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How Do the Emerging Markets Central Bank Talk? A Big Data Approach to the Central Bank of Turkey

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Summary*

We apply the natural language processing or computational linguistics (NLP) to the analysis of the communication policy (i.e statements and minutes) of the Central Bank of Turkey (CBRT). While previous literature has focused on Developed countries, we extend the NLP analysis to the Central Banks of the Emerging Markets using the Dynamic Topic Modelling approach. The results show that the topic evolution dynamics of the CBRT and how the Monetary Policy complexity increased after the global financial crisis as the topic network analysis evinces. We also show how the CBRT statements and minutes' stance has been changing over time and how the CBRT feels about the different topics got from its monetary policy communication reports as economic activity, inflation, global capital flows and other topics, including the alternative monetary policies. Finally, we confirm previous empirical results by showing how the Central Bank communication policy is able to influence the financial markets through the term structure of the interest rates. Nonetheless, neither communication has particularly significant effects on inflation nor real economic activity, thus reflecting that standard monetary policy is needed to ultimately validate communication policies.

Key words: Natural Language Processing**,** Dynamic Topic Models**,** Central Bank Communication, Sentiment Analysis, Monetary policy, Network Analysis, Vector Autoregression.

JEL classification: E52, E58

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1. Introduction

Big Data and Data Science techniques allows us to measure and analyze text using natural language processing methodology, also known as text mining or computational linguistics. The information included in the media, blogs, economic and financial reports, etc. in the form of text could fully complement and improve our structured databases traditionally used in economic research. Thus, using statistical techniques and computational tools, we quantify text extracting meaning from letters, that is, we convert text into data. This novel approach, which permits to complement and combine traditional economic tools with new emerging tools thanks to the use of Big Data, has plenty of applications with a huge potential for economic research.

In this working paper, we focus on the monetary policy analysis through the measurement and monitorization of the Central Banks' communication strategy. This communication strategy refers to the information that the Central Banks release about the current economic situation, its current and future policy intentions together with the expected path for future monetary policy decisions. It has become an important tool for understanding monetary policy decision. Morevoer, it is also a complementary tool for Central Banks to manage expectations about the future direction of the monetary policy.

We measure and monitor Central Banks' communication strategy using large databases of text from their monetary policy reports and press releases thanks to the use of machine learning algorithms for natural language processing and topic modelling. Furthermore, we exploit the emotional dimension through sentiment analyisis to extract semantics of opinion words and sentences in the text and analyze sentiment patterns across topics using the Lexicon approach.

Previous literature has used these computational linguistics models to analyze the Federal Reserve communication transparency strategy (Hansen et al, 2014) as well as the effects of this communication strategy on real economic variables (Hansen et al, 2015). From a methodological point of view, they do it using Latent Dirichlet Allocation (LDA)[1] that estimates what fraction of time each speaker in each section of each meeting spends on a variety of topics. Our main contribution to this research area is to measure Central Bank communication strategy for an Emerging Country like Turkey and to go one step ahead in the computational approach to incorporate dynamics and topic evolution to this analysis using Dynamic Topic Models (DTM), which is a particular case of Structural Topic Models (STM) (Roberts et al. 2013).

Beyond the NPL techniques, this working paper complements the analysis of Central Bank communication policies and its effects on financial markets and real variables. The NPL analysis described in the first part of this paper will help us to understand deeply how the Emerging Markets' Central Banks talk. Particularly, we detail the most important included topics in the communication documents, what is their sentiment in the text when they are commented and how they interact over time. In the second part, we analyze how the monetary policy communication impacts on

1: Blei et al (2003).

financial markets and the real economy, thus complementing the literature of the Central Bank communication policies.[2]

The working paper is structured as follows. In section 2 we describe the empirical strategy including the dynamic topic model and the sentiment analysis used in the paper. The identification of the main topics is also described.

The main empirical results are described in section 3. We show the evolution of the main selected topics by the Dynamic Topic Model using Turkish Central Bank minutes and statements since 2006 to 2017 and how they have changed over time. Beyond this, we analyze the topics' sentiment including the monetary policy stance by the CBRT. More important, we analyze the topic interconnectedness according to different periods as the full fledge inflation targeting, the global financial crisis and the post crisis period.

In section 4 we check the robustness of our model through the comparison of NPL versus human expert coding. This will help to contrast our results and the accuracy of both the NPL algorithms and the supporting dictionary used by the Dynamic Topic Model and the sentiment analysis.

The impact of the communication strategy on the markets and real variables is tested in section 5 by introducing the monetary policy stance in a VAR model. In the model, we assess the impact of the monetary policy sentiment on long term rates, inflation and economic activity

Finally, we describe the main conclusions of our work in section 6, where we assess how our results compare with the previous literature.

2. Empirical Strategy: Dynamic Topic Models and Sentiment Analysis

In this section we describe the NLP techniques for the analysis of the communication policy of the Central Bank of Turkey. First, we describe the Dynamic Topic Model approach to get the latent vector of topics in the documents. Once the topics have been identified, we analyze the sentiment of the different topics and, in particular, the monetary policy sentiment extracted from the Central Bank documents. Beyond this, we use a network analysis to describe the changing relationship between topics and how this interconnectedness can become more complex and challenging over time.

2.1 Dynamic Topic Models

We analyze Turkish Central Bank wording on monetary policy using communication reports (statements and minutes). Documents in the analysis are defined as paragraphs of these communication reports. To clean the text, documents with less than 200 characters are excluded (i.e. titles, contents sections or other documents which have little economic content) from the corpus (the structured set of texts to be analyzed). Then, words are stemmed (reduce a word to their semantic root) to generate tokens. Further feature selection is conducted on the tokens: First, common stopwords and words with length 3 or less are removed and the remaining words are stemmed. Second tokens are filtered out based

2: For a survey on Central Bank Communication Policies check the survey by Blinder et al (2008).

on a *term-frequency-inverse-document-frequency* (tf.idf) index (Manning and Schutze 1999). Words of the lowest quantile are removed. This indexing scheme is, unsurprisingly, combined of a *term-frequency index* (*tf*), which is just the count of a given word in a document, and a *document frequency index* (*df*), which is the number of documents that contain a given word. Then, the tf.idf used to filter words out is:

$$tf.idf_i = mean(tf_{ij}) * log_2\left(\frac{N}{df_i}\right),$$

where *i* indexes terms and *j* documents. This index gives high weight to frequent words through the *tf* component, but if a word is very prevalent through the corpus; its weight is reduced through the *idf* component. The aim of this filtering procedure is to remove very unfrequent as well as very frequent words, proxying for filtering out words with low semantinc content. Lastly, once words were removed, a second filter was applied to remove documents containing less than one.

We use computational linguistics and different specifications of topic modelling. Latent Dirichlet Allocation (LDA) (Blei, Ng, and Jordan 2003) is a Bayesian model assuming a document is generated by a latent mixture of topics. These mixtures follow a Dirichlet prior distribution. To introduce time-series dependencies into the data generating process, we use the dynamic topic model (DTM), a particularization of the Structural Topic Models (STM) where each time period has a separate topic model and time periods are linked via smoothly evolving parameters. STM (Roberts et. al. 2016) explicitly introduces covariates into a topic model allowing us to estimate the impact of document-level covariates on topic content and prevalence as part of the topic model itself. The process for generating individual words is the same as for plain LDA. However both objects can depend on potentially different sets of document-level covariates: Topic Prevalence (each document has P attributes that can affect the likelihood of discussing topic k) and Topic Content (each document has an A-level categorical attribute that affects the likelihood of discussing term v overall and of discussing it within topic k). Therefore, STM models text as a set of documents (each document being a list of words) being generated by a mixture of a (user defined) number of latent topics (each topic being a distribution over the whole collection of words in the text) drawn from a Multinomial distribution whose parameters k and d are drawn from a LogisticNormal distribution with the allowance to include covariates in the LogisticNormal hyperparameters to have differences across time and topics.

This model assumes that the ordering of the words in a document is not relevant (bag of words). This assumption is inherited as STM is an extension of the Latent Semantic Indexing algorithm (an SVD of the Document-Term-Matrix). As such, the assumption states that the algorithm only cares about the *occurrence* of the words (Manning et al. 2008). Moreover, we assume that the documents and words are *conditionally independent and indentically distributed*. This assumption is a necessity when trying to model language as a mixture of distributions, following de Finetti's Theorem.

