

Borradores de ECONOMÍA

Effects of the central bank's
communications in Colombia. A
content analysis.

Por: Luis E. Arango,
Javier Pantoja,
Carlos Velásquez

Núm. 1024
2017



tá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Col

Effects of the central bank's communications in Colombia. A content analysis.

Luis E. Arango
Banco de la República

Javier Pantoja
Universidad EAFIT

Carlos Velásquez*
Universidad EAFIT and
Bancolombia

Abstract

We carry out a reading analysis that consists of two elements. First, we observe the coherence between monetary policy actions and press releases. In this case, we found that inflation and growth are significant themes in the adoption of the policy measures between September 2004 and March 2016. Moreover, when inflation and economic growth are both raising the monetary actions becomes tighter. Nevertheless, economic activity has always coefficients greater than those of inflation. In second place, the monetary authority goes beyond explanations in the press releases: there are some traces of forward guidance in a number of communications with different degrees of commitment. We also assess whether Colombia's Central Bank uses its communications as a complementary monetary policy tool and estimate the effectiveness of this strategy. To do so, we use a machine learning technique to unveil the semantic structure of the central bank's communications. This technique allows us to extract some semantic factors that are used in a structural VAR to identify and measure the impact of these communications on inflation expectations. Our results indicate that Colombia's Central Bank uses communications as a monetary policy tool and that this strategy influences market inflation expectations.

JEL classification: C4, E4, E5.

Keywords: *text mining, content analysis, latent semantic analysis, central bank's communications.*

* The opinions expressed herein do not represent the Banco de la República, nor Bancolombia nor their respective boards of directors. Research assistance of María Paula Medina Pulido and Nataly Andrea Pedraza Jiménez is greatly acknowledged. This paper has benefited from the comments and suggestions of Andrés González. Corresponding author: Luis Eduardo Arango: larangth@banrep.gov.co; phone + 57 1 3430676; Carrera 7 No. 14-78, Banco de la República, Bogotá-Colombia.

“The field of economics should be expanded to include serious quantitative study of changing popular narratives. To my knowledge, there has been no controlled experiment to prove the importance of changing narratives in causing economic fluctuations” (Shiller, 2017)

1. Introduction

The inflation targeting strategy is characterized, apart from announcing specific inflation targets, by high transparency, fluid and clear communication to the public, and explicit accountability mechanisms (see Hamann, Hofstetter and Urrutia, 2012).

Due to improvements in information processing technology and more connected financial markets, agents have a higher ability to anticipate central banks’ measures which has led to a loss of effectiveness of monetary policy based upon surprises (Woodford, 2001).¹ As a response to this circumstance, central banks began to change their strategy towards a more transparent approach in which they allow markets to know more about the monetary policy process and future decisions. In the monetary policy framework, transparency can be understood as the degree in which a central bank releases information about economic outlook, objectives, strategy, future decisions, monetary policy rules, parameters, and other signals that can be used by markets to shape expectations and make decisions.² As Poole (2001) states, the presumption of this approach is that agents can make more efficient decisions when they can correctly predict the actions of central banks. Thus, transparency allows central banks to signal future policy intentions, which can be regarded as an alternative policy instrument.

Eusepi and Preston (2007) suggest that within an inflation targeting strategy more information about the monetary policy process, such as the variables used and the parameters of monetary policy rule, should be released. Whereas Svensson (1998) and Neuenkirch (2012) find that transparency is welfare improving, the works of Walsh (2006) and Van der Cruijssen, Eijffinger and Hoogduin (2010), who deal with the problem of establishing an optimal transparency policy, conclude that transparency is welfare improving up to an optimum that depends on the characteristics of each market. Neuenkirch (2013) finds that an intermediate level of transparency is optimal.

Communications of monetary authority on policy decisions are aimed either at explaining the actions or at driving inflation expectations.³ In this sense, Blinder, Ehrmann, Fratzcher, Haan y Jansen (2008) pointed out that “... the evidence suggests that communication can be an important and powerful part of the central bank’s toolkit since it has the ability to move financial markets, to enhance the predictability of monetary policy decisions, and potentially to help achieve central banks’ macroeconomic objectives”.⁴ Announcements are different from communications in the

¹ Goodfriend (1986) condensed the critics for the secrecy of the Federal Reserve.

² Romer and Romer (2000) showed that central bank forecasts are better than those made by private institutions.

³ Woodford (2001) stated that “monetary policy is the art of managing expectations”.

⁴ Using a macroeconomic model, Blinder and his coauthors showed that central bank communications would not be important in the case of three unrealistic assumptions. These are in turn: a stationary economy, symmetric information

sense that the former provide markets with information on tangible actions to be applied immediately such as, for instance, asset purchases, exchange rate management decisions, and so on. Communications, on the other hand, are normally associated with the economic outlook, objectives, strategies, future decisions and the reasons that support these (Blinder et al., 2008). Announcements are expected to have a more direct influence on actual market behavior than on expectations. Several papers have studied the effects of announcements on financial markets' behavior and volatility, and others the effect on exchange rate and commodities (Rigobon and Sack, 2006). In this paper we focus on communications instead of announcements, which makes it necessary to use very different methodologies.

The economic downturn of the past decade, which drove interest rates in developed economies to historically low levels, showed that inflation targeting countries might not be the only ones that can complement monetary policy with a good communication strategy. The zero-lower bound restricted the use of traditional monetary policy in such a way that a number of central banks explored unconventional policies, including promises of future policy actions, aimed at driving the expectations of households and the private sector.⁵ Monetary policy communications can sometimes be used to improve and catalyze policy effects and sometimes as the main and unique alternative to carrying out monetary policy actions, which is the case under zero-lower bound restriction (Campbell, Evans, Fisher and Justiniano, 2012). This led to a new line of research which established that central bank communications are crucial in monetary policy as a mechanism to guide market expectations.

The monetary policy has been traditionally studied from a quantitative perspective, and in Colombia little academic attention has been paid to the role of the central bank's communications. However, the potential use of central bank communications as a tool to manage expectations, motivates our interest in evaluating the impact of these communications in the Colombian economy. To our knowledge, Castro (2012) is the only article focused on the effect of Colombia's central bank's communications.

This paper contributes to the existing literature in two main aspects. In first place, it investigates whether Colombia's central bank's communications are in line with the policy actions. For this purpose, we propose a content analysis on monetary policy communications spanning between September 2004 and March 2016, and selected four main themes (inflation and inflation expectations, economic activity, exchange rate, and international context) to test the hypothesis that the measures are connected to them. Secondly, we check whether monetary policy communications are used as a complementary tool to monetary policy actions. Thus, the paper evaluates the quantitative impact of Colombia's central bank's communications on the economic situation

between market agents and central banks, and rational expectations. They cite some reasons why these assumptions are unrealistic. Clearly, the economy is not stationary, symmetric information is rejected and, regarding expectations, Blinder et al. (2008) emphasized that a learning process is more accurate to describe the way agents introduce monetary policy in their decisions.

⁵ Given the zero-lower bound, forward guidance has emerged as a complementary policy. This can be either Delphic or Odyssean. The former takes places when the board gives signals about future actions but there is no commitment to take them while in the latter there is such a commitment.

indicator (ISE) and on inflation expectations. This is achieved using a structural VAR approach described below.

