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Guttler, Caio; Meurer, Roberto and Da Silva, Sergio

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Caio Guttler[a], **Roberto Meurer**[a], **Sergio Da Silva**[a*]

[a] *Department of Economics, Federal University of Santa Catarina, 88049970 Florianopolis SC, Brazil*

Abstract

Employing both cointegration analysis and a variety of Granger causality tests, we examine whether the Brazilian stockmarket is efficient in processing new information about public macroeconomic data (semi-strong efficiency). We find the stockmarket to be inefficient, which is in line with most results for other emerging markets.

JEL classification: G14, E44

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* Corresponding author.
E-mail address: professorsergiodasilva@gmail.com (S. Da Silva).

1. Introduction

If past information about public macroeconomic data can affect current stock prices, the stockmarket is inefficient because such a piece of information is not embodied in the prices. This is dubbed semi-strong informational inefficiency. Since macro data can be considered more important for emerging markets than for their developed counterparts (Muradoglu and Metin, 1996), semi-strong efficiency matters more for the emerging markets. In this connection, this paper examines whether the Brazilian stockmarket is efficient in processing new information about macroeconomic data.

Efficiency studies employing variables from the macroeconomy and stockmarket are commonly performed using cointegration as well as Granger causality (Granger, 1986; Yunh, 1997; Al-Loughani, 1998). The efficient market hypothesis is rejected in the presence of lagged causality from a macro variable to the stock price. Reverse causality from the lagged stock price to the macro variable does not reject efficiency, though. Here rational investors are solely anticipating the behavior of the macro variable prior to the release of new information. A contemporaneous causal relationship between the macro variable and the stock price does not reject efficiency either. Here stock market participants are just promptly reacting to new information.

The prices of two different stocks in efficient markets cannot cointegrate (Granger, 1986). If they could, an error correction mechanism would exist, and then price changes could be predicted. But this is at odds with weak efficiency, i.e. the absence of predictability from a price's own time series. Evidence supporting long run causality (semi-strong inefficiency) exists if the coefficient of the error correction term departs significantly from zero (e.g. Al-Loughani, 1998).

Tables 1 and 2 bring together some semi-strong informational efficiency studies for developed and emerging markets respectively. The tables update the information in O'Hanlon (1991) and Al-Loughani (1998). As can be seen, roughly most studies find the emerging markets to be inefficient.

It is not so surprising to find the Brazilian stockmarket inefficient before the 1990s. The market had low liquidity, operationally immature regulation, and the traded volume concentrated in a few stocks. In the 1990s there occurred financial reforms and (from the second half of the decade on) macroeconomic stability. For this reason our study concentrates on data beginning in 1995. Previous work assessing the efficiency of the Brazilian stockmarket did not consider either macro variables or the techniques of cointegration and Granger causality (Camargos and Barbosa (2003) provide a survey). Tabak and Lima (2002) employed these techniques but did not take the macroeconomic variables into account.

Some think that cointegration does not necessarily mean inefficiency. This is so because of (1) the low statistic power of the test, (2) omitted variables, such as risk premium, and (3) the possibility that market participants deliberately disregard the information in the error correction model because of its irrelevance for profits (Crowder, 1996). Other skeptical views include Dwyer and Wallace (1992), Engel (1996), and Caporale and Pittis (1998). These authors think that the existence of cointegration only means that stock prices can be predicted to some degree. Despite this caveat, this paper follows the trend in the empirical literature on efficiency and considers cointegration along with Granger causality.

The rest of the paper is organized as follows. Section 2 describes data. Section 3 presents analysis, and Section 4 concludes.

