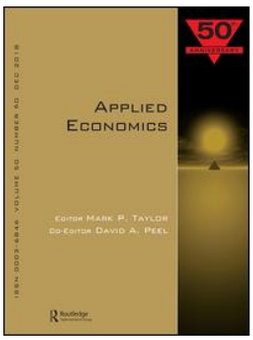

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Disagreement in inflation expectations: empirical evidence for Colombia

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ABSTRACT

The literature on expectation disagreements in emerging economies is scarce. This paper examines the disagreements in inflation expectations for the Colombian economy during the 2010–2017 period. We combine empirical tests with an analysis of a *monthly survey of expectations of financial analysts in Colombia* to obtain valuable evidence to formulate guidelines on the expectations modelling in developing economies. The findings indicate that disagreements present inertia and that inflation volatility increases disagreements. However, the central bank's stance, as established through a press release, can reduce disagreement. Moreover, if central bank communication is clear and there is a credible inflation target, there tend to be fewer disagreements.

KEYWORDS

Disagreements; inflation expectations; communication; clarity

JEL CLASSIFICATION

E37; E58; E44

I. Introduction

The variables that outline macroeconomic dynamics are based on expectations. Despite this, the factors that affect expectation formation and the beliefs that agents report in surveys are open questions (Capistrán and Timmerman 2009; Siklos 2013; Coibion and Gorodnichenko 2015). Disagreements in inflation expectations, as well as other macroeconomic variables, can lead to the wrong investment decisions and affect resource allocation (Sims 2003). Moreover, significant disagreements in the market resemble a demand shock with high unemployment (Beckmann and Czudaj 2018). Consequently, it is essential that policymakers take into account disagreements in inflation expectations.

A necessary condition for successful policy intervention is that the cross-section dispersion of expectations be minimal (Dovern, Fritsche, and Slacalek 2012). As a result, increasing attentions have been paid to better understanding the causes of disagreements in macroeconomic models. Specifically, important studies such as Mankiw, Reis, and Wolfers (2003), Capistrán and Timmerman (2009), and Coibion and Gorodnichenko (2015) argue that the analysis of disagreements may be key to providing greater clarity around the results of economic policy shocks.

Several emerging economies have adopted inflation targeting regimes to manage expectations (Bernanke et al. 1999). Despite this, emerging economies show poor financial market development, hindering proper expectation formation. Therefore, central banks should seek mechanisms that allow them to properly manage expectations in order to anchor agents' projections and reduce inflationary uncertainty. In expectation management, monetary policy commitment to an inflation target is a powerful tool for reducing market uncertainty and generating forecasting convergence (De Mendonça 2007; Capistrán and Timmerman 2009; Jansen 2011a; Ehrmann, Eijffinger, and Fratzscher 2012; Montes et al. 2016). Thus, it is important to expand research on the effects of communication on disagreement in inflation expectations in emerging economies.

The main purpose of this study is to analyse the effects of the monetary policy stance, the credibility and clarity of central bank communication on disagreement in inflation expectations in Colombia, a small developing economy with an inflation targeting system. Disagreements about inflation tend to be greater when there are no credible inflation targets to anchor expectations, which is typical in developing economies.

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Additionally, the measurement of inflation expectations is a recent task, and the reputation of the Central Bank of Colombia is under construction (Ciro and de Mendonça 2017). From the Colombian experience, surveys are an important source of information that has so far been underresearched. Therefore, it is relevant to begin to combine empirical tests with surveys' analyses to obtain valuable evidence to generate guidelines on expectations modelling in developing economies.

Our empirical evidence helps policymakers identify factors that can alter inflation expectations and identifies strategies to unify agents' forecasts in emerging economies. This paper contributes to our understanding of the effects of central bank communication on inflation expectations disagreements in several respects. First, using the method applied by Montes et al. (2016) and Ballantyne et al. (2016), this study shows that central bank announcements are beneficial in terms of reducing disagreements in expectations and generating convergence in the financial market forecast. Second, it analyses the economy of Colombia, a country in Latin America for which research on the possible effects of communication on market expectations is lacking. Third, it reveals that an inflation targeting strategy is crucial to reducing disagreement. In particular, it provides that monetary policy signalling and the clarity of central bank press releases are important tools for reducing disagreements in Colombia. In short, the results of this study allow us to formulate strategies to improve financial stability and may be of interest to economic policymakers and researchers.

The remainder of this paper is organized as follows. Section 2 presents a brief review of the empirical literature on disagreements. In Section 3, we define and analyse disagreement about inflation expectations and present the methodology for measuring the effect of communication on disagreement. Section 4 presents the econometric estimates and discusses the results. Finally, Section 5 concludes.

II. Empirical evidence: a brief review

Rigidities in information are a cause of disagreements in expectations. In this regard, important empirical evidence and new macroeconomic models suggest that disagreements reflect the different incentives and abilities of agents to collect and process information (see, for example, Coibion and Gorodnichenko 2012, 2015).

Beyond the proposals of full-information rational expectations models, several studies show that agents are heterogeneous and that information is transmitted slowly with access and noise restrictions. Agents have different skills to filter information, and their forecasts are not the same. Each forecaster (professional, consumer, firm, central bank) has peculiarities that are explained by differences in belief updating and in perspectives of sporadic information received (see, for example, Mankiw, Reis, and Wolfers 2003; Branch 2004; Capistrán and Timmerman 2009; Lahiri and Sheng, 2010; Dovern, Fritsche, and Slacalek 2012; Coibion and Gorodnichenko 2015; Beckmann and Czudaj 2018).

Disagreements in inflation expectations can be due to several factors. Empirical studies show that disagreements are sensitive to economic shocks, institutional frameworks and macroeconomic performance indicators. Regarding the first factor, Coibion and Gorodnichenko (2012) show that disagreements respond to technological and price shocks. In the same spirit, policy shocks may increase disagreements due to the different ways in which agents extract information signals (see Coibion and Gorodnichenko 2012).

