A comparative analysis of macroeconomic and financial variables' influence on Brazilian stock and real estate markets

Abstract

Numerous studies have sought to investigate the relationship between macroeconomic variables and financial market evolution. Such analyses, however, have focused on the stock market. The present research, as a distinction, included the index of real estate funds (IFIX) in its approach. In this context, the study comparatively analyzed the impact of macroeconomic indicators (interest rates, inflation, industrial production, and the exchange rate) and financial indicators (the S&P 500 and the oil price) on the Ibovespa and the IFIX from January 2015 to December 2019. This period was chosen due to the peculiar characteristics of the resumption of economic growth after the 2014–2016 recession in a context of changes in the degree of intervention in the economy. The research addressed the historical evolution of stock and real estate fund indices, such as the Ibovespa and the IFIX, respectively, which showed a positive trajectory, especially from 2016 onward. To achieve its objective, the research applied the vector with error correction (VEC) econometric model to determine whether there is a possibility of diversification between the two markets. Among the results obtained were relatively convergent behavior of the Ibovespa and the IFIX in the face of macroeconomic and financial shocks, according to the impulse response functions of the estimated econometric model, which prevents diversification between the two markets.

Keywords: Financial market; Stock market; Real estate market; Ibovespa; IFIX

1. Introduction

The Brazilian financial market, especially from the 2000s onward, underwent an evolutionary process in terms of new products in an economic context of price stability consolidation with the implementation of an inflation-targeting regime, relative fiscal balance, and a floating exchange rate. In this scenario, the main stock exchange in Latin America, Bolsa do Brasil (B3), showed intense growth in terms of both value and volume of operations, with a strong increase in the number of investors, in an international scenario marked by high liquidity and rising commodity prices. The expansion process, however, was interrupted by the 2008 international financial crisis. After the crisis, the main international markets recovered, while the Brazilian stock exchange showed less dynamic behavior, which was also due to changes in the macroeconomic policy. In the 2010s, the Brazilian economy experienced a period of stagnation that, among other factors, resulted in a strong recession in 2014–2016, which in turn led to a significant drop in the value of financial assets.

After the end of the recession, it was possible to observe a consistent drop in the basic interest rate in a scenario of low inflation and ample international liquidity. Parallel to the social security reform, completed in 2019, there was optimism in the market about the future of the economy as the government signaled that other reforms would take place, such as administrative and tax reforms, to solve the fiscal problem in the country. As a reflection of this movement, the Ibovespa, the main Brazilian stock index, reached an important historical mark of 117,203 points in December 2019. In nominal terms, the annual return was 31.58%. The real estate fund index (IFIX) had a return of 35.98% in the same year. Also in 2019, the number of individuals registered on the Brazilian stock exchange surpassed 1.5 million.

In this context, this article adopts a comparative approach to identify the impacts of macroeconomic and financial indicators on the Ibovespa and the IFIX and to seek an answer to the following question: How did macroeconomic and financial variables influence the Ibovespa and the IFIX, comparatively, in the period from 2015 to 2019? The research hypothesis was that there are differences between the impacts of the main macroeconomic variables (the interest rate, industrial production, inflation, and the exchange rate) and those of the financial indicators (the S&P 500 and the oil price) that occurred in the period from 2015 to 2019, on the market stock and in real estate. Thus, the study aimed to determine whether it is possible to diversify the risk, from investors' perspective, between the two markets.

The period studied was justified by the fact that the Brazilian economy suffered a strong recession between 2014 and 2016 and that, since 2015, the economic indicators have gradually started to show signs of a mild recovery, despite the fact that the recession only ended in 2016, as shown by Vartanian and Garbe (2019). In addition, for the second time in history after the constitution of 1988, a process of impeachment of the president began, also in 2015, which culminated in a change of the country's government in 2016. The shares and bonds traded on B3 reacted positively to the new government. At the same time, there was an important advance in the real estate fund market, which developed with the creation of several classes. As a methodology, the research applied an econometric vector autoregressive (VAR) model. Due to the characteristics of the series used, which have a unit root, as will be detailed later, the study adopted a VAR model with error correction, called the vector error correction (VEC) model.

To achieve the research objectives, in addition to this introduction, the research is organized as follows. Section 2 discusses the theoretical framework, which presents not only the main references concerning the topic in question but also a brief description of the capital market's historical evolution in Brazil. Subsequently, section 3 provides the research methodology, which consists of the application of an autoregressive vector model with error correction (VEC model), and the data used. In section 4, the analysis of the results and the discussion are presented. Finally, section 5 contains the study's final considerations.

