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The value of understanding central bank communication

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ABSTRACT

This paper examines whether the communication of a central bank can complement its actions to coordinate market expectations and ultimately steer long-term interest rates. More specifically, we propose a measure of common understanding between the central bank and market participants and we assess how it alters the sovereign yield spreads of a sample of core and distressed countries in the euro area. We build a latent semantic analysis of the official transcripts of the press conferences that the European Central Bank holds at the end of each reserve maintenance period. We report empirical evidence supporting the importance of communication for implementing monetary policy decisions. Specifically, we show that the communication of the ECB was altered by the announcement of unconventional measures and that it significantly impacted sovereign spreads in the euro area.

1. Introduction

> "(…) *we recognise that a high degree of common understanding between the central bank and the public at large is in our best interests because, by reducing uncertainty and bolstering credibility, it facilitates the conduct of monetary policy*."
>
> (W. Duisenberg, "Jean Monnet" Lecture, 2000.)

> "*More generally, in recent years central banks have worked hard to improve communication with the public; a key objective of this effort is better alignment of market expectations of policy with the policy-making committee's own intentions*."
>
> (B. Bernanke and V.R. Reinhart, American Economic Review, 2004, p 86.)

Over the last decades central banks have become more transparent. This increased transparency, which reinforces the accountability of more independent central banks, has triggered diverse initiatives to strengthen their communication with the public: central banks now communicate more and rely on several alternative communication channels to convey their messages. The European Central Bank itself for example organises regular press conferences, where it explains its monetary policy decisions to market participants. Besides its regular Economic Bulletin, the central bank also publishes a series of forecasts of macroeconomic indicators for the euro area and the official accounts of the monetary policy decisions are now accessible on its website. In the same vein, over the last years, its policymakers also communicated more extensively at conferences, in press interviews, as well as in live chats with European citizens.

There is now a growing stream of research that focuses on the importance of central bank communication for guiding the expectations of market participants. For example, in the euro area, the work of Rosa and Verga (2008) suggests that the 3-month Euribor futures market reacts to the tone of the communication of the European Central Bank (ECB). The evidence reported in Falagiarda and Reitz (2015) shows that the impact of communication extends to longer tenors: the authors indeed report empirical evidence of the sensitivity of sovereign yield spreads to the announcement of unconventional monetary policy measures taken by the ECB. On top of the actions decided by the central bank, its communication therefore plays a critical role in the implementation of its monetary policy (Blinder et al., 2008). The work of Winkler (2000) offers the first comprehensive analysis of the desired attributes of the communication of a central bank, where it is shown that clarity, honesty and common understanding are its necessary components.

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This paper contributes to the literature in several ways. First, we examine how the communication of a central bank can complement its actions. More specifically, we develop a measure of common understanding between policymakers and market participants that we extract from the official transcripts of the press conferences that the European Central Bank holds at the end of each reserve maintenance period to communicate its monetary policy decisions. Each conference follows a similar structure, where the president of the central bank first reads an introductory statement prepared by the Governing Council of the institution. This statement explains the interest rate decisions made by the central bank. When this introductory statement ends, the president then answers the questions raised by a panel of journalists attending the conference with a view to clarifying the official message conveyed to the market. In this paper, we exploit the transcripts of this unique direct interaction between the central bank and the market, here represented by the panel of journalists, to measure the common understanding of the policy decisions communicated by the ECB. To the best of our knowledge, we are the first to examine the similarity between those two parts of the press conference of the ECB. Our sample covers the 145 press conferences of the ECB over the period from January 2004 to December 2016, where for each conference, we work at the individual word level. In line with the literature, we also extend our analysis of central bank communication by examining the similarity of introductory statements from period to period. By the same token, we build a measure of how similar the questions and answers sessions of ECB press conferences were over time.

Second, with a view to isolating the main signals conveyed by the press conferences, we subject their transcripts to a latent semantic analysis (LSA). This part of our analysis relies on the methods developed in Deerwester et al. (1990) and has been recently used to analyse central bank communication by Acosta (2015) to gauge the content similarity of FOMC minutes and transcripts. It essentially consists in a singular value decomposition of the term-document matrix built from text transcripts. The latent semantic analysis allows identifying latent factors, in the same spirit as the principal components extracted through a principal component analysis, by examining how terms are connected in a corpus of texts. This is, for example, the approach followed by Boukus and Rosenberg (2006). In this paper, we use this process to reduce the noise present in our term-document matrix and we retain an optimal number of 25 latent factors to capture the content of ECB press conferences. This textual analysis, as we argue, allows us to more precisely build our set of central bank communication measures. Finally, we assess whether the communication of the central bank can support its actions to steer the sovereign yield spreads of a sample of ten euro area countries. We specifically anticipate that, in line with Morris and Shin (2008), the communication of the central bank has the ability to coordinate the expectations of market participants, which ultimately is expected to alter long-term yield spreads.

Our results can be summarised as follows. First, we show that the message conveyed by the central bank through its introductory statements was highly persistent over time, except when the ECB announced specific unconventional measures taken as the financial crisis unfolded in the euro area. Our measure of common understanding is on average relatively moderate and peaks when the outright monetary transactions were announced. Second, our analysis lends further empirical support to the hypothesis that the communication of the central bank has the power to reinforce its actions, especially in distressed countries. We specifically report that the tensions observed in the sovereign debt markets eased in periods of improved common understanding between the central bank and market participants. We finally report that the similarity of introductory statements or of questions and answers, however, fail to alter sovereign spreads significantly. Our results are supported by a series of robustness checks and alternative model specifications. In particular, we show that our results are robust to potential endogeneity issues related to the computation of sovereign bond yield spreads and to the amount of noise that is filtered from the central bank communication through the latent semantic analysis.

The remaining of this paper is structured as follows. Section 2 reviews the literature on the analysis of central bank communication. The results of our empirical analysis of the impact of central bank communication on sovereign yield spreads are reported in Section 3. In this section, we also discuss a series of robustness checks. Finally, we conclude in Section 4.

2. Review of the literature

The communication of central banks has always triggered a lot of interest. From market participants first, who carefully listen to each word pronounced by central bankers to anticipate how their communication can potentially move markets. From the academic literature then, where researchers have long tried to build methods to analyse their communication in a systematic manner. This review of the literature focuses on the major initiatives taken in academic research.

