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Macroeconomic Determinants of the Brazilian Stock Market: An Autoregressive Distributed Lag Approach

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Abstract

The purpose of this study is to analyze the influence of macroeconomic variables on the performance of the Brazilian stock market between January 2010 and May 2024. The variables selected for the investigation include the IPCA, GDP, Selic interest rate, real effective exchange rate, EMBI and the money supply by M1 aggregate. Estimations were carried out using the Autoregressive Distributed Lag (ARDL) method, which allows cointegration tests to be carried out using both level and first difference variables. The main results of the study indicate that the performance of the Brazilian stock market seems to be directly linked to a stable economic environment, characterized by low levels of inflation and interest rates, compatible with maintaining economic growth.

Keywords

Macroeconomic Variables, ARDL Model, Co-Integration, Brazilian Stock Market

1. Introduction

Increases in inflation, changes in interest rates, fluctuations in the exchange rate and changes in the level of economic activity make it difficult for economic agents to make spending and investment decisions and generate uncertainties that can increase volatility and affect the performance of the stock market (Costa Filho, 2014; Bernardelli & Castro, 2020). This process can limit the growth of publicly traded companies and, consequently, reduce the generation of employment and income in the country, since it makes it more difficult to raise funds directly on the stock market to finance productive investments (Nongnit et al., 2022).

It is no coincidence that several studies have sought to analyze how changes in macroeconomic variables can affect the stock market. In the study by Franzen et al. (2009), for example, stock prices and the investment decisions of economic agents depend directly on a country's economic and political stability, as well as credit risk and fundraising power. Bernardelli and Bernardelli (2016) point out that stock prices capture a country's level of economic activity, since the good performance of companies is strictly linked to economic growth.

In the case of Brazil, the introduction of the Real Plan in 1994 marked the end of hyperinflation, establishing a more stable and less risky environment for investors. It is in this context that Chicoli and de Sousa (2016) state that the Brazilian stock market gained greater significance in the 1990s due to the implementation of measures against hyperinflation.

Therefore, this study aims to assess the influence of economic factors on the Brazilian stock market in the period between January 2010 and May 2024. The importance of this analysis lies in its ability to provide a more in-depth understanding of how the stock market reacts to variations in economic indicators. The results obtained in this study have the potential to provide valuable insights for economic policymakers, portfolio managers and investors. By understanding the dynamics of economic factors and stock market performance, these agents can improve their decision-making capacity, reducing risks and increasing the likelihood of success in their investments.

In methodological terms, an Autoregressive Distributed Lag (ARDL) model was estimated to analyze the cointegration between the selected variables and examine the short- and long-term effects. The variables selected for the investigation include the IPCA, GDP, the Selic interest rate, the real effective exchange rate (REER), the EMBI and the money supply by M1 aggregate, which will be detailed in the data and methodology section. What sets this study apart is its methodological approach, which has been little explored by other studies on the subject, as well as its analysis of a period in which there were several events that influenced Brazilian macroeconomic policy and, by hypothesis, the results of the country's stock market. Highlights in this regard include the so-called New Macroeconomic Matrix implemented during Dilma Rousseff's government, the impeachment process and the change in the way the country's economy is run under the Temer government, the COVID-19 pandemic and the increase in public spending, along with other spending and measures taken by the Bolsonaro government with a view to re-election, such as the so-called Fuel PEC (Constitutional Amendment No. 123 of July 14, 2022) and Complementary Law 192/2022, which set a 17% ICMS ceiling on fuel, electricity and telecommunications and public transport services, promoting a forced drop in inflation from the second half of 2022 onwards.

In addition to this introduction and the concluding remarks, the paper is divided into three other sections. Section 2 consists of a review of the international and national literature on the influence of economic factors on the stock market. Section 3 then presents in detail the data used, and the methodology employed in

this study. Finally, Section 4 contains the results of the study.

2. Theoretical Framework

The content of scientific studies on the effects of macroeconomic variables on the stock market, price formation, economic development and stock market performance is quite dense. This topic contains a bibliographical review on the subject, made up of national and international studies that fundamentally used the ARDL method to estimate their respective models, as was done in this work.

For some time now, several studies, such as those by Tian and Ma (2010), Pal and Mittal (2011), Bekhet and Matar (2013), Chia & Lim (2015), Bahmani-Oskooee and Saha (2016), have been studying the influence of macroeconomic variables on the stock market in several countries using the ARDL method. **Table 1** shows that this method continues to be widely used to achieve this same objective in the recent period. In addition to the ARDL method, these studies end up having in common the use of some similar explanatory variables, such as the exchange rate (ER), industrial production index (IPI, as a proxy for economic growth), consumer price index (CPI), money supply (measured by M1, M2 or M3)[1] and interest rate (IR), mostly used in natural logarithm. The impacts of these variables on the stock market are varied, but those originating from the exchange rate, money supply and inflation seem to be the most powerful.

