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# What market (spot or future) reflects news first? An analysis in the frequency domain for Brazilian stock market

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## Abstract

What market (spot or future) reflects news first? This question is investigated with Granger causality and Breitung and Candelon (2006) causality test in the frequency domain for Brazilian stock market. The results differ depending on which index (ETF, exchange traded funds, or the spot index) is used for the spot market. The future market causes the index and ETF (for most of the frequency). But ETF only helps to predict future market for intraday operations in the very short term.

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## 1. Introduction

What stock market reacts to the news first in Brazil: the spot or the future market? This question is receiving a lot of attention in the literature lately. The efficient market hypothesis says that new information must be incorporated in the company value in the same way in all markets. However institutional differences (i.e. transaction costs) can lead to a distinct reaction between markets (Schlusche, 2009).

This paper aims to answer what market reacts to the news first. In this way the methodology used here is the Granger causality and the Breitung and Candelon (2006) causality test in the frequency domain. So, the relation between the spot and future markets is analyzed from the causality point of view regarding Brazilian market.

There are three important points in this paper. First, there are no studies that address the causality between the spot (especially considering ETF, exchange traded funds) and the future markets using the frequency domain apparently. Second, few papers analyze the relation between spot, ETF and future markets[1]. Finally, the Brazilian evidence shows that the behavior between the future and spot index and between the future and ETF is distinct, mainly on the predictive aspect.

The paper is organized in four sections beyond this introduction. The next section provides a review of the literature about the cost-of-carry model and a brief overview of the empirical literature about the causality between the future and spot markets. In section 3 we provide a brief explanation of the methodology used in this paper with focus in the Breitung and Candelon (2006) causality test. Section 4 shows the results for the Brazilian stock market. The last section summarizes the conclusions.

## 2. Cost-of-Carry model and causality empirical literature

The cost-of-carry model is used to price the asset in the future, which is given by the following expression

$$f_{t,l} - s_t = (r_{t,l} - q_{t,l})(l-t) + n_t^* \quad (1),$$

where $f_{t,l}$ is the log of future price index at time *t* with maturity *l*, $s_t$ is the log of spot price index at time t, *r* is the risk free interest rate, *q* is the dividend yield related to the spot price, $(l-t)$ is the time to maturity of future contract and $(r_{t,l} - q_{t,l})(l-t)$ is the cost-of-carry. The $n_t^*$ must be stationary or persistent arbitrage opportunities exist (Tsay, 2010).

Considering the fact that the series $f_{t,l}$ and $s_t$ has unit root, the equation (1) shows that the series are cointegrated after adjusting the interest rate and the dividend yield effects (the cointegrated series is $n_t^*$). Thus, series in first differences ($\Delta f_{t,l} = f_{t,l} - f_{t-1,l}$ and $\Delta s_{t,l} = s_{t,l} - s_{t-1,l}$) tend to be stationary and, therefore, will be used in this form in Breitung e Candelon (2006) test, that will be commented ahead.

A question about the relation between the future and spot markets is which market reflects new information on price first. On the one hand, if you consider that the transaction cost is smaller in the future markets, the price should adjust first in this market. This is a result of the trader's possibility to negotiate obtaining profit from the new information received, incurring in smaller costs. On the other hand, traders with information about individual companies, should trade these determined stocks instead of

[1] Schlusche (2009), Theissen (2012) and Deville et al (2013) are some examples of studies that analyze ETF and future market.

the whole index. Thus, the specific company information must be incorporated to the spot index price first (THEISSEN, 2012).

Several empirical studies have been using linear and nonlinear vector autoregression (VAR), vector error correction (VEC) or related procedures to investigate the spot and future markets dynamics. The empirical researches have produced mixed results: (a) future price tends to impact spot price (Chan, 1992, Abyankar, 1998, Theissen, 2012, and Schlusche, 2009), (b) spot price tends to react before the future price (Subrahmanyam, 1991, Moosa, 1996, and Shyy et al, 1996) and (c) a existence of a bidirectional relation between spot and future prices (Silvapullle and Moosa, 1999, Hasan, 2005, and Chang and Lee, 2008). Thus, this work seeks to contribute (and is useful) specifying the relationship in the frequency domain especially if there is a bidirectional relationship between the future and spot index. The next section provides a detailed explanation about the methodology used in this work.