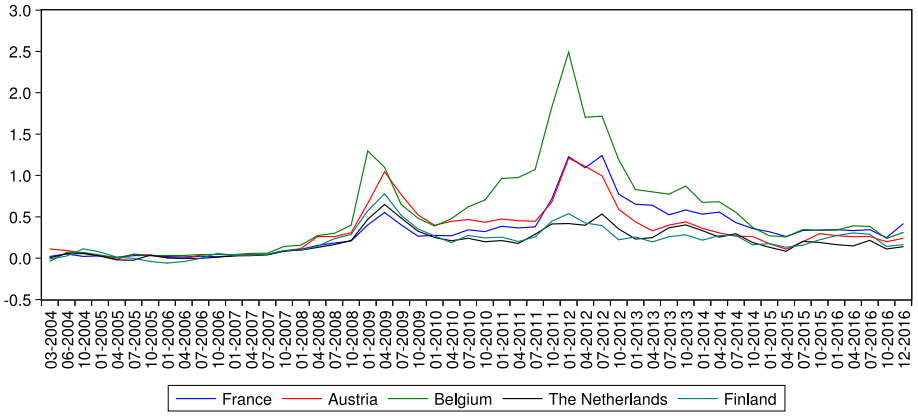
A first stream of research has converted the qualitative signals sent through the communication of central banks into quantitative measures, notably by coding speeches according to specific criteria. This is the approach of Hayo and Neuenkirch (2010) who examined whether the communication of the Federal Reserve drives its decisions. In their paper, speeches are converted into a ternary indicator, that is, a three-scale indicator taking values from −1, signalling an accommodative monetary policy stance, to +1 for a restrictive stance, while the value 0 is attributed to neutral communications. The work of Rosa (2011) similarly extracts a ternary 'wording indicator' from FOMC speeches and shows that the communication of the Federal Reserve alters the dynamics of the stock market in the United States. The author stresses the importance of communication as a tool for controlling external variables. In the euro area, the introductory statements of the press conferences of the European Central Bank have been under the scrutiny of the models of Berger et al. (2011) and Picault and Renault (2017). While Berger et al. (2011) rely on the content of introductory statements to measure a 'stance indicator', Picault and Renault (2017) measure their tone and show that, similar to the US case, it affects the volatility of the stock market. There is now a large and growing literature that makes use of such methods and the communication of most major central banks around the world is now covered.

A number of papers in the literature however departed from such coding approaches, which, as they argue, introduce a certain degree of subjectivity in the rules used for coding texts. To overcome this subjectivity bias, textual analysis methods have been developed and are now largely applied to the communication of central banks. This paper specifically focuses on the latent semantic analysis (LSA) of texts, which emerged from the work of Deerwester et al. (1990). This is for example the approach followed by Hendry and Madeley (2010), where the authors run a latent semantic analysis of the press releases of the Bank of Canada. The method allows them to identify a number of latent factors among those releases and the authors examine their influence on short and long-term interest rates. The work of Hendry (2012) similarly uses a latent semantic analysis to assess how the commentaries reported through Reuters services compare to the official statements of the Bank of Canada. In this respect, by comparing the official communication of a central bank to its perception by journalists, this work is close to the intuition developed in our paper. The evidence reported by the author lends further empirical support to the ability of central bank communication to affect the volatility of interest rates. Finally, the literature notes the importance of central bank communication to support its actions. Both must be consistent (Brand et al., 2010) and the communication must be clearly delivered (Coenen et al., 2017) for maximum impact.

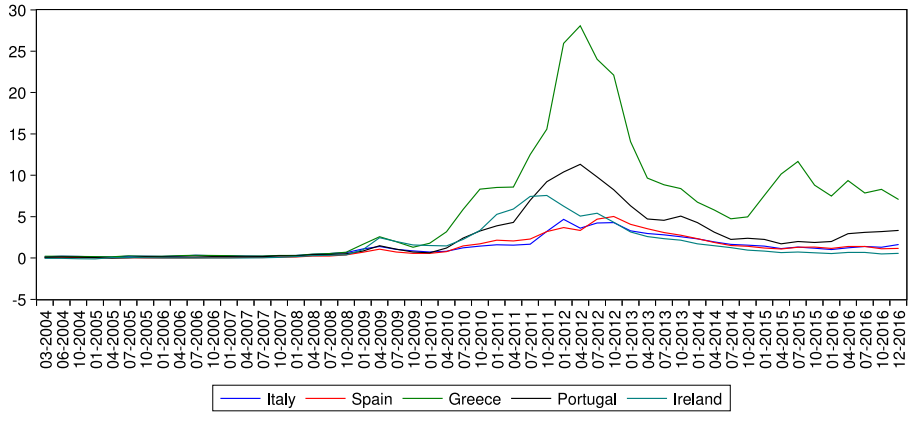
3. Empirical analysis

This papers examines whether and how the central bank can ease tensions in sovereign debt markets through its communication as well as through its operations. This section details the empirical setting used in our analysis as well as the construction of our measures. The sample period considered in this paper goes from January 2004 to December 2016. As in Afonso et al. (2015), we cover ten euro area countries. We specifically consider France, Austria, Belgium, the Netherlands and Finland as core euro area countries. In contrast, Italy, Spain, Greece, Portugal and Ireland are countries that faced tensions over the sample period considered in this paper and consequently form our sample of distressed countries. For each country, we measure the sovereign yield spread as the average difference between the yield that prevails on its 10-year maturity benchmark bond on a given period and the yield that prevails on the corresponding benchmark bond of a reference country. In this paper, the yield spread of each country is measured against Germany, which stands as our reference country. The data is from Macrobond. Since the EMU, this spread is essentially composed of a credit and of a liquidity component (Codogno et al., 2003), but the credit component markedly outweighs its liquidity component (see, among others, Oliveira et al., 2012). The evolution of the spread of each country reported in Fig. 1 lends further support to our sample split of core versus distressed countries. As the Figure shows, although the dynamics of the spreads of all countries are initially similar, the sovereign spreads of distressed countries deteriorated very markedly when the sovereign debt crisis hit the euro area. Over our sample period, the spread on Greek bonds peaked at a level close to 30, which is about 10 times higher than the peak value observed among core countries.

Central bank communication. Our analysis of the communication of the central bank builds on the work of Morris and Shin (2008). The authors suggest that through its communication, the central bank can coordinate expectations among market participants. More specifically, when faced with official communication from the central bank, market participants tend to overweight the information conveyed by the central bank and correspondingly underweight their own private signals. This ultimately leads to more aligned expectations among market participants. While, as the authors discuss, central bank actions directly influence the short-term part of the yield curve, it is however those expectations that drive its longer tenors. Beyond this coordination role, Born et al. (2014) add a signalling role to the communication of the central bank. Over our sample period, the European Central Bank (ECB) held 145 press conferences where the president of the central bank explained the interest rate decisions made by the Governing Council in an official introductory statement. Jung et al. (2010), who review the preparation of this statement, highlight its importance regarding the transparency of the decisions made by the central bank. This statement invariably starts at 14.30 on the Thursday that precedes the end of each reserve maintenance period and is subsequently followed by a session where the president answers the questions raised by a panel of accredited journalists attending the conference. This is the most direct systematic interaction between this institution and market participants. This therefore offers a unique opportunity to examine how the monetary policy stance is conveyed to market participants. This also allows to



(a) Core countries



(b) Distressed countries

Fig. 1. Evolution of sovereign bond yield spreads over the period from 2004:Q1 to 2016:Q4. The Figure shows the evolution of the 10-year sovereign yield spreads of core euro area countries (Panel A) and of distressed countries (Panel B). Germany is set as the reference country in spread computations. The data is quarterly.

observe the immediate reaction of journalists to the words pronounced by the president of the central bank. Through their questions, they can ask the central bank to clarify its official message and as such it plays an important role (Ehrmann and Fratzscher, 2009). In Europe, the institution maintains an official record of this discussion that is published on its website. Against this background, we specifically anticipate that, by coordinating market expectations, a clear message delivered by the central bank decreases uncertainty and has therefore the potential to ease the tensions observed on the sovereign debt market. This leads to the following hypothesis to be tested:

Hypothesis 1. A strong alignment of views between the central bank and market participants drives down sovereign spreads.

