Effects of monetary policy news on the behavior of financial assets: evidence from Brazil before and after the global crisis based on a bivariate VAR-GARCH model (2006-17)

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Abstract

The impact of news releases about the inflation targeting regime on the financial market is analyzed by estimating a bivariate VAR GARCH-BEKK-in-mean model. We use daily data, from January 2006 to May 2017, of stock prices index (IBOVESPA), exchange rate (BRL/USD) and interbank deposit rate (DI360). We developed a positive and negative news index to measure the impact of news releases based on Caporale et al. [2016] and Caporale et al. [2018]. Although the literature on the subject is vast, this paper fills relevant gaps in three ways. First, we investigate the bidirectional relationship between monetary policy related news releases and the behavior of asset prices before and after the 2008 crisis in Brazil. Second, we consider the relationship between the second moments of the variables of interest, using the conditional volatility as a proxy for uncertainty. Third, we provide a time series approach to measure the effect of macroeconomic related news releases on financial asset returns. The results indicate that there are mean spread effects from news for exchange rate and the Brazilian stock index: (i) the GARCH-in-mean parameter is significant for positive and the difference of news for the DI360; (ii) monetary policy and external shocks are significant as expected with exception of external shocks for the Brazilian stock index; and (iii) there are volatility spillovers and changes of this volatility after the crisis for stock index and DI360.

Keywords: Bivariate VAR-GARCH; Brazil; News
JEL Classfication: C14; C22; E31

Resumo

O impacto das notícias sobre as metas do regime de inflação, no mercando financeiros, foram analisadas por um modelo VAR GARCH-BEKK bivariado. Foram usados dados diários, de janeiro de 2006 até maio de 2017, dos preços de ações (IBOVESP), câmbio (BRL/USD) e taxa de depósito inter bancários (DI360). Foram desenvolvidos índices de notícias positivos e negativos para medir o impacto das notícias, com base em Caporale et al. [2016] e Caporale et al. [2018]. Apesar da vasta literatura sobre o tema, esse artigo se propõe a contribuir de três forma. Primeiro, investigando a relação bidirecional entre política monetária as notícias e o comportamento dos preços dos ativos antes e após a crise de 2008 no Brasil. Segunda, consideramos a relação entre o segundo momento das variáveis de interesse, usando a volatilidade condicional como uma proxy para a incerteza. Terceiro, utilizamos técnicas de séries temporais para medir o efeito macro econômico das notícias nos retornos de ativos financeiros. Os resultados encontrados indicam que existe efeito de propagação na média das notícias na taxa de câmbio e no índice de ações : (i) o GARCH tem significância na média para positivo e tem diferença para notícias para o DI360; (ii) politicas monetárias e choques externos são significantes, como esperado, com exceção dos choques externos do índice de ações Brasileiro; e (iii) existe impacto da volatilidade e mudanças na volatilidade após a crise para o índice de ações e DI360.

Keywords: VAR-GARCH bivariado; Brasil; Notícias
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1 Introduction

The development of studies investigating the behavior of prices and returns of financial assets is longstanding, and the demand for appropriate models has increased substantially with the rising complexity of financial products, the closer connection between markets, technical progress, and more recently, the occurrence of economic crises. Among the variables studied in the financial and capital markets, volatility stands out.

Although it may seem simple, the concept of volatility does not have a single definition. It is generally associated with the concept of risk in relation to the return of a financial asset class. Thus, the literature and the market in general define it as the standard deviation of the returns of a financial asset, in each period, conditional on the information existing at the beginning of the period.

Faced with the subjectivity of the concept of volatility, the literature has advanced in finding different ways of estimating and analyzing this important unobserved variable. In this sense, the choice of the estimation method and its analysis depend on the purpose of the estimation. In this paper, following the macrofinance literature, we consider the models in which volatility depends on past asset values.

In this class of models, volatility characteristics are known, with their variation in time (heteroskedasticity) and a tendency to cluster in certain periods, so that small variations tend to be succeeded by small variations and large ones tend to be succeeded by large variations. This is the concept behind the first model of this class, developed by Engle [1982]: ARCH (AutoRegressive Conditional Heteroskedasticity).

The literature advanced further with the seminal contribution of Bollerslev [1986], with extension to the GARCH (Generalized ARCH). In addition, researchers recognized the need to expand the multivariate GARCH case, leading to the Multivariate GARCH (GARCHM) model, initially proposed by Bollerslev et al. [1988], through the VEC model. The main motivation of the multivariate models is to estimate the relationship between the volatility and co-volatility of various assets and markets.

The macrofinance literature has paid relevant attention to assessing the impacts of economic news on financial assets. The recent global financial crisis of 2007-09 whetted the interest of analysts and researchers to investigate the effect of macroeconomic events on market volatility. Indeed, after the outbreak of the crisis, the mindset of actors, in particular investors, became more sensitive in this highly uncertain environment, a situation that still exists.

Several empirical investigations have been developed to analyze the effects of agents feelings, especially of investors, on the financial and capital market. However, in the context of monetary policy, these works are mostly applied to analyze the effects of their (forward-looking) behavior, the information about which is collected in statements and policy committee minutes, or by investigating the impacts of policies on financial assets.

For daily and higher frequency data, an extensive literature examines finance in several dimensions. In this range of empirical research, news of various macroeconomic natures, such as economic activity, inflation, interest rate expectations, trade and capital flows are considered. This type of analysis focuses on evaluating the impacts of macroeconomic factors as inputs for portfolio allocation strategies. However, the focus of this paper goes further. The idea here is to bring to the discussion the impact of events associated with monetary policy on the behavior of financial assets in the Brazilian market. Precisely, we analyze how the news about the con-

duction of monetary policy affects the market volatility, represented by variance of the return of assets used as proxies in the model.

Although the international literature is extensive, we did not find any work applied to Brazil with daily data to capture the effects of macroeconomic news on the behavior of financial assets. Specifically, there are no academic studies for the Brazilian economy that have examined how the market reacts to news related to the conduction of monetary policy.

To fill this gap and contribute to the literature, we perform an empirical analysis of the effects of the news involving monetary policy and its spillovers on the financial market. Through the VAR-GARCH methodology, with daily data between January 2006 and May 2017, we evaluate the impact of the market perception of the Brazilian Central Bank (BCB) performance, notably in relation to its mandate to bring inflation down to the central target (Inflation Targeting Regime - ITR) before and after the global financial crisis, on three financial variables: (i) stock prices, (ii) exchange rates and (iii) interbanking deposit (poxy for short run future interest rate).

To evaluate market perception, we develop a positive and negative news index, with daily data on the BCB's monetary policy performance. In general, the present study is an adaptation to the Brazilian case, based on the proposal of Caporale et al. [2016] and Caporale et al. [2018].

Besides contributing to the empirical literature by estimating a bivariate VAR-GARCH (1,1) model to examine the effects of both negative and positive news on assets prices, the motivation of this paper stems from the fact that a central bank (CB) with a single mandate, as in Brazil, within the ITR may cause market volatility and have important implications, such as long-term interest rate inertia. In other words, to the extent the CB is unable for some reason to achieve its objective, the market quickly corrects asset prices, forcing monetary policy to react. However, during the global financial crisis the Brazilian government and BCB adopted a series of macroprudential measures. Indeed, it is no surprise that news about monetary policy had little effect on average returns, and volatility in particular, during the period studied.

From the foregoing, the motivation of this study is twofold. First, we did not find any studies examining the bi-directional relationships between monetary policy news and asset prices in Brazil in a bivariate VAR-GARCH framework. Second, this is the first study to contemporaneously examine the impact of negative (positive) and the difference between negative and positve monetary policy news on the mean and variance of the Brazilian equity and currency markets.

This paper makes a threefold contribution. First, it focuses on the relationship between monetary policy news and asset prices before and after the 2008 crisis in Brazil, for which limited evidence is available. Second, it considers the linkages between the second moments of the variables of interest, so that the conditional volatility can be seen as a proxy for uncertainty, whose role we are therefore able to assess in this context. Third, this paper also contributes by providing a time series approach, which is better suited to capturing time variation in daily data series and considers a considerably longer sample time frame.

We find little evidence of the impact of news on the behavior of the Brazilian financial market, represented here by the exchange rate and the stock index. In relation to the former, we find little influence, both on the average of returns and their volatility, of negative (positive) news about the ability of monetary policy to guide inflation to the central target. The stock index was sensitive to negative news before and after the crisis. Additionally, for both variables, there is evidence that the specialized media was influenced by market closure. Finally, the estimation for the 360-day interbank deposit we find a significant influence on average and the volatility in its returns for positive and the diference of news.

In addition to this introduction, this paper consists of four more sections. In the second we review the literature on macroeconomic news and surprises and their impacts on the financial market. In the third, we present the data and econometric method. In the fourth we discuss the empirical results. The fifth section concludes.