Castro (2012) makes an analysis focused on the effect of communications and concludes that monetary policy press releases are not significant in explaining yield curve movements. His scope of analysis is similar to ours; however, our approach differs from his in the way we analyze communications and the variable we focus on, which is inflation expectations instead of interest rates. In fact we use an advanced machine learning technique known as Latent Semantic Analysis (LSA)⁶ and evaluate the impact of communications within different structural VAR specifications. By contrast, our results show that these press releases have an impact on the inflation expectations derived from instruments at different maturities.⁷

The paper develops as follows. The next section describes the content analysis performed and the results. Section 3 enunciates the principles of the LSA and shows the themes derived from the singular value decomposition. Section 4 presents and discusses the results of the structural VAR. Finally section 5 draws some preliminary conclusions.

2. Information content

The information content that we carry out in this article consists of two elements. The first is a reading approach that looks for some possible signals or guides included in the policy communications. The second consist of the application of a machine learning technique, called LSA,⁸ aimed at unveiling feasible linguistic structures of Colombia's central bank communications, which allow the construction of latent semantic factors used within a structural VAR model to test the hypothesis that shocks linked to press releases related to policy decisions can affect the inflation expectations. To carry out these tasks, we analyze the accompanying press releases of policy decisions launched by the monetary authority between September 2004 and March 2016.

2.1. Reading approach

The main purpose of this application of the reading approach is to suggest whether Colombia's central bank uses its communications to provide signals of current and future monetary policy actions; in other words, we are trying to observe the consistency between the measures and the content of press releases. This approach relies on the identification of some themes within the text of communications to which we assign values depending on the tone in which these are referenced in each document. We group the tone in which the themes are stated in three broad categories: upwards, downwards, and neutral. Thus, we can assign them –without loss of generality- the values of 1, -1 and 0, respectively.⁹ According to our interpretation of the reading approach, Colombia's

⁶ See Bholat, Hansen, Santos and Schonhardt-Bailey (2015) for a primer on text mining techniques applied to analyses of central banks.

⁷ Flórez-Jiménez and Parra (2014) explore the effect of escape clauses under zero-lower bound conditions.

⁸ Latent Dirichlet Allocation and Descending Hierarchical Classification are other text mining techniques (see Bholat et al., 2015).

⁹ For example, if the press document refers to increasing inflation we assign 1 but if the monetary authority refers to this variable as going downwards we assign -1, and so on with the rest of variables.

central bank's communications normally refer to four main themes: inflation and inflation expectations, economic activity, exchange rate, and international context, the latter including commodity prices. Table A1 in the Appendix shows the reference of themes.

Table 1 shows the results of OLS times-series estimations of the change in the intervention rate of the different themes included in the press releases accompanying the measure. Model (1) includes the four topics; however only inflation and economic activity are significant. Unfortunately, this model, as well as model (2), does not have good properties. Even model (3), which includes lags of inflation and economic activity, does not improve the Durbin-Watson statistic. To reduce the remaining structure of the innovation process, model (4) includes two lags of the intervention rate while retaining the themes related to inflation and economic activity, which are still significant. Accordingly, when the monetary authority regards that each of these two variables is moving upwards, the intervention rate will move in the same direction. In the case in which each of them moves downwards the intervention rate will move accordingly. Model (4) also shows the inertia of policy actions: once the monetary authority starts to intervene, it continues a few periods with the same action. In our estimates, the third lag was not significant.

Table 1. Policy response to selected topics. 2004:09 and 2016: 03.

Factors	Dependent variable: Intervention rate variation measured in basic points								
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)
Inflation	7.7546 ^{***} (2.0953)	7.5660 ^{***} (1.9847)	5.1476 ^{**} (2.1535)	4.2491 ^{**} (1.6232)	8.4682 ^{***} (2.5847)	2.5018 (1.6783)	3.1680 [*] (1.6575)	2.3997 (1.6561)	6.3256 ^{**} (2.8226)
Inflation (t-1)			5.2561 ^{**} (2.1604)						
Economic activity (growth)	14.4085 ^{***} (2.2033)	14.2358 ^{***} (2.0829)	10.6860 ^{***} (2.7698)	6.6627 ^{***} (1.8719)	8.9638 ^{***} (2.1542)	3.0895 (2.1680)	4.9754 ^{**} (1.9694)	3.2941 (2.0600)	6.9191 ^{***} (2.4160)
Economic activity (growth) (t-1)			4.7879 ^{***} (2.7684)						
Exchange rate	-2.4684 (3.5589)								
International context	-0.8041 (2.4382)								
Inflation up × growth up					-12.1547 ^{**} (5.8394)				-8.4661 (6.1368)
Inflation down × growth down						-17.5340 ^{***} (5.8052)			
Inflation up × growth down							11.8290 ^{***} (4.9371)		9.4423 [*] (5.2155)
Inflation down × growth up								18.3537 ^{***} (5.4364)	
Intervention rate variation (t-1)				0.4149 ^{***} (0.0849)	0.4104 ^{***} (0.0838)	0.3529 ^{***} (0.0845)	0.3696 ^{***} (0.0855)	0.3545 ^{***} (0.0836)	0.3756 ^{***} (0.0853)
Intervention rate variation (t-2)				0.2211 ^{***} (0.0796)	0.2023 ^{**} (0.4682)	0.2368 ^{***} (0.0774)	0.2286 ^{***} (0.0782)	0.2302 ^{***} (0.0766)	0.2140 ^{***} (0.0787)
Constant	-3.7664 [*] (2.1488)	-3.9270 ^{**} (2.0029)	-3.7127 [*] (2.0222)	-1.5043 (1.6126)	1.4024 (2.1184)	1.8732 (1.9236)	0.6129 (1.8142)	1.8891 (1.8496)	2.2109 (2.1472)
Adjusted R²	0.3112	0.3187	0.3707	0.5783	0.5887	0.6028	0.6079	0.6235	0.6135
Durbin-Watson	1.0035	0.9934	0.9111	1.9761	1.9871	1.9825	1.9584	1.9975	1.9758
N	139	139	138	137	137	137	137	137	137

Note: *** significant at 99%; ** significant at 95%; * significant at 90%. Source: Banco de la República's press releases and authors' interpretations (see Table A1 in the Appendix).

Model (5) in Table 1 also includes the interaction of inflation and economic activity when both move upwards simultaneously (and this interaction takes the value of 1). When this is the case, the intervention rate still reacts to these two themes, and the inertia in the actions remains; however, the

sign of the interaction suggests that policy takes this simultaneous occurrence into account. Model (6), on the other hand, shows that when both variables move downwards (and this interaction takes the value of 1) the monetary authority relaxes the policy stance by reducing the intervention rate.

Models (7) to (9) describe the reactions of monetary authority under more challenging. In these cases, inflation and economic activity are moving in different directions. In the first of these models, the interaction takes the value of -1 when inflation is moving upwards while the aggregate economy is declining. Under these circumstances, the monetary authority has reduced the intervention rate as well as when the inflation is going down and economic activity is rising, a case which corresponds to model (8). However, notice that stronger actions are taken when the interaction of model (7) is present. Finally, model (9) illustrates the decisions of monetary authority when inflation and economic growth are both rising and when only the former is increasing. In this case, the monetary policy reduces the impulse to increase the intervention rate suggested by the coefficient (6.33). It is important to note that in all models fitted, the coefficients associated to economic growth are greater than those linked to inflation and that always that economic activity is declining monetary policy tends to relax the stance.

In sum, the results in Table 1 show some consistency between the monetary authority's policy actions and the topics covered in the press releases. Thus, there is some room for continuing with content analysis of the communications.