Table 1. Selected works that evaluated the impact of macroeconomic variables on the stock market using the ARDL method.

Author(s)	Variables	Country(ies)	Main results
Alexander & Al-Malkawi (2022)	Stock market indices (SMI), exchange rate (ER), industrial production index (IPI), gold price, oil price, consumer price index (CPI) and interest rate (IT). All variables were used in natural logarithm.	India	In the long term, the exchange rate is the main variable influencing the stock market and is negatively related to this explained variable. In the short term, there seems to be a positive relationship between the lagged values of the price of crude oil and the Indian stock market index.
Asravor & Fonu (2021)	SMI, CPI, IPI, foreign direct investments (FDI), ER, money supply (M2) and school performance index. All variables were used in natural logarithm.	Gana	Money supply, inflation and human capital have a negative impact on stock market development, while foreign direct investment and the interest rate have a positive impact on stock market development.

[1]M1, M2, M3 and M4 are monetary aggregates that are classified according to their liquidity. M1 is the aggregate made up of the most liquid assets, i.e., paper money held by the public and demand deposits; M2 is made up of M1 plus savings deposits and private securities issued by depository institutions; and M3 adds depository investment fund quotas and repo operations with public and private securities to M2.

Continued

Çakir (2021)	SMI, ER, IR and stock market volatility index. All variables were worked out in natural logarithm.	Türkiye	RE has asymmetric effects on the three main Turkish stock market indices, both in the short and long term. Thus, in the long term, currency appreciation has a positive and significant effect on the country's stock market indices, but currency devaluation has no effect.
Devi & Bansal (2022)	SMI, CPI, IR, FDI, GDP e ER. All variables were worked out in natural logarithm.	India	There is evidence of a positive and significant relationship between economic growth, the exchange rate and inflation and stock prices. The results of ARDL's long-term estimates are also consistent in the short term.
Devkota & Dhungana (2019)	SMI, IR, ER, money supply (M2) and gold price. All the variables were worked out in natural logarithm.	Nepal	The interest rate is the most determining factor for the stock market index in Nepal, while the price of gold and the real exchange rate have insignificant impacts.
El Abed & Zardoub (2019)	SMI, IR, ER, oferta de moeda (M3), CPI and IPI. All the variables were worked out in natural logarithm.	Germany	The interest rate has a negative and significant impact on the stock market and the effect of the CPI on stock returns is positive and significant.
Furqan et al. (2023)	SMI, FDI, IR and stock market index.	Bangladesh, Pakistan and Sri Lanka	Foreign direct investment and the exchange rate also have a significant and positive influence on the performance of these countries' stock markets.
Humpe & McMillan (2020)	SMI, IR, IPI and CPI.	G7 countries	Relação positiva de longo prazo entre os preços das ações, a produção industrial e os preços no consumidor, bem como uma relação negativa com as taxas de juro reais.
Hussain et al. (2023)	SMI, FDI, CPI, GDP, banking sector development and stock market liquidity. All variables in natural logarithm.	Australia, Belgium, France, Germany, Japan, the Netherlands, Norway, Switzerland, the UK and the USA.	GDP, the development of the banking sector and foreign direct investment have a positive impact on stock market development, while inflation and stock market liquidity have a negative impact on stock market development in the G-10 economies.

Continued

Javangwe & Takawira (2022)	SMI, CPI, IR and ER.	South Africa	The impact of the exchange rate on the stock market can be positive in the short term and negative in the long term.
Khan (2019)	SMI, CPI, IR and ER.	China	The exchange rate has a negative and significant influence on stock market returns. The results for inflation and the interest rate indicate a negative and statistically significant effect on stock returns.
Norehan & Ridzuan (2020)	SMI, CPI, IR, ER, domestic savings and money supply. All variables in natural logarithm.	Malaysia	Inflation and the exchange rate are significant and have positively influenced the stock market, while domestic savings and money supply in general have a negative impact on this market.
Nusair & Al-Khasawneh (2022)	SMI, CPI, IPI and economic policy uncertainty. All variables in natural logarithm.	G7 countries	Uncertainty over economic policy has a significant negative impact on stock market performance in the short and long term.
Samanta & Deo (2021)	SMI, CPI, IR, money supply (M3), IPI and ER. All the variables were worked out in natural logarithm.	India	The IPI, IR and ER seem to negatively impact the return of the Indian stock market in the long term. In the short term, although money supply (M3) has a positive relationship with stock market performance, its magnitude is insignificant, while inflation (CPI) has a negative relationship.
Sathavara & Poojara (2022)	Stock index of small and medium-sized companies, IPI, ER, CPI, exports and retail sales index. All variables in natural logarithm.	India	IPI, ER, CPI and exports have a positive and significant long-term relationship with the stock market index, while industrial production and the natural logarithm of the retail sales index have a negative impact.

Source: Own elaboration.