2. Literature Review

One of the most relevant indexes in the Brazilian and Latin American capital markets is the Ibovespa index, created in 1968 and used to measure the performance of the stock market as it represents the largest publicly traded companies in Brazil and their respective performance. The index is the main financial performance indicator of the most traded securities on B3. According to Meurer (2006), the index works as a thermometer that measures the Brazilian stock market through a point system based on reais (R$) and that calculates the average performance of a theoretical portfolio with the largest shares, represented and traded on the stock exchange. The index, in addition to considering the variations in the prices of the assets that are part of its theoretical portfolio, also reflects the payment of all types of earnings of the companies that issue such shares, according to Costa Junior (1990).

One of the operating presuppositions of the world financial market is based on the efficient market hypothesis of Fama (1970), in which the negotiated prices incorporate all the information available to all the participants in this industry. As knowledge is transmitted at an ever-increasing speed, macroeconomic, social, and environmental data, among others, can change the dynamics of various stock exchanges around the world. Economic changes in one country can affect other economies and thus systematically alter the flow of capital from one country to another. Several authors, such as Farber and Hallock (1999a, 1999b), Floros and Tsetsekos (1996), Hardouvelis (1986), Hu and Li (1998), Jain (1988), and Rapach (2001), have conducted studies to analyze the macroeconomic and financial impacts of stock prices in different countries.

According to Santos (2021), among the 20 largest stock exchanges in the world, B3 occupies the 10th position for market value. Among the American countries, it is the third-largest stock exchange, behind only to the USA and Canada, which shows the relevance of the indexes chosen for the study since B3 is the largest exchange in Latin America. In addition to the Ibovespa index, which, as mentioned, is the main index of B3 and represents the Brazilian stock market, another selected indicator, also from B3, is the IFIX, which represents real estate investment funds (FII) and which showed itself in the period of research to be one of the financial assets that has experienced strong growth in recent years. According to Anbima (2019), real estate funds reached the record mark of 1 million shareholders in the first half of 2019, double the number of active accounts in the same period of 2018. After the 2014–2016 recession, there was a resumption of the real estate market, thus boosting the positive performance of real estate funds. Currently, there are 412 real estate funds across the country, according to Anbima (2021). With a scenario of falling interest rates, real estate investment fund issues have followed a trajectory of annual growth, rising from R$13.41 billion in 2018 to R$41.4 billion in 2019.

Brazil's economic history over the years has been characterized by economic and political cycles. Brazil is one of the largest iron ore producers and is the third-largest exporter of soy in the world, in addition to having a reference industrial center in Latin America and a solid and secure financial system. Thus, like every developing economy, it continues to experience economic cycles, which are also caused by political issues. In early 2016, due to the coercive conduct of former president Luís Inácio Lula da Silva, who was accused of corruption, there was a perception that the government at the time, characterized by increased intervention in the economy and unsustainable macroeconomic policies, would not be able to remain in charge. On August 31 of the same year, President Dilma Rousseff lost the position of President of the Republic, and the Vice President, Michel Temer, assumed the position of head of the executive power in Brazil. These political changes constituted one of the motivations for this research, in addition to the fact that Brazil is the largest country in Latin America, with the largest GDP and population in the region.

In Brazil, there are multiple titles aimed at real estate ventures or businesses. Among the various existing securities, the IFIX is a total return index that measures the average performance of the quotations of a theoretical portfolio of real estate funds, composed of the most traded funds on B3 and weighted by the funds' market value. Real estate investment funds were regulated in 2008, and since then they have become one of investors' preferences. According to Scolese et al. (2015), investors in real estate funds seek profitability through a constant flow of income in the form of rent or other types of real estate income, such as real estate appreciation. The real estate fund industry consists of several segments, such as shopping malls, corporate buildings, warehouses for logistics distribution centers, bank agencies, schools, hospitals, hotels, and residential properties, among others. There are also real estate funds that finance real estate transactions, called receivable funds. In this case, the property does not exist and the objective is to finance the sector's expansion projects, comprising financial bills (certificates of real estate receivables, real estate credit bills, and mortgage bills, which are certificates representing receivable debt. Another category is mixed funds, the asset portfolios of which concentrate on real estate bills and real estate from widely varying sectors. The IFIX, which is the industry index, was created in 2012 with the objective of measuring a specific portfolio composed of real estate funds listed in trading environments within B3. The calculation is retroactive, starting on December 30, 2010, with an initial quotation of 1,000 points. Having a benchmark allows market participants to compare the performance of their investments as well as enabling the preparation of analytical studies, according to Moraes and Serra (2017).