Apart from the themes that the central bank's communications have emphasized, we also carry out a content analysis to observe whether there are phrases in the communications that might be somehow signaling future policy actions. In our view, the central bank might have introduced some guidance as a monetary policy mechanism into 13 out of 139 press releases. Table 2 reports 13 phrases introduced by Colombia's central bank in its monetary policy communications, which we consider as forward guidance signals (see also Table A1 in the Appendix).

The first phrase appeared in January 2005; this communication stated that the board would keep the contraction windows closed, meaning that the central bank would not increase the intervention rate in the following months; this same phrase appeared in February and March 2005. The board kept the intervention rate unaltered until September of that year. In August 2007, the board made public its decision to pause the rate increments and, consequently, the intervention rate remained unaltered until January 2008.

An escape clause event of forward guidance¹⁰ can be observed in June 2008. The board stated its intention of "...maintaining the current stance of monetary policy..." but it introduced an escape clause: "However, if the inflation expectations begin to affect prices and wages, this position would need to be revised..." Delphic forward guidance events can be observed in September 2009 and July 2012, while Odyssean forward guidance events are observed in March 2011 and May 2011. All in all, these 13 phrases might suggest that Colombia's central bank uses its communications not only to explain the monetary policy measures but also as a crucial complementary monetary policy tool.

¹⁰ Escape clause refers to a statement in which the board commits to do something under certain conditions, if those conditions change the board is not committed to do it.

Table 2. Some forward guidance signals

Date	Signal of future actions	Posterior decisions		
		$t+1$	$t+2$	$t+3$
Jan-05	...the board will continue its discretionary intervention in the exchange market and will keep the contraction windows closed...	0	0	0
Feb-05	...the board will continue its discretionary intervention in the exchange market and will keep the contraction windows closed...	0	0	0
Mar-05	...the board decided to keep the intervention rate unaltered... and will keep the contraction windows closed...	0	0	0
Aug-07	...the board decided to pause the rates increments to obtain more information about the incidence...	0	0	0
Jun-08	...it is prudent, therefore, to maintain the current stance of monetary policy. However, if the inflation expectations begin to affect prices and wages, this position would need to be revised....	25	0	0
Sep-09	...intervention rate stability is expected in the near future	0	-50	0
Oct-09	...the board expects that the inflation target set for 2010 can be met without upward pressure on the intervention rate in the near future...	-50	0	0
Mar-11	...the board considers appropriate and prudent to continue gradually reducing monetary stimulus...	25	25	25
May-11all this suggests that the adjustment to a less expansionary monetary policy should continue.	25	25	25
Aug-11	... on balance, the board considered it prudent to pause in interest rate increases.	0	0	25
Sep-11	...therefore, the board considered appropriate to continue with the pause in interest rate increases intervention.	0	25	0
Oct-11	... if real domestic indicators continue with the current dynamism and no further spread of the external situation occurs, it is likely that the economy requires less monetary stimulus...	25	0	25
Jul-12	...according to the assessment of the current balance of risks, all members of the board considered appropriate to reduce the interest rate intervention. Some members proposed further reductions to the finally adopted.	-25	0	0

Note: Posterior decisions refer to the intervention rate change in the first, second and third month after the forward guidance signal was released. **Source:** Banco de la República and authors' interpretations.

2.2 Latent semantic analysis

Natural Language Processing (NLP) is a field of computer science that investigates and develops tools to facilitate the interactions between computers and humans. To this end, NLP uses several mathematical techniques that are able to interpret texts and speeches in a way that resembles the way humans do. The NLP approach has been widely used in academic and non-academic contexts such as automatic translation, text-reduction, text-simplification, text and speech segmentation, sentiment analysis, semantic analysis, etc.¹¹

¹¹ See, Downey, Broadhead and Etzioni (2007), Bengio, Ducharme, Vincent and Jauvin (2003), Collobert et al. (2011) and Bholat et al. (2015) for more insights about NLP.

In this paper we use a linear-algebra-based NLP method called Latent Semantic Analysis (LSA), which is a statistical method used to represent the words that compose a text, first used by Deerwester, Dumais, Furnas, Landauer and Harshman (1990).¹² This technique can be applied to the wording entered in the formal documents released by central banks to announce monetary policy decision-making (see Boukus and Rosenberg, 2006; Hendry and Madeley, 2010; Takeda and Keida, 2017, among others). The technique allows for the deduction of relationships between words derived from their usage in different kinds of passages. Moreover, LSA allows for the creation of methods to link word-word, word-passage and passage-passage relationships to some human cognitive phenomena; it also suggests an approximation to human knowledge by studying theories of reasoning and understanding.

The first step in LSA consists simply of counting the number of times a word appears in a specific document. Thus one can figure out how important each word is in said document or, from another perspective, which words best describe the document. For example, imagine that one is analyzing a medical report. In this case, she could expect the word “doctor” to appear more times than, let us say, the word “floor”, even though this word might appear in the document. So, if we find that the word “doctor” appears ten (10) times while “floor” does so just once (1), it is likely that an accurate way to describe the content of the text would include the former one.

However, analyzing a single document is not the general goal of NLP but rather analyzing a set of them. Thus, the next step is to repeat the counting of words across all documents. This way, texts are transformed into a matrix-like structure called Term Document Matrix (TDM), denoted by $C_{m \times n}$, where each row represents a word and each column a document. Thus, the entry $c_{i,j}$ is the number of times word i is found in document j . For example, if we are analyzing 10 medical reports and the word “doctor” appears 3 times in the first report, 5 times in the second one and twice in the third, the matrix will look like Table 3.

Table 3. Term document matrix of medical reports.

Word / document	Document 1	Document 2	Document 3	...
Nurse	6	4	4	...
Doctor	3	5	2	...
Medication	10	1	3	...
Hospital	1	2	4	...
Room	2	3	1	...
Floor	0	1	0	...

Source: authors' design.

The TDM makes it possible to assess the relevance of each word within each document. For example, the word “medication” is especially important in document 1. Furthermore, the relevance of words can be made comparable across documents by normalizing the weights of words. It considers two types of weights: local and global weights. The former, denoted by $w_{i,j}$, refers to the weight of word i in document j ; that is, the relative importance of word i in document j . This is given by

¹² See also Landauer, Folts and Laham (1998) for an application to psychology.

$$lw_{i,j} = \frac{f_{i,j}}{\max_t f_{i,j}} \quad (1)$$

where $f_{i,j}$ represents the frequency in which word i appears in document j . The most frequent word in j will have a weight of 1 whereas words with little presence will have a weight close to 0. The global weight, denoted by gw_i , identifies the load that word i has all through the n documents analyzed and is computed as:

$$gw_i = \log \frac{n}{n_i} \quad (2)$$

where n_i is the number of documents in which word i appears. According to this measure, if a word appears in all documents, it will not be relevant in describing the differences among them; this is why the lower n_i relative to n , the larger the global weight of the word will be.

