The High-Frequency Impact of Macroeconomic Announcements on the Brazilian Futures Markets*

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Abstract

The estimation of the impact of macroeconomic announcements on the Brazilian futures markets is used to uncover the relationship between macroeconomic fundamentals and asset prices. Using intraday data from October 2008 to January 2011, we find that external macroeconomic announcements dominate price changes in the Foreign Exchange and Ibovespa markets, while the impact of the domestic ones is mainly restricted to interest rate contracts. We additionally propose an investment strategy based on the conditional price reaction of each market that achieved a success rate of 70% in an out-of-sample study. Finally, we document the impact on volume and bid-ask spreads.

Keywords: High-frequency data, Macroeconomic announcements, Financial markets, Investment strategy, Futures markets, Brazil.

JEL Codes: E44, F31, G14.

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1. Introduction

The study of the behavior of asset returns is central for financial economists and a wide range of applications benefit from such interest, including risk management, market efficiency, and asset pricing. But it is far from clear how markets arrive at prices and, more specifically, how they incorporate news related to the state of the economy. In this sense, we want to shed light on the controversy over the relationship between economic fundamentals and asset price formation by estimating the impact of macroeconomic announcements on the Brazilian futures market. The event study literature combined with the availability of intraday data offers a suitable approach to identify exogenous shocks, thus overcoming some difficulties inherent to the literature. Conversely, it brings econometric issues related to market microstructure that need to be addressed.

The event study literature has concentrated its efforts on understanding market reactions and co-movements in advanced economies. In this sense, it will be particularly interesting to compare the results applied to an emerging market, in particular the Brazilian one, in which external factors supposedly exert great influence on the development path of the domestic economy. Andritzky et al. (2007, 2011), for instance, had already studied first- and second-order effects of macroeconomic announcements for the most liquid emerging market bonds. Note, however, that both studies were restricted to the sovereign bond market as opposed to our study that focuses on the main domestic markets of an emerging country. Also, quite uniquely in the international arena, Brazilian futures markets are the most liquid ones, both for interest rates and for exchange rates. Therefore, this study concentrates on the markets where price discovery is most likely to take place.

The transactions data are provided by BM&FBovespa (BVMF), the Brazilian company responsible for clearing and trading futures and equity market transactions. The sample period goes from October 2008 to January 2011, totaling 513 days, and contains tick-by-tick information from the interest rate (IR), foreign exchange (FX), and stock index (Ibovespa) futures markets on prices, volume, and bid-ask offers as well. In addition, we construct a database of announcements with the surprise component of six economic indicators. The domestic announcements are the interest rate decision made by the monetary policy committee (COPOM), the monthly industrial sector production (PIM), and the consumer inflation (IPCA), while their external counterparts, all of them originated in the USA, are the FOMC interest rate decision,[1] non-farm payroll indicator (PR), and the consumer price index (CPI).

Bearing that in mind, we compute the aggregate effect of each announcement by summing up the impact estimates over progressive larger time windows. This procedure enables us to offer different dimensions to the reaction of each market, a contribution to the literature that will be tested for its practical application.

[1] We also included Quantitative Easing (QE) announcements.

Firstly, we give an indication of how fast markets react to each announcement type, enabling us to discuss its relative efficiency. We also take an empirical look at the persistence patterns among markets in an attempt to determine if individual announcements impose temporary or permanent effects on prices, volume, and bid-ask spreads. But to what extent does it translate into movements in the financial market? Our third metric, the intensity of the impact on each market, should answer this question.

The main findings are as follows. First, our study provides evidence of the link between economic fundamentals and asset prices. We find that external macroeconomic announcements dominate price changes in the FX and Ibovespa futures markets where reactions are, in general, immediate and persistent relative to monetary (FOMC) and real economy (PR) surprises. We also conclude that the IR market is affected by events that potentially affect its monetary rule, based on the inflation targeting approach. This is the reason why the impact of announcements on the IR market is less intense and restricted to domestic events. State dependence, in turn, can interfere in the relative magnitude of the coefficients that measure the impact of announcements, occasionally canceling out predicted impacts as shown by the estimates for the IPCA announcement.

Combined, such information could advocate the use of information on announcements as an input to high-frequency trading strategies, an additional motivation for this work. Actually, an investment strategy based on the conditional price reaction of each market showed promising results in an out-of-sample study. Under this approach, investors decide their trading position depending on the combination between sign impact and surprise direction. We are able to correctly identify returns' signs, conditional on the surprise's sign, in 70% of the cases. Besides, aggregate results show positive returns for all markets.

We also contribute to the existing literature by incorporating liquidity (trading volume) and informational (bid-ask spread) variables as market participants will benefit from a broader outlook of time periods surrounding macroeconomic announcements. We conclude that, contrary to price reaction, the impact of trading volume is widespread among all announcements and business cycles. We document large differences in the relative magnitude of trading volume reactions that are theoretically attributed to the precision of each announcement. The significant reaction from the IR market to COPOM announcements and from both FX and Ibovespa markets to FOMC and PR ones is an indication of differential levels of informational content. Finally, we find that bid-ask spreads often revert in face of external announcements, which can be attributed to different trading phases.

The remainder of the paper is organized as follows. Section 2 reviews the related literature, focusing on the recent developments in event studies. Section 3 briefly presents background information on the Brazilian futures market. Section 4 explores the details of the construction of the database and presents the methodology used in the paper, which has been based on the work of Andersen

et al. (2007). Section 5 discusses the results with an application to the real data. Finally, Section 6 contains our concluding remarks.

2. Related Work

The link between economic fundamentals and asset prices has been extensively studied in the financial economics literature. When working with daily data, the biggest issue is to identify structural shocks. An identification strategy based on the heteroskedasticity in the data was proposed by Ehrmann et al. (2011) in a study with daily frequency data. This framework was used to identify the degree and direction of financial transmission between the Euro area and the United States in the bond, stocks, and exchange rate markets. A similar approach had been applied by Rigobon and Sack (2003) in their study on the contemporaneous impact of stock and bond markets in the USA.

Although empirical studies for emerging countries are scarcer, there has been a growing interest in the subject recently. Using event study analysis for Mexico, Brazil, and Chile, Kolscheen (2011) found no significant relation between monetary surprises and exchange rates around monetary policy committee meetings. For the Brazilian case, Moura and Gaião (2014) were able to identify the effect of a wide range of macroeconomic announcements on the domestic bond market. Mendonça and Faria (2013), in turn, offered a more particular perspective upon the effect of monetary decisions on the bond market while Eid and Gonçalves (2011) and Oliveira and Romaguera (2013) studied the effect of monetary surprises on the Brazilian stock market. All the aforementioned studies share the fact that they were based on daily instead of intraday data, an explicit contribution of this study to the literature. Besides, the effect of macroeconomic announcements has been measured for a sole financial market, in contrast to our proposal of assessing it for the three main domestic financial markets at once.

The use of high-frequency data makes it possible to identify a structural shock by focusing on specific situations when a prevailing force moves the financial market. In the high-frequency event study literature, the central hypothesis is that macroeconomic announcements, used as a proxy for public information about macroeconomic fundamentals, have price-relevant information that is quickly incorporated into prices through trading.

The high-frequency association between returns and fundamentals has been acknowledged by Fleming and Remolona (1997). Using data from August 1993 to August 1994, the authors documented that the 25 largest price moves and trading surges in the U.S. bond market were related to macroeconomic announcements. Fair (2003) also took advantage of the availability of intraday data and identified abnormal returns on the U.S. stock market from 1982 to 1999. Such returns were then associated with economic news released at exactly the same time. Moreover, the author corroborated that each market was moving according to what is expected from theory, depending on the announcement type studied.

On the same agenda, Faust et al. (2007) evaluated the effect of macroeconomic announcements on the U.S. bond and exchange rate markets. Contrary to Fair (2003), the authors made a regression-type analysis where the dependent variable was the return on a 20-minute window around each announcement and the independent one was its surprise component. In general, the authors found that stronger-than-expected releases[2] for real and nominal activity cause dollar appreciation and raise U.S. rates at all horizons. Using 5-minute returns, Melvin and Ahn (2007) identified regime switches in the German Mark and Dollar markets around 10 FOMC meetings between 1994 and 1995. They concluded that the switch from liquidity to informed trading occurred during the meeting, suggesting an earlier adjustment of positions prior to its end.

Also based on a high-frequency event study analysis, Andersen et al. (2003) proposed an alternative structure for the construction of the database of returns which will be explored in further detail in Section 4. Using 5-minute returns from January 1992 to December 1998, the authors analyzed the impact of macroeconomic announcements on the relationship between the dollar and major currencies (German Mark, Japanese Yen, British Pound, Swiss Franc, and Euro), finding that bad news had greater impact than any good one, the so-called asymmetric effect. Departing from the same framework, Andersen et al. (2007) concluded for the existence of a state-dependent link from economic fundamentals to the bond, exchange, and stock markets in the USA, Germany, and the UK. The authors also found that systematic effects are usually short-lived and restricted to the first 5-minute interval.

Recent high-frequency studies provided additional evidence on the link between economic fundamentals and asset prices in different markets and sample periods. Using 5-minute returns from September 2000 to September 2008, Hussain (2011) documented the significant influence of domestic monetary policy on the return and volatility of U.S. and four European stocks (Germany, France, Switzerland, and the UK). Lapp and Pearce (2012), in turn, found that greater-than-expected inflation and employment rise futures bond prices. Beechey and Wright (2009) also confirmed the highly significant and immediate impact of macroeconomic announcements on long-term U.S. bonds and inflation-nominated ones between February 2004 and June 2008. Rosa (2011) made the important distinction in terms of empirical strategy between assessing the impact of monetary policy actions and statements. In this respect, Conrad and Lamla (2010) created communication indicators to deal with the issue of interpreting monetary statements in their analysis of first- and second-order effects of the European Central Bank (ECB) communications on the EUR-USD exchange rate.

When it comes to the relationship between price and volume, Bamber and Cheon (1995) find evidence of public announcement with small price changes and

[2]Inflation surprises (CPI and PPI) were not significant to exchange rate returns at the 1% level.

high trading volume. Actually, nearly a quarter of firm-specific earnings announcements generate divergent reactions in terms of magnitude. Accordingly, there is a literature aimed at providing answers of what can be inferred from public announcements by its trading volume.

Empirical studies have already documented that announcements increase trading volume in different markets. Balduzzi et al. (2001), for instance, documented significant and persistent post-announcement increases in trading volume in the interdealer broker market for U.S. bonds. Concerning the FX market, Chaboud et al. (2004) also reported a sharp increase in trading volume after U.S. announcements in the global interdealer spot market. Basically, two factors were identified as important drivers of trading volume. The first one is that public announcement provides the grounds for uncertainty resolution implying that trading volume prompted by a public announcement is positively related to the precision of the announcement.

