, Jeff; Kodrzycki, Yolanda K.; Little, Jane Sneddon; Olivei, Giovanni P.	2009	Understanding Inflation and the Implications for Monetary Policy: A Phillips Curve Retrospective
Hamori, Shigeyuki; Hamori, Naoko	2009	Introduction of the Euro and the Monetary Policy of the European Central Bank
Lucas, Jr., Robert E.	2012	Collected Papers on Monetary Theory:
Mercer, Jeffrey M.	2001	The Role of Monetary Policy in Investment Management
Taylor, Lester D.	2010	Capital, Accumulation, and Money
Walsh, Carl E.	2010	Monetary theory and policy
White, Lawrence H.	1999	The theory of monetary institutions
Woodford, Michael	2003	Interest and prices: foundations of a theory of monetary policy

We use the 1-, 2-, 3-, 5-, 7-, 10-, 20, and 30-year US treasury constant maturity rate – defined as DGS1, DGS2, DGS3, DGS5, DGS7, DGS10, DGS20, and DGS30 – for our empirical application, where we test our index and compare its predictability power with the Correa and the Harvard-IV dictionaries. The US treasury interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019.[2] Table 19 shows the descriptive statistics of the interest rates level and the 5-day volatility.

To control for the crisis effect on the interest rates and the volatility we consider macroeconomic variables as in Faust et al. (2007): consumer price index (CPI), output (GDP), housing starts (HS), initial job claims (IJC), non-farm payroll (NFP), consumer sentiment (CS), retail sales (RS), international trade balance (IT), and unemployment rate (UR). The data is from the repository of the Archival Federal Reserve of Economic Data (ALFRED St. Louis) and is vintage. The data from the CPI, DP, HS, IJC, NFP, CS, RS, IT, and UR is from April 27, 2000 to December 20, 2019. In the regressions, we standardize the macroeconomic indicators.

To identify the terminology that central banks employ, we use announcements of the Fed and the ECB. From the Fed, we consider the terms in the speeches given, during their presidency, by Greenspan and Bernanke (until December 2011); the statements from March 28, 2006 and May 1, 2019; and the minutes used to create the index. From the ECB, we gather the terms in the introductory statements and the questions and answers sessions from March 28, 2006 to May 1, 2019.

4.4 The Crisis dictionary and the Index

We aim to create a dictionary to measure the level of crisis in central bank communications. To reduce lexicographic effort, we train a regularized logistic regression classifier with books of monetary policy that belong to two categories: general theory or economic/financial crisis. We only consider those terms the classifier highlights as an economic/financial crisis.

[2]The 30-year Treasury constant maturity series was discontinued on February 18, 2002, and reintroduced on February 9, 2006.

Table 19 – **FOMC Minutes, Interest Rates and Volatility**

This table contains descriptive statistics for the sample of future rates with constant maturities. The data is from March 8 to April 4, 2019 for The US treasury interest rates up to 20 years and is February 10, 2006 to April 18, 2019 for the 30-year interest rate. Units are expressed in basic points.

Panel A: FOMC Minutes		
	Number	Mean Number of Words
FOMC Minutes	122	4313.93 (1364.40)

Panel B: Interest Rates						
	Min	Max	Mean	Std	Skew	Kurt
DGS1	0.08	5.30	1.53	1.63	1.00	-0.34
DGS2	0.16	5.29	1.75	1.52	0.89	-0.55
DGS3	0.28	5.26	1.97	1.41	0.80	-0.62
DGS5	0.56	5.23	2.41	1.24	0.61	-0.75
DGS7	0.91	5.23	2.76	1.11	0.46	-0.88
DGS10	1.37	5.26	3.10	1.02	0.34	-1.12
DGS20	1.69	5.61	3.63	1.00	0.13	-1.39
DGS30	2.11	5.35	3.62	0.81	0.34	-1.23

Panel C: Volatility						
	Min	Max	Mean	Std	Skew	Kurt
$\sigma(DGS1)$	0.00	30.10	2.39	2.61	3.76	20.01
$\sigma(DGS2)$	0.00	29.70	3.72	2.79	2.72	12.11
$\sigma(DGS3)$	0.45	28.51	4.26	2.78	2.42	10.38
$\sigma(DGS5)$	0.63	24.47	4.96	2.76	1.91	6.03
$\sigma(DGS7)$	0.45	24.41	5.15	2.69	1.84	5.98
$\sigma(DGS10)$	0.89	23.69	4.93	2.50	1.87	6.61
$\sigma(DGS20)$	0.45	17.21	4.82	2.33	1.52	3.64
$\sigma(DGS30)$	0.63	18.29	4.77	2.40	1.54	3.61

Before training the classifier, we pre-process the books in two steps. First, to identify the terminology that central banks employ, we collect announcements from the Fed and the ECB. From the Fed, we gather speeches, statements, and minutes and, from the ECB, the introductory statements and the questions and answers sessions. Once we compile all the announcements, we stem each term with the Porter algorithm and discard those terms with less than three characters. From this process, we get 13473 unique terms. In the next step, we use this list to pre-process the books.

Second, we pre-process the books that will be part of the training sample. Tables 17 and 18 show the twenty-six books of monetary policy we use to train the classifier; we label fourteen books as economic crisis and twelve books as general theory. To each word in the books, we apply the Porter stemmer. Then, we remove the terms that are not listed in the central bank terminology (from step one); are listed as country, city, or stopwords; or whose frequency is lower than 12.[3] Finally, we tokenize the remaining content of each book into sentences. These sentences, classified as economic crisis or general theory, is our training sample.

From this process, we obtain 49101 sentences from the crisis books, and 54030 sentences from the general theory books, and 7392 unique terms.

4.4.1 The Classifier

The framework of the logistic regression classifier is the standard bag-of-features. Let $\{t_1, t_2, .., t_p\}$ the predefined set of terms that can appear in any the sentences. Let $I_j(s_i)$ an indicator function that takes the value 1 when term j appears in sentence i and 0 otherwise. Then, each sentence s_i is represented by a vector $\mathbf{v}_i = (I_1(s_i), I_2(s_i), .., I_p(s_i))$.

In the binary logistic regression, the probability that the i-th sentence s_i belongs to the class $c_i \in \{-1, 1\} = \{crisis,\ monetary\ policy\}$ is:

$$P(c_i|\mathbf{s}_i) = \frac{1}{1 + e^{-c_i(\beta_0 + \boldsymbol{\beta}^T \mathbf{v}_i)}}. \tag{4.1}$$

In order to estimate the vector of parameters $\boldsymbol{\beta}$, we use the model known as the elastic net. The elatic-net linearly combines the L_1 and L_2 penalties of respectively the lasso and ridge regression. The elastic-net estimate is defined by

$$\begin{aligned} \hat{\beta} \ =& \underset{\beta}{\text{argmax}} \sum_{i=1}^{n} \log \frac{1}{1 + e^{-c_i(\beta_0 + \boldsymbol{\beta}^T \mathbf{v}_i)}} \\ & \text{subject to } \Big(\alpha \sum_{j=1}^{p} |\beta_j| + (1-\alpha) \sum_{j=1}^{p} \beta_j^2\Big) \leq \lambda, \end{aligned} \tag{4.2}$$

[3] The list of countries is from the Encyclopædia Britannica. The list of cities (with a population larger than 5000) is from GeoNames. The list of stop words is from the NLTK python library.

where the first equation is the log-likelihood of the logistic regression with n sentences. The second equation is the elastic-net regularization. The free parameters λ and α control the amount of regularization and the combination of L_1 and L_2 penalties, respectively. The first term of the regularization forces a sparse solution; one drawback of the lasso regularization is that, when there are strong correlations among terms, it arbitrarily selects which covariates to include in the model. The second term of the regularization solves this problem by encouraging highly correlated features to be averaged.

We start by finding the the optimal value of λ for the lasso regularization with the Bayesian information criterion (BIC):

$$\text{BIC} = -2\ LL_\lambda + k \log n, \tag{4.3}$$

where LL_λ is the likelihood of the logistic regression model, corresponding to a specific λ, with k non zero parameters. To use the BIC for model selection, we only have to choose the model giving the smallest BIC over the set of models considered.

