"MONETARY POLICY IN COLOMBIA AND ITS IMPACT ON TREASURY BONDS (TES), A STUDY OF EVENTS".

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DEGREE WORK

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Abstract

The present work will focus on analyzing one of the channels of transmission of monetary policy, the portfolio channel, evaluating the impact which the movements of the intervention rate of the Bank of the Republic (TI-BR from now on) have on treasury bonds (TES1). Likewise, the impact on equity will be reviewed (we use the Colcap2 index) and on short-term interest rates (the DTF3 and the IBR4 will be used).

Initially and under the methodology of "study of events5"; using time windows of 5, 10 and 30 days, and without including the effect of the so-called "surprise component6", it was found that there is a relationship, statistically significant, that allows us to affirm that, the changes in the TI-BR, cause effects on TES market rates.

However, when the "surprise component" effect is included in the estimates, the results change significantly, in the sense that the investment decisions of the stock market agents already incorporate the possible results of the decision of the Board of Directors of the Bank of the Republic (JD-BR), on its policy rate, making the effect that can be generated in the market rates of the TES, be discounted and only when a surprise is generated, greater than 50 basis points, between the decision of the issuer and what the stock market estimated, can explain a real impact on the valuation of the TES.

These results are obtained under an extended market model (CAPM7), which includes the surprise component and later this result is corroborated by means of an analysis of variance, Anova8, where its factors are contrasted, evidencing that no impact is generated in the rates of TES market; explained basically by the "perfect analysis of the market", on the decisions of the issuer and the transmission of the monetary policy, under the portfolio channel.

The Objective Inflation (IO) scheme, implemented in Colombia since 1999, has been quite successful, not only for directing inflation within the target range set by the issuer, but also because it allowed us to confirm the important degree of "credibility9" in the which is currently the Central Bank of Colombia and its monetary policy decisions.

JEL Classification: E43, E52, F31

Keywords: Monetary Policy, Reference rate, transmission mechanisms, efficient markets hypothesis, event study, surprise component

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1 They are the most representative titles in the large portfolios in Colombia. At the March 2018 cut, the mandatory pension funds maintain 31.3% of their portfolios (70 billion) in treasury Bonds (TES) and 15.3% (34 billion) in local shares.

2 Index calculated by the BVC, which reflects the price variations of the 20 most traded shares in the Colombian market, where the adjusted Market Capitalization value of each company determines its participation within said index.

3 Interest rate that on average they promised to pay to savers banks, savings and housing corporations, financial corporations and commercial finance companies for term certificates (CDT) with 90 days open during the last week.

4 Interest rate that reflects the price at which banks are willing to offer or to attract money market resources. The IBR is calculated from the contributions of the participants in the IBR trainers scheme, where the quoted rates correspond to the nominal interest at which these entities are indifferent between lending and receiving resources for the respective term.

5 This methodology was developed by Ball and Brown (1968) and later Fama et al. (1969). Some more recent references are: Attiya (2009), Fadl (2011) and Oberndorfer, Wagner and Ziegler (2001) and recently Gómez, Villamizar and Leiva (2016).

6 The surprise is measured as the difference (in basic points) between the rate estimated by the market analysts, which will be the decision of the Central Bank, (increase, decrease or keep its policy rate equal), vs the rate finally announced by the sender.

7 The CAPM model (Capital Asset Pricing Model) is a valuation model of financial assets developed by William Sharpe that allows estimating its expected profitability based on systematic risk.

8 An analysis of variance (ANOVA) tests the hypothesis that the means of two or more populations are equal. The ANOVA evaluates the importance of one or more factors when comparing the means of the response variable in the different levels of the factors.

9 A central bank is credible when market agents believe it will do what it says it will do (Blinder, 2000) or, in Cukierman's (1986) terms, a central bank is credible if its policy of pursuing price stability, or reach an inflation target, is taken by private agents as the basis to form their expectations.
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1. Introduction

It is important to analyze the impact of monetary policy on the stock market, as its results will allow us, on the one hand, to evaluate the success of the "objective inflation" (IO) strategy adopted in Colombia since 1999, as a factor determinant in the control of inflation and the formation of expectations; on the other hand, to corroborate the transmission mechanism of the monetary policy towards its different channels, and also to establish if there are possible opportunities to generate profits in the negotiation of market instruments, contrary to the hypothesis of efficient markets.\(^{10}\)

In Colombia, the transmission of the impact of the TI-BR, at market rates, has been revised several times: Huertas, Jalil, Olarte and Romero (2005) found that the movements in the intervention rates of the BR affect the interbank rate (TIB); the DTF and the preferential, treasury, ordinary and consumer credit rates.

For his part, Amaya (2006) studied the way in which the banks establish their interest rates and found that the interbank rate (TIB), proxy of the TI-BR, affects the marginal rate of the certificates to term (CDTs) and the credit market rate in an important and rapid way.

Melo and Becerra (2006), present evidence in favor of a response of the interbank rate and the CDT to shocks in the rate of expansion auctions. On the other hand, Betancourt, Vargas and Rodríguez (2006) also model the banking sector and establish the existence of responses of interest rates on term deposits and M3, after checking some macroeconomic variables.

In turn, Arango, Gonzalez, Leon and Melo (2008) point out that: "under the perfect credibility of the monetary authority, a restrictive monetary policy (that is, an increase in the monetary policy rate) will temporarily raise short-term interest rates (money is increased in all instances of the market) and reduce long-term inflation rates."

The objective inflation strategy adopted in Colombia is based on the assumption that the BD-BR exerts an important influence on the set of interest rates (active and passive) of the economy, through its main policy instrument, the Repo rate or Intervention rate (TI-BR). Under the assumption that interest rates have one component associated to the real interest rate and another to inflation expectations, it can be explained that, through movements in the TI-BR, the central bank may affect the trajectory of expectations of future inflation and through these, future inflation.

The reaction of the rates of the stock market instruments to the movements in the intervention rates of the central banks, is explained by changes in the expectations on the levels of the market rates, throughout the life of said bonds. The hypothesis that the interventions of the monetary authority affect market interest rates has been successfully verified in some advanced countries (Cook and Hahn, (1989), Dale, (1993), Roley and Sellon, (1995), Kuttner, (2001), and Demiralp and Jorda, (2004), among others).

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\(^{10}\) The Efficient Market Hypothesis (HME) argues that all relevant information should be reflected in the prices of stock values, Eugene Fama (1970) Stock Market

\(^{11}\) This is the rate at which commercial banks and financial institutions lend to each other. It is the rate which is first affected by the decisions of the issuer.
2 Theoretical framework

2.1 Channels of transmission of monetary policy

One way to assess the degree of transmission of changes in the interest rate of intervention of the Bank of the Republic (TI-BR) to market interest rates, is to measure it after the decision of the central bank to raise or lower this rate. That is, to calculate how much a specific interest rate has varied, after the monetary authority modifies its policy rate.

This methodology does not take into account the effects of the agents' expectations about the transmission, since the market can anticipate and partially incorporate the expected variations in the interest rates of the economy and, therefore, the transfer would be underestimated. The latter is important since, in theory, both anticipated changes and those not anticipated by financial institutions have an effect on the fixing of market interest rates.

