Lead-Lag Analysis of BM&F Bovespa Future and Spot Markets

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Abstract

This paper aims to analyze the Lead-Lag relationship between the future market and the spot market of BM&F Bovespa. The model was based on Brooks, Rew e Ritson (2001). Different from the original model, the estimates were based on GARCH model, because they are financial series, generally heteroscedastics. All necessary study parameters were estimated successfully. The Lead-Lag Model indicated that there is no lead and the Granger indicated unidirectional causality, of the future Market on the spot. The results support the idea of lack of arbitrage opportunity between this two market. About the evidence found that past information in prices affect current prices is an evidence against to the Efficient Markets Hypothesis.

Keywords: Lead-Lag, Efficient Markets Hypothesis, Econometrics.

Introduction

According to Efficient Market Hypothesis (EMH), all available information must be incorporated into asset's pricing. Therefore, all prices should be balanced, without one asset being able to provide information on another asset's future behavior (Fama, 1970). Jensen (1978) postulates that the market is efficient in relation to a give information set and the possible economic gains through employment of this specific set. If a data set is incorporated to an specific group of assets, it would be expected, based on EMH, that this same set be incorporated to all other assets. If an asset systematically incorporates new data faster, there is the Lead-Lag effect. If this effect is large enough to generate large economic gains, it configures a violation to EMH.

The relationship between future and spot markets has been studied in other countries by Brooks, Rew and Ritson (2001), Kawaller, Koch and Koch (1987), Stoll and Whaley (1990), Bhattacharya (1987), Chang (1992), Kang, Lee and Lee (2006) and Pati and Rajib (2010). Focusing on the situation of a company issuing papers in different countries, Matsumoto and Borges (2004) and Medeiros and Lima (2006) found evidence of difference in the brazilian stock prices and their ADRs, without investigating a possible leadership effect, a possibility raised by Oliveira Neto (2010), based on Brennan, Jegadeesh and Swaminatha (1993), Holden and Subrahmanyam (1992) and Foster and Viswanatan (1993), who connected the number of analysts which follow a certain asset and the speed with which information is incorporated to a specific stock set.

Thus, the present study aims to investigate evidences of the Lead-Lag effect on Brazil between spot market, represented by the Bovespa Index, and the future market, represented by Bovespa Future Index, for this relationship is fundamental to theory and for financial reality. A central topic in this theme is how fast new information is incorporated to

asset prices. On the theoretical field, EMH is a set of hypotheses, constituting a core assumption for building price and pricing equilibrium models; on reality, the possibility of some markets incorporating new information faster than others create clear arbitration possibilities between different markets, which surely interests investors.

Literature Review

Researches on Lead-Lag effect do not usually deepen debates on the theme, specially regarding the inefficiency which causes this effect in the first place. Thus, there is no common sense on EMH violation. Efficient Market Hypothesis (EMH), in turn, defines that a market agent can't reach consistently above average returns on a arbitrated asset on all occasions. This hypothesis has as its core the supposition that an asset's price shows the information of its emissing institution, ceasing the possibility of extraordinary economic gains. The asset's price suffers changes in a fast or slow pace, based on the informational content of its market (Fama, 1965).

About the different Lead-Lag types, Oliveira Neto (2010) postulates four conditions which marks these divisions, being: (a) future and spot market relations in the same country; (b) relations between stock markets in different countries; (c) relations among different companies in the same country; and (d) relations between a companies's stock papers in different countries.

Future and spot market relations in the same country

Bhattacharya (1987), Stoll and Whaley (1990), Chang (1992), Kang, Lee and Lee (2006), Brooks, Rew and Ritson (2001) and Kawaller, Koch and Koch (1987) compared the behaviors of a on spot index and the future contract based on the spot index, or between the spot index and its calls. In a perfectly functioning system, with equal contractual relationships, assets and contract prices should be simultaneously set (KANG; LEE; LEE, 2006). However, this does not occur in reality.