Then, we define the parameters of the elastic-net regularization. To ensure the L_2 regularization is strong enough to prevent the exclusion of mildly correlated terms by the L_1 penalization, we set $\alpha = 0.05$. To preserve the weight of the L_1 regularization, we set $\lambda = \alpha \cdot \lambda^*$, where λ^* is the value of λ with the smallest BIC via cross validation. Once we train the logistic regression with the elastic-net regularization, we reduce the word space we need to analyze manually from 7392 unique terms to 809.

4.4.2 The Index

Once we identify which of the 809 terms will form the crisis dictionary, we obtain the crisis sentiment of a document d as follows:

$$crisis(d) = \frac{\sum\limits_{t \in CD} f(t,d)}{\sum\limits_{t} f(t,d)}, \tag{4.4}$$

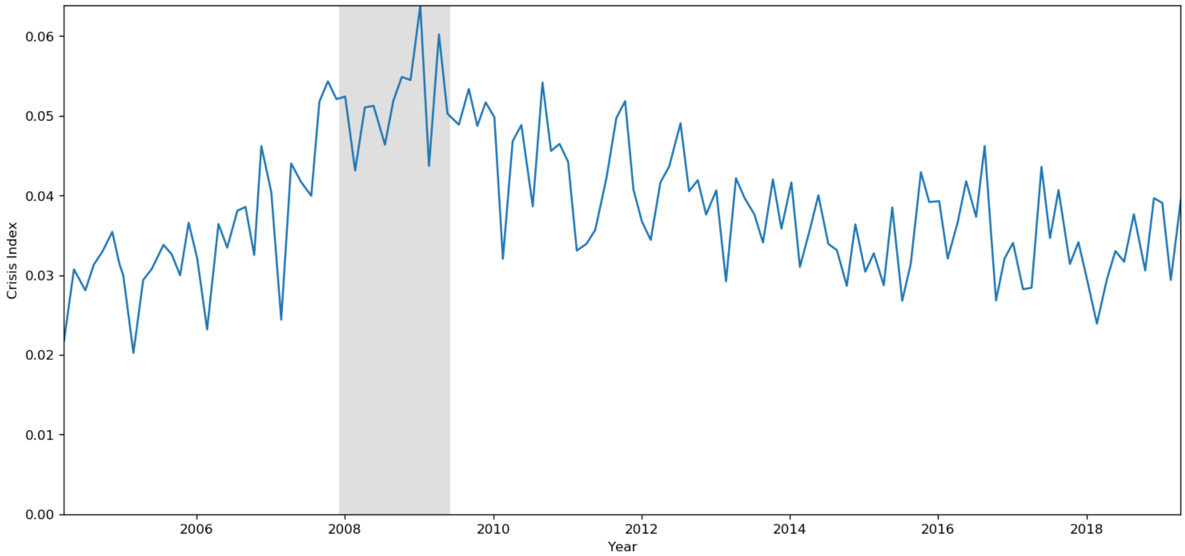


Figure 6 – **Index of Economic/Financial Crisis Index.**
The crisis index is constructed by measuring the percentage of words belonging to the crisis dictionary words. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019. Gray area corresponds to US business cycle contraction from the NBER's Business Cycle Dating Committee.

where $f(t, d)$ is the frequency of term t in document d and CD is the set of terms of the crisis dictionary. Figure 6 shows the time series of the crisis index for the FOMC minutes and Figure 2 shows the most relevant terms in the index.

To facilitate comparison, we standardize the indices created with the crisis, the finacial stability, and the Harvard-IV dictionaries.

4.5 Methodology

To explain the effect that the crisis sentiment of FOMC minutes has on the US treasury interest rates returns for the 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-year maturities, we use the following equation:

$$\Delta R_t^y = \alpha + \beta \ \Delta Crisis_t, \tag{4.5}$$

Figure 7 – **Relative importance of words.**
The word cloud is generated by estimating the relative importance of the words within the set of Federal Reserve minutes. A larger word has more relevance in the estimation of the index value for the minute. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019.

where ΔR_t^y represents the interest rate difference between the day the announcement is released and the previous day for maturity y; $\Delta crisis_t$ represents the crisis measure difference between the FOMC minute release in day t and the previous one.

To study the effect the crisis sentiment has on the volatility, we use the following model:

$$VOL_t^y = \alpha_1 + \alpha_2 \ Release_t + \alpha_3 \ VOL_{t-5}^y + \beta \ Crisis_t, \tag{4.6}$$

where $VOL_t^y = \sqrt{\frac{1}{5}\sum_{i=0}^{4} {R_{t+i}^y}^2}$ represents the interest rate variation in a time window of five working days, and $crisis_t$ is the crisis measure of the FOMC minute release in day t. The dummy variable $Release_t$ takes the value of one when the announcement is released and zero otherwise.

Table 20 – **Federal Reserve FOMC Minutes Crisis Index and Interest Rate**

This table shows the regressions from Equation (4.5). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. Each regression is performed with the FOMC minutes crisis index. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	DGS1	DGS2	DGS3	DGS5	DGS7	DGS10	DGS20	DGS30
const	-0.25	-0.09	0.16	0.24	0.31	0.56	0.74	0.78
	(0.33)	(0.40)	(0.46)	(0.51)	(0.50)	(0.46)	(0.45)	(0.48)
crisis	-0.30	-0.91**	-0.88*	-1.37**	-1.35***	-1.09**	-0.77*	-0.73
	(0.34)	(0.43)	(0.49)	(0.56)	(0.52)	(0.47)	(0.44)	(0.45)
$Adj.R^2$	-0.0028	0.0250	0.0162	0.0387	0.0390	0.0285	0.0108	0.0096
n	121	121	121	121	121	121	121	106

Table 20 shows that the content of the FOMC minutes affects the interest rate level of the US treasuries. The index shows that an increment (decline) in the crisis sentiment predicts a reduction (increase) of the interest rate level for all the maturities. The prediction is statistically significant at the 1% level for the 7-year treasury and at the 5% level for the 2-, 5-, and 10-year treasuries. These results are in line with the announcement both expressing economy slowdown concerns and signaling the market to expect a lower interest rate; the US does not experience double-digit inflation since the early 1980s, so, as expected, the crisis sentiment does not signal a higher future interest rate.

Table 21 – **Federal Reserve FOMC Minutes Crisis Index and Volatility**

This table shows the regressions from Equation (4.6). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. Each regression is performed with the FOMC minutes crisis index. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	σ_{DGS1}	σ_{DGS2}	σ_{DGS3}	σ_{DGS5}	σ_{DGS7}	σ_{DGS10}	σ_{DGS20}	σ_{DGS30}
const	0.73***	1.42***	1.71***	2.24***	2.59***	2.61***	2.61***	2.98***
	(0.05)	(0.08)	(0.09)	(0.09)	(0.10)	(0.10)	(0.08)	(0.20)
Release	0.12	0.03	-0.01	0.04	-0.01	-0.05	-0.08	-0.19
	(0.15)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.17)	(0.17)
Vol_{-5}	0.69***	0.62***	0.60***	0.55***	0.50***	0.47***	0.46***	0.37***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
crisis	0.05	0.02	0.06	0.36	0.55**	0.68**	0.59**	0.63**
	(0.16)	(0.23)	(0.23)	(0.22)	(0.25)	(0.28)	(0.25)	(0.30)
$Adj.R^2$	0.4782	0.3809	0.3583	0.3012	0.2496	0.2262	0.2148	0.1825
n	3785	3785	3785	3785	3785	3785	3785	3301

Table 21 shows the effect of the crisis index on volatility. We observe the crisis index has a statistically significant effect on longer maturities. An increment (decline) in the crisis sentiment, predicts a increase (reduction) of the volatility. The effect is statistically significant for the 7-, 10-, 20-, and 30-year treasuries. As expected, an increment in the crisis sentiment signals concerns about the economic outlook and increase in the volatility of markets.

4.6 Robustness tests

We test if our index provides relevant information to the market when we add relevant macroeconomic information to the model. We also compare the predictability power of our index with indices created with the Correa, the Harvard-IV, and the Loughran-MacDonald dictionaries.