2 Expected Effect of News and the Related Literature

There is extensive literature that associates economic fundamentals and asset prices. The effects of macroeconomic news on assets prices have been analyzed extensively in the more recent financial literature. The theoretical motivation comes from asset pricing models according to which factors driving macro series such as consumption and investment should also affect asset prices [Merton [1973]]. Asset prices are expected to react to information, especially surprises, regarding the behavior of macroeconomic variables which in turn, systematically affect agents' expectations about the future of the economy. In effect, there is a direct impact on cash flows, due to the change in the discount factor (which is a function of the interest rate and the risk premium), and consequently, asset prices in general.

Although the crisis aroused interest in studying of the impact of news, both good and bad, on macroeconomic policy, interest in this subject is not recent. An example of this is the contribution of Pearce and Roley [1984]. The authors examined the daily response of stock prices to announcements about some macroeconomic variables in the US market, covering the period between September 1977 and October 1982: (i) money supply; (ii) inflation; (iii) real economic activity; and (iv) discount rate. For macroeconomic surprises, they compared the effect on the expectations of agents, as measured by a survey among market participants and economists, of the announcements of each indicator on their respective dates. Through an OLS model with lagged variables, the authors found evidence that new information on monetary policy had a significant effect on the S&P500 (stock index). In addition, inflation and surprises about economic activity also had implications for the behavior of the US stock market, as seen by the S&P 500's daily returns.

As for the exchange rate, with daily data from January 1999 to December 2000, Galati and Ho [2003] investigated the influence of macroeconomic news on the daily exchange rates of the euro against the dollar in the first two years of the Economic and Monetary Union (EMU). The authors collected data on macroeconomic indicators of the US and central countries of the Euro Zone. Following Balduzzi et al. [2001] and Andersen et al. [2003], they created a news index (macroeconomic surprise) based on the difference between the announcement of the variable and the market expectation of the standard deviation of the sample.

Galati and Ho [2003] found evidence that the exchange rate between the euro and dollar is influenced by macroeconomic news. The impact was greater when news changed from positive to negative. In addition, the authors also found that the relationship between macroeconomic news and the euro/dollar rate exhibits considerable time variation. Finally, they found some evidence that the market is more inclined to react to bad news, while generally ignoring positive news about macroeconomic indicators.

One of the pioneering works on the impact of macroeconomic news on financial asset behavior was the article by Balduzzi et al. [2001]. They investigated how macroeconomic surprises (the difference between market expectations and the actual outcome of each variable) affected the behavior of the US government bond market. With intraday data, with a difference between five

minutes before the announcement and thirty minutes afterward, they found evidence that the news had a strong impact on daily prices of three-month, two-year 10-year and 30-year T-bills. In addition, they also found important implications for yield curve models and interest rate dynamics in the US market.

Balduzzi et al. [2001] showed that the differential impact of news on instruments with different maturities is consistent with the existence of least two uncertainty factors that affect the term structure. Moreover, the almost instantaneous adjustment of prices to public news suggested that jumps are a needed component of realistic time-series models of interest rates. Finally, the authors found that surprises explain a substantial portion of price volatility and that bid-ask spreads tend to revert quickly to their normal levels, suggesting that public information is rapidly absorbed in prices.

Flannery and Protopapadakis [2002] also found evidence that stock market returns are significantly correlated with inflation and monetary expansion. They estimated a GARCH model with daily stock index returns for the US economy, where realized returns and their conditional volatility depended on 17 macro series announcements. This study is an extension of Pearce and Roley [1984] with a daily (close-to-close) data on return to the value-weighted NYSE-AMEX-NASDAQ market index obtained from the Center for Research in Security Prices (CRSP), from the beginning of January 1980 through year-end 1996. They used the same survey employed by Pearce and Roley [1984], but with the most extensive dataset ever employed to study the impact of macro conditions on equity returns. Of these, the inflation measures affected only the returns' conditional volatility, while the monetary aggregate affected both returns and conditional volatility.

Another seminal paper that served as the starting point for a range of contributions to the literature on volatility was that of Andersen et al. [2003]. In this study, the authors, using daily high frequency data (every five minutes), between January 3, 1992 and December 30, 1998, investigated the effects between market expectations and official announcements for 41 macroeconomic indicators on the market in view of the US exchange rate. They empirically analyzed how the exchange market (dollar against the German mark, British pound, Japanese yen, Swiss franc and euro) reacted during the day to macroeconomic surprises.

Andersen et al. [2003] used a multivariate GARCH (1,1) model and the results indicated that macroeconomic surprises (difference between macroeconomic expectations and macroeconomic realizations) produced conditional mean jumps, and the high frequency exchange rate dynamics were linked to fundamentals. Furthermore, they found evidence that the market reacts to news asymmetrically, i.e., bad news has greater impact than good news on the spot currency market.

Some studies have also evaluated the reaction of the financial and capital markets to the news about a particular macroeconomic variable. An example is the contribution of Boyd et al. [2005], who analyzed the financial market's reaction to news about the labor market, specifically unemployment data. The authors used monthly data on unemployment covering the period from February 1957 to December 2000. The news was classified according to the macroeconomic surprise framework, i.e., they measured the anticipated and unanticipated (news) component of the unemployment figures announced every month. The authors' proposal was to evaluate the US stock market reaction to unemployment news.

The main conclusion of Boyd et al. [2005] was that on average stock prices rise when there is bad unemployment news during expansions, and fall during contractions. Furthermore, they found two factors that affected the price of stocks but did not affect the price of risk-free government bonds: the equity risk premium and the expected future growth of dividends. The first reacted positively to unemployment news during expansions, but not during contractions. They also

found that dividend growth expectations responded negatively to unemployment during both expansions and contractions and had a larger response during contractions.

Andersen et al. [2007] investigated the real-time interactions among US, German and British stock, bond and foreign exchange markets in the periods surrounding US macroeconomic news. As an econometric method, the authors estimated a multivariate GARCH model to identify the cross-relationships between these markets in light of the news about the US macroeconomics. In other words, they explored the movements of asset prices in these three markets under the influence of the US market.

Their results were especially intriguing regarding stock market responses to news, which displayed distinct state dependence. In particular, they found that bad macroeconomic news has the traditionally expected negative equity market impact during contractions, but a positive impact during expansions. This explains the small stock market news reaction effect when averaged across expansions and contractions, as reported in the previous literature. The asymmetric responses manifest themselves in very different stock and bond return correlations across the business cycle. Andersen et al. [2007] verified that these distinct correlation patterns are not limited to the period around announcements; rather, they apply generally for trading day returns in expansions and contractions. They conjectured that such real-time correlation measures would be useful for more refined classification of the phase of the business cycle.

Following the global financial crisis of 2008-09, there was strong interest in the empirical literature to study the effects of economic news on asset behavior. With the use of a Poisson-Gauss-GARCH process with time-varying jump intensity, which allows responding to such information, Rangel [2011] examined the effect of macroeconomic news releases on stock market volatility. The day of the announcement, per se, was found to have little impact on jump intensities. Employment releases were an exception. However, when macroeconomic surprises were considered, inflation shocks showed the persistent effect while monetary policy and employment shocks had only short-lived effects. Also, the jump intensity responded asymmetrically to macroeconomic shocks. Their results provided evidence of macroeconomic variables' relevance in explaining jump dynamics and improving volatility forecasts on event days.

Birz and Lott Jr [2011] proposed a different route to examine the effects of macroeconomic news on stock price behavior in the US market. They used time series of closing daily returns of the S&P 500 from January 1991 to June 2004. They then picked out returns for the release days from the economic data series. They proposed a different way to find the effects of macroeconomic news on stock price behavior in the US market. To do this, they developed a complex set of information about the real economy as announced in the media to serve as a proxy for macroeconomic news.

For Birz and Lott Jr [2011], besides reporting statistical facts, newspaper stories also indicate whether the news media perceive something as important and may also reveal how the economy has been performing in relation to expectations. In addition, newspaper stories can reveal the meaning of the statistical data on different economic conditions and therefore can indicate the actual news associated with the release. To conduct statistical analysis, they classified the newspaper articles for conversion into a quantitative measure.

To test their hypothesis, the authors regressed stock returns on their newspaper variable, along with various control variables including economic surprises and the state of the business cycle. They found strong and statistically significant relationships between stock returns and newspaper headlines about unemployment and GDP. This was true even though stock returns were not significantly correlated with economic surprises in the time period. Although GDP growth is one of the most common measures of economic activity, the authors stated they were the first

to find an effect of US GDP news announcements on the US stock market.