Disagreements in inflation expectations are also affected by the management of central banks. That is, greater central bank independence and higher credibility produce more predictable monetary policy and, therefore, reduce the dispersion of expectations. In addition, transparency matters, and the release of central bank inflation forecasts decreases disagreements (see, Ehrmann, Eijffinger, and Fratzscher 2012; Dovern, Fritsche, and Slacalek 2012; Siklos 2013; Montes et al. 2016; Beckmann and Czudaj 2018). Similarly, in the case of emerging economies, Montes et al. (2016) find that greater clarity around inflation targeting helps reduce disagreements about future inflation.

Regarding the behaviour of macroeconomic variables, the empirical evidence is conclusive in pointing out that inflation disagreements increase with volatility and the level of inflation observed

(see Capistrán and Timmerman 2009; Lamla and Maag 2012; Siklos 2013; Beckmann and Czudaj 2018). There is also evidence that disagreements change with the business cycle. As Mankiw, Reis, and Wolfers (2003), Döpke and Fritsche (2006), Dovern, Fritsche, and Slacalek (2012), and Montes et al. (2016) have documented, the recession cycle is characterized by higher uncertainty that significantly affects disagreements. There are also studies that show that the media coverage, its heterogeneity and the number of inflation reports affect disagreements, especially among consumers (see, Lamla and Maag 2012). To sum up, disagreement about inflation expectations is an indicator that shows how agents process the information supplied by the central bank and macroeconomic data.

III. Methodology and data

This section is organized into several parts. The first subsection presents the method of measuring disagreement in inflation expectations, which includes the fixed-horizon forecasts approach. In the second subsection, we present the database of disagreements and discuss their behaviour. Finally, the third subsection presents the empirical approach to analysing the determinants of disagreements, focusing on the influence of central bank communication.

Fixed horizon forecasts

Inflation expectation disagreements can be measured in several ways. First, disagreements can be calculated as the difference between the maximum and the minimum value of inflation expectations (Montes et al. 2016; Ballantyne et al. 2016). Second, disagreement can be measured using the interquartile range and the standard deviation (Mankiw, Reis, and Wolfers 2003; Capistrán and Timmerman 2009; Ehrmann, Eijffinger, and Fratzscher 2012; Siklos 2013). Both measures seek to identify differences across agents in inflation expectations. However, since the Central Bank of Colombia does not publish information on each surveyed agent's forecast, we cannot calculate disagreement as the interquartile range.[1] Therefore, in the present paper, the method of studying the disagreement follows the basic model of Montes et al. (2016), and we measure the disagreements in inflation forecasts as the difference between the maximum and minimum values of expected inflation as follows:

$$dis_t X^{a+j} = E_t^{max} X^{a+j} - E_t^{min} X^{a+j} \quad (1)$$

where dis_t is disagreements about inflation expectations at time t, which is the moment when the forecast is made by agent i with $i \in I$, and I is the set of surveyed agents. The variable to be forecast is X (in this case annual inflation). $E_{i,t}X^{a+j}$ represents the forecast calculated by the ith agent at time t for the value that X takes at the end of year $a+j$, with a being the year when expectations are formed, and $j = 0$ is the current year. Thus, $E_t^{max}\ X^{a+j} = \max\left(E_{i,t}X^{a+j}, i \in I\right)$ denotes the maximum value, while $E_t^{min}\ X^{a+j} = \min\left(E_{i,t}X^{a+j}, i \in I\right)$ denotes the minimum predicted value of the set of agents.

$E_{i,t}X^{a+j}$ forecast is a fixed-event forecast. In fact, in the surveyed period, forecast error decreases when the forecast is made closer to the end of the year. This pattern of a decreasing forecast horizon over the year causes seasonal behaviour in disagreement measures based on fixed-event forecasts, since the dispersion of inflation expectations tends to decrease as the forecast horizon is shortened. Disagreement may be lower in December of each year after schematizing the economic outlook.[2] Moreover, disagreement may be higher in January due to the economic uncertainty ahead. Therefore, forecasts should be weighted; otherwise, at the end of each year, there will always be lower disagreement.

To avoid the seasonal behaviour inherent to disagreement measures based on fixed-event forecasts, fixed-horizon forecasts should be used, for example, one year ahead. Thus, we need adequate

[1] In the Colombian case, statistics are presented in an aggregate form and comprise measures of central tendency such as mean and median, and measures of statistical dispersion such as standard deviation, minimum and maximum values. There are no statistics available on the expectations of each respondent.

[2] Disagreements observed in February 2010 for the inflation expectation at the end of 2010 tend to be higher than the disagreements observed in October 2010. Divergence tends to increase again in February 2011, when forecast horizon changes again. See Dovern, Fritsche, and Slacalek (2012).

weighting so that all forecast periods are comparable regardless of the season, as in Mankiw, Reis, and Wolfers (2003), Patton and Timmermann (2010), Dovern, Fritsche, and Slacalek (2012), and Montes et al. (2016). Accordingly, the fixed horizon forecast is calculated as a weighted average of fixed event forecasts as follows:

$$E_t X^{12(j+1)} = \frac{12-(m-1)}{12} E_t X^{a+j} + \frac{(m-1)}{12} E_t X^{a+j+1} \quad (2)$$

with $j = 0, 1, 2, 3, \ldots, T$, where m represents the month in which the forecast is made, and $E_t X^{12(j+1)}$ denotes the weighted average forecast of agents' inflation expectations for the value X will take at the end of the next $12(j+1)$ months. For example, the February 2010 inflation forecast for the end of 2010 is calculated as follows:

$$E_t X^{12} = \frac{11}{12} E_t X^{a} + \frac{1}{12} E_t X^{a+1} \quad (3)$$

where $E_t X^{a}$ is the value of the inflation forecast developed by the agent for the end of 2010, and $E_t X^{a+1}$ is the value of the forecast for the end of 2011. Thus, the inflation forecast for February 2010 is an average of the inflation forecast for the current year (2010) and the next year (2011) weighted by their participation in the forecast period horizon.[3] After transforming each fixed event forecast (i.e., the minimum and maximum separately) into fixed horizon forecasts, we construct the series of disagreements based on Equation (1).