In the Brazilian context, not many studies have used the ARDL model in their estimations. As a result, some studies have looked at the influence of macroeconomic factors on stock market performance using different estimation methods. Caluz et al. (2021), for example, sought to study the effects of economic policies and macroeconomic factors on the country's stock market performance, using VAR and VECM models, with monthly data from 2003 to 2016. The results showed a positive short-term relationship between the exchange rate and the

Ibovespa index, as well as with the credibility of inflation targets in the long term. In addition, they suggested the existence of a negative relationship between the money supply and the Brazilian stock market performance index.

Andrade et al. (2022) analyzed the period from 2011 to 2020 using a linear regression model with panel data. He found statistically significant relationships between the Selic interest rate and GDP, and the share prices of companies listed on B3. While the relationship between the Selic interest rate and share prices was negative, these prices responded positively to GDP. A similar result was found in the analysis carried out by Bernardelli and Castro (2020), who applied the generalized least squares method with praiswinsten correction, along with a database from 2003 to 2019. The authors found a positive relationship between the Ibovespa index and GDP, suggesting that the growth of this indicator is accompanied by growth in the prices of shares on the Brazilian stock market.

Soares, Firme and Lima Júnior (2021) investigated the period from 2003 to 2018 using an ARDL model. Unlike Andrade et al. (2022), they found that the sign of the Selic interest rate seems to vary over time in relation to the effect caused on the Ibovespa index, not pointing out the real effect of the interest rate on the domestic stock market. However, it is worth noting that the results indicate that there is a drop in the Ibovespa index when market agents are surprised by a higher nominal interest rate, while the opposite is true. Furthermore, the authors observed that currency devaluation, i.e., an increase in the exchange rate in the short term, has a negative relationship with the country's stock market, since in the long term it would attract foreign investors, a result that differs from that of Caluz et al. (2021).

Grôppo (2005) used a structural VAR model and data from 1995 to 2003 to evaluate the performance of the Brazilian stock market. The study pointed to a high sensitivity of the Ibovespa index in relation to the Selic interest rate in the short term, indicating that the economic agents operating in this market see fixed income investments as a substitute for shares. In addition to the high sensitivity in relation to the Selic interest rate, Bernardelli & Bernardelli (2016) pointed out that the volume of international reserves and confidence indicators explain price formation in the Brazilian stock market in the period 2000-2017, also using a VAR model.

In short, the not insignificant number of studies evaluating macroeconomic factors and their effects on the stock markets of various countries helps to illustrate the importance of this type of approach. In the case of this study, the methodology and data used to achieve the same objective will be presented below.

3. Data and Methodology

3.1. Data

Before presenting the methodology, the variables used in this study will be listed. The data is monthly, from January 2010 to May 2024, involving seven variables, one of which is the explained variable and the other six are the explanatory

variables.

These are the Bovespa index of the Brazilian stock market provided by B3; the Selic interest rate, the IPCA inflation index, the real effective exchange rate, gross domestic product (GDP), the money supply by aggregate M1 and, finally, the EMBI index. The explained variable is the Bovespa index, while the others are the explanatory variables.

Table 2 details these variables, their sources and the expected sign for each of them:

Table 2. Description of variables.

Variable	Description	Expected Signal	Source
BOV	Performance indicator for shares traded on B3.	+	B3
IPCA	Broad Consumer Price Index.	-	IBGE
SELIC	Selic interest rate index accumulated in the month annualized at base 252.	-	Central Bank of Brazil's Time Series Management System (SGS).
RER	Real effective exchange rate index.	-	Central Bank of Brazil's Time Series Management System (SGS).
GDP	Gross Domestic Product.	+	Central Bank of Brazil's Time Series Management System (SGS).
M1	Aggregate money supply (M1).	+	Central Bank of Brazil's Time Series Management System (SGS).
EMBI	Indicator of the daily performance of emerging countries' debt securities in relation to US Treasury bonds.	-	IPEADATA.

Source: Own elaboration.

The aforementioned variables have theoretical support especially in the works cited in Table 1 and were used to compose the model that will be estimated in the work, which was specified as follows:

$$LBOV_t = \alpha_0 + \alpha_1 LIPCA_t + \alpha_2 LSELIC_t + \alpha_3 LRER_t + \alpha_4 LGDP_t + \alpha_5 LM1_t + \alpha_6 LEMBI_t + \epsilon_t \quad (1)$$

where:

$LBOV_t$ represents the natural logarithm of the Bovespa index in period t;

$LIPCA_t$ denotes the natural logarithm of the consumer price index in period t;

$LSELIC_t$ indicates the natural logarithm of the interest rate in period t;

$LRER_t$ corresponds to the natural logarithm of the real effective exchange rate in period t;

$LGDP_t$ equals the natural logarithm of the Gross Domestic Product in period t;

$LM1_t$ symbolizes the natural logarithm of the aggregate money supply in period t;

$LEMBI_t$ describes the natural logarithm of the index measuring the performance of securities issued by emerging markets in period t;

ϵ_t = refers to the error term in period t.