As liquidity can be related to information asymmetry, the effect on spreads will be confronted with trading volume in order to assess this relationship. Kyle (1985) has shown that asymmetric information is positively related to illiquidity. Considering that spreads are a market maker's protection from informed trading, informed traders lose the camouflage provided by noisy trading in low liquid markets. All else equal, profits based on inside information trading can be maximized in a frequently traded asset. In view of this framework, trading volume and spreads should present a negative association, in contrast to the findings of Balduzzi et al. (2001), who found that both trading volume and bid-ask spreads increase in the U.S. bond market after macroeconomic announcements.

3. Background: Futures Market in Brazil

Before getting into the details of the database construction, it is important to discuss the reason why we opted for the futures market instead of the spot market. BVMF, the company that manages the organized domestic derivatives transactions in Brazil, plays a dominant role in the pricing process of certain assets (see Garcia and Ventura (2012), for an assessment of price discovery in the Brazilian FX market) due in part to the preference of local investors to trade in their environment. At the heart of this alleged preference, two factors emerge: firstly, BVMF acts as central counterparty clearing house, guaranteeing financial liquidity and managing risk for the trades executed in its environments; secondly, regulatory restrictions in the spot market restrain transactions of key agents whose only alternative is to trade at BVMF.

This conjecture is corroborated by standard practice in the market. When the Brazilian National Treasury auctions off federal bonds, for instance, the decision on which offers to accept is based on the price of the nearest-to-maturity futures contract. Along similar lines, a wide range of short-term FX operations originally designed for the spot market are synthetically reproduced in the futures market.

As a result, in a unique world example, the exchange rate is formed in the futures FX market, which is approximately nine times bigger than the spot one in terms of trading volume. Finally, stock index futures are also far more liquid than their ETF (exchange-traded funds) counterparts also on the grounds of risk management and liquidity.

In all of the above-mentioned markets, orders are settled on an order-to-order basis. With no intermediation from market makers, the protection against the action of informed traders is possible through limit orders and there are contracts with different maturities traded on the same day. In the FX market, in particular, expiration date is on the first business day of the contract month. The shorter-term contracts, expiring in the subsequent month, are always the most liquid ones, concentrating approximately 90% of the FX trading volume. Two days before expiration, traders move to the following contract month and the final database is selected by switching contracts according to liquidity. Ibovespa futures[3] market is similar to the FX one, where short-term contracts concentrate most of the trading volume and, every two months, there is a switch to the nearest-to-maturity contract two days before expiration.

Although liquidity remained a criterion of choice, the fact that the IR futures market works in a different way brings an additional element to its database construction. On a given trading day, there is a wider range of IR contract maturities with high trading volume, including medium- and long-term contracts. However, only the January contracts present regular trades compatible with sampling every five minutes.

In view of this restriction, we propose a procedure in order to minimize large differences in risk premium as we switch between contracts. Between October 2008 and December 2008, the selected contract is the one expiring in January 2010. In 2009 and 2010, the selected contracts expired in January 2011 and January 2012, respectively. Finally, in January 2011, the January 2013 contract was selected. Such procedure leads to time-to-maturity contracts that share a medium-term range, between one and two years ahead of the trading day.

In terms of the number of transactions, Table 1 shows that FX contracts are the most frequently traded with at least one transaction at each 3-second interval, followed by Ibovespa and IR ones, which are traded every 5 and 30 seconds, respectively. Note that this is not a homogenous statistic as, around announcement releases, all markets trade more frequently than they do on average. Thus, we do not expect any problems concerning our database, because, as will be demonstrated, we work with selected observations around announcement releases.

[3]BVMF codes have six digits. The first three identify the contract ("IND", for Ibovespa futures, "DOL", for exchange rate ones and "DI1" for interest rates). The final three digits identify month and year of contract maturity.

Table 1
Daily average trading volumes for each futures market between October 2008 and January 2011

This table reports quantitative data from each futures market analyzed including the number of transactions and trading volume. The sample covers the period from October 2008 to January 2011 and the table is consolidated by calendar year.

	IR		FX		Ibovespa	
	#of transactions (in thousands)	Volume(in trillion BRL)	#of transactions (in thousands)	Volume(in trillion USD)	#of transactions (in thousands)	Volume(in trillion BRL)
2008 (Oct to Dec)	43.2	1.32	551.9	1.94	259.6	0.18
2009	164.1	9.30	2,793.4	6.62	1,311.5	0.89
2010	161.3	18.8	3,095.6	7.31	2,338.7	1.20
2011 (Jan)	14.7	1.09	169.2	0.46	141.7	0.08

4. Data and methodology

We collect data from the IR, FX, and Ibovespa contracts specified in Section 3 from October 1st, 2008 to January 31st, 2011, or 513 trading days. As any intraday database, it contains price, volume, quantity, date and time for every transaction, including order books. We conduct our study following the common practice of the high frequency literature (see Andersen et al. (2003, 2007), Beechey and Wright (2009), and Hussain (2011), among others) in which sampling occurs regularly at each 5-minute interval.

All futures markets open at 09:00 a.m. and close at 06:00 p.m. The IR market has a trading interruption between 04:00 p.m. and 04:50 p.m. that will not impact our estimates since announcements did not coincide with such interruptions. Since all selected markets are highly liquid, we expect to minimize error measurement by considering the last price in a 5-minute grid as the prevailing one. Returns for each contract were then computed at each 5-minute interval as the log-difference between consecutive 5-minute transaction prices. Taking order cancelation into account, spreads are derived as the relative difference between bid and ask values ($\frac{ask-bid}{bid}$) and are measured in percentage points (p.p.). Similarly, the last available spread is the prevailing one in each 5-minute grid. Trading volume, in turn, refers to the sum of the number of traded contracts at each 5-minute interval.

Table 2 provides information on the sample sizes and summary statistics for the 5-minute return, trading volume, and spread series. The average returns are, as expected, zero for all markets while the standard deviations range from 0.05% in the FX market to 4.3% in the Ibovespa one. All distributions show excess kurtosis and are positively skewed, except for FX market returns. Negative first-order autocorrelation holds for all distributions of returns. High first-order autocorre-

lation, as the one observed in the Ibovespa market trading volume and spread, suggests that persistence is a dominant feature of both distributions.

The resulting database has information on returns, trading volumes, and bid-ask spreads of the entire sample period, totaling 55,404 observations (513 days ×1085-minute intervals per day). In the spirit of the event study literature, we must be able to identify time periods around announcements so as to avoid concurrent effects on returns. More precisely, we must define an estimation window that must be wide enough to capture announcement effects but not so wide to allow returns to be affected through other channels.

Table 2
Summary statistics for 5-minute returns, trading volumes, and spreads

This table provides a set of summary statistics regarding each futures market under study, based on 5-minute returns, trading volumes, and spreads. Returns are computed as the log-difference between consecutive 5-minute transaction prices. Spreads are derived as the relative difference between bid and ask values ((ask-bid)/bid) and are measured in percentage points (p.p.). Trading volume, in turn, refers to the sum of the number of traded contracts at each 5-minute interval. The sample period goes from October 2008 to January 2011.

	IR	FX	Ibovespa
Sample size	55,504	55,504	55,504
Final sample	50,274	55,504	55,504
	Returns		
Mean	0.00%	0.00%	0.00%
Standard deviation	0.32%	0.05%	4.05%
Skewness	0.23	-0.13	0.61
Kurtosis	552.2	316.2	1123.4
First-order autocorrelation	-0.30	-0.01	-0.47
	Trading volumes		
	IR	FX	Ibovespa
Mean	973,3	2,586,0	541.9
Standard deviation	2,000.3	2,522.8	411.5
Skewness	5.1	2.7	2.1
Kurtosis	43.9	14.0	8.9
First-order autocorrelation	-0.07	0.51	0.63
	Spreads		
	IR	FX	Ibovespa
Mean	0.11%	0.06%	0.06%
Standard deviation	0.14%	0.08%	0.05%
Skewness	1.8	16.0	6.6
Kurtosis	289.1	553.2	166.6
First-order autocorrelation	-0.15	-0.15	0.64

Following Andersen et al. (2007), we collect twenty 5-min observations around each announcement, two of them before and 18 after it. The small interval before announcements is needed to identify, if any, the relative impact on returns, trading volumes, and bid-ask spreads. When announcements are released after the market is closed, we opt to consider the last two 5-minute intervals of the current day

as the pre-announcement period and the 18 first ones of the following day as the post-announcement period. In this case, markets absorb the news during the night and there is no way to avoid a quicker adjustment in the morning. The same logic was applied to the cases where the announcement is made at the first interval of the day. With the selection procedure proposed above, the final database ended up with 2,504 observations.

As our aim is to investigate short-term effects on the futures market, our choice of announcements gave preference to quantitative indicators as opposed to report analysis and policy statements, a kind of release in which we would not be able to identify the exact time of the initial impact. In Brazil, it would be the case of the Inflation Report and COPOM minutes[4] whose impact on the domestic term structure of interest rates has been investigated by Janot and El-Jaick (2012). In addition, our work is severely limited by the fact that only few domestic announcements have up-to-date expectations.

Accordingly, we have chosen the most important domestic and external indicators according to the following types of announcement: monetary, price, and real economy. Both interest rate decisions made by COPOM and FOMC, respectively, are the most relevant monetary announcements and we include Quantitative Easing (QE) announcements for reasons that will be discussed soon. The choice for the price type is also straightforward as target inflation rules aim at consumer prices. With respect to the real economy, we refer to Fair (2003) to justify the use of the non-farm payroll indicator as the author finds evidence of its superior impact on the U.S. stock market. In Brazil, the domestic industrial production is not only the most reliable one, but it is also the subject of many institutional forecasts and attracts the interest of the academy. In Table 3, we present details of the macroeconomic indicators, including their periodicity and additional information concerning public releases.

Let S_t^k be the surprise component of each announcement, our variable of interest. Real economy and inflation surprise components will be calculated following Balduzzi et al. (2001), where the discrepancy between unit measures justifies the normalization procedure in (1), also allowing a relative comparison between results.

$$S_t^k = \frac{A_{kt} - E_{kt}}{\widehat{\sigma_k}} \tag{1}$$

where A_{kt} is the released value for announcement k, E_{kt} denotes its expectation and σ_k is the standard deviation's surprise of each announcement. Time t is a discrete variable that indexes each announcement date.

As far as expectations are concerned, Rigobon and Sack (2008) pointed out that they are noisy and hard to measure. As much as possible, it is important to

[4]COPOM minutes (or "Ata do COPOM") are released 1 week after the target interest rate decision and subjected to deep revision by market participants in order to anticipate the interest rate path.

This table reports a set of information regarding the six macroeconomic announcements under study. This set includes the day of the week when the public release of each announcement occurred, its periodicity, and local and Brazilian time. We also report the number of releases during the sample period, which ranges from October 2008 to January 2011.