To measure the contagion effect of the global crisis on emerging Asian countries, Kim et al. [2015], using a multivariate GARCH model, proposed a novel approach that simultaneously estimates the conditional correlation coefficient and the effect of its determining factors over time, which can be used to identify the channels of spillovers. They found some evidence of financial contagion around the collapse of Lehman Brothers in September 2008. They further found a dominant role of foreign investment for the conditional correlations in international equity markets. The dollar-Libor/OIS spread, the sovereign CDS premium, and foreign investment were found to be significant factors affecting the foreign exchange market.

Similarly, Bekiros [2014] analyzed the contagion of the crisis on the BRICS countries. To examine the dynamic linear and nonlinear causal linkages, a stepwise filtering method was introduced, for which vector autoregressions and various multivariate GARCH representations were adopted. The sample covered the after-Euro period and included the financial crisis and the Eurozone debt crisis. The empirical results showed that the BRICS became more internationally integrated after the US financial crisis and further substantiated the contagion effects. Furthermore, some nonlinear causal links persisted after filtering during the examined period. According the author, this indicates that nonlinear causality can, to a large extent, be explained by simple volatility effects, although tail dependency and higher moments may be significant factors of the remaining interdependencies.

Caporale et al. [2016] analyzed the effects of macroeconomic news on the returns of eight Eurozone countries (Belgium, France, Germany, Greece, Ireland, Italy, Portugal and Spain) with the application of the VAR-GACH model. To do so, they created a daily positive (negative) news index based on GDP, unemployment, retail sales and durable goods output for the period from January 1994 to December 2013. In addition, they controlled for monetary policy and stock market globalization using domestic interest rates (90-day Treasury bill rates) and a proxy for the global stock market index (US stock market index).

Specifically, Caporale et al. [2016] investigated whether macroeconomic news affected the stock markets of these countries differently before and after the global financial crisis. They concluded that positive (negative) news had significant positive (negative) effects on stock returns in all cases (especially in Ireland and Portugal). Furthermore, the markets responded more to negative news, and the reaction to both types of news appeared to have increased during the financial crisis. News volatility had a significant impact on both stock returns and their volatility, the effects being again more pronounced in the case of negative news and bigger in the recent crisis period, especially in peripheral countries of the euro area. Specifically, the authors found an increase in news volatility always to be associated with a decrease in stock returns. The exogenous factors considered, namely the US 90-day Treasury bill rate and US stock returns, had the expected negative and positive effects respectively on stock returns. Finally, the conditional correlations between stock returns and positive (negative) news were significant and positive (negative), and their increase in absolute value in the case of negative news during the financial crisis indicated higher sensitivity of financial markets to negative releases.

More recently, Caporale et al. [2018] analyzed the effects of macro news on the spread between the yield on the 10-year German Bund and sovereign bonds for the same euro area countries that they studied in Caporale et al. [2016]. Through a bivariate VAR-GARCH model, they concluded that negative news had a significant positive impact on yield spreads for all countries except Italy for the pre-crisis period (before September 2008). In addition, they found that markets responded more intensely to negative news.

In relation to the news volatility, Caporale et al. [2018] found that it has a significant impact

on yield spread volatility, the effects being more pronounced in the case of negative news and bigger in the most recent crisis period, especially in the peripheral countries of the euro area.

Following Caporale et al. [2016] and Caporale et al. [2018], we chose the VAR-GARCH-in-mean model, as detailed below, motivated by its properties: this type of specification enables the researcher to test for causality in variance, causality in mean and GARCH in mean effects (along with the conditional correlations) within the same framework. Given the relatively high number of model parameters (in particular, considering the fact that in our case the inclusion of dummy variables to anlalyze the effects of the global crisis doubled the number of cross parameters to be estimated), the chosen specification appears to be the most appropriate to model the time-varying dynamic linkages with the variables of interest. Furthermore, we apply the same method as those authors to the Brazilian market. However, we replicate the news index only regarding monetary policy in Brazil to assess its impact on the foreign exchange market and stock market.

Although there is vast international literature on the subject, we found no studies on how macroeconomic news, especially about monetary policy, affects the Brazilian market. In this sense, the present work, in addition to contributing to the literature on econometrics applied to finance by estimating the bivariate model VAR-GARCH (1,1), also seeks to advance research on market behavior, considering other institutional aspects, such as macroprudential regulation and policy and their effects on market dynamics.

3 Data and Methodology

3.1 The Data

The dataset consists of daily closing exchange rates and equity market index (Ibovespa) for the Brazilian market (from Bloomberg). The sample period for runs from 2nd January 2006 to 11th May 2017, yielding 2,853 observations. Daily returns for each series are computed by taking the first difference of the logarithm of total index return and exchange rate multiplied by 100 respectively for the Ibovespa and the exchange rate series. Thus,

$$r_t = log(I_t/I_{t-1}) * 100 \tag{1}$$

Where I_t and I_{t-1} denote the current day's closing level and the previous day's closing level respectively. As we are dealing with volatility, we use as dependent variables the return of financial indicators as a proxy for the behavior of the assets as a function of monetary policy. To control for the effects of global volatility and other aspects that may contaminate the behavior of assets that are not within the scope of monetary policy, we use as control variables the VIX and Brazilian 5-year CDS (as country risk measures), both obtained from the Bloomberg database. Known also as the fear gauge, the index (ticker VIX) is a common measure for the implied volatility of S&P 500 index options. It is therefore an indication of the public's expectation of upcoming volatility in the S&P 500 during the course of the following 30 days.

We collected all monetary policy information in Brazil during the sample period. For this, we used as data source the Broadcast terminal of Agencia Estado, which is widely used by the local financial market as a real-time source of financial, economic, political, geopolitical and other information. After selecting approximately 55,000 monetary policy items in the period,

we filtered the data to select only information involving dynamics of monetary policy, notably with respect to whether the inflation target would be met or not. After that, we selected 1,226 positive news items and 1,658 negative ones. It is important to mention that not every day had news, and on some days there were more than one news item.

News headlines were selected using an extensive string search, containing words indicating articles dealing with monetary policy. Specifically, we searched for and discriminated between articles and highlight news with negative and positive connotations about monetary policy's ability to guide inflation to the target.

The data for construction of the news index were collected from Broadcast, in which all the references to the Brazilian Central Bank in the headline count or contents of reports and alerts were first considered comprehensively in the search. The news items were selected using an extensive search string, containing words as well as macroeconomic variables related to monetary policy and also allowing the distinction between articles with a potentially positive or negative connotation. The distinction for the classification of the news refers to the existence or not of a benign risk or factor for the fulfillment of the inflation target. In this case, the beliefs of the market were also considered regarding the need to extend easing/tightening cycles and dissent/consensus on decisions.[1]

Following Caporale et al. [2016] and Caporale et al. [2018], we created an index to analyze the effects of positive and negative news reported by the media. According to the authors, this method, using an extensive search string, is considered suitable for being able to capture the effects of a high frequency series for a relatively large sample, which differs from the others applied in the literature. The daily negative (positive) news index is defined as follows:

$$Negative(Positive)NewsIndex = ln[e + MPnegative(positive)news] \tag{2}$$

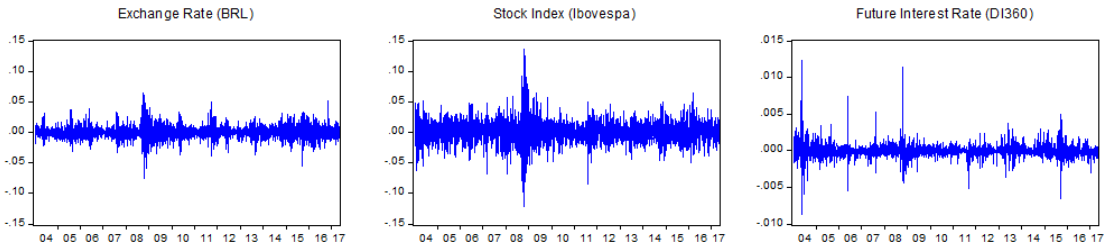
3.2 Descriptive Statistics and Tests

The descriptive statistics presented in Table 7 show that on average the number of negative news releases is bigger than that of positive ones for the full sample. Note that this result may have been influenced by the post-crisis period (due to the larger number of negative news items than positive ones), which was an extremely troubled period in the domestic scenario, also influenced by political issues. Regarding the pre-crisis period (2006-2007), positive news was more common than negative news. This may have been influenced by the favorable economic cycle caused in Brazil by the commodities boom and the very orthodox position of the BCB in that period regarding inflation, which was very close to the target, and in some moments below it (2006-2007).