4.6.1 Macroeconomic Information

To test whether the crisis index provides extra information to the market, we regress Equations (4.5) and (4.6) with macroeconomic information available when the minute is released. If all the relevant information is transmitted by the macroeconomic indicators, then the index should be statistically insignificant. The following equation is an extension of Equation (4.5), and we use it to test the significance of the crisis index to predict the interest rate:

$$\begin{aligned} \Delta R_t^y = \; & \alpha + \beta_1 \; \Delta Crisis_t + \beta_2 \; \Delta CPI_t + \beta_3 \; \Delta GDP_t + \beta_4 \; \Delta HS_t + \beta_5 \; \Delta IJC_t + \\ & \beta_6 \; \Delta NFP_t + \beta_7 \; \Delta CS_t + \beta_8 \; \Delta RS_t + \beta_9 \; \Delta IT_t + \beta_{10} \; \Delta UR_t, \end{aligned} \quad (4.7)$$

where each macroeconomic indicator ΔCPI_t, ΔGDP_t, ΔHS_t, ΔIJC_t, ΔNFP_t, ΔCS_t, ΔRS_t, ΔIT_t, and ΔUR_t is the difference between the value known when the minute is release and the previous one.

To test the significance of the crisis index to predict volatility we also extend Equation (4.6). Then, the equation of the volatility with the macroeconomic variables is:

$$\begin{aligned} VOL_t^y = \; & \alpha_1 + \alpha_2 \; Release_t + \alpha_3 \; VOL_{t-5}^y + \beta_1 \; Crisis_t + \beta_2 \; |\Delta CPI_t| + \beta_3 \; |\Delta GDP_t| + \beta_4 \; |\Delta HS \\ & \beta_5 \; |\Delta IJC_t| + \beta_6 \; |\Delta NFP_t| + \beta_7 \; |\Delta CS + \beta_8 |\Delta RS_t| + \beta_9 \; |\Delta IT_t| + \beta_{10} \; |\Delta UR_t|, \end{aligned}$$

where each macroeconomic indicator $|\Delta CPI_t|$, $|\Delta GDP_t|$, $|\Delta HS_t|$, $|\Delta IJC_t|$, $|\Delta NFP_t|$, $|\Delta CS_t|$, $|\Delta RS_t|$, $|\Delta IT_t|$, and $|\Delta UR_t|$ is the absolute value of difference between the value known when the minute is release and the previous one.

Table 22 to 29 show the effect of the crisis index onthe interest rates of the 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-year treasuries. From the tables, Column 10 shows the crisis index is significant at the 10% confidence for the 5-, 7-, and 10-year treasuries even even when we added macroeconomic information.

Tables 30 to 37 show the effect of the crisis index on the volatility of the 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-year treasuries. Column 12 shows the regression when we added all the macroeconomic indices. The crisis index remain significant at the 1-% level for the 7-, 10-, and 20-year treasuries.

Table 22 – **Federal Reserve FOMC Minutes Crisis Index and 1-Year Interest Rate ($DGS1$)**

This table shows the regressions from Equation (4.6.1) of the 1-Year treasury constant maturity interest rate 1-day change ($DGS1_t - DGS1_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS1$ are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	-0.25	-0.26	-0.29	-0.32	-0.32	-0.31	-0.31	-0.32	-0.32	-0.33
	(0.33)	(0.32)	(0.33)	(0.32)	(0.32)	(0.32)	(0.31)	(0.31)	(0.31)	(0.31)
FOMC Minutes										
crisis	-0.30	-0.24	-0.19	-0.12	-0.10	-0.10	-0.16	-0.15	-0.14	-0.14
	(0.34)	(0.35)	(0.33)	(0.33)	(0.33)	(0.33)	(0.35)	(0.34)	(0.35)	(0.35)
Economic Announcements										
Prices and Output										
CPI		0.46	0.48	0.44	0.44	0.45	0.44	0.41	0.41	0.41
		(0.36)	(0.36)	(0.34)	(0.34)	(0.34)	(0.34)	(0.32)	(0.32)	(0.31)
GDP			-0.64	-0.70	-0.71	-0.72	-0.73	-0.72	-0.73	-0.73
			(0.72)	(0.72)	(0.71)	(0.71)	(0.69)	(0.69)	(0.69)	(0.69)
Housing activity, Labor Market, Expectations and Trade										
HS				0.71***	0.71***	0.72***	0.70***	0.66***	0.70***	0.72***
				(0.23)	(0.23)	(0.23)	(0.24)	(0.23)	(0.24)	(0.24)
IJC					0.16	0.16	0.17	0.17	0.11	0.10
					(0.21)	(0.21)	(0.21)	(0.20)	(0.21)	(0.20)
NFP						0.09	0.07	0.05	0.05	0.03
						(0.24)	(0.25)	(0.24)	(0.24)	(0.24)
CS							0.49	0.52	0.50	0.56
							(0.39)	(0.39)	(0.40)	(0.39)
RS								0.28	0.27	0.27
								(0.28)	(0.29)	(0.28)
IT									0.23	0.20
									(0.23)	(0.24)
UR										-0.30
										(0.25)
$Adj.R^2$	-0.0028	0.0062	0.0170	0.0495	0.0429	0.0351	0.0436	0.0409	0.0366	0.0334
n	121	121	121	121	121	121	121	121	121	121

Table 23 – **Federal Reserve FOMC Minutes Crisis Index and 2-Year Interest Rate ($DGS2$)**

This table shows the regressions from Equation (4.6.1) of the 2-Year treasury constant maturity interest rate 1-day change ($DGS2_t - DGS2_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates (DGS1) are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	-0.09	-0.10	-0.10	-0.13	-0.12	-0.11	-0.10	-0.13	-0.13	-0.16
	(0.40)	(0.40)	(0.40)	(0.39)	(0.39)	(0.39)	(0.38)	(0.38)	(0.38)	(0.37)
FOMC Minutes										
crisis	-0.91**	-0.87**	-0.88**	-0.78*	-0.73*	-0.72*	-0.77*	-0.75*	-0.74*	-0.75*
	(0.43)	(0.44)	(0.44)	(0.43)	(0.44)	(0.44)	(0.45)	(0.43)	(0.44)	(0.44)
Economic Announcements										
Prices and Output										
CPI		0.27	0.27	0.22	0.22	0.25	0.24	0.19	0.20	0.19
		(0.36)	(0.36)	(0.34)	(0.34)	(0.34)	(0.34)	(0.33)	(0.32)	(0.31)
GDP			0.04	-0.03	-0.07	-0.09	-0.09	-0.08	-0.10	-0.10
			(0.72)	(0.72)	(0.72)	(0.72)	(0.71)	(0.69)	(0.69)	(0.70)
Housing activity, Labor Market, Expectations and Trade										
HS				0.85**	0.87**	0.88**	0.86**	0.79**	0.87**	0.92**
				(0.37)	(0.37)	(0.36)	(0.36)	(0.37)	(0.36)	(0.37)
IJC					0.44	0.43	0.44	0.44	0.32	0.31
					(0.38)	(0.39)	(0.39)	(0.38)	(0.37)	(0.35)
NFP						0.27	0.26	0.21	0.22	0.18
						(0.33)	(0.34)	(0.34)	(0.33)	(0.33)
CS							0.40	0.44	0.41	0.54
							(0.45)	(0.45)	(0.44)	(0.44)
RS								0.53	0.51	0.50
								(0.36)	(0.38)	(0.36)
IT									0.46	0.40
									(0.37)	(0.36)
UR										-0.61*
										(0.37)
$Adj.R^2$	0.0250	0.0208	0.0125	0.0431	0.0433	0.0387	0.0376	0.0425	0.0457	0.0525
n	121	121	121	121	121	121	121	121	121	121

Table 24 – **Federal Reserve FOMC Minutes Crisis Index and 3-Year Interest Rate ($DGS3$)**