We further expect that similar content delivered by the central bank in its introductory statement from period to period hints at more predictable messages, which is similarly expected to lower sovereign spreads due to lower uncertainty. The work of Ehrmann and Talmi (2017), that focuses on the statements of the Bank of Canada, indeed suggests that their similarity over time affects the volatility of financial instruments. The importance of this dimension of central bank communication is further supported by the findings of Amaya and Filbien (2015), who measured the period-to-period similarity of the introductory statement of the ECB. By the same token, persistence in the concerns raised by market participants from period to period makes the message more predictable. On the one hand, a higher degree of similarity during the question and answer session of press conferences is an indicator of the coherence of questions and answers over time, thus revealing a smooth communication between the president of the institution and the press. On the other hand, a weaker alignment signals a quarter-on-quarter change in concerns implying a higher risk of disagreement or a misalignment of concerns between the president and the press. Our second hypotheses are accordingly:

Hypothesis 2a. Stable content (over time) delivered through introductory statements lowers sovereign spreads.

Hypothesis 2b. Similar concerns raised by market participants from period to period in questions to the central bank are associated with tighter spreads.

Our analysis of central bank communication accordingly works at the word level, based on the official transcripts of those meetings that are made available on the ECB website after the meeting has ended. A term-document (hereafter TDM) matrix is built from those transcripts where each line identifies a word pronounced in at least one meeting over our sample period and each column indexes the corresponding meeting. At this stage, in line with the textual analysis literature, common English words which do not convey significant meaning, the so-called stop words (e.g., the, and, of), are removed. Each element in the matrix then reports the number of times $w_{i,m}$ that each word i is pronounced during each meeting m. To examine the interactions between the central bank and market participants, we separate, for each meeting, the introductory statement (IS hereafter) from the questions and answers part (QA hereafter), that is, we treat them as separate documents. Our corpus of documents is therefore composed of 290 documents, of which 145 are introductory statements and 145 are their corresponding questions and answers parts. We rely on Matlab's TMG package to build and subsequently filter our TDM (Zeimpekis and Gallopoulos, 2006). Over the sample period considered here, an average of 2250 words composed the introductory statement and 4966 words were pronounced during the questions and answers part of the press conference. In total, 9490 different words were used at those press conferences. To match the frequency of spread determinants identified in the literature, we aggregate our meeting-based TDM to a quarterly TDM, where the introductory statements of a quarter are grouped in a single column. In a similar way, the raw counts of the words pronounced in the questions to the central bank and the answers from its president are also aggregated in a single column for each quarter. The quarterly TDM accordingly contains $T = 104$ columns, which corresponds to $T/2$ columns of IS and $T/2$ columns of QA. The raw counts are subsequently adjusted to reflect the information conveyed by each word, under the assumption that a word that is pronounced in every column conveys relatively little information. In contrast, words pronounced only infrequently may turn out to be more informative. In this paper, we use the 'inverse document frequency' adjustment as our normalisation scheme, as in Ehrmann and Talmi (2017). The adjusted frequencies $f_{i,t}$ are accordingly computed as:

$$f_{i,t} = w_{i,t} \times \log_2\left(\frac{T}{\sum_{t=1}^{T} D_{i,t}}\right) \tag{1}$$

where $w_{i,t}$ is the raw count of word i in column t and $D_{i,t}$ is a binary variable that is 1 when word i is pronounced in column t and is 0 otherwise. T denotes the total number of columns composing our TDM.

The objective of our analysis of the TDM matrix is essentially twofold. First we aim at capturing the alignment of views between the central bank and market participants. We consider that aligned views lead to the same words being pronounced in similar frequencies across the IS and QA parts of each meeting. For each meeting, we therefore measure the cosine similarity between its pair of IS and QA columns in the TDM matrix to quantify the strength of their similarity. By construction the cosine similarity measure is bounded between 0 (no similarity) and +1 (perfect similarity) and is as such easy to interpret. Our measure of common understanding between the central bank and market participants is defined as:

$$IP_t = \frac{\sum_{i=1}^{N} f_{i,t}^{IS} \times f_{i,t}^{QA}}{\sqrt{\sum_{i=1}^{N} (f_{i,t}^{IS})^2} \times \sqrt{\sum_{i=1}^{N} (f_{i,t}^{QA})^2}} \tag{2}$$

where $f_{i,t}^{IS}$ (resp. $f_{i,t}^{QA}$) is the adjusted frequency of word i pronounced in the introductory statements (resp. questions and answers) of quarter t. N is the total number of terms in the TDM matrix.

Second, similar to Acosta and Meade (2015), we want to measure how the content of the IS (resp. QA) varies from quarter to quarter. We accordingly measure the introductory statement similarity as:

$$II_t = \frac{\sum_{i=1}^{N} f_{i,t}^{IS} \times f_{i,t-1}^{IS}}{\sqrt{\sum_{i=1}^{N} (f_{i,t}^{IS})^2} \times \sqrt{\sum_{i=1}^{N} (f_{i,t-1}^{IS})^2}} \tag{3}$$

The similarity of questions and answers over time is defined as:

$$PP_t = \frac{\sum_{i=1}^{N} f_{i,t}^{QA} \times f_{i,t-1}^{QA}}{\sqrt{\sum_{i=1}^{N} (f_{i,t}^{QA})^2} \times \sqrt{\sum_{i=1}^{N} (f_{i,t-1}^{QA})^2}} \tag{4}$$

Central bank operations. Over the period considered in this paper, the European Central Bank has taken several measures to provide liquidity to safeguard the banking system. Before the crisis, those operations mainly consisted in main refinancing operations organised on a weekly basis as variable-rate tenders. As the subprimes crisis propagated to the euro area, the ECB took several unconventional measures, including the launch of a fixed-rate full-allotment at the weekly main refinancing operations as well as a series of longer-term refinancing operations. As the literature suggests, a number of those measures had significant impacts on sovereign spreads: the securities market programme (SMP) of May 2010 (Ghysels et al., 2017; Eser and Schwaab, 2016) and the outright monetary transactions (OMT) of July 2012 (Altavilla et al., 2016) notably helped ease the tensions observed in sovereign debt markets. Those measures were importantly complemented by specific programs such as two covered bond purchase programmes (CBPP1 in May 2009 and CBPP2 in October 2011) and an asset purchase programme (APP in January 2015). There is similar evidence that policy measures also reduced long-term spreads in the US markets, in quiet as well as in crisis periods (see, e.g., Mallick et al., 2017). Beyond the words pronounced by the central bank in its official

Table 1
Start of the financial crisis and the unconventional policies of the ECB.

Name	Definition	Period
Subprimes	Start of the financial crisis in the euro area	2007:Q3
FRFA	Fixed-rate full-allotment procedure for providing liquidity through the main refinancing operations	2008:Q4
CBPP1	First covered bond purchase programme	2009:Q2
SMP	Securities market programme	2010:Q2
CBPP2	Second covered bond purchase programme	2011:Q4
OMT	Outright monetary transactions and the "Whatever it takes" statement of Mario Draghi	2012:Q3
FG	Start of ECB forward guidance	2013:Q3
TLTRO	Targeted longer-term refinancing operations	2014:Q2
APP	Asset purchase programme	2015:Q1

This Table reports the dummy variables controlling for the propagation of the US subprimes crisis to the euro area and for the unconventional measures taken by the European Central Bank. Each variable is 1 on the quarter when the measure is announced and is 0 otherwise.

communication, we therefore also expect its actions to drive sovereign spreads:

Hypothesis 3. The monetary injections and the unconventional measures taken by the central bank helped lower sovereign spreads.