2. Data

We gathered monthly data of selected macroeconomic variables as well as the stockmarket index of the Brazilian economy from January 1995 to December 2005. The source was the Central Bank of Brazil website and Ipeadata. The Sao Paulo Stock Exchange (Bovespa) index was selected to represent the Brazilian stockmarket. For the macro variables, we considered GDP, inflation rate (as measured by the extended consumer price index, IPCA), the base interest rate (dubbed Selic), and country risk, as measured by the spread between the C-bond (major bond of the Brazilian foreign debt) and the US treasury bond of same maturity. The reason why the Selic rate and country risk were considered was that these may affect stock prices through either companies' cash flows or the discount rate (that the companies use to reckoning the cash flows in present value). To track monetary and exchange rate policies we also considered broad money, i.e. M4, and the exchange rate (dollar price of the Brazilian currency, the *real*). Sometimes we employed industrial production in place of GDP, but this did not matter for results. All the variables were taken in natural logs.

3. Analysis

To test for both cointegration and Granger causality one needs first to find a series' integration order. Stationarity is a precondition to Granger causality. The preconditions to cointegration are the series to be integrated of same order and the order to be different from zero. Table 3 shows the results of the augmented Dickey-Fuller (ADF) and Phillips-Perron tests for the series in levels. As can be seen, one cannot reject the null hypothesis of lack of stationarity. The base interest rate was considered nonstationary as well, in part because of the low significance of the finding of stationarity in the ADF test. Yet the series are stationary in first differences (Table 4). The exchange rate series in levels presents a structural break in 13 January 1999, when a currency crisis struck. But it is already known in literature with the help of Perron's test for series with structural breaks that this very series does get stationary in first differences (Moura and Da Silva, 2005).

Since the series are integrated, and in an order different from zero, i.e. they are $I(1)$, cointegration tests between the variables can be employed. Granger causality can also be tested for the series in first differences. One then needs to choose an optimal number of lags to be used in these tests. Here we estimated VAR models with up to 12 lags. The model with one lag was selected by both Akaike and Schwarz criteria.

Johansen test shows that the series cointegrate. The trace statistic points to three vectors of cointegration at the 5 percent significance level. Yet we considered the two vectors suggested by the maximum eigenvalue (5 percent significant). This is consistent with the assumption that the Brazilian stockmarket is semi-strong informationally inefficient. Or at least, that stock prices can be predicted to some degree.

The existence of cointegration calls for an estimation of the error correction mechanism tracking the pace of adjustment from short run disequilibrium toward long run equilibrium. After choosing the optimal number of lags by Akaike and Schwarz criteria, we found a short run equation with the error correction mechanism as follows.

$$\Delta\text{BOV} = -0.0029 - 0.0106E_{1t-1} - 1.0986E_{2t-1} - 0.0634\Delta\text{BOV}_{t-1} - 1.2125\Delta\text{GDP}_{t-1}$$
$$(-0.1745) \quad (-0.4838) \quad (-1.5660) \quad (-0.4506) \quad (-0.6679)$$
$$+2.4898\Delta\text{CPI}_{t-1} - 0.3455^{*}\Delta r_{t-1} + 0.1205^{**}\Delta i_{t-1} + 0.5736^{*}\Delta e_{t-1} + 0.1768\Delta\text{M4}_{t-1} \tag{1}$$
$$(-1.5793) \quad (-2.7662) \quad (1.9897) \quad (2.7672) \quad (0.2199)$$

[*] significant at 1%

[**] significant at 5%

( ) t statistic

$R^2 = 0.1933$.

In equation (1), Δ stands for first differences, BOV is a closing quote of the Bovespa index, r is country risk, i is the Selic interest rate, and e is the nominal exchange rate. As expected, the adjustment parameters of the error correction mechanism, E_1 and E_2, are negative. This means that deviations from the path toward long run equilibrium are reverted. Yet this finding is to be viewed with caution because its significance is relatively low.

Granger causality is tested through

$$\Delta\text{BOV}_t = \gamma + \alpha_1\Delta\text{GDP}_{t-1} + \beta_1\Delta\text{CPI}_{t-1} + \delta_1\Delta r_{t-1} + \varphi_1\Delta i_{t-1} + \theta_1\Delta e_{t-1} + \xi_1\Delta\text{M4}_{t-1} + \varepsilon_t\,. \tag{2}$$

Results for block causality are in Table 5. The null that the macro variables do not jointly cause the Bovespa index is rejected at the one percent significance level. In particular, country risk, exchange rate, and interest rate cause the stockmarket index.