## 3. Methodology

The methodology used in this study is based on the linear VEC to test the Granger causality between spot and future markets. In order to verify the temporal precedence in accordance with the trading interval considered, the Breitung and Candelon (2006) causality test is done.

The Breitung and Candelon (2006) test allow to distinguish the causality between to low and high frequencies using VAR. Consider the following VAR represented in MA (moving average)

$$z_t = \Phi(L)\varepsilon_t = \Psi(L)\eta_t \quad (2),$$

where $\Psi(L)$ and $\Phi(L)$ are polynomials with lag operator(L), $\eta_t$ the orthogonalized shock, $z_t = [X_t, Y_t]'$, $\varepsilon_t$ the white noise vector, $\Psi(L) = \Phi(L)G^{-1}$ and G the inferior triangle matrix of Cholesky decomposition.

When the series have unit root and are cointegrated (as in our case), we can represent alternatively the VAR like the following way:

$$\Delta z_t = \tilde{\Phi}(L)\varepsilon_t = \tilde{\Psi}(L)\eta_t \quad (3),$$

where $\Delta z_t$ is stationary and the difference between (2) and (3) is $z_{t-1}$, which was subtracted from both sides of the equation (2). The Breitung and Candelon (2006) causality test in the frequency domain in the presence of cointegration would be given by (from Geweke, 1982):

$$M_{X->Y}(\omega) = \log\left[1 + \frac{\left|\tilde{\Psi}_{12}(e^{-i\omega})\right|^2}{\left|\tilde{\Psi}_{11}(e^{-i\omega})\right|^2}\right] \quad (4),$$

if $\left|\tilde{\Psi}_{12}(e^{-i\omega})\right| = 0$, then X doesn't cause Y in $\omega$ frequency.

As for the data considered in the study for the Brazilian stock market, the option was to use the Bovespa index futures mini contract (F). We choose this way because the number of negotiations is higher in this kind of contract comparing to Bovespa index futures. Because of this, we can obtain 1687 intraday data for every 10 minutes of trade to the period from 04/17/2012 until 06/13/2012 of the same contract. The interest rate used in the cost-of-carry model was daily CDI (Interbank Deposit Certificates). The ETF index was multiplied per 1000 to have the same dimension as the future index. The Bovespa index (Ibovespa, S) was used as spot market in the same way as ETF. All the data used in this paper was provided by Bloomberg. The future price index was adjusted

for interest rate and the effects of dividends, denoted by F*. Next we will discuss our results.

## 4. Results

The results focus on linear VEC between spot (Ibovespa and ETF) and future markets, Granger and Breitung and Candelon (2006) causality tests. Table I presents the VEC between the future and spot markets. The speed of adjustment coefficient or error correction term (ECT) is significant only for the equation in the spot market (for ETF and S). This means that only the spot market adjusts to maintain equilibrium. The intuition behind this result is that the future market imposes the information faster than the spot market. In other words, the futures market reflects the impact of news and then the spot market reacts. This suggests that the future market dominates the market pricing.

