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SERVICES FOR SCIENCE AND EDUCATION

The Impact of Monetary Policy on the Brazilian Stock Market

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ABSTRACT

This research used VAR/VEC methodology to explore mainly the impact of monetary policy on the Brazilian stock market. Due to persistent inflation the Brazilian Central Bank (BACEN) used high real interest rates for a long time. Recently, before COVID crisis, BACEN reduced dramatically the interest rate and provoking an outstanding performance of the Brazilian stock market. We used monthly data from January/2010 to December/2022 and the macroeconomic variables applied are described as follows: IBOVESPA Stock Market Index (IBOV), Inflation Rate (IPCA), Real Exchange Rate (EER), Economic Activity Index (IBC-Br), Interest Rate (CDI) and Intermediate Money (M2/GDP). Research results indicate that the most powerful macroeconomic variables in the Brazilian stock market are EER, CDI and M2_GDP. There is strong evidence that monetary policy affects the Brazilian stock market not only through the interest rate channel but also through an unexpected change in the monetary aggregate levels. Liquidity levels in the economy expressed by an increase of monetary aggregates tends to affect the stock market stronger than by the reduction of interest rate level.

Keywords: Stock Market, Monetary Policy, Interest Rate

INTRODUCTION

Brazilian economy used to be fully influenced by high inflation rates for more than three decades. For this reason, the Brazilian Central Bank (BACEN) applied positive interest rates to face persistent inflation. This approach, however, contributed to increase sharply government´s debt what subsequently influenced inflation in medium and long terms. Lately, government´s debt was under control making feasible consistent interest rate reduction. The Brazilian stock market behavior seems to be fully affected by monetary policy.

The main objective of monetary policy is to control inflation and provide stable economic conditions for prosperity. Monetary policy actions affect the real economy through the following channels: interest rate, consumption, and wealth effect. The monetarists argue that monetary policy affects growth by not anticipating changes in the stock of money. Considerable changes in the stock of money should certainly affect stock prices since equities are claims on future economic output [9].

Before the Covid crisis and the Ukraine-Russia war, the Brazilian Central Bank dropped interest rates to the lowest level ever in Brazil. Subsequently, the stock market begun to react positively. The valuation of companies started to increase continuously due mainly and apparently to interest rate decline. After those events, due to inflation restart caused by offer reduction of goods, the Central Bank quickly escalated the increase of the interest rate.

In this new economic environment, the BACEN adopted low interest rate and depreciated exchange rate macroeconomic framework. Low interest rates tend to boost private investment and families´ consume, moreover the depreciated exchange rate tends to improve foreign accounts. At the same time, economic agent expectations have increased supporting stock market recovery.

We used monthly data from January/2010 to December/2022 and the macroeconomic variables applied are described as follows: IBOVESPA Stock Market Index (IBOV), Inflation Rate (IPCA), Real Exchange Rate (EER), Economic Activity Index (IBC-Br), Interest Rate (CDI) and Intermediate Money (M2/GDP). All data were collected from the Brazilian Institute of Geography and Statistics (IBGE), Brazilian Institute for Applied Economic Research (IPEADATA) and Central Bank of Brazil (BACEN). Figure 1 shows the time course of the macroeconomic variables that will be used in this study.