On the one hand, Kang, Lee and Lee (2006) worked with *Korean Stock Exchange's* KOSPI 200 index. The authors found that the future and call indexes lead the spot index on 10 minutes regarding returns and 5 minutes regarding volatility, considering the non-synchronic transaction and spread effects between buy and sell orders. On the other hand, Brooks, Rew and Ritson (2001) studied the same effect in the *London Stock Exchange* on the relationship between the spot index and future contracts of the FTSE 100 market index. It has been found that it is possible to foresee the on spot market behavior based on information on the future market, since the latter leads the former.

Building on another index, the S&P 500 (*Standart&Poor's* 500), Koch and Koch (1987) applied a three-stage least squares model with one minute frequency data; however, they did not isolate possible synchrony problems, such as Kang, Lee and Lee (2006). The authors found weak evidence of lead-lag effects between the spot and the future market, but there is an evidence of the future index leadership over the spot index of 20 to 45 minutes. Analyzing the same index, Jong and Nijman (1997) found that the S&P 5000 future index leads the spot market, using as research data minute by minute information. It was again found that information is incorporated by the future market before the spot market, with a 10 minute average delay. On the few times where a reverse leadership was found, delay was of, at most, 2 minutes.

Relations between stock markets in different countries

Collins and Kothari (1989) found that the American market is able to anticipate information on companies in a very significant way. Taking into account the size of the

American economy, its index behavior can be a valuable source of primary information to other countries markets, making a delay a natural occurrence.

Baur and Jung (2006), tested the influences between the American and the German market, finding that the operations which happened in one market while the other was not operating were not immediately absorbed at the time of the opening; also, the authors did not find significant influences on the moment both markets were operating at the same time, allowing for possible synchrony problems.

Susmel and Engle (1994) investigated the possible existence of a lead-lag effect between New York and London's markets, but with no relevant findings. On similar studies, Kofman and Martens (1997) found a mutual influence, being the American over the English a bit stronger than the reverse. Oliveira and De Medeiros (2009), upon observing Dow Jones and Bovespa indexes, found a 6 minutes gap between both markets, indicating a violation of the EMH theory.

Relations among different companies in the same country

Open market companies can also suffer with the *Lead-Lag effect*. For Foster and Viswanathan (1993) and Holden and Subrahmanyam (1992), information incorporation speed increases when the number of analysts in a company increases. For Merton (1987), the analist quota is non-linear related with the size of the company – therefore, bigger companies incorporate information faster than smaller ones.

Relations between companies's stock papers in different countries

According to Ahearne, Griever and Warnok (2004), when considering the neighborhood effect – a bias where people prefer close companies because of the lower monitoring costs – it is feasible that some investors cease monitoring on real time the relationship between stocks and its Depositary Receipts (DR). Thus, those firms that count on a bigger number of analysts are more able to absorb information; however, it bears reminding that the neighborhood effect may have adverse effects, for investors may follow upon stock variation, and not on the DRs. Therefore, it will be harder for DRs to incorporate information from foreign markets. In this context, it is expected that the stock markets leads DRs.

Research Model and Hypotheses

This study employed Pati and Rajib (2010) proposed model – which was successfully used on research by Oliveira Neto, De Medeiros and Queiroz (2012). The relationship between future and spot markets presented in the theoretical model is represented by the Cost of Carry Model, as bellow:

$$F_t^* = S_t e^{(r-d)(T-t)} \quad ...(1)$$

$$f_t^* = s_t + (r-d)(T-t) \quad ...(2)$$

Where:
F_t^* e f_t^*: future index on t time (today).
S_t e s_t:: spot index on t time (today).
r: discount rate or risk free rate continuum.
d: market portfolio dividend growth rate.
$T-t$: time lapse until contract maturity.