Table I – Vector error correction

| Cointegration Relation | | | Cointegration Relation | | |
|---|---|---|---|---|---|
| Variables | Dependent variable | | Variables | Dependent variable | |
| | F* | | | F* | |
| S | 1.00 *** | | ETF | 1.00 *** | |
| **Vector error correction** | | | **Vector error correction** | | |
| Variables | Dependent variable | | Variables | Dependent variable | |
| | ΔF* | ΔS | | ΔF* | ΔETF |
| ECT | 0.03 | 0.10 *** | ECT | 0.06 | 0.09 *** |
| $\Delta F^*_{t-1}$ | -0.06 | 0.78 *** | $\Delta F^*_{t-1}$ | -0.33 *** | 0.24 *** |
| $\Delta F^*_{t-2}$ | 0.02 | 0.56 *** | $\Delta F^*_{t-2}$ | 0.02 | 0.32 *** |
| $\Delta F^*_{t-3}$ | 0.01 | 0.38 *** | $\Delta F^*_{t-3}$ | -0.11 | 0.03 |
| $\Delta F^*_{t-4}$ | 0.04 | 0.28 *** | $\Delta F^*_{t-4}$ | -0.11 | -0.10 |
| $\Delta F^*_{t-5}$ | 0.03 | 0.22 *** | $\Delta F^*_{t-5}$ | -0.05 | -0.06 |
| $\Delta F^*_{t-6}$ | -0.07 | 0.17 *** | $\Delta F^*_{t-6}$ | -0.04 | -0.01 |
| $\Delta F^*_{t-7}$ | -0.10 | 0.08 *** | $\Delta F^*_{t-7}$ | -0.21 *** | -0.25 *** |
| $\Delta F^*_{t-8}$ | -0.01 | 0.06 *** | | | |
| $\Delta S_{t-1}$ | -0.02 | -0.60 *** | $\Delta ETF_{t-1}$ | 0.31 *** | -0.27 *** |
| $\Delta S_{t-2}$ | -0.01 | -0.42 *** | $\Delta ETF_{t-2}$ | -0.04 | -0.35 *** |
| $\Delta S_{t-3}$ | -0.02 | -0.32 *** | $\Delta ETF_{t-3}$ | 0.11 | -0.02 |
| $\Delta S_{t-4}$ | -0.05 | -0.22 *** | $\Delta ETF_{t-4}$ | 0.13 | 0.11 |
| $\Delta S_{t-5}$ | -0.03 | -0.18 *** | $\Delta ETF_{t-5}$ | 0.04 | 0.05 |
| $\Delta S_{t-6}$ | 0.11 * | -0.10 *** | $\Delta ETF_{t-6}$ | -0.05 | -0.08 |
| $\Delta S_{t-7}$ | 0.03 | -0.08 *** | $\Delta ETF_{t-7}$ | 0.21 *** | 0.23 *** |
| $\Delta S_{t-8}$ | 0.02 | -0.01 | | | |
| Adjusted $R^2$ | 0.0134 | 0.7484 | Adjusted $R^2$ | 0.0242 | 0.0320 |

Note: *, ** and *** represent, respectively, a statistically significant at 10%, 5% and 1%.

Regarding the short-term dynamics, Bovespa index reacts to almost all eight lags of the variables, while the ETF is less influenced by lags of the variables. The futures market does not react to his past in the case of VEC with Ibovespa, but answers few lags in the VEC with ETF. In general, the effect of future index (in modulus) is greater than the lags of the spot market in the equation of the spot market. As the spot market depends more on the futures market lagged returns than vice versa (especially for the Ibovespa), this indicates that the futures market dominates the process to reflect the information in the price. The next step discusses the causality between the variables.

Table II presents the Granger causality test between the spot (ETF and S) and futures markets. The test shows that the future market Granger cause the Bovespa index, while the Bovespa index does not cause the future market in the Granger sense. Our results follow the empirical finance literature in the causality field, for example Green and Joujon (2000). However when we consider ETF instead of Ibovespa, the null hypothesis of no Granger causality is rejected in both sides. This result means that the causality between ETF and Future Index is bidirectional in this case, which means that one helps to predict the other. There is a pattern change between using Bovespa Index or ETF that should be considered mostly by traders. The futures market clearly dominates the pricing process in the case of the Bovespa index.

Table II – Granger causality test derived from the VEC

| Granger causality test | |
|---|---|
| Null hypothesis | p-value |
| F* doesn't cause S | 0.00 |
| S doesn't cause F* | 0.38 |
| | |
| F* doesn't cause ETF | 0.00 |
| ETF doesn't cause F* | 0.00 |

The Breitung and Candelon (2006) test is based on frequency domain and because of this, allow us to measure the causality in the very short and short term in the intraday market. The causality tests between future and spot market (ETF and S) are presented in the next four figures 1A, 1B, 2A and 2B. In the figures, the thin continuous line shows the critical value of the test at 5% significance level (5.99 for any frequency) and the thick line indicates the test statistic for all frequencies $\omega$ in the range of 0 to $\pi$. The case in which the test statistic is larger than the critical value points out that the null hypothesis of no predictability is rejected.