Table 3
List of macroeconomic indicators, periodicity, time and day of the announcement release

Origin	Type	Indicator	Day of the week	Periodicity	Local time	Brazilian time	Source	# events in the sample
	Monetary	Interest rate decision (COPOM)	Wednesday	45 days	18:30	18:30	Central Bank of Brazil	15
	Price	Consumer price (IPCA)	Usually on Friday	Monthly	09:00	09:00	Brazilian Statistical authority (IBGE)	22
	Real Economy	Industrial Production (PIM)	Random	Monthly	09:00	09:00	Brazilian Statistical authority (IBGE)	26
	Monetary	Interest rate decision (FOMC statements) and QE announcements	Usually on Tuesday**	45 days**	13:15**	15:15 or 16:15**	U.S. Federal Reserve (FED)	22***
	Price	Consumer price (CPI)	Wednesday or Friday	Monthly	08:30	10:30 or 11:30*	Bureau of Labor Statistics	25
	Real Economy	Non-farm Payroll (PR)	Friday	Monthly	08:30	10:30 or 11:30*	Bureau of Labor Statistics	19

Note: FOMC and COPOM are the central bank committees responsible for the decision on the short-term interest rates.
IPCA and PIM are the initials for the consumer price index and monthly industrial production in Brazil.
QE: Quantitative Easing
* The difference is due to differences in daylight saving times.
** The periodicity and time information refer only to interest rate decisions by FOMC.
*** Includes four QE announcements.

capture expectations directly from market prices.[5] Otherwise, one should analyze carefully the survey's historical results; for instance, it is not good if they always fail in one direction. In Brazil, the Central Bank releases a weekly survey (FOCUS Survey) that, besides showing the average perception of financial agents about some indicators, also informs the average of the Top 5 agents, i.e., those who had the best recent forecasts. Using this specific indicator, the standard deviation of the absolute value of the surprise is comparable to the one based on Bloomberg forecasts,[6] which are our reference in the case of inflation and real economy external indicators.

Monetary surprise deserves special attention as our database starts at the onset of the financial crisis of 2008. Since there were no expectations of a reversion on monetary easing, equation (1) would imply a monetary surprise very close to zero if we considered short-term yields.

But recall that we are interested in the announcement impact and, in fact, statements released by FOMC reveal more than just the target fund, giving insights about the state of the economy and also suggesting the future path of the target rate. In this respect, Swanson and Williams (2013) investigated the effect of the zero lower bound on the term structure of interest rates and its responsiveness to macroeconomic announcements. The authors concluded that, between 2008 and 2010, monetary policy was as effective as usual. By using event study methods with daily and intraday data, Neely (2010) also found that Quantitative Easing (QE) announcements substantially reduced long-term U.S. and foreign bond yields as well as the foreign exchange value of the dollar. In fact, FOMC meetings sustained its ability to impact long-term maturity yields, producing daily variations in 5- and 10-year bonds compatible with sizable "normal time" surprise changes in the federal funds rate, as calculated by Gürkaynak et al. (2005) and Glick and Leduc (2013). D'Amico et al. (2012) found that the term premium of long-term bonds was more responsive to QE operations. Similar effects were found by Joyce et al. (2011) in their assessment of the quantitative easing policy in the United Kingdom, where they found that medium- to long-term government bond yields were reduced by about 100 basis points, and by Fatum et al. (2012) in their study of monetary policy in Japan between 1999 and 2006.

Accordingly, shorter-term maturity bonds do not seem appropriate to capture the monetary surprise component of an FOMC meeting, at least for the unconventional sample period under study. In Wright (2012), monetary shock was computed based on the first principal component of a set of bond futures traded at the Chicago Mercantile Exchange (CME), ranging from 2 to 30 years to maturity. We

[5]Domestic and external interest rate expectations are measured from market prices.

[6]Most high frequency studies take announcements' expectations from Money Market Services (MMS) forecasts, which we do not possess. Publicly available Bloomberg data present market consensus for CPI only in the first decimal place, which partially explains their relative high standard deviation.

opt for a more traditional strategy, based on robustness checks. In our reference scenario, we chose a long-term maturity, the constant 10-year-maturity Treasury bill, to measure the impact of an FOMC/QE meeting release. As a robustness check, we will provide the results for the 1-year and 2-year contracts, all of them provided by the FED. As we have only daily data on U.S. bonds, the surprise component will be calculated as the difference between the closing rate on the FOMC/QE day and the day before, resting on the assumption that it is the main factor driving interest rates and that the risk premia are constant in between. We analyzed the economic calendar from 2008 to 2011 and could not identify any concurrent macroeconomic announcements released on a regular basis. Although we cannot rule out the effect of non-regular events, we will refer to Faust et al. (2003) to assume that the correlation between the surprise taken from daily and intraday futures data around the days on which FOMC meetings are held is very close to one.

Gagnon et al. (2011) and Krishnamurthy and Vissing-Jørgensen (2011) identified eight relevant communications related to QE1, which will be included in our database of announcements. Our sample period also encompasses the second round of QE, or QE2. We will again follow Krishnamurthy and Vissing-Jørgensen (2011) and include two[7] dates concerning QE2: September 21st, 2010[8] and November 3rd, 2010.[9]

Since the zero-bound constraint does not apply to domestic monetary surprises, the expectation parameter is the closing rate of a short-term (with time to maturity of 30 calendar days) interest rate swap contract traded at BVMF 1 day before the announcement. Along the same line of reasoning, we will check the results with a 1-year-to-maturity contract to account for a broader[10] impact of a COPOM meeting.

Figure 1 presents the evolution of the normalized surprises for all six announcements. In Brazil, the Central Bank did not cut interest rates immediately after the Lehmann Brothers' event and the coordinated interest rate cuts held by central banks worldwide in the last quarter of 2008. Only at the beginning of 2009 did the Central Bank of Brazil start to cut interest rates aggressively even when inflationary pressures indicated otherwise. Hence, domestic monetary surprises were mostly negative up to the March 2010 meeting when COPOM started a contractionary monetary cycle that lasted until mid-2011. The abrupt shifts in the conduct of monetary policy in such a short period of time explain the erratic behavior of COPOM surprises and reveal a disagreement between market and Central Bank expectations over the duration and intensity of each monetary

[7] Krishnamurthy and Vissing-Jørgensen (2011) suggested three dates, but October 10th, 2010 is missing in our sample.

[8] At 03:15 p.m. (GMT) or 06:15 p.m. (local time).

[9] At 04:15 p.m. (GMT) or 06:15 p.m. (local time).

[10] In Brazil, the term structure of the interest rate is severely limited by a shorter investment horizon. In this sense, a 1-year contract can act as a medium-term yield.

cycle. Moreover, the fact that surprises are mainly negative shows that the market expected a more hawkish monetary policy than the one actually employed.

Prior to the financial crisis, the Brazilian economy experienced high growth rates led mostly by consumer expenditures. With the decline in commodity prices and in consumer credit availability, there was a consensus that the external scenario would imply a deflationary price pressure. On the other hand, federal governments and central banks worldwide, including the Brazilian one, responded to the crisis with aggressive expansion of fiscal and monetary balances. Thus, there were two opposing driving forces at work with an unpredictable combined outcome. Actually, until mid-2009, the fact that IPCA and PIM[11] surprises were high shows that inflation and real economy indicators were harder to predict immediately after the crisis. We can also conclude that the signs of the surprises are rather persistent, revealing that market forecasts fail to predict and recognize persistent shifts in the level of those economic indicators, in agreement with the findings of Andolfatto et al. (2008), who explained the bias towards inflation expectations by rational expectation agents with imperfect information.

Until mid-2009, QE and FOMC statements promoted a reduction in long-term bonds and, by assumption, in the surprise component. Note also that the highest negative surprises refer to QE-related announcements. On November 25th, for instance, QE1 was launched by the FED. On March 18th, 2009, the FED announced that it would inject US$ 1 trillion to aid the economy by buying treasury bonds and mortgage securities, generating a high negative surprise associated with a significant reduction in long-term bonds. In the same period, CPI and PR surprises were mostly negative, reflecting the uncertainties over the state of the economy and the difficulties surrounding the conduct of monetary policy.

From the second semester of 2009, as the economy started to present signs of recovery, all external announcements exhibited a well-behaved pattern, characterized by fewer outliers and constant shifts between positive and negative ones, displaying minor error persistence.

4.1 The model

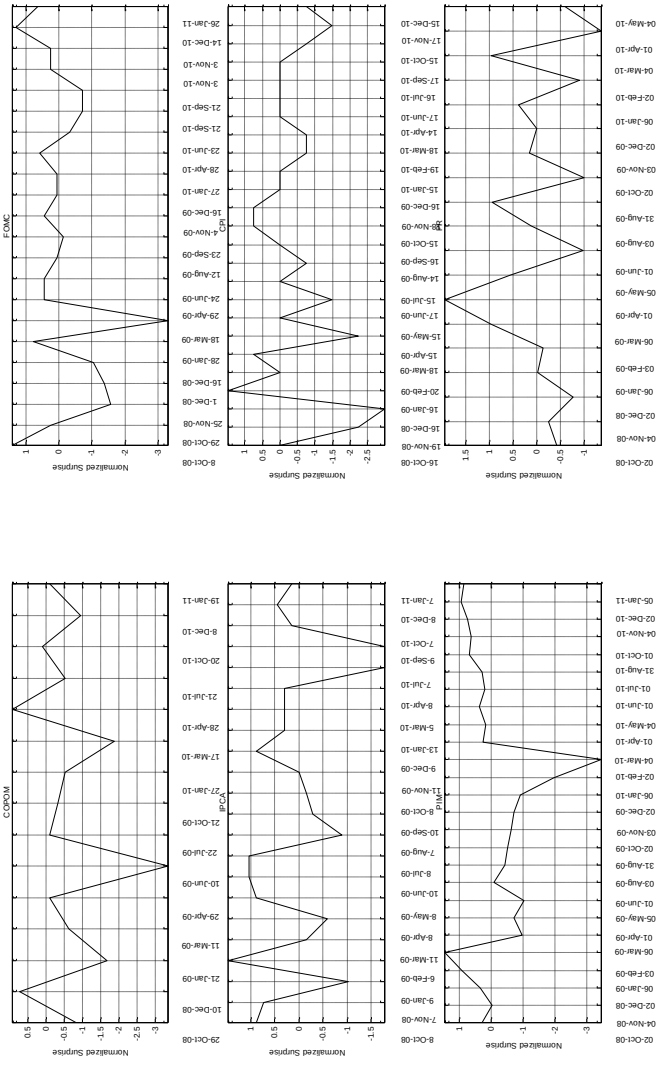
Directly inspired by Andersen et al. (2003, 2007), we propose a linear model in order to measure the short-term dynamics of the selected variables after macroeconomic announcements. We run different regressions, one for each market and independent variable, as follows:

$$X_t^h = \beta_0^h + \beta_1^1.X_{t-1}^1 + \beta_1^2.X_{t-1}^2 + \beta_1^3.X_{t-1}^3 + \sum_{k=1}^{6}\sum_{j=0}^{3} \chi_{kj}^h.S_{t-j}^k + \epsilon_t^h \qquad (2)$$

[11] Recall that PIM announcements are lagged by 2 months. So, for instance, a January 2009 release refers to what happened in November 2008.