This table shows the regressions from Equation (4.6.1) of the 3-Year treasury constant maturity interest rate 1-day change ($DGS3_t - DGS3_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates (DGS1) are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.16	0.15	0.17	0.12	0.12	0.13	0.14	0.11	0.09	0.07
	(0.46)	(0.46)	(0.46)	(0.44)	(0.44)	(0.44)	(0.44)	(0.44)	(0.43)	(0.43)
FOMC minutes										
crisis	-0.87*	-0.82	-0.84*	-0.70	-0.66	-0.65	-0.71	-0.68	-0.67	-0.67
	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.52)	(0.50)	(0.51)	(0.52)
Economic Announcements										
Prices and Output										
CPI		0.40	0.39	0.31	0.30	0.32	0.31	0.26	0.26	0.25
		(0.43)	(0.44)	(0.40)	(0.40)	(0.41)	(0.41)	(0.39)	(0.38)	(0.37)
GDP			0.32	0.22	0.17	0.17	0.16	0.17	0.14	0.14
			(0.77)	(0.77)	(0.76)	(0.77)	(0.76)	(0.75)	(0.76)	(0.77)
Housing activity, Labor Market, Expectations and Trade										
HS				1.34***	1.35***	1.36***	1.35***	1.26***	1.40***	1.45***
				(0.39)	(0.39)	(0.39)	(0.39)	(0.40)	(0.40)	(0.40)
IJC					0.40	0.40	0.41	0.40	0.20	0.19
					(0.38)	(0.38)	(0.38)	(0.38)	(0.37)	(0.36)
NFP						0.16	0.15	0.09	0.11	0.06
						(0.40)	(0.41)	(0.41)	(0.39)	(0.39)
CS							0.41	0.46	0.41	0.53
							(0.55)	(0.54)	(0.52)	(0.53)
RS								0.62	0.59	0.58
								(0.39)	(0.42)	(0.41)
IT									0.79*	0.74*
									(0.43)	(0.43)
UR										-0.59
										(0.43)
$Adj.R^2$	0.0153	0.0138	0.0079	0.0760	0.0736	0.0665	0.0645	0.0709	0.0901	0.0935
n	121	121	121	121	121	121	121	121	121	121

Table 25 – **Federal Reserve FOMC Minutes Crisis Index and 5-Year Interest Rate ($DGS5$)**

This table shows the regressions from Equation (4.6.1) of the 5-Year treasury constant maturity interest rate 1-day change ($DGS5_t - DGS5_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates (DGS1) are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.16	0.15	0.17	0.12	0.12	0.13	0.14	0.11	0.09	0.07
	(0.46)	(0.45)	(0.45)	(0.43)	(0.43)	(0.43)	(0.43)	(0.42)	(0.41)	(0.41)
FOMC Minutes										
crisis	-1.37**	-1.30**	-1.33**	-1.17**	-1.14**	-1.14**	-1.19**	-1.15**	-1.14**	-1.15**
	(0.56)	(0.57)	(0.56)	(0.55)	(0.56)	(0.55)	(0.56)	(0.53)	(0.54)	(0.55)
Economic Announcements										
Prices and Output										
CPI		0.50	0.48	0.39	0.39	0.39	0.38	0.31	0.31	0.30
		(0.59)	(0.60)	(0.55)	(0.55)	(0.56)	(0.57)	(0.51)	(0.50)	(0.48)
GDP			0.56	0.44	0.41	0.41	0.40	0.42	0.39	0.40
			(0.79)	(0.78)	(0.76)	(0.76)	(0.76)	(0.74)	(0.75)	(0.75)
Housing activity, Labor Market, Expectations and Trade										
HS				1.57***	1.58***	1.58***	1.56***	1.45***	1.57***	1.63***
				(0.41)	(0.41)	(0.41)	(0.41)	(0.40)	(0.42)	(0.42)
IJC					0.24	0.24	0.25	0.24	0.06	0.05
					(0.43)	(0.43)	(0.42)	(0.41)	(0.41)	(0.40)
NFP						0.01	-0.00	-0.07	-0.06	-0.11
						(0.43)	(0.44)	(0.43)	(0.42)	(0.41)
CS							0.40	0.47	0.42	0.57
							(0.58)	(0.55)	(0.54)	(0.53)
RS								0.81*	0.78	0.77
								(0.47)	(0.49)	(0.47)
IT									0.69	0.62
									(0.45)	(0.44)
UR										-0.72
										(0.46)
$Adj.R^2$	0.0387	0.0390	0.0369	0.1120	0.1058	0.0980	0.0947	0.1067	0.1150	0.1206
n	121	121	121	121	121	121	121	121	121	121

Table 26 – **Federal Reserve FOMC Minutes Crisis Index and 7-Year Interest Rate ($DGS7$)**

This table shows the regressions from Equation (4.6.1) of the 7-Year treasury constant maturity interest rate 1-day change ($DGS7_t - DGS7_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS7$ are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.31	0.30	0.32	0.26	0.26	0.26	0.26	0.23	0.21	0.19
	(0.50)	(0.50)	(0.50)	(0.47)	(0.47)	(0.47)	(0.47)	(0.47)	(0.46)	(0.46)
FOMC Minutes										
crisis	-1.35***	-1.28**	-1.31**	-1.14**	-1.14**	-1.14**	-1.20**	-1.16**	-1.15**	-1.16**
	(0.52)	(0.52)	(0.52)	(0.51)	(0.51)	(0.52)	(0.52)	(0.49)	(0.51)	(0.51)
Economic Announcements										
Prices and Output										
CPI		0.51	0.50	0.40	0.40	0.39	0.38	0.31	0.31	0.30
		(0.62)	(0.63)	(0.58)	(0.58)	(0.59)	(0.60)	(0.54)	(0.53)	(0.51)
GDP			0.48	0.35	0.34	0.35	0.34	0.36	0.33	0.34
			(0.72)	(0.71)	(0.70)	(0.70)	(0.69)	(0.67)	(0.68)	(0.68)
Housing activity, Labor Market, Expectations and Trade										
HS				1.59***	1.59***	1.58***	1.56***	1.45***	1.55***	1.60***
				(0.40)	(0.40)	(0.40)	(0.39)	(0.39)	(0.40)	(0.41)
IJC					0.06	0.06	0.07	0.07	-0.08	-0.09
					(0.42)	(0.42)	(0.41)	(0.41)	(0.42)	(0.42)
NFP						-0.11	-0.13	-0.20	-0.19	-0.24
						(0.42)	(0.43)	(0.42)	(0.41)	(0.40)
CS							0.47	0.54	0.50	0.63
							(0.57)	(0.54)	(0.53)	(0.53)
RS								0.85*	0.82*	0.81*
								(0.44)	(0.45)	(0.43)
IT									0.58	0.52
									(0.44)	(0.43)
UR										-0.61
										(0.46)
$Adj.R^2$	0.0390	0.0399	0.0363	0.1158	0.1082	0.1008	0.0995	0.1139	0.1180	0.1201
n	121	121	121	121	121	121	121	121	121	121

Table 27 – **Federal Reserve FOMC Minutes Crisis Index and 10-Year Interest Rate ($DGS10$)**

This table shows the regressions from Equation (4.6.1) of the 10-Year treasury constant maturity interest rate 1-day change ($DGS10_t - DGS10_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS10$ are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.56	0.54	0.57	0.52	0.52	0.51	0.51	0.48	0.47	0.44
	(0.46)	(0.46)	(0.46)	(0.44)	(0.44)	(0.44)	(0.44)	(0.44)	(0.44)	(0.43)
FOMC Minutes										
crisis	-1.09**	-1.03**	-1.06**	-0.92**	-0.92**	-0.93**	-0.98**	-0.94**	-0.93**	-0.94**
	(0.47)	(0.47)	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)	(0.44)	(0.45)	(0.45)
Economic Announcements										
Prices and Output										
CPI		0.46	0.45	0.37	0.37	0.35	0.34	0.27	0.28	0.27
		(0.63)	(0.64)	(0.59)	(0.59)	(0.61)	(0.62)	(0.56)	(0.56)	(0.53)
GDP			0.51	0.40	0.41	0.42	0.41	0.42	0.41	0.41
			(0.59)	(0.59)	(0.58)	(0.58)	(0.57)	(0.55)	(0.56)	(0.56)
Housing activity, Labor Market, Expectations and Trade										
HS				1.36***	1.36***	1.35***	1.33***	1.23***	1.31***	1.38***
				(0.36)	(0.35)	(0.36)	(0.35)	(0.35)	(0.36)	(0.37)
IJC					-0.04	-0.04	-0.03	-0.03	-0.16	-0.17
					(0.41)	(0.41)	(0.40)	(0.40)	(0.42)	(0.41)
NFP						-0.19	-0.20	-0.27	-0.26	-0.32
						(0.42)	(0.42)	(0.42)	(0.41)	(0.38)
CS							0.35	0.41	0.38	0.54
							(0.52)	(0.50)	(0.49)	(0.48)
RS								0.76*	0.74*	0.73*
								(0.43)	(0.44)	(0.42)
IT									0.46	0.39
									(0.38)	(0.37)
UR										-0.79*
										(0.45)
$Adj.R^2$	0.0285	0.0292	0.0272	0.0955	0.0877	0.0812	0.0774	0.0907	0.0917	0.1034
n	121	121	121	121	121	121	121	121	121	121