In our model, we include the amount outstanding of money injected by the ECB through its main refinancing operations (MRO) as well as through the longer-term refinancing operations (LTRO). We further control for the announcement of specific unconventional measures taken by the central bank as well as other significant crisis events by including a set of dummy variables for the corresponding periods. Those events are reported in Table 1.

Macroeconomic control variables. The literature provides extensive evidence of the influence of macroeconomic conditions in determining sovereign spreads. In particular, the work of Maltritz (2012) examines the drivers of the spreads of EMU countries. We follow the author and include the following macroeconomic controls in our model: deficit, debt to GDP ratio, interest payments, GDP growth, inflation, gross fixed capital formation, trade balance, openness, terms of trade, debt to EMU, the amount of public debt, the US government bond yield and a proxy for market sentiment. Similar to the work of Maltritz (2012), our controls are measured relative to Germany. We proceed in two steps to align the observation periods of all macroeconomic data. First, we extrapolate (linearly) all data at a daily frequency. Second, we compute the average of the daily interpolated data into quarterly data to match the observation frequency used in our model. Table 2 details all control variables.

Descriptive statistics for the central bank operations and for our set of control variables are reported in Table 3. Over our sample period, the liquidity injected by the European Central Bank through LTROs was on average about 2.5 times larger than through the weekly MROs. The amount outstanding at LTROs peaked at 1078.732 billion EUR, while the maximum amount outstanding at MROs was correspondingly 317.722 billion EUR. There is notable variability in the set of macroeconomic control variables measured against Germany (the reference country), which confirms that the ten countries considered in this paper faced different macroeconomic conditions between 2004 and 2016. The US government bond yield stood at an average of 1.473 percent and ranged from 0.103 percent to 5.076 percent. The spread between corporate and Treasury bonds, which proxies for market sentiment, showed similar variability over the period (it ranged from 1.619 percent to 5.465 percent).

Our model of the determinants of sovereign spreads is constructed as a seemingly-unrelated regression (SUR), which allows for a potential correlation of error terms across countries (see, e.g., the discussion in Arghyrou and Kontonikas, 2012). Therefore, our empirical analysis relies on the following system of equations:

$$S_{i,t} = \alpha_i + \beta_1 C_t + \beta_2 A_t + \gamma Z_{i,t} + \delta S_{i,t-1} + \varepsilon_{i,t} \quad (5)$$

where $i = 1, \ldots, 10$ denotes country i and $S_{i,t}$ is the 10-year sovereign yield spread of country i in quarter t. C_t contains our communication indicators and A_t represents the actions taken by the central bank. Z is the matrix of macroeconomic control variables. $\varepsilon_{i,t}$ are country-specific error terms that, in the seemingly-unrelated regression framework, are

Table 2
Macroeconomic control variables.

Name	Definition	Source	Frequency
Public finance indicators			
Deficit	Net lending (+) or net borrowing (−) (percentage of GDP)	Eurostat	Quarterly
Debt to GDP	General government gross debt (percentage of GDP)	IMF	Yearly
Interest payment	Gross government interest payments divided by the total amount of debt of the previous year	OECD	Yearly
State of the economy			
GDP growth	Real GDP growth per capita, in percent (2005 constant prices)	OECD	Yearly
CPI	Change in consumer prices, in percent	IMF	Monthly
Gross fixed capital formation	Gross fixed capital formation (percentage of GDP)	Eurostat	Quarterly
External sector			
Trade balance	Exports minus imports (free on board prices, percentage of GDP)	OECD	Quarterly
Openness	Exports plus imports (free on board prices, percentage of GDP)	OECD	Quarterly
Terms of trade	Change in terms of trade goods and services (2005 = 100), in percent	European Commission	Yearly
Liquidity			
Debt to EMU	Gross public debt (Maastricht criterion) divided by the gross public debt of euro area 15	OECD	Yearly
Debt amount	Gross public debt (Maastricht criterion), in trillion EUR	OECD	Quarterly
Global conditions			
US government yield	US benchmark government 12-month yield	Bloomberg	Daily
Corp.-Treasury spread	US corporate BBB/Baa - 10-year Treasury spread	Bloomberg	Daily

This Table defines the list of macroeconomic control variables used in this paper (see, e.g., Maltritz, 2012).

Table 3
Descriptive statistics.

Variable	Label	Mean	Std. Dev.	Median	Minimum	Maximum
Central bank liquidity provision						
MRO	MRO	168.959	87.105	148.628	34.501	317.722
LTRO	LTRO	413.191	269.187	420.697	57.733	1078.732
Public finance indicators						
Deficit	DEF	−2.972	4.608	−2.800	−34.038	9.183
Debt to GDP	DEBG	12.404	32.086	6.502	−41.680	113.156
Interest payment	INT	0.005	0.007	0.004	−0.007	0.030
State of the economy						
GDP growth	GDPG	−0.293	3.345	−0.4430	−11.549	24.763
CPI	CPI	0.228	1.216	0.261	−6.135	5.059
Gross fixed capital formation	GFCF	1.951	3.693	2.234	−9.300	12.135
External sector						
Trade balance	TBAL	−7.101	8.959	−7.847	−26.801	20.015
Openness	OPEN	7.353	41.852	−10.862	−37.354	114.854
Terms of trade	TOT	−2.560	3.622	−2.603	−12.757	5.030
Liquidity conditions						
Debt to EMU	LIQ	−0.165	0.087	−0.208	−0.260	0.003
Debt amount	DEBT	13.176	31.956	7.995	−42.687	109.203
Global conditions						
US govt. yields	USGY	1.473	1.726	0.531	0.103	5.076
Corp.-Treasury spread	MS	2.661	0.823	2.642	1.619	5.465

This Table reports descriptive statistics for the amount outstanding at the central bank refinancing operations and for our set of macroeconomic control variables relative to the reference country. In this Table, MRO and LTRO amounts are expressed in billions of euros and DEF, DEBT, GDPG, CPI, GFCF, TBAL, OPEN, USGY and MS are multiplied by 100.

allowed to be correlated across countries. α, β, γ and δ are parameters to be estimated. In particular, α_i corresponds to the country-specific intercept of the model.

Our results for this baseline model are reported in Table 4 for both core and distressed euro area countries. We also consider two alternative specifications of the model. In Model 2, we remove the set of dummy variables controlling for the announcements of unconventional measures and the macro-economic controls are dropped from Model 3. While all reported models are estimated as seemingly-unrelated regressions, we also examine the alternative pooled ordinary least-squares estimates, which, unlike our SUR estimates, rely on an assumption of uncorrelated errors across countries. Being qualitatively similar, the results are not reported here but remain available upon request.