These two weights are combined in order to obtain a third measure of the relevance of each word i in document j adjusted by its global weight in order to avoid the domination of big documents. Thus, we obtain:

$$x_{i,j} = \frac{gw_{i,j} \times lw_{i,j}}{\sqrt{\sum_{i=1}^m gw_{i,j} \times lw_{i,j}}} \quad (3)$$

Total weight, $x_{i,j}$, introduces a balance between the relevance of the word i for the document j and the relevance of the word i across the whole set of documents. The entries of matrix $X_{m \times n}$, $x_{i,j}$, correspond to the transformed term-document-matrix which is not necessarily squared or symmetric. Matrix X can be factorized using Singular Value Decomposition (SVD) in the product of three characteristic matrices. This decomposition corresponds to,

$$X = UDV^T \quad (4)$$

where $U_{m \times n}$ and $V_{n \times n}$ are orthonormal vectors. Moreover, they are (left and right, respectively) singular vectors of X matrix or orthonormal eigenvectors of XX^T and $X^T X$, respectively. The singular values of X –determined uniquely by the SVD– are the positive square roots of the eigenvalues of XX^T and $X^T X$ placed by decreasing size in the diagonal of matrix D : $\sigma_1 \geq \dots \geq \sigma_n$.¹³

The m -rows of U are words and its n -columns are latent factors that represent specific subjects contained through the documents. The element $u_{i,j}$ of U is the marginal contribution of word i on theme j . Likewise, the n -rows of V are documents and its n -columns are the same factors; consequently, the i, j^{th} element of V , $v_{i,j}$, represents the importance of subject j in document i . This fact is particularly interesting when documents are organized chronologically because in this case the columns of V represent time series that reflects the importance of each subject in central bank communications. Such time series are then introduced in our VAR representation of the semantic structure of communications. Finally, D is a diagonal matrix where each entry represents the global importance of each subject among the whole set of documents. According to Hendry and Madeley

¹³ Thus, the rank(X) is the number of singular values of X different from zero; the absolute value of $\det(X)$ is the product of singular values $\sigma_1 \cdot \dots \cdot \sigma_n$; and, σ_1/σ_n in the condition number of X if $\sigma_n \neq 0$.

(2010), this is the importance of each theme in explaining the variance of meaning across the documents. The weights of matrix U guide the selection of how many factors are introduced in the VAR model.

We follow Boukus and Rosenberg (2006) to extract the meaning of monetary policy press releases.¹⁴ These documents, spanning between September 2004 and March 2016, are ordered chronologically and pre-processed before being submitted to the treatment described above. We drop the lines referring to the proper decision with respect to the intervention rate as well as the systematic phrases in which the monetary authority says that the ... “Board will continue monitoring the evolution of the facts and maintain its commitment to maintaining inflation and inflation expectations anchored to the target”. To clean the documents, we also dropped accent marks, some stop-words, and unnecessary references such as “Board”. Then we constructed the TDM and carried out the factorization.¹⁵

Figure 1 presents the words that shape the themes to be used in the structural VAR model. Figure 1 is built based upon the ten words with the highest absolute values in the first 20 columns (themes) of matrix U . These 20 themes account for 44.4% of the variance across documents. In the case of the words from the documents that we decide to factorize, the underlying themes are mostly related to prices, inflation, inflation expectations, monetary policy actions, aggregate economy and to particular sectors.

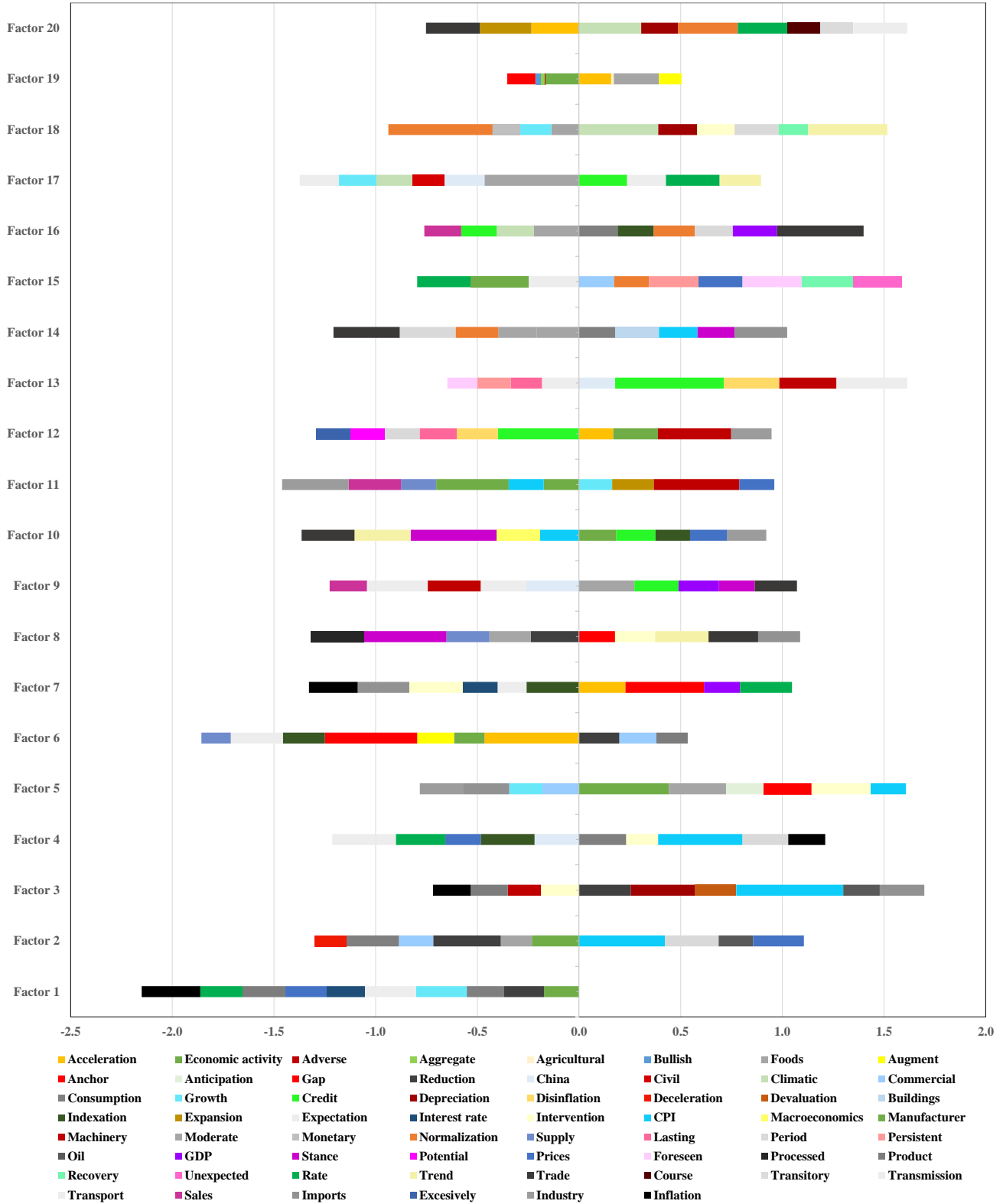
As we can observe, the themes that emerge from our analysis give more weight to monetary policy, behavior of prices, inflation and expectations, and much less to real activity. Accordingly, the press releases seem to show that in Colombia the monetary authority weighs inflation, more than any other variable, in the context of press releases. Nevertheless, particular words such as anchor, intervention, food, normalization, interest rate, economic activity, machinery, stance, etc. outline the themes. Interestingly, other words describing the phase of the cycle or the persistence of the shocks are also important (recall the results of section 2.1).

Four themes are of particular interest to us and are used in the empirical sections below. These are themes 7, 9, 17 and 20. Theme 7 is highly related to monetary policy; this is shaped by the words: acceleration, anchor, expectation, imports, indexation, inflation, interest rate, intervention, GDP, and rate. Theme 9 is outlined by the words: foods, China, credit, expectation, machinery, GDP, stance, trade, transmission and sales. Theme 17 is made by the words: foods, China, growth, credit, expectation, intervention, monetary, normalization, period, rate, trend, and transmission. Finally, theme 20 is shaped by the words: acceleration, climatic, depreciation, expansion, normalization, rate, trade, course, transitory and transport. This factor is more related to the business cycle.