The linearization of the Price Equilibrium Relationship (applying the napierian logarithm), as in equation 2, represents the general research principle, which shows the

possibility of the future market being dependent on the capitalized spot market, highliting the carrying cost of the on sight stock papers. This condition implies that the variation of future versus spot prices should be stable, oscillating around the same range; otherwise, one market leads the other, creating arbitration opportunities.

The equilibrium hypothesis validity was tested with econometric models based on cointegration tests of future and spot prices, in order to prove or refute the existence of a long term relationship between indexes, and of Lead-Lag models for the differences. In order to minimize Schwarz's information criteria, the number of lags needed must be known.

This study had as it main objective to evaluate evidences of the Lead-Lag effect between Bovespa Spot Index and its futures contracts. An econometric model, based on Brooks, Rew and Ritson (2001) was applied, with adjustments for structural breaks on the level equation, as in Oliveira Neto, Medeiros and Queiros (2012).

The following hypothesis were adopted:

H_0: there is no Lead-Lag effect;
H_1: favorable evidence of Lead-Lag effect.

It is known that, when manipulating asset prices in econometric models, these prices are frozen on level. In order to evaluate the cointegration of time series, it is necessary that both series are integrated at the same level. If cointregration exists, Granger (1998) causality happens, at least in one way. In this study, it is expected that this causality happens, from the Future Bovespa Index to the Spot Bovespa Index – this meaning that changes in the future index happen before changes in the spot index. It is important to consider that Granger's causality has a temporal element: not that one predicts the other, but that one happens before the other.

Cointegration was tested through Engle-Granger method in two stages, employing a dummy variable for a structural change. Gregory and Hansen (1996) suggest this structure when there is a break in the structure when the intercept changes, in the long-term equation. This method has its first stage represented by the long-term relationship expressed in Equation 3.

$$s_t = \gamma_1 + \gamma_2 f_t + \gamma_3 D + Z_t \qquad ...(3)$$

Where:
s_t: spot prices log;
γ_1: constant;
$\gamma_2 f_t$: slope coefficient multiplied by future prices log;
$\gamma_3 D$: slope coefficient multiplied by a dummy variable for a structure change of the intercept of the cointegration relationship; and
Z_t: stochastic error.

As affirmed by Gregory and Hansen (1996) and Brooks, Rew and Ritson (2001), if the regression error between two first order variables (I), is integrated with the zero order I (0), it is possible to affirm that the variables are cointegrated. In order to verify the stationary residuals hypothesis, the second stage of the model, the Augmented Dickey-Fuller test.

If there is cointegration among the presented series, there exists an Error Correction Vector (ECV) reflected on Equation 4 of the short-term model, based on Brooks, Rew and Ritson (2001), but employing the GARGH Model (equation 5), instead of the ordinary least square model. With the purpose of addressing possible problems from data heteroscedasticity usually found in such temporal series, the VECM estimation, through a GARCH-BEKK

model, as in Pati and Rajib (2010).

$$\Delta s_t = \beta_1 + \beta_2 \Delta f_{t-1} + \beta_3 \Delta s_{t-1} + \beta_4 ECM_{t-1} + \varepsilon_t \qquad ...(4)$$

Where:
Δs_t: spot contract price variation on time *t* (today).
β_1: constant.
$\beta_2 \Delta f_{t-1}$: slope coefficient multiplied by the future index variation on t-1 (yesterday);
$\beta_3 \Delta s_{t-1}$: slope coefficient multiplied by the spot index variation on t-1 (yesterday);
$\beta_3 \Delta s_{t-1}$: slope coefficient multiplied by the Error Correction Mechanism;
ε_t: Error, which average zero and variable variance (GARCH structure), as in Equation 5.

$$GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1) \qquad ...(5)$$

Data

The collected data represent the price of future hypothetical portfolios, based on assets listed in the Sao Paulo Stock Market (BM&F Bovespa). Althoug the spot index is only a proxy for market performance, the Futre Bovespa Index represent closed deals among the involved.