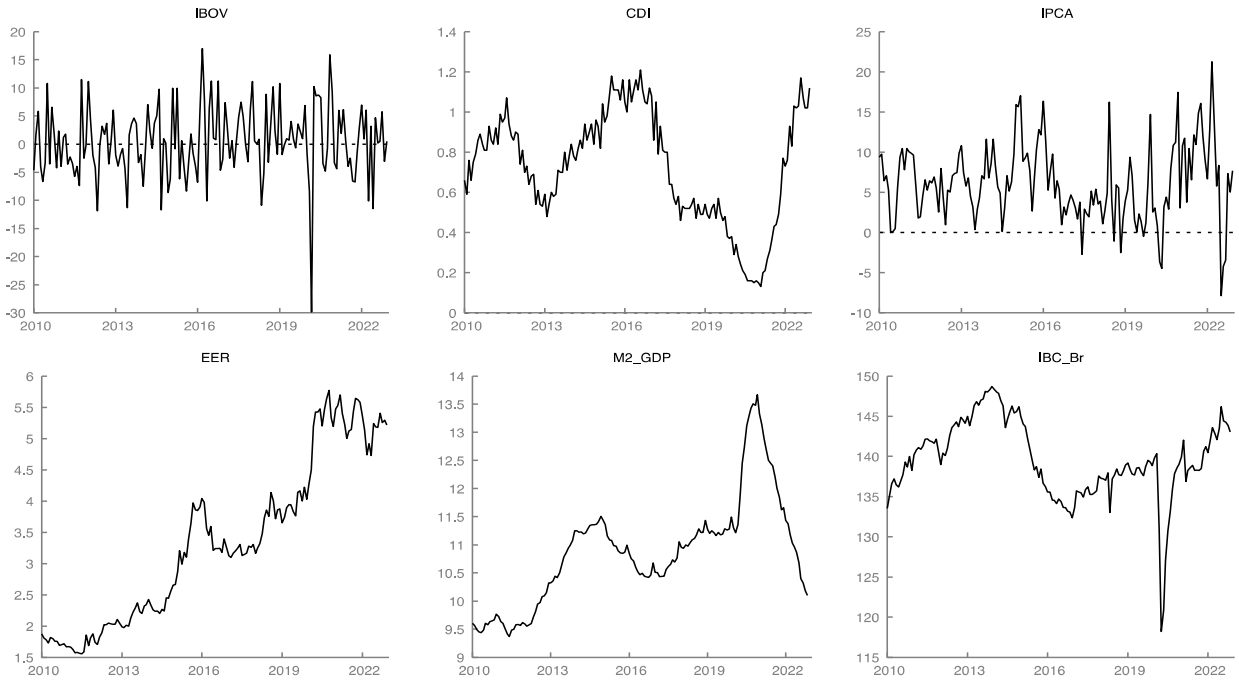


Figure 1 – Macroeconomics variables time series
Source: Own research.

This research tries to explain the sensitive process on the Brazilian stock market due to changes in the monetary policy. The remainder of the paper is organized as follows: beyond this introduction, present relevant literature review in 2; VAR/VEC methodology is explained in 3; empirical results are presented in 4; especially data collected, and the results are presented. In 5 conclusions are addressed and finally all references are listed.

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LITERATURE REVIEW

According to [8] there is relationship between the monetary policy implemented by the Central Bank of Brazil and the stock market. They found that monetary policy has a significant effect on the stock market but is only responsible for a small proportion of market variation. The analysis at the sector level with expected returns identifies that the financial sector is the most affected by this policy, whereas with excess returns only industrial goods are significantly affected. Finally, the monetary shock is explained by unanticipated variations in the unemployment rate, in the Industrial Production Index, in the General Market Price Index, and in the Broad Consumer Price Index.

[9] made research and took a comprehensive look at the monetary policy and stock market dynamics from the African perspective, using five indicators namely, S&P global equity indices, inflation rate, money and quasi growth (M2), real interest rate and GDP growth in a panel VAR model. The study established that, the stock markets of the 12 African countries are positively affected contemporaneously by their respective monetary policies through the interest rate channel but could not find evidence to the reverse reaction.

Authors [7] analyzed the empirical evidence about *(i)* the influence of macroeconomic variables and economic policies on country risk and *(ii)* the influence of macroeconomic variables and country risk on the main Brazilian index of the stock market (Ibovespa). The empirical evidence was obtained through the application of ordinary least squares (OLS), generalized method of moments (GMM) and GMM systems. The results found suggest that monetary policy and public debt management, as well as credibility and reputation affect country risk and the performance of the Brazilian stock market.

[1] examined the effects of monetary policy on stock market performance and to know whether monetary policies in various countries affect their own stock market performance and development. The study employed vector error correction model (VECM) on data of the following countries: Australia and New Zealand representing Australia; India and Indonesia representing Asia; Nigeria and South Africa representing Africa; Chile and Trinidad and Tobago representing South America and Jamaica and the United States representing North America. The study used data from 1988 to 2008. The study found out that monetary policy variables such as money and quasi money growth and interest rates proxied by lending rate as well as intermediate target of monetary policy inflation rate measured at consumer price index have long run relationship with stock market performance measured by growth of market capitalization. This was observed using unit root tests to test for the stationarity of the data as well as cointegration analysis to test for long run equilibrium relationship between the variables.

METHODOLOGY

Economic models in general are expressed from a set of variables that can evolve over time. Time series modeling is based on two main approaches: structural and non-structural models. Based on Vector Autoregression Model (VAR) and Vector Error Correction Model (VECM) it is possible to lay down the relationships among economic variables based on their short run and long-term dynamics. The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random

disturbances on the system of variables. In turn, we can analyze long-run equilibrium relationships among endogenous variables and short-run deviations from that equilibrium using the VECM estimation. Moreover, the adjustment coefficients show us how the short-run deviations or disequilibrium are corrected.