Figure 1
Evolution of announcement surprises

This figure shows the evolution of the surprises for each macroeconomic announcement identified in the upper portion of each subplot. The vertical axis corresponds to the normalized surprise as in (1). Each data point on the horizontal axis is associated with a different release of a given announcement. The sample period goes from October 2008 to January 2011.



where t refers to each 5-minute interval, h refers to each market (IR=1, FX=2, Ibovespa=3) and k identifies the six announcements described above. X_t^h are the returns, bid-ask spread or trading volume of each market h, respectively. S_t^k takes the computed value of the announcement surprises at the first 5-minute interval after the announcements and zero afterwards.

The terms indexed by X_{t-1}^h on the right-hand side of (2) are lagged dependent variables that stand for autoregressive effects and cross-market lagged correlations, improving the properties of residuals and acting as control variables. In principle, higher-order lagged terms could be introduced into the specification, but our tests show the lack of signification of such terms, which justifies our choice for first-order lags.

Due to the time-varying nature of the innovations ϵ_t^h, the Ordinary Least Square (OLS) estimation of model (2) would produce consistent, but inefficient, coefficient estimates. We again follow Andersen et al. (2007) and apply a two-step correction procedure for heteroskedasticity based on Weighted Least Squares (WLS). In the first step, we perform an OLS regression of (2), whose absolute residuals are used to estimate equation (3) as shown below. Finally, (2) is recalculated through WLS using (3) as volatility weighting.

$$\left|\widehat{\epsilon_t^h}\right| = \sum_{i=1}^{9} \theta_i^h \left|\widehat{\epsilon_{t-i}^h}\right| + \sum_{j=1}^{9} \lambda_j D_t^j + \sum_{k=1}^{6}\sum_{j=0}^{3} \gamma_{kj}^h D_{t-j}^k + \mu_t^h \tag{3}$$

where $\widehat{\epsilon_t^h}$ is the first-step residual for each market h, D_t^j is the dummy that identifies each observation's hour and D_{t-j}^k is the announcement dummy set to 1 when observations are related to macroeconomic announcement k.

The first term of equation (3) accounts for serial correlation or ARCH effects and the second one, for the intraday volatility. Note that, contrary to Andersen et al. (2007), we opt to control for the hourly volatility (nine trading hours per day) instead of using each 5-minute intervals to avoid overparameterization. The last term controls for announcement-specific volatility patterns.

When we replace the dependent variable in (2) with each market's trading volume and spread, it is important to highlight that economic surprises are replaced with their dummy counterparts, a key modification to the original model.[12] Consider a public authority planning a neutral market intervention, i.e., one that is aimed only at restoring supply and demand equilibrium. Suppose the authority wants to avoid periods in which there is a drop in liquidity, which could induce noise and excess volatility. In contrast to high-frequency traders seeking return

[12]By replicating model (2) for trading volumes and bid-ask spreads, with announcement surprises as independent variables instead of dummies, impact estimates were mainly insignificant. Given the persistent and widespread reactions observed in the latter case, we speculate that, although trading volume and bid-ask spread fluctuations are related to announcements, reactions are not correlated to the surprise components.

premia, the most relevant decision criteria for this kind of agent are the average effect of each announcement, as the agents will not plan an intervention based on information that they do not possess ex-ante, i.e., the direction of the surprise.

Both variables also present a pronounced seasonal pattern.[13] Spreads reach their peak in the first 2 hours of the trading session and are relatively stable afterwards. With respect to trading volume, we can define three different volume regimes. At the beginning of the trading session, we identify a high trading regime, followed by low volume at lunchtime and a new period of higher volume afterwards. Hence, we need to modify each 5-minute variable in order to avoid bias in the results and we opt to compute spreads and trading volumes as a ratio relative to their corresponding hourly mean figures. According to this new definition, the coefficients must be interpreted correctly as the impact of the announcement on spreads and volume relatively to the hourly mean.[14]

According to equation (2), the effect of macroeconomic announcements on the futures market is measured within a 20-minute post-release window, split into four 5-minute intervals. We will derive our measures of interest based on the aggregate effect by summing up coefficient estimates in a progressive aggregation up to 20 minutes. In formal terms, we have:

$$\begin{aligned} Five &- minute\ aggregation : H0 : \chi^h_{k0} = 0 \\ Ten &- minute\ aggregation : H0 : \chi^h_{k0} + \chi^h_{k1} = 0 \\ Fifteen &- minute\ aggregation : H0 : \chi^h_{k0} + \chi^h_{k1} + \chi^h_{k2} \\ Twenty &- minute\ aggregation : H0 : \chi^h_{k0} + \chi^h_{k1} + \chi^h_{k2} + \chi^h_{k3} = 0 \end{aligned} \quad (4)$$

where h refers to each market and k stands for the announcements. The indexes (0,1,2,3) refer to the 5-, 10-, 15-, and 20-minute surprise coefficient estimates. The p-values will be computed by means of a Wald test on each aggregate effect.

First of all, we want a measure of speed or of how fast each market reacts to each announcement. The surprise component of an announcement is tantamount to the release of new public information. According to the semi-strong form of efficient market hypothesis, the surprise component should be instantaneously reflected in asset prices. We will derive this information by identifying the first interval where the aggregate effect is significant. Another important aspect to be assessed is the persistence effect, or how long[15] the announcement will be an explanatory factor. An overreacting market could respond instantaneously to a surprise and,

[13]Hourly average trading volume (number of traded contracts) and spread per futures market are available upon request.

[14]We also modeled the intraday behavior of trading volume and bid-ask spreads using cubic splines with hourly knots. Under this alternative model, impact estimates were mainly insignificant. We attribute the contrasting results to the fact that splines potentially add noise to the high-frequency observations, contrary to our proposed specification, which preserves the proportionality between sequential observations.

[15]Persistence is frequently measured in the literature with the half-life criterion. Our first-order serial correlation, however, is not high enough to allow its application to the present study.

at the next interval, adjust to the previous price level. More efficient markets are expected to exhibit a more persistent pattern, i.e., in reacting to a surprise, they will sustain their price levels along the estimation window. So, a market is persistent to a given announcement as long as its aggregate effect is significant. Finally, the point estimate of the last significant aggregate effect is a direct measure of intensity or of how much the surprise affects each market.

5. Results

As the previous section makes clear, we estimate individual regressions for each futures market (IR, FX, and Ibovespa) and variable of interest (returns, trading volume, and bid-ask spread) under study, whose results are provided in Tables 4, 5, and 6. Rather than commenting on the regressions individually (see Tables 10, 11, and 12 in the Appendix), we organize the most interesting aspects of the empirical results in terms of the three indicators mentioned in Section 4: how fast (efficiency), how long, (persistence), and how much (intensity).

We additionally want to check for business cycle singularities. In the first months that followed the peak of the financial crisis, Brazil suffered a dramatic turnaround in its economic prospects. The first sign of recovery did not appear until the second quarter of 2009 with the release of a positive quarterly GDP after two consecutive positive industrial production indicators. The contraction period should thus comprise observations from October 2008 to March 2009, while the expansion one should include observations from April 2009 to January 2011. Note, however, that such definition would yield a very short contraction subsample with few observations. We will partially circumvent this problem by running two regression sets for each pair of futures market and variable of interest, one for the full sample and another for the expansion period. Differences in the results will then be associated with state dependence. The fact that expansion period R^2 is superior to the full sample one (see Table 10 in the Appendix) for all markets provides additional support to this procedure.

5.1 The impact of macroeconomic announcements on returns

Bearing that in mind, Table 4 displays the response of each market's return to the surprise component of the selected macroeconomic announcements. As shown in Panel A, when a significant impact is verified, markets react quickly at the first 5-minute interval. In most cases, however, we observe price reversions given that only few announcements show persistent effects up to the 20-minute estimation window.

In the IR market, in particular, responses are not only fast but short-lived as well. Reactions to FOMC and PR surprise components, for instance, vanish after 5 minutes. Even COPOM and IPCA, the most important domestic announcements related to monetary decisions, keep their influence only up to a 10-minute time. At this point, it should be noted that COPOM statements are released when markets

Table 4
Impact of macroeconomic announcements on the returns of each futures market

The table refers to the impact of announcements on returns and is divided into three panels according to the three measures of interest (how fast, how long, and how much) mentioned in Section 4. Panel A reports the first interval where the aggregate effect is significant. Panel B shows the persistence indicator or "how long," which refers to the last interval where the aggregate effect is significant. Finally, the point estimate of the last significant aggregate effect is the direct measure of intensity shown in Panel C. Returns are computed as the log-difference between consecutive 5-minute transaction prices. The database covers the period from October 2008 to January 2011 for the six announcements listed in Table 3.

Panel A: How fast						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	5 min	5 min	5 min	5 min	5 min	5 min
IPCA	No impact	5 min	5 min	No impact	No impact	No impact
PIM	No impact	No impact	No impact	No impact	5 min	5 min
FOMC	5 min	5 min	5 min	5 min	5 min	5 min
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	5 min	5 min	5 min	5 min	5 min	5 min
Panel B: How long						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	10 min	10 min	5 min	5 min	20 min	20 min
IPCA	No impact	10 min	5 min	No impact	No impact	No impact
PIM	No impact	No impact	No impact	No impact	5 min	5 min
FOMC	5 min	5 min	20 min	20 min	20 min	20 min
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	5 min	5 min	5 min	5 min	20 min	20 min
Panel C: How much						
Reported coefficients are expressed in percentage points for a unit shock. A unit shock from COPOM and FOMC is equal to 25 basis points; IPCA and CPI: 0.10 p.p.; PIM: 1.0 p.p.; PR: 100,000 jobs.)						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	-0.128	-0.107	-0.055	-0.071	0.173	0.094
IPCA	No impact	0.041	0.047	No impact	No impact	No impact
PIM	No impact	No impact	No impact	No impact	0.023	0.046
FOMC	0.029	0.029	0.191	0.089	-0.329	-0.313
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	0.032	0.028	-0.045	-0.051	0.151	0.182

Note: All the estimates consider a 5% level of significance. Coefficients were normalized to facilitate interpretation.

are closed, which surely alters the dynamics of information absorption relative to other announcements. In principle, this should increase the immediate impact and obscure potential changes in the level attributed to COPOM, justifying the low persistence observed in the results.