The three financial variables exhibit higher leptokurtic behavior and the Jarque-Bera statistics decisively reject the normality assumption associated with the return distribution for the Brazilian market, due to the presence of positive skewness and high kurtosis, as shown in Table 8. The rejection of normality is expected in daily financial data, strengthening our motivation to use a VAR-GARCH model. This is due to the fact that the residuals still present correlation, indicating a possible dependence (also nonlinear), which is confirmed by the fact that the squared residuals are strongly correlated.

[1]The details of the method for the selection of words and the index construction are in Appendix A.1 in this study.

Figure 1: Log Returns: BRL, Ibovespa and DI360 returns



Source: Bloomberg.

Before applying the VAR-GARCH (1,1) model, it is necessary examine whether the residuals of the dependent variables whether truly evince conditional heteroskedasticity - the ARCH effect. According to Engle [1982], that is achieved by the ARCH-LM test. To confirm the aforesaid presence of conditional heteroskedasticity, Engle [1982] introduced the ARCH-LM (Lagrange Multiplier) test.

The ARCH effect is significant in both series, so the ARCH models are suitable for further analysis. The results can be found in Table 1 and the residuals in Figure 1.

For the econometric method applied in this work, the literature recommends to verify a possible nonlinear dependence in the time series analyzed, because the white noise and white chaos cannot be distinguished by the Ljung-Box statistical tests. To differentiate between the white noise and white chaos, to help identify the type of nonlinear structure, and hence improve the model's formulation, we performed the BDS test of Broock et al. [1996].

Table 1: ARCH effect

	BRL	Ibovespa	DI360
ARCH-LM test	0.0000	0.0060	0.0000

Notes: The null hypotesis states that there is no ARCH effects int the residuals.

The BDS test became more compelling given the thin trading adjustments we made to the data. The test is based on the null hypothesis of independent and identically distributed (iid) residuals and analyzes the presence of nonlinear dependence in the return series. The BDS test results, with epsilon values ranging from half to two times the standard deviation for 2 to 6 correlation dimensions, are shown in Table 2.

Table 2: Brock, Dechert and Sheinkman Test - BDS

Stock Index returns (Ibovespa)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.009	5.935	0.00
3	0.024	9.662	0.00
4	0.035	11.792	0.00
5	0.041	13.349	0.00
6	0.044	14.654	0.00
Exchange rate returns (BRL)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.023	13.989	0.00
3	0.005	18.820	0.00
4	0.069	21.878	0.00
5	0.081	24.446	0.00
6	0.086	26.812	0.00
Future Interest Rate (DI360)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.203	189.83	0.00
3	0.346	204.09	0.00
4	0.446	221.71	0.00
5	0.515	246.95	0.00
6	0.564	281.30	0.00

Notes: Tests the null hypotesis of linearity a time series model.

The BDS test can also be applied to residual analysis. If the model is considered appropriate, the residuals are expected to have no defined pattern. In other words, the residuals should be classified as white noise. For this, it is necessary to investigate if the residuals are independent and identically distributed (iid) with zero mean.

According to Broock et al. [1996], the BDS test has as null hypothesis the classification of the residuals as iid, while the alternative hypothesis is the presence of linear or nonlinear dependence in the residuals. Also, the test was applied to the series of residuals obtained from the estimation of a VAR-GARCH (1,1) model. The results indicated the presence of nonlinearity in all series, as shown in Table 3.

Table 3: Brock, Dechert and Sheinkman Test - BDS (Residuals)

Stock Index returns (Ibovespa)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.025	17.085	0.00
3	0.040	17.158	0.00
4	0.048	17.303	0.00
5	0.050	17.098	0.00
6	0.048	17.241	0.00
Exchange rate returns (BRL)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.009	5.988	0.00
3	0.024	9.715	0.00
4	0.035	11.845	0.00
5	0.041	13.408	0.00
6	0.044	14.721	0.00
Future Interest Rate (DI360)			
Dimension Correlation	BDS Statistic	z-Statistic	Prob.
2	0.028	19.051	0.00
3	0.044	19.054	0.00
4	0.053	19.058	0.00
5	0.055	18.916	0.00
6	0.054	19.206	0.00

Notes: Applied to the residuals from a fitted linear time series model, tests the null hypotesis of linearity.

3.3 The BEKK Model

Proposed by Engle and Kroner [1995], this model bears the name of its authors Baba-Engle-Kraft-Kroner (BEKK). According to Bollerslev et al. [1988], this model can be considered a restricted version of the VEC model. In this model, Ht is defined as:

$$H_t = CC' + \sum_{j=1}^{q}\sum_{k=1}^{K} A_{kj}' r_{t-r} r_{t-r}' A_{kj} \sum_{j=1}^{p}\sum_{k=1}^{K} B_{kj}' H_{t-j} B_{kj} \tag{3}$$

Where A_{kj}, B_{kj} and C are arrays of parameters with dimensions N X N, and C is lower triangular. Known as BEKK *(p, q, K)*, the model has this decomposition of the conditional covariance matrix, which automatically guarantees that it is definite positive.

Let $\otimes$ be the Kronecker product between two matrices, that is, each element ij of the first matrix multiplies the second whole matrix, resulting in a block matrix. The model is stationary if, and only if, the eigenvalues of

$$\sum_{j=1}^{q}\sum_{k=1}^{K} A_{kj} \otimes + A_{kj} \sum_{j=1}^{p}\sum_{k=1}^{K} B_{kj} \otimes B_{kj} \tag{4}$$

are less than 1 in modulus.

The order K ensures the generality of the model, allowing increasing the number of parameters

to try to improve the series studied. However, when $K > 1$, the identifiability problem arises, because there is no longer a single parameterization to obtain the represented model.[2]

According to Silvennoinen and Teräsvirta [2009], the disadvantage of the BEKK model consists of the large number of parameters: *(p+q)KN*^{2} *+ N(N+1)/2*. In order to simplify the model, we can define B and A as diagonal arrays, resulting in the so-called DBEKK (diagonal BEKK or BEKK diagonal). The number of parameters decreases to *(p+q)KN + N(N+1)/2*, although it still is considered high. Kroner and Ng [1998] introduced a constraint, where $B = \lambda$, where $\lambda > 0$ is a scalar and D is a diagonal matrix. Finally, there is a more restricted version, the BEKK scalar, in which $A = aI_N$ and $B = bI_n$, with a and b being scalars and in being the identity matrix of order N. With this we arrive at: [3]

$$H_t = CC^{'} + A^{'} r_{t-r} r_{t-r}^{'} A + B^{'} H_{t-1} B \tag{5}$$

3.4 The Estimated Model

The univariate time series models were pioneers in the volatility studies of the return of financial assets, especially when this volatility has a behavior varying over time. These studies evolved into multivariate cases. In this paper we use appropriate models for financial series that present the variance evolving over time. There is a large variety of nonlinear models available in the literature. Here we focus on some extensions of the class of ARCH models (autoregressive with conditional heteroscedasticity), introduced by Engle [1982].

A generalization of ARCH models was suggested by Bollerslev (1986), the so-called GARCH ("generalized ARCH") model. A GARCH model can be used to describe volatility with fewer parameters than an ARCH model.

However in many research situations there is a need to consider more than one asset, and consequently its correlations. Thus, just as time-varying volatility gained momentum in research, the varying correlation began to gain prominence with the multivariate GARCH models (MGARCH).

Following Caporale et al. [2016] and Caporale et al. [2018] we represent the first and second moments of stock market, exchange rate and news using a VAR-GARCH (1,1)-in-mean process. To try to capture the possible effects of the global financial crisis of 2008, a dummy variable (denoted by *) is included in the model with a switch on 15 September 2008, that is, on the day of the outbreak of the crisis with the failure of Lehman Brothers. In its most general specification the model takes the following form:

$$X_t = \alpha + \beta X_{t-1} + \theta h_{t-1} + \delta f_{t-1} + \mu_t \tag{6}$$

[2]Engle and Kroner (1995) presented the conditions for the solution of this identification problem.

[3]In addition to the VEC and BEKK models, the multivariate family still offers conditional correlation models, which separately specify marginal variances and conditional covariates, such as: (i) CCC (Constant Conditional Correlation); (ii) DCC (Dynamic Conditional Correlation) (iii) cDCC (corrected Dynamic Conditional Correlation); and (iv) ADCC (Asymmetric DCC). It is not our intention to present all multivariate models for volatility. For this, see Bollerslev [1990], Longin and Solnik [1995], Tse [2000], Engle and Sheppard [2001], Bera and Kim [2002], Aielli [2006] and Silvennoinen and Teräsvirta [2015].

$$X_t = \begin{bmatrix} return_t \\ News_t \end{bmatrix}, \alpha = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \end{bmatrix}, \beta = \begin{bmatrix} \beta_{11} & \beta_{12} + \beta_{12}^* \\ \beta_{21} & \beta_{22} \end{bmatrix} \tag{7}$$

$News_t$ may contain positive or negative news, or the difference between negative and positive news. β_{12} captures the effects of news on average returns. $\beta_{12} + \beta_{12}^*$ measures the effects after the crisis. β_{21} captures the causal effects of returns on news, i.e., how journalists can be influenced by market closure when they write *negative (positive)* news about average returns.