As our results show, the degree of common understanding between the central bank and market participants significantly affects sovereign spreads over our sample period. The negative sign suggests that the degree of alignment of views plays a significant role in reducing sovereign yield spreads, which, in line with our Hypothesis 1, lends further support to the importance of this aspect of the communication of the central bank for maintaining financial market resilience. Our results however provide only weak support for our Hypotheses 2a and 2b: yield spreads are indeed only weakly altered by the similarity of introductory statements from period to period. Our results further hint at the existence of a mixed (albeit insignificant) influence of the similarity of questions and answers on yield spreads. Core and distressed countries exhibit similar patterns. In contrast, the liquidity provided by the central bank through its operations had a negative and significant impact mainly on the yield spreads of distressed countries. The negative effect of the longer-term refinancing operations (LTRO) is more pronounced for distressed euro area countries than the positive influence of the main refinancing operations (MRO) on the core countries. The reported evidence is accordingly mixed for our Hypothesis 3. The results are importantly robust to the alternative specifications of our model considered in this paper. Overall, our tests therefore suggest that the communication of the central bank is an important tool for controlling yield spreads in the euro area which supplements its (conventional and unconventional) operational tools (i.e., its actions).

Concerning the control variables, our results are consistent with the literature. We notably find a strong persistence in euro area sovereign bond yield spreads with a positive and significant impact of the lagged dependent variable. Regarding core euro area countries, the negative contributions of the indicators of the state of the economy (GDP growth and gross fixed capital formation) indicate that improving conditions tend to reduce sovereign bond yield spreads. In contrast, an increase in the spread between US BBB corporate bonds and Treasuries widens the spreads of core euro area countries.

3.1. A latent semantic analysis of the TDM

Further considerations of our term-document matrix show that, over the sample period considered in this paper, out of the 3311 different words pronounced during introductory statements, 80 percent of the content of each speech can be represented by only 448 different words. In the same vein, 9206 different words were pronounced during the questions and answers parts of the meeting, but only 1170 different words are necessary to capture 80 percent of those parts. This therefore suggests that press conferences by nature contain noisy signals that could be further filtered to better capture (i.e., isolate) the message sent by the central bank to market participants. Against this background, we subsequently conduct a latent semantic analysis (LSA hereafter) of our TDM matrix with a view to filtering out the unnecessary elements (i.e., the noise) and only retaining its main signals. The technique, based on the work of Deerwester et al. (1990), has demonstrated its ability to efficiently capture the latent message of term-document matrices. Our LSA mainly consists in a singular value decomposition of our quarterly TDM, with the objective of extracting a set of underlying (latent) factors. We start with the full TDM matrix of adjusted frequencies composed of N words (i.e., the rows of the matrix) and T columns (hence $T/2$ quarters). The singular value decomposition breaks down the TDM matrix in a product of 3 sub-matrices as:

$$\underset{(N\times T)}{TDM} = \underset{(N\times T)}{U} \times \underset{(T\times T)}{S} \times \underset{(T\times T)}{V'} \tag{6}$$

The U matrix contains the eigenvectors of $TDM \times TDM'$ and the V matrix is made of the eigenvectors of $TDM' \times TDM$. The S matrix

Table 4
Baseline model estimates – full TDM.

Model	Core Countries			Distressed Countries		
	(1)	(2)	(3)	(1)	(2)	(3)
Dependent Variable: 10-year sovereign yield spread						
Central Bank Communication						
Common understanding	−0.631***	−0.803***	−0.587**	−3.535**	−2.716**	−2.973**
	(0.208)	(0.265)	(0.138)	(1.431)	(1.265)	(1.497)
IS Similarity	0.171*	0.034	−0.037	0.848	0.404	0.503
	(0.092)	(0.124)	(0.112)	(0.596)	(0.582)	(0.641)
QA Similarity	−0.035	0.014	0.115	−0.379	−0.121	0.574
	(0.130)	(0.172)	(0.167)	(0.871)	(0.814)	(0.958)
Central bank Actions						
MRO	0.885***	0.361	0.794	−1.495	−0.614	0.611
	(0.280)	(0.327)	(1.730)	(1.509)	(1.366)	(9.966)
LTRO	0.052	0.048	1.054**	−1.556***	−1.170***	−0.351
	(0.057)	(0.069)	(0.533)	(0.352)	(0.318)	(0.410)
Public Finance						
Deficit	0.001	0.003		−0.003	−0.009	
	(0.001)	(0.002)		(0.010)	(0.010)	
Debt to GDP	0.001	0.001		0.004	0.004	
	(0.001)	(0.002)		(0.003)	(0.004)	
Interest payment	3.204	4.621**		10.329	6.086	
	(2.158)	(2.317)		(8.768)	(6.878)	
State of the Economy						
GDP growth	−0.007	−0.011*		−0.018	−0.028**	
	(0.004)	(0.006)		(0.012)	(0.013)	
CPI	0.013	0.011		0.006	0.027	
	(0.009)	(0.009)		(0.023)	(0.026)	
Gross fixed capital formation	−0.017*	−0.018**		0.020	0.029	
	(0.008)	(0.008)		(0.021)	(0.024)	
External Sector						
Trade balance	−0.002	−0.001		0.004	0.004	
	(0.006)	(0.006)		(0.008)	(0.008)	
Openness	0.001	0.001		−0.003	−0.002	
	(0.001)	(0.001)		(0.007)	(0.007)	
Terms of trade	−0.004	−0.001		−0.001	0.019	
	(0.005)	(0.006)		(0.014)	(0.015)	
Liquidity Conditions						
Debt to EMU	0.016	0.016		−0.374	0.328	
	(0.228)	(0.255)		(1.058)	(1.066)	
Debt Amount	7.356	9.597		−0.814	−1.417	
	(5.170)	(6.114)		(1.632)	(4.692)	
Global Conditions						
US govt. yields	−0.020	−0.013		−0.140**	−0.140**	
	(0.012)	(0.015)		(0.065)	(0.065)	
Corp.-Treasury spread	0.085***	0.053***		0.104	0.104	
	(0.016)	(0.018)		(0.796)	(0.080)	
Lagged dependent variable	included	included	included	included	included	included
Intercept						
Country-specific intercepts	included	included	included	included	included	included
Unconventional measures	included	not included	included	included	not included	included
Observations	255	255	255	255	255	255

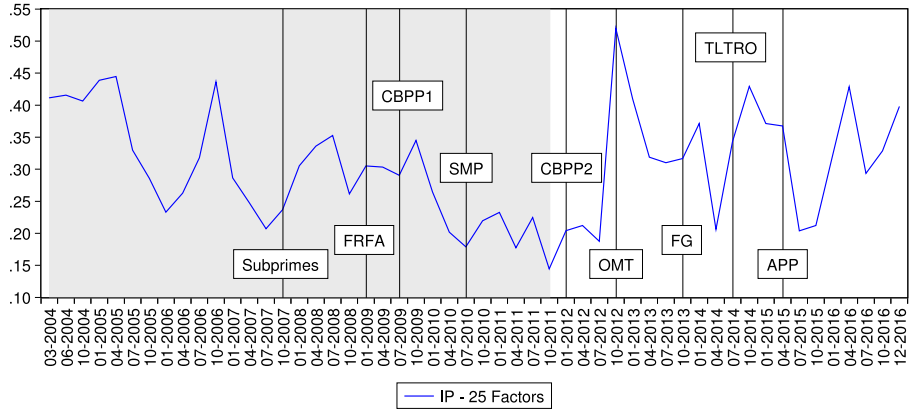
This Table reports our seemingly-unrelated regression estimates for our baseline model. Model 1 is the full model (central bank indicators and control variables). Dummies for the unconventional measures are removed in Model 2 and macroeconomic controls are dropped in Model 3. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The corresponding standard errors are reported in the parentheses.