IPCA releases, which anchor COPOM decisions, mattered only in the expansion period, suggesting that the economic interpretation of macroeconomic announcements is ambiguous and depends on the cyclical position of the economy. Remember that our sample starts at the beginning of the 2008's financial crisis. From October 2008 to March 2009, considering that worldwide financial systems experienced severe liquidity shocks, monetary authorities were less concerned about inflation and directed monetary policy instruments mainly towards preserving the functionality of the banking system. Moreover, policymakers expected a future deceleration of inflation indexes due to the colder economy and lower commodity prices. In the expansion period, however, domestic announcements were back on stage, since monetary authority decisions were not bounded by the external scenario. This result thus suggests that the contraction period, not included as a separate subsample only due to the small amount of observations, can generate sufficient noise so as to eliminate the significance of this coefficient.

FX and Ibovespa markets, in turn, react mostly to external indicators. The FX market displays immediate reactions to COPOM, PR, and FOMC surprise components, but only the latter is persistent up to 20 minutes. The results for the Ibovespa market reveal that it is the futures market that exhibits the most widespread reaction to announcements in terms of persistence as long as the impact of COPOM, FOMC, and PR are significant at the 5% level up to 20 minutes.

By contrast, PIM and CPI have a negligible impact on the futures markets for all announcements and from all perspectives. To some extent, the "no impact" of PIM is counterintuitive, reflecting the erratic behavior of its surprise component. CPI's lack of impact, in turn, has another interpretation and rests on the fact that our sample period covered a period in which U.S. policymakers assigned a relatively low importance to inflation due to the financial crisis.

In addition to identifying the existence of a measurable announcement effect, it is important to clarify the direction of such effects presented in Table 4, Panel C. For the sake of directness and simplicity, we will restrain the quantitative analysis to the most persistent announcements, which are supposedly the most robust ones.[16]

In the IR market, we find an excess return of -0.107 p.p. in response to a 25-basis-points' COPOM surprise and 0.041 p.p. in response to a 0.10 p.p. IPCA surprise. Both impacts are persistent up to 10 minutes in the expansion period.

[16]The negative coefficient of non-farm payrolls on FX returns, which means that good news for the U.S. economy leads to strengthening of BRL, is a counterintuitive effect that does not hold in practice. Note, however, that such impact is short-lived and does not last after 5 minutes of its public release and can be attributed to noise rather than sign.

If the Central Bank underreacts to inflation expectations, medium-term interest rates are expected to rise because the financial market expects inflation figures to rise accordingly, imposing a new monetary contraction cycle to start earlier than previously expected. Until mid-2010, domestic monetary policy experienced a shift in the reaction function while the Central Bank implemented a progressive decline in the prime interest rate, Selic. In this period, the Central Bank was less reactive to current inflation pressures and confident that a deflationary external scenario would bring inflation expectations down, as extensively documented by COPOM minutes and quarterly inflation reports.

There are several ways that underreacting to inflation expectations could negatively affect medium-term yields, as implied by our results. Investors possess long-term bonds and, according to their portfolio composition, are subjected to various degrees of duration risk. Since futures interest rates directly affect bond yields, the longer a bond's duration, the more sensitive its price is to changes in the IR futures market. In such a case that the IR market does not totally agree with the scenario proposed by monetary authorities, rising inflation expectations deteriorates medium- and long-term bond prices, while the opposite happens in terms of yields. Liquidity is another transmission channel that may offer a suitable explanation. In periods characterized by high uncertainty levels, investors usually shift portfolio composition towards short-term bonds. The resulting lower demand for longer-term bonds produces higher interest rates. Also, another potential driving factor is the Brazilian financial market's perception that the worldwide commitment to keep interest rates low in the sample period could induce a low interest rate regime in Brazil, longer than it would be recommended, in view of the domestic inflation figures and expectations.

The same rationale applies to a higher-than-expected IPCA when IR futures rates rise, anticipating a tighter stance of monetary policy by COPOM. Both FOMC and PR surprise component estimates reveal an increase in futures interest rates when subjected to a positive shock, suggesting that a better-than-expected U.S. economy drives interest rates up. But both impacts are short-lived, reinforcing the dominance of domestic factors in the IR market.

By taking into account previous studies (Kohlscheen, 2011, 2012), it is not surprising to find that the FX market is sensitive only to FOMC announcements while the domestic ones showed only transitory or nonexistent impacts, probably due to the important role of foreign investors.[17] In effect, Fratzscher (2011) finds that domestic interest rate changes have no significant effect for explaining capital flow to Latin America, both during the crisis period and afterwards. In both samples, FOMC is the main factor driving returns when a 25-basis-point surprise raises FX returns by 0.191 p.p. and 0.089 p.p. in the full sample and in the

[17] In general, foreign investors account for approximately 15% of the FX traded futures contracts. However, their importance grows substantially when we consider investors' position on the spot market.

expansion period, respectively. So, an unexpected increase in U.S. long-term interest rates appreciates the dollar vis-à-vis the domestic currency (BRL). External announcements are primarily responsible for changing the volume and direction of investment flow to the domestic economy. In this sense, higher interest rates or a better state of the economy takes liquidity away from emerging countries and leads to dollar appreciation, which is consistent with the findings of Andersen et al. (2007) and Faust et al. (2007). If we extrapolate this conclusion to the most recent monetary events, our results show that the announcements related to the tapering of the quantitative easing policy by the Federal Reserve shall appreciate the dollar. That is exactly what Aizenman et al. (2014) found by using a panel framework with daily data between November 2012 and October 2013 for a group of 26 emerging countries.

Following the same line of reasoning,[18] Ibovespa futures are directly and persistently affected by two external announcements: FOMC and PR. A 25-basis-point FOMC surprise impacts stock futures returns by -0.329 p.p. and -0.313 p.p. in the full sample and in the expansion period, respectively. Hence, a monetary policy easing is related to positive returns in Brazil, consistent with Aizenman et al. (2014), who found that FOMC QE announcements were strongly associated with positive stock market returns in countries experiencing current account deficits, including Brazil. Non-farm payroll figures emerge as an important announcement and its surprise component is positively associated with domestic stock index returns. PR is persistent in both periods, when a 100,000-job surprise increases returns in the stock market by 0.151 p.p. and 0.182 in the full sample and expansion period, respectively. This suggests not only that the dividend effect is higher than the cost of capital one, but also that real economy shocks are correlated between the Brazilian and U.S. economies. This contrasts with the results of Boyd et al. (2005), who found that the increase in unemployment is good news for the U.S. stock market in the expansion period. We find support to our results in the study of Elder et al. (2012), who find positive effects of an unexpected improvement of the U.S. economy on copper prices using intraday data from 2002 to 2008, together with the high weight of commodity-related stocks in the composition of Ibovespa.

Finally, a COPOM surprise amounting to 25-basis-point raises Ibovespa futures returns by 0.173 p.p. and 0.094 p.p. in the full sample and expansion period estimates, respectively. This finding is at odds with the available evidence based on daily data (Eid and Gonçalves, 2011, Oliveira and Romaguera, 2013), who found a negative association between monetary surprises and the Brazilian stock market. Our interpretation is that the sensitivity of Ibovespa futures to a domestic monetary shock may be due to more than just the adjustment of the cost of capital: revision of expectations over central bank independence and commitment to policy rules may play an even more important role, assigning a greater impact of

[18] Approximately 50% of the Ibovespa futures contracts belong foreign investors.

monetary decisions to the dividend effect. More importantly, impact is found to be highly persistent up to 20 minutes after market opening. In view of this prolonged effect, compared to the one observed in the IR market, we can conjecture that a COPOM shock primarily affects the IR market and, after its stabilization, it is then transmitted to Ibovespa futures contracts.

5.2 Impact of macroeconomic announcements on trading volume and spreads

Similarly to Bamber and Cheon (1995), we find no straightforward connection between trading volume and returns changes since there are announcements that do not impact returns at all but impact trading volume instead, and vice versa. PIM and CPI, for instance, have an important overall effect on trading volume with no corresponding impact on returns. In the FX and Ibovespa markets, trading volume is affected by all external announcements at the first 5-minute interval. The impact on the IR trading volume, in turn, is dominated by domestic announcements, although CPI and PR also produce changes in terms of trading volume.

From Table 5 (Panel B), it is noteworthy to determine that impacts, when significant, are highly persistent up to 20 minutes after the announcement release. Due to agent heterogeneity, liquidity trading shall occur in stages, with investors trading at different times, leading to an impact on trading volume that is spread over the post-announcement window.

As shown in Table 5 (Panel C), the COPOM surprise component increases the number of traded contracts in the IR market by 3.34 and 3.92 relatively to the hourly average in the full sample and expansion period estimates, respectively. If we deseasonalize the data, the increase in the number of traded contracts amounts to 4,880 and 5,730, respectively. If we refer back to theory, one can associate such remarkable result to COPOM's high information precision and its success in solving agents' uncertainty. One caveat, however, is that FOMC surprises are largely insignificant during the observation period, a counterintuitive finding, when confronted with the importance of FOMC-related news, that deserves further investigation. As far as the FX and Ibovespa markets are concerned, the dominant role is performed by FOMC and PR surprises. In the expansion estimates, FOMC raises FX and stock trading volumes by 1.88 and 2.43 times relatively to the hourly average, respectively, while the PR impact is in the same order of magnitude. Besides market microstructure considerations, the superior informational quality of the dominant announcements can also stimulate trading.

From Table 6 (Panel A), we can see that spreads are affected mainly by domestic announcements where impact is immediate in the vast majority of situations. Taking trading volume as a proxy for liquidity, the association between liquidity and spreads is not confirmed, as the increase in spreads is not accompanied by a reduction in trading volume.

Table 5
Impact of macroeconomic announcements on the trading volume of each futures market

The table shows the impact of announcements on trading volume and is divided into three panels according to the measures of interest (how fast, how long, and how much) mentioned in Section 4. Panel A reports the first interval where the aggregate effect is significant. Panel B shows the persistence indicator or "how long," which refers to the last interval where the aggregate effect is significant. Finally, the point estimate of the last significant aggregate effect is a direct measure of intensity of Panel C. Trading volume refers to the sum of the number of traded contracts at each 5-minute interval. The database covers the period from October 2008 to January 2011 for the six announcements listed in Table 3.

Panel A: How fast						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	5 min	5 min	5 min	5 min	5 min	5 min
IPCA	5 min	5 min	No impact	No impact	5 min	5 min
PIM	5 min	5 min	5 min	5 min	No impact	No impact
FOMC	No impact	No impact	5 min	5 min	5 min	5 min
CPI	5 min	5 min	5 min	5 min	5 min	5 min
PR	5 min	5 min	5 min	5 min	5 min	5 min
Panel B: How long						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	20 min	20 min	20 min	20 min	5 min	5 min
IPCA	20 min	20 min	No impact	No impact	5 min	5 min
PIM	20 min	20 min	20 min	20 min	No impact	No impact
FOMC	No impact	No impact	20 min	20 min	20 min	20 min
CPI	20 min	20 min	15 min	20 min	5 min	5 min
PR	20 min	20 min	20 min	20 min	20 min	20 min
Panel C: How much						
Reported coefficients are expressed considering the seasonal adjustment proposed in Section 4. Thus, the coefficient unit is the hourly average trading volume prevailing at the time of the announcement release.)						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	3.34	3.92	0.95	1.61	0.25	0.38
IPCA	2.05	1.64	No impact	No impact	-0.19	-0.23
PIM	0.99	1.11	1.05	1.39	No impact	No impact
FOMC	No impact	No impact	1.55	1.88	2.25	2.43
CPI	0.17	1.4	0.53	0.66	0.32	0.32
PR	1.27	3.13	2.04	2.13	1.56	1.79

Note: A 5% level of significance is considered in all estimates.