Population is theoretically finite and discreet. Sample is constituted of 2443 registered price quotation. Data series begins on January 2 2002, and ends on 09 november 2011. Data are arranged in daily occurrence, and were obtained in the Economática field.

Analysis and Discussion

The research had as its objective evaluate evidences of Lead-Lag effects between the Spot Bovespa Index and future contracts of the same index, with null hypothesis being the inexistence of the effect. If H1 is refuted, the future market must lead the spot market.

Following tables (1 and 2) presents the descriptive statistics of the daily return data on the future and spot Bovespa index.

In this study's time series, the average return, median and the lowest and highest of the future index are 4.6% higher than the spot index. However, standard deviation for the spot index is more than twice for the future index series (113%).

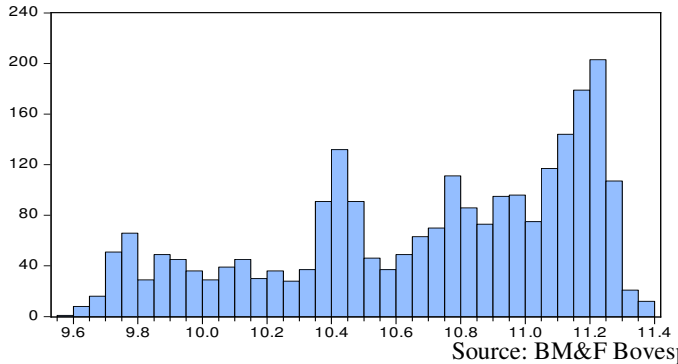
Jarque-Bera test was highly significant on both series, implying the rejection of the normality of data hypothesis. Both series present excessive kurtosis and negative asymmetry, the spot series being slightly more asymmetric.

Table 1: Descriptive Statistics

	LNSPOT
Mean	10.69552
Median	10.79416
Maximum	11.3892
Minimum	9.593571
Standard Deviation	0.471432
Skewness	-0.577143
Kurtosis	2.176231
Jarque-Bera	204.7003
P-value	0.000000
Observations	2443

Source: BM&F Bovespa

Graph 1: Spot Index data distribution



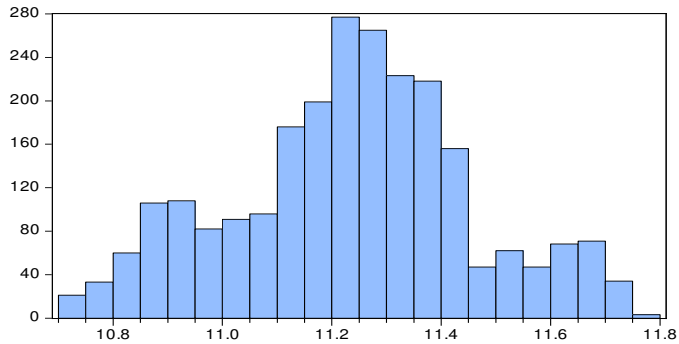
Source: BM&F Bovespa

Table2: Descriptive Statistics

	LNFUT
Mean	11.23509
Median	11.24454
Maximum	11.75864
Minimum	10.70195
Standard Deviation	0.221394
Skewness	-0.051374
Kurtosis	2.706012
Jarque-Bera	9.872357
P-value	0.007182
Observations	2443

Source: BM&F Bovespa Data

Graph 2: Future Index data distribution



Source: BM&F Bovespa

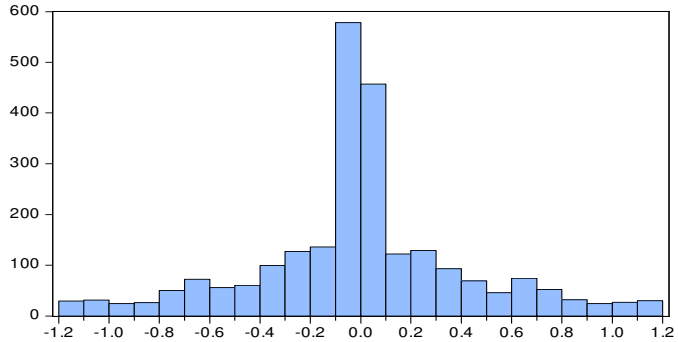
Same statistics were calculated for the first difference between indexes (future and spot). The following tables and charts, show that both series do not have normal distribution, but the first difference series has a positive asymmetry.