The IFIX was included in some rare studies in the literature that sought to analyze the impact of macroeconomic variables on the index that represents the real estate market. Maia and Souza (2015) estimated a multiple linear regression model, using ordinary least squares (OLS), to assess the factors that affected the IFIX, such as the interest rate and the General Real Estate Market Index (IGMI-C), in addition to the Ibovespa. The authors found strong explanatory power of the interest rate and IGMI-C over the IFIX. The Ibovespa variable did not show a significant influence on the IFIX. According to Marchiori et al. (2015), who used a vector autoregressive (VAR) model, there is a weak relationship between the IFIX and the Ibovespa. Thus, in the authors' view, diversifying real estate funds and stocks linked to the Ibovespa may reduce the overall risk of a portfolio. According to Orru Neto (2015), who analyzed the relationship between the IFIX, inflation, the exchange rates, and the Ibovespa through a multifactorial model to identify a possible hedge for economic variables, the IFIX offers better protection when there is market turmoil than investments in the stock market, but the study found no protection against macroeconomic variables, such as the inflation and exchange rates.

The S&P 500 index, which measures the performance of the shares of 500 large American companies listed in different sectors on the US stock exchange, has also been studied based on shocks in macroeconomic and financial variables. In studies such as those by Ajayi et al. (1998), Funke (2006), Heaney (2002), Humpe (2009), Matsuda (2006), and Sirucek (2012), the researchers' aim was to investigate whether there is a significant relationship between stock market returns and changes in macroeconomic variables.

In addition to traditional macroeconomic variables, such as the interest rate and inflation, for example, many studies, such as those by Basher (2012) and Sirucek (2012), have used oil prices as a relevant variable for analyzing the effects on financial markets. According to Sadorsky (1999), an increase in oil prices results in inflationary pressure; that is, it causes an increase in interest rates, which directly affects the fall of the stock market. In this sense, Grigoryev (2010) pointed out evidence that the oil price effect has a high negative correlation with the stock market.

For the purposes of this research, the variables considered were the GDP, inflation, the interest rate, and the exchange rate as macroeconomic indicators, in addition to the oil price and the S&P 500 index as financial variables. The influence that such variables are able to exert on the Ibovespa and IFIX indices was observed. The selected variables have appeared recurrently in the aforementioned studies as well as in the analyses by Caselani (2005), Grôppo (2006), and Pimenta Júnior and Higuchi (2008).

According to Cusinato (2013), the gross domestic product (GDP) represents the value of all goods and services produced in a country, which can then be used as a "thermometer" of the economy, while the Industrial Production Index (IP) is considered to be the most important indicator for measuring the level of economic activity in a country. The available industrial production data are usually more frequent than the GDP data. While GDP data are presented on a quarterly basis, industrial production data are presented on a monthly basis. In this context, it is common to use industrial production to estimate economic cycles. According to Humpe (2009), analyses or comparisons in relation to aggregate production can use the gross domestic product or industrial production. Authors such as Chen et al. (1986), Maysami and Koh (2000), and Mukherjee and Naka (1995) used industrial production in their analyses to compare the influences on the capital market. Data from the Industrial Production Index were used as a proxy for the GDP in this research as well.

The basic interest rate in Brazil is the Selic rate, defined every 45 days at the meetings of the Monetary Policy Committee of the Central Bank of Brazil (Copom). Grôppo (2006) stated that there is an inverse relationship between the interest rate and the Ibovespa. When the interest rate decreases, investors tend to seek investment alternatives to obtain greater gains, taking on greater risks. In this context, the variable income market is one of the alternatives. According to Pimenta Júnior and Higuchi (2008), the increase in the basic interest rate makes the fixed income market more attractive, causing an exchange with the capital market for fixed income. According to Caselani and Eid Junior (2008), an increase in the interest rate reduces the value of companies, increasing the volatility of stock returns. Pimenta Júnior and Higuchi

(2008) used a VEC model and determined that the Ibovespa is affected by the Selic rate and the exchange rate.

In another study, Pimenta Júnior (2004) indicated that the high inflation rate affects economic activity, thus influencing the Ibovespa. The author identified a negative relationship between the inflation rate and the Ibovespa. The study also applied the Granger causality test and found that inflation, in addition to other macroeconomic variables, is causally related to the Ibovespa. Silva (2012) established, through the application of a VEC model, that inflation, measured by the IPCA, the GDP, and the exchange rate, has a significant impact on the Ibovespa. The study also applied the Granger causality test and identified bidirectional causality between inflation and the Ibovespa. Santana et al. (2018) asserted that the Ibovespa is explained by the IPCA and the Selic.