Equally important is the fact that external announcements have little, if any, impact on spreads. We refer to Balduzzi et al. (2001) in order to provide an explanation for this finding. The quick reversion of bid-ask spreads can be attributed to the dominance of informed trading in an initial trading phase. Such view can be reconciled with price impacts, where coefficients are only significant at the first interval. The persistence of trading volume beyond spreads' reversion is evidence of a second trading phase where liquidity trading prevails, which supposedly occurs when markets face domestic announcements.

Assuming that spread increases are related to the presence of informed traders, why should this informational advantage be persistent for domestic announcements? It is realistic to infer that external announcements are more difficult to forecast and interpret by domestic traders, reducing the proportion of informed traders in relative terms. In the full sample, COPOM, IPCA, and PIM raise IR market spreads by 0.61, 1.19, and 1.21 times.[19] In the FX and Ibovespa markets, estimates share the same signs and orders of magnitude.

By additionally analyzing goodness of fit through its R2 levels (see Tables 12 and 13 in the Appendix), we conclude that macroeconomic announcements are economically important in explaining both trading volume and spreads.

5.3 Robustness to changes in the monetary surprise

We proceed by outlining that the use of longer-term bonds as a proxy for the monetary surprise is justified by the fact that FOMC releases reveal more than the prime rate and give hints on the future decision, impacting the term structure of interest rates, even at the zero bound. However, this is far from obvious, since using daily changes in longer-term bonds implies additional assumptions concerning time-varying risk premia and additional factors driving rates other than the FOMC announcements. The best way to assess robustness is by changing the baseline contract and to analyze changes in the results.

Our reference scenario bases its monetary surprise upon a long-term treasury bond, with 10 years to maturity. If, instead, we take a medium-term contract, for instance, 2 years to maturity, there are no changes in the impact signs and only one change in our persistence indicator: the impact of a 25-basis-point FOMC surprise in the FX market, in the expansion period, is faster (15 minutes as opposed to 20 minutes). If we change the contract to a shorter one, with 1 year to maturity, the impact of an FOMC surprise on the Ibovespa market vanishes in the expansion period. We can state that the use of a shorter-term contract implies a lesser impact on Brazilian futures markets. In contrast, when we use a longer maturity contract in the domestic surprise calculus, a 1-year SWAP contract, COPOM surprises display higher point estimate reactions when returns are taken as the dependent variable. In the expansion period, for instance, stock markets are positively related to a 25-basis-point COPOM monetary surprise, raising

[19] Again, relative to the hourly average spread.

Table 6
Impact of macroeconomic announcements on the spread of each futures market

The table shows the impact of announcements on spread and is divided into three panels according to the measures of interest (how fast, how long, and how much) mentioned in Section 4. Panel A reports the first interval where the aggregate effect is significant. Panel B shows the persistence indicator or "how long," which refers to the last interval where the aggregate effect is significant. Finally, the point estimate of the last significant aggregate effect is a direct measure of intensity of Panel C. Spreads are derived as the relative difference between bid and ask values ((ask-bid)/bid) and are measured in percentage points (p.p.). The database covers the period from October 2008 to January 2011 for the six announcements listed in Table 3.

Panel A: How fast						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	5 min	5 min	5 min	5 min	5 min	20 min
IPCA	5 min	5 min	5 min	5 min	5 min	5 min
PIM	5 min	5 min	5 min	5 min	5 min	5 min
FOMC	5 min	10 min	5 min	5 min	No impact	No impact
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	5 min	5 min	5 min	5 min	5 min	No impact
Panel B: How long						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	20 min	No impact	20 min	20 min	20 min	20 min
IPCA	20 min	20 min	20 min	20 min	20 min	20 min
PIM	20 min	20 min	20 min	20 min	20 min	20 min
FOMC	20 min	10 min	20 min	20 min	No impact	No impact
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	20 min	20 min	20 min	20 min	5 min	No impact
Panel C: How much Excess returns are expressed in percentage points. Reported coefficients are adjusted to the fact that volume is expressed in logarithms and the explanatory variable is a dummy.)						
	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
COPOM	0.61	No impact	1.77	0.58	2.29	0.86
IPCA	1.19	1.14	2.00	1.93	0.95	0.63
PIM	1.21	1.30	1.76	1.76	0.19	0.86
FOMC	0.54	0.13	0.31	0.36	No impact	No impact
CPI	No impact	No impact	No impact	No impact	No impact	No impact
PR	0.41	0.43	0.39	0.44	0.31	No impact

Note: A 5% level of significance is considered in all estimates.

returns by 0.25%. In general, it is thus fair to say that the use of longer maturities amplifies the impact of the monetary surprise.

In terms of volume, the change in the definition of monetary surprises does not alter the results. Apart from minor changes in the intensity coefficients, COPOM's and FOMC's influence on trading volume is more pronounced in the IR and Ibovespa markets, respectively. COPOM preserves its impact on spreads in all markets, while the use of a shorter-term contract does not change the fact that FOMC has no impact on the IR market trading volume.

5.4 Application: Out-of-sample performance based on an announcement timing strategy

To provide a sense of the practical application of the returns model, we describe an approach for measuring the potential gains associated with the methodology described in Section 4. The interpretation of the impact of returns for each announcement provides the tools to devise a simple strategy where one takes a portfolio position immediately after the announcement is released, i.e., as soon as its surprise is known. In this framework, investors take a long or short position depending on the combination between sign impact and surprise direction, as shown in the table below.

We restrain our analysis to the expansion period as we believe markets were better behaved away from the extreme events of the last quarter of 2008 and the first quarter of 2009, leading to more stable and structural estimates. We separate 80% of the observations for the in-sample estimates, shown in the table below, and the remaining 20% for the out-of-sample exercise. We also focus only on persistent announcements, i.e., those with significant aggregate coefficients up to 20 minutes after their release. The exceptions to the persistence rule are the estimated impacts of COPOM and IPCA on the IR market, whose aggregation window has been reduced to 10 minutes providing that such announcements are publicly available while markets are closed, leading to differential informational absorption as shown in Table 4.

The results in Table 7 generate the following high-frequency trading strategy, as shown in Table 8. In order to take advantage of the information contained in macroeconomic announcements, investors should trade immediately after identifying the surprise component. Note that the investment holding period varies according to the previous persistence definition (10 minutes for investments in the IR market after COPOM and IPCA announcements and 20 minutes for the remaining ones).

Table 7
In-sample estimates of persistent impact based on regression results for each market and announcement in the expansion period

This table shows the intensity coefficient for models (2) and (3) when the returns are the dependent variable and the sample is limited to the expansion period, i.e., from April 2009 to September 2010. The intensity (or "How much") coefficient is measured by the point estimate of the last significant aggregate effect in (4). Reported coefficients are expressed in percentage points for a unit shock. A unit shock from COPOM and FOMC: 25 basis points; IPCA and CPI: 0.10 p.p.; PIM: 1.0 p.p.; PR: 100,000 jobs.

	IR	FX	Ibovespa
COPOM	-0.078	No impact	0.059
IPCA	0.033	No impact	No impact
PIM	No impact	No impact	No impact
FOMC	No impact	0.149	-0.224
CPI	No impact	No impact	No position
PR	No impact	No impact	0.042

Table 8
Summary of the announcement timing strategy based on regression results

	IR	FX	Ibovespa
COPOM	Sell, if surprise is positive. Buy, otherwise.	No position	Buy, if surprise is positive. Sell, otherwise.
IPCA	Buy, if surprise is positive. Sell, otherwise.	No position	No position
PIM	No position	No position	No position
FOMC	No position	Buy, if surprise is positive. Sell, otherwise	Sell, if surprise is positive. Buy, otherwise.
CPI	No position	No position	No position
PR	No position	No position	Buy, if surprise is positive. Sell, otherwise

The above strategy will be tested in 23 announcement releases from October 2010 to January 2011, a 4-month period. Transaction costs, including registration and exchange fees, are taken directly from BVMF,[20] which offers special conditions for investors registered as high-frequency traders. A pricing model of differentiated and decreasing fees based on the volume executed by investors is used. Our results can be labeled conservative since the worst-case scenario will be applied, that is, the one with the highest proportional fees compatible with small high-frequency investments. It is implied that prices are exogenous and the strategy will not interfere in market equilibrium. In practical terms, if we impose a threshold of approximately 0.25% of the average 5-minute trading volume to define small investors, this would result in the following initial investments: $ 500,000 in the FX market; BRL 500,000 in the IR market; and BRL 100,000 in the Ibovespa market.

In Table 9, it is clear that the consolidated results are positive for all announcements. It turns out that 16 out of 23 recommended positions generate positive returns, resulting in a 70% success rate, an encouraging outcome. However, performance across announcements is not homogenous. While all FOMC-related positions matched the anticipated market directions for all markets, COPOM's influence on the stock market shows the lowest success rate, with 1 positive return out of 3. In terms of markets, FX has the highest success rate (100.0%), followed by IR (66.7%) and Ibovespa (58.8%).

Table 9
Results of the strategies based on regression results, in nominal terms and in percentage points

This table shows the ex-post profit/loss of a portfolio constructed according to the announcement timing strategy of Table 8 and the following initial investments: $ 500,000 in the FX market; BRL 500,000 in the IR market; and BRL 100,000 in the Ibovespa market. Results are organized in terms of announcements and consolidated by each futures market. The sample covers the expansion period from April 2009 to January 2011.

	IR (in BRL)	FX (in BRL)	Ibovespa (in BRL)
COPOM	BRL 614.01		-BRL 253.98
IPCA	BRL 7.50		
PIM			
FOMC		BRL 1441.80	BRL 331.58
CPI			
PR			BRL 160.75
Total	BRL 621.51	BRL 1441.80	BRL 238.34
Excess return as a percentage of initial investment	0.12%	0.29%	0.24%

[20] http://www.bmfbovespa.com.br/shared/iframe.aspx?altura=3200&idioma=pt-br&url=www.bmf.com.br/bmfbovespa/pages/boletim1/bd_manual/programa-de-incentivo-para-HFT.asp

6. Conclusion

This paper explores the role of macroeconomic announcements in the Brazilian futures market in order to assess the link between economic fundamentals and asset pricing. Although it has been the subject of many empirical studies, the issue is far from resolved. The main issue is that returns are affected by a number of factors that are not easily identifiable at low frequency. Intraday data allowed us to separate the effect of announcements properly and we are able to find robust evidence of this impact in specific announcements and states of the economy.