Database and considerations

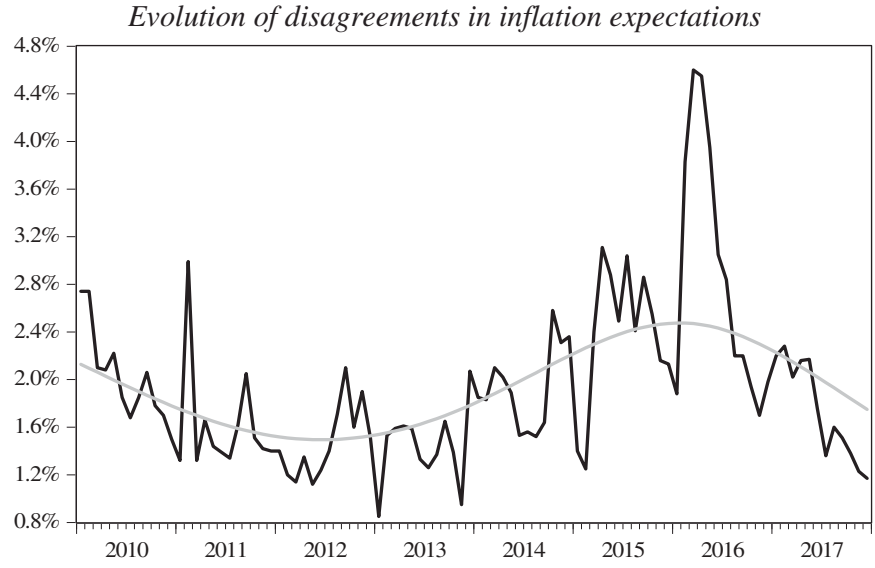
The Central Bank of Colombia has been concerned with consolidating the inflation targeting system through different communication channels. For this purpose, it has implemented different surveys to measure agents' inflation expectations and monitor the anchoring of expectations to the announced inflation targets. We use those surveys to measure disagreements in order to understand the heterogeneous behaviour of agents related to their perceptions of monetary policy.

In the Colombian case, expectations are measured through surveys of financial market participants. A *monthly survey of financial analysts' expectations* aims to measure the dynamics of inflation forecasts, along with other variables such as exchange rates and economic growth. Data from this survey have been available since the end of 2003 and include 30 to 40 local and foreign analysts of the Colombian financial market. The survey includes actors from banking institutions, brokerage firms, specialized academic centres, financial corporations, and pension funds who reveal their inflation expectations for the current month and for the current year (fixed event forecast). This information is available on Central Bank of Colombia website, where investors and researchers can find important information on macroeconomic and financial variables.

Disagreements were constructed from the *monthly survey of financial analysts' expectations*. The study period runs from January 2010 to December 2017 (at a monthly frequency). We chose this period because since 2010, the central bank has had a stable inflation target and tolerance intervals. Prior to this period, the inflation range and target were not stable and tended to decrease. Over the 2003–2009 period, there were six changes in the inflation range and target as the inflation targeting system was consolidated. Following the period of deflation experienced by the Colombian economy from 2003 to 2009, expectations fluctuated greatly such that differences could not be entirely attributed to disagreements among agents. Therefore, the behaviour of disagreement should be examined over a more stable period for the inflation targeting regime.

Based on Equation (1), Figure 1 illustrates disagreement about inflation expectations over the 2010–2017 period in the Colombian economy. From 2010 to 2017, disagreement of an average of 1.93% was observed, reaching a minimum of 0.85% in January 2013 and a maximum of 4.60% in March 2016. Two periods stand out. The first period runs from 2010 to 2012 and is

[3]There is a methodology for computing weights optimally. In this regard, Knüppel and Vladu (2016) perform an optimal approximation for fixed-horizon forecasts using fixed-event forecasts by minimizing the mean-squared approximation error.



Variable	Mean	Min.	Max.	SD	Kurtosis
dis_t	1.9379	0.8500	4.6000	0.7345	6.1503

Figure 1. Evolution of disagreements in inflation expectations.

Note: Data obtained from the Central Bank of Colombia. Trend calculated using the Hodrick-Prescott filter.

characterized by a decreasing trend, significant anchoring of inflation expectations and consolidation of central bank credibility (Galvis and Anzoátegui 2018). The second period run from 2013 to 2016, and shows solid growth in disagreements in inflation expectations during a significant reduction in the oil price, a major shock to domestic prices and Colombian economic performance.

Empirical approach

According to the literature review, disagreements may be due to several factors. One of these factors is agents' perceptions of the inflation target announced by the central bank, that is, bank credibility (see, De Mendonça 2007; Ballantyne et al. 2016; Beckmann and Czudaj 2018). A second factor is inflation volatility due to possible internal or external economic shocks (Capistrán and Timmerman 2009; Lamla and Maag 2012; Siklos 2013; Montes et al. 2016). Finally, disagreements present an important inertia factor. That is, past disagreements affect current performance (Mankiw, Reis, and Wolfers 2003; Coibion and Gorodnichenko 2015). Thus, the following basic model is initially considered:

$$dis_t = \alpha_1 + \alpha_2 dis_{t-1} + \alpha_3 vol(\pi_{t-1}) + \alpha_4 |\pi^{\varepsilon} - 3.0|_{t-1} + \varepsilon_t^1 \quad (4)$$

where dis_t is the disagreement about inflation expectation, dis_{t-1} is the disagreement of the previous period, $vol(\pi_{t-1})$ is the inflation volatility, $|\pi^{\varepsilon} - 3.0|_{t-1}$ is the absolute value of deviations of expected inflation from the core inflation target of the central bank and is a measure of monetary policy credibility, and ε_t^i is the residual term. The explanatory variables operated with a one-period lag to avoid possible endogeneity problems. According with the methodology of Capistrán and Timmerman (2009) and Ehrmann, Eijffinger, and Fratzscher (2012) to compute the inflation volatility, we estimate a GARCH(1,1) model of an AR(1) model for observed inflation. Then, we extracted estimates of conditional volatility as a measure of inflation volatility (see Table A1-Appendix for more details).