¹⁴ Press releases are used instead of minutes to avoid possible noise in the meaning extraction process. This is because press releases provide more concise information which can improve the ability of LSA to extract the real factors embedded in the communications.

¹⁵ The pre-processed press releases are available from the authors upon request and matrices are available upon request.

Figure 1. Underlying factors or themes



Source: Banco de la República and authors' computations.

In the next section, we introduce these factors into a structural VAR set up, to observe whether communications, alone or accompanied by the policy measure, have any effect on inflation expectations.

3. Empirical analysis and results

We use a structural vector autoregression (SVAR) model to estimate the effect of shocks linked to communications on inflation expectations as measured by the break-even inflation¹⁶. The vector of variables is given by: $x_t = [y_t \ \pi_t^e \ f_t]$, where y_t is the log of the Economic Situation Indicator (ESI) a proxy for the economic activity released monthly by the official bureau of statistics, π_t^e represents the break-even-inflation expectations¹⁷ computed with the government instruments negotiated in the secondary market of debt, and f_t is any of the factors derived from the method described above. The reduced-form of the first difference of these series can be written as:¹⁸

$$\Delta x_t = c + \sum_{k=1}^K F_k \Delta x_{t-k} + e_t, \quad (5)$$

while the structural model can be represented by an infinite-order moving-average process MA(∞):

$$\Delta x_t = m + \sum_{k=0}^{\infty} A_k v_{t-k} \quad (6)$$

where v_t represents a vector of three structural shocks: aggregate supply (or technology) shocks, aggregate demand shocks and shocks linked to the communication component of the inflation targeting strategy. We impose the following long-run identifying restrictions: the aggregate supply shocks have no long-run effects on the selected factor; aggregate demand shocks have long-run effects on neither the log of ESI nor the factor; finally, communication shocks have no long-run effects on the log of ESI. Accordingly, the identifying restrictions are:

$$\sum_{k=0}^{\infty} a_{12,k} = 0, \sum_{k=0}^{\infty} a_{13,k} = 0, \sum_{k=0}^{\infty} a_{31,k} = 0, \sum_{k=0}^{\infty} a_{32,k} = 0 \quad (7)$$

Given the structure of the VAR model, we test whether overidentifying restrictions are not rejected by the data. In the first place, we use the break-even-inflation expectations derived from the five years maturity bonds and factor 7. The election was made on the grounds of the no rejection of the overidentifying restrictions. This model generates the accumulated responses of the log of ISE, the five-years ahead inflation expectations as measured by break-even-inflation and theme 7 to the shocks shown in Figure 2.

Accordingly, aggregate supply shocks have long run effects in our measure of economic activity while demand shocks have long run effects in inflation expectations. Given this latter response of inflation expectations, the central bank's communications are set to counteract the effect of aggregate demand shocks on inflation expectations. Thus, press releases of the central bank not only

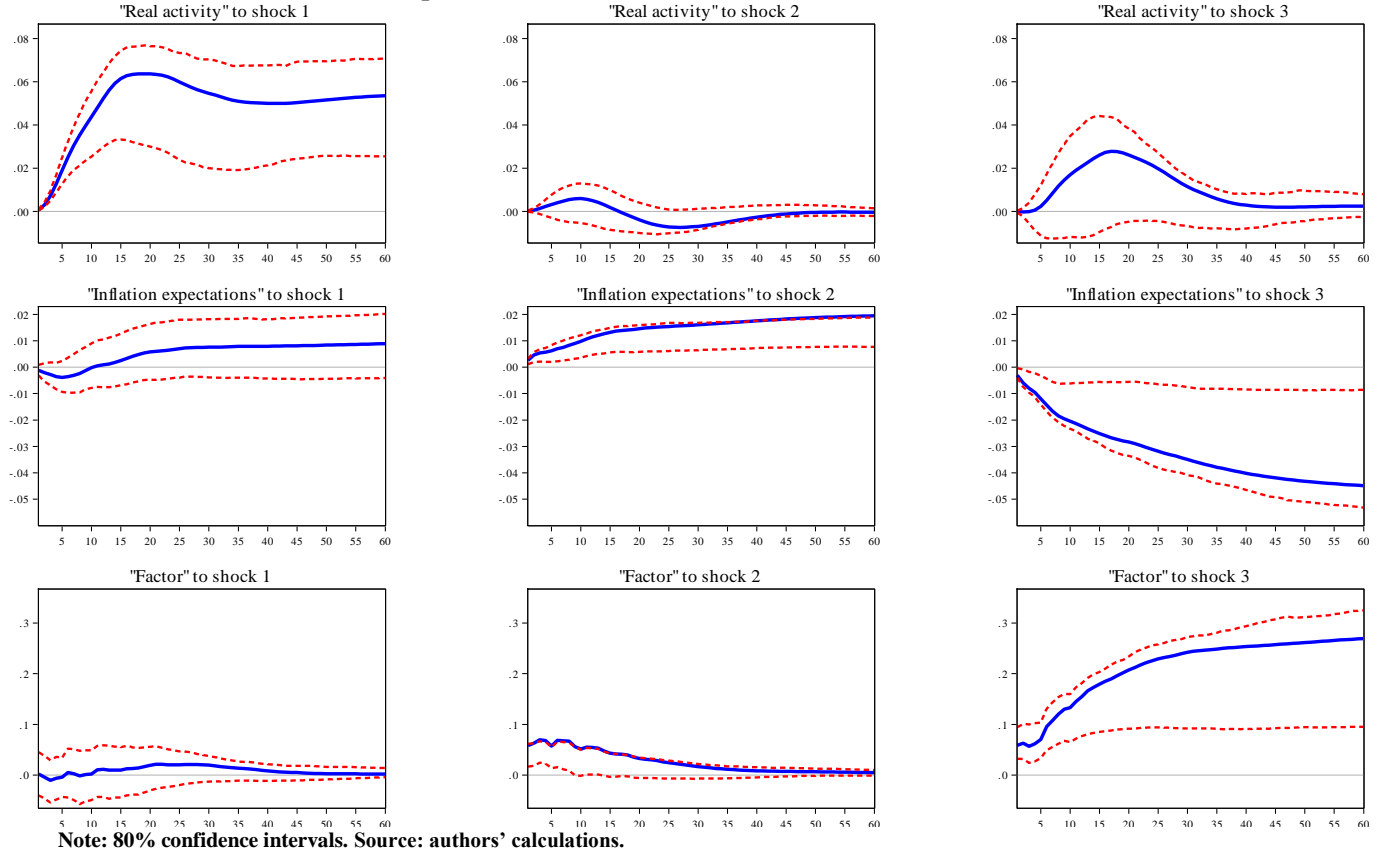
¹⁶ This empirical application is in the spirit of Smith and Becker (2015), who tested the effectiveness of forward guidance in the interest rates for the United States.

¹⁷ For this variable we use across all empirical exercises, break-even-inflation expectations of one, five and ten years ahead.

¹⁸ In fact, we use a difference of order twelve for the log of economic situation indicator to obtain a smoother impulse-response. However, the model is also supported by a monthly difference.

explain the policy and give signals of commitment to help reducing the effect of demand shock on inflation expectations.