Table 28 – **Federal Reserve FOMC Minutes Crisis Index and 20-Year Interest Rate ($DGS20$)**

This table shows the regressions from Equation (4.6.1) of the 20-Year treasury constant maturity interest rate 1-day change ($DGS20_t - DGS20_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS20$ are from March 08, 2004 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.74	0.72	0.76*	0.72*	0.72*	0.70	0.71	0.67	0.66	0.64
	(0.45)	(0.45)	(0.45)	(0.43)	(0.43)	(0.43)	(0.43)	(0.43)	(0.43)	(0.42)
FOMC Minutes										
crisis	-0.77*	-0.68	-0.73*	-0.60	-0.60	-0.61	-0.64	-0.61	-0.60	-0.60
	(0.44)	(0.44)	(0.43)	(0.44)	(0.44)	(0.44)	(0.43)	(0.43)	(0.43)	(0.43)
Economic Announcements										
Prices and Output										
CPI		0.60	0.58	0.51	0.51	0.47	0.47	0.40	0.41	0.40
		(0.62)	(0.64)	(0.60)	(0.60)	(0.62)	(0.62)	(0.57)	(0.57)	(0.55)
GDP			0.66	0.57	0.57	0.58	0.57	0.58	0.57	0.57
			(0.51)	(0.52)	(0.52)	(0.52)	(0.51)	(0.49)	(0.50)	(0.50)
Housing activity, Labor Market, Expectations and Trade										
HS				1.22***	1.22***	1.20***	1.19***	1.09***	1.16***	1.22***
				(0.35)	(0.35)	(0.34)	(0.34)	(0.33)	(0.34)	(0.35)
IJC					0.01	0.01	0.01	0.01	-0.10	-0.11
					(0.40)	(0.40)	(0.39)	(0.38)	(0.40)	(0.39)
NFP						-0.26	-0.27	-0.33	-0.33	-0.37
						(0.42)	(0.43)	(0.42)	(0.41)	(0.39)
CS							0.27	0.33	0.31	0.43
							(0.49)	(0.47)	(0.47)	(0.46)
RS								0.74*	0.72*	0.71*
								(0.43)	(0.43)	(0.41)
IT									0.43	0.37
									(0.37)	(0.36)
UR										-0.62
										(0.46)
$Adj.R^2$	0.0108	0.0181	0.0208	0.0775	0.0695	0.0642	0.0588	0.0720	0.0721	0.0767
n	121	121	121	121	121	121	121	121	121	121

Table 29 – **Federal Reserve FOMC Minutes Crisis Index and 30-Year Interest Rate ($DGS30$)**

This table shows the regressions from Equation (4.6.1) of the 30-Year treasury constant maturity interest rate 1-day change ($DGS30_t - DGS30_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS30$ are from February 21, 2006 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
const	0.78	0.82*	0.85*	0.82*	0.81*	0.81*	0.84*	0.87*	0.87*	0.84*
	(0.48)	(0.47)	(0.47)	(0.46)	(0.46)	(0.46)	(0.47)	(0.47)	(0.46)	(0.46)
FOMC Minutes										
crisis	-0.73	-0.64	-0.68	-0.62	-0.60	-0.61	-0.64	-0.58	-0.58	-0.58
	(0.45)	(0.46)	(0.46)	(0.46)	(0.45)	(0.46)	(0.45)	(0.45)	(0.45)	(0.46)
Economic Announcements										
Prices and Output										
CPI		0.75	0.75	0.73	0.73	0.74	0.76	0.70	0.72	0.71
		(0.87)	(0.88)	(0.85)	(0.85)	(0.86)	(0.85)	(0.78)	(0.78)	(0.74)
GDP			0.50	0.44	0.41	0.42	0.40	0.44	0.41	0.46
			(0.53)	(0.56)	(0.55)	(0.55)	(0.54)	(0.52)	(0.54)	(0.54)
Housing activity, Labor Market, Expectations and Trade										
HS				0.93**	0.94**	0.93**	0.92**	0.81**	0.91**	0.99**
				(0.42)	(0.42)	(0.43)	(0.42)	(0.41)	(0.44)	(0.44)
IJC					0.20	0.20	0.19	0.14	0.04	0.02
					(0.43)	(0.42)	(0.42)	(0.42)	(0.45)	(0.44)
NFP						-0.21	-0.23	-0.30	-0.25	-0.25
						(0.53)	(0.53)	(0.53)	(0.50)	(0.48)
CS							0.33	0.46	0.41	0.59
							(0.58)	(0.55)	(0.55)	(0.56)
RS								0.72	0.68	0.66
								(0.48)	(0.47)	(0.44)
IT									0.45	0.37
									(0.40)	(0.39)
UR										-0.81
										(0.51)
$Adj.R^2$	0.0096	0.0209	0.0174	0.0335	0.0252	0.0170	0.0110	0.0198	0.0191	0.0333
n	106	106	106	106	106	106	106	106	106	106

Table 30 – **Federal Reserve FOMC Minutes Crisis Index and 1-Year Interest Rate Volatility (σ_{DGS1})**

This table shows the regressions from Equation (4.8) of the 1-Year treasury constant maturity interest rate volatility (σ_{DGS1}) of the next 5-days after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS1$ used for the volatility calculations σ_{DGS1} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	2.39***	0.73***	0.73***	0.77***	0.54***	0.53***	0.57***	0.55***	0.45***	0.42***	0.43***	0.45***
	(0.04)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.08)	(0.09)	(0.10)	(0.11)
Release	0.05	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	(0.23)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Vol_{-5}		0.69***	0.69***	0.69***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***
		(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
FOMC Minutes												
crisis			0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.04	0.05	0.05
			(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
Economic Announcements												
Prices and Output												
CPI				-0.05	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
				(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
GDP					0.52***	0.52***	0.53***	0.53***	0.53***	0.52***	0.53***	0.53***
					(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Housing activity, Labor Market, Expectations and Trade												
HS						0.02	0.02	0.01	0.02	0.01	0.01	0.01
						(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
IJC							-0.08**	-0.08**	-0.09**	-0.10**	-0.09**	-0.09**
							(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
NFP								0.03	0.02	0.02	0.02	0.02
								(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
CS									0.16**	0.16**	0.16**	0.16**
									(0.07)	(0.06)	(0.06)	(0.06)
RS										0.06	0.06	0.06
										(0.05)	(0.04)	(0.05)
IT											-0.01	-0.01
											(0.05)	(0.05)
UR												-0.02
												(0.05)
$Adj.R^2$	-0.0003	0.4783	0.4782	0.4782	0.4878	0.4877	0.4879	0.4878	0.4889	0.4890	0.4889	0.4888
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 31 – **Federal Reserve FOMC Minutes Crisis Index and 2-Year Interest Rate Volatility (σ_{DGS2})**

This table shows the regressions of the 2-Year treasury constant maturity rate volatility (σ_{DGS2}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS2$ used for the volatility calculations σ_{DGS2} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	3.72***	1.42***	1.42***	1.41***	1.16***	1.14***	1.11***	1.01***	0.98***	0.93***	0.88***	0.86***
	(0.05)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)	(0.09)	(0.10)	(0.11)	(0.11)	(0.12)	(0.13)
Release	-0.03	0.03	0.03	0.03	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.24)	(0.20)	(0.20)	(0.20)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Vol_{-5}		0.62***	0.62***	0.62***	0.58***	0.58***	0.58***	0.58***	0.58***	0.57***	0.57***	0.57***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.05	0.04	0.04
			(0.23)	(0.23)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)
Economic Announcements												
Prices and Output												
CPI				0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.02
				(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
GDP					0.67***	0.67***	0.67***	0.67***	0.67***	0.65***	0.64***	0.64***
					(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Housing activity, Labor Market, Expectations and Trade												
HS						0.03	0.03	0.02	0.02	0.01	0.02	0.02
						(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IJC							0.04	0.04	0.04	0.02	0.01	0.00
							(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
NFP								0.16**	0.16**	0.16**	0.15**	0.15**
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.05	0.04	0.02	0.02
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.15***	0.15**	0.15**
										(0.06)	(0.06)	(0.06)
IT											0.10*	0.10*
											(0.06)	(0.06)
UR												0.02
												(0.05)
$Adj.R^2$	-0.0003	0.3811	0.3809	0.3808	0.3944	0.3943	0.3943	0.3952	0.3952	0.3962	0.3966	0.3965
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

4.6.2 Other Indices

Because the financial stability dictionary created by Correa can be considered an alternative method of measuring crisis sentiment, we use it to asses the predictive power of our index. With the Correa dictionary, we create the financial stability index with the FOMC minutes and regress Equations (4.5) and (4.6). Tables 38 and 39 show the results for the interest rate and volatility, respectively.