This result is repeated in the causality in pairs (Table 6). CPI, country risk, and exchange rate all Granger-causes the stockmarket index. This index also causes interest rate and exchange rate, which means that market participants anticipate these variables.

Moreover, there is bidirectional causality between the stockmarket index and the exchange rate.

If two variables present a common trend, current changes in one variable can be partly due to the fact that the variable's movement follows the other's trend. Since such causality refers to the long run, it cannot be tracked by the usual Granger test, which considers short run information (Islam and Ahmed, 1999). Because taking first differences can lead to the omission of long run information on the causal relation between variables, it has been suggested an "advanced Granger causality test" (Islam and Ahmed, 1999). If the series cointegrate, using the Granger causality test with the error correction mechanism prevents the possibility of not finding a causal relationship in at least one direction. The usual Granger test does not take this into account. Table 7 shows block causality using this advanced Granger test, where the error correction mechanism in equation (1) is employed. Our finding of inefficiency is entirely replicated.

We also tested Granger causality for the series in levels following the methodology suggested by Toda and Yamamoto (1995). Their technique does not rely on either stationarity or cointegration. Thus the risks associated with a possible misidentification of the series' order of integration are reduced. Even if the series are nonstationary, a VAR model in levels can be estimated and the Wald test can be employed on the condition that one is in the know about the series' maximum lag. Thus the tests are estimated with d extra lags, and the order of the VAR becomes $p = k + d$, where k is the order of the optimal lag selected by Akaike and Schwarz criteria. Here selecting the lags is critical, especially when both the theory and statistical results point to a small number of lags in the VAR component (Toda and Yamamoto, 1995). We found an optimal lag of one. Then we considered the series in levels with up to 42 lags.

With the maximum lag, country risk, interest rate, and exchange rate all causes the stockmarket index (Table 8).

Data on the three macro variables above are usually released on a daily basis, but this is not so of the other ones; for these, data release occurs after the period they refer to. The CPI data are only released up to the 15th day of the subsequent month, M4 data are released by the 20th day, and GDP data are released by the 30th day. Because Akaike and Schwarz criteria suggested only one lag in the previous causality tests, these cannot capture the macro variables whose information is made public with delay. Nevertheless, taking expectations of the macro variables into account produces the finding that GDP also causes the stockmarket, thereby reinforcing the case for inefficiency.

To get the series' expectations we employed ARMA(p,q) forecasting models for the first differences. Table 9 shows the selected model for every variable by considering the significance of the estimated coefficients as well as Akaike and Schwarz criteria. The series proved stationary at the one percent significance level with the help of ADF and Phillips-Perron tests (not shown).

To get the number of lags, we estimated VARs with up to 12 lags. By Akaike and Schwarz criteria we selected the VAR with two lags. Then we tested block causality (Table 10). Expectations of the macro variables jointly cause the stockmarket index. And causality tests in pairs repeated this finding (Table 11). Table 11 also shows bidirectional causality between the stockmarket index and the expectations of country risk, exchange rate, and interest rate.

Next we built the expectation series in levels taking the sum of a data point at $t-1$ with that at t. Apart from the interest rate, the resulting series were nonstationary in levels (not shown). Taking VARs with up to 12 lags, Akaike and Schwarz criteria suggested the selection of the VAR with one lag. Johansen test detected cointegration (except for the interest rate series). The trace and maximum eigenvalue statistics both pointed to two cointegration vectors at the 5 percent significance level.

Table 12 shows the advanced Granger causality test. There is evidence that inflation and GDP expectations seem to cause the stockmarket index. Also, the Toda and Yamamoto test suggests the expectations of inflation, GDP, and exchange rate to cause the stockmarket with 41 lags (Table 13).