Following the approach of Jansen and De Haan (2005), Montes et al. (2016), and Siklos (2016), future monetary policy intentions influence the

level of disagreement in inflation expectations. More specifically, as Rosa and Verga (2007) show, the expectations formed by agents around the same communication of the central bank, related to possible short-term monetary policy stances also affect financial volatility and, consequently, may have an effect on disagreements. In the Colombian case, press releases are the bank's main communication channel and receive great attention from financial markets as it allows for timely identification of changes in monetary policy.

According to Rosa and Verga (2007), the central bank's future policy stance can be quantified by the monetary policy communication signalling index (C_{t-1}^{MP}), taking values from −1, 0 to +1 based on the words used by the central bank in its press releases. The monetary policy communication signalling index takes the value +1 when the central bank signals that is it likely to raise the interest rate at the next meeting. The index takes the value −1 when the central bank signals, that is, it is likely to reduce the interest rate at the next meeting. Finally, the index takes the value 0 when the bank shows no signs of changing the interest rate in the short term as is consistent with price stability. This type of analysis is called content analysis, and the glossary of words used to classify the position of the Central Bank of Colombia in each *Press Release of the Board of Directors* over the 2010–2017 period is reported in the Appendix, Table A5. Thus, the basic model is expanded to include the monetary policy communication signalling. The following model is considered as a second specification:

$$\begin{aligned} dis_t = {} & \alpha_5 + \alpha_6 dis_{t-1} + \alpha_7 vol(\pi_{t-1}) \\ & + \alpha_8 \left|\pi^{\varepsilon} - 3.0\right|_{t-1} + \alpha_9 \; C_{t-1}^{MP} + \varepsilon_t^2 \end{aligned} \tag{5}$$

The clarity of central bank communication is an important variable that reflects the quality of information provided and increases the likelihood that the public understands the central bank's objectives. According to Jansen (2011a), clear communication reduces information asymmetry between the central bank and the public. To measure clarity, we use the Flesch index (1948). A similar method is applied by Jansen (2011a, 2011b), Bulíř, Čihák, and Jansen (2013), and Montes et al. (2016). Thus, a third model considered:

$$\begin{aligned} dis_t = {} & \alpha_{10} + \alpha_{11} dis_{t-1} + \; \alpha_{12} vol(\pi_{t-1}) \\ & + \alpha_{13} \left|\pi^{\varepsilon} - 3.0\right|_{t-1} + \alpha_{14} \; C_{t-1}^{MP} \\ & + +\alpha_{15} F_{t-1}^{MP} + \varepsilon_t^3 \end{aligned} \tag{6}$$

where F_{t-1}^{MP} is the Flesch index. According to Ferrando-Belart (2004), clarity refers to the ease with which a document can be read and understood. Therefore, we used the Flesch index adjusted by the method of Barrio-Cantalejo et al. (2008), which defines a readability scale to measure the ease of reading a text in Spanish.[4] The Flesch index uses three variables: the total number of syllables (L), the number of words (W), and the number of sentences (S). Based on these variables, the Flesch index is calculated as follows:

$$F_t^{PM} = 206.835 - \frac{62.3S}{P} - \frac{W}{S} \tag{7}$$

The index analyses grammatical readability; i.e., it determines whether a text is easier to read if shorter words and phrases are used in bank communication. Thus, an increase in the index (F_{t-1}^{MP}) of central bank press releases means an increase in the clarity of the information provided.[5] Figure 2 presents the explanatory variables. In general, it is observed that over the 2015–2016 period, the volatility of inflation increased, and the difference between expectations and the inflation target grew, that is, credibility fell. The performance of these variables may be a cause of the increase in disagreements observed.[6]

IV. Empirical evidence

The first procedure needed when using time series is a test for the presence of unit roots. Therefore, before estimating all the models, we performed the augmented Dickey-Fuller (ADF) unit root test, the

[4]To analyse the readability of a text in Spanish, changes to the Flesch formula (1948) are required to capture typographical features of the Spanish language. See Barrio-Cantalejo et al. (2008).

[5]The interpretation scale of the Flesch index is defined in the interval 0–40: very difficult; 40–55: somewhat difficult; 55–65: normal; 65–80: fairly easy; 80–100: very easy.

[6]Appendix A.1 provides the details of the data sources and the time series used in this study. The descriptive statistics are presented in Appendix A.2.