The resulting likelihood function of the above-mentioned generative process is intractable. Thus parameter estimation is conducted via a Variational EM algorithm, this is, in the E-step, a lower bound of the loglikelihood function is found through a simplified version of the likelihood function using Jensen's inequality, while the actual model parameters are computed in the M-step by optimizing the lowerbound.

2.2 Sentiment Analysis

To measure the tone or sentiment we rely on Lexicon methods using the Loughran-McDonald dictionary (Loughran McDonald 2009). This dictionary was created specifically to analyze financial texts, and solved a missclassifcation issue of certain specific financial or economic words in standard sentiment analysis dictionaries, such as the Hardvard Psychosociological Dictionary, examples proposed by the authors are *liability, deprecation* or *foreign*, which do not have a sentiment charge in a financial text, but they do in regular speech. Furthermore, other than the standard "directional" word lists measuring words associated with positive and negative tone, the LM dictionary also provides other measures, such as economic growth. We also apply the FED dictionary for financial stability (Correa et al, 2017). Using the *negative* and *positive* words of this dictionary, the average "tone" of a given document is computed by:

$$\text{Average tone} = 100 * \frac{\sum Positive\ words \ \ - \sum Negative\ words}{\sum Total\ words}$$

The score ranges from -100 (extremely negative) to +100 (extremely positive) but common values range between -10 and +10, with 0 indicating neutral. A neutral sentiment can be the result of a neutral language or a balancing of some extreme positive sentiments compensated by negative ones. Once negative and positive words are identified with each dictionary, we construct a tone variable based on the balance between the number of positive and negative words that appear in a given document divided by the total number of words included in the document.

To build the sentiment indices, we use the topic mixture computed from the DTM in combination with dictionary methods to compute weighted average tones, following the approach proposed by Hansen and McMahon (2015). This allows generating different sentiment measures from a set of text, and focusing that sentiment on the topics of interest.

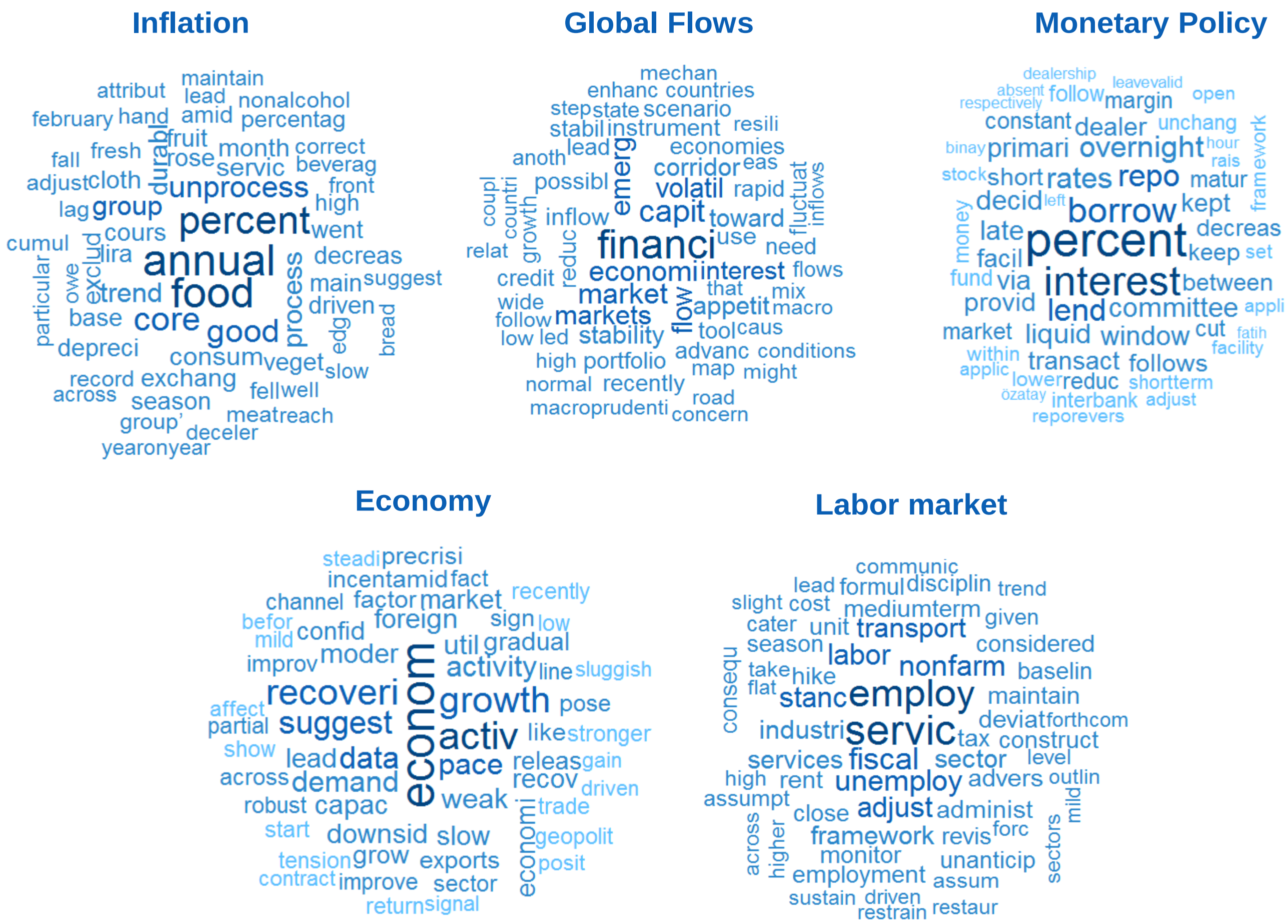
3. Empirical Results: How the Central Bank of Turkey Talks

In this section we present the main results of applying the NPL techniques to the Statements and Minutes of the Central Bank of Turkey from 2006 to 2017. The first section (3.1) describes some of the 30 latent vectors extracted by the Dynamic Topic Model. In the second section (3.2), we look at the evolution of these topics over time while the interconnectedness of the topics is explained in the third section (3.3). Finally, we show the sentiment of these topics, including the sentiment of the monetary policy stance in the last section (3.4).

3.1 The evolution of Topics in the Central Bank of Turkey Minutes & Statements

Getting information from the CBRT Monetary Policy documents from the web from March 2006 to September 2017, we pre-process the text, converting it into data. We apply NPL techiques and topic modelling through the Dynamic Topic Model (DTM), asking the algorithms to select 30 latent vectors of words. It is up to the anaylist to provide meaning to the topics estimated by the DTM. While some of the estimated topics are related to the internal wording of the bank (when and where meetings are held) or direct comment on graphs or economic results, most topics have economic interpretability, this is, out of 30 estimated topics, 22 have a direct economic interpretation. While all the topics are different, in order to facilitate the analysis, topics assessed to have a common theme have been aggreagated in 7 groups: FX and Liquidity (3 Topics), Inflation Non Core (3 Topics), Monetary Policy (8 Topics), Economic Activity (3 Topics), Labor Market (3 Topics), Global Flows and BOP (1 Topic), Fiscal and Structural (1 Topics), Other (8 Topics). Figure 3.1.1 shows the results to some of these groups.

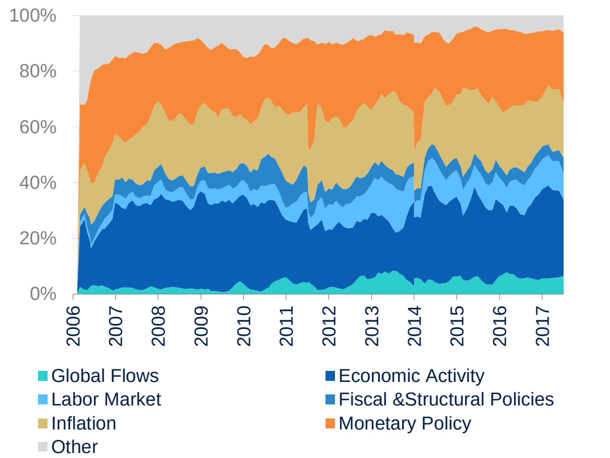
Figure 3.1.1 Word Clouds of some of the estimated topics



Source: Own Calculations

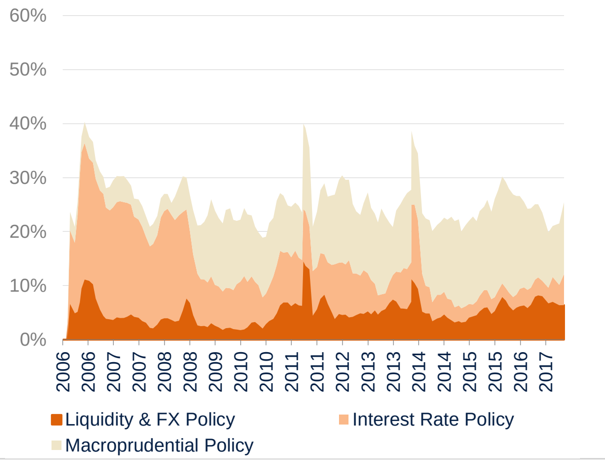
Regarding to the prevalence over time of these topics, Figure 3.1.2 presents the estimated document average mixture weight of the topics within the documents. This can be interpreted as the percentage of the content within a document that is related to a particular topic. As stated before, the topics with relevant economic semantics account for most of the weights within the communications, ranging from over 80% to just above 90%, On average (2007-17) the topics with greater influence (or weight) are *Economic Activity (26%)*, *Monetary Policy (26%)* and *Inflation (21%)*.