In Equation (1), the prefix L indicates that the model uses data in the log form, α_0 corresponds to the constant term of the model, while $\alpha_1, \cdots, \alpha_6$ corresponds to the coefficients of the explanatory variables.

3.2. Estimation Method

The Autoregressive Distributed Lag (ARDL) method was defined to conduct the investigation with the aim of analyzing the relationship between the selected variables in both the short and long term. According to Pesaran, Shin and Smith (2001), this model was chosen for the following reasons: 1) it can be used with stationary regressors I(0), non-stationary regressors at level I(1) or mutually cointegrated regressors, unlike other cointegration methods, which require lags of the same order; 2) it can solve problems related to omitted variables and autocorrelation; and, additionally, 3) it can be applied even when a small data sample is available.

The general form of the ARDL model, described by Pesaran (1997), is presented with lags in the explanatory variables and the explained variable, as shown in the following equation:

$$\Delta Y_t = \alpha_0 + \alpha_{it} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \sum_{i=0}^{n} \beta_1 \Delta Y_{t-1} + \sum_{i=0}^{p} \beta_2 \Delta X_{t-1} + \varepsilon_t. \quad (2)$$

In Equation (2), Δ indicates the first difference; Y_t the dependent variable; α_0 the constant; α_{it} the trend; Y_{t-1} the lagged dependent variable; δ_1 e δ_2 the long-term parameters; X_{t-1} the explanatory variable; β_1 e β_2 the short-term parameters and ε_t is the error term.

To verify the existence of cointegration, the bounds test is used, which makes it possible to analyze whether there is a long-term relationship between the variables in the model based on the Wald F-statistic.

Given these considerations and the variables mentioned above, the ARDL model used in this work is defined as follows:

$$\begin{aligned} \Delta LBOV_t = {} & \alpha_0 + \alpha_{it} + \delta_1 LBOV_{t-1} + \delta_2 LIPCA_{t-1} + \delta_3 LSELIC_{t-1} \\ & + \delta_4 LRER_{t-1} + \delta_5 LGDP_{t-1} + \delta_6 LM1_{t-1} + \delta_7 LEMBI_{t-1} \\ & + \sum_{i=0}^{n} \beta_1 \Delta LIPCA_{t-i} + \sum_{i=0}^{n} \Delta LSELIC_{t-i} \beta_2 + \sum_{i=0}^{n} \Delta LRER_{t-i} \beta_3 \\ & + \sum_{i=0}^{n} \beta_4 \Delta LGDP_{t-i} + \sum_{i=0}^{n} \beta_5 \Delta LM1_{t-i} + \sum_{i=0}^{n} \beta_6 \Delta LEMBI_{t-i} + \varepsilon_t. \end{aligned} \quad (3)$$

As mentioned above, the bounds test will be used to verify the presence of cointegration. In this context, the null hypothesis (H_0) is formulated as follows:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0. \quad (4)$$

This hypothesis implies that there is no cointegration. On the other hand, the alternative hypothesis, which confirms the presence of a long-term relationship between the variables, is put as follows:

$$H_0 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq 0. \quad (5)$$

Thus, if the calculation of the F-statistic exceeds the upper limit in the bounds test, this indicates the presence of cointegration. However, if it falls below the test limit, the null hypothesis is not rejected, suggesting the absence of cointegration. If the F-statistic lies between the upper and lower limits, the test result is inconclusive (Pesaran, Shin, & Smith, 2001).

Determining the existence of cointegration will depend on the significance of the ECM term. For the model discussed in this paper, it will be presented in the following form:

$$\begin{aligned}\Delta LBOV_t = {} & \alpha_0 + \alpha_{it} + \sum_{i=0}^{n} \beta_1 \Delta LIPCA_{t-i} + \sum_{i=0}^{n} \beta_2 \Delta LSELIC_{t-i} \\ & + \sum_{i=0}^{n} \beta_3 \Delta LTCR_{t-i} + \sum_{i=0}^{n} \beta_4 \Delta LPIB_{t-i} + \sum_{i=0}^{n} \beta_5 \Delta LM1_{t-i} \\ & + \sum_{i=0}^{n} \beta_6 \Delta LEMBI_{t-i} + e + \omega ECM_{t-1} + \varepsilon_t .\end{aligned} \tag{6}$$

The ECM, expressed in Equation (6), makes it possible to measure the short-term impacts of the independent variables, including lags of the explained variable, and the rate of adjustment (represented by the variable ω) in the model. This rate indicates the time needed for the dependent variable to reach its long-term equilibrium after the occurrence of an exogenous shock in the short term.

The Augmented Dickey Fuller (ADF) unit root test was applied to verify the stationarity of the variables; the Durbin-Watson test was used to examine the presence of serial autocorrelation in the model; the White test was used to point out any evidence of heteroscedasticity; the LM (Breusch-Godfrey) test to analyze whether the model's residuals are autocorrelated; and finally, the COSUM, recursive COSUM and squared COSUM tests were applied to check whether the model is stable at a 5% significance level.