Finally, we tested contemporaneous causality between the macro variables and the stockmarket index through the equation as follows.

$$\begin{aligned}\Delta \mathrm{BOV} = \gamma + \alpha_0 \Delta \mathrm{GDP}_t + \alpha_1 \Delta \mathrm{GDP}_{t-1} + \beta_0 \Delta \mathrm{CPI}_t + \beta_1 \Delta \mathrm{CPI}_{t-1} + \delta_0 \Delta r_t + \Delta r_{t-1} \\ + \varphi_0 \Delta i_t + \varphi_1 \Delta i_{t-1} + \theta_0 \Delta e_t + \theta_1 e_{t-1} + \xi_0 \Delta \mathrm{M4}_t + \xi_1 \Delta \mathrm{M4}_{t-1} + \varepsilon_t\end{aligned} \quad (3)$$

The Wald test (Table 14) rejected the null of $\alpha_0 = \beta_0 = \delta_0 = \varphi_0 = \theta_0 = \xi_0 = 0$. Thus the macro variables affect the stockmarket contemporaneously. This finding was replicated including the E_{t-1} term in (3). The coefficient of the error correction term was negative and significant at one percent.

4. Conclusion

We find a long run relationship between selected macroeconomic variables of the Brazilian economy and its stockmarket index. Also, a variety of Granger causality tests, from the usual test to an "advanced" test to Toda and Yamamoto test all suggests that the macroeconomic variables jointly cause the stockmarket index. We thus find evidence of semi-strong informational inefficiency of the Brazilian stockmarket. Or at least, that stock prices can be predicted to some degree. Incidentally we also find the macro variables to affect the stockmarket contemporaneously. This suggests that market participants promptly react to the release of new information.

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Table 1. Some studies of semi-strong informational efficiency for developed markets

Author	Methodology	Data	Country	Macro Variable	Conclusion
Davidson and Froyen (1982)	Tobin theoretical model and Rozeff's portfolio forecasting	Monthly, July 1954–March 1977	USA	Monetary aggregates, interest rate	Efficiency
Mookerjee (1987)	Granger causality	Monthly, 1975–1985	USA, UK, CAN, JPN, GER, ITA, SUI, NET	Monetary aggregates	Efficiency: USA, UK
Kamarotou and O'Hanlon (1989)	Granger causality	Quarterly, 1971Q1–1984Q4	USA, JPN, CAN, UK	Industrial production, unemployment	Efficiency: USA, JPN, CAN
Jeng *et al.* (1990)	Granger causality	Annual, 1921–1930	USA, UK, CAN, FRA	Monetary aggregates	Efficiency: CAN, FRA
O'Hanlon (1991)	Granger causality	Annual, 1968–1987	UK	Profit rate, returns of 222 stocks	Inefficiency
Yuhn (1997)	Cointegration	Monthly, January 1970–March 1991	USA, UK, CAN, JPN, GER	Dividends, stock prices	Efficiency: USA, CAN
Cheung and Ng (1998)	Cointegration	Quarterly, 1957Q1–1992Q4	CAN, GER, ITA, JPN, USA	Oil price, real output, monetary aggregates, consumption	Efficiency: JPN
Okunev *et al.* (2002)	Linear and nonlinear Granger causality	Weekly, January 1980–August 1999	AUS	Real output	Inefficiency

Table 2. Some studies of semi-strong informational efficiency for emerging markets

Author	Methodology	Data	Country	Macro Variable	Conclusion
Cornelius (1993)	Granger causality and cointegration	Monthly, January 1984–June 1990	IND, KOR, MAS, MEX, TWN, THA	Monetary aggregates	Inefficiency
Muradoglu and Metin (1996)	Cointegration	Monthly, January 1986–December 1993	TUR	Inflation, budget deficit, interest rate, exchange rate, monetary aggregates	Inefficiency
Balaban and Kunter (1996)	Granger causality	Daily, January 1989–July 1995	TUR	Interest rate, exchange rate, monetary aggregates	Inefficiency
Al-Loughani (1998)	Granger causality and cointegration	Monthly, February 1993 –June 1997	KUW	Monetary aggregates, bank credit, interest rate, oil price	Efficiency
Ibrahim (1999)	Granger causality and cointegration	Monthly, January 1987 –June 1996	MAS	Industrial production, consumer price index, monetary aggregates, domestic credit, official foreign exchange reserves, exchange rate	Inefficiency
Kwon and Shin (1999)	Granger causality and cointegration	Monthly, January 1980–December 1992	KOR	Exchange rate, trade balance, real output, monetary aggregates	Inefficiency
Hanousek and Filer (2000)	Granger causality	Monthly, January 1993–June 1999	CZE, HUN, POL, SVK	Monetary aggregates, industrial production, budget deficit, inflation, exchange rate, imports, exports, trade deficit	Efficiency: CZE
Al-Qenae *et al.* (2002)	Panel data analysis	Annual, 1981–1997	KUW	Real output, interest rate, inflation	Efficiency