Other methodologies are also used to measure the effects of the monetary policy rate on market rates, amongst which are: narrative evidence, autoregressive vectors, ex ante returns, CAPM models, variance analysis (ANOVA) and, of course, "analysis of study of events ".

The responsibility for the monetary policy rests with the Board of Directors of the Bank of the Republic (JD-BR hereafter) whose main mandate is the control of inflation, under a scheme of Objective Inflation (IO). If, as a result of the issuer's assessment of the state of the economy, it is concluded that there are risks of inflation deviating from the target range (3% +/- 1%), within a certain time horizon, and that said deviation it is not due to transitory shocks, the JD-BR will proceed to modify its policy position, adjusting its main instrument, the intervention interest rate, also called the REPO rate.

Each time the JD-BR modifies its intervention rate, it sets in motion the transmission mechanism of the monetary policy towards its different channels. This consists of the impact (+/-) which is caused, with a certain lag in the interest rates of the banking market (TIB, DTF, IBR, etc.,); the exchange rate (TRM); the expectations of inflation and, consequently, the prices (see, price / rate effect of a bond) of the main instruments of fixed income and variable income.

According to Loayza and Schmidt-Hebbel (2002); the monetary policy rules used by the Central Banks evaluate their efficiency and optimality mainly through four transmission channels of monetary policy: the interest rate channel, the asset price channel (here the TES are located), the exchange rate channel, and the credit channel. These channels affect the macroeconomic variables with different speeds and intensities.
2.2 Impact of monetary policy decisions

In reviewing the literature, we find several studies that analyze the impact of Monetary Policy decisions in the stock market, when central banks adjust their reference rate; among them we find the following documents:

M. Thorbecke (1997) analyzed the response of the share yields, in the face of changes in the rates of the USA’s federal funds, finding that there is a large, statistically significant relationship, between the changes of the federal funds and share prices; and concludes that "a reduction in the rates of federal funds causes increases in the yields of the shares and that the increases in these rates produce a reduction in the returns of the stock market". For his analysis he used four different methods: autoregressive vector, narrative evidence, analysis of study of events and ex ante returns.

Bernanke and Kuttner (2003), tried to explain the reaction of the stock market in the face of the monetary policy measures taken by the FED, using the methodology of the study of events, finding that it is necessary, in order to properly analyze the effects of monetary policy in the profitability of the market, "to establish adequately the difference between the expected monetary policy actions, and those not expected ...".

The results of their research showed that the market reacts strongly to the surprise changes in the federal funds rate. For example, they found that the weighted value index of the Center for Research in Security Prices (CRSP) recorded a gain of 1%, in response to a surprise drop of 25 basis points in the interest rate. In turn, an unexpected cut in the federal funds rate by 25 basis points caused an increase of 1.3% in the prices of the shares that make up the S & P 500.

On the other hand, Ehrmann and Fratzscher (2004), using the methodology of study of events, and in light of the Hypothesis of the Efficient Markets (HME), studied the effects of the "surprise component"
in the profitability of the shares in the days in which the announcement is made. As a result, they found that an increase in the rate of federal funds by 100 basis points decreases the returns of the stock market by 5.5%, with a significance level of 1%.

In turn, Gagnon et al. (2011) in their work "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases.", analyze the effect of Quantitative Easing "QE" on the financial market of the United States. In particular, the authors measure the effect of LSAP on the rate of return of treasury bonds of 2 to 10 years, agency debt to 10 years, 30-year MBS, corporate bond index Baa, 10-year swap rate, and 10-year term bonus of treasury bonds (T-bills). They conclude that there is sufficient evidence to state that the purchases led to long-term and economically significant reductions in long-term interest rates for a range of instruments, including some that were not in the purchase programs.

On the other hand, Rai (2012), makes the estimation of Quantitative Easing in different economic variables, such as long-term interest rates, the financial markets and economic activity (unemployment) in the United States. For his part Nellis (2013), seeks to estimate the effectiveness of QE, that is, if each of these Federal Reserve interventions loses its effectiveness due to anticipation by the agents of these measures.

Neely (2014) estimates the effect of forward orientation (Forward Guidance) and the LSAP on the return of 10-year bonds, both in the United States and other advanced economies. In this study the methodology of study of events is used with a window of the one-day event and it concludes that the forward orientation and the LSAP were effective in decreasing the rate of return of 10-year bonds. These results apply for both Japan (18 basis points) and Australia (63 basis points).

Leyva, Gómez, Valencia, Villamizar, (2016) using the methodology of "study of events", managed to find significant evidence that the returns of share indexes of a group of emerging countries, reacted to the statements of the Federal Reserve Committee (FOMC) on the future of the large-scale asset purchase program (LSAP).

In particular, they managed to establish that the unconventional policy employed by the FED had a significant impact on the return of stock indexes in emerging countries. Specifically, it is established that the QE1\textsuperscript{12} affects by 7.314%, the QE2 by -2.988% and the QE3 by 2.290% the return of the indexes of a sample of emerging countries. The aggregate effect of the entire asset purchase program has a positive effect on all regions and on the total sample. Specifically, the effect of the entire asset purchase program on the return of the indexes of the total sample is 6,616%.

2.3 Credibility of the Central Bank

Rodriguez, (2016)\textsuperscript{13}, found that the credibility of monetary policy in Colombia has been changing, and its evolution has been marked by the behavior of monetary policy and the position of the Bank of the

\textsuperscript{12} The FED began, from November 2008 to March 2010, a series of operations with its member banks, known as "QE1", (Quantitative Easing 1) consisting of open market operations, buying US $ 600 billion in securities backed by mortgages, and US $ 100 billion in consumer loans, Treasury bills, bonds and notes. In November 2010, the FED began the second round of liquidity injection known as QE2. In total, 600 billion dollars were injected again. In September 2011, the Twist operation began, with the objective of exchanging short-term bonds for long-term bonds, for a program amount of 400 thousand dollars, and it was to last until June 2012. In September 2012, the third liquidity injection round known as the QE3, unlike the previous ones this did not have an expiration date and the only condition is that it would inject 85 billion dollars per month.

\textsuperscript{13} Credibility, anchoring of expectations and transmission of monetary policy in a target inflation scheme, Diego Rodriguez, National University of Colombia, 2016. Degree thesis
Republic in the different episodes of the economic cycle. From 2004 to 2015, an increase in credibility stands out, which has been translated not only into the level of the same variable, but into a greater convergence of the nominal anchor to the announced inflation target: "Credibility should be taken as a continuous variable, that is to say, one cannot speak categorically of a credible or non-credible monetary policy, but one with a certain degree of credibility."

Likewise, greater credibility leads to less volatility in the intervention rate and dispersion of expectations, which is why the monetary authority's concern to maintain this intangible asset is justified, since it helps to anchor expectations and increase the capacity of the central banker to handle monetary policy with more announcements than frequent movements in the intervention instrument.

3 Methodology of study of events

Reviewing the literature allows us to conclude that the "event study methodology" is the most appropriate to measure the impact of the TI-BR on fixed-income securities (TES). The works of Fama, (1991), Kuttner (2001), Bernanke and Kuttner (2003) and Ehrmann and Fratzscher (2004), confirm this.

This methodology allows us to establish if there are changes (variations in market rates %) which generate changes in the price of a financial asset, in the face of movements in the IT-BR.