A vector error correction (VEC) model is a restricted VAR designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

Assume two times series Y_t, and X_t, are integrated of order d, $\left(Y_t, X_t \sim I(d)\right)$ if there exists β such that $Y_t - \beta X_t = u_t$, where u_t is integrated of order less than d, i.e. $(d-b)$, we say that Y_t and X_t are cointegrated of order $d-b$, $(Y_t, X_t \sim CI(d,b))$. Initially, consider autoregressive vector (VAR) model with p lags as follows:

$$\boldsymbol{y}_t = \mathbf{v} + \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \boldsymbol{A}_2\boldsymbol{y}_{t-2} + \cdots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{\epsilon}_t, t = 1, 2, \ldots, T \quad (1)$$

where $\boldsymbol{y}_t$ is a $K \times 1$ vector of variables, $\mathbf{v}$ is a $K \times 1$ vector of parameters, $\boldsymbol{A}_1 - \boldsymbol{A}_p$ are $K \times K$ matrices of parameters, and $\boldsymbol{\epsilon}_t$ is a K × 1 vector of disturbances. $\boldsymbol{\epsilon}_t$ has mean 0, has covariance matrix Σ, and is $i.i.d.$ normal over time. The $VAR(p)$ in equation (1) can be rewritten as a VECM.

$$\Delta\boldsymbol{y}_t = \mathbf{v} + \prod y_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \, \Delta\boldsymbol{y}_{t-i} + \boldsymbol{\epsilon}_t \quad (2)$$

where $\prod = \sum_{j=1}^{p} \mathbf{A}_j - \boldsymbol{I}_k$ and $\boldsymbol{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{A}_j$. If $\boldsymbol{y}_t$ has cointegration relationship, then $\prod \boldsymbol{y}_{t-1} \sim I(0)$ and equation (2) can be written as follows:

$$\Delta\boldsymbol{y}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\boldsymbol{y}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \, \Delta\boldsymbol{y}_{t-i} + \mathbf{v} + \boldsymbol{\delta}t + \boldsymbol{\epsilon}_t \quad (3)$$

where $\boldsymbol{\beta}'\boldsymbol{y}_{t-1} = \boldsymbol{ECM}_{t-1}$ is the error correction term, which reflects long-term equilibrium relationships between variables, $\boldsymbol{\alpha}$ is the coefficient of long-term adjustment and the above formula can be written as follows:

$$\Delta\boldsymbol{y}_t = \boldsymbol{\alpha}\boldsymbol{ECM}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \, \Delta\boldsymbol{y}_{t-i} + \mathbf{v} + \boldsymbol{\delta}t + \boldsymbol{\epsilon}_t \quad (4)$$

In the VECM structure proposed by Johansen, in [5], a constant and linear trend is allowed along with the r cointegration relations. In general, we can rewrite the VECM in equation (4) to allow

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quadratic time trend in the levels of the data and constant or a linear time trend for the differences as

$$\Delta \boldsymbol{y}_t = \boldsymbol{\alpha}(\boldsymbol{\beta}' \boldsymbol{y}_{t-1} + \boldsymbol{\mu} + \boldsymbol{\rho} t) + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \, \Delta \boldsymbol{y}_{t-i} + \boldsymbol{\gamma} + \boldsymbol{\tau} t + \boldsymbol{\epsilon}_t \quad (5)$$

where $\mathbf{v} = \boldsymbol{\alpha}\boldsymbol{\mu} + \boldsymbol{\gamma}$ e $\boldsymbol{\delta} t = \boldsymbol{\alpha}\boldsymbol{\rho} t + \boldsymbol{\tau} t$; $\boldsymbol{\mu}$ and $\boldsymbol{\rho}$ are $r \times 1$ vectors of parameters and $\boldsymbol{\gamma}$ and $\boldsymbol{\tau}$ are $\mathbf{K \times 1}$ vectors of parameters; $\boldsymbol{\gamma}$ is orthogonal to $\boldsymbol{\alpha}\boldsymbol{\mu}$, and $\boldsymbol{\tau}$ is orthogonal to $\boldsymbol{\alpha}\boldsymbol{\rho}$; that is, $\boldsymbol{\gamma}' \boldsymbol{\alpha}\boldsymbol{\mu} = \mathbf{0}$ and $\boldsymbol{\tau}' \boldsymbol{\alpha}\boldsymbol{\rho} = \mathbf{0}$.

RESULTS AND DISCUSSION

Statistical inspection of data clearly highlights that the variable the IBOVESPA Stock Market Index (IBOV) showed the highest relative dispersion measured by the Person's coefficient of variation (C.V.) in the period from 2010 to 2022. It was followed by the price index (IPCA), exchange rate (EER) and interest rate (CDI). A symmetric distribution such as a normal distribution has a skewness of 0 and kurtosis of 3. According to Table 1, we can conclude that the data distribution is neither symmetric nor normal.