The data on positive and negative news, as reported by the media, was discussed in the previous section. We control for exogenous shocks for Brazil and global financial market shocks by including in the mean equation the Brazilian 5 year-CDS index and the VIX:

$$\delta = \begin{bmatrix} \delta_{11} & \delta_{12} \\ 0 & 0 \end{bmatrix} \tag{8}$$

The parameters δ_{11} and δ_{12} control for exogenous shocks of country risk perception and global volatility. The Brazilian CDS rate is commonly used to capture domestic effects such as political uncertainty, monetary policy execution and fiscal aspects. The VIX, which measures the volatility of the US stock exchange options represented by the SP500, has broader effect and reflects the spillovers to the international market.

$$\theta = \begin{bmatrix} \theta_{11} + \theta_{11}^* & 0 \\ 0 & 0 \end{bmatrix} \tag{9}$$

The GARCH-in-mean parameter, θ_{11}, captures mean returns effects from news volatility, while $\theta_{11} + \theta_{11}^*$ measures this effect after the crisis. The residual vector, $\mu_t = [\mu_{1t}, \mu_{2t}]$, is bivariate and normally distributed $\mu_t | I_{t-1}$ $N(0, H_t)$. Furthermore, the conditional covariance matrix is given by,

$$H_t = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix} \tag{10}$$

Therefore, the second moment takes the form:

$$H_t = C_0' C_0 + A_{11}' \left[e_{t-1}' e_{t-1} \right] A_{11} + G_{11}' H_{t-1} G_{11} \tag{11}$$

The dynamic of H_t process is a linear function of its own past and of the squares of the past innovations. The parameters of this equation are given by C_0, which is restricted to be upper triangular and matrices A_{11} and G_{11}.

$$A_{11} = \begin{bmatrix} a_{11} & 0 \\ a_{21} + a_{21}^* & a_{22} \end{bmatrix} \tag{12}$$

The parameter a_{21} measures the causality in variance of negative (positive) news before the crisis

and $a_{21} + a_{21}^*$ after the crisis. The parameter g_{21} measures the causality of the past volatility on the variance of negative (positive) news before the crisis and $g_{21} + g_{21}^*$ after the crisis.

$$G_{11} = \begin{bmatrix} g_{11} & 0 \\ g_{21} + g_{21}^* & g_{22} \end{bmatrix} \tag{13}$$

4 Empirical Results

The quasi-maximum likelihood estimates of the Bivariate VAR-GARCH (1,1) model, from equation 6 and 11, are reported in Tables 4 and 5 and 6 for the exchange-rate (BRL), stock index (Ibovespa) returns and interbank deposit (DI360), respectively. Overall, the results indicated that the VAR-GARCH (1,1) specification captured satisfactorily the persistence in returns and squared returns for the exchange rate and equity indexes (Ibovespa). The estimates of the parameters of the VAR-GARCH(1,1) model as well as the associated robust standard errors, p-value and likelihood function values are presented as follows.

Table 4: Estimated VAR GARCH (1,1): BRL/USD

Exchange rate returns						
	Negative		Positive		Negative - Positive	
	Coeff.	P-valor	Coeff.	P-valor	Coeff.	P-valor
Conditional mean Equation						
α_1	-0.0003	0.7355	-0.0014	0.1272	-0.0001	0.8113
α_2	-0.9813	0.0000	0.9240	0.0000	-0.0301	0.0000
β_{11}	-0.0779	0.0004	-0.0838	0.0002	-0.0763	0.0006
β_{12}	0.0005	0.6520	0.0003	0.7043	0.0017	0.1247
β_{12}^*	-0.0005	0.6072	0.0011	0.0344	-0.0019	0.1204
β_{21}	-0.1968	0.4741	-0.1070	0.6279	-0.2687	0.5276
β_{22}	0.1007	0.0000	0.1195	0.0000	0.1199	0.0000
δ_{11}	0.0196	0.0006	0.0187	0.0011	0.0184	0.0014
δ_{12}	-0.0060	0.0057	-0.0052	0.0243	-0.0056	0.0120
θ_{11}	0.0102	0.7966	0.0099	0.4068	-0.0072	0.4105
θ_{11}^*	-0.0009	0.9821	-0.0192	0.2110	0.0054	0.2604
Conditional Variance Equation						
c_{11}	-0.0004	0.6560	-0.0012	0.0000	-0.0012	0.0000
c_{21}	-0.0011	0.0011	-0.0005	0.1982	0.0003	0.5914
c_{22}	0.0172	0.0000	-0.0094	0.0000	-0.0267	0.0000
g_{11}	0.9334	0.0000	0.9315	0.0000	0.9299	0.0000
g_{21}	0.0009	0.0164	-0.0001	0.7688	0.0002	0.4762
g_{21}^*	-0.0001	0.7266	-0.0003	0.2823	0.0000	0.6867
g_{22}	0.9837	0.0000	0.9845	0.0000	0.9858	0.0000
a_{11}	0.3488	0.0000	0.3518	0.0000	0.3561	0.0000
a_{21}	-0.0003	0.8461	0.0005	0.6694	0.0003	0.8004
a_{21}^*	-0.0001	0.9503	-0.0008	0.6235	0.0007	0.5275
a_{22}	-0.1470	0.0000	-0.1662	0.0000	-0.1296	0.0000
LogLik	7885.34		8365.36		6709.26	

Notes: Quasi-Maximun likelihood estimates of bivariate VAR-GARCH(1,1) model, equations 6 and 11.

The Table 4 exhibits the estimation for the exchange rate. The estimated parameter vector of the mean return α=(α_1, α_2) generally show non-significant results for the assets, except for the interbank rate when interacted with positive news. The news mean parameter (negative/positive/difference), α_2 is significant and has the expected signal for all considered assets.

For the exchange rate, the autoregressive parameters of level equation, β = (β_{11}, β_{12}+β_{12}^*, | β_{21}, β_{22}) , show that there are autoregressive effects on the exchange rate and the news index. The parameter β_{12} which allows for mean spread effects from news is not significant, but β_{12}^*

is significant for positive news, indicating a possible change after the crisis. The GARCH-on-mean parameters θ_{11} and θ^*_{11} are not significant. Control parameters, δ_{11} and δ_{12}, associated with monetary policy and external shocks are significant as expected. The results of the estimation of the dynamic of the heteroskedasticity process show that there are both significant autoregressive and square innovations dependence. In this case there are no significant volatility spillovers, because the a_{21} and a^*_{21} are not significant.

Table 5: Estimated VAR GARCH (1,1): IBOV

Exchange rate returns						
	Negative		Positive		Negative - Positive	
	Coeff.	P-valor	Coeff.	P-valor	Coeff.	P-valor
Conditional mean Equation						
α_1	0.0025	0.1623	0.0011	0.5859	0.0002	0.8132
α_2	-0.9892	0.0000	0.9321	0.0000	-0.0319	0.0000
β_{11}	-0.0786	0.0009	-0.0809	0.0007	-0.0793	0.0008
β_{12}	-0.0006	0.8305	-0.0007	0.7084	-0.0042	0.1174
β^*_{12}	0.0027	0.3014	-0.0027	0.8093	0.0058	0.0444
β_{21}	0.1090	0.5135	-0.2050	0.1465	-0.1035	0.6922
β_{22}	0.0941	0.0000	0.1110	0.0000	0.1166	0.0000
δ_{11}	0.0196	0.0006	0.0187	0.0011	0.0184	0.0014
δ_{12}	-0.0060	0.0057	-0.0052	0.0243	-0.0056	0.0120
θ_{11}	0.0102	0.7966	0.0099	0.4068	-0.0072	0.4105
θ^*_{11}	0.0061	0.5430	-0.0106	0.7197	-0.0179	0.0910
Conditional Variance Equation						
c_{11}	0.0025	0.0000	0.0026	0.0000	0.0025	0.0000
c_{21}	0.0001	0.7496	0.0000	0.9970	0.0002	0.7352
c_{22}	0.0189	0.0000	0.0100	0.0000	-0.0281	0.0000
g_{11}	0.9526	0.0000	0.9519	0.0000	0.9525	0.0000
g_{21}	0.0008	0.1665	0.0003	0.3986	0.0007	0.0648
g^*_{21}	-0.0009	0.0429	-0.0003	0.4588	-0.0001	0.0201
g_{22}	0.9820	0.0000	0.9835	0.0000	0.9839	0.0000
a_{11}	0.2593	0.0000	0.2601	0.0000	0.2584	0.0000
a_{21}	-0.0085	0.0021	-0.0024	0.2283	-0.0054	0.0002
a^*_{21}	-0.0098	0.0018	0.0034	0.2052	0.0006	0.0006
a_{22}	0.1512	0.0000	0.1704	0.0000	0.1387	0.0000
LogLik	6329.03		6817.23		5168.19	

Notes: Quasi-Maximun likelihood estimates of bivariate VAR-GARCH(1,1) model, equations 6 and 11.