This paper will focus on estimating the effect of Bank of the Republic interventions on the market interest rates for some references of the TES B Pesos and TES UVR, in the medium and long term. The effects on Colcap, DTF and IBR will also be reviewed. The study period is: January 2016 to January 2018.

For this type of analysis, the information is usually divided into 2 sub-samples or windows: the estimation and the event, given an event in time $t = \text{DE}$

The first comprises the period $t = [1, T_1 - 1]$, and the second comprises $t = [T_1, T_2]$ around the day of the event (DE). The schematic representation is presented below:

![Illustration 2 Scheme of the Events Analysis](source: Mackinley 1997, author’s settings)

14 This methodology was developed by Ball and Brown (1968) and later Fama et al. (1969). Some more recent references are: Attiya (2009), Fadl (2011) and Oberndorfer, Wagner and Ziegler (2001) and recently Gómez, Villamizar and Leiva (2016).

15 The final value of a financial asset corresponds to the net present value of the asset, discounted with the market IRR, that is why it is an inverse relationship between the price and the rate. This is known as the dirty price.
In this case, the methodology is biased towards studies of short-term events, taking into account that it seeks to estimate the effect of interventions by the Bank of the Republic, on the returns of different securities in a maximum period of 30 days (given that the information of the data is daily).

For purposes of the time window, the results obtained will be reviewed with windows of 30, 10 and 5 days; since, having daily information, these periods should reflect the effects of the Bank of the Republic’s interventions, in the interest rate of the selected TES.

According to Patton, Rose and Tabak (2003), one of the ways to define an optimal time window is to analyze the behavior of the market before interventions of the Central Bank.

Arango, González, León and Melo (2006), found that the Central Bank, to enjoy credibility in the market can affect the performance of secondary market rates of return. Their results allowed them to show that it is with a time window of 30 days, that "reactions in the spread of domestic interest rates" are observed.

Once the optimal window is defined, the effects will be evaluated, including the surprise component, which is defined as the difference between the estimated IT-BR, according to market surveys¹⁶ and the observed IT-BR.

That is to say there is surprise when the market estimates on the decisions of the Central Bank, show a significant difference (greater than 25 basis points). Of the selected sample, (from January 1, 2016 to January 31, 2018), a “surprise” of 25 (+/-) basic points occurs between the Ti-BR and what was expected by the market only 8 times; the other observations show that the market is correct in its forecast of the intervention rate, according to the following table:

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¹⁶ Data was taken from the financial opinion survey, (EOF) of Fedesarrollo and the BVC.
Table 1. Series of TI-BR vs Estimated TI 2016-1/2018-1

<table>
<thead>
<tr>
<th>Date</th>
<th>Observed TI-BR (a)</th>
<th>Estimated TI-BR (b)</th>
<th>Surprise (a-b) (Basic points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>jan-16</td>
<td>6.00%</td>
<td>6.00%</td>
<td>0</td>
</tr>
<tr>
<td>feb-16</td>
<td>6.25%</td>
<td>6.25%</td>
<td>0</td>
</tr>
<tr>
<td>mar-16</td>
<td>6.25%</td>
<td>6.50%</td>
<td>-25</td>
</tr>
<tr>
<td>Apr-16</td>
<td>7.00%</td>
<td>6.75%</td>
<td>25</td>
</tr>
<tr>
<td>may-16</td>
<td>7.25%</td>
<td>7.25%</td>
<td>0</td>
</tr>
<tr>
<td>jun-16</td>
<td>7.50%</td>
<td>7.50%</td>
<td>0</td>
</tr>
<tr>
<td>jul-16</td>
<td>7.75%</td>
<td>7.75%</td>
<td>0</td>
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<tr>
<td>Aug-16</td>
<td>7.75%</td>
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<td>sep-16</td>
<td>7.75%</td>
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<td>7.75%</td>
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<td>0</td>
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<tr>
<td>nov-16</td>
<td>7.75%</td>
<td>7.75%</td>
<td>0</td>
</tr>
<tr>
<td>Dec-16</td>
<td>7.50%</td>
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<td>Jan-17</td>
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<td>mar-17</td>
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<td>6.50%</td>
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<td>oct-17</td>
<td>5.00%</td>
<td>5.25%</td>
<td>-25</td>
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<tr>
<td>nov-17</td>
<td>4.75%</td>
<td>5.00%</td>
<td>-25</td>
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<tr>
<td>Dec-17</td>
<td>4.75%</td>
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<td>Jan-18</td>
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<td>Apr-18</td>
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<td>jun-18</td>
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<td>0</td>
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<tr>
<td>jul-18</td>
<td>4.25%</td>
<td>4.25%</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Fedesarrollo-BVC Financial Opinion Survey and Author Calculations

Assumptions of study of events methodology:

i. Efficient financial markets (before an unexpected intervention).
ii. The expected effect must be fast and persistent.

This last result is based on:

- Only unexpected interventions are important. The reason is that, if these interventions are expected by the agents, they are anticipated, making the effect not significant.
- News of changes in monetary policy is immediately incorporated into the prices and that effect is expected to be permanent.
For example, if the aforementioned conditions are met, it would be expected that the interventions of the Central Bank have an effect, in the same sense, on the market interest rates of the TES (medium and long term), and the effect is persistent. When talking about the performance of shares, it is expected that this will decrease after the intervention of the Central Bank of increases in the TI-BR.

The study of events methodology can be carried out in the following steps:

- The first step is very important, since it defines the type of events that will be used in the estimates. For this research work, events are defined as those in which Bank of the Republic interventions imply changes in their reference interest rate.
- Identify the estimate, the event(s) and post events windows. As mentioned, the estimates seek to see the effect in the short term, of the Bank of the Republic estimates. According to Mackinley (1997), if the event includes "surprise gains", the time window must include at least the next day of the intervention, in order to capture the effects that occur after said event.

In mathematical terms, the event window can be defined as:

$$ event\ window = \{ t \in \mathbb{Z} | T_1 < t < T_2 \} \quad (1) $$

Where $T_1$ represents the beginning of the window and $T_2$ the end of it. The index $t$ shows the intermediate steps, when $t = 0$, is the day of the event or intervention, when having discrete time, $t$ must be a whole number, which is why the condition $t \in \mathbb{Z}$ is established.

This means that the definition of the window is defined by:

$$ L_{ev} = T_2 - T_1 \quad (2) $$

- Estimate the parameters, using the data of the financial assets, as well as the selected events and windows.
  - The average return $\bar{r}_i$ and the volatility $\sigma_e$, using the constant average model.
  - $\alpha_i$ and $\beta_i$ and $\sigma_e$, of the market model.
  - Calculate the abnormal returns $ra_{i,t} = r_{i,t} - \bar{r}_i$.
  - Calculate the abnormal accumulated returns $raa_{i,t}(t_1, t_2) = \Sigma_{t_1}^{t_2} ra_{i,t}$

The average normal return for the estimation window, in this case, is calculated as the average of the percentage variation of the interest rate for each of the TES mentioned in the following section:

$$ \bar{r}_i = \frac{1}{t_1 + t_2} \Sigma_{t_1}^{t_2} ra_{i,t} \quad (3) $$

In this exercise, the parameters $\alpha_i$ and $\beta_i$, are not estimated, to reach the average return. The explanation is, the non-availability of economic fundamentals with daily information, to include as control variables.