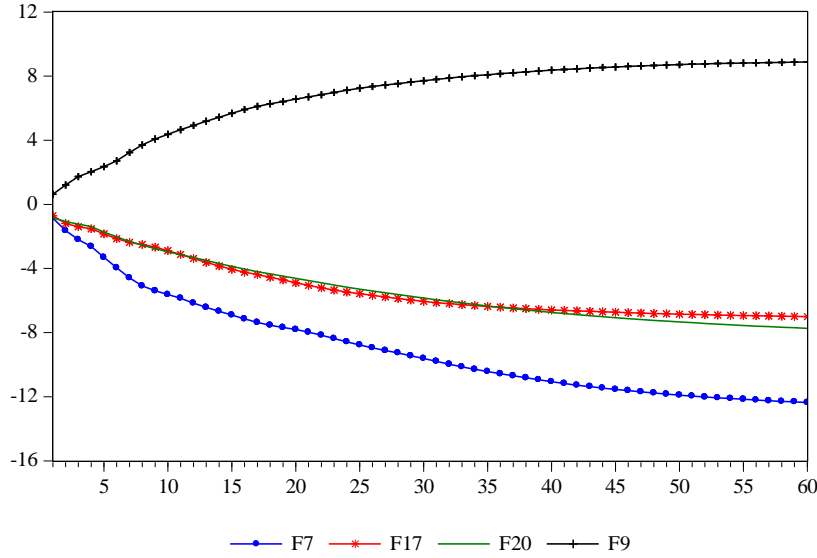
Figure 2. Accumulated response to structural innovations of economic activity, five years-ahead inflation expectations, and communications (theme 7).



It is worth mentioning that some other factors such as 9, 10, 11, 12, and 15, generate accumulated impulse responses that increase the inflation expectations. Figure 3 shows the impulse response of inflation expectations to communication shocks. With factors 7, 17 and 20, communication shocks reduce inflation expectations while factor 9 has the opposite effect. This could happen when the monetary authority tried to introduce inflation within the target range of 2010 and 2013, years in which inflation was rather low or when the press releases did not transmit what the market was expecting.

However, one might argue that the responses of inflation expectations in the previous structural VAR specification are due to some omitted variables. That is, the model lacks some controls such as the explicit intervention of the monetary authority. Consequently, the following specifications of the model include, apart from the factors extracted from the communications of the central bank, the interbank interest rate ibr_t , the proxy of the intervention (policy) rate.

Figure 3. Accumulated response to structural innovations linked to communications of inflation expectations



Note: 80% confidence intervals. Factor 20 corresponds to a model with inflation expectations one year ahead, factors 7 and 9 correspond to models with inflation expectations five years ahead and factor 17 corresponds to a model with inflation expectations ten years ahead. Source: authors' calculations.

In this case, the vector is given by: $x_t = [y_t \ \pi_t^e \ f_t \ ibr_t]$, where ibr_t is the interbank interest rate, proxy of the intervention rate. In this instance, the following long-run identifying restrictions are imposed: only technology shocks have long run effects on economic activity; in addition, shocks linked to aggregate demand phenomena –inflation expectations- have long-run effects in neither the selected factor nor in the interbank interest rate; the selected factor does not respond to technology shocks; conversely, the nominal interest rate is affected in the long run by technology and monetary policy shocks. The identifying restrictions are given by:

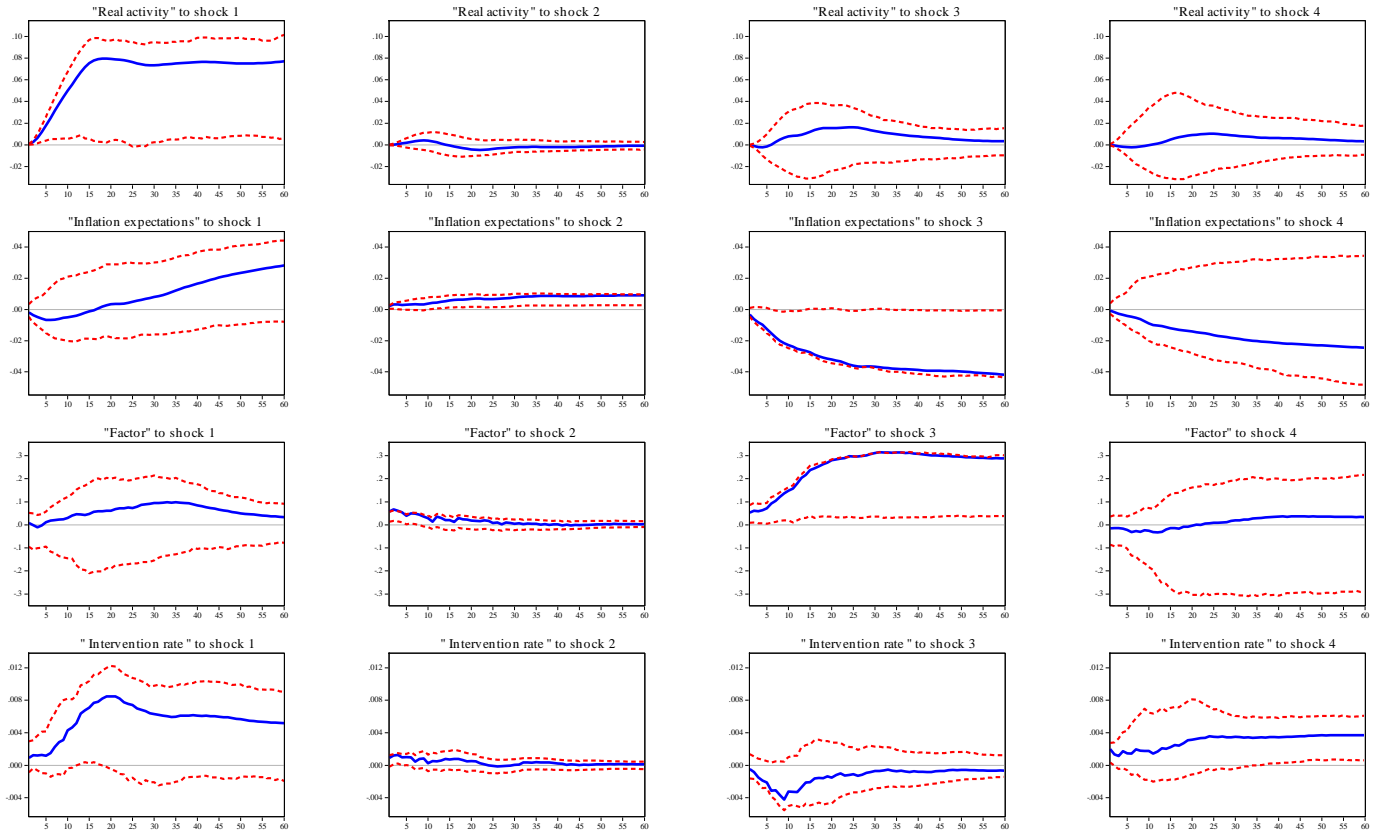
$$\begin{aligned}
 \sum_{k=0}^{\infty} a_{12,k} &= 0, \quad \sum_{k=0}^{\infty} a_{13,k} = 0, \quad \sum_{k=0}^{\infty} a_{14,k} = 0, \\
 \sum_{k=0}^{\infty} a_{31,k} &= 0, \quad \sum_{k=0}^{\infty} a_{32,k} = 0, \\
 \sum_{k=0}^{\infty} a_{42,k} &= 0, \quad \sum_{k=0}^{\infty} a_{43,k} = 0.
 \end{aligned} \tag{8}$$

This set of restrictions implies that all shocks might have long-run effects in inflation expectations; we allow the data to tell us how long the effects of the shocks are. In the first place, the model described above produces the responses of Figure 4. By again using factor 7 in the VAR specification, the central bank's communications affect the path of inflation expectations. In Figure 4, five years-ahead inflation expectations are affected by communications while the intervention rate can barely affect said variable. We could interpret that these two elements of the inflation targeting strategy can, in tandem, obtain the results aimed at by the monetary authority.