This study contributes to the literature on the impact of macroeconomic announcements on emerging markets. By testing six announcements between October 2008 and January 2011, we find that external monetary policy (FOMC) is not only the main factor driving returns in the FX market, but also the single persistent one, where a 25-basis-point surprise raises FX returns by 0.191 p.p. and 0.089 p.p. in the full sample and expansion period, respectively, 20 minutes after its release. A more widespread reaction to macroeconomic announcements is observed in the Ibovespa futures market. A negative association between FOMC surprises and stock returns has been identified implying that U.S. monetary policy easing is related to positive stock returns in Brazil. In contrast, non-farm payroll records are positively associated with domestic stock index returns suggesting that the dividend effect is higher than the cost of capital one and also that real economy shocks are correlated between the Brazilian and U.S. economies. In the IR market, we find a negative correlation between COPOM surprises and returns that can be credited to the misalignment between financial market and central bank expectations about inflation during the sample period. IPCA surprises, exactly as anticipated by theory, are positively related to futures interest rates.

We also offer a practical application of the study by constructing an announcement timing investment strategy where investors take a long or short position depending on the combination between sign impact and surprise direction. This approach enables us to directly assess the potential gains associated with our methodological framework. As a matter of fact, it showed promising results in an out-of-sample study as we are able to correctly anticipate the direction of the returns, conditional on the sign of surprises, in 70% of the cases. State dependence is found to be a potential factor driving market returns by changing the magnitude of the coefficients that measure the impact of announcements, occasionally eliminating predicted impacts as implied by the non-significance of estimates for the IPCA announcement in the full sample, which is in contrast to the persistent results in the expansion period.

Overall, our results point to large differences in the relative weight of domestic and external announcements. In Andersen et al. (2007), for instance, domestic events (in this case, taking the USA as domestic country) play a central role in asset pricing. In our study, domestic dominance is restricted to the IR market while external announcements govern price changes in the FX and Ibovespa futures

markets.

Similarly, we contribute to the literature by finding that announcements are followed by greater trading volume, suggesting that uncertainty resolution triggers transactions in all markets irrespective of the business cycle. More importantly, contrary to price reaction, the effect on trading volume is widespread, showing that the absence of price reaction is not a sufficient condition to overrule the announcement importance. We also document large differences in the relative magnitude of trading volume reactions, attributing it to differential levels of informational content between announcements. We finally find that bid-ask spreads often quickly revert when external announcements are released which, from a microstructure viewpoint, can indicate the prevalence of different kinds of investors and trading phases.

Finally, we show that the impact of IPCA announcements on the IR market returns varies according to the sample period. In contrast to the full sample results, point estimates are significant when the database is restricted to the expansion cycle. In this regard, both theoretical work (Blanchard, 1981, Veronesi, 1999) and empirical work (Andersen et al., 2007) showed that asset price response to news is state-dependent, suggesting that the context may define the way financial markets process information.

Due to data availability, though, state dependence could not be properly assessed. Further research can shed some light on this issue as long as one is able to split subsamples according to the economic cycle and eventually check if markets react differently to whether a business cycle change is domestically-driven or externally-driven. There are other open questions that can guide future research. In particular, the investigation of correlation across markets could indicate common factors that make them move together. The impact on volatility is another important issue that comes up naturally.

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Appendix

Table 10
Regression results for returns

The table shows WLS estimation results for models (2) and (3), one for each futures market and sample period, where variable X refers to returns. Point estimates and standard deviations are reported, the latter one in brackets. Surprises are normalized according to (1). Note: Significance levels: * 90%;** 95%;*** 99%.

	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
IR	-0.04600	-0.07780**	0.02340	0.02570	-0.07900**	0.00013
Return (t-1)	(0.02860)	(0.03240)	(0.02170)	(0.02210)	(0.03140)	(0.03880)
FX	-0.01080	-0.01340	0.02220	0.01120	-0.07940**	0.23000**
Return (t-1)	(0.01590)	(0.01890)	(0.02860)	(0.03010)	(0.03350)	(0.04720)
Ibovespa	-0.00842	-0.00108	-0.00025	-0.01910	-0.01850	0.05610
Return (t-1)	(0.00950)	(0.01280)	(0.01380)	(0.01620)	(0.02860)	(0.03800)
COPOM	-0.00055***	-0.00053***	-0.00024***	-0.00031***	0.00067***	0.00061***
surprise (t)	(0.00018)	(0.00018)	(0.0009)	(0.00008)	(0.00015)	(0.00015)
COPOM	-0.00001	0.00006	0.00023**	0.00032***	-0.00037*	-0.00014
surprise (t-1)	(0.00018)	(0.00018)	(0.00011)	(0.00009)	(0.00019)	(0.00018)
COPOM	0.00002	0.00004	-0.00007	0.00001	0.00011	-0.00005
surprise (t-2)	(0.00020)	(0.00019)	(0.00014)	(0.00009)	(0.00020)	(0.00018)
COPOM	0.00009	0.00027	-0.00028**	-0.00015*	0.00035	0.00057***
surprise (t-3)	(0.00023)	(0.00022)	(0.00014)	(0.00009)	(0.00023)	(0.00019)
IPCA	0.00017	0.00044***	0.00033**	0.00015	-0.00018	0.00020
surprise (t)	(0.00014)	(0.00014)	(0.00013)	(0.00012)	(0.00018)	(0.00025)
IPCA	0.00001	-0.00016	-0.00018	-0.00006	-0.00010	-0.00001
surprise (t-1)	(0.00018)	(0.00017)	(0.00017)	(0.00012)	(0.00023)	(0.00025)
IPCA	0.00025	0.00017	-0.00009	-0.00014	0.00016	0.00027
surprise (t-2)	(0.00019)	(0.00016)	(0.00017)	(0.00012)	(0.00021)	(0.00022)
IPCA	-0.00017	-0.00014	0.00021	0.00014	-0.00017*	-0.00006
surprise (t-3)	(0.00018)	(0.00016)	(0.00017)	(0.00011)	(0.00023)	(0.00023)
PIM	-0.00014	-0.00014	0.00008	0.00014	0.00017	0.00034***
surprise (t)	(0.00011)	(0.00010)	(0.00011)	(0.00009)	(0.00010)	(0.00012)
PIM	0.00011	-0.00013	-0.00012	-0.00002	-0.00017	-0.00024*
surprise (t-1)	(0.00014)	(0.00014)	(0.00012)	(0.00009)	(0.00011)	(0.00015)
PIM	0.00002	-0.00001	0.00004	0.00002	-0.00011	-0.00002
surprise (t-2)	(0.00017)	(0.00015)	(0.00012)	(0.00009)	(0.00013)	(0.00013)
PIM	-0.00006	-0.00007	-0.00009	-0.00008	0.00017	0.00022*
surprise (t-3)	(0.00015)	(0.00013)	(0.00011)	(0.00009)	(0.00012)	(0.00012)
FOMC	0.00017*	0.00018*	0.00079***	0.00061***	-0.00084***	-0.00050***
surprise (t)	(0.00009)	(0.00009)	(0.00012)	(0.00010)	(0.00018)	(0.00019)
FOMC	0.00005	-0.00003	0.00028	0.00030***	-0.00074**	-0.00125***
surprise (t-1)	(0.00011)	(0.00009)	(0.00020)	(0.00011)	(0.00030)	(0.00015)
FOMC	-0.00014	-0.00021**	0.00001	0.00001	-0.00017	0.00006
surprise (t-2)	(0.00013)	(0.00010)	(0.00019)	(0.00012)	(0.00034)	(0.00021)
FOMC	0.00002	-0.00003	0.00007	-0.00008	-0.00022	-0.00018
surprise (t-3)	(0.00013)	(0.00009)	(0.00020)	(0.00013)	(0.00034)	(0.00021)
CPI	-0.00004	-0.00002	0.00007	0.00001	-0.00007	0.00003
surprise (t)	(0.00008)	(0.00013)	(0.00010)	(0.00013)	(0.00016)	(0.00022)
CPI	-0.00015	-0.00024*	0.00001	-0.00004	0.00028*	0.00040***
surprise (t-1)	(0.00009)	(0.00014)	(0.00011)	(0.00012)	(0.00015)	(0.00020)
CPI	0.00011	-0.00007	0.00017*	0.00035***	-0.00035**	-0.00016
surprise (t-2)	(0.00010)	(0.00014)	(0.00009)	(0.00012)	(0.00016)	(0.00021)
CPI	0.00007	0.00006	-0.00006	-0.00001	0.00008	0.00003
surprise (t-3)	(0.00009)	(0.00012)	(0.00010)	(0.00010)	(0.00015)	(0.00019)
PR	0.00030***	0.00027**	-0.00042***	-0.00048***	0.00096***	0.00118***
surprise (t)	(0.00013)	(0.00012)	(0.00016)	(0.00014)	(0.00032)	(0.00033)
PR	-0.00010	-0.00013	0.00043*	0.00047**	0.00008	0.00020
surprise (t-1)	(0.00015)	(0.00013)	(0.00022)	(0.00019)	(0.00038)	(0.00041)
PR	0.00006	0.00004	0.00005	0.00004	-0.00001	-0.00001
surprise (t-2)	(0.00014)	(0.00014)	(0.00022)	(0.00019)	(0.00038)	(0.00042)
PR	-0.00013	-0.00011	0.00007	0.00011	0.00039	0.00035
surprise (t-3)	(0.00014)	(0.00013)	(0.00023)	(0.00020)	(0.00037)	(0.00039)
Observations	2,482	1,788	2,482	1,788	2,482	1,788
R-squared	0.015	0.030	0.037	0.060	0.038	0.080

Table 11
Regression results for returns

The table shows WLS estimation results for models (2) and (3), one for each futures market and sample period, where variable X refers to trading volume. Point estimates and standard deviations are reported, the latter one in brackets. Surprises are normalized according to (1). Note: Significance levels: * 90%;** 95%;*** 99%.