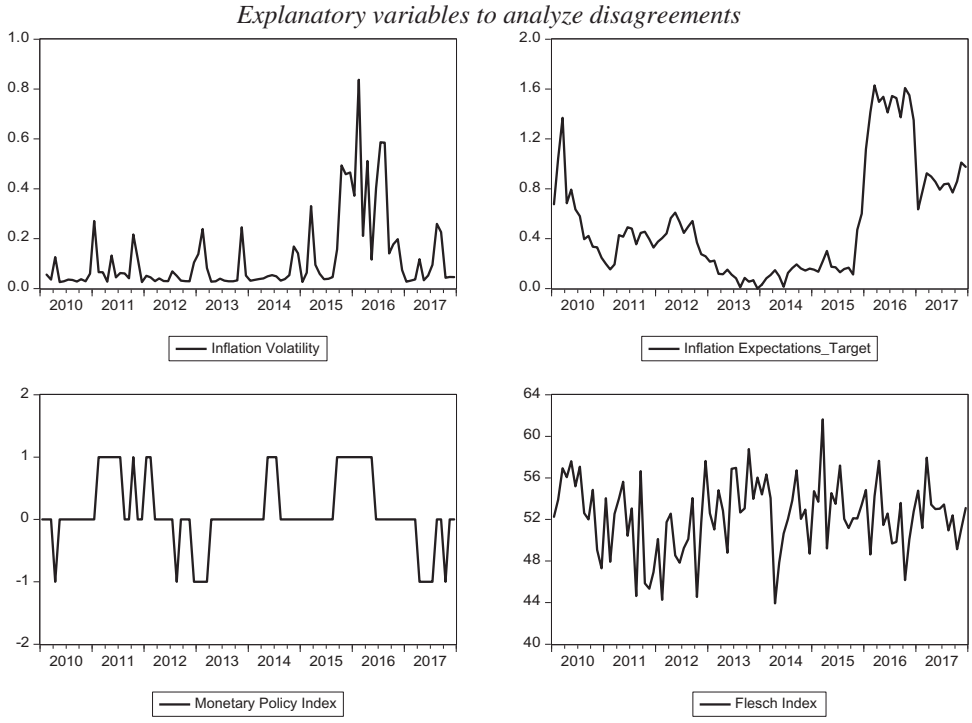


Figure 2. Explanatory variables to analyse disagreements.
Note: Data obtained from the Central Bank of Colombia.

Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test presented in Table A3 of the Appendix. The advantage of contrasting the results of the ADF and PP tests with the result of the KPSS test lies in the low power of the first two tests, which tend to not reject the null hypothesis. The decision criterion for the integration order was the convergence between the result of the KPSS test and at least one of the other two tests (ADF or PP). Based on the test results, all the variables used in Equations (4)–(6) are integrated of order zero.

We use two methods: ordinary least squares (OLS) with a Newey-West correction matrix and one-step generalized method of moments (GMM). According to Wooldridge (2003), the main reason for using the GMM approach is that the OLS estimator can lose confidence in the presence of serial correlation, heteroscedasticity or nonlinearity and endogeneity problems typical of time series that invalidate their properties. Due to these issues, the GMM estimator is more appropriate as it does not suppose normality and works properly in the presence of endogeneity. We need to take into account overidentifying restrictions for an efficient GMM estimator (Wooldridge 2003). Thus, to evaluate the overidentification conditions for implementing GMM, we performed a Hansen J-test for overidentification (1982) through lagged dependent variables.

Two variants of GMM were used. The first is GMM with a Newey-West covariance and weighting matrix (GMM-HAC). The second is GMM with a two-step covariance matrix as derived by Windmeijer (2005) (Windmeijer-GMM). According to Windmeijer (2005), this method is useful because it corrects possible significance biases in parameters for small samples. The significance of parameters was maintained in the models estimated with both GMM approaches.

The results of Equations (4)–(6) are reported in Table 1. First, we estimate Equation (4), which evaluates the effect of a disagreement lag, inflation volatility and central bank credibility. Then, we estimate Equation (5) and add the monetary policy communication signalling index. Finally, we add the clarity index to Equation (6) to obtain the joint effect of credibility, monetary policy signalling, and the clarity of central bank communication.

Table 1. Effects of communication on inflation expectation disagreements (OLS and GMM).

Dep variable dis_t:	**OLS-HAC**			**GMM-HAC**			**GMM-Windmeijer**		
Regressors	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
C	0.5150***	0.5845***	0.5663***	0.3999***	0.5523***	0.5951***	0.4186**	0.5294***	0.5972***
	(0.1421)	(0.1334)	(0.1297)	(0.0896)	(0.0873)	(0.0575)	(0.1749)	(0.1663)	(0.1171)
	[3.6239]	[4.3811]	[4.3657]	[4.4609]	[6.3239]	[10.344]	[2.3923]	[3.1833]	[5.0999]
dis_{t-1}	0.6823***	0.7002***	0.7312***	0.7240***	0.7391***	0.6941***	0.7078***	0.7449***	0.6921***
	(0.0763)	(0.0601)	(0.0605)	(0.0418)	(0.0345)	(0.0244)	(0.0836)	(0.0710)	(0.0501)
	[8.9375]	[12.017]	[12.084]	[17.313]	[21.370]	[28.446]	[8.4898]	[10.483]	[13.799]
$vol(\pi_{t-1})$	0.8468**	0.6596**	0.7710**	0.8184***	0.6796***	0.9080***	0.8847**	0.6455**	0.8728***
	(0.3770)	(0.2954)	(0.2919)	(0.1661)	(0.1812)	(0.0984)	(0.3460)	(0.3219)	(0.1714)
	[2.2459]	[2.2329]	[2.6411]	[4.9255]	[3.7505]	[9.3327]	[2.5567]	[2.0049]	[5.0905]
$\lvert\pi^{\epsilon} - 3.0\rvert_{t-1}$	0.2171**	0.2441**	0.1962**	0.2470***	0.2115***	0.2500***	0.1993**	0.1925**	0.2452***
	(0.1273)	(0.1021)	(0.0997)	(0.0438)	(0.0425)	(0.0318)	(0.0777)	(0.0728)	(0.0617)
	[1.9604]	[2.3906]	[1.9681]	[3.3591]	[4.9668]	[7.8464]	[1.9604]	[2.6426]	[3.9690]
C^{MP}_{t-1}		−0.2628**	−0.2495**		−0.2531***	−0.1818***		−0.2047**	−0.1950**
		(0.1213)	(0.1187)		(0.0720)	(0.0403)		(0.1010)	(0.0772)
		[−2.1663]	[−2.1014]		[−3.5140]	[−4.5115]		[−2.0264]	[−2.1355]
F^{MP}_{t-1}			−0.0080			−0.0154***			−0.0138**
			(0.0093)			(0.0039)			(0.0066)
			[−0.8672]			[−3.8850]			[−2.0777]
R^2adj	0.66	0.73	0.74	0.66	0.72	0.72	0.66	0.72	0.72
F-statistic	43.73	50.38	41.77						
P(F-stat)	0.00	0.00	0.00						
J-Stat				0.41	8.71	8.24	0.45	9.22	8.07
p(J-stat)				0.81	0.84	0.87	0.76	0.86	0.88
No. Instruments				6	18	19	6	18	19