Figure 3.1.2 CBRT Topics evolution (in %)



Source: BBVA Research

Figure 3.1.3 CBRT Monetary Policy topics evolution (%)



Source: BBVA Research and CBRT

- The *Economic Activity* topics show a great deal of fluctuation. Its initially high weight shrinked somehow from 2010 to 2014 (displaced by the *Employment* and *Global Flows* topics), to increase its importance after the 2016 slump in the economy. Employment has been also fluctuating, but increasing its relevance since 2012.

- The *Inflation* topic has been gaining momentum in the documents, especially after periods in which supply shocks rapidly passed through to consumer prices.

- The *Fiscal and Structural* topics have kept a low but constant weight. This is the expected result as the Central Banks make references to these policies in the sense that they can affect monetary policy. The average tone dedicated to these topics during 2006-16 is 6% which is slightly higher than the average of fiscal words used by the Federal Reserve (4.2%), Bank of Japan (2.4%), Bank of England (3.5%) and Riks Bank(3.2%) but lower than the European Central Bank (11.9%) for the period 1999-2011.[3]

- Unsurprisingly, the *Monetay Policy* component is one of the most relevant in the CBRT communications, navigating around 26% of the documents. However the nature of monetary policy changes over time, in order to address this issue, Figure 3.1.3 presents a disaggregation of the topics found in the *Monetary Policy* component. We can appreciate that while liquidity and FX policies remain more or less constant during the first period (until 2010), while the weight marginally increased during the second half. However, there is a noticeable change from

3: Allard,J et Al (2012). Central Bank communication on fiscal policy. ECB Working Paper Series September 2012.

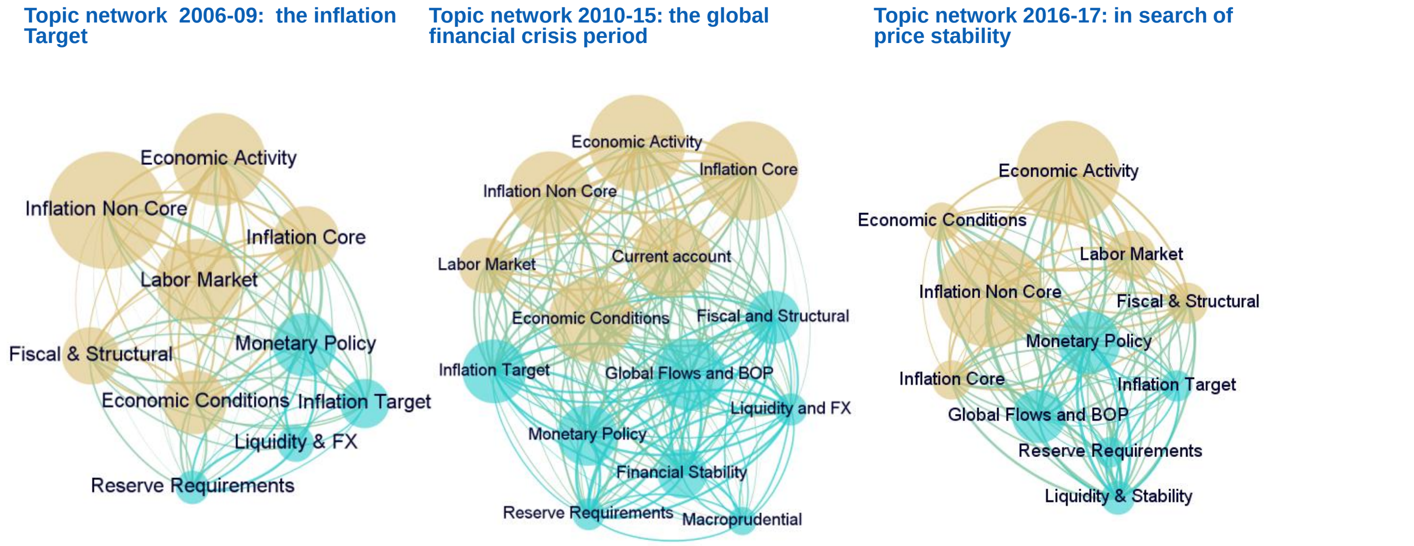
traditional interest rate policies and macroprudential ones, with the former especially important during the first years (the disinflation period) and the Macro prudential policy gaining momentum since 2009 first and 2014. Here, maybe it is difficult to disentangle between the traditional interest rate policy and the macroprudential since the implementation of the interest corridor, which has been sometimes associated as a macroprudential tool.[4]

- Finally, although always presenting a low weight (4% average), the *Global Capital Flows* discussions have been gaining presence, thus reflecting the increasing importance of global conditions and capital flows since the financial crisis. This is particularly true in the Post-Lehman years and after Bernanke's tapering (6% average of the topic). This increase has been parallel to the macroprudential monetary policy increase.

3.2 The increasing complexity of Monetary Policy: network analysis

We also use the results from the DTM to build networks and analyse the interrelations between the topics and how this relational structure can change over time. The DTM with 30 topics is estimated three-fold, using only the data for each of the period of the Turkish economic history. After aggregating the topics in similar groups as the main analysis, we build the networks using the mean weights of each group as nodes and the correlation matrix of probability of occurrence of the words averaged across topic groups as edges. Figure 3.2.1 shows the networks between the main topics identified in the CBRT texts and how they are interconnected with each other depending on the challenges that the monetary authority faces at every period of time. Node color indicates clusters using a community detection algorithm called modularity developed by Blondel et al (2008). Topics for which labeling is unknown are removed from the graph in the interest of visual clarity.

Figure 3.2.1 Network analysis: topic relationships and evolution over time



Source: BBVA Research

4: See Binici, M., Erol, H, Kara, Ozlu, P. & Unalmis , D (2013). Interest Rate Corridor: A New Macroprudential Tool?.CBRT Research Notes in Economics.

- During the *full fledge inflation targeting period before the financial crisis (2006-09)*, both core and non core inflation nodes display signs of centrality and relevance. These are clearly related to the economic conditions and labor markets as key determinants of inflation pressures. During this period, monetary policies are clearly aligned with the prominence of the standard monetary policy.

- In the *Global Financial Crisis period (2010-15)* the monetary policy of the Turkish Central Banks and the Emerging Markets became increasingly complex. As the recession hit these economies, the economic activity conditions increased their presence and inflation worries reduced its weight. External factors appeared in the network, especially the Global capital flows and current account balances worried. Monetary policy increased in complexity, and the traditional and standard monetary policy was divided between standard monetary policy, liquidity and exchange rate management and macroprudential policies. On top of this, financial stability topics gained momentum in the discussions.

- There is a *return to price stability discussions in the recent period (2016-2017).* While economic activity and labor market remain in the network, inflation increased its presence in the policy texts. This time, the focus is on non core inflation woes, which is consistent with cost push supply shocks and structural problems to cope with food price volatility. Policies are somehow more normalized and aligned than during the crisis period, but global capital flows remained present as the FED tapering is also generating capital flows volatility.

3.3 The Sentiment of the CBRT communication policy

Mixing these weights of different topics with the Lexicon approach, we track the sentiment evolution in any of the vectors or group of words. Figures 3.3.1 and 3.3.2 are illustrative of the sentiment of some of the topics. The following graphs show the sentiment included in the monetary policy documents relative to different topics:

- The first important aspect is the divergence trend of economic activity and the labor market, as depicted in Figure 3.3.1, while the economic conditions sentiment has been improving after the slump in the 3Q of 2016, the labour market sentiment performance remains lagging behind. This is particularly true at the end of the sample when the economic activity is jumping but the labour market, although improving, is still lagging.