	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
IR	0.104***	0.106***	0.007	0.012	0.008	0.014
Volume (t-1)	(0.022)	(0.026)	(0.013)	(0.016)	(0.009)	(0.011)
FX	-0.025	0.003	0.236***	0.225***	0.015	0.021
Volume (t-1)	(0.030)	(0.033)	(0.025)	(0.029)	(0.014)	(0.016)
Ibovespa	0.036	0.030	0.011	0.017	0.278***	0.279***
Volume (t-1)	(0.042)	(0.045)	(0.028)	(0.031)	(0.022)	(0.025)
COPOM	1.137***	1.268***	0.463**	0.784***	0.249**	0.384***
dummy (t)	(0.245)	(0.278)	(0.199)	(0.236)	(0.125)	(0.151)
COPOM	0.909***	0.816***	0.034	0.126	0.025	-0.069
dummy (t-1)	(0.247)	(0.282)	(0.190)	(0.233)	(0.125)	(0.153)
COPOM	0.955***	1.477***	0.156	0.358	-0.019	-0.103
dummy (t-2)	(0.246)	(0.284)	(0.179)	(0.222)	(0.123)	(0.149)
COPOM	0.343	0.361	0.298	0.340	0.005	0.086
dummy (t-3)	(0.243)	(0.279)	(0.189)	(0.231)	(0.125)	(0.154)
IPCA	0.881***	1.086***	0.116	0.197	-0.191*	-0.228*
dummy (t)	(0.237)	(0.255)	(0.166)	(0.183)	(0.101)	(0.115)
IPCA	0.246	0.176	0.247	0.140	0.213**	0.196*
dummy (t-1)	(0.247)	(0.269)	(0.153)	(0.171)	(0.104)	(0.118)
IPCA	0.404	0.135	-0.077	-0.041	-0.250**	-0.215*
dummy (t-2)	(0.231)	(0.245)	(0.153)	(0.173)	(0.100)	(0.113)
IPCA	0.518	0.246	-0.188	-0.241	-0.038	-0.054
dummy (t-3)	(0.227)	(0.237)	(0.157)	(0.177)	(0.099)	(0.114)
PIM	0.407*	0.533**	0.615***	0.869***	-0.020	0.006
dummy (t)	(0.224)	(0.244)	(0.160)	(0.185)	(0.096)	(0.111)
PIM	0.142	0.096	0.113	0.076	0.055	0.052
dummy (t-1)	(0.228)	(0.250)	(0.162)	(0.192)	(0.095)	(0.110)
PIM	0.283	0.262	0.169	0.157	-0.106	-0.188*
dummy (t-2)	(0.218)	(0.234)	(0.149)	(0.169)	(0.095)	(0.109)
PIM	0.154	0.224	0.175	0.289*	-0.042	-0.095
dummy (t-3)	(0.215)	(0.230)	(0.151)	(0.174)	(0.093)	(0.105)
FOMC	-0.254	-0.178	0.584***	0.717***	0.767***	0.980***
dummy (t)	(0.267)	(0.293)	(0.169)	(0.183)	(0.134)	(0.155)
FOMC	0.459*	0.489*	0.478***	0.568***	0.778***	0.746***
dummy (t-1)	(0.259)	(0.282)	(0.171)	(0.187)	(0.141)	(0.162)
FOMC	-0.136	-0.098	0.181	0.240	0.234*	0.249*
dummy (t-2)	(0.264)	(0.287)	(0.161)	(0.175)	(0.132)	(0.151)
FOMC	0.099	0.104	0.305*	0.359**	0.466***	0.454***
dummy (t-3)	(0.262)	(0.285)	(0.165)	(0.180)	(0.131)	(0.150)
CPI	0.582**	0.744***	0.633***	0.732***	0.324***	0.321***
dummy (t)	(0.238)	(0.257)	(0.125)	(0.145)	(0.099)	(0.113)
CPI	0.407*	0.357	-0.00175	0.062	-0.065	-0.093
dummy (t-1)	(0.239)	(0.258)	(0.131)	(0.151)	(0.098)	(0.114)
CPI	0.069	0.127	-0.0979	-0.072	-0.190**	-0.220**
dummy (t-2)	(0.229)	(0.250)	(0.123)	(0.146)	(0.095)	(0.112)
CPI	0.217	0.167	-0.0952	-0.061	-0.055	-0.028
dummy (t-3)	(0.223)	(0.247)	(0.123)	(0.146)	(0.093)	(0.109)
PR	2.082***	2.468***	1.729***	1.688***	1.406***	1.619***
dummy (t)	(0.238)	(0.259)	(0.132)	(0.152)	(0.096)	(0.109)
PR	0.731***	1.011***	-0.0292	0.022	0.147	0.132
dummy (t-1)	(0.269)	(0.303)	(0.146)	(0.172)	(0.111)	(0.126)
PR	0.229	-0.094	0.177	0.203	0.003	0.039
dummy (t-2)	(0.237)	(0.258)	(0.129)	(0.149)	(0.098)	(0.112)
PR	-0.123	-0.256	0.164	0.214	0.001	0.002
dummy (t-3)	(0.222)	(0.235)	(0.135)	(0.155)	(0.099)	(0.111)
Observations	2,482	1,788	2,482	1,788	2,482	1,788
R-squared	0.081	0.112	0.132	0.143	0.184	0.213

Table 12
Regression results for spreads

The table shows WLS estimation results for models (2) and (3), one for each futures market and sample period, where variable X refers to the bid-ask spread. Point estimates and standard deviations are reported, the latter one in brackets. Surprises are normalized according to (1). Note: Significance levels: * 90%;** 95%;*** 99%.

	IR		FX		Ibovespa	
	Full sample	Expansion period	Full sample	Expansion period	Full sample	Expansion period
IR	0.08450***	0.06290*	0.02370	0.02610	-0.04220	-0.01230
Spread (t-1)	(0.02740)	(0.03130)	(0.02450)	(0.02110)	(0.03440)	(0.03360)
FX	0.01100	0.06690***	0.05310*	0.05360*	-0.03600	-0.04190
Spread (t-1)	(0.01730)	(0.02470)	(0.02940)	(0.03090)	(0.02790)	(0.03240)
Ibovespa	0.01790	0.03060	0.03930**	0.04020**	-0.00315	0.00968
Spread (t-1)	(0.01310)	(0.01900)	(0.01550)	(0.01580)	(0.02720)	(0.03150)
COPOM	0.63300***	0.19700	1.76400***	0.62900***	1.58900***	0.40900
dummy (t)	(0.13200)	(0.20200)	(0.14700)	(0.16100)	(0.20100)	(0.25800)
COPOM	-0.08070	-0.19500	-0.09340	-0.06530	0.19800	0.13500
dummy (t-1)	(0.12800)	(0.16200)	(0.17800)	(0.17700)	(0.19700)	(0.20400)
COPOM	-0.00751	0.03480	0.00686	-0.10200	0.32500*	0.11300
dummy (t-2)	(0.11000)	(0.14400)	(0.17300)	(0.18800)	(0.18900)	(0.18100)
COPOM	0.06530	0.10100	0.09650	0.11500	0.17900	0.20000
dummy (t-3)	(0.10200)	(0.12500)	(0.13300)	(0.13200)	(0.15800)	(0.15500)
IPCA	0.71000***	0.66300***	1.88300***	1.74000***	0.88200***	0.44600***
dummy (t)	(0.10800)	(0.12000)	(0.13200)	(0.11300)	(0.19000)	(0.17300)
IPCA	0.39700***	0.31900**	-0.02620	-0.02020	0.06450	0.05930
dummy (t-1)	(0.12000)	(0.13300)	(0.15500)	(0.13100)	(0.18500)	(0.16500)
IPCA	0.07000	0.11000	0.15100	0.14400	-0.11300*	-0.08000
dummy (t-2)	(0.10900)	(0.12900)	(0.14700)	(0.13200)	(0.17700)	(0.15500)
IPCA	0.01160	0.05250	-0.00654	0.06700	0.11200	0.20400
dummy (t-3)	(0.09490)	(0.11200)	(0.12800)	(0.11400)	(0.15100)	(0.14100)
PIM	0.95300***	1.05400***	1.72000***	1.75700***	0.77500***	0.50100***
dummy (t)	(0.10600)	(0.11800)	(0.11900)	(0.10200)	(0.14100)	(0.13500)
PIM	0.08360	0.05040	-0.05240	-0.03260	0.34000**	0.35400**
dummy (t-1)	(0.10700)	(0.12900)	(0.13200)	(0.11600)	(0.15400)	(0.15000)
PIM	0.07680	0.11800	0.05990	0.04830	0.07340	-0.03250
dummy (t-2)	(0.09040)	(0.10400)	(0.11300)	(0.09800)	(0.14200)	(0.13100)
PIM	0.09970	0.08130	0.03070	-0.01120	0.00371	0.04160
dummy (t-3)	(0.08620)	(0.09810)	(0.09680)	(0.08440)	(0.12300)	(0.11400)
FOMC	0.24200**	0.13000	0.21200**	0.22100***	-0.03200	-0.05690
dummy (t)	(0.10900)	(0.12400)	(0.08580)	(0.06710)	(0.10700)	(0.09900)
FOMC	0.27400**	0.25100**	0.13800	0.14500**	-0.08470	-0.09670
dummy (t-1)	(0.10700)	(0.11700)	(0.09010)	(0.07230)	(0.10700)	(0.09760)
FOMC	-0.02500	-0.01940	-0.01280	0.00302	-0.16900*	-0.20500**
dummy (t-2)	(0.09810)	(0.10600)	(0.07730)	(0.05910)	(0.09360)	(0.08440)
FOMC	0.04680	-0.05160	-0.02460	-0.00982	0.03740	0.05260
dummy (t-3)	(0.09330)	(0.10300)	(0.07170)	(0.05430)	(0.09190)	(0.08140)
CPI	0.14000	0.08700	0.09120	0.06670	0.03610	0.01010
dummy (t)	(0.08780)	(0.10400)	(0.07540)	(0.06690)	(0.12500)	(0.11700)
CPI	-0.03710	-0.06810	-0.00304	0.05590	0.05160	0.03830
dummy (t-1)	(0.08520)	(0.10000)	(0.07800)	(0.06950)	(0.11700)	(0.10700)
CPI	0.02010	0.00590	0.00623	0.04640	0.13500	0.13400
dummy (t-2)	(0.07530)	(0.09020)	(0.06880)	(0.06300)	(0.10500)	(0.09960)
CPI	0.04290	0.04080	-0.02440	0.01630	0.08900	0.07660
dummy (t-3)	(0.07580)	(0.09070)	(0.06520)	(0.05880)	(0.10500)	(0.09990)
PR	0.41000***	0.45400***	0.22200**	0.25800***	0.31400**	0.11400
dummy (t)	(0.09050)	(0.10200)	(0.10200)	(0.08530)	(0.13500)	(0.12500)
PR	-0.03450	-0.03120	0.06350	0.07880	-0.00728	0.00512
dummy (t-1)	(0.08180)	(0.09230)	(0.10400)	(0.08740)	(0.13300)	(0.12000)
PR	-0.00839	0.03300	0.14500	0.11700	0.07540	0.02680
dummy (t-2)	(0.08250)	(0.09310)	(0.09270)	(0.07920)	(0.12800)	(0.11200)
PR	0.04120	-0.02780	-0.03950	-0.01050	-0.08650	-0.11200
dummy (t-3)	(0.07880)	(0.08760)	(0.08280)	(0.07070)	(0.12500)	(0.11200)
Observations	2,482	1,788	2,482	1,788	2,482	1,788
R-squared	0.110	0.117	0.245	0.302	0.074	0.034