Table 3: Descriptive Statistics

	DLNSPOT
Mean	-0.000735
Median	-0.001985
Maximum	1.164921
Minimum	-1.17261
Standard Deviation	0.427789
Skewness	0.003468
Kurtosis	3.84759
Jarque-Bera	72.64527
P-value	0.000000
Observations	2443

Source: BM&F Bovespa Data

Graph 3: Spot Index first difference data distribution



Source: BM&F Bovespa

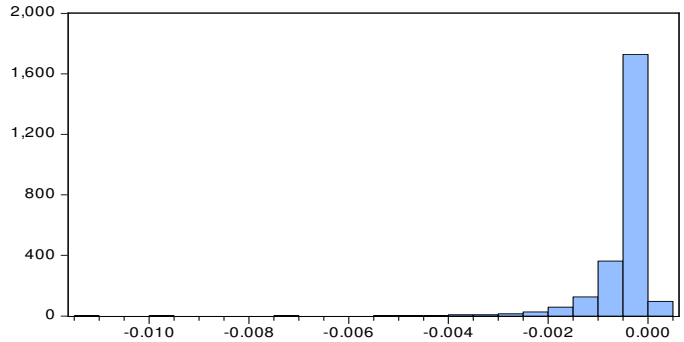
Table 4: Descriptive Statistics

	DLNFUT
Mean	-0.000434
Median	-0.000223

Maximum	0.000000
Minimum	-0.011019
Standard Deviation	0.000696
Skewness	-5.45448
Kurtosis	5460229
Jarque-Bera	283164.2
P-value	0.000000
Observations	2443

Source: BM&F Bovespa Data

Graph 4: Future Index first difference data distribution



Source: BM&F Bovespa

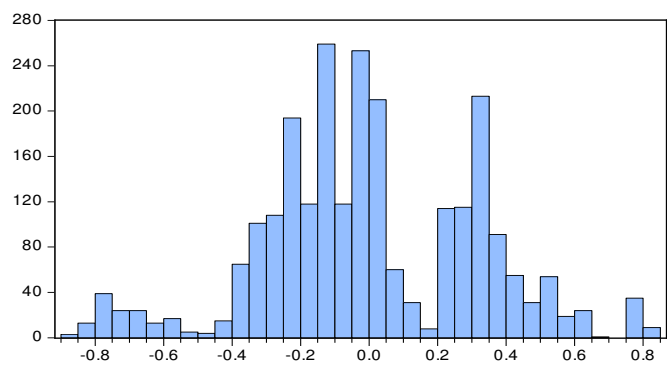
As for the Error Correction Mechanism (ECM) distribution, deriving from the mean equation, there is a time series with negative asymmetry (Table 5 and Graph 5), but with a non-significant Jarque-Bera value, which does not allow to reject the hypothesis of normal distributed data; therefore, ECM is considered normally distributed.

Table 5: Descriptive Statistics

	ECMVD
Mean	3.39E-15
Median	-0.27399
Maximum	0.834257
Minimum	-0.867850
Standard Deviation	0.317714
Skewness	-0.026696
Kurtosis	3.129760
Jarque-Bera	2.004105
P-value	0.367125
Observations	2443

Source: BM&F Bovespa data

Graph 5: Error Correction Mechanism (ECM) data distribution



Source: BM&F Bovespa

Model Estimates

Before estimating the Lead-Lag Model, evidence of cointegration was tested with the two stage Engle-Granger method, whose results are presented on Table 6. All terms were significant. A R^2 of 0.54 demonstrates that the long term model tested suggests that the future index explains 54% of the spot index variance. The global significance model test (F) was 1.466, with a significant p-statistic.