Finally, Figure 5 shows the accumulated effects on shocks linked to communications of the central bank. Again, shocks to communications factors affect inflation expectations at different horizons, but factor 9 increases it. Interestingly, this factor as well as 17, are both shaped with the word “foods”. As we can observe, shocks linked to the former increases inflation expectations while

socks connected to the latter produce an effect which is lower to those associated to factors 7 and 20. Thus, the content of this word might be very special for agents and should be used with some caution in the press releases.

Figure 4. Accumulated response to structural innovations of economic activity, five years-ahead inflation expectations, communications (theme 7) and intervention rate.



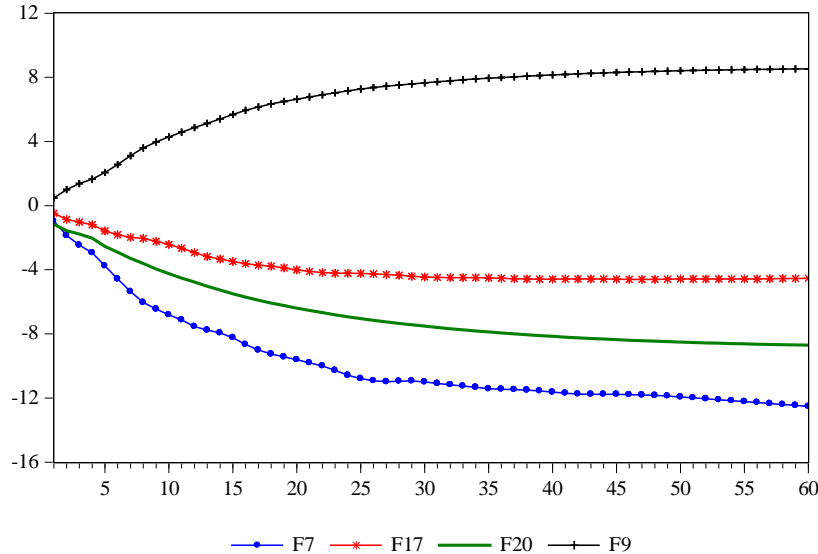
Note: 80% confidence intervals. Source: authors' calculations.

4. Conclusions

Two of the pillars of the inflation targeting strategy are transparency and communication. In this work we provide evidence that press releases, the way in these two pillars materialize, are important in many respects. The reading analysis we carried out consists of two elements. In first place, we observe the coherence between monetary policy actions and press releases. In this case, we found that inflation and growth are significant themes in the adoption of the policy measures. Moreover, when inflation and economic growth are both raising the monetary actions becomes tighter. Nevertheless, in this simple exercise between the consistency of the intervention rate movements and press releases, economic activity has always coefficients greater than those of inflation and declining economic activity tends to coincide with reductions in the interest rate. In second place,

the monetary authority goes beyond explanations in the press releases. There are some traces of forward guidance in a number of communications with different degrees of commitment.

Figure 5. Accumulated response to structural innovations linked to communications of inflation expectations



Note: 80% confidence intervals. Factor 20 is in a model with inflation expectations one year ahead, factors 7 and 9 are in models with inflation expectations five years ahead and factor 17 corresponds to a model with inflation expectations ten years ahead.

We also employ, for the first time in Colombia, Latent Semantic Analysis to unveil the semantic structure of the central bank's communications between September 2004 and March 2016. This machine learning technique allowed us to extract some semantic factors or themes that are used in a structural VAR to identify and measure the impact of these communications on inflation expectations. Our results indicate that Colombia's Central Bank uses communications as a monetary policy tool and that this strategy influences market inflation expectations. Regardless of the fact that more evidence is needed by using different techniques, communications can be an important complement to the monetary policy measures.

References

- Bengio, Y., Ducharme, R., Vincent, P., and Jauvin, C. (2003). A neural probabilistic language model. *Journal of machine learning research*, 3(Feb), 1137-1155.
- Bholat, D. M., Hansen, S., Santos, P. M., and Schonhardt-Bailey, C. (2015). Text mining for central banks: handbook. *Centre for Central Banking Studies* (33). pp. 1-19.
- Blinder, A.S., Ehrmann, M., Fratzcher, M., De Haan, J., and Jansen, D.J., 2008, Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence.
- Boukous, E. and Rosenberg, J.V., 2006, The information content of FOMC minutes. *Working Paper Federal Reserve Bank of New York*.
- Campbell, J. R., Evans, C. L., Fisher, J. D., and Justiniano, A. (2012). Macroeconomic effects of Federal Reserve forward guidance. *Brookings Papers on Economic Activity*, 2012(1), 1-80.
- Castro, F., 2012, Señales de política monetaria y movimientos en la estructura a plazo de la tasa de interés en Colombia. *Archivos de Economía* 387.
- Collobert, R., Weston, J., Bottou, L., Karlen, M., Kavukcuoglu, K., and Kuksa, P. (2011). Natural language processing (almost) from scratch. *Journal of Machine Learning Research*, 12(Aug), 2493-2537.
- Deerwester, S., Dumais, S. T., Furnas, G. W., Landauer, T. K., and Harshman, R. (1990). Indexing by latent semantic analysis. *Journal of the American society for information science*, 41(6), 391.
- Downey, D., Broadhead, M., and Etzioni, O. (2007, January). Locating Complex Named Entities in Web Text. *IJCAI* (Vol. 7, pp. 2733-2739).
- Eusepi, S. and Preston, B., 2007, Central Bank Communication and Expectations Stabilization. *NBER Working Paper* No. 13259, Issued in July 2007.
- Florez-Jiménez, M.L. and Parra-Polanía, J.A., 2014, Forward Guidance with an escape clause: When a half promise is better than a full one. *Banco de la República de Colombia*.
- Goodfriend, M., 1986, Monetary Mystique: Secrecy and Central Banking. *Journal of Monetary Economics* 17, 63-92.
- Hamann, F., Hofstetter, M., and Urrutia, M. (2014). Inflation targeting in Colombia, 2002–12. *Economía*, 15(1), 1-37.
- Hendry, S., and Madeley, A. (2010). Text mining and the information content of Bank of Canada communications (No. 2010, 31). *Bank of Canada Working Paper*.
- Landauer, T.K., Folts, P.W. and Laham, D., 1998, An Introduction to Latent Semantic Analysis. *Discourse Processes*, 25, 259-284.
- Neuenkirch, M., 2012, Managing financial market expectations: The role of central bank transparency and central bank communication. *European Journal of Political Economy*, 28,1–13.

- Neuenkirch, M., 2013a, Central bank transparency and financial market expectations: The case of emerging markets. *Economic Systems*, 37, 598–609.
- Poole, W., 2001, Expectations. *Federal Reserve Bank of St. Louis Review*, 83, 1, 1–10.
- Rigobon, R., and Sack, B. (2006). Noisy Macroeconomic Announcements, Monetary Policy, and Asset Prices (No. 12420). *National Bureau of Economic Research, Inc.*
- Romer, C.D. and Romer, D.H., 2000, Federal Reserve Information and the Behavior of Interest Rates. *American Economic Review*, 90, 3, 429–457.
- Shiller, R., 2017, Narrative Economics. *American Economic Review*, 107(4): 967–1004
- Smith, A. L., and Becker, T. (2015). Has forward guidance been effective?. *Economic Review-Federal Reserve Bank of Kansas City*, 57.
- Svensson, L. E. (1998). Inflation Targeting as a Monetary Policy Rule.
- Takeda, Y. and Keida, M., 2017, Computer-based narrative analysis of the Bank of Japan's Governor Kuroda. VOX CEPR's Policy Portal. Obtenido de <http://voxeu.org/article/central-bank-communication-strategies>.
- Van der Crujssen, C., Eijffinger, S., and Hoogduin, L., 2010, Optimal central bank transparency. *Journal of International Money and Finance*, 29(8), 1482–1507.
- Walsh, C. E. (2006). Optimal Economic Transparency. In Workshop, May (Vol. 8, p. 10).
- Woodford, M., 2001, Monetary Policy in the Information Economy.