The figure 1A shows the non-rejection of the null hypothesis of no predictability of the Ibovespa in very short or short-term intraday market by the future index. Figure 1B shows that null hypothesis is rejected, so that future index causes the Ibovespa regardless of the time considered. So far, the results of the causality test in the frequency domain only corroborated the results of the Granger test.

However, the relation between the spot and future markets is different if we consider ETF, instead of Ibovespa, as we are going to show in figures 2A and 2B. The null hypothesis of non predictability of the future market index by ETF is rejected for $\omega \in [1.64, 2.43]$ and $\omega > 2.75$ as we can see in figure 2A. Thus, the ETF helps to predict the future market index with a lag horizon of less than 23 minutes and

approximately 26 to 38 minutes[2]. According to the figure 2B, the index futures market causes ETF for frequencies lower than 1.08, between 1.29 and 2.10 and greater than 2.59. Thus, the futures market would help in predicting the ETF for periods less than 24 minutes, between 30 and 49 minutes and up to 58 minutes. It is noteworthy that in the very short term intraday operations (time intervals of less than 20 minutes), there is bidirectional causality between ETF and index futures, while the Ibovespa is caused by the future regardless of the term. In operations intraday longer term (over one hour), there is unidirectional causality, in which the future index helps to predict ETF and Ibovespa. Such movement for ETF must be associated with evidence of VEC that only ETF responds to deviations from the long run. Thus, if the intention is to predict the future index should use the index ETF and not the Ibovespa. This is the main result of this research. The future index would be predicted up to 40 minutes ahead only by ETF. Overall, the future index dominates the pricing process regardless of the index used for the spot market mainly for longer periods trading.

Figure 1A – Ibovespa causing future index

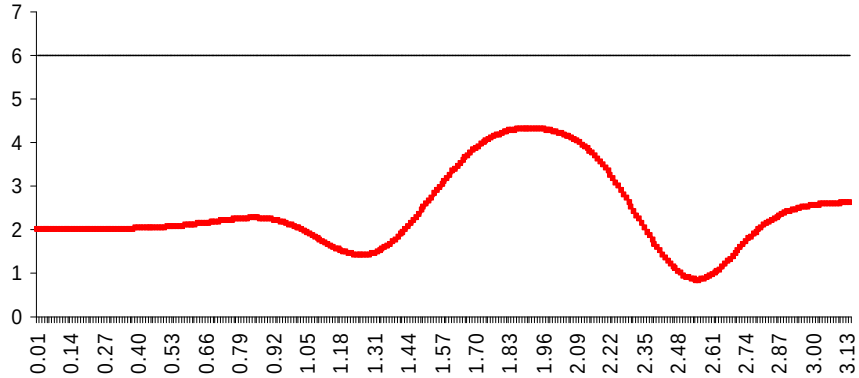
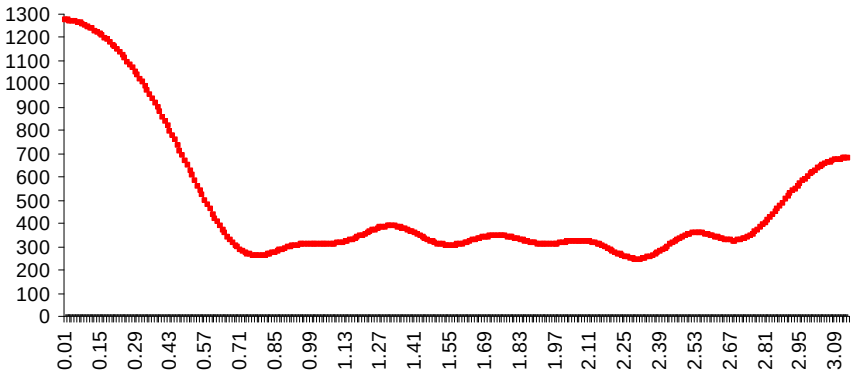



Figure 1B – Future index causing Ibovespa




[2] Consider $\omega$ the frequency, T the number of observations, $\pi$ the number pi and j for the jth frequency. Then, the translation of the frequency in number of periods depends on the variable j. The variable j is obtained from $\omega = \frac{2.\pi.j}{T}$ and then determines the number of periods from T/j (HAMILTON, 1994).