Table 3. Stationarity tests for the series in levels

Variable	ADF(p^a)	Prob.	Z^b	Prob.
Bovespa index	−2.6124(3)^d	0.2757	−2.2184^d	0.4751
GDP	−0.9943(2)^c	0.7540	4.0720	0.9999
CPI	−3.0763(1)^d	0.1164	−2.7632^d	0.2137
Country risk	−1.8404(1)^c	0.3596	−0.8464	0.3475
Selic interest rate	−3.2147(0)^d	0.0861***	−3.1024^d	0.1101
Exchange rate	−1.4229(2)^c	0.5692	−1.5699^c	0.4951
M4	5.8877(1)	0.9999	8.4750	0.9999

[a] optimal lag from Schwarz criterion, [b] Z is Phillips-Perron test,
[c] model with a constant, [d] model with a constant and trend, *** significant at 10%

Table 4. Stationarity tests for the series in first differences

Variable	ADF(p^a)	Prob.	Z^b	Prob.
Bovespa index	−9.1181(0)^c	0.0000*	−9.0000^c	0.0000*
GDP	−4.7005(0)	0.0000*	−5.1056	0.0000*
Industrial production	−13.4623(0)	0.0004*	−13.4662	0.0000*
CPI	−4.5390(0)^c	0.0003*	−4.6113^c	0.0002*
Country risk	−8.1909(0)	0.0000*	−8.1909	0.0000*
Selic interest rate	−13.2596(0)	0.0000*	−13.3286	0.0000*
Exchange rate	−7.6353(1)	0.0000*	−7.4350	0.0000*
M4	−7.7870(0)^c	0.0000*	−4.2795	0.0000*

[a] optimal lag from Schwarz criterion, [b] Z is Phillips-Perron test,
[c] model with a constant, * significant at 1%

Table 5. Block causality tests (first differences)

Null Hypothesis	χ^2	Prob.
GDP does not Granger-cause the Bovespa index	0.1545	0.6942
CPI does not Granger-cause the Bovespa index	1.2093	0.2715
Country risk does not Granger-cause the Bovespa index	7.3266	0.0068*
Selic interest rate does not Granger-cause the Bovespa index	3.7468	0.0529***
The exchange rate does not Granger-cause the Bovespa index	7.3496	0.0067*
M4 does not Granger-cause the Bovespa index	0.3568	0.5503
All the above variables do not Granger-cause the Bovespa index	18.5157	0.0051*

* significant at 1%, *** significant at 10%

Table 6. Causality tests in pairs (first differences)

Null Hypothesis	F	Prob.
GDP does not Granger-cause the Bovespa index	0.2580	0.6124
Bovespa index does not Granger-cause the GDP	2.5807	0.1107
CPI does not Granger-cause the Bovespa index	4.2842	0.0405**
Bovespa index does not Granger-cause the CPI	1.5808	0.2110
Country risk does not Granger-cause the Bovespa index	2.9553	0.0880***
Bovespa index does not Granger-cause country risk	1.9857	0.1612
Selic interest rate does not Granger-cause the Bovespa index	2.6600	0.1054
Bovespa index does not Granger-cause the Selic interest rate	10.5769	0.0015*
The exchange rate does not Granger-cause the Bovespa index	3.6136	0.0596***
Bovespa index does not Granger-cause the exchange rate	6.4310	0.0124**
M4 does not Granger-cause the Bovespa index	1.1896	0.2775
Bovespa index does not Granger-cause M4	0.0536	0.8173