Table 1 – Descriptive Statistics

Variable	N	Mean	S.D.	C.V.	Skewness	Kurtosis	Min	Max
IBOV	156	0.49	6.29	12.91	-0.49	5.59	-29.90	16.97
IPCA	156	6.15	4.75	0.77	0.23	3.52	-7.86	21.27
EER	156	3.34	1.30	0.39	0.34	1.87	1.56	5.77
IBC-Br	155	139.59	4.87	0.03	-0.74	5.44	118.23	148.70
CDI	156	0.72	0.28	0.38	-0.31	2.24	0.13	1.21
M2/GDP	155	10.88	0.97	0.09	0.71	3.60	9.37	13.67

Source: Own research.

To check whether the series are stationary or not, the Augmented Dickey-Fuller (ADF), KPSS and Phillips-Peron test were used. Table 2 indicates that variables IBOV and IPCA are stationary in level, I(0). The other variables are stationary in first difference I (1).

Table 2 – ADF, KPSS and PP tests results in level and first difference for the monthly series

Level							
Variables	**ADF**		**KPSS**		**Phillips-Perron**		**Results**
	Statistics	**p-value**	**Statistics**	**Critical Value (p-value)**	**Statistics**	**p-value**	
IBOV	-11.624	0.0000	0.157	0.462 (p > 0.10)	-11.608	0.0000	Stationary
IPCA	-6.352	0.0000	0.288	0.462 (p > 0.10)	-2.874	0.0042	Stationary
EER	-0.533	0.2976	0.708	0.148 (p > 0.10)	-2.978	0.1417	Non-Stationary
IBC-Br	-2.497	0.1163	2.709	0.462 (p < 0.10)	-2.671	0.0815	Non-Stationary
CDI	-1.595	0.4863	3.425	0.462 (p < 0.10)	-1.268	0.6436	Non-Stationary
M2/GDP	-1.157	0.1246	0.637	0.148 (p < 0.10)	-0.710	0.9701	Non-Stationary
First difference							
Variables	**ADF**		**KPSS**		**Phillips-Perron**		**Integration Order**
	Statistics	**p-value**	**Statistics**	**Valor Crítico (p-value)**	**Statistics**	**p-value**	
IBOV	-	-	-	-	-	-	I(0)
IPCA	-	-	-	-	-	-	I(0)
EER	-12.088	0.0000	0.064	0.462 (p > 0.10)	-12.087	0.0000	I(1)
IBC-Br	-9.403	0.0000	0.077	0.462 (p > 0.10)	-9.814	0.0000	I(1)
CDI	-19.725	0.0000	0.141	0.462 (p > 0.10)	-18.430	0.0000	I(1)
M2/GDP	-7.044	0.0000	0.267	0.462 (p > 0.10)	-7.229	0.0000	I(1)

Source: Own research.

The lag order selection of VAR was implemented considering the Likelihood Ratio (LR), Prediction Error (FPE) and Akaike (AIC)' Information Criteria, Table 3, and the Lagrange-multiplier test for Autocorrelation (Table 4).

Table 3 - Selection-order criteria of lags of the VECM model for the macroeconomic variables

lag	**LL**	**LR**	**df**	**p**	**FPE**	**AIC**	**HQIC**	**SBIC**
0	-1630.16				483.339	23.208	23.259	23.3335
1	-742.176	1776	36	0.000	0.002729	11.1231	11.48*	12.0014*
2	-686.254	111.84	36	0.000	0.002063	10.8405	11.5034	12.4717
3	-648.613	75.281	36	0.000	0.002029	10.8172	11.786	13.2013
4	-598.214	100.8	36	0.000	0.001676	10.613	11.8877	13.7499
5	-563.201	70.028	36	0.001	0.001735	10.627	12.2077	14.5168
6	-533.743	58.916	36	0.009	0.001965	10.7198	12.6064	15.3625
7	-498.58	70.325	36	0.001	0.00208	10.7316	12.9242	16.1272
8	-458.32	80.521	36	0.000	0.002081	10.6712	13.1697	16.8197
9	-413.611	89.417	36	0.000	0.001994	10.5477	13.3521	17.449
10	-386.707	53.809	36	0.028	0.002517	10.6767	13.7871	18.3309
11	-351.912	69.589	36	0.001	0.002924	10.6938	14.1101	19.1009
12	-281.053	141.72	36	0.000	0.002108	10.1993	13.9216	19.3593
13	-201.949	158.21	36	0.000	0.001411	9.58793	13.6162	19.5008
14	-129.085	145.73*	36	0.000	0.001086*	9.06504*	13.3992	19.7308

Source: Own research.