- The relation between activity and inflation (“the Phillips Curve”) has also changed overtime as observed in Figure 3.3.2. Before the crisis, the output sentiment was leading the inflation one in the same direction and a more stable manner. However, this link softens since 2001 onwards, maybe due to the increasing role of supply shocks.

Figure 3.3.1 Activity & Labor Market sentiment (normalized 3m moving average)

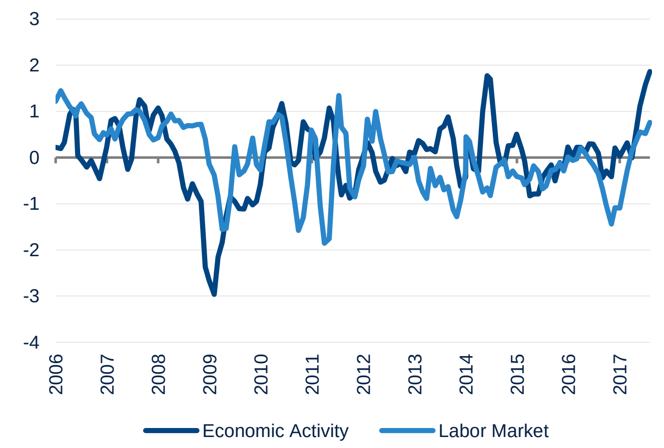
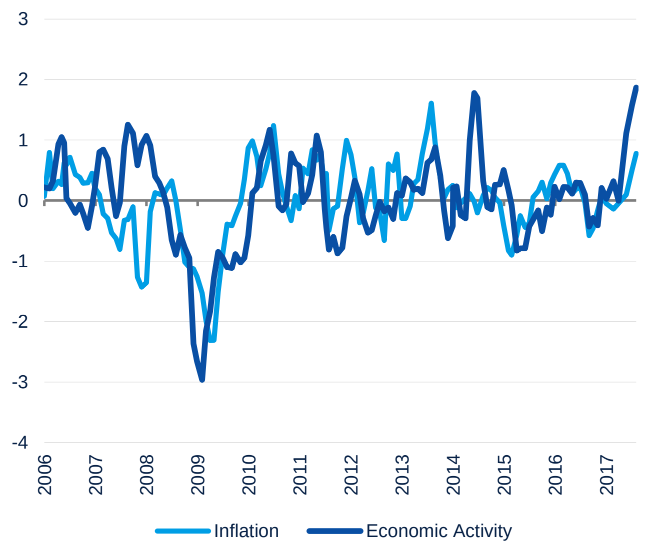
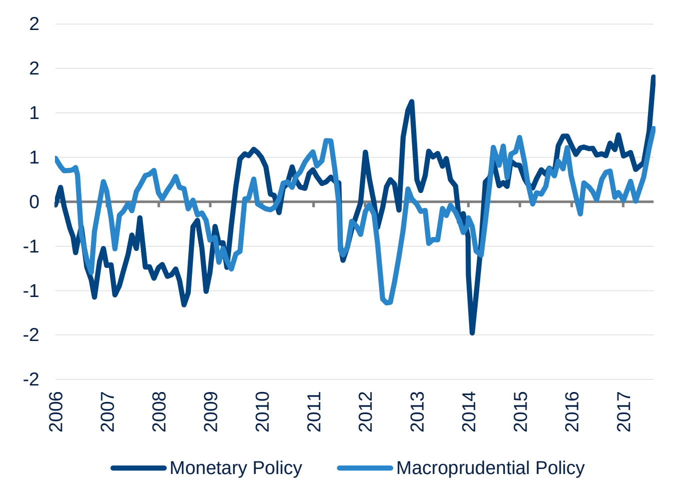


Figure 3.3.2 Inflation Core and Non Core Sentiment (normalized 3m moving average)



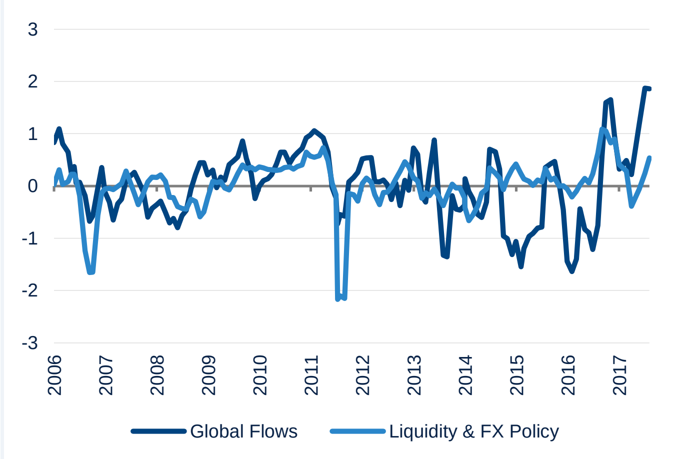
- The sentiments on different monetary policies have also changed over time but we can appreciate the differences between the standard monetary policy and the macroprudential one in Figure 3.3.3. Particularly, we observe the tightening of macro prudential policy in the period of 2012 to 2014, when credit growth rates were growing very fast and the CBRT relied more intensive in macroprudential policies.
- This analysis also allows us to assess the relationship between Global Capital flows and some specific monetary policies such as the ones identified as FX and Liquidity policies. Figure 3.3.4 shows how the CBRT has fine tuned this policy to temper capital flows of sharp FX movements. However, given the higher volatility from both of capital flows since the Bernanke's tapering, the ability to stem flows has been challenged.

Figure 3.3.3 Monetary Policies (normalized 3m moving average)



Source: BBVA Research

Figure 3.3.4 CBRT Capital flows sentiment (normalized 3m moving average)

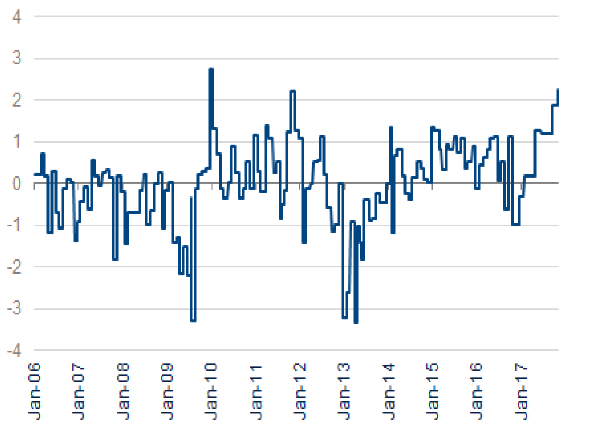


Source: BBVA Research and CBRT

A final and straightforward use of NLP techniques has been employed to assess the monetary policy stance from both the Statements and Minutes of the monetary policy. In this sense, using the lexicon approach, we analyse the tone or sentiment of the latent topics, which should be an adequate tool to understand the stance of monetary policy included in the texts.

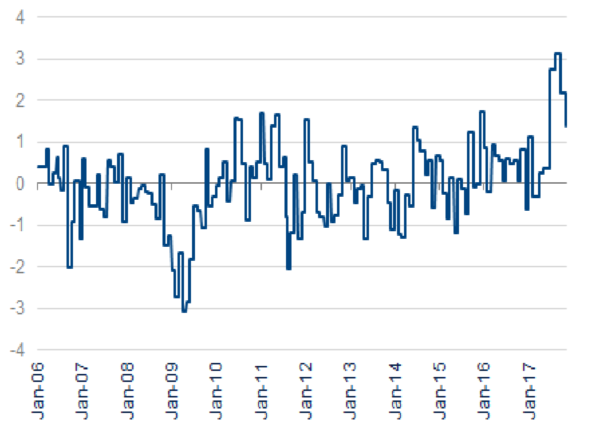
- Figure 3.3.5 and 3.3.6 show the standardized sentiment about inflation in both the Statements and Minutes. The sentiment in both texts falls sharply after the Lehman Crisis once deflationary forces kick in. However, inflationary sentiment recovered rapidly and the supply cost push shocks once the sharp depreciation of the exchange rate start to pass through to inflation. Beyond this, the most salient feature of the graph is the recent spike in inflation sentiments, with no precedents during the period 2006-17. Note thate there is a difference between the sentiment in the Statements and Minutes as the former are shorter and have to be formalized between the Board Members. The Sentiment of the minutes includes the staff assessment which includes a more detailed assessment of the economic situation.
- The CBRT texts show the worries regarding current inflation momentum and that the CBRT is very aware of the situation. As a consequence, the stance of monetary policy is really tight according to the sentiment analysis and it constitutes a reversion of the policy implemented during most of 2016. It has no precedents (only just after the international financial crisis to avoid the second round effects of the sharp depreciations of Emerging Market currencies) and is very unusual in the Post-Lehman period. In short, monetary policy remains about being clearly above neutral levels in a tightening mode.