Note: Significance level: (***) denotes significance at 0.01, (**) denotes significance at 0.05, (*) denotes significance at 0.1. Standard deviation in parentheses and t-statistics in brackets. P(F-stat) reports the p-value of F-test for significance of regression. P(J-stat) reports the p-value of J-test for overidentification. The list of GMM instruments is available in Table A6 of the Appendix.

An examination of the results shows that they are in line with expectations based on the theoretical perspective, and the estimated parameters are significant. The coefficient associated with the lag in disagreement is significant and positive in all models presented, which indicates inertia in disagreement about inflation expectations. This disagreement persists because, in many cases, market agents are slow to understand the current economic outlook. In sticky information models, agents do not update information at the same speed and, thus, inflation forecast divergences persist over time (Coibion and Gorodnichenko 2015). This is an important result that allows us to observe the adjustment dynamics of the forecast created by each financial market agent (Mankiw and Reis 2002; Ehrmann, Eijffinger, and Fratzscher 2012).

Furthermore, the inflation volatility coefficient shows the expected sign and is significant in all specifications. Higher inflation volatility generates distrust in expectation formation. This volatility negatively affects investment, actual production, and employment (see Hossain 2014; Sims 2003; Judson and Orphanides 1999). According to Coibion and Gorodnichenko (2012), in sticky information models, the degree to which agents update their information depends on macroeconomic volatility. Consequently, an increase in inflation volatility is associated with higher macroeconomic uncertainty that directly affects disagreement about inflation forecasts. These findings are compatible with those reported in studies such as Mankiw, Reis, and Wolfers (2003), Capistrán and Timmermann, (2009), Ehrmann, Eijffinger, and Fratzscher (2012), Dovern, Fritsche, and Slacalek (2012), and Siklos (2013).

As reported in Table 1, the coefficient associated with central bank credibility has a positive effect on disagreement. That is, the disagreement tends to be high when inflation expectations move away from the target (Ballantyne et al. 2016; Siklos 2016). Lower central bank credibility widens the differences in agents' expectations of future inflation behaviour and increases disagreement over the forecast (see, Beckmann and Czudaj 2018). This result shows that in emerging economies, inflation targeting systems, together with mechanisms that facilitate expectation management, are important tools for reducing disagreements (Montes et al. 2016; Falck, Hoffmann, and Hürtgen 2017).

Regarding the effects of monetary policy signalling on disagreements, we can conclude that the estimated parameter is negative and significant in all models. Thus, we can affirm that the central bank's position, established through a press release, can reduce disagreement in inflation expectations. Press release content allows agents to learn new information about the economic outlook and to understand the causes of inflation, the monetary authority's preferences and strategy and the policy stance (Rosa and Verga 2007). This helps agents anchor their expectations in the bank's targets and reduces dispersion in the inflation forecast. In sum, the press release of the Central Bank of Colombia is a powerful tool for reducing disagreement among financial market participants.

Finally, the coefficient measuring the effect of press release clarity shows the expected sign, although it is only statistically significant in estimates using GMM. When the central bank presents its point of view clearly, agents have a better understanding of the success probability for the inflation targets announced by the bank. Similarly, more precise information on the monetary policy stance reduces uncertainty about inflation control and leads to price formation that is anchored in the announced targets. Thus, increased clarity generates agreement among agents about future inflation. Similar results are reported by Fracasso, Genberg, and Wyplosz (2003), Jansen (2011a), Bulíř, Čihák, and Jansen (2013), and Montes et al. (2016).

Robustness

To ensure the robustness of the results and dynamically observe the behaviour of the relationships, we develop a vector autoregressive (VAR) model. The dynamic analysis of the VAR model is performed through impulse response functions, which evaluate the change in the analysis variable caused by shocks or innovations generated by residual variables over time (Sims 1980). The conventional method implies orthogonality, and

therefore, the result may depend on the order of the variables in the VAR system. According to Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998), we used a generalized impulse response function to eliminate the issue of variable order in the VAR model. The generalized impulse response function helps solve possible problems with contemporaneous correlation between variables and is an appropriate specification for an analysis without considering dependent and independent variables.

The estimation and impulse response analysis are carried out for the following set of variables dis_t, $vol(\pi_{t-1})$, $|\pi^{\varepsilon} - 3.0|_{t-1}$, C_{t-1}^{MP} and F_{t-1}^{MP}. We selected the VAR order lag based on the Hannan-Quinn information criterion (HQC), which is consistent and suitable for small samples; see Table A4 in the Appendix. Moreover, the roots of the VAR model fulfil the stability condition (see, Figure A1 in the Appendix).

As shown in Figure 3, regarding the deviations in expected inflation from the inflation target, our credibility variable, we found that a positive shock in expected inflation deviations from the target (TARGET_INF_EXP) increases disagreement. This evidence reinforces the result presented above and suggests that strong anchoring of inflation expectations to the target is important for reducing disagreements in inflation expectations (Montes et al. 2016).

Furthermore, we noted that an inflation volatility shock has a positive and significant effect on disagreement. As reported by Coibion and Gorodnichenko (2012) and Beckmann and Czudaj (2018), disagreement tends to fall after a shock. The evidence points to the direction indicated above: increases in macroeconomic volatility hinder the forecast, and consequently, disagreements between the agents increase (see Dovern, Fritsche, and Slacalek 2012; Ehrmann, Eijffinger, and Fratzscher 2012; Montes et al. 2016).