We find the index created with our dictionary significantly outperforms the index created with the Correa dictionary. This result empirically shows that for the FOMC minutes: a) crisis and financial stability are not negatively related concepts; b) the crisis sentiment is statistically and economically more significant to explain the interest rate level and volatility of the U.S. Treasury.

We also create an index of the sentiment of the minutes with the Harvard-IV and the Loughran-MacDonald dictionaries. To measure the negative sentiment with the Harvard-IV, we count the proportion of negative terms as in Tetlock, Saar-Tsechansky and Macskassy (2008). Tables 40 and 41 show the result when we use Equations (4.5) and (4.6). We see the negative index fails to predict the interest rate level and volatility of the US treasuries.

We use the Loughran-MaDonald and create an index with the relative frequency of words that appear in the "uncertain" category as in Picault and Renault (2017). Tables 42 and 44 show the results on the interest rate level when we use Equations (4.5) and (4.6).

Table (4.6) shows that the uncertain index predicts interest rate level of the 30-year US Treasury. However, when we add the real time macroeconomic variables (Equation (4.8)), the predictability of the index becomes insignificant.

4.7 Conclusion

We construct a central bank independent crisis dictionary with the aid of a supervised machine learning algorithm. Our machine learning approach reduces 90% of the human supervision efforts. With the dictionary, we create a crisis index that measures the crisis sentiment of the FOMC minutes. We observe that during the 2007-2008 financial crisis, the crisis index reach up to 6% of the total number of words. We also test the predictability power of the crisis index on the interest rate and volatility of the U.S.treasury constant maturities.

We find that an increment (decline) in the crisis sentiment predicts a reduction (increase) of the interest rate for intermediate-term treasuries. We also show that an increment (decline) in the crisis sentiment predicts an increase (reduction) in the volatility for long-term maturities. We also test the predictability power of the indices created with the Correa, the Harvard-IV, and the Loughran-McDonald dictionaries. Our crisis index significantly outperforms these alternative indices in predicting the interest rate and volatility of the U.S.treasury constant maturities.

Table 32 – **Federal Reserve FOMC Minutes Crisis Index and 3-Year Interest Rate Volatility (σ_{DGS3})**

This table shows the regressions of the 3-Year treasury constant maturity rate volatility (σ_{DGS3}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS3$ used for the volatility calculations σ_{DGS3} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.27***	1.71***	1.71***	1.70***	1.47***	1.48***	1.41***	1.30***	1.24***	1.18***	1.09***	1.05***
	(0.05)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)	(0.12)	(0.12)	(0.12)	(0.13)
Release	-0.04	-0.01	-0.01	-0.01	-0.04	-0.04	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04
	(0.24)	(0.20)	(0.20)	(0.20)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Vol_{-5}		0.60***	0.60***	0.60***	0.57***	0.57***	0.56***	0.56***	0.56***	0.55***	0.55***	0.55***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.06	0.06	0.07	0.07	0.08	0.09	0.08	0.08	0.07	0.06
			(0.23)	(0.23)	(0.21)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)
Economic Announcements												
Prices and Output												
CPI				0.02	0.04	0.04	0.02	0.01	0.01	0.01	0.02	0.02
				(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
GDP					0.63***	0.63***	0.63***	0.63***	0.64***	0.61***	0.58***	0.59***
					(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.01	-0.01	-0.03	-0.03	-0.04	-0.02	-0.01
						(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IJC							0.13***	0.13**	0.12**	0.10**	0.08	0.08
							(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
NFP								0.18***	0.18***	0.18***	0.16***	0.17***
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.08	0.07	0.04	0.04
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.19***	0.19***	0.19***
										(0.06)	(0.06)	(0.06)
IT											0.19***	0.19***
											(0.06)	(0.06)
UR												0.05
												(0.05)
$Adj.R^2$	-0.0003	0.3585	0.3583	0.3582	0.3704	0.3702	0.3709	0.3723	0.3724	0.3741	0.3760	0.3760
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 33 – **Federal Reserve FOMC Minutes Crisis Index and 5-Year Interest Rate Volatility (σ_{DGS5})**

This table shows the regressions of the 5-Year treasury constant maturity rate volatility (σ_{DGS5}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS5$ used for the volatility calculations σ_{DGS5} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.96***	2.24***	2.24***	2.18***	1.97***	2.08***	1.98***	1.87***	1.80***	1.73***	1.59***	1.54***
	(0.05)	(0.09)	(0.09)	(0.10)	(0.11)	(0.12)	(0.12)	(0.12)	(0.13)	(0.13)	(0.13)	(0.13)
Release	-0.03	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.25)	(0.21)	(0.20)	(0.20)	(0.19)	(0.20)	(0.20)	(0.20)	(0.20)	(0.19)	(0.20)	(0.20)
Vol_{-5}		0.55***	0.55***	0.54***	0.52***	0.52***	0.52***	0.51***	0.51***	0.50***	0.49***	0.49***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.36	0.35	0.36*	0.33	0.34*	0.35*	0.34*	0.34	0.33	0.32
			(0.22)	(0.22)	(0.20)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)
Economic Announcements												
Prices and Output												
CPI				0.10*	0.12**	0.13**	0.09	0.09	0.08	0.09	0.11*	0.11*
				(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
GDP					0.57***	0.59***	0.58***	0.59***	0.59***	0.56***	0.51***	0.51***
					(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.14***	-0.14***	-0.16***	-0.16***	-0.17***	-0.14***	-0.13***
						(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IJC							0.20***	0.20***	0.19***	0.17***	0.12**	0.12**
							(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
NFP								0.17***	0.17***	0.17***	0.13**	0.14**
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.12	0.10	0.05	0.05
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.26***	0.26***	0.25***
										(0.07)	(0.07)	(0.07)
IT											0.35***	0.35***
											(0.06)	(0.06)
UR												0.07
												(0.05)
$Adj.R^2$	-0.0003	0.3009	0.3012	0.3017	0.3122	0.3132	0.3152	0.3163	0.3167	0.3199	0.3270	0.3271
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 34 – **Federal Reserve FOMC Minutes Crisis Index and 7-Year Interest Rate Volatility (σ_{DGS7})**

This table shows the regressions of the 7-Year treasury constant maturity rate volatility (σ_{DGS7}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS7$ used for the volatility calculations σ_{DGS7} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	5.15***	2.58***	2.59***	2.53***	2.34***	2.51***	2.38***	2.29***	2.20***	2.12***	1.95***	1.91***
	(0.04)	(0.11)	(0.10)	(0.11)	(0.13)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Release	-0.09	-0.01	-0.01	-0.01	-0.03	-0.04	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04
	(0.25)	(0.21)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Vol_{-5}		0.50***	0.50***	0.49***	0.48***	0.47***	0.47***	0.47***	0.46***	0.45***	0.42***	0.42***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.55**	0.54**	0.55**	0.50**	0.52**	0.52**	0.51**	0.52**	0.50**	0.49**
			(0.25)	(0.25)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.25)	(0.24)
Economic Announcements												
Prices and Output												
CPI				0.11*	0.12**	0.13**	0.09	0.08	0.08	0.09	0.11*	0.12*
				(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
GDP					0.48***	0.50***	0.50***	0.50***	0.51***	0.46***	0.39***	0.40***
					(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.20***	-0.21***	-0.22***	-0.22***	-0.24***	-0.20***	-0.19***
						(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IJC							0.25***	0.24***	0.24***	0.21***	0.15***	0.14**
							(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
NFP								0.16**	0.16**	0.16**	0.11*	0.12*
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.14**	0.13*	0.06	0.06
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.34***	0.34***	0.34***
										(0.07)	(0.07)	(0.07)
IT											0.49***	0.49***
											(0.06)	(0.06)
UR												0.06
												(0.05)
$Adj.R^2$	-0.0002	0.2484	0.2496	0.2502	0.2580	0.2603	0.2635	0.2646	0.2654	0.2712	0.2854	0.2854
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 35 – **Federal Reserve FOMC Minutes Crisis Index and 10-Year Interest Rate Volatility (σ_{DGS10})**