Figure 3.3.5 CBRT Statements Sentiment



Source: Own Elaboration

Figure 3.3.6 CBRT Minutes Sentiment



Source: Own Elaboration

4. Validating the Dynamic Topic Model: a comparison with Human Coding

While Ex-ante criteria for selecting an empirical approach are suggestive, in practice, it is also crucial to validate the performance of the estimation approach ex post (Gentzkow et al, 2017)[5]. This is particularly true in the cases that Unsupervised Generative Models, in which LDA and Topic models are included. Here, there are no direct observations of the true attributes of the target of research but latent information which depends on prior assumptions imposed on the structure of the model. Besides, validation is particularly important when dictionary methods are used, as in this case the prior information will depend also on the selection criteria of dictionaries.

When the goal is forecasting, the primary tool for validation is checking out-of-sample predictive accuracy of the models. However, in our case we are not interested in prediction, but rather to obtain some latent topics, their sentiment and the relation among the topics over time. One effective approach to validate this analysis is the so-called manual audits or some cross-checking on the fitted values against the coding a human would produce by hand. As suggested by Gentzkow et al. (2017), the subsample of documents does not need to be large in order to be valuable and validate (often as few as 20 or 30 documents is enough to provide a sense of whether the model is performing as desired). A good example of this is Baker et al. (2016)[6], who perform a careful manual audit for their macroeconomic uncertainty index.

In our case, we can also validate our results with external ones as those obtained by Demiralp, Kara & Ozlu (2012)[7] . These authors analyse the statements of Turkey Central Bank from February 2002 to July 2010 and construct a dummy to detect unanticipated changes in the policy statements by directly going through market commentaries associated with each policy statement. They identify whether the statement involves any surprise, using the market

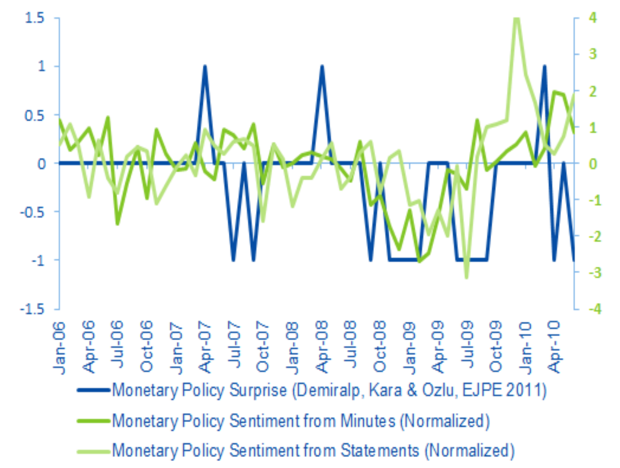
5: Gentzkow, Matthew and Kelly, Bryan T. and Taddy, Matt, Text As Data (February 15, 2017). Available at SRN: https://ssrn.com/abstract=2934001 or http://dx.doi.org/10.2139/ssrn.2934001
6: Baker, S. R., N. Bloom, and S. J. Davis (2016). Measuring economic policy uncertainty. Quarterly Journal of Economics (4), 1593–1636.
7: Demiralp, Selva & Kara, Hakan & Özlü, Pınar, 2012. "Monetary policy communication in Turkey," European Journal of Political Economy, Elsevier, vol. 28(4), pages 540-556.

commentaries regularly published before and after the statement/report is released using the Reuters News database. Basically, they search the market participants' commentaries both before and after the policy decision. Then, they compare these a priori expectations with market commentaries after the policy decision in order to detect surprises in communication by the market participants (i.e an unexpected change in the MPC's assessment of the economic conditions or the monetary policy outlook). Although the authors recognize some difficulties they also identify the direction of the surprise (whether the statement was more “hawkish” or “dovish” than expected or “neutral”). They also compute the magnitude of the “unanticipated” interest rate change by using the Central Bank of Turkey Surveys.

As we identify the “sentiment” or “tone” of the monetary policy for a period of time coincident with their work (January 2006 to July 2010) we can compare our sentiment index with their “surprise” index. Although the measures are not exactly the same (we measure the included sentiment in the monetary policy reports and they assess the surprise and the magnitude of analysts from these statemens), there should be some association, as extreme values in our sentiment should go in line with some of the surprises unless the analyst perfectly foresee the direction of monetary policy. We include both our “statements” and “minutes” sentiment to assess the association of our sentiment indices with their results. The reason to include the “minutes” is that they should provide a more complete assessment of the meeting. As minutes corresponding to a meeting are published with one month lag we associate the minutes relative to a month to the events or surprises in the previous month.

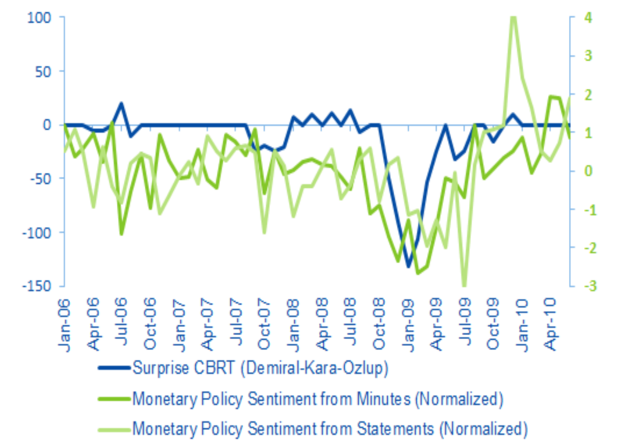
Graph 4.1 and 4.2 show the association between the different measures. The correlation between the sentiment in statement and minutes is not particularly high (0.13 and 0.17) as the monetary policy surprise in is a binary variable with some 0 included in the sample. However, the association is clear in the case of the magnitude of the surprises as now all the series are linear and the sentiment variables can assess the magnitude of the tone. This is particularly true for the case of the minutes (0.6 vs 0.4 in the statements) which is not surprising at all as these documents include a more complete information about the true discussion oh the monetary policy meetings. As the magnitude surprises were measured manually, these results confirm the sentiment indicator validity as a tool for monetary policy research.

Figure 4.1 Sentiments on Statements, Minutes and Surprises



Source: BBVA Research

Figure 4.2 Sentiments on Statements, Minutes and Magnitude of Surprises



Source: BBVA Research and CBRT

5. Monetary Policy “News”, Finacial Markets and the Economy

In their seminal survey on the effects of Central Bank Communications policy (Woodford, 2005), the authors recognize that what they call “short-run” central bank communication (i.e disclosing central bank views on the outlook for the economy and monetary policy) has a substantial impact on financial markets. Official statements, reports, and minutes appear to have the clearest and most consistent empirical effects on financial markets through the “creation” of news or narratives. As economic conditions are not stationary, the central banks are nor fully commited to a stick policy rule and the expectation can be non rational, the margin of monetary police news to affect financial market becomes obvious.

Given that our sentiment measure allows us to assess the information content or news included in monetary policy reports, a logical consequence of this is to ask whether the central bank can influence market expectations and therefore make the policy more predictable. If so, a second important question is how does the central bank communication affect the ultimate goal variables of monetary policy as inflation and/or growth?

In the previous section, we show how monetary “sentiment” is associated to market analyst surprises and how this correlation is relatively high (0.6). Our goal is to further explore on role of the monetary communication transmission mechanism and its impact on inflation and real variables.

We proceed on a different way to answer the effects of Monetary Policy statemens on markets interest rates, as well as on inflation and real variables. Given the rapid response of financial markets to Central Banks communications, we use a high frequency (daily) event study to analize how the market rates response to the Central Bank monetary policy statements through the yield curve. To analyze the real effect, we rely in VAR models as a conventional view to explore impulse response analysis of some variables to a shock in a particular one. As we have built an alternative measure of the monetary policy "sentiment" we can check its effects on the economy relative to a traditional interest rate monetary policy shock.