The Table 5 reports the results of the estimation of the Brazilian stock index. The autoregressive parameters are significant for stock index and news, while the parameter which allows for mean spread effects from news (β_{12}) is not significant, but β^*_{12} is significant for difference between negative and positive news, indicating an increase of this effect after he crisis. Futhermore, the GARCH-on-mean parameter (θ_{11}) is significant, there are effects to the difference between negative and positive news considering the significance of 10%. The parameter δ_{11}, associated with monetary policy, is significant, while the parameter δ_{12}, related whit external shocks, is significant, too. The dynamic of the heteroskedasticity process show that that there are both significant autoregressive and square innovations dependence. There are significant volatility spillovers (a_{21}) for negative and the difference between negative and positive news. The significance of the parameter a^*_{21} for negative and the difference of news shows an increase of volatility after the crisis. This increase also happens with the parameter associated with autoregressivity of heteroscedasticity, g^*_{21}.

Table 6: Estimated VAR GARCH (1,1): DI360

Exchange rate returns						
	Negative		Positive		Negative - Positive	
	Coeff.	P-valor	Coeff.	P-valor	Coeff.	P-valor
Conditional mean Equation						
α_1	0.0000	0.5029	0.0003	0.0002	0.0001	0.2016
α_2	-0.9883	0.0000	0.9355	0.0000	-0.0294	0.0000
β_{11}	0.0566	0.0080	0.0317	0.1364	0.0462	0.0291
β_{12}	-0.0001	0.3174	-0.0002	0.0031	-0.0001	0.4790
β^*_{12}	0.0001	0.5371	0.0000	0.7759	-0.0001	0.5108
β_{21}	-4.2028	0.3112	-2.4138	0.4149	-3.2861	0.5957
β_{22}	0.0954	0.0000	0.1076	0.0000	0.1198	0.0000
δ_{11}	0.0022	0.0000	0.0024	0.0000	0.0023	0.0000
δ_{12}	-0.0006	0.0004	-0.0006	0.0000	-0.0006	0.0001
θ_{11}	-0.0045	0.1829	-0.0019	0.0607	-0.0017	0.0246
θ^*_{11}	0.0045	0.1817	0.0023	0.8535	0.0006	0.1190
Conditional Variance Equation						
c_{11}	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
c_{21}	0.0001	0.0000	-0.0001	0.7069	-0.0001	0.0000
c_{22}	-0.0187	0.0000	-0.0097	0.0000	-0.0264	0.0000
g_{11}	0.9230	0.0000	0.9172	0.0000	0.9188	0.0000
g_{21}	-0.0001	0.5358	0.0002	0.3891	0.0003	0.0667
g^*_{21}	0.0004	0.0469	0.0002	0.2674	0.0001	0.2454
g_{22}	-0.9818	0.0000	-0.9836	0.0000	-0.9860	0.0000
a_{11}	0.3714	0.0000	0.3836	0.0000	-0.3819	0.0000
a_{21}	0.0002	0.2697	-0.0001	0.4380	0.0001	0.0026
a^*_{21}	-0.0007	0.2663	0.0000	0.4740	-0.0009	0.0002
a_{22}	0.1536	0.0000	0.1707	0.0000	0.1292	0.0000
LogLik	15339.16		15842.33		14175.00	

Notes: Quasi-Maximun likelihood estimates of bivariate VAR-GARCH(1,1) model, equations 6 and 11.

Finally, the Table 6 displays the results for the 360-day interbank deposit shows that the autoregressive parameters are significant for DI360 and news with the exception of β_{11} hen positive news is used in the endogenous vector, while the parameters which allow for mean spread effects from news (β_{12} and β^*_{12}) are not significant except for positive news. The GARCH-on-mean parameter (θ_{11}) is significant for positive and the difference of news, showing that positive news reduces the effects of volatility on this rate. Since the parameter θ^*_{11} is not significant, there are no significant effects of post-crisis news. Control parameters associated with monetary policy and external shocks, δ_{11} and δ_{12}, are significant as expected. The dynamic of the heteroskedasticity process show that that there are both significant autoregressive and square innovations dependence. For the difference between negative and positive news there is significant volatility spillovers and a decrease of volatility after the crisis.

According to Birz and Lott Jr [2011], in some cases, as we have found, the news surprises are not statistically significant. According to the authors, this is not particularly surprising if one considers that specific news items are released on a very small percentage of trading days, in contrast to newspaper coverage, which is daily, and therefore can only have a very limited impact [Caporale et al. [2018]]. Similar to them, the VIX (δ_{12}) was found to be highly significant in all cases, which suggests that uncertainty in the US stock market (a proxy for global instability) tends to widen the spread. In addition, country risk, measured by the 5-year-CDS rate (δ_{11}), which encompasses other variables (fiscal, external accounts, economic activity and institutional issues) not computed in the context of monetary policy news, was also highly significant in explaining the average exchange rate returns.

Concerning the conditional variance equation, the estimated *own-market* coefficients are statistically significant and the estimates of g_{11} suggest a relatively high degree of persistence. The results suggest that negative and positive news volatility has a significant impact on exchange-rate volatility [4]. On the other hand, the magnitude of the causality effect (a_{21}) is not statistically

[4] As Caporale et al. [2018], note that the sign cannot be established

significant for negative and positive news. In others words, there is evidence that before the crisis, there was no impact of news on volatility. Furthermore, there is no evidence of the 2008 crisis affecting the causality-in-variance dynamics. In this sense, both positive and negative news also did not cause volatility of the exchange rate in the post-crisis period ($a_{21} + a_{21}^{*}$).

In this regard, Janot and Macedo [2016] used intraday and daily high-frequency data between October 2011 and March 2015, to test the effects of BCB interventions in the foreign exchange market. Also, to verify that the last signal by the BCB to intervene and the size of the interventions affected the dynamics of the currency market, the authors also considered the impact of surprise in the disclosure of macroeconomic indicators. They concluded that the BCB is able to affect market conditions and the participants? feelings when the interventions are carried out by surprising the market and with adequate size, that is, very large or very small interventions may not have the expected effect.

In addition, between 2010 and 2011, the BCB and Brazilian fiscal authorities adopted various macroprudential policies. A number of these measures applied to the foreign exchange market, with the objective of mitigating the intensity and volatility of capital flows. According to Portugues [2017], the target was to limit large, short-term and speculative capital inflows, particularly carry trade transactions.

4.1 Robustness check

As a robustness check, following Caporale et al. [2018], we also considered the difference between negative and positive news indexes (Figure 2 in the Appendix). The causality-in-mean effect and the causality-in-variance spillovers of news are not significant for the BRL. However, for the stock index, the evidence reveals a difference between the news impacts on the pre-crisis mean and the variance of post-crisis returns in 2008 (see Figures 3, 4 and 5 in the Appendix). As already explained, the reason for more stable exchange rate behavior in the face of negative and positive monetary policy news may be due to the BCB's interventions in the foreign exchange market and also to the unconventional measures adopted in the country in 2010 and 2011.

5 Conclusion

This paper has adopted a bivariate VAR GARCH-BEKK-in-mean model to examine the effects of news releases about the inflation targeting regime on stock prices index returns, exchange rate and interbank deposit rate using daily data from January 2006 to May 2017. The selected model also controls for exogenous and global financial market shocks by including the Brazilian 5 year-CDS index and the VIX. The relationship between news and financial assets is justified by investor psychology, as documented in the literature.

Following Caporale et al. [2016] and Caporale et al. [2018], this paper uses a positive and negative index of news, collected from Broadcast, as a proxy of investor behavior towards the news. This paper fills relevant gaps in three ways. First, we investigate the bidirectional relationship between monetary policy related news releases and the behavior of asset prices before and after the 2008 crisis in Brazil. Second, we consider the relationship between the second moments of the variables of interest, using the conditional volatility as a proxy for uncertainty. Third, we provide a time series approach to measure the effect of macroeconomic related news releases on financial asset returns. The results can be summarized as follows.

The estimated parameter of the mean return generally show non-significant results for the assets, except for the interbank deposit rate when interacted with positive news. The autoregressive parameters of mean equation show that there are autoregressive effects on the financial variables and the news index. Control parameters associated with monetary policy and external shocks are significant as expected. There are not mean spread effects, except for the interbank deposit rate when interacted with positive news indicating a decrease in the return of this asset. The results indicate that there are significant mean spread effects on the average after the crisis for the exchange rate with positive news and for the stock prices index returns with the difference between negative and positive news.