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Table 4 - Lagrange-multiplier test for Autocorrelation in VAR model (postestimation)

lag	chi2	df	Prob > chi2
1	31.7390	36	0.67148
2	29.0039	36	0.78956
3	33.3024	36	0.59756
4	31.4802	36	0.68340
5	39.5825	36	0.31313
6	38.6453	36	0.35100
7	29.6863	36	0.76201
8	29.7551	36	0.75915
9	30.9349	36	0.70810
10	33.3345	36	0.59603
11	37.7489	36	0.38927
12	43.7713	36	0.17502
13	26.3585	36	0.88034
14	24.9231	36	0.91761

Source: Own research.

The Granger causality test is controlled to determine whether one time series is useful in predicting another. So, a time series X_t causes Granger Y_t if it can be shown that these X_t values provide statistically significant information about future Y_t values. In others word, we used the Granger causality test for determining if one time series is valuable in forecasting another one. A time series X_t is accepted to Granger-cause Y_t if it can be shown, usually through a series of t-tests and F-tests on lagged values of X_t. The number of lags to be included is usually chosen using an information criterion such as the Akaike, Schwarz or Hannan Quinn information criterions. [2].

In Table 5, Granger's causality assessment for the macroeconomic variables, demonstrates that there is a bidirectional relationship between each one of them. This implies that the lags of each of them are relevant to predict the behavior of the other.

Table 5 – Granger Causality

Equation	Excluded	chi2	df	Prob > chi2
IBOV	IPCA	36.764	14	0.001
IBOV	EER	33.53	14	0.002
IBOV	IBC-Br	28.718	14	0.011
IBOV	CDI	27.858	14	0.015
IBOV	M2/GDP	39.281	14	0.000
IBOV	ALL	176.04	70	0.000
IPCA	IBOV	24.395	14	0.041
IPCA	EER	70.761	14	0.000
IPCA	IBC-Br	53.656	14	0.000
IPCA	CDI	39.774	14	0.000
IPCA	M2/GDP	109.33	14	0.000

IPCA	ALL	306.09	70	0.000
EER	IBOV	52.405	14	0.000
EER	IPCA	68.033	14	0.000
EER	IBC-Br	92.435	14	0.000
EER	CDI	24.636	14	0.038
EER	M2/GDP	62.207	14	0.000
EER	ALL	280.75	70	0.000
IBC-Br	IBOV	55.921	14	0.000
IBC-Br	IPCA	24.077	14	0.045
IBC-Br	EER	33.83	14	0.002
IBC-Br	CDI	33.895	14	0.002
IBC-Br	M2/GDP	29.556	14	0.009
IBC-Br	ALL	221.42	70	0.000
CDI	IBOV	32.14	14	0.004
CDI	IPCA	32.076	14	0.004
CDI	EER	31.932	14	0.004
CDI	IBC-Br	30.205	14	0.007
CDI	M2/GDP	32.857	14	0.003
CDI	ALL	275.75	70	0.000
M2/GDP	IBOV	53.216	14	0.000
M2/GDP	IPCA	37.863	14	0.001
M2/GDP	EER	47.132	14	0.000
M2/GDP	IBC-Br	136.75	14	0.000
M2/GDP	CDI	60.702	14	0.000
M2/GDP	ALL	569.72	70	0.000

Source: Own research.

The Johansen Test is the most effective econometric test to detect time series co-integration, [2]. The approach proposed by [5] performs trace and eigenvalue statistics for co-integration detection. The trace and maximum eigenvalue tests, proposed by [5] and [6] presented in Tables 6 and 7 verified the existence of two cointegration vectors. The trace test and maximum eigenvalue test, shown in the following equations.

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln (1 - \widehat{\lambda_i})$$

$$J_{max} = -T \ln (1 - \hat{\lambda}_{r+1})$$

Where T is the sample size and $\widehat{\lambda_i}$ is the i-th largest canonical correlation. The trace test (J_{trace}) tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. In turn, the maximum eigenvalue test (J_{max}) assesses the null hypothesis of r cointegrating vectors against the alternative hypothesis of $r + 1$ cointegrating vectors.

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Table 6 - Trace Test for cointegration - Johansen

Null Hyphotesis	Alternative Hyphotesis	Trace Statistic	5% Critical Value
r=0	r>0	153.57	82.49
r<=1	r>1	70.30	59.46
r<=2	r>2	**36.95***	**39.89**
r<=3	r>3	17.80	24.31
r<=4	r>4	8.63	12.53

Source: Own research.
Note: The Trace Test indicates that there are three equations of cointegration.