is diagonal and contains the singular values of the TDM, which are the square roots of the eigenvalues of $TDM \times TDM'$ (or equivalently of $TDM' \times TDM$). By retaining only the largest k singular values, it is therefore possible to construct a truncated term-document matrix (TDM_k) based on k latent factors, in which a potentially significant amount of noise will be filtered out:

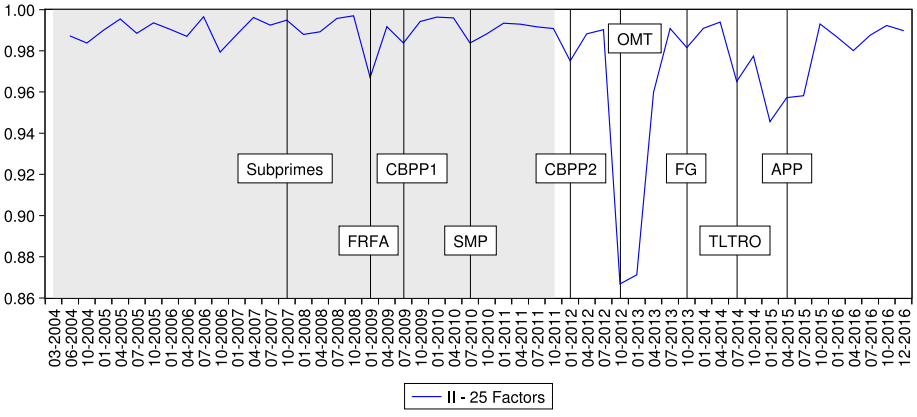
$$\underset{(N\times T)}{TDM_k} = \underset{(N\times k)}{U_k} \times \underset{(k\times k)}{S_k} \times \underset{(k\times T)}{V_k'} \tag{7}$$

The optimal number of singular values to retain is usually identified in a way similar to principal components analyses, that is, through the use of a scree plot of the eigenvalues. We accordingly truncate our TDM at 25 singular values,[1] that is, $k = 25$. We then compute the cosine similarities between the columns of the resulting truncated matrix at this optimal level of 25 latent factors. We accordingly define $IP_{i,t}^{k=25}$ as our measure of common understanding based on the TDM truncated at $k = 25$ latent factors and $II_{i,t}^{k=25}$ (resp. $PP_{i,t}^{k=25}$) as the period-to-period similarity in introductory statements (resp. in questions and answers)

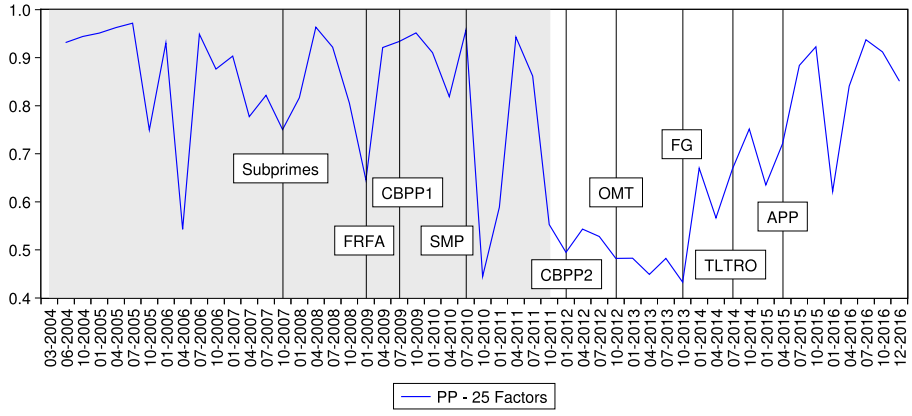
[1] Retaining 25 latent factors appears optimal as the first 25 factors have a contribution larger than a uniform contribution.



(a) Common understanding between the central bank and market participants.



(b) Similarity of consecutive introductory statements.



(c) Similarity of consecutive questions and answers sessions.

Fig. 2. Central bank communication variables over the period from 2004:Q1 to 2016:Q4. This Figure shows the evolution of the cosine similarity measure between the introductory statements and the questions and answers of ECB press conferences (Panel A), between consecutive introductory statements (Panel B) and between consecutive questions and answer sessions (Panel C). All measures are based on a truncated term-document matrix based on 25 latent factors. The vertical lines mark the beginning of the financial crisis in the euro area and the announcement dates of the main unconventional measures of the ECB. The grey area denotes to the presidential mandate of Jean-Claude Trichet; the white area corresponds to Mario Draghi's mandate.

extracted from the truncated TDM. Fig. 2 shows the evolution of our proximity measures over the sample period considered in this paper. The vertical lines on the Figure denote the start of the financial crisis in the euro area as well as the announcement of the main unconventional measures taken by the ECB over this period. The grey area represents the mandate of Jean-Claude Trichet as president of the institution, then followed by Mario Draghi over the period in white. As the Figure suggests, our IP variable is relatively low, showing that only moderate similarity exists between the words pronounced during introductory statements and those used during the questions and answers to journalists. Its average level stands at 0.305. The measure appears reactive to the announcement of unconventional measures, especially to the announcement of the outright monetary transactions (OMTs) where it peaks at a level of 0.520. An examination of the similarity of introductory statements over time shows a different picture: the similarity measure is extremely high and persistent, consistent with the fact that the introductory statement is a communication tool prepared by the Governing Council before the conference. Over our sample period, it

Table 5
Model estimates – TDM truncated at 25 latent factors.

Model	Core Countries			Distressed Countries		
	(1)	(2)	(3)	(1)	(2)	(3)
Dependent Variable: 10-year sovereign yield spread						
Central Bank Communication						
Common understanding	−0.322***	−0.353***	−0.322**	−1.420**	−1.503**	−1.743**
	(0.101)	(0.127)	(0.138)	(0.665)	(0.620)	(0.772)
IS Similarity	0.304	0.927*	0.461	4.911*	1.016	6.262*
	(0.427)	(0.522)	(0.601)	(2.499)	(0.685)	(3.341)
QA Similarity	−0.030	−0.082	−0.042	−0.516	−0.323	−0.649
	(0.062)	(0.073)	(0.078)	(0.340)	(0.358)	(0.441)
Central bank Actions						
MRO	0.692**	0.527*	−0.082	−1.310	−1.317	−2.380**
	(0.277)	(0.317)	(1.857)	(1.819)	(1.662)	(1.036)
LTRO	0.020	0.062	0.034	−2.013***	−1.640***	−1.069**
	(0.071)	(0.085)	(0.083)	(0.446)	(0.413)	(0.448)
Public Finance						
Deficit	0.001	0.003		−0.001	−0.004	
	(0.002)	(0.002)		(0.001)	(0.010)	
Debt to GDP	0.001	−0.001		−0.001	−0.002	
	(0.002)	(0.002)		(0.001)	(0.005)	
Interest payment	3.352	4.764**		9.173	6.406	
	(2.101)	(2.251)		(8.794)	(9.212)	
State of the Economy						
GDP growth	−0.008	−0.009*		−0.020	−0.035***	
	(0.005)	(0.005)		(0.013)	(0.013)	
CPI	0.012	0.010		0.018	0.028	
	(0.009)	(0.009)		(0.026)	(0.026)	
Gross fixed capital formation	−0.018**	−0.018**		0.016	0.024	
	(0.008)	(0.008)		(0.600)	(0.027)	
External Sector						
Trade balance	−0.001	−0.001		0.029	0.030	
	(0.006)	(0.005)		(0.030)	(0.031)	
Openness	0.001	0.001		−0.001	−0.002	
	(0.001)	(0.001)		(0.014)	(0.015)	
Terms of trade	−0.002	0.001		−0.031	−0.041	
	(0.005)	(0.005)		(0.026)	(0.026)	
Liquidity Conditions						
Debt to EMU	0.118	0.175		−1.003	−0.561	
	(0.226)	(0.242)		(1.408)	(1.429)	
Debt Amount	−9.410*	−1.290**		−5.427	−6.770	
	(5.170)	(0.589)		(4.495)	(4.507)	
Global Conditions						
US govt. yields	−0.021*	−0.002*		0.079	−0.071	
	(0.012)	(0.014)		(0.093)	(0.088)	
Corp.-Treasury spread	0.085***	0.048***		0.260**	0.189*	
	(0.016)	(0.018)		(0.110)	(0.102)	
Lagged dependent variable	included	included	included	included	included	included
Intercept						
Country-specific intercepts	included	included	included	included	included	included
Unconventional measures	included	not included	included	included	not included	included
Observations	255	255	255	255	255	255