Only in the case of the interbank deposit rate, the GARCH-on-mean parameter is significant for positive and the difference of news, showing that positive news reduces the effects of volatility on this asset. The results of the estimation of the dynamic of the heteroskedasticity process show that there are both significant autoregressive and square innovations dependence. There are significant volatility spillovers for the stock prices index returns with negative and the difference between negative and positive news. This causality-in-variance is also observed when the interbank deposit rate and the news difference is used. It may also be noted that there are indications of variations in conditional heteroscedasticity after the crisis for the stock prices index returns and the interbank deposit rate.

Our results provides some implications for policy makers in Brazil. The relationship between our indexes of news and assets are time depend. There are significant causality-in-variance between news volatility and the assets except for the exchange rate. There are indications of changes in conditional heteroscedasticity after the crisis. The results reveal the effectiveness of macroprudential policies to control exchange rate volatility after the crisis.

Referências

Guglielmo Maria Caporale, Fabio Spagnolo, and Nicola Spagnolo. Macro news and stock returns in the euro area: A var-garch-in-mean analysis. *International Review of Financial Analysis*, 45:180–188, 2016.

Guglielmo Maria Caporale, Fabio Spagnolo, and Nicola Spagnolo. Macro news and bond yield spreads in the euro area. *The European Journal of Finance*, 24(2):114–134, 2018.

Robert F Engle. Autoregressive conditional heteroscedasticity with estimates of the variance of united kingdom inflation. *Econometrica: Journal of the Econometric Society*, pages 987–1007, 1982.

Tim Bollerslev. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, 31(3):307–327, 1986.

Tim Bollerslev, Robert F Engle, and Jeffrey M Wooldridge. A capital asset pricing model with time-varying covariances. *Journal of political Economy*, 96(1):116–131, 1988.

Robert C Merton. An intertemporal capital asset pricing model. *Econometrica: Journal of the Econometric Society*, pages 867–887, 1973.

Douglas K Pearce and V Vance Roley. Stock prices and economic news, 1984.

Gabriele Galati and Corrinne Ho. Macroeconomic news and the euro/dollar exchange rate. *Economic notes*, 32(3):371–398, 2003.

Pierluigi Balduzzi, Edwin J Elton, and T Clifton Green. Economic news and bond prices: Evidence from the us treasury market. *Journal of financial and Quantitative analysis*, 36(4): 523–543, 2001.

Torben G Andersen, Tim Bollerslev, Francis X Diebold, and Clara Vega. Micro effects of macro announcements: Real-time price discovery in foreign exchange. *American Economic Review*, 93(1):38–62, 2003.

Mark J Flannery and Aris A Protopapadakis. Macroeconomic factors do influence aggregate stock returns. *The review of financial studies*, 15(3):751–782, 2002.

John H Boyd, Jian Hu, and Ravi Jagannathan. The stock market's reaction to unemployment news: Why bad news is usually good for stocks. *The Journal of Finance*, 60(2):649–672, 2005.

Torben G Andersen, Tim Bollerslev, Francis X Diebold, and Clara Vega. Real-time price discovery in global stock, bond and foreign exchange markets. *Journal of international Economics*, 73(2):251–277, 2007.

José Gonzalo Rangel. Macroeconomic news, announcements, and stock market jump intensity dynamics. *Journal of Banking & Finance*, 35(5):1263–1276, 2011.

Gene Birz and John R Lott Jr. The effect of macroeconomic news on stock returns: New evidence from newspaper coverage. *Journal of Banking & Finance*, 35(11):2791–2800, 2011.

Bong-Han Kim, Hyeongwoo Kim, and Bong-Soo Lee. Spillover effects of the us financial crisis on financial markets in emerging asian countries. *International Review of Economics & Finance*, 39:192–210, 2015.

Stelios D Bekiros. Contagion, decoupling and the spillover effects of the us financial crisis: Evidence from the bric markets. *International Review of Financial Analysis*, 33:58–69, 2014.

William A Broock, José Alexandre Scheinkman, W Davis Dechert, and Blake LeBaron. A test for independence based on the correlation dimension. *Econometric reviews*, 15(3):197–235, 1996.

Robert F Engle and Kenneth F Kroner. Multivariate simultaneous generalized arch. *Econometric theory*, 11(1):122–150, 1995.

Annastiina Silvennoinen and Timo Teräsvirta. Multivariate garch models. In *Handbook of financial time series*, pages 201–229. Springer, 2009.

Kenneth F Kroner and Victor K Ng. Modeling asymmetric comovements of asset returns. *The review of financial studies*, 11(4):817–844, 1998.

Tim Bollerslev. Modelling the coherence in short-run nominal exchange rates: a multivariate generalized arch model. *The review of economics and statistics*, pages 498–505, 1990.

Francois Longin and Bruno Solnik. Is the correlation in international equity returns constant: 1960–1990? *Journal of international money and finance*, 14(1):3–26, 1995.

Yiu Kuen Tse. A test for constant correlations in a multivariate garch model. *Journal of econometrics*, 98(1):107–127, 2000.

Robert F Engle and Kevin Sheppard. Theoretical and empirical properties of dynamic conditional correlation multivariate garch. Technical report, National Bureau of Economic Research, 2001.

Anil K Bera and Sangwhan Kim. Testing constancy of correlation and other specifications of the bgarch model with an application to international equity returns. *Journal of Empirical Finance*, 9(2):171–195, 2002.

GP Aielli. Consistent estimation of large scale dynamic conditional correlations. *Unpublished paper: Department of Statistics, University of Florence*, 2006.

Annastiina Silvennoinen and Timo Teräsvirta. Modeling conditional correlations of asset returns: A smooth transition approach. *Econometric Reviews*, 34(1-2):174–197, 2015.

Marcio Magalhães Janot and Leonardo Peixoto Macedo. Efeitos das intervenções cambiais sobre a taxa de câmbio futura no brasil. *Revista Brasileira de Economia*, 70(4):457–480, 2016.

Miriam Oliveira Silva Portugues. *Three Essays on Macroprudential Policy*. Tese de Doutorado, IE/UFRJ, 2017.

A Appendix

Figure 2: Monetary Policy News Index (Jan.2006 to May.2017)