Table 7 - Maximum Eigenvalue Test for cointegration - Johansen

Null Hyphotesis	Alternative Hyphotesis	Maximum Statistic	5% Critical Value
r=0	r=1	83.25	36.36
r=1	r=2	33.35	30.04
r=2	r=3	**19.14**	**23.80**
r=3	r=4	9.17	17.89
r=4	r=5	7.96	11.44

Source: Own research.
Note: The Maximum Eigenvalue test indicates that there are three cointegrating equations.

In general, when the time series variables are non-stationary, a level VAR model is not appropriate as it produces a spurious regression. However, it is possible to have common dynamic non-stationary series between such series, making the vector error correction model (VECM) more suitable. Thus, if Y_t and X_t are cointegrated, spurious regression no longer arises. According to the stationarity and cointegration tests, we estimate a VECM model assuming all means and trends are zero to evaluate the short and long-term relationships between the macroeconomic variables, as well as to check the behavior of the main performance indicator of shares traded on the Brazilian Stock Exchange, the B3. In other words, check how the IBOV indicator is affected by the cyclical movements of the IPCA, EER, CDI, M2/GDP and IBC-Br variables.

Table 8 presents the cointegration vectors, normalized for the Bovespa Index (IBOV) and IPCA variables, where the IBOV will be the variable of interest in this work.

Table 8 - Cointegration vector normalized.

	IBOV	IPCA	EER	IBC-BR	CDI	M2/GDP
CE 1	1	0	5.47	0.41	4.44	-7.22
			(0.000)	(0.001)	(0.108)	(0.000)
CE 2	0	1	-12.17	-0.92	-6.89	15.24
			(0.000)	(0.000)	(0.135)	(0.000)

Source: Own research.
Note: Statistics in parenthesis refer to p-value of the estimated parameter with 5% significance level.

To ascertain the long-term causality between IPCA and EER and IBC_Br and CDI and M2/GDP and IBOV, the "CE 1" and "CE 2" must show a negative coefficient and a significant p-value. Note, in Table 9, that the coefficient of "CE 1" is equal -1,865 and its p-value equal to 0,071 at a 10% significance level. Since both conditions were validated, this VECM shows that there is a long-term relationship between all macroeconomic variables.

Table 9 – VECM estimation coefficients

	Coef.	Std. Err.	z	P > z	[95% Conf. Interval]	
D_IBOV						
_CE1						
L1.	**-1,865**	1,033	-1,810	**0,071**	-3,890	0,160
_CE2						
L1.	**-0,843**	0,526	-1,600	**0,109**	-1,874	0,188
IBOV						
L12D.	-0,262	0,143	-1,830	0,067	-0,543	0,018
IPCA						
L2D.	0,946	0,550	1,720	0,086	-0,132	2,024
EER						
L2D.	-11,490	7,044	-1,630	0,103	-25,296	2,316
L6D.	-20,836	7,535	-2,770	0,006	-35,603	-6,068
IBC_Br						
L2D.	-1,324	0,631	-2,100	0,036	-2,560	-0,088
L8D.	-1,477	0,695	-2,130	0,034	-2,838	-0,115
L12D.	-0,975	0,502	-1,940	0,052	-1,958	0,009
CDI						
L7D.	46,717	18,227	2,560	0,010	10,992	82,441
L8D.	35,816	16,405	2,180	0,029	3,662	67,969
L11D.	-33,630	17,487	-1,920	0,054	-67,904	0,643
M2/GDP						
L7D.	20,831	11,663	1,790	0,074	-2,028	43,691
L10D.	19,756	10,929	1,810	0,071	-1,665	41,177
L12D.	-22,806	11,736	-1,940	0,052	-45,808	0,195

Source: Own research.

Also, according to Table 9, it is possible to note the presence of short-term causality between the variables with the Bovespa Index. It is also observed from the results that the second lags of the variables IPCA, EER and IBC_Br were statistically significant, at a significance level of 10% and this means that in the very short term the Ibovespa Index (IBOV) responds more quickly to variations in inflation, in exchange rate, on the monetary side, and on the economic activity indicator, on the real side of the economy.

The consistency of the results of the VECM estimation is confirmed by the Lagrange multiplier test. As shown in Table 10, the null hypothesis of absence of autocorrelation was not rejected in each of the chosen lags.