The abnormal returns, $ra_{i,t}$, for each of the TES, are calculated by subtracting each percentage variation of the interest rate:
The observations of abnormal returns must be added in order to make statistical inference about the event:

\[ CAR_i(T_1, T_2) = \sum_{T = T_1}^{T_2} AR_{i,T} \]

Where:

\( CAR_i \), are the cumulative returns of instrument \( i \) in the event window.

Standardized test-\( t \)

\[ SAR_{i,T} = \frac{AR_{i,T}}{SD(AR_{i,T})} \]

\[ SD(AR_{i,T}) = \sqrt{\frac{1}{L_1 - 1} \sum_{t = T_0}^{T_1} AR_{i,t}^2} \]

\[ \theta_T = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} SAR_{i,T} \]

Where:

\( SAR_{i,T} \), are the standardized returns of instrument \( i \).

\( SD(AR_{i,T}) \), is the sample standard deviation of the abnormal returns for the estimation window.

\( \theta_T \), is the test statistic that seeks to determine with a 1-Alpha confidence level if the events affect the expected returns of the financial instruments.

Test-\( t \) for Accumulated Abnormal Returns

\[ \frac{CAR_i(T_1, T_2)}{SD(CAR_i)} = \frac{\sum_{T = T_1}^{T_2} AR_{i,T}}{\sqrt{L_2 D(AR_{i,T})}} \]

For the estimation, the return of the day of the event \( R_0 \) is compared with the returns observed during a control period before the event. If the return of the day of the event is statistically significant compared to the returns of the period before the event, it can be concluded that the event has a significant effect on the returns.

Now, for this research work, we follow the methodology proposed by Patnaik, Singh and Shah (2013), to perform the inference, by means of which extreme values are defined at 2.5% for the lower and upper limit for non-contaminated events:

Assuming you have a series of return times like \( x_{i,t} = 1, \ldots, T \). For the \( q \) quantile of interest, \( Q(x, q) \), is identified, such that \( \Pr(x_t > Q(x, q)) = q \). In this way, the data set for the upper limit is obtained:

\[ E^+ = \{i \} \text{ such that } x_i > Q(x, q) \]
In a similar way the lower limit is defined, the total set of events is defined as \( E = E^+ \cup E^- \), which is the set of extreme values.

The window of events of interest has an amplitude before and after \( W \) days, before and after the date of the event. We define the set of uncontaminated events of extreme events in the upper limit \( E^+_j \), as the dates \( \{j\} \), where:

\[
j \in E^+ \quad (j + k) \notin E^+ \quad k \in \{-W, \ldots, -1, 1, \ldots, W\}
\]

This traditional statistical inference is described in the following steps:

- There are \( N \) events. Each event is expressed in a series of time, of the cumulative returns mentioned, on the date and within the window of the event, the statistical summary corresponds to the average of the accumulated returns.

- Sampling is performed with replacement at the level of events. Each sample by means of bootstrap is constructed by performing the sample with replacement \( N \) times, within the set of \( N \) events. For each event, this average of the accumulated returns is taken. In this way we obtain a series of average return times, which is a brushstroke of the distribution of the statistic.

- This procedure is repeated 1,000 times to obtain the complete distribution of the accumulated returns.

### 4 Description of data

A sample with the following treasury titles is selected: TES B Fixed rate with due dates: 09/11/2019; 07/24/2020; 04/05/2022; 07/24/2024; 08/26/2026; 09/18/2030; 06/30/2032; and TES B UVR with due dates: 11/21/2018; 10/03/2021; 04/28/2028; 04/04/2035; the data of market rates of these bonds are taken from the Bloomberg source. The impact on the main stock index for variable equities will also be reviewed (COLCAP) and for securities other than TES, such as CDTs and private sector bonds, the DTF and IBR indices will be reviewed. The dates of the interventions made by the Bank of the Republic are taken from the Central Bank page, as well as for the "surprise component" data from Financial opinion survey of Fedesarrollo and BVC.

The analysis is carried out for the period between January 1, 2016 and January 31, 2018. For the estimation, the dates of the interventions of the Bank of the Republic are taken as those in which the Central Bank changed its interest rate (increased, decreased); it is not taken into account when it is kept the same; according to the following table:
Table 2 shows the intervention dates of the Bank of the Republic, together with the type of modification to the intervention interest rate. From January 1, 2016 until July of the same year, the interventions consisted of increases in the interest rate, with the objective of redirecting the inflation rate towards the target range (2% -4%). From August to November 2016 there were no changes in the TI-BR; then from February 2017 until August of the same year is a period of decrease and then a mixed period between declines of the TI-BR and periods without changes in the rate.

To determine the differentiated effects of the Bank of the Republic’s interventions (increases and decreases in the interest rate), two sets of information were defined in terms of dates; the first from February 1st 2016 to August 1st 2016. In this period of time the interventions were aimed at returning
the inflation rate to its target range. The other period is taken as of August 2016, where most interventions consisted of interest rate decreases.

4.1 Statistical analysis of the data

<table>
<thead>
<tr>
<th>TES expiry</th>
<th>Nº observations</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Estándar deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/26/2026</td>
<td>554</td>
<td>7.21</td>
<td>6.12</td>
<td>9.46</td>
<td>0.3</td>
</tr>
<tr>
<td>09/18/2020</td>
<td>554</td>
<td>7.41</td>
<td>6.35</td>
<td>9.85</td>
<td>0.17</td>
</tr>
<tr>
<td>06/30/2024</td>
<td>284</td>
<td>6.99</td>
<td>6.11</td>
<td>7.46</td>
<td>0.03</td>
</tr>
<tr>
<td>07/24/2024</td>
<td>554</td>
<td>6.93</td>
<td>5.76</td>
<td>9.04</td>
<td>0.17</td>
</tr>
<tr>
<td>07/24/2020</td>
<td>554</td>
<td>6.46</td>
<td>5.13</td>
<td>8.54</td>
<td>0.61</td>
</tr>
<tr>
<td>05/04/2022</td>
<td>554</td>
<td>6.73</td>
<td>5.59</td>
<td>8.98</td>
<td>0.86</td>
</tr>
<tr>
<td>09/11/2019</td>
<td>554</td>
<td>6.28</td>
<td>4.75</td>
<td>8.3</td>
<td>0.97</td>
</tr>
<tr>
<td>03/10/2021</td>
<td>554</td>
<td>2.94</td>
<td>1.92</td>
<td>3.98</td>
<td>0.47</td>
</tr>
<tr>
<td>04/28/2028</td>
<td>554</td>
<td>7.36</td>
<td>6.37</td>
<td>9.7</td>
<td>0.81</td>
</tr>
<tr>
<td>04/04/2035</td>
<td>510</td>
<td>3.76</td>
<td>3.3</td>
<td>4.68</td>
<td>0.26</td>
</tr>
<tr>
<td>11/21/2018</td>
<td>554</td>
<td>6.07</td>
<td>4.66</td>
<td>7.88</td>
<td>0.97</td>
</tr>
<tr>
<td>03/25/2033</td>
<td>554</td>
<td>3.78</td>
<td>3.21</td>
<td>4.77</td>
<td>0.32</td>
</tr>
<tr>
<td>04/17/2019</td>
<td>554</td>
<td>2.49</td>
<td>1.01</td>
<td>3.57</td>
<td>0.61</td>
</tr>
<tr>
<td>02/23/2023</td>
<td>554</td>
<td>3.12</td>
<td>2.19</td>
<td>4.23</td>
<td>0.44</td>
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<td>05/07/2025</td>
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<td>3.31</td>
<td>2.54</td>
<td>4.58</td>
<td>0.46</td>
</tr>
<tr>
<td>10/24/2018</td>
<td>554</td>
<td>6.1</td>
<td>4.52</td>
<td>8.08</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Source: Bloomberg and author’s calculations

In Table 3, the main descriptive statistics of the TES series used in the estimation are presented. The smallest standard deviation is found in the longer term securities, for example, TES with maturity 04/04/2035.