4. Results

4.1. Descriptive Statistics and Movement of Model Variables

Table 3 presents descriptive statistics, showing, for example, that the natural logarithm of the Brazilian stock market index (LIBOV) has an average of 11,227, with a minimum of 10,606 and a maximum of 11,806. **Figure 1** illustrates that in the period analyzed in this study, this index was at its lowest levels between 2010 and 2015, when it rose again until 2020, a year in which it was severely affected by the COVID-19 pandemic, especially from March onwards. The recovery began at the end of 2020, with the market's characteristic volatility and peaking in December 2023.

In the case of the basic interest rate (Selic) and inflation measured by the IPCA, it is interesting to note in **Figure 1** that the Selic rate experienced a significant increase from January 2010 onwards due to the increase in the IPCA observed in the same period. Similarly, after the impeachment of President Dilma in 2016, the Selic rate rose again during the Temer government, which implemented austere economic policies that contributed to reducing inflation during that period. In 2020, marked by the COVID-19 pandemic, inflationary growth returned, notably due to the increase in the prices of agricultural commodities and the breakdown

of global supply chains, which led to a new increase in the Selic rate starting in April of the following year, with a movement that only ended in August 2022, given the drop observed in the IPCA. From then on, this latter index became more stable, remaining within the full inflation target pursued by the Central Bank (4.5% per year), and allowed the basic interest rate to fall, at least until May 2024, when the sequence of declines was halted due to the increase in fiscal risk and an adverse external scenario, especially in relation to US monetary policy.

Table 3. Descriptive statistics.

Variables	Average	Minimum	Maximum	Standard Deviation
LIBOV	11.227	10.606	11.806	0.329
LIPCA	0.005	−0.006	0.016	0.003
LSELIC	0.899	0.0188	0.132	0.032
LRER	4.644	4.273	5.038	0.206
LGDP	13.217	12.554	13.777	0.304
LEMBI	5.531	4.985	6.275	0.253
LMI	19.750	19.264	20.293	0.312

Source: Own elaboration.

The annual variation of GDP, in the period analyzed by the work, highlights relevant information that can be followed through **Figure 1**. In the early 2010s, Brazil experienced robust economic growth, driven by industry (which grew 10.1% that year), followed by agriculture (growth of 6.5%) and services (whose increase was 5.4%), according to information from IBGE[2]. In contrast, between 2011 and early 2017, the country experienced a period of lower economic growth rates, due to corruption scandals, problems in macroeconomic management and large demonstrations by the population. It is important to note that in 2017, after the impeachment of then-President Dilma and the inauguration of her vice president, Michel Temer, the index, which had fallen severely in 2015 and 2016 (3.55% and 3.31%, respectively), returned to being positive, although it was around 1.0%. In the first year of the Bolsonaro government, the economic growth rate was also around 1.0% and then came the COVID-19 pandemic, which dropped domestic GDP by 3.88% in 2020. The following year, GDP grew by 3.3%, driven by fiscal and monetary stimulus granted by the government to combat the effects of the COVID-19 pandemic on the domestic economy. In 2022, fiscal stimulus was even more relevant, especially due to the Bolsonaro government's efforts to gain electoral viability in the new presidential election, implementing, in addition to increasing public spending on income transfers, measures that artificially reduced inflation. The new cycle of reductions in the Selic rate that began in the second half of 2023, the continuation of the expansionary fiscal policy, with an increase

[2]For more details, see IBGE. System of Quarterly National Accounts—SCNT.

in income transfers, the good dynamism of the labor market and the reduction in household debt through the so-called "Desenrola Brasil" Program[3] continued to drive economic growth in 2024.

Regarding the real effective exchange rate (LRER) index, Figure 1 shows a significant increase in this rate between January 2015 and January 2016, possibly associated with the political crisis that occurred during this period. During the COVID-19 pandemic, a considerable increase in the domestic real effective exchange rate index was also observed. The increase may be linked to the growth in fiscal risk during the period, attributable to extraordinary spending due to the pandemic. In addition, the difficulty in controlling the increase in deaths from COVID-19 and a slow vaccination process contributed to the extension of the pandemic, intensifying concerns regarding fiscal disruption. Fiscal noise and concerns about the interest rate in the US economy also contributed to raising the exchange rate at the end of the first half of 2024.

As illustrated in Figure 1, the movements of the EMBI performance index appear to be closely related to those of the real effective exchange rate. During the economic crisis of 2015 to 2016, a notable increase in the EMBI was observed, suggesting a greater perception of risk by economic agents. In contrast, there was a reversal of the trend from 2016 to 2017, a period in which more austere economic policies were implemented, aiming to control public spending and combat inflation. During the COVID-19 pandemic, between 2020 and 2021, the index showed an upward trajectory, stabilizing throughout 2021 until the end of 2022, with a downward movement from then on.