The response of disagreement to a change in the clarity index (INDEX_FLESCH) is negative, although not significant; thus, a positive clarity shock may reduce disagreement about inflation expectations, but it must be accompanied by other policies. This result partially supports the finding presented in Table 1, namely, that central bank communication is an important tool for reducing differences between agents when forecasting inflation. At the same time, the response to disagreement around a change in the monetary

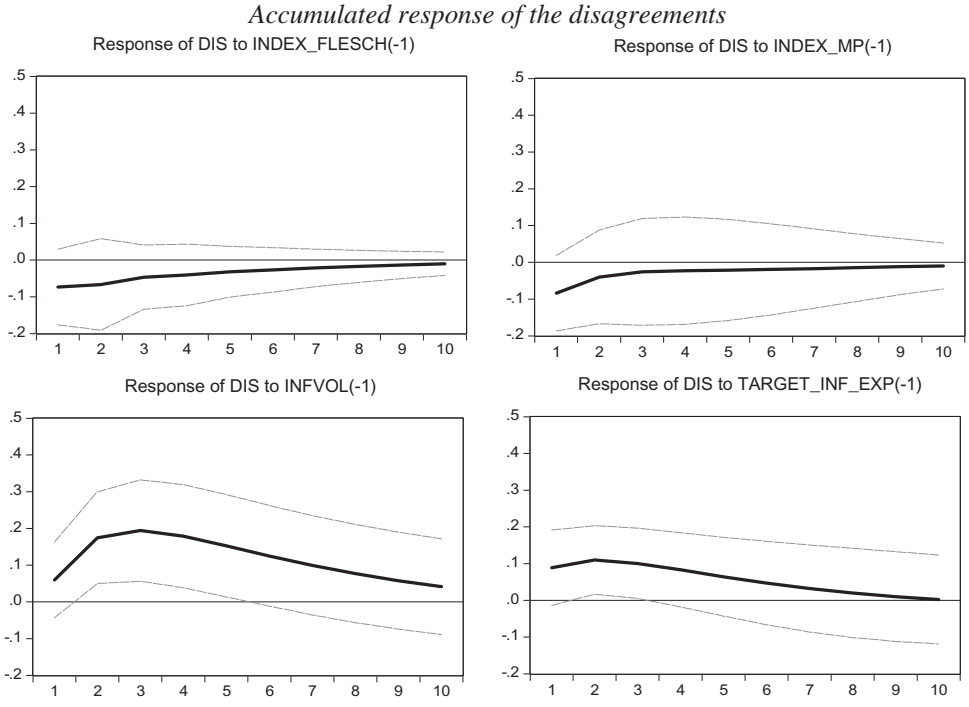


Figure 3. Accumulated response of the disagreements.

Note: Accumulated response to a generalized standard deviation innovation ± 2 SE.

policy stance index (INDEX_PM) is negative, although it is not significantly different from zero. This result suggests that press release content is important for reducing disagreement, but press releases can be improved to have greater effects.

V. Conclusions

This paper analysed the main determinants of disagreement about inflation expectations in the Colombian economy. Specifically, we evaluate the contribution of central bank credibility and the effects of its communication on reducing disagreement in inflation expectations. Three important aspects emerge from the empirical analysis. First, the findings show the importance of credibility as a central bank tool for reducing inflation expectation disagreements in the market. Second, the signal sent by central bank communication on future monetary policy is relevant to disagreement. If the central bank signals a future increase in interest rates, the evidence points to a decline in disagreement. In addition, if central bank communication is clear, disagreement tends to fall. Finally, we found evidence of strong inertia in disagreement, which suggests uncertainty about future inflation behaviour and monetary policy management.

The evidence shows that there is room for the central bank to improve its communication with markets about the inflation targeting regime of Colombia in order to decrease inertia and facilitate the anchoring of inflation expectations to the target. Moreover, the central bank should be more concerned about inflation volatility since this factor was found to stimulate disagreement.

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No potential conflict of interest was reported by the authors.

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Appendix

Table A1. Variables used and sources.

Variable name	Description	Source
dis_t	Disagreement about inflation expectations: calculated based on the expectations survey.	Created by the authors based on the methodology of fixed horizons of Equation (2) from data of the Central Bank of Colombia. http://www.banrep.gov.co/es/encuestas
$vol(\pi_t)$	Inflation volatility: The following model was considered:$\pi_t = \alpha + \beta\pi_{t-1} + \varepsilon_t {\sigma_t}^2 = \theta + \delta\varepsilon_{t-1} + \gamma{\sigma_{t-1}}^2$ The residual term, ε_t, were modeled as GARCH(1,1) model. We extracted the estimates of the conditional volatility as a measure of inflation volatility. The observed inflation was calculated from the cumulative variation in consumer price index.	Created by the authors based on data from the Central Bank of Colombia http://www.banrep.gov.co/es/indice-precios-consumidor-ipc
$\lvert\pi^e - 3.0\rvert_t$	Absolute value of the difference between inflation expectations and target: constructed based on the average value of inflation expectations recorded in central bank surveys.	Created by the authors based on data from the Central Bank of Colombia http://www.banrep.gov.co/es/encuestas
C_t^{MP}	Index of monetary policy stance based on press releases for the 2010–2017 period.	Central Bank of Colombia http://www.banrep.gov.co/es/comunicados-junta
F_t^{MP}	Clarity index of press releases: each press release was inserted into the text analyzer https://legible.es/which measures the linguistic readability for Inflesz index.	Central Bank of Colombia http://www.banrep.gov.co/es/comunicados-junta Text readability analyzer https://legible.es/
π_t	Cumulative inflation over the past 12 months; inflation was calculated from the cumulative variation in consumer price index.	Central Bank of Colombia http://www.banrep.gov.co/es/indice-precios-consumidor-ipc

Note: Created by the authors.