<table>
<thead>
<tr>
<th>TES with expiry</th>
<th>Nº observations</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Estándar deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/25/2026</td>
<td>553</td>
<td>-0.05</td>
<td>-3.42</td>
<td>3.42</td>
<td>0.88</td>
</tr>
<tr>
<td>09/18/2030</td>
<td>553</td>
<td>-0.05</td>
<td>-3.04</td>
<td>3.2</td>
<td>0.81</td>
</tr>
<tr>
<td>06/30/2032</td>
<td>553</td>
<td>0</td>
<td>-2.2</td>
<td>2.49</td>
<td>0.68</td>
</tr>
<tr>
<td>07/24/2024</td>
<td>553</td>
<td>-0.06</td>
<td>-3.01</td>
<td>3.57</td>
<td>0.82</td>
</tr>
<tr>
<td>07/24/2020</td>
<td>553</td>
<td>-0.06</td>
<td>-3.48</td>
<td>3.55</td>
<td>0.83</td>
</tr>
<tr>
<td>05/04/2022</td>
<td>553</td>
<td>-0.05</td>
<td>-3.59</td>
<td>3.95</td>
<td>0.86</td>
</tr>
<tr>
<td>09/11/2019</td>
<td>553</td>
<td>-0.07</td>
<td>-4</td>
<td>3.32</td>
<td>0.82</td>
</tr>
<tr>
<td>03/10/2021</td>
<td>553</td>
<td>-0.07</td>
<td>-7.92</td>
<td>8.75</td>
<td>1.59</td>
</tr>
<tr>
<td>04/25/2028</td>
<td>553</td>
<td>-0.05</td>
<td>-3.49</td>
<td>5.13</td>
<td>0.82</td>
</tr>
<tr>
<td>04/04/2035</td>
<td>553</td>
<td>-0.04</td>
<td>-8.05</td>
<td>4.91</td>
<td>1.12</td>
</tr>
<tr>
<td>11/21/2018</td>
<td>553</td>
<td>-0.07</td>
<td>-3.82</td>
<td>4.34</td>
<td>0.8</td>
</tr>
<tr>
<td>03/25/2033</td>
<td>553</td>
<td>-0.02</td>
<td>-7.97</td>
<td>5.02</td>
<td>1.15</td>
</tr>
<tr>
<td>04/17/2019</td>
<td>553</td>
<td>-0.14</td>
<td>-12.1</td>
<td>16.48</td>
<td>2.41</td>
</tr>
<tr>
<td>02/23/2023</td>
<td>553</td>
<td>-0.06</td>
<td>-7.89</td>
<td>15.89</td>
<td>1.7</td>
</tr>
<tr>
<td>05/07/2026</td>
<td>553</td>
<td>-0.07</td>
<td>-8.35</td>
<td>6.04</td>
<td>1.48</td>
</tr>
<tr>
<td>10/24/2018</td>
<td>553</td>
<td>-0.08</td>
<td>-3.29</td>
<td>4.17</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Source: Bloomberg and author’s calculations

The descriptive statistics of the percentage variations, Table 4, show interesting results. For example, for all public debt securities, except TES B due 06/30/2032 (yield is very close to zero), the percentage variation of the interest rate is negative. On the other hand, the highest volatility found is in those
medium-term securities; TES with maturity 04/17/2019, and TES with maturity 03/10/2021. These results can be explained due to the perception of greater uncertainty in the medium term than in the long-term period, in which adjustments can be presented that allow the rates to converge towards the expected values.

5 Results of estimations

5.1 Window of 30 days without effect of surprise component

An initial exercise is carried out, which consists of including all the dates of interventions of the Bank of the Republic, from February 2, 2016 to January 30, 2018. In this exercise, all selected TES bonds are also included. The problem with carrying out this exercise is that it is impossible to differentiate the effect of the increases in the interest rate, as well as the decreases, on the percentage variations of the interest rates of the TES. As can be seen in Figure 1, from \( t_0 \), a negative average percentage variation is presented in the TES set.

The results confirm that for the TES included in the estimate there is a negative percentage change in the percentage variations of medium and long-term interest rates (Graph 1). Graph 1 shows that, before interventions, at \( t = 0 \), the expected and observed percentage variations are similar, but after the interventions there is a negative effect on the percentage variation of the TES rates. By including all the Bank of the Republic’s interventions, that is, increases and decreases in the interest rate, after \( t = 0 \) the effect is a negative variation. This result is consistent with the results found in estimates for other countries.

For the aforementioned reason, two exercises are carried out: the first includes only the interventions in which the Bank of the Republic increased the interest rate (from February 1, 2016 to August 1, 2016) (Graph 2); the second exercise includes the interventions in which the Central Bank lowered the interest rate (December 19, 2016 until January 31, 2018) (Graph 3).
Graph 2 Accumulated Effect with Increase of TI-BR

Source: Bloomberg rates and author’s calculations

Graph 3 Accumulated Effect with Decrease of TI-BR

Source: Bloomberg and author’s calculation

Graphs 2 and 3 present the results of the estimates for the two sets of dates; in the first case, the effect of the increases in the interest rate on the TES. As can be seen, when the BR increases the TI, the effect on the percentage variation of the TES rate is higher, (negative variation); consistent with what was expected. In addition to the analysis of the TES as a whole, an individual analysis was carried out for each of the public debt securities, which are presented in Annexed A, Figures 4, 5 and 6.
5.2 Window of 10 days without effect of surprise component

Graph 4. Accumulated Effect TI-BR over TES

Similar to the 30-day window, there is a negative percentage change in the percentage variations of medium and long-term interest rates (Graph 4). By including all the Bank of the Republic interventions, i.e., increases and decreases in the interest rate, after $t = 0$, the effect is a negative variation.

Graphs 5 and 6 present the results of the estimates for the two sets of dates; in the first case there is the effect of the increases in the interest rate on the TES set, and in the second case with decreases in the TI-BR.