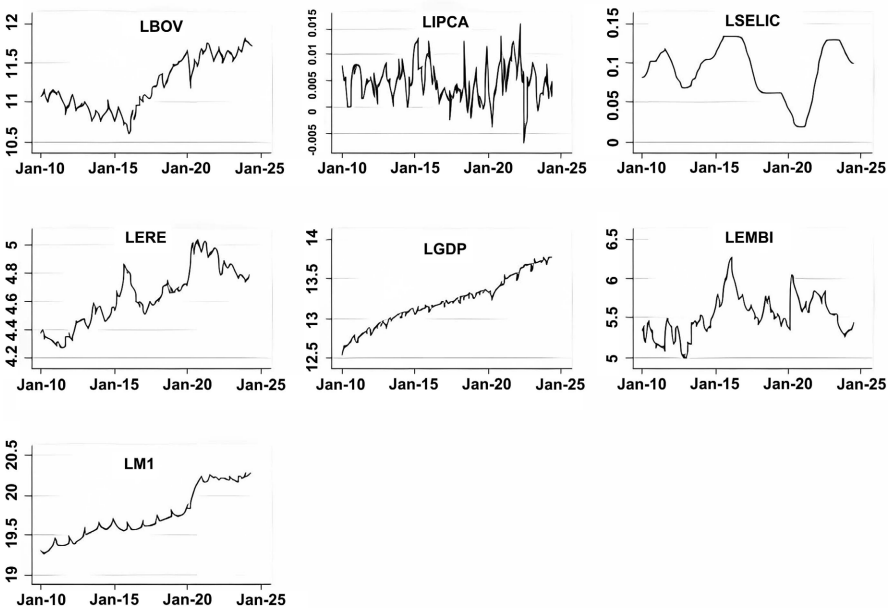

Figure 1. Evolution of model variables (Jan/2010-May/2024). Source: Own elaboration.

[3]This program aimed to encourage the renegotiation of debts of people registered in defaulters' registries to reduce indebtedness and facilitate the resumption of access to credit. It was created in July/2023 by Provisional Measure 1.176/2023, which was later transformed into Law 14.690/2023, sanctioned on 10/04/2023.

Regarding the evolution of the money supply by the M1 aggregate, Figure 1 reveals a continuous growth of this supply throughout the decade. This increase may be associated with the positive economic growth and the low incidence of the Selic interest rate observed in some months of the period analyzed in the study, which increase the demand for money, respectively, due to transaction and speculation reasons. Evidently, the price increases observed in the period also require a greater quantity of money due to the transactional reason, given that its purchasing power decreases.

4.2. Model Estimation Tests and Results

The results of the model estimation indicate how the movements observed in the explanatory variables affected the Brazilian stock market in the period analyzed in the study. Initially, it is worth noting that the Augmented Dickey Fuller (ADF) unit root test for the variables at the level is found in Table 4. As can be seen, only the LIPCA, LSELIC and LEMBI series presented stationarity at the level, while the other series are stationary in first difference.

Next, the Durbin-Watson test suggests that there is no autocorrelation problem, the White test shows no evidence of heteroscedasticity and the LM (Breusch-Godfrey) indicates that the model residuals do not have autocorrelation (Table 6). Together with the results of R^2 and adjusted R^2, these tests indicate that there is no evidence of misspecification in the estimated model (Table 6).

In turn, the Cusum Recursive, Cusum OLS and Cusum Squared tests presented in Figure 2 were used to assess the stability of the ARDL model in relation to its long-term coefficients and short-term dynamics. The upper and lower lines of these tests indicate the 5% significance level. The results suggest that the model remains stable and does not exhibit systematic structural instabilities over time.

Table 4. ADF unit root test.

Variables	Lags	Statistics (t)	Order of Integration of Series
		ADF	
LBOV	4	−7.411***	I(1)
LIPCA	1	−5.813***	I(0)
LSELIC	3	−3.120***	I(0)
LRER	1	−8.649***	I(1)
LGDP	3	−0.067***	I(1)
LEMBI	2	−2.579*	I(0)
LM1	1	−10.694***	I(1)

Source: Own elaboration. *Indicates rejection of the null hypothesis at 10% significance; **Indicates rejection of the null hypothesis at 5% significance; ***Indicates rejection of the null hypothesis at 1% significance.

Once the robustness of the model results was signaled, the bounds test was performed, the results of which presented in Table 5 indicate the presence of long-

term cointegration between variables, at the 1% significance level, since the F statistic is greater than the critical values.