This table shows the regressions of the 10-Year treasury constant maturity rate volatility (σ_{DGS10}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS10$ used for the volatility calculations σ_{DGS10} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade.Standard errors of the average is between parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.94***	2.60***	2.61***	2.51***	2.35***	2.53***	2.39***	2.30***	2.21***	2.14***	1.98***	1.92***
	(0.04)	(0.10)	(0.10)	(0.11)	(0.13)	(0.14)	(0.14)	(0.14)	(0.14)	(0.13)	(0.13)	(0.13)
Release	-0.07	-0.05	-0.05	-0.05	-0.06	-0.07	-0.06	-0.07	-0.06	-0.07	-0.07	-0.06
	(0.24)	(0.21)	(0.20)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Vol_{-5}		0.47***	0.47***	0.46***	0.45***	0.45***	0.44***	0.44***	0.44***	0.42***	0.39***	0.39***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.68**	0.66**	0.67**	0.62**	0.63**	0.64**	0.63**	0.63**	0.61**	0.61**
			(0.28)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)
Economic Announcements												
Prices and Output												
CPI				0.17***	0.18***	0.19***	0.15**	0.14**	0.14**	0.14**	0.17***	0.18***
				(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
GDP					0.39***	0.41***	0.40***	0.41***	0.41***	0.36***	0.29***	0.30***
					(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.22***	-0.23***	-0.24***	-0.24***	-0.26***	-0.22***	-0.21***
						(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IJC							0.28***	0.28***	0.27***	0.24***	0.18***	0.18***
							(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
NFP								0.16***	0.16***	0.16**	0.11*	0.12*
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.15**	0.13**	0.06	0.06
									(0.07)	(0.07)	(0.06)	(0.06)
RS										0.32***	0.32***	0.32***
										(0.08)	(0.07)	(0.07)
IT											0.50***	0.50***
											(0.06)	(0.06)
UR												0.07
												(0.05)
$Adj.R^2$	-0.0002	0.2241	0.2262	0.2282	0.2342	0.2376	0.2424	0.2436	0.2446	0.2505	0.2676	0.2678
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 36 – **Federal Reserve FOMC Minutes Crisis Index and 20-Year Interest Rate Volatility (σ_{DGS20})**

This table shows the regressions of the 20-Year treasury constant maturity rate volatility (σ_{DGS20}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS20$ used for the volatility calculations σ_{DGS20} are from March 08, 2004 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.83***	2.60***	2.61***	2.52***	2.43***	2.68***	2.57***	2.47***	2.35***	2.28***	2.14***	2.12***
	(0.04)	(0.08)	(0.08)	(0.09)	(0.10)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
Release	-0.08	-0.08	-0.08	-0.09	-0.09	-0.10	-0.09	-0.10	-0.09	-0.09	-0.09	-0.09
	(0.21)	(0.18)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)
Vol_{-5}		0.46***	0.46***	0.45***	0.45***	0.44***	0.44***	0.43***	0.43***	0.41***	0.38***	0.38***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FOMC Minutes												
crisis			0.59**	0.58**	0.58**	0.52**	0.53**	0.54**	0.52**	0.53**	0.51**	0.51**
			(0.25)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.25)	(0.25)
Economic Announcements												
Prices and Output												
CPI				0.16***	0.16***	0.18***	0.14**	0.13**	0.12**	0.13**	0.16***	0.16***
				(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
GDP					0.18**	0.21***	0.20***	0.21***	0.21***	0.15*	0.07	0.07
					(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.29***	-0.29***	-0.31***	-0.31***	-0.33***	-0.29***	-0.28***
						(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
IJC							0.24***	0.23***	0.23***	0.20***	0.14**	0.13**
							(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
NFP								0.16***	0.15***	0.15***	0.10*	0.10*
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.22***	0.20***	0.13**	0.13**
									(0.06)	(0.06)	(0.06)	(0.06)
RS										0.34***	0.35***	0.35***
										(0.07)	(0.07)	(0.07)
IT											0.53***	0.53***
											(0.06)	(0.06)
UR												0.03
												(0.05)
$Adj.R^2$	-0.0002	0.2130	0.2148	0.2168	0.2182	0.2249	0.2289	0.2303	0.2330	0.2410	0.2631	0.2630
n	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785	3785

Table 37 – **Federal Reserve FOMC Minutes Crisis Index and 30-Year Interest Rate Volatility (σ_{DGS30})**

This table shows the regressions of the 30-Year treasury constant maturity rate volatility (σ_{DGS30}) after the Federal Reserve FOMC minutes from Equation (4.8). FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS30$ used for the volatility calculations σ_{DGS30} are from February 12, 2006 to April 18, 2019. The regression is performed over 12 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.77***	2.97***	2.98***	2.81***	2.74***	3.07***	2.89***	2.72***	2.51***	2.44***	2.32***	2.33***
	(0.04)	(0.20)	(0.20)	(0.19)	(0.20)	(0.23)	(0.22)	(0.21)	(0.20)	(0.21)	(0.18)	(0.18)
Release	-0.11	-0.10	-0.19	-0.18	-0.19	-0.19	-0.20	-0.20	-0.18	-0.19	-0.18	-0.18
	(0.24)	(0.20)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.18)	(0.18)
Vol_{-5}		0.37***	0.37***	0.36***	0.36***	0.35***	0.35***	0.35***	0.34***	0.32***	0.29***	0.29***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
FOMC Minutes crisis			0.63**	0.58**	0.58**	0.51*	0.54*	0.53*	0.50*	0.50*	0.47	0.47
			(0.30)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)	(0.29)	(0.29)	(0.29)
Economic Announcements												
Prices and Output												
CPI				0.33***	0.34***	0.31***	0.28***	0.28***	0.29***	0.29***	0.32***	0.32***
				(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)
GDP					0.16*	0.20**	0.18**	0.19**	0.21**	0.17**	0.05	0.05
					(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.47***	-0.47***	-0.46***	-0.48***	-0.48***	-0.47***	-0.47***
						(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)
IJC							0.36***	0.35***	0.34***	0.31***	0.22***	0.23***
							(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)
NFP								0.24***	0.24***	0.23***	0.12**	0.12**
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.34***	0.32***	0.23***	0.23***
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.32***	0.30***	0.30***
										(0.08)	(0.07)	(0.07)
IT											0.64***	0.64***
											(0.07)	(0.07)
UR												-0.01
												(0.05)
$Adj.R^2$	-0.0002	0.1806	0.1825	0.1896	0.1905	0.2013	0.2097	0.2126	0.2191	0.2254	0.2576	0.2574
n	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301

Table 38 – **Federal Reserve FOMC Minutes Financial Stability Index and Interest Rate**

This table shows the regressions from Equation (4.5). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. The regression is performed with the FOMC minutes financial stability index. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	DGS1	DGS2	DGS3	DGS5	DGS7	DGS10	DGS20	DGS30
const	-0.25	-0.10	0.15	0.22	0.29	0.54	0.73	0.78
	(0.33)	(0.41)	(0.46)	(0.51)	(0.51)	(0.47)	(0.45)	(0.49)
fin. stab.	0.23	-0.43	-0.72	-1.03	-0.99	-0.75	-0.47	-0.46
	(0.34)	(0.62)	(0.67)	(0.81)	(0.76)	(0.68)	(0.64)	(0.70)
$Adj.R^2$	-0.0063	-0.0037	0.0018	0.0085	0.0075	0.0024	-0.0038	-0.0052
n	121	121	121	121	121	121	121	106

Table 39 – **Federal Reserve FOMC Minutes Financial Stability Index and Volatility**

This table shows the regressions from Equation (4.6). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	σ_{DGS1}	σ_{DGS2}	σ_{DGS3}	σ_{DGS5}	σ_{DGS7}	σ_{DGS10}	σ_{DGS20}	σ_{DGS30}
const	0.73***	1.42***	1.71***	2.24***	2.59***	2.61***	2.61***	2.98***
	(0.05)	(0.08)	(0.09)	(0.09)	(0.10)	(0.10)	(0.08)	(0.20)
ann	0.12	0.03	-0.01	0.04	-0.01	-0.05	-0.08	-0.19
	(0.15)	(0.20)	(0.20)	(0.20)	(0.21)	(0.20)	(0.18)	(0.16)
vollag	0.69***	0.62***	0.60***	0.55***	0.50***	0.47***	0.46***	0.37***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
crisis	0.09	-0.03	0.01	0.31	0.44	0.54	0.43	0.45
	(0.16)	(0.30)	(0.29)	(0.26)	(0.29)	(0.33)	(0.28)	(0.39)
$Adj.R^2$	0.4782	0.3809	0.3583	0.3011	0.2491	0.2253	0.2139	0.1812
n	3785	3785	3785	3785	3785	3785	3785	3301