Graph 5 Accumulated Effect with Increase of TI-BR
5.3 Window of 5 days without effect of surprise component

When including the whole TES sample, and with a window of 5 days, a different effect is observed to the 30 and 10-day windows; that is to say, there is an effect of a slight rise during the first two days and then a fall after the moment of intervention (T0). Graph 7.
When only the IT-BR's single-upload period is taken, i.e., from January 1 to July 29, 2016, negative and continuous changes are observed, starting on the 2nd day after T0. Graph 8

When only the TI-BR's down-time period is taken, that is, from February 2017 to August 2017, as in the previous one, negative and continuous changes are observed, starting one day after T0. Graph 9.
5.4 Window of 5 days with effect of surprise component

To analyze the effect of the TI-BR, on the TES, including the effect of the surprise component, we will use the following extended market model:

\[ R_{it} = \alpha_i + \beta_i Rm_t + \delta_i SI_t + e_{it} \]

The extended market model used in the estimates is basically the CAPM, including the surprise component, where: \( R_{it} \), is the yield of the asset i in the period t, \( Rm_t \), is the market yield, in this case the index COLCAP is taken, and SI is the surprise in period t. The residuals \( E(e_{it}) = 0 \) and \( var(e_{it}) = \sigma^2_e \) are assumed.

**Graph 10 Effect of TI-BR Total Period and Surprise**

With the estimate for the total period (2016 to 2018), it is found that the interventions of the Bank of the Republic increase the interest rates of the TES during the first three days, but afterwards the effect is reversed. An explanation for this result is that the Bank of the Republic's interventions at the beginning of 2016 were increased and then, as of 2017, the monetary policy was expansionary, which can be seen in the behavior of the TES after the third day.
The results found for the year 2016, (TI-BR increase only), show that the increases had the expected effect; i.e., they increased the rates of the TES, during the two days following the intervention, but this effect was temporary, since after the third day there is evidence of a decrease in the TES rates. This result demonstrates the effectiveness of monetary policy, in the sense that agents anticipate changes in the TI-BR.

When the effect of the surprise component is included, a window of 5 days and the period where there is only decrease of TI-BR are observed after T0, changes (positive) in the series, starting from 1st day, Graph 12.
For the period in 2017, from the beginning of February, in which the Bank of the Republic lowered its interest rate, the effect on the TES interest rate was aligned with the decisions of the Central Bank, in the sense that these rates decreased, which seems to show the transmission of monetary policy through the interest rate channel.

When we analyze the effects on the DTF, we find the expected effect of the interventions of the Bank of the Republic; decreases of the TI-BR generate a negative impact in the percentage variations of this rate, while the effect is positive before increases in the rate (Graph 16). In the case of the DTF and the IBR, the window worked is 10 days, since it is weekly. The changes in the percentage variations are respectively 6.63% and -6.32%. Both the effect on the DTF, and on the IBR index, of the interventions of the central bank, are effects that are transmitted with a delay of six to ten months (6-10).

According to Vargas and Hamann (2010), there is a cointegration relationship, previously found by Galindo and Hofstetter (2008), between the interest rates of mortgage loans (TICH) and the yields of public debt securities (TES). In this paper it is concluded that in the long term, the relationship between both rates is one to one. Therefore, both monetary policy (through a low and credible inflation target) and fiscal policy (through greater fiscal solvency) can help reduce interest rates on mortgage loans in the long term.

In the short term, it is found that an intervention of 100 basis points in the Bank of the Republic’s policy interest rate is transmitted to the spread of the TICH-TES with a lag of six to 10 months and has a maximum effect of 40 -60 bps, after controlling for its effects on other macroeconomic variables.

As with the DTF, the expected effects are found for the IBR, Graph 17. The changes in the percentage variations are respectively 4.62% and -6.96%.
For the percentage variations of the COLCAP stock index, there are no differentiated effects from the Bank of the Republic interventions; with both increases and decreases in the interest rate of the Central Bank, the effect is positive. The changes in percentage variations are respectively 3.02% and 1.06%.
5.5 Second Measurement of abnormal returns with extended CAPM

According to the methodology mentioned in chapter 3, and the results of the estimations, it could be stated statistically that changes in the TI-BR generate changes in the local market of more representative fixed-income instruments (TES).

If we define the window:

\[
\begin{align*}
\text{Day of the event, } & t=0 \\
L_1, & \text{is the length of the estimation window} \\
L_2, & \text{is the length of the event window} \\
Y, & \text{The sample of abnormal returns for each bond } i \text{ in the event window is given by the following model that includes the SP500; Colcap and TRM index:}
\end{align*}
\]

\[
\Delta R_{it} = \Delta R_{it} - \hat{\alpha} - \hat{\beta}_1 \Delta \text{Intervention} - \hat{\beta}_2 R_{SP500} - \hat{\beta}_3 R_{COLCAP} - \hat{\beta}_4 R_{TRM}
\]

Observations of abnormal returns must be added in order to make inferences about the event:

\[
\text{CAR}_i(T_1, T_2) = \sum_{T=T_1}^{T_2} AR_{i,T}
\]

Standardized test-t

\[
SAR_{i,T} = \frac{AR_{i,T}}{SD(AR_{i,T})}
\]
\[
SD(AR_{i,T}) = \sqrt{\frac{1}{T_1 - 1} \sum_{t=T_0}^{T_1} AR_{i,t}^2}
\]

\[
\theta_T = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} SAR_{i,T}
\]

Test-t for Accumulated Abnormal Returns

\[
\frac{CAR_i(T_1, T_2)}{SD(CAR_i)} = \frac{\sum_{T=T_1}^{T_2} AR_{i,T}}{\sqrt{L_2D(AR_{i,T})}}
\]

It is important to mention that the \( \theta_T \) event analysis statistic is significant when the monetary policy announcement changes more than 25 bps, so the abnormal returns are explained by a high variation of the monetary intervention.

We obtain the following results, which confirm that, as a consequence of the changes in the country’s monetary policy rate, there are no changes in the market rates of the observed securities when the surprise component is taken into account.

<table>
<thead>
<tr>
<th>Event Date</th>
<th>Interventions</th>
<th>( \theta_T ) Test</th>
<th>Impact on the market</th>
</tr>
</thead>
<tbody>
<tr>
<td>18/03/2016</td>
<td>Model 1</td>
<td>-2.94</td>
<td>NO</td>
</tr>
<tr>
<td>29/04/2016</td>
<td>Model 2</td>
<td>-1.1</td>
<td>NO</td>
</tr>
<tr>
<td>27/05/2016</td>
<td>Model 3</td>
<td>1.36</td>
<td>NO</td>
</tr>
<tr>
<td>22/06/2016</td>
<td>Model 4</td>
<td>1.21</td>
<td>NO</td>
</tr>
<tr>
<td>29/07/2016</td>
<td>Model 5</td>
<td>1.65</td>
<td>NO</td>
</tr>
<tr>
<td>16/12/2016</td>
<td>Model 6</td>
<td>-0.82</td>
<td>NO</td>
</tr>
<tr>
<td>24/02/2017</td>
<td>Model 7</td>
<td>0.89</td>
<td>NO</td>
</tr>
<tr>
<td>24/03/2017</td>
<td>Model 8</td>
<td>0.37</td>
<td>NO</td>
</tr>
<tr>
<td>28/04/2017</td>
<td>Model 9</td>
<td>0.53</td>
<td>NO</td>
</tr>
<tr>
<td>26/05/2017</td>
<td>Model 10</td>
<td>-0.67</td>
<td>NO</td>
</tr>
<tr>
<td>30/06/2017</td>
<td>Model 11</td>
<td>-0.69</td>
<td>NO</td>
</tr>
<tr>
<td>27/07/2017</td>
<td>Model 12</td>
<td>-1.21</td>
<td>NO</td>
</tr>
<tr>
<td>31/08/2017</td>
<td>Model 13</td>
<td>-1.12</td>
<td>NO</td>
</tr>
<tr>
<td>27/10/2017</td>
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<td>0.02</td>
<td>NO</td>
</tr>
<tr>
<td>24/11/2017</td>
<td>Model 15</td>
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<td>NO</td>
</tr>
<tr>
<td>29/01/2018</td>
<td>Model 16</td>
<td>0.09</td>
<td>NO</td>
</tr>
</tbody>
</table>