5.1 The CBRT communication policy transmission to the markets

In this section we designed an event window analysis to assess whether the monetary policy communication affects the market rates corresponding to the short part of the term structure of interest rates and the long part of the yield curve. For the short part of the curve, we choose the interbank deposits rates at one, three and six months. For the long term, we selected the bonds swap rates of three months, one year and two years as these markets are more liquid than the bond rates[8].

We proceed in two steps. First we compute changes in the sentiment of the statements higher than one standard deviation from 20016 to November 2017. We found fourteen events of which only one included a material increase of interest rates, thus we eliminate the possibility of the effects coming from the increase of interest rates rather than changes in the communication policies. Once these events are identified, we build a window of twenty labor days before and after the day in which the sharp change in moneraty policy tone happened. The interest rates are expressed in terms of differences to the event of change in sentiment "t". Therefore, the graphs show the increase or decrease of interest rates twenty working days before and after and relative to the previous day of the event "t" to capture the impact also in the day of the change in sentiment. We also distinguish between "normal" changes in sentiment (below one standard deviation) and "sharp" changes (one standar deviation or higher" for both positives changes in sentiment or "tighter" policy and negative changes or "easining"). The main reults can be observed in the Figures 5.1.1 to 5.1.4 are the following:

- Positive changes in sentiment in the monetary policy statements have clear effects on both the short term interbank deposit rates and the long term swap rates (Figures 5.1.1 to 5.1.4). However, this result holds only in the case of sharp changes while minor changes in sentiment (below one standard deviation) have minor positive effects only in the interbank market. In the case of sharper changes in sentiment there is a positive effect along the yield curve which is near 5bp in the first two weeks and increase thereafter to near 20 bp in the interbank and near 35 bp in the the bond swap curve. There is also some positive slope effects as the changes in the 2 year swap rate is near 10 bp higher that the one month interbank rate. The fact that the change of sentiment tends to increase with the maturity of the contract is in line with those obtained for Turkey by Demiralp, Kara and Ozlu (2002) and consistent with those obtained in earlier literature (see Andersson et al., 2006; Kuttner, 2001; Demiralp and Jorda, 2004; Kohn and Sack, 2003).

8: We also repeat the analysis with the bond yields and results did not change substamtially.

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Figure 5.1.1 Response of Interb. rates to Mild Positive Changes in Sentiment (Tight)
(bp, change in sentiments lower than1 standard deviation)

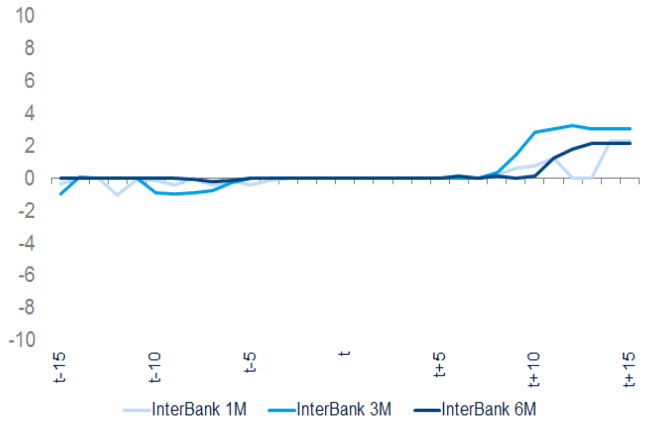


Figure 5.1.2 Response of Bond Swap Rates to Mild Positive Changes in Sentiment (Tight)
(bp, change in sentiments lower than1 standard deviation)

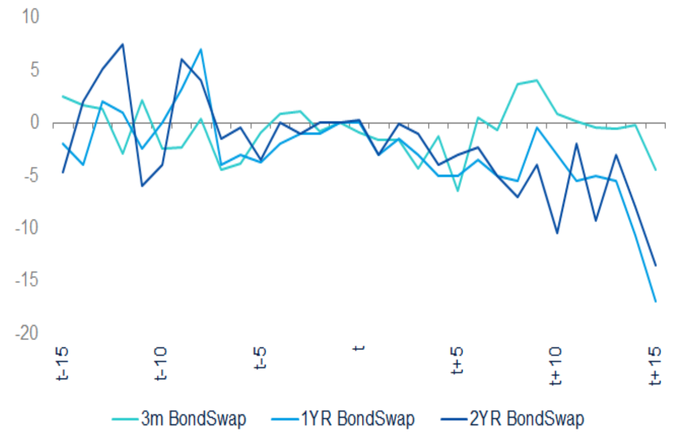


Figure 5.1.3 Response of Interb. rates to positive changes in Sentiment
((bp, change in sentiments higher than1 standard deviation)

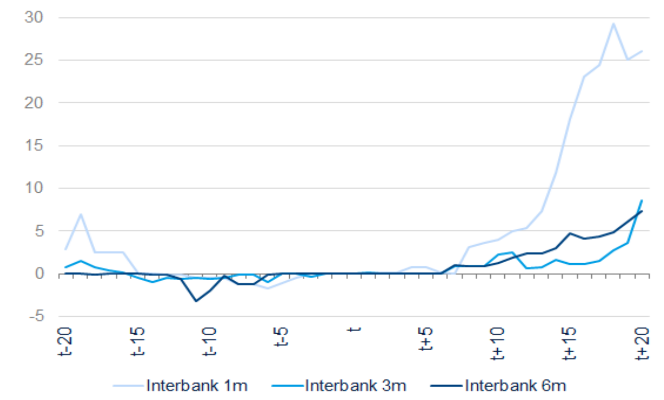
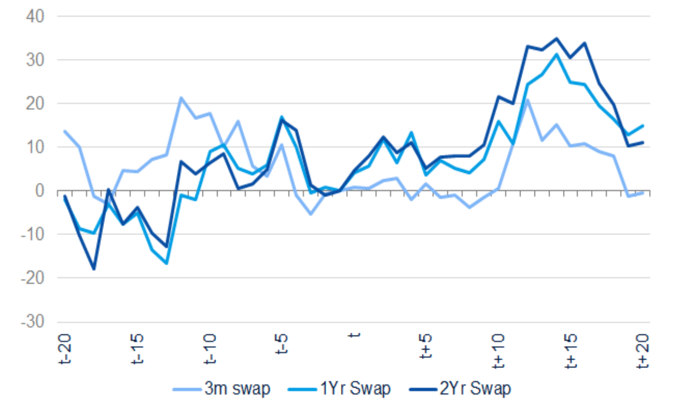


Figure 5.1.4 Response Bond Swap Rates curve to positive changes in Sentiment
(bp, change in sentiments lower than1 standard deviation))



- The negative changes in Sentiment (easing) have negative effects in the yield curve. However this is only the case in the case of changes in sentiment below one standard deviation. These changes are more inmediate and have an impact of near 10 bp at the end of the first week increasing the negative effect thereafter. The negative effect is increasing along the maturities of the yield curve with an extra ten basis point effect in the bond swap rates. When the changes in negative sentiments are larger than one standard deviation, the short term rates increase (rather than the decrease) and swap bond rates stabilize. This pattern can be the result of several explanations. First, it could be the consequence of market participants interpreting the policy changes both intense but transitory ("leaning against the wind") to cope with a recession period similar to events as the Lehman Brother´s collapse in

2009. In these situations, markets anticipate the reaction of the Central Bank but once the monetary authority fulfills the market expectations they stabilize rather than continue to signal further easing of monetary policy, as markets perceive the movement as a sharp but transitory reaction. This is consistent with the movements in Figure 5.1.8 where expectations decrease rapidly before the change in the sentiment but stabilizes thereafter. It can be also the result of lack of credibility if the market perceives that a sharp reduction of the official interest rates will be only temporary as the exchange rate depreciation after the monetary policy easing will pose inflationary pressures in the medium term.