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Table 10 - Lagrange-multiplier test for Autocorrelation in VECM model (postestimation)

lag	chi2	df	Prob > chi2
1	43.4223	36	0.1845
2	36.9156	36	0.4264
3	35.3524	36	0.4992
4	32.8449	36	0.6195
5	41.4072	36	0.2465
6	37.0115	36	0.4221
7	33.4933	36	0.5884
8	22.5906	36	0.9602
9	33.6254	36	0.5821
10	37.3255	36	0.4080
11	47.9063	36	0.0886
12	27.9510	36	0.8289
13	42.0027	36	0.2269

Source: Own research. Note: 5% Significance level.

Although the results are consistent, it was not possible to guarantee the efficiency from the disturbance normality test for some equations, as shown in Table 11.

Table 11 - Jarque-Bera test for normality of disturbances

Equation	chi2	df	Prob > chi2
D_IBOV	46.370	2	0.00000
D_IPCA	0.467	2	0.79166
D_EER	6.344	2	0.04192
D_IBC_Br	12.606	2	0.00183
D_CDI	3.211	2	0.20074
D_M2/GDP	0.288	2	0.86607
ALL	69.286	12	0.00000

Source: Own research.

The null hypothesis of Jarque-Bera test states that the residuals of variables are normally distributed. For some equations, this statistic is significantly rejected, implying non-normality of their disturbances. Although the VECM estimated coefficients are consistent, they may admit some degree of inefficiency.

The problem of the inefficiency of the coefficients would not be so relevant when the intention is to analyze the impulse response functions and forecast the macroeconomic variables. [4] compared the forecasting performance of a cointegrated system with the forecasting performance of a VAR and reached the conclusion that the forecasting gains of cointegrated systems appear in longer forecasting horizons and that this relative gain in forecast performance clearly depends upon the chosen data transformation.

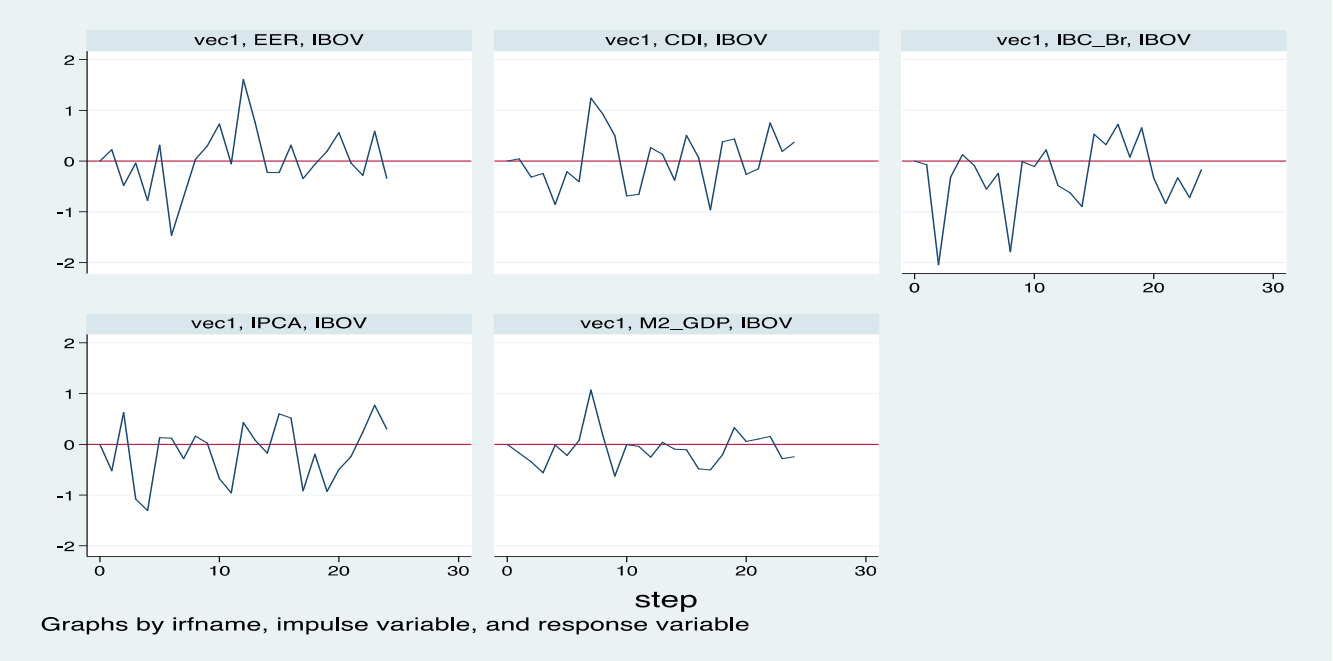


Figure 2 - Impulse response function (IRF)

Source: Own research.