This Table reports our seemingly-unrelated regression estimates where our central bank communication variables are computed from the truncated TDM with 25 latent factors. Model 1 is the full model (central bank indicators and control variables). Dummies for the unconventional measures are removed in Model 2 and macroeconomic controls are dropped in Model 3. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The corresponding standard errors are reported in the parentheses.

is on average 0.981. The measure however decreases markedly on the period when OMTs were announced where it drops to a low of 0.867. The measure of the similarity in questions and answers over time fluctuates between periods of high similarity and periods of significant lows. There is much more variability (i.e., dispersion) in this measure than in the others, which is consistent with its exclusive focus on the questions and answers part of the press conferences. Those are by definition not standardised, hence resulting in lower similarities from period to period. This measure is on average 0.764 with a peak value recorded at the beginning of our sample period at 0.972 and a low value of 0.433 when the ECB implemented its forward guidance. Against this background, we then run the same seemingly-unrelated regressions where our raw communication variables are now replaced by their filtered (i.e., truncated) versions. Our model accordingly becomes:

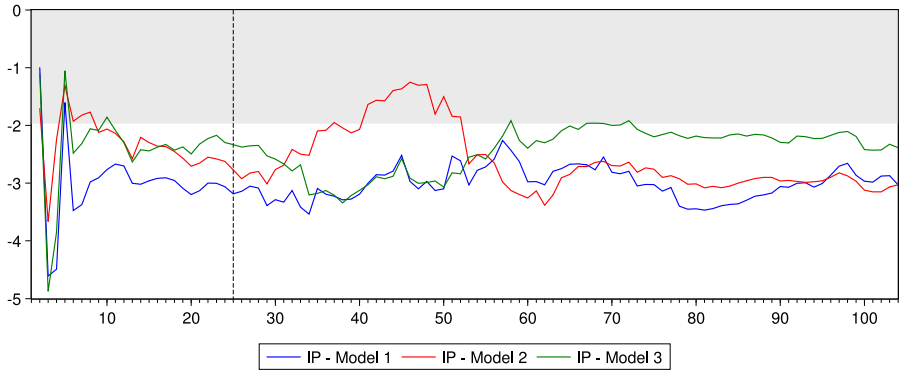
$$S_{i,t} = \alpha_i + \beta_1 C_t^{k=25} + \beta_2 A_t + \gamma Z_{i,t} + \delta S_{i,t-1} + \varepsilon_{i,t} \quad (8)$$

Table 5 shows the results of this regression where our central bank communication variables ($C_t^{k=25}$) are now based on the optimal number of latent factors extracted from the term-document matrix. As in our baseline estimations of the model, it appears that sovereign yield spreads react both to the communication of the central bank and to its actions. First, sovereign spreads decrease when the central bank and

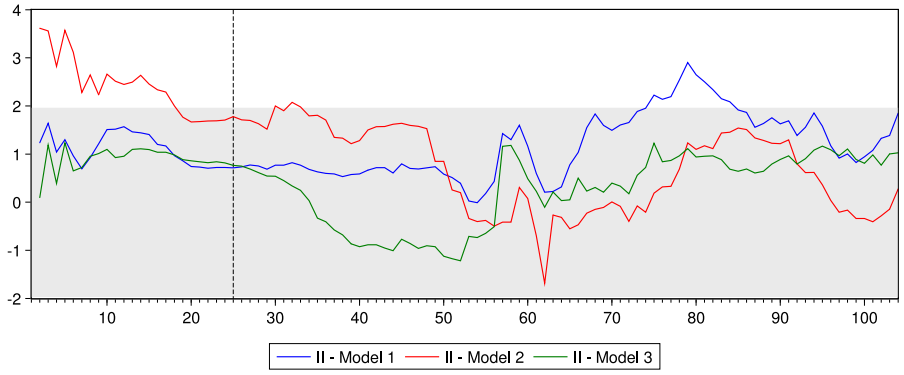
journalists share a stronger common understanding. The result holds for both core and distressed euro area countries, but the coefficient is markedly higher for distressed countries. Second, the longer-term refinancing operations of the central bank similarly helped ease tensions in the sovereign debt markets of distressed countries. This series of results based on the optimal decomposition of the term-document matrix is qualitatively similar to our baseline estimates and as such it lends further support to our initial conclusions.

3.2. Robustness checks

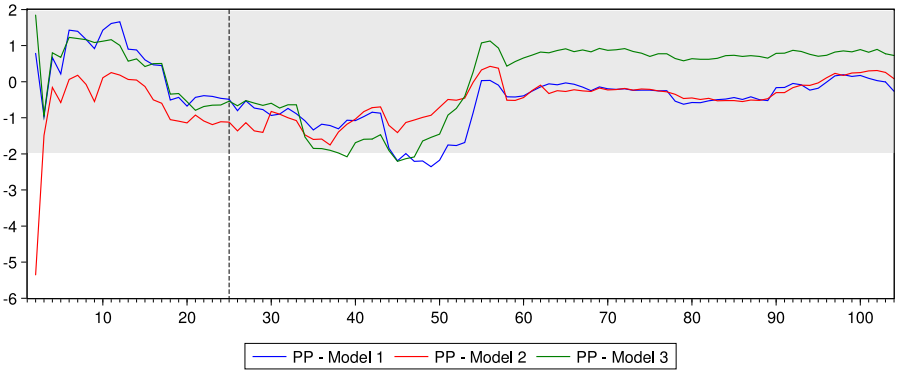
In this section, we proceed to a number of robustness checks regarding the above analyses. First, we assess the sensitivity of our results to the truncation level used to approximate the term-document matrix. To this end, we build a truncated TDM that retains a minimum of 2 latent factors and we compute our associated central bank communication variables. We then re-estimate our three alternative model specifications with these communication variables. These steps are iteratively repeated until the truncated TDM includes a maximum of 104 latent factors (in this case, the truncated TDM is equivalent to the full TDM). The estimated t-statistics of the central bank communication variables are reported graphically in Fig. 3 (core countries) and in Fig. 4 (distressed countries), where the horizontal axis denotes the number of latent factors used to build the truncated TDM and the shaded area represents the region of statistical insignificance of the parameters (at the 5% level). In the Figures, the complete model (Model 1) is in blue, and the alternative specifications are in red (Model 2 with no dummy variables controlling for the period) and in green (Model 3 with no



(a) Common understanding between the central bank and market participants.