Table 6: Long Term Relationship

$$s_t = \gamma_1 + \gamma_2 f_t + \gamma_3 D + Z_t$$

	Value	P-statistics
γ_1	-6.6133	0.000000
γ_2	1.5433	0.000000
γ_3	0.1193	0.000000
R^2	0.54	-

F	1.466000	0.000000

Source: BM&F Bovespa Data

The second stage consisted of the Z stationarity test, the stochastic error term. The unit root ADF test was used, with a significant p-value. From these results, it is possible to reject the unit root null hypothesis, meaning that the error is stationary; therefore, there is cointegration among series, which points to a long term relationship between then.

Table 7: Unit Root Test

Variável	ADF	P-statistics
Z_t	-23.93	0.000000

*Null hypothesis rejected at 5%

Source: BM&F Bovespa Data

With evidence of cointegration, the Error Correction Vector (ECV) was introduced in order to study balance and lead relationships among the temporal series. The univariate GARCH model was used in order to estimate the ECV, with only one mean equation, for the series involved are financial, being naturally heteroscedastic (ALEXANDER, 2005).

About estimated parameters, β_2 is non-significant at 5%, which translates in the future market not leading the spot market and reinforces the efficiency thesis. However, there is evidence of past information influencing present prices, going against the efficiency thesis. A positive and significant Error Correction Mechanism indicates that the long term equilibrium relationship is the determined by the spot price, and future prices converge towards the spot price.

Table 8: Short Term Relationship

$$\Delta s_t = \beta_1 + \beta_2 \Delta f_{t-1} + \beta_3 \Delta s_{t-1} + \beta_4 ECM_{t-1} + \varepsilon_t$$

	Value	P-statistics
β_1	-0.011	0.000000
β_2	0.1483	0.8943
β_3	-0.497335	0.000000
β_4	0.8775	0.000000

Source: BM&F Bovespa Data

As for the error term ε_t with null mean, with the intercept and structured with a GARCH model (based on its changing variance, parameters presented in Table 9), the values found suggests there are volatility overflows between past and future and between the spot and future markets. *C(1)* constant was not significant.

Table 9: Error Term Variance Equation

$$GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1)$$

Value	P-statistic
1.40E-06	0.6220
0.0827000	0.000000
0.9240	0.000000

Fonte: Dados BM&F Bovespa

At last, Granger Causality was tested (Table 10), indicating that the future market leads the spot market, generating conflicting results with the Lead-Lag model. Therefore, the evidences do not support Brooks, Rew and Ritson (2001) findings for the English market, and Tse (1995) for the Japanese market.

Table10: Granger Causality

Null hypothesis:	F-statistic	P-statistic
	1.03E+03	2.00E-188
	3.4802	0.0622

Source: BM&F Bovespa Data

Summary and Conclusions

The present study intended to study the Lead-Lag effect between future and post BM&F Bovespa's markets. The adopted model was based on Brooks, Rew and Ritson (2001) but, different from the original model which used Least Ordinary Squares estimations, in this study, estimates were based on the GARCH models, since the series involved are financial.

All required parameters were successfully estimated. When comparing Granger Causality with the Lead-Lag Model, results were divergent: Lead-Lag Model shows no leadership, while Granger Causality points to unidirectional causality of the future market over the spot market.

Despite the ambiguity, both models support that there are no arbitration opportunities between those two markets. Evidences of past price information influencing present prices indicate some possible market inertia. Nevertheless, it is contrary evidence to Efficient Market Hypothesis (EMH).

At last, the GARCH estimated model for the short term error structuring presents evidences of volatility overflows from the future to the spot market and from the past to the future market. Investigation of these volatility overflows poses as an important issue, in order to better understand the direction and magnitude of such overflows.

Another important discussion point would be the structural breaks that may create arbitration opportunities and pay off specific strategies for such economic dynamics.

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