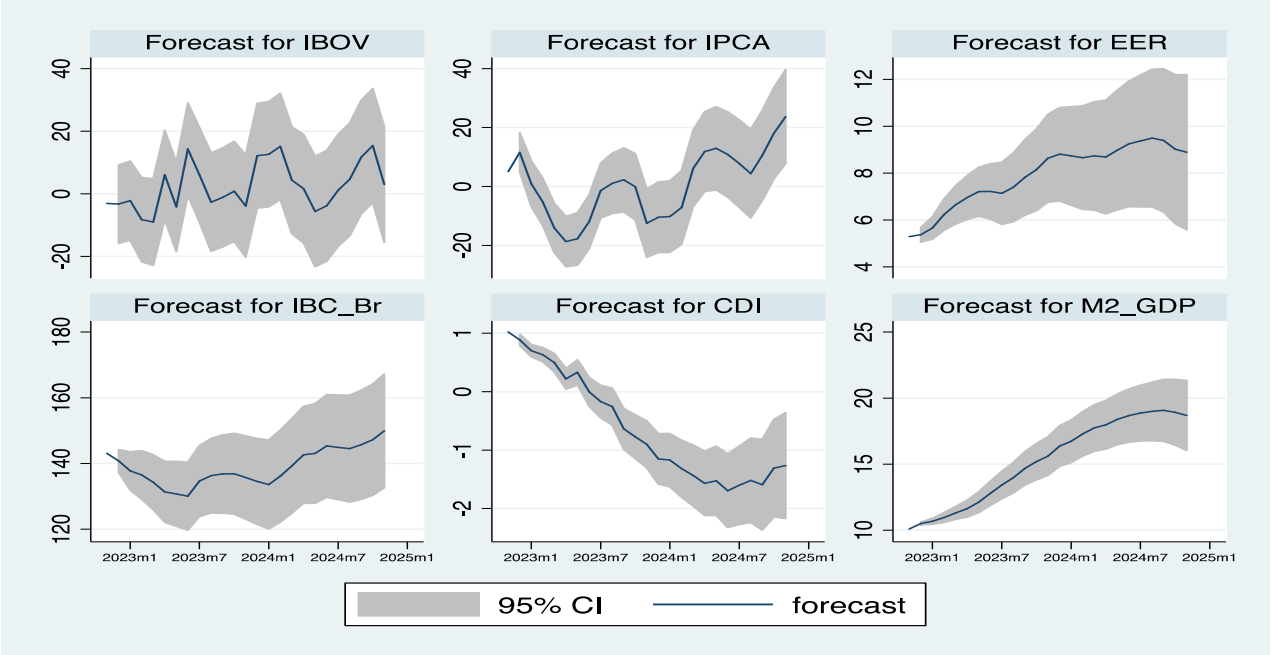


Figure 3 – Forecast for macroeconomics variable (24 periods ahead)

Source: Own research.

According to IRF in Figure 2, the most powerful macroeconomic variables in the Brazilian stock market index are EER, CDI and M2_GDP. Depreciation of exchange rate tends to depress the stock market as well as an increase of the interest rate. On the other hand, an increase in the monetary aggregate M2_GDP because of an expansionary monetary policy tends to boost the stock market. Forecasting results in Figure 2 provided by the model point out that IBOV will

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continue the up and down movements without any clear tendency, inflation rate IPCA tends to increase, exchange rate will depreciate in the next periods, economic growth seems to decline up to 2024 and increase after that, interest rate CDI should decline continuously and monetary aggregate M2_GDP should increase in the next following years.

CONCLUSION

The main goal of this research is to investigate the relationship between monetary policy and the Brazilian stock market. The VECM approach was applied, and data are from Jan/2010 to Dec/2022. Relevant outcomes corroborate findings from [1] and [8] so that, there is strong evidence that monetary policy affects the Brazilian stock market not only through the interest rate channel but also through an unexpected change in the monetary aggregate levels. Liquidity levels in the economy expressed by an increase of monetary aggregates tends to affect the stock market stronger than by the reduction of interest rate level. Another relevant outcome is that all macroeconomic variables investigated have bidirectional relationship with the Brazilian stock market index.

The model also provided forecasting results indicating that inflation will continue to rise, and the exchange rate should continue to depreciate. The Central Bank, according to these expectations, should continue to apply high real interest rate policy, what will continue contaminate the stock market performance.

The Brazilian Central Bank has a very relevant task to adjust interest rates and liquidity levels for not improving inflation and provide stable conditions for economic growth expressed by a healthy stock market.

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