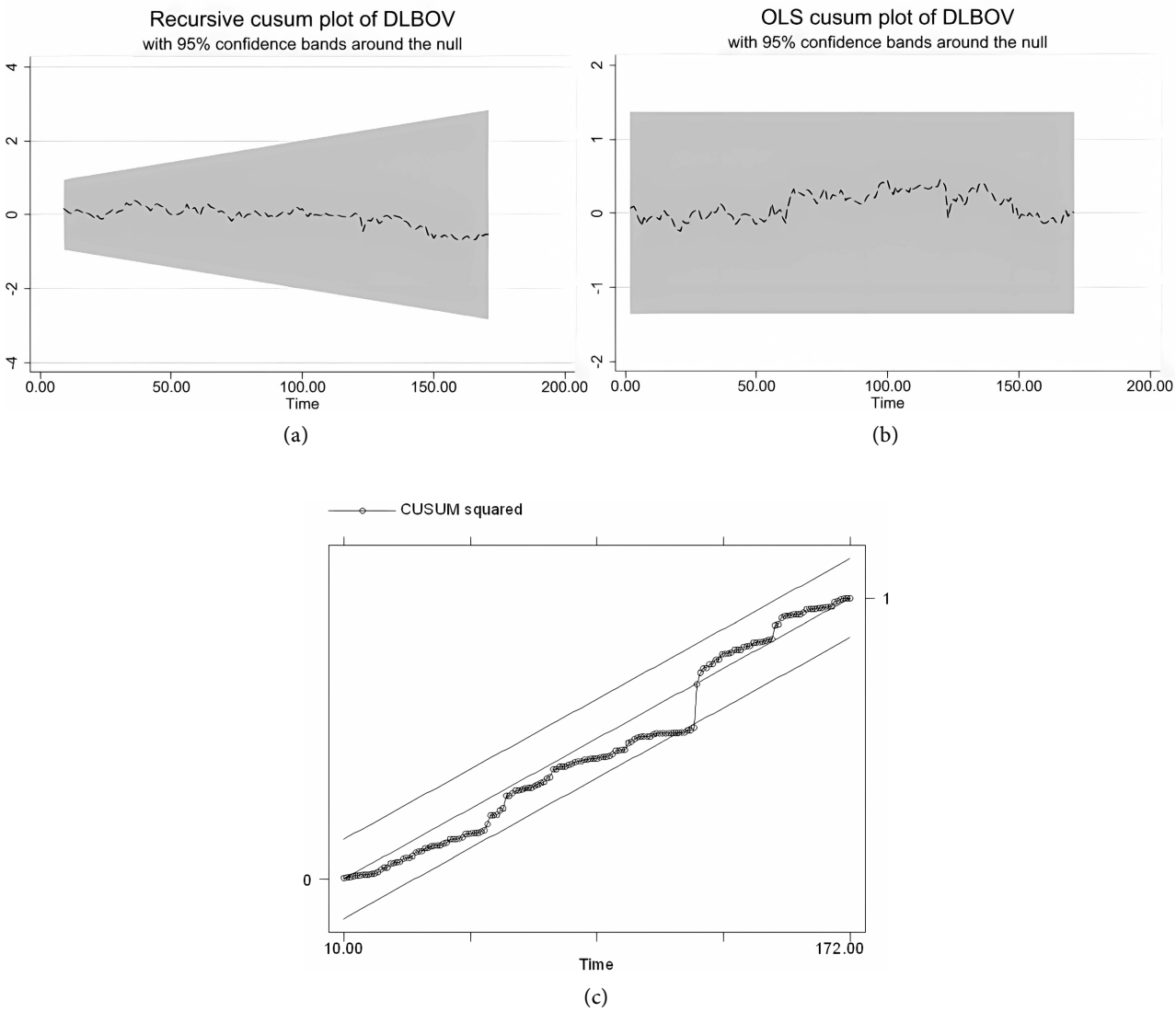

Figure 2. CUSUM tests. Source: Own elaboration.

Table 5. ARDL (Bounds Limits) cointegration test.

	Critical Values						
F statistic	I(0) *Bound*			I(1) *Bound*			Cointegration
	10%	5%	1%	10%	5%	1%	
22.571	2.142	2.485	3.228	3.292	3.721	4.628	Yes

Source: Own elaboration.

Regarding the coefficients of the explanatory variables of the model, as can be seen in Table 6 and Table 7, the only variable that did not present statistical significance in the short and long term was M1. The Selic rate and GDP were not

significant in the short term, and the others were significant in the short and long term. The coefficients found suggest that inflation measured by the IPCA has a relevant negative impact on the Bovespa index in both the short and long term. These results are in line with the empirical literature and suggest that the rise in domestic prices can have adverse impacts on the performance of stocks, since, in addition to reducing the investment capacity of economic agents, it reduces the purchasing power of consumers, thus leading to a tendency for the economy to cool down and companies' profits to reduce, making stocks less attractive from the point of view of return, as highlighted by Khan (2019).

Also as expected, although it did not show statistical significance in the short term, the basic interest rate appears to negatively affect the dynamics of the Brazilian stock market in the long term, at a 10% significance level. The suggestion is that a rising interest rate leads investors to migrate to the fixed income market, where returns are potentially higher and risks are lower, which may result in a reduction in capital raising by companies through the stock market. Other empirical studies on the subject, such as those by, Chia and Lim (2015), Khan (2019), Devkota and Dhungana (2019), Humpe and McMillan (2020), Çakir (2021) and Javangwe and Takawira (2022) presented results in the same direction.