Table A2. Descriptive statistics.

Variable	Mean	Min.	Max.	St. Deviation	Kurtosis
dis_t	1.9995	0.85000	4.6000	0.7582	5.5005
$vol(\pi_t)$	0.0477	−0.8674	0.6856	0.3000	4.1396
$\lvert\pi^e - 3.0\rvert_t$	0.4679	0.0009	1.6297	0.4592	3.8040
C_t^{MP}	0.1944	0.0000	1.0000	0.3985	3.3842
F_t^{MP}	52.1150	43.9400	58.7800	3.5900	2.6651

Source: Created by the authors.

Table A3. Unit root and stationarity tests.

Series	ADF				PP				KPSS			
	Lags	Esp.	Test	CV (1%)	Band	Esp.	Test	CV (1%)	Band	Esp.	Test	CV (1%)
dis_t	0	T,C	−4.13	−4.07	2	T,C	−4.14	−4.07	6	C	0.56	0.73
$vol(\pi_t)$	0	N	−4.59	−2.59	2	N	−4.62	−2.59	4	C	0.11	0.73
$\lvert\pi^e - 3.0\rvert_t$	0	C	−9.02	−2.59	3	N	−0.38	−2.59	6	C	0.25	0.73
C_t^{MP}	0	N	−4.17	−2.60	2	N	−4.06	−2.60	4	C	0.10	0.73
F_t^{MP}	0	C	−7.46	−3.51	4	T,C	−7.67	−4.07	5	C	0.12	0.73

Note: Created by the authors. CV = critical value. Trend (T), and/or constant (C), or neither a constant nor a trend (N) are included based on Schwarz information criterion. The KPSS Test was used with Newey-West band.

Table A4. Selection of VAR lag order (Dependent: Dis).

Lag	With constant	Without constant
	HQC	HQC
1	−11.13[a]	−11.42[a]
2	−10.65	−10.68
3	−9.77	−9.44
4	−9.18	−8.88
5	−8.80	−8.59

Note: HQC: Hannan-Quinn information criterion. [a]Indicates lag order chosen by criterion.

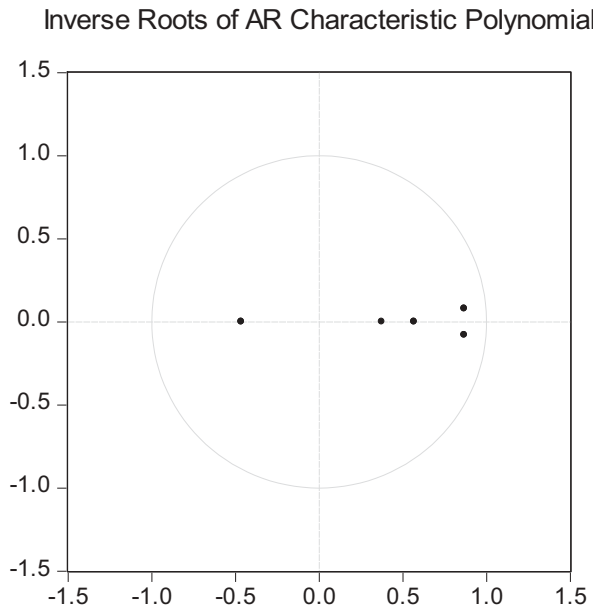

Figure A1. VAR Stability.

Source: Created by the authors.

Table A5. Words used to construct the monetary policy stance index.

Glossary	Index
Inflation was higher than projected.	+1 (Contractionary)
Monetary stimulus should be gradually reduced.	
The average of core inflation measures increases and exceeds the midpoint of the target range.	
Inflation expectations increased.	
GDP growth higher than expected.	
Core inflation indicators decreased, remaining within the inflation target range.	0 (Neutral)
Economy on the path to recovery.	
Inflation will remain within the long-term target range.	
The average of core inflation measures kept on target.	
Inflation expectation risks have moderated.	
Economic indicators and their forecasts show a product level converging toward its potential.	
Risks determined by inflation rise have decreased.	-1 (Expansionary)
Both the average of core inflation and inflation expectations are below the long-term target.	
Colombian economy is growing below potential.	
Observed and forecast inflation is below the 3% target and no upward pressure is expected.	
Core inflation measures remained relatively stable.	
The economy needs greater liquidity.	

Source: Created by the authors.

Table A6. List of GMM instruments.

Model	Instruments
Model (1)	DIS_{-2}, DIS_{-3}, $vol(\pi)_{-2}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-2}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-3}$
Model (2)	DIS_{-5}, DIS_{-6}, DIS_{-7}, DIS_{-8}, DIS_{-9}, $vol(\pi)_{-2}$, $vol(\pi)_{-3}$, $vol(\pi)_{-4}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-2}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-3}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-4}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-5}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-6}$, $C^{MP}{}_{-2}$, $C^{MP}{}_{-3}$, $C^{MP}{}_{-4}$, $C^{MP}{}_{-5}$, $C^{MP}{}_{-6}$
Model (3)	DIS_{-5}, DIS_{-6}, DIS_{-7}, DIS_{-8}, DIS_{-9}, $vol(\pi)_{-2}$, $vol(\pi)_{-3}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-2}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-3}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-4}$, $\lvert\pi^{e}\text{-}3.0\rvert_{-5}$, $C^{MP}{}_{-2}$, $C^{MP}{}_{-3}$, $C^{MP}{}_{-4}$, $C^{MP}{}_{-5}$, $C^{MP}{}_{-6}$, $F^{MP}{}_{-2}$, $F^{MP}{}_{-3}$, $F^{MP}{}_{-4}$,

Source: Created by the authors.