5.6 Contrast with an Anova model

It was decided to perform a variance analysis to observe whether there is a change or not in the yields of the bonds as a result of the surprise (BR-vs-Market Expectation).
If we define the following model:

$$\Delta R_{it} = \beta 0 + \beta 1 D 1 + \beta 2 D 2 + \beta 3 D 3 + \beta 4 D 4 + \epsilon t$$

Where:

- $D_1$: $\{1\}$ if the surprise is $-50$ basis points, $\{0\}$ otherwise
- $D_2$: $\{1\}$ if the surprise is $-25$ basis points, $\{0\}$ otherwise
- $D_3$: $\{1\}$ if the surprise is $25$ basis points, $\{0\}$ otherwise
- $D_4$: $\{1\}$ if the surprise is $50$ basis points, $\{0\}$ otherwise

The analysis of variance ANOVA, allows us to determine whether or not there are differences in the average of a quantitative variable from groups.

For the analysis of events, the dependent variable is the variation of the rates of the bonds (yields), and the independent variables are categories that represent the surprises that were presented in the market.

Currently there are five categories, (-50, -25, 0, +25 and +50 pbs); when a regression is made where the independent variable is categorical, a variable must be excluded, since the inverse of the matrix, the variable that is excluded and remains as the base category of the model, is zero (no surprise), making the model for fixed-income instruments; there is no statistical evidence that shows that there is an impact on the market when there are surprises.

We obtain the following Results:

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Surprise</td>
<td>0.337%</td>
<td>-0.019%</td>
<td>-0.024%</td>
<td>-0.025%</td>
<td>-0.027%</td>
<td>-0.030%</td>
<td>-0.032%</td>
</tr>
<tr>
<td>2. Surprise</td>
<td>0.072%</td>
<td>-0.020%</td>
<td>-0.022%</td>
<td>-0.023%</td>
<td>-0.024%</td>
<td>-0.025%</td>
<td>-0.027%</td>
</tr>
<tr>
<td>3. Surprise</td>
<td>0.034%</td>
<td>-0.039%</td>
<td>-0.040%</td>
<td>-0.041%</td>
<td>-0.042%</td>
<td>-0.043%</td>
<td>-0.045%</td>
</tr>
<tr>
<td>4. Surprise</td>
<td>0.025%</td>
<td>-0.030%</td>
<td>-0.031%</td>
<td>-0.032%</td>
<td>-0.033%</td>
<td>-0.034%</td>
<td>-0.037%</td>
</tr>
<tr>
<td>5. Surprise</td>
<td>0.050%</td>
<td>0.039%</td>
<td>0.051%</td>
<td>0.052%</td>
<td>0.053%</td>
<td>0.054%</td>
<td>0.057%</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.033%</td>
<td>0.001%</td>
<td>0.003%</td>
<td>0.005%</td>
<td>0.007%</td>
<td>0.009%</td>
<td>0.011%</td>
</tr>
<tr>
<td>-0.014%</td>
<td>-0.017%</td>
<td>-0.019%</td>
<td>-0.021%</td>
<td>-0.023%</td>
<td>-0.025%</td>
<td>-0.027%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>18</th>
<th>18</th>
<th>18</th>
<th>18</th>
<th>18</th>
<th>18</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.341</td>
<td>0.134</td>
<td>0.073</td>
<td>0.135</td>
<td>0.267</td>
<td>0.006</td>
<td>0.200</td>
</tr>
<tr>
<td>F</td>
<td>1.40</td>
<td>0.506</td>
<td>0.273</td>
<td>0.190</td>
<td>1.18</td>
<td>0.907</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
The results of the estimation using an Anova model, allow us to corroborate that: "No statistical significance is observed in the estimators and in joint test F". The only reference instrument that is affected by the surprise component is the TES that expires in November 2018 (TFIT06211118), but only when the surprise turns out to be higher than 50 basis points. On average it is observed that when the surprise is 50 basis points the return of this instrument increases by 8 basis points.

5.7 Quantification of the real impact on a TES portfolio

To try to quantify in monetary terms, what happens when the market does not succeed in its estimates of the change in the policy rate, and under the assumption that the market has already discounted this effect, we will perform the following exercise

1. We took the event of November 24, 2017, when the BR lowered its policy rate from 5.0% to 4.75% and the market estimated that it was a rate of 5.25% and a low from 25 bps to 5% generating a difference of 25 bps (surprise) between the real rate and the estimated market rate. See table 1

2. We build a portfolio of TES TF and TES UVR, and we value it during the days: t-1, t + 0 and t + 3, that is, November 23, November 24 (event day) and November 27 2017; with the following result

Table No 7. Impact on a TES portfolio. Event Nov 24, 2017 (-25 bps)