Figure 5.1.5 Response of Interb. rates to mild Negative changes in Sentiment
(in bp relative to the change in one standard deviation in statement sentiment)

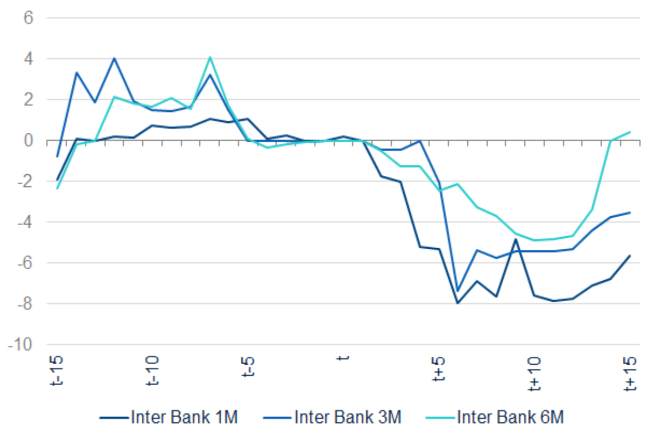


Figure 5.1.6 Response of Bond Swap Rates curve to mild negative changes Sentiment
(in bp relative to the change in one standard deviation in statement sentiment)

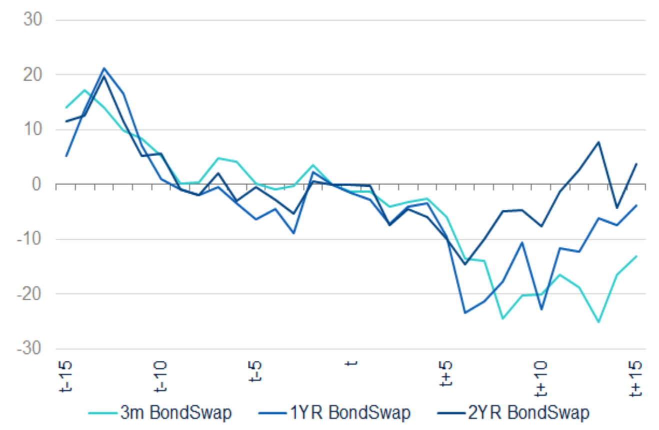


Figure 5.1.7 Response of Interb. rates to negative changes in Sentiment
(bp, change in sentiments lower than1 standard deviation)

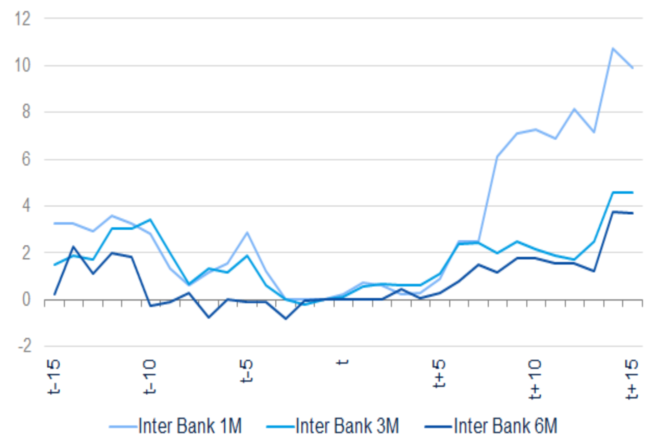
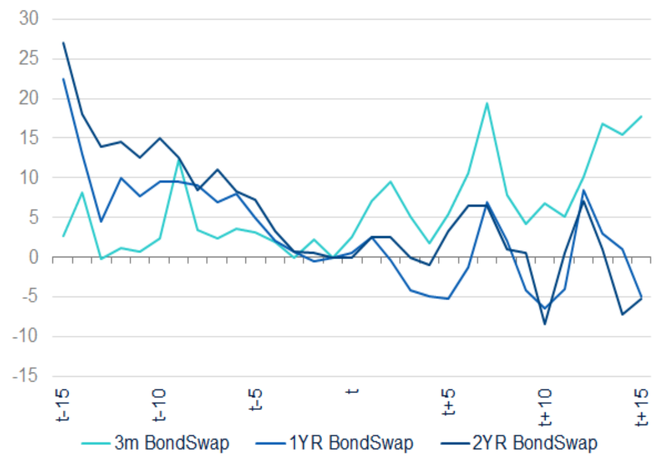


Figure 5.1.8 Response of Swap Rates curve to Negative Chnages in Sentiment
(bp, change in sentiments lower than1 standard deviation)



In sum, our results are consistent with previous literature and show that interest rates react to the Central Banks communications on the right direction, consistent with the work by Ehrmann and Fratzscher (2007b), which find that statements generally move financial markets in the intended direction: statements suggesting tightening lead to higher rates, while statements suggesting easing lead to lower rates. The magnitude in basis points is also consistent with the previous work for Turkey (see Demiral, Kara and Ozlu, 2012). Although the reaction looks to be symmetric in term of magnitude there are some asymmetries in how the market reacts to normal (below one standard deviations) or sharp changes (one standard deviation or higher) in tightening or easing signals. Particularly, we show that the reaction of the markets to positive changes in sentiment has higher and significant effects in the case of sharp changes with neutral effects on normal changes. In constrast, normal negative changes in sentiment are effective and in the right directions (signaling further declines in rates) while they stabilize after sharp changes in sentiment[9].

5.2 The CBRT communication policy effects on inflation and real variables

A key issue in the identificacion of monetary policy in the VAR is the order of the variabels. A ”standard” way to identify monetary policy shocks is through zero contemporaneous restrictions. Using the standard monetary VAR including output growth, inflation and the interest rate we identify the monetary policy shock using the following restrictions: 1) Monetary policy shocks do not affect output within the same period 2) Monetary policy shocks do not affect inflation within the same period. These two restrictions are not sufficient to identify all the shocks but are sufficient to identify the monetary policy shock (Christiano Eichenbaum and Evans, 1999)[10].

A simple way to implement the restrictions is to take the Cholesky decomposition of the variance covariance matrix in a system in which the federal funds rate is ordered. The last column of the impulse response functions is the column of the monetary policy shock. A similar approach can be found in the analisys that uses FAVAR models (Bernanke and Boivin, 2003)[11], here the authors distinguish between “fast-moving” and “slow-moving” variables. The “slow-moving” series are basically predetermined in the current and include production and price series, while examples of “fast-moving” variables include interest rates, exchange rate series or financial markets series.

Taking these considerations in mind we estimate two alternative VAR models, one accounting for a traditial tool of monetary policy (the official interest rate) and the sentiment extracted from the minutes. The specification of the model is the following:

$$Y_t = A(L)Y_{t-l} + u_t$$

$$Y_t = B(L)u_t \quad (1)$$

In order to assess the difference in effects between the standard monetary policy and the effects of sentiment or news included in the minutes, we estimate two alternative models in monthly frequency for the period 2010-2017. The first

9: Sahminan, S (2008) shows that there is asymmetry in the effects of the statements, that is, the statements with loose policy inclination tend to be more effective relative to the statements with tight policy inclination.
10: Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy" Journal of Political Economy, 113(1): 1-45, February 2005.
11: Bernanke, B. & Boivin, J. "Monetary Policy In A Data-Rich Environment," Journal of Monetary Economics, 2003, v50 (3,Apr), 525-546.

model is the standard one, including the vector of variables $Y_t = [y_t, \pi_t, i_t, i_t^{lt}]$ representatives of the change in economic activity (y_t), change in consumer prices or inflación (π_t), an interest rate representative for the official interest rate (i_t), and a long term interest rate (i_t^{lt}) to assess the impact of the monetary policy on the long term rates. In general, it is accepted that central bank interest rates (i_t) and communications (st) influence expectations of future short-term rates thus influencing long-term rates and other financial-market prices. These prices, in turn, influence such macro variables as inflation and output, y_t and π_t. The second model will include the same variables except for the official interest rate, which will be replaced by s_t then leading to the vector $Y_t = [y_t, \pi_t, s_t, i_t^{lt}]$. The estimations include a lag for all the variables as suggested by the Bayesian Schwartz criteria and allow for time trend which is significant for some of the variables as the interest and market rates.

As mentioned before, we use the Cholesky factorization of the shocks to account for the fact that ouput and inflation will not be immediately affected by the monetary policy sentiment index, but fast reaction variables as the long term interest rates will response contemporaneously to the monetary shock. The MA representation of the VAR can be expressed as:

$$Y_t = B(L)v_t \quad (2)$$

The identification of the relevant structural parameters, given the estimation of the reduced form, is a traditional problem in econometrics. A structural model is obtained by assuming orthogonality of the structural shocks and imposing some plausible restrictions on the elements in *B(L).* Following the literature, we assume that the underlying orthogonal structural disturbances (εt) can be written as linear combinations of the innovations (vt):

$$v_t = S\varepsilon_t \quad (3)$$

where S is the (4x4) contemporaneous matrix. The VAR can then be written in terms of the structural shocks as:

$$Y_t = C(L)\varepsilon_t \quad (4)$$

Where *B(L)S= C(L)*. Clearly, if S is identified, we can derive the MA representation in (4) since B(L) can be calculated from the reduced-form estimation of (2). Hence, to go from the reduced-form VAR to the structural interpretation, restrictions must be applied on the S matrix. Only then, the relevant structural parameters from the covariance matrix of the reduced-form residuals can be recovered.