Figure 2A – ETF causing future index

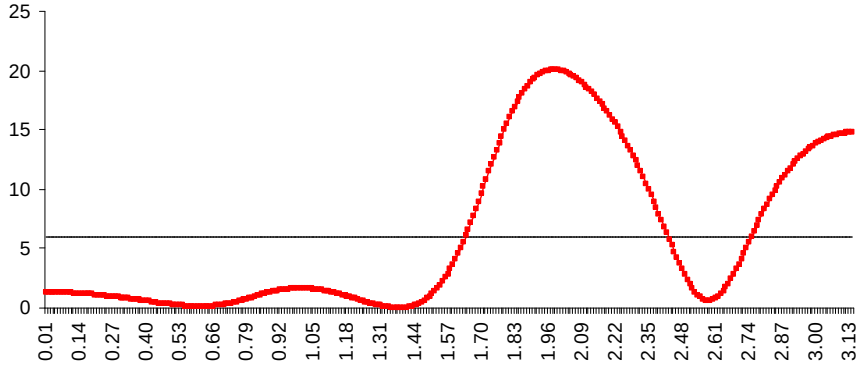
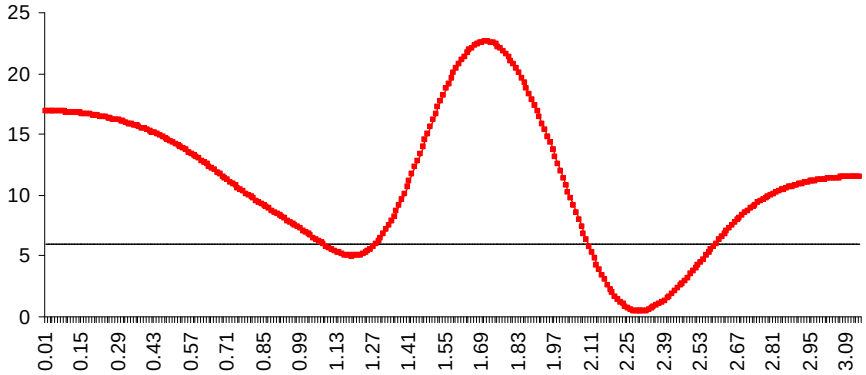



Figure 2B – Future index causing ETF




## 5. Conclusions

This paper discusses what market (spot or futures) reacts first to news in case of Brazilian stock market. The methodology used for this purpose is the Granger causality test and Breitung and Candelon (2006) causality test in the frequency domain. This study differs from most by addressing the spot index and the ETF as the spot market.

The futures market reflects the impact of news and then the spot market (mainly for the Bovespa index) reacts. This suggests that the future market dominates the market pricing process for Brazil.

Evidence for Brazil shows that the relationship between the spot and future markets is different depending on the spot market index (Ibovespa or ETF) used. It is noteworthy that in the very short term intraday operations (within 20 minutes), there is bidirectional causality between ETFs and index futures, while the Bovespa index is caused by the future market regardless of the term. In operations intraday longer term (over one hour), there is unidirectional causality, in which the future index helps to predict the ETF and the Ibovespa. The unidirectional causality between ETFs and index futures only for longer periods should be linked to evidence that only the ETF adjusts to maintain long-term relationship. Thus, if the interest is to predict the future index, ETF should be used (not Ibovespa). This is the main recommendation coming from the study. In turn, the future index would be predicted up to 40 minutes ahead only by ETF.

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