* significant at 1%, ** significant at 5%, *** significant at 10%

Table 7. Block "advanced" causality tests (first differences)

Null Hypothesis	χ^2	Prob.
GDP does not Granger-cause the Bovespa index	0.4461	0.5042
CPI does not Granger-cause the Bovespa index	2.4942	0.1143
Country risk does not Granger-cause the Bovespa index	7.6518	0.0057*
Selic interest rate does not Granger-cause the Bovespa index	3.9590	0.0466**
The exchange rate does not Granger-cause the Bovespa index	7.6574	0.0057*
M4 does not Granger-cause the Bovespa index	0.0484	0.08260
All the above variables do not Granger-cause the Bovespa index	20.6824	0.0021*

* significant at 1%, ** significant at 5%

Table 8. Toda and Yamamoto causality tests (variables in levels)

Null Hypothesis	12 lags		24 lags		36 lags		42 lags	
	F	Prob.	F	Prob.	F	Prob.	F	Prob.
GDP does not cause the Bovespa index	1.2288	0.2752	1.0719	0.4010	1.1681	0.529	1.4818	0.3552
Bovespa index does not cause GDP	1.0485	0.4123	1.2646	0.2296	1.1201	0.3941	3.8648	0.0670***
Industrial production does not cause the Bovespa index	1.2113	0.2868	1.1755	0.3006	1.4810	0.1621	0.9398	0.6062
Bovespa index does not cause the industrial production	1.3812	0.1885	1.0759	0.3969	0.9768	0.5356	0.4813	0.9128
CPI does not cause the Bovespa index	1.5601	0.1168	0.7615	0.7662	0.8149	0.7156	1.2741	0.4336
Bovespa index does not cause CPI	1.3439	0.2073	1.4604	0.1202	1.0583	0.4520	0.7663	0.7198
Country risk does not cause the Bovespa index.	0.5797	0.8536	0.7173	0.8138	0.7787	0.7549	3.4173	0.0856***
Bovespa index does not cause country risk	0.5061	0.9061	0.3983	0.9925	0.6608	0.8705	2.5236	0.1514
Selic interest rate does not cause the Bovespa index	1.1700	0.3158	2.0263	0.0145**	1.9170	0.0517***	11.1188	0.0066*
Bovespa index does not cause Selic interest rate	1.2185	0.2820	1.0095	0.4698	1.1141	0.3994	0.9522	0.5986
The exchange rate does not cause the Bovespa index	0.7847	0.6648	1.0266	0.4504	0.9751	0.5375	3.6359	0.0758***
Bovespa index does not cause the exchange rate	1.3277	0.2159	1.1189	0.3532	1.0885	0.4230	0.6134	0.8269
M4 does not cause the Bovespa index	1.0023	0.4531	0.7459	0.7835	0.8386	0.6890	1.7440	0.2801
Bovespa index does not cause M4	1.1394	0.3385	1.4657	0.1180	1.1839	0.3400	1.089	0.5214

* significant at 1%, *** significant at 10%

Table 9. Selected forecasting models (first differences)

Variable	Model
GDP	ARMA [(2;3),2][a]
Industrial production	ARMA (3,3)
CPI	ARMA (2,1)
Country risk	MA(1)
Selic interest rate	ARMA(3,3)
Exchange rate	MA(1)
M4	ARMA[(1;3),2][b]

[a]AR(2); AR(3); MA(1); MA(2)
[b]AR(1); AR(3); MA(1); MA(2)

Table 10. Block causality tests for expectations (first differences)

Null Hypothesis	χ^2	Prob.
Expected GDP does not Granger-cause the Bovespa index	1.3689	0.5044
Expected CPI does not Granger-cause the Bovespa index	6.3089	0.0427**
Expected country risk does not Granger-cause the Bovespa index	4.5646	0.1020
Expected Selic interest rate does not Granger-cause the Bovespa index	6.7978	0.0334**
Expected exchange rate does not Granger-cause the Bovespa index	2.3154	0.3142
Expected M4 does not Granger-cause the Bovespa index	2.0222	0.3638
All the above variables do not Granger-cause the Bovespa index	20.4136	0.0597***