<table>
<thead>
<tr>
<th>Date</th>
<th>Nominal Value</th>
<th>Fixed Rate</th>
<th>Market Rate Day 23 Nov 2017</th>
<th>Market Rate 24 Nov 2017</th>
<th>Market Rate 27 Nov 2017</th>
<th>Bps = (a) - (b)</th>
<th>VPN 23 Nov 2017</th>
<th>VPN 27 Nov 2017</th>
<th>Utility in valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/jul/20</td>
<td>10,000,000</td>
<td>11.00</td>
<td>5.00</td>
<td>5.31</td>
<td>5.28</td>
<td>-1</td>
<td>11,745,529.133</td>
<td>11,750,033.275</td>
<td>10,644,142</td>
</tr>
<tr>
<td>04/may/22</td>
<td>10,000,000</td>
<td>7.00</td>
<td>5.79</td>
<td>5.77</td>
<td>5.75</td>
<td>-4</td>
<td>10,846,530.461</td>
<td>10,868,975.184</td>
<td>22,454,707</td>
</tr>
<tr>
<td>24/jul/24</td>
<td>10,000,000</td>
<td>10.00</td>
<td>6.21</td>
<td>6.17</td>
<td>6.16</td>
<td>-4</td>
<td>12,345,197.864</td>
<td>12,382,628.195</td>
<td>23,959,797</td>
</tr>
<tr>
<td>26/aug/26</td>
<td>10,000,000</td>
<td>7.50</td>
<td>6.59</td>
<td>6.58</td>
<td>6.55</td>
<td>-4</td>
<td>10,733,079.625</td>
<td>10,805,573.932</td>
<td>32,536,294</td>
</tr>
<tr>
<td>28/sep/28</td>
<td>10,000,000</td>
<td>6.00</td>
<td>6.79</td>
<td>6.78</td>
<td>6.78</td>
<td>0</td>
<td>9,764,555.337</td>
<td>9,773,693.381</td>
<td>9,138,044</td>
</tr>
<tr>
<td>16/sep/30</td>
<td>10,000,000</td>
<td>7.75</td>
<td>6.82</td>
<td>6.82</td>
<td>6.80</td>
<td>-4</td>
<td>10,917,533.897</td>
<td>10,943,751.817</td>
<td>26,417,932</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Nominal Value</th>
<th>Fixed Rate</th>
<th>Market Rate Day 23 Nov 2017</th>
<th>Market Rate 24 Nov 2017</th>
<th>Market Rate 27 Nov 2017</th>
<th>Bps = (a) - (b)</th>
<th>VPN 23 Nov 2017</th>
<th>VPN 27 Nov 2017</th>
<th>Utility in valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>17/abr/19</td>
<td>5,000,000</td>
<td>3.50</td>
<td>2.93</td>
<td>2.89</td>
<td>2.83</td>
<td>-11</td>
<td>1,331,695.106</td>
<td>1,341,373.613</td>
<td>9,688,057</td>
</tr>
<tr>
<td>10/mar/21</td>
<td>5,000,000</td>
<td>3.50</td>
<td>2.45</td>
<td>2.42</td>
<td>2.38</td>
<td>-4</td>
<td>1,352,836.790</td>
<td>1,336,239.474</td>
<td>3,408,365</td>
</tr>
<tr>
<td>07/may/25</td>
<td>5,000,000</td>
<td>3.50</td>
<td>2.93</td>
<td>2.89</td>
<td>2.83</td>
<td>-11</td>
<td>1,331,695.106</td>
<td>1,341,373.613</td>
<td>9,688,057</td>
</tr>
<tr>
<td>25/mar/31</td>
<td>5,000,000</td>
<td>3.50</td>
<td>3.54</td>
<td>3.53</td>
<td>3.51</td>
<td>-2</td>
<td>1,205,760.522</td>
<td>1,210,950.185</td>
<td>5,169,663</td>
</tr>
<tr>
<td>04/abr/35</td>
<td>5,000,000</td>
<td>4.75</td>
<td>3.58</td>
<td>3.57</td>
<td>3.54</td>
<td>-3</td>
<td>1,487,131.761</td>
<td>1,495,163.481</td>
<td>8,031,720</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Nominal Value</th>
<th>Fixed Rate</th>
<th>Market Rate Day 23 Nov 2017</th>
<th>Market Rate 24 Nov 2017</th>
<th>Market Rate 27 Nov 2017</th>
<th>Bps = (a) - (b)</th>
<th>VPN 23 Nov 2017</th>
<th>VPN 27 Nov 2017</th>
<th>Utility in valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>25,000.000</td>
<td>prom bps</td>
<td>-7</td>
<td>6,674,945,230</td>
<td>6,702,807,986</td>
<td>27,862,757</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Bloomberg data and author’s calculation

The result, in the case of TF TES, is a decrease in market rates, between November 23 and 27 of 3 bps, on average, representing a real valuation of $ 135 Million.
In the case of UVR TES, the effect is a decrease in rates of 7 basis points, on average, representing a valuation for this portfolio of $27 million for the purposes of If we plot the yield curves of these TES TF and TES UVR, for the days 23 to 27 November 2017, the downward movement of both curves is observed, which represents valuation in the portfolios.

**Graph 16. Evolution of the Performance Curve**
4. Conclusions and recommendations

One of the main tools available to the Central Banks, which operate under the objective inflation scheme (IO), is the intervention rate or Monetary Policy rate, (TI-BR) which, for the Colombian case, is determined each month\(^\text{17}\) seeking to achieve the goal of inflation targeting, sustainable economic growth and an adequate level of unemployment. This rate has short and long term effects on bank interest rates (TIB, DTF, IBR, etc.), on the price of financial assets (TES), on the exchange rate and inflation expectations.

The Objective Inflation (IO) scheme, implemented in Colombia since 1999, has been quite successful, not only because it brought inflation to the defined target range, but also because it allowed us to corroborate the important degree of credibility\(^\text{18}\) in which it is located, currently the Central Bank of Colombia and its monetary policy decisions; those that result in an achievement of low and stable inflation, in line with sustainable economic growth.

Graph 17. Inflation vs Inflation Target BR

As of 1999, the barrier of inflation exceeding two digits (9.23% ea) is broken and from 2010 to 2018, where the goal is defined at 3%. +/- 1 pp, inflation, with certain exceptions, (2015 and 2016) explained by shocks outside the monetary authority (child phenomena, strikes, oil prices and others) has been around the defined target range.

The foregoing is also evident in the Fedesarrollo and the Colombian Stock Exchange (BCV), Anif and the BR itself. (Table No. 1), where you can see the symmetry of the two series of the TI-BR (observed vs survey), and where only 8 times, of the sample taken, market agents do not match the policy position BR, with a difference of 25 bps (+/-).

\(^{17}\) As of 2018, the Board of Directors of the Bank of the Republic (JDBR) continue to meet 12 times a year and in just 8 of them it decides on the level of the intervention interest rate. In the other meetings the other matters under their control are decided upon.

\(^{18}\) A central bank is credible when agents believe that it will do what it says it will do (Blinder, 2000) or, in Cukierman’s (1986) terms, a central bank is credible if its policy of pursuing price stability, or more exactly reaching its inflation target, is taken by private agents as the basis to form its expectations.
Under the assumption that interest rates have a component associated with the real interest rate and another with inflation expectations, it can be explained that, through movements in the TI-BR, the Central Bank can affect the trajectory of expectations of future inflation and through these, future inflation. This is known as the transmission channels of monetary policy.

The hypothesis that monetary authority interventions affect market interest rates has been successfully verified in some advanced countries (Cook and Hahn, 1989; Dale, 1993; Roley and Sellon, 1995; Kuttner, 2001; and Demiralp and Jorda, 2004, among others).

Initially and under the methodology of “event study”, using time windows of 5, 10 and 30 days, and not including the effect of the so-called “surprise component”, it was found that there is a statistically significant relationship that allows us to affirm that, the movements in the TI-BR, cause effects on the market rates of the TES.

However, when the effect of the “surprise component” is included in the estimates, the results change significantly, in the sense that in the investment decisions of the agents, the possible movements in the TI-BR are already incorporated, causing the market absorbs this effect and only when a surprise is generated, and this is greater than 50 bps, can a real impact on the market rates of TES be explained.

The following graph shows the trend that the market rates of fixed income instruments TES B Pesos have had during the study period, evidencing that regardless of the interventions of the Central Bank to increase or decrease its rate, the IRR of The TES market has had a downward trend during the analysis period, which is due more to factors other than the issuer’s decisions.

Graph 18. Tendency of TES TF Rates vs TI-BR
In the case of the DTF interest rate, there is the expected effect of the Bank of the Republic’s interventions; decreases in the interest rate generate a positive impact on the percentage variations of this rate, while in the face of increases in interest rates the effect is negative. With this the expected direction is confirmed by means of the transmission channel of the interest rate. See Figure 22.

On the IBR index side, there are no differentiated effects from the Bank of the Republic’s interventions; with both increases and decreases in the Central Bank’s interest rate, the effect is positive.

Graph 19. Tendency of DTF, IBR TIB Rates vs TI-BR
Annex A

In this annex, the results for each bond are presented under a 10-day window.

Graph 20. Effect of TI-BR for each Instrument
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