Appendix

Table A1. Factors derived from the reading approach

Date	Inflation	Economic growth	Exchange rate	International context	Signal	Intervention rate variation
01/09/2004	-1	1	-1	0		0
01/10/2004	-1	1	-1	1		0
01/11/2004	-1	-1	0	-1		0
01/12/2004	-1	-1	-1	0		-25
01/01/2005	-1	-1	0	0	1	0
01/02/2005	-1	0	0	0	1	0
01/03/2005	-1	0	0	0	1	0
01/04/2005	-1	0	0	0		0
01/05/2005	-1	0	0	0		0
01/06/2005	-1	0	0	0		0
01/07/2005	-1	1	0	0		0
01/08/2005	-1	1	0	0		0
01/09/2005	-1	0	0	0		0
01/10/2005	-1	0	0	0		0
01/11/2005	0	0	0	0		-50
01/12/2005	-1	0	0	0		0
01/01/2006	-1	1	0	0		0
01/02/2006	-1	1	0	0		0
01/03/2006	-1	1	0	0		0
01/04/2006	-1	1	0	0		25
01/05/2006	-1	1	0	0		0
01/06/2006	-1	1	0	0		25
01/07/2006	-1	1	0	0		0
01/08/2006	1	0	0	0		25
01/09/2006	-1	1	0	0		25
01/10/2006	-1	1	0	1		25
01/11/2006	-1	1	0	0		0
01/12/2006	-1	1	0	0		25
01/01/2007	-1	1	0	0		25
01/02/2007	-1	1	0	0		25
01/03/2007	-1	1	0	0		25
01/04/2007	-1	1	0	0		25
01/05/2007	1	1	0	0		25
01/06/2007	0	1	0	0		25
01/07/2007	-1	1	0	1		25
01/08/2007	-1	1	0	0	1	0
01/09/2007	-1	1	0	1		0
01/10/2007	-1	1	0	0		0
01/11/2007	-1	1	0	1		25
01/12/2007	1	1	0	0		0
01/01/2008	1	1	0	-1		0
01/02/2008	1	1	0	-1		25
01/03/2008	1	1	0	-1		0
01/04/2008	-1	1	0	-1		0
01/05/2008	-1	1	0	0		0
01/06/2008	1	-1	0	0	1	0
01/07/2008	1	-1	0	0		25
01/08/2008	1	-1	1	-1		0
01/09/2008	1	-1	0	-1		0
01/10/2008	-1	-1	1	0		0
01/11/2008	-1	0	0	0		0
01/12/2008	-1	-1	0	-1		-50
01/01/2009	-1	-1	0	-1		-50
01/02/2009	-1	-1	1	-1		-100
01/03/2009	-1	-1	0	-1		-100
01/04/2009	-1	-1	0	-1		-100
01/05/2009	-1	-1	0	1		-100
01/06/2009	-1	-1	0	1		-50
01/07/2009	-1	0	-1	1		0
01/08/2009	-1	1	0	1		0
01/09/2009	-1	1	0	0	1	-50
01/10/2009	-1	1	0	-1	1	0
01/11/2009	-1	0	0	1		-50
01/12/2009	-1	1	0	1		0
01/01/2010	-1	1	0	1		0
01/02/2010	1	1	0	1		0
01/03/2010	-1	1	0	1		0
01/04/2010	-1	0	0	1		-50
01/05/2010	1	0	0	1		0
01/06/2010	1	1	0	1		0

Source: Colombia's central bank communications; authors' interpretations.

Table A1 (continued). Factors derived from the reading approach

Date	Inflation	Economic growth	Exchange rate	International context	Signal	Intervention rate variation
01/07/2010	1	1	-1	1		0
01/08/2010	-1	1	-1	1		0
01/09/2010	1	1	0	1		0
01/10/2010	-1	1	1	1		0
01/11/2010	1	1	1	1		0
01/12/2010	1	1	1	-1		0
01/01/2011	1	1	0	1		0
01/02/2011	1	1	0	-1		25
01/03/2011	-1	1	0	1	1	25
01/04/2011	0	1	0	1		25
01/05/2011	-1	1	0	0	1	25
01/06/2011	1	1	0	1		25
01/07/2011	1	1	0	-1		25
01/08/2011	1	1	0	-1	1	0
01/09/2011	0	1	0	-1	1	0
01/10/2011	1	1	0	-1	1	0
01/11/2011	1	1	0	-1		25
01/12/2011	-1	1	0	-1		0
01/01/2012	1	1	0	-1		25
01/02/2012	-1	1	0	-1		25
01/03/2012	0	-1	-1	-1		0
01/04/2012	-1	-1	-1	-1		0
01/05/2012	-1	-1	1	1		0
01/06/2012	0	-1	0	-1		0
01/07/2012	-1	-1	0	-1		-25
01/08/2012	-1	-1	0	-1		-25
01/09/2012	1	-1	0	-1		0
01/10/2012	0	-1	0	-1		0
01/11/2012	0	-1	0	-1		-25
01/12/2012	-1	-1	0	-1	1	-25
01/01/2013	-1	1	0	1		-25
01/02/2013	-1	-1	0	-1		-25
01/03/2013	-1	-1	0	-1		-50
01/04/2013	1	-1	0	-1		0
01/05/2013	1	1	1	-1		0
01/06/2013	0	-1	1	0		0
01/07/2013	1	1	1	0		0
01/08/2013	-1	1	1	-1		0
01/09/2013	0	1	0	1		0
01/10/2013	0	1	-1	1		0
01/11/2013	-1	1	0	1		0
01/12/2013	-1	1	0	1		0
01/01/2014	0	1	1	1		0
01/02/2014	0	1	0	1		0
01/03/2014	1	1	0	-1		0
01/04/2014	0	0	-1	1		25
01/05/2014	0	1	-1	1		25
01/06/2014	1	1	0	1		25
01/07/2014	-1	1	0	-1		25
01/08/2014	1	1	0	1		25
01/09/2014	0	1	1	-1		0
01/10/2014	0	1	1	-1		0
01/11/2014	1	1	1	-1		0
01/12/2014	0	-1	1	-1		0
01/01/2015	0	1	1	-1		0
01/02/2015	1	1	1	-1		0
01/03/2015	1	-1	1	1		0
01/04/2015	1	-1	-1	-1		0
01/05/2015	1	-1	1	-1		0
01/06/2015	-1	-1	1	-1		0
01/07/2015	0	0	1	-1		0
01/08/2015	1	-1	1	-1		0
01/09/2015	1	1	1	-1		25
01/10/2015	1	1	1	-1		50
01/11/2015	1	1	1	-1		25
01/12/2015	1	1	1	-1		25
01/01/2016	1	1	1	-1		25
01/02/2016	1	1	1	-1		25
01/03/2016	1	1	-1	0		25

Source: Colombia's central bank communications; authors' interpretations.