** significant at 5%, *** significant at 10%

Table 11. Causality tests in pairs for expectations (first differences)

Null Hypothesis	F	Prob.
Expected GDP does not Granger-cause the Bovespa index	0.8259	0.4403
Bovespa index does not Granger-cause expected GDP	0.1667	0.8466
Expected CPI does not Granger-cause the Bovespa index	2.5084	0.0856***
Bovespa index does not Granger-cause expected CPI	0.7266	0.4857
Expected country risk does not Granger-cause the Bovespa index	0.9853	0.3763
Bovespa index does not Granger-cause expected country risk	97.4013	6.0E–26*
Expected Selic interest rate does not Granger-cause the Bovespa index	3.4550	0.0347**
Bovespa indeed does not Granger-cause expected Selic interest rate	4.0488	0.0197**
Expected exchange rate does not Granger-cause the Bovespa index	0.2270	0.7973
Bovespa index does not Granger-cause expected exchange rate	7.4231	0.0009*
Expected M4 does not Granger-cause the Bovespa index	0.8335	0.4370
Bovespa index does not Granger-cause expected M4	2.4856	0.0875***

* significant at 1%, ** significant at 5%, *** significant at 10%

Table 12. Block "advanced" causality tests for expectations (first differences)

Null Hypothesis	χ^2	Prob.
Expected GDP does not Granger-cause the Bovespa index	3.3878	0.0657***
Expected CPI does not Granger-cause the Bovespa index	5.5524	0.0185**
Expected country risk does not Granger-cause the Bovespa index	1.4071	0.2355
Expected exchange rate does not Granger-cause the Bovespa index	0.2564	0.6126
Expected M4 does not Granger-cause the Bovespa index	0.7073	0.4000
All the above variables do not Granger-cause the Bovespa index	8.8848	0.1138

** significant at 5%, *** significant at 10%

Table 13. Toda and Yamamoto causality tests for expectations (variables in levels)

Null Hypothesis	12 lags		24 lags		36 lags		41 lags	
	F	Prob.	F	Prob.	F	Prob.	F	Prob.
Expected GDP does not cause the Bovespa index	1.3625	0.1987	1.4386	0.1340	0.7875	0.7364	2.2933	0.2716
Bovespa index does not cause expected GDP	0.9461	0.5058	1.2953	0.2128	0.8360	0.6859	0.4365	0.9075
Expected CPI does not cause the Bovespa index	1.5641	0.1167	0.7737	0.7508	0.8196	0.7031	15.5113	0.0217**
Bovespa index does not cause expected CPI	1.3510	0.2052	0.8662	0.6415	0.9415	0.5763	1.0657	0.5691
Expected country risk does not cause the Bovespa index	0.4758	0.9240	0.8367	0.6771	1.2486	0.3135	1.4779	0.4287
Bovespa index does not cause expected country risk	14.6111	2.1E–16*	6.2350	1.3E–8*	3.0787	0.0067*	13.7080	0.0259**
Expected exchange rate does not cause the Bovespa index	0.6845	0.7622	0.8818	0.6226	0.7273	0.7968	32.3330	0.0074*
Bovespa index does not cause expected exchange rate	2.8098	0.0026*	1.4925	0.1117	1.3598	0.2463	3.3494	0.1338
Expected M4 does not cause the Bovespa index	1.1022	0.3683	0.7914	0.7306	0.9934	0.5246	4.9127	0.1067
Bovespa index does not cause expected M4	2.6377	0.0046*	2.6396	0.0016*	1.8941	0.0748***	1.1010	0.5546

* significant at 1%, ** significant at 5%, *** significant at 10%

Table 14. Wald test

Test Statistic	Value	Prob.
F	32.3937	0.0000*
χ^2	194.3619	0.0000*

* significant at 1%

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