Table 6. Estimation of long-term coefficients.

Variables	Coefficients	*P*-Value
	ARDL Model (4, 0, 1, 1, 2, 1, 0)	
LIPCA	−1.16	0.10*
LSELIC	−0.11	0.10*
LRER	−0.37	0.00***
LGDP	−0.27	0.09*
LEMBI	0.19	0.04***
LM1	0.08	0.26
R^2: 0.7241		
Adjusted R^2: 0.6967		
Durbin-Watson: 2.0468		
LM test: 0.4875		
White test: 0.4636		

Source: Own elaboration. *10% significance; **5% significance; ***1% significance.

Table 7. Estimation of short-term coefficients.

Variables	Coefficients	*P*-Value
	ARDL Model (4, 0, 1, 1, 2, 1, 0)	
LIPCA	−1.95	0.09*

Continued

LSELIC	−1.94	0.13
LRER	−0.38	0.02**
LGDP	−0.11	0.32
LGDP (1)	0.24	0.04**
LEMBI	−0.41	0.000***
LM1	0.14	0.25
EC_{t-1}	−1.16	0.00***

Source: Own elaboration. *10% significance; **5% significance; ***1% significance.

It was also observed that the real effective exchange rate (ERR) has an inverse relationship with the performance of the Brazilian stock market, at 1% and 5% significance levels, respectively, in the long term and in the short term. These results provide clues that the depreciation of the domestic currency can affect the earnings of listed companies. For Alexander and Al-Malkawi (2022) and Javangwe and Takawira (2022), the negative impact of the exchange rate on the stock market may be due to the increase in import costs of raw materials and equipment by listed companies; from the point of view of exporting companies, Khan (2019) states that their profitability can be negatively impacted by exchange rate volatility, affecting the stock market; And, in the case of India, Pal and Mittal (2011) state that in developing countries, where huge amounts of foreign currency are needed, stock prices are severely hit by exchange rate depreciation.

The Gross Domestic Product (GDP) appears to have negatively influenced the value of shares traded in the country in the short term, but in the long term, the coefficient found indicates that its lagged values have a positive impact on the domestic stock market. It is worth noting that the period analyzed by the study covers years of very significant declines in domestic economic growth, seen during 2015 and 2016, as well as in 2020, due to the COVID-19 pandemic.

The EMBI variable, which assesses the daily performance of emerging country debt securities in relation to US Treasury bonds, showed signs of negative influences on the performance of the Bovespa index in the short term and positive influences in the long term. As mentioned, the period analyzed in this study involves events that greatly increased the risk perception of economic agents, especially in 2015, 2020 and 2023, which appear to negatively affect domestic stock prices fundamentally in the short term. These results suggest that economic agents have the view that variable income assets are substitutable in relation to fixed income securities, corroborating the conclusions of Grôppo (2005).

Finally, it is important to highlight that the coefficient of the variable EC_{t-1} presented a negative sign and was statistically significant at the 1% level, as required by the ARDL model to confirm the existence of a long-term equilibrium relationship between the variables used in the model. The result found indicates that there is a relatively high speed of adjustment to long-term equilibrium.

5. Conclusion

This study aimed to examine the performance of the Brazilian stock market from January 2010 to May 2024, verifying the influence of macroeconomic factors on this market. The choice was to apply the ARDL method, which allows the cointegration test to be performed on stationary variables at the level or in first difference. The tests performed indicated that the results obtained were statistically robust and stable over time.

That said, it is pertinent to make some comments regarding the results found in this study. There are indications that inflation as measured by the IPCA is the variable that has the greatest negative impact on the value of shares traded on the Brazilian stock market, both in the short term and in the long term. In these two periods, the negative influence of the real exchange rate on the performance of the Ibovespa index also stands out.

Specifically in the short term, lagged GDP seems to be the only variable that positively affects the value of shares on the Brazilian market, while the coefficient of the EMBI index points to the relevance of country risk in explaining any falls in the value of shares traded on this market. In turn, the interest rate measured by the Selic seems to have a negative influence on B3's performance fundamentally in the long term, given that it did not show statistical significance in the short term.

Based on these results, it is understood that the performance of the Brazilian stock market appears to be directly linked to a stable economic environment, characterized by low levels of inflation and interest rates, compatible with the maintenance of economic growth. Obviously, the results of this study are related to a specific period and as is known, macroeconomic variables do not have similar behavior over time, being subject to supply shocks, political factors, changes in the external scenario, among other factors that can alter them in the short and long term. This suggests the need for new studies in the future to once again assess the impact of macroeconomic variables on the Brazilian stock market and may even explore potential asymmetries in the relationship between macroeconomic variables and the stock market, analyzing possible changes in the indicators used in the study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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