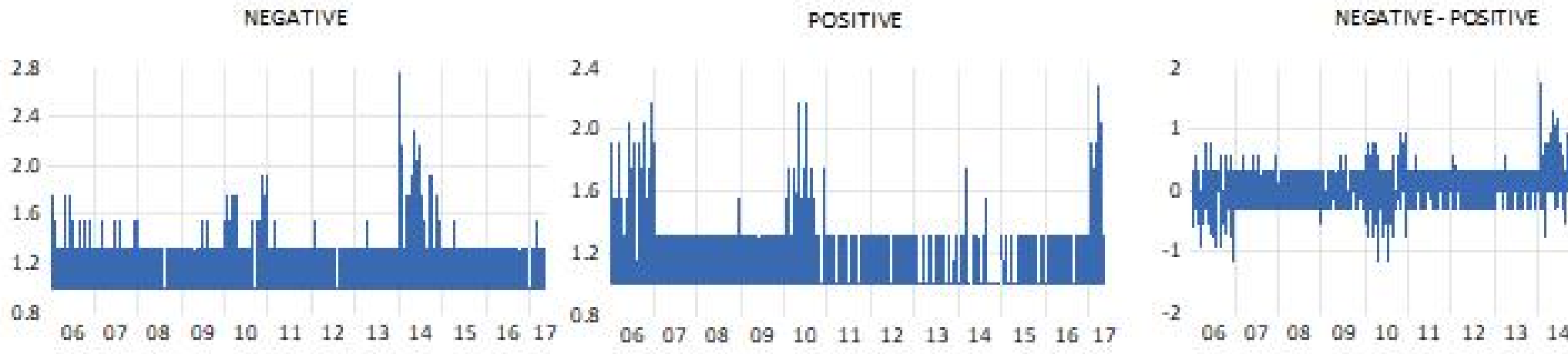


Figure 3: Conditional Correlation between BRL and Monetary Policy News Index

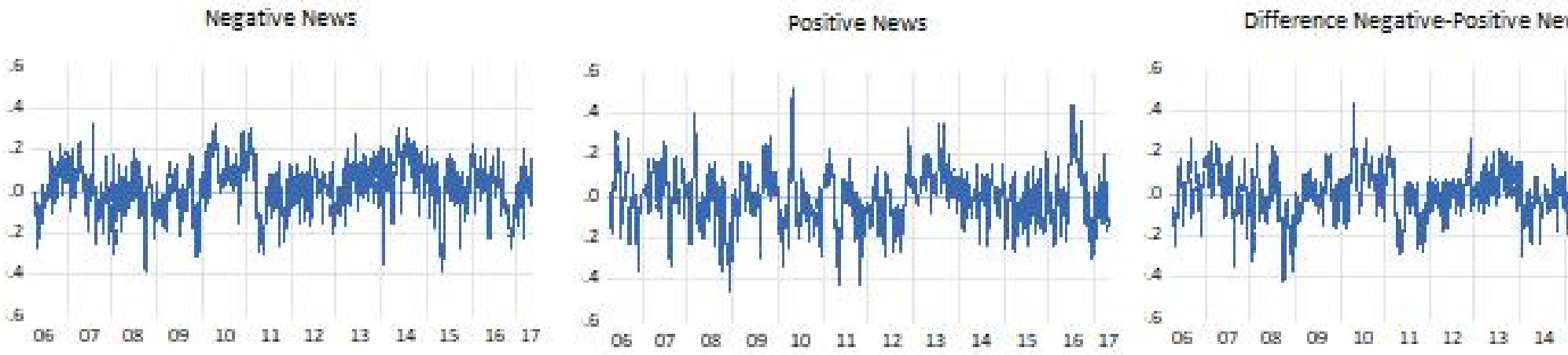


Figure 4: Conditional Correlation between Ibovespa and Monetary Policy News Index

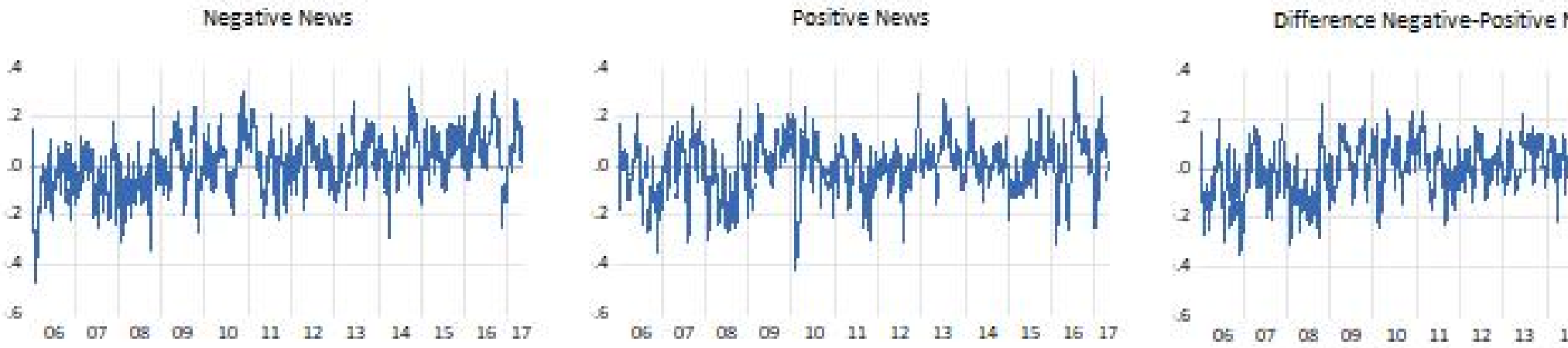


Figure 5: Conditional Correlation between DI360 and Monetary Policy News Index

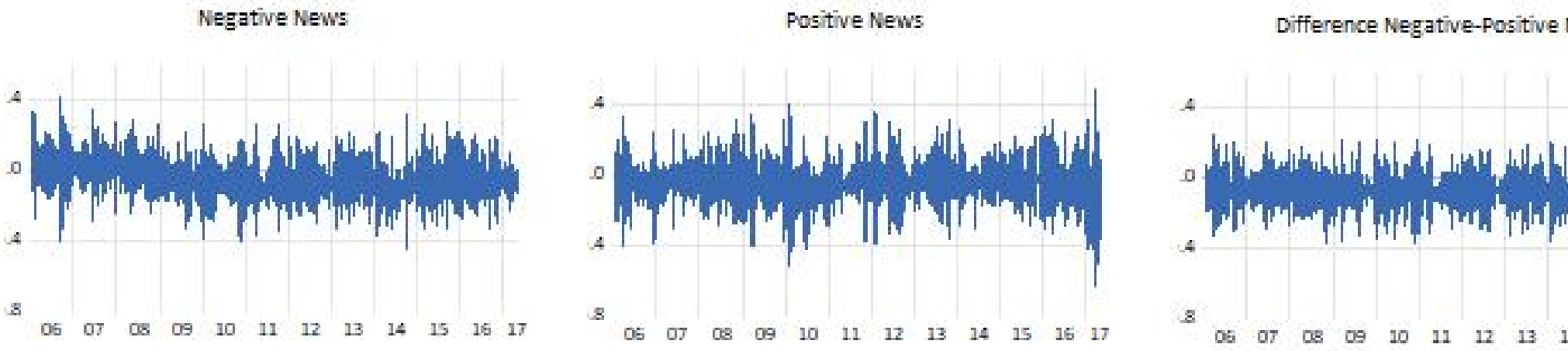


Table 7: Descriptive Statistics - positive and negative news

	NEGATIVE	POSITIVE	NEG_POS
Mean	1.099511	1.068964	0.030548
Median	1.000000	1.000000	0.000000
Maximum	2.754824	2.274009	1.754824
Minimum	1.000000	1.000000	−1.274009
Std. Dev.	0.171980	0.156660	0.253576
Skewness	1.963006	2.690879	−0.040431
Kurtosis	9.298060	12.23062	5.472987
Jarque-Bera	6547.533	13571.67	727.7769
Probability	0.000000	0.000000	0.000000
Sum	3136.906	3049.754	87.15204
Sum Sq. Dev.	84.35425	69.99505	183.3861

Table 8: Descriptive Statistics - exchange rate and equity index returns

	RBRL	RDI360	RIBOV
Mean	0.0001	0.0000	0.0002
Median	−0.0001	0.0000	0.0002
Maximum	0.0639	0.0114	0.1367
Minimum	−0.0758	−0.0064	−0.1209
Std. Dev.	0.0108	0.0007	0.0176
Skewness	0.2459	1.5858	0.0108
Kurtosis	7.7809	33.1871	8.6551
Jarque-Bera	2745.9	109522.4	3801.7
Probability	0.0000	0.0000	0.0000
Sum	0.2903	−0.0662	0.7125
Sum Sq. Dev.	0.3340	0.0017	0.8841
Observations	2853	2853	2853

Notes: The stock market and exchange rate returns are the daily percentage changes in the closing values of the Ibovespa and BRL. News count refers to the local monetary policy media coverage. Note that descriptive statistics refer to raw daily data (story counts). The sample size covers the period 1 February 2006 to 15 May2017, for a total of 2,853 observations.

A.1 News

The method used to compose the news index was guided by Caporale et al. [2018], considering the following equation:

$$Negative(Positive)NewsIndex = ln[e + MPnegative(positive)news] \tag{14}$$

As a procedure to construct the index, three steps were necessary: news survey, initial filter and classification. The data used were daily and had the exact time of disclosure of the news. Due to the size of the database, data were collected annually and consolidated in the final stage.

In the first step, the news used for the elaboration of the database was extracted from AgÃªncia Estado through the news source Broadcast. This news source has national scope and is a reference for agents focused on economics, business and finance in Brazil. The research criterion used consisted of conducting an extensive survey of all the news items that contained reference to the Brazilian Central Bank (BCB), regarding its performance in line with the inflation targeting mandate, either in the headline or in the contents of market reports and alerts.

The option of searching for Central Bank and applying filtering processes assured the greatest possible base with relevant themes on the topic of analysis. The second stage of filtering the base was necessary due to the existence of other news items not relevant for analysis, such as swap transactions, public bond auctions, disclosure of primary balance data, credit data and politically biased speeches or from other international central banks, which were excluded from the database.

Finally, the third step was to classify the selected news items that contained words and also macroeconomic variables related to monetary policy and to distinguish between articles with a potentially positive or negative connotation. The distinction for classification of news refers to the existence or not of a risk or benign factor to the fulfillment of the inflation tar-get to be pursued by the monetary authority. In this case, consideration was also taken to the understand the market, to make necessary the extension of cycles of cuts and in-creases to the basic rate and the dissension/ consensus about the decisions. Examples of news are:

"EVEN LOWER INFLATION EXPECTATION SHOULD NOT EASE INTEREST" - Negative news

"FALL IN IPCA [consumer price index] SHOWS BREAKS FROM RIGID EXPECTATIONS, SAYS ANALYST " - Positive news

"UAM: WITH TODAY'S DECISION, THE END OF THE CYCLE OF HIGH / INTEREST APPROACHES" - Positive news