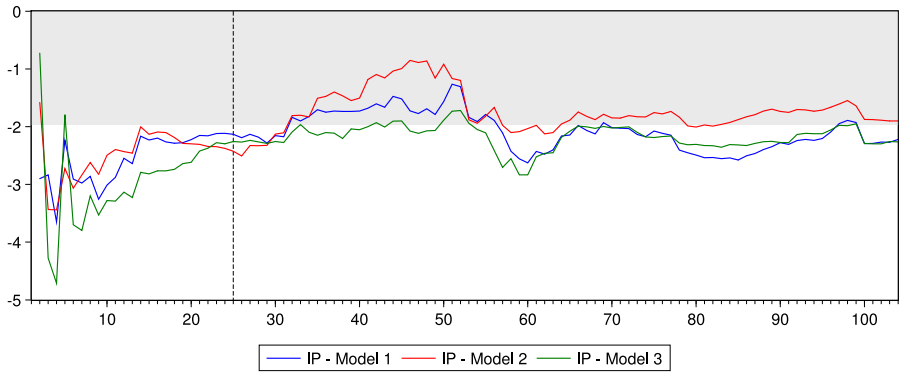


(b) Similarity of consecutive introductory statements.



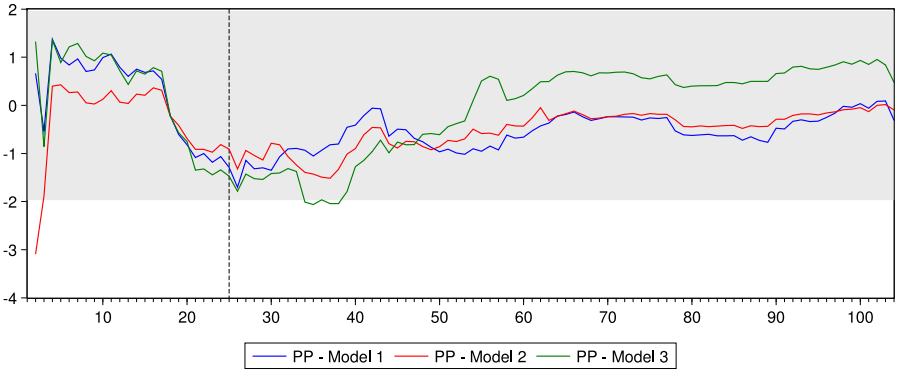
(c) Similarity of consecutive questions and answers sessions.

Fig. 3. Significance of the central bank communication variables in core countries. This Figure shows the t-statistics of the test for the significance of common understanding (Panel A), similarity of consecutive introductory statements (Panel B) and similarity of consecutive questions and answers sessions (Panel C) at each truncation level of the term-document matrix. The horizontal axis denotes the number of latent factors included in the truncated TDM. Model 1 is the full model (in blue), dummies for the unconventional measures are removed in Model 2 (in red) and macroeconomic controls are dropped in Model 3 (in green). The shaded area denotes the insignificance region at the 5% level. (For interpretation of the references to colour in this Figure legend, the reader is referred to the Web version of this article.)



(a) Common understanding between the central bank and market participants.

(b) Similarity of consecutive introductory statements.



(c) Similarity of consecutive questions and answers sessions.

Fig. 4. Significance of the central bank communication variables in distressed countries. This Figure shows the t-statistics of the test for the significance of common understanding (Panel A), similarity of consecutive introductory statements (Panel B) and similarity of consecutive questions and answers sessions (Panel C) at each truncation level of the term-document matrix. The horizontal axis denotes the number of latent factors included in the truncated TDM. Model 1 is the full model (in blue), dummies for the unconventional measures are removed in Model 2 (in red) and macroeconomic controls are dropped in Model 3 (in green). The shaded area denotes the insignificance region at the 5% level. (For interpretation of the references to colour in this Figure legend, the reader is referred to the Web version of this article.)

macroeconomic control variables). The dashed line shows the optimal truncation level of the TDM used in the previous section as a reference point.

More specifically, the significance of our common understanding variable as a function of the truncation level of the term-document matrix is reported in Panel A of the Figures. The t-statistics of the three models remain essentially outside the insignificance area, which lends further empirical support to the significance of the negative influence of common understanding on the yield spreads of both core and distressed euro area countries. In contrast, the Figures also show that sovereign spreads remain significantly unaltered by the similarity of consecutive introductory statements (Panel B) or of consecutive sessions of questions and answers (Panel C) and that this latter finding is importantly unaffected by the level of truncation of the TDM.

Second, we have additionally addressed the issue of endogeneity. There are two main sources of potential endogeneity: (i) reverse causality and (ii) auto-correlation. To account for the risk of reverse causality that could arise from the definition of our endogeneous variable, we alternatively assessed the influence of the communication of the central bank on the sovereign spreads measured on the day before the first press conference of the following quarter. In that specific setting, the spreads are clearly posterior to the communication of the ECB for the quarter considered, hence ruling out potential reverse causality issues. We have finally examined alternative model specifications where we

removed the lagged dependent variable. Being qualitatively similar to our main findings, the results of these estimations are not reported here but remain available from the authors.

4. Concluding remarks and policy implications

Over the last decades, the communication of central banks has taken increasing importance to convey messages to market participants. Every word pronounced by central bankers is carefully examined to identify potential hidden signals. Morris and Shin (2008) suggest that, through this communication, the central bank can coordinate the expectations of market participants, leading to reduced market uncertainty. As the work of Winkler (2000) shows, to achieve this objective, the communication of the central bank must however be clear, honest and a common understanding must emerge among participants. We show that besides enhancing transparency through the quantity of information disclosed or by expanding the communication channels, the quality of central bank communication also takes crucial importance.

Against this background, we assess the ability of the communication of the European Central Bank to ease tensions in the sovereign debt markets of core and distressed euro area countries. We propose a measure of common understanding between policy makers and market participants that we extract from the proximity of concerns expressed through the introductory statements of the press conferences and their subsequent questions and answers sessions with journalists. Whereas the reaction of yield spreads to the similarity of consecutive introductory statements or questions and answers is rather weak, we show that common understanding lowers those spreads in both core and distressed countries. We report that the communication of the European Central Bank can complement its actions, which we find was particularly effective in distressed countries. Our analysis relies on a latent semantic analysis of a term-document matrix built from the words pronounced at ECB press conferences, where an optimal number of 25 latent factors is initially retained. As our results show, our findings are nevertheless robust to the number of retained latent factors and to a number of alternative model specifications or other robustness checks.

Those results contribute to the understanding of the dynamics of sovereign yield spreads and lend further support to the importance of central bank communication in the transmission of monetary policy decisions. In particular, by applying textual analysis methods to the official communication of a central bank, this paper provides a framework for transforming qualitative signals into quantitative information that can be used in economic or financial research. As we show in this paper, the analysis of speech similarity is a promising research area, as it allows the researcher to capture the degree of common understanding or the proximity of different communication channels. We claim that this method has the power to improve our understanding of central bank communication.

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