To identify S, we first assume that the vector of ε_t is normalized so that they all have unit variance. The normalization of cov(ε_t) implies that SS' = Ω. With a four-variable system, this imposes ten restrictions on the elements in S. Following the standard literature in identifying monetary policy shocks, the recursive order between monetary policy shocks and the macroeconomic variables implies the following restriction on the S matrix

$$\begin{bmatrix} y \\ \pi \\ s \\ i^{lt} \end{bmatrix} = \begin{bmatrix} s_{11} & 0 & 0 & 0 \\ s_{21} & s_{22} & 0 & 0 \\ s_{31} & s_{32} & s_{33} & 0 \\ s_{41} & s_{42} & s_{43} & s_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_y \\ \varepsilon_\pi \\ \varepsilon_s \\ \varepsilon_i \end{bmatrix} \quad (5)$$

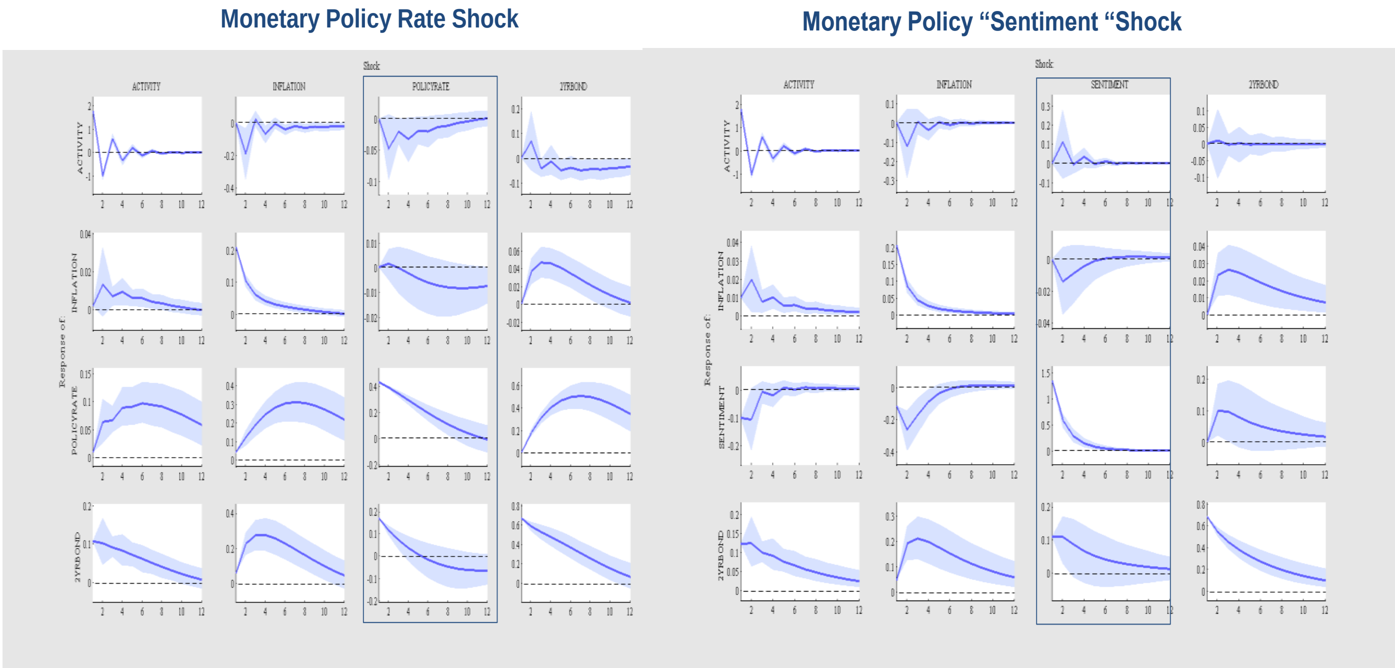
Note that this follows the Christiano, Eichenbaum and Evans (1999)[12] restrictions, mainly that monetary policy shocks do not affect output and inflation in the same month (as zero restrictions have been imposed) in the lower triangular S matrix. Beyond this, long term rates don't affect monetary policy in the same period as the monetary (or sentiment) is affected in the same period by output and inflation only (s_{34}=0), but long term rates can react in the same period by the rest of all variables and in this sense, it is the fastest reaction variable in the model.

The impulse response functions for the alternative model can be observed in the Figure 5.2.1. The standard model can be observed on the left hand side of the Figure. The results show how a monetary policy shock is well identified as it leads in both cases to a decline of the output followed by inflation. The reaction of the financial markets is also inmediate, in the same direction and has some persistence, thus confirming the expectation hypothesis.

What are the effects of the sentiment on monetary policy in the financial markets and the economy? Our first result shows that the "Central Bank Communication" or "sentiment" shocks have significant effects on long term rates. In fact, the impulse response shock of the two year bond shows a higher and more persistent response from the sentiment shock. This is line with previous results for the Federal Reserve (Demiralp and Jorda, 1999)[13] which confirms empirically how only surprise changes can affect a rational mechanism that explains the long term rates as a weighted average of interest rates.

12: Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy" Journal of Political Economy, 113(1): 1-45, February 2005
13: Demiralp, S. and Jorda, O. (1999). "The transmission of monetary policy via announcement effects". WP 99-06 University of California at Davis

Figure 5.2.1 Monetary Policy Rate and Monetary Policy Sentiment Shocks in a 4 VAR Model



Source: Own Calculations

This result confirms those obtained for previous empirical works for both Developed and Emerging Central Banks. While most of the studies have focused in the analysis of the developed Central Banks (Ehrmann and Fratzscher (2007b) and Musard-Gies (2006), there is also some evidence for the Emerging Markets. This is the case of Rozkrut et al (2007), which finds that Central Banks “talk” in the Czech Republic, Hungary, and Poland influences behavior of financial markets, Sahminan (2008) for the case of Central Banks of Indonesia and Thailand, Garcia-Herrero, Girardin and Lopez-Marmolejo (2015) for the case of Brazil and Garcia-Herrero, Girardin and Dos Santos (2015) for Brazil. For the case of Turkey, Demiralp, Kara and Ozlu (2012) find some evidence of the communication policy influencing the financial markets.

The effects of Central Banks communication sentiment on inflation are lower than in the standard interest rates model, but they are felt faster just immediately after the sentiment shocks. Another crucial difference is that sentiment shocks affecting inflation have not a significant effect on activity. This last result is consistent with the survey by Blinder et al (2008), which finds virtually no evidence on the effects of central bank communication. More recently Hansen and MacMahon (2015) using computational linguistics (NPL techniques) shows in a FAVAR framework that while there is evidence of effects on markets variables communication policies, they do not have relevant effects on real variables.

6. Conclusion

We have applied Big Data and Data Science techniques to the analysis of the monetary policy reports of the Central Bank of Turkey. We found that the NLP techniques are an adequate tool to the analysis of monetary policy in Turkey since they help us to understand the main challenges and the evolution of Turkish Monetary Policy. In this sense, these new methods should be considered as a relevant tool to complement the traditional ones.

There are a couple of significant insights from the policy texts. First, topics under discussion have been changing over time as the global economic conditions have changed substantially. The traditional discussions on inflation were replaced by economic conditions and capital flows volatility during the crisis, but they are now returning to the fore. Second, the monetary policy strategy has increased complexity as the financial crisis amplified capital flows volatility; and the standard monetary policy has to be complemented with macroprudental and liquidity policies to deal with inflation and financial stability simultaneously.

The analysis shows some insights on actual juncture. The prominence on inflation has increased in both core and non core inflation. In fact, the inflation topic is increasingly important again. Besides, the commitment to a tight monetary policy stance to deal with it is now at maximum levels.

The robustness check comparing the algorithms with human expert coding shows that NPL techniques are a valid tool for the sentiment analysis of the Monetary Policy in Turkey. In this sense, the high correlation found in our analysis with previous expert coding confirms the validity of our result and the use of the ML dictionary.

Our results confirm the importance of the Central Bank Communication policy driving expectations of the future path of monetary policy and this widens across the yield curve spectrum. However, less conclusive results are obtained for the impact on both inflation and real variables, thus reflecting that standard monetary policy would be needed to ultimately validate verbal policies.

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