Table 40 – **Federal Reserve FOMC Minutes Sentiment with the Harvard-IV Dictionary and Interest Rate**

This table shows the regressions from Equation (4.5). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. The regression is performed with the FOMC minutes with the Harvard-IV dictionary. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	DGS1	DGS2	DGS3	DGS5	DGS7	DGS10	DGS20	DGS30
const	-0.26	-0.11	0.14	0.21	0.28	0.53	0.72	0.79*
	(0.33)	(0.41)	(0.46)	(0.52)	(0.51)	(0.46)	(0.45)	(0.48)
harvard neg.	0.63**	0.39	0.51	0.44	0.53	0.69	0.69	0.78
	(0.32)	(0.40)	(0.45)	(0.51)	(0.48)	(0.44)	(0.43)	(0.48)
$Adj.R^2$	0.0267	0.0003	0.0035	-0.0015	0.0022	0.0123	0.0138	0.0151
n	121	121	121	121	121	121	121	106

Table 41 – **Federal Reserve FOMC Minutes Sentiment with the Harvard-IV Dictionary and Volatility**

This table shows the regressions from Equation (4.6). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	σ_{DGS1}	σ_{DGS2}	σ_{DGS3}	σ_{DGS5}	σ_{DGS7}	σ_{DGS10}	σ_{DGS20}	σ_{DGS30}
const	0.73***	1.42***	1.71***	2.24***	2.58***	2.60***	2.60***	2.97***
	(0.05)	(0.08)	(0.09)	(0.09)	(0.11)	(0.10)	(0.08)	(0.20)
ann	0.12	0.03	-0.01	0.04	-0.01	-0.05	-0.08	-0.10
	(0.15)	(0.20)	(0.20)	(0.20)	(0.21)	(0.21)	(0.18)	(0.20)
vollag	0.69***	0.62***	0.60***	0.55***	0.50***	0.47***	0.46***	0.37***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
crisis	0.07	0.03	0.02	0.08	-0.02	-0.03	-0.11	-0.21
	(0.13)	(0.18)	(0.18)	(0.17)	(0.19)	(0.21)	(0.17)	(0.20)
$Adj.R^2$	0.4782	0.3809	0.3583	0.3007	0.2482	0.2239	0.2128	0.1806
n	3785	3785	3785	3785	3785	3785	3785	3301

Table 42 – **Federal Reserve FOMC Minutes Sentiment with the Loughran-MacDonald Dictionary and Interest Rate**

This table shows the regressions from Equation (4.5). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. The regression is performed with the FOMC minutes with the Harvard-IV dictionary. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	DGS1	DGS2	DGS3	DGS5	DGS7	DGS10	DGS20	DGS30
const	-0.25	-0.11	0.14	0.21	0.28	0.54	0.73	0.77
	(0.33)	(0.41)	(0.46)	(0.52)	(0.51)	(0.47)	(0.45)	(0.48)
crisis	0.19	0.12	-0.00	0.02	0.09	0.11	0.01	0.13
	(0.28)	(0.34)	(0.38)	(0.42)	(0.41)	(0.38)	(0.36)	(0.43)
$Adj.R^2$	-0.0045	-0.0075	-0.0084	-0.0084	-0.0081	-0.0078	-0.0084	-0.0088
n	121	121	121	121	121	121	121	106

Table 43 – **Volatility**

Table 44 – **Federal Reserve FOMC Minutes Sentiment with the Loughran-McDonald Dictionary and Volatility**

This table shows the regressions from Equation (4.6). Each column represents a treasury constant maturity interest rate for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-Year after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; interest rates are from March 08, 2004 to April 18, 2019; except for the 30-year treasury that is from February 9, 2006 to April 18, 2019. Robust standard errors in parentheses.

	σ_{DGS1}	σ_{DGS2}	σ_{DGS3}	σ_{DGS5}	σ_{DGS7}	σ_{DGS10}	σ_{DGS20}	σ_{DGS30}
const	0.73***	1.42***	1.71***	2.24***	2.59***	2.60***	2.60***	2.98***
	(0.05)	(0.08)	(0.09)	(0.09)	(0.10)	(0.10)	(0.08)	(0.20)
ann	0.12	0.03	-0.01	0.04	-0.01	-0.05	-0.08	-0.10
	(0.15)	(0.20)	(0.20)	(0.20)	(0.21)	(0.20)	(0.18)	(0.20)
vollag	0.69***	0.62***	0.60***	0.55***	0.50***	0.47***	0.46***	0.37***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
crisis	0.09	-0.08	0.01	-0.27	-0.36*	-0.37*	-0.25	-0.48**
	(0.14)	(0.18)	(0.16)	(0.17)	(0.19)	(0.20)	(0.17)	(0.21)
$Adj.R^2$	0.4782	0.3809	0.3583	0.3010	0.2488	0.2246	0.2131	0.1815
n	3785	3785	3785	3785	3785	3785	3785	3301

Table 45 – **Federal Reserve FOMC Minutes the Loughran-McDonald Dictionary and 30-Year Interest Rate ($DGS30$)**

This table shows the regressions from Equation (4.6.1) of the 30-Year treasury constant maturity interest rate 1-day change ($DGS30_t - DGS30_{t-1}$) after the release of the FOMC minutes. FOMC minutes are from March 18, 2004 to April 10, 2019 that correspond to the FOMC meetings held between January 27-28, 2004 and March 19-20, 2019; the interest rates $DGS30$ are from February 21, 2006 to April 18, 2019. The regression is performed over 10 models, nested by the FOMC minutes crisis index, and economic announcements: Prices and Output, Housing Activity, Labor Market, Expectations and Trade. Robust standard errors in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
const	4.77***	2.97***	2.98***	2.80***	2.73***	3.07***	2.89***	2.72***	2.51***	2.45***	2.32***	2.33***
	(0.04)	(0.20)	(0.20)	(0.19)	(0.20)	(0.23)	(0.22)	(0.21)	(0.20)	(0.21)	(0.18)	(0.18)
ann	-0.11	-0.10	-0.10	-0.10	-0.11	-0.12	-0.12	-0.12	-0.12	-0.12	-0.11	-0.12
	(0.24)	(0.20)	(0.20)	(0.19)	(0.19)	(0.19)	(0.20)	(0.20)	(0.19)	(0.19)	(0.20)	(0.20)
vollag		0.37***	0.37***	0.36***	0.36***	0.35***	0.35***	0.35***	0.34***	0.32***	0.29***	0.29***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
FOMC Minutes												
crisis			-0.48**	-0.48**	-0.48**	-0.51***	-0.46**	-0.44**	-0.46**	-0.43**	-0.37*	-0.37*
			(0.21)	(0.19)	(0.19)	(0.20)	(0.20)	(0.20)	(0.21)	(0.20)	(0.21)	(0.21)
Economic Announcements												
Prices and Output												
CPI				0.34***	0.34***	0.32***	0.28***	0.28***	0.29***	0.30***	0.32***	0.32***
				(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)
GDP					0.16**	0.20**	0.19**	0.19**	0.21***	0.17**	0.05	0.05
					(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Housing activity, Labor Market, Expectations and Trade												
HS						-0.48***	-0.49***	-0.47***	-0.49***	-0.49***	-0.48***	-0.48***
						(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)
IJC							0.35***	0.34***	0.34***	0.30***	0.22***	0.22***
							(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)
NFP								0.23***	0.23***	0.23***	0.12**	0.12**
								(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
CS									0.35***	0.32***	0.24***	0.24***
									(0.07)	(0.07)	(0.07)	(0.07)
RS										0.31***	0.30***	0.30***
										(0.08)	(0.07)	(0.07)
IT											0.64***	0.64***
											(0.07)	(0.07)
UR												-0.01
												(0.05)
$Adj.R^2$	-0.0002	0.1806	0.1815	0.1890	0.1899	0.2012	0.2092	0.2120	0.2188	0.2250	0.2572	0.2569
n	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301	3301

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