Regarding the exchange rate, Vartanian (2012) identified significant long-term relationships regarding the behavior of the stock market and the exchange rate. When analyzing the studies on the returns of the financial market and the exchange rate, the study by Ajayi et al. (1998) is also prominent; these authors sought to understand the relationship between stock returns and exchange rate variations, finding unidirectional causality in the Granger sense of stock returns compared with the exchange rate. According to Lee and Solt (2001), the exchange rate variations induced by macroeconomic factors indicate a devaluation of financial market assets; that is, the stock market reacts negatively to exchange rate devaluations.

In the empirical literature review, research was also sought to determine which variables influence the Ibovespa and the IFIX in a comparative way, but no comparative studies were found. Caselani and Eid Junior (2008) identified an influence of macroeconomic indicators on the volatility of the Ibovespa between January 1995 and September 2003. They used 35 shares and based their investigation on the closing price of the shares in the sample. The macroeconomic variables used in their study were obtained from the database of the Institute for Applied Economic Research (IPEA): the real interest rate, the GDP, inflation, and the exchange rate. In addition, the representation by the US Dow Jones Stock and the New York Stock Exchange indices was considered. The study concluded that, in Brazil, as in the United States, macroeconomic indicators directly affect the stock market.

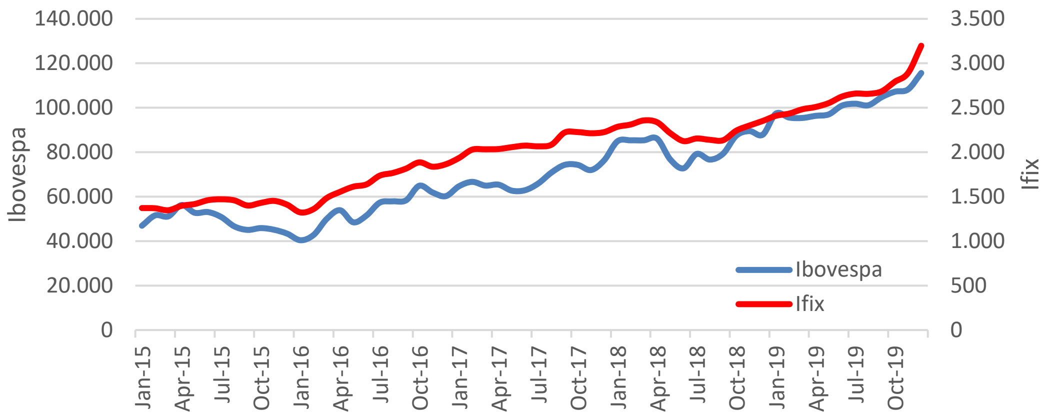
Leite et al. (2012) stated that the analysis of data that affect the financial market must consider the relationship between the exchange rate and the Ibovespa, especially in times of international crises. The period investigated in the authors' study was from July 2008 to January 2019. They found a significant relationship between the exchange rate, inflation, and the Ibovespa and a negative reaction of the Ibovespa to an exchange rate devaluation.

Vartanian (2012) assessed the existence of the contagion effect of the Dow Jones index, commodity prices, and exchange rate in the period 1999–2010 on the Ibovespa. The study showed that the Brazilian stock index reacts positively to commodity price shocks and the Dow Jones index, in addition to reacting positively to exchange rate depreciation. The study also found evidence of co-integration between the Brazilian and the American stock exchange but no evidence of long-term interactions between the Ibovespa, the commodity prices, and the exchange rate. Another study, by Grôppo (2006), related the dynamics between the Ibovespa and monetary policy variables and showed that interest and exchange rates (in the short and long term) affected the Ibovespa index.

3. Methodology

To investigate the comparative influence of macroeconomic and financial variables on the Brazilian stock and real estate markets, an autoregressive vector model was estimated based on the main variables identified in the literature. The selected time frame consisted of the period between January 2015 and December 2019, with the selection of closing data from both the Ibovespa and the IFIX. The choice of the initial period resulted from political and economic changes and the beginning of a process of gradual recovery of the variable income market in Brazil after the stagnation verified in the first half of the decade. The end of the period was justified by the availability of data during the period of the research and by the wish to avoid the sudden changes caused by the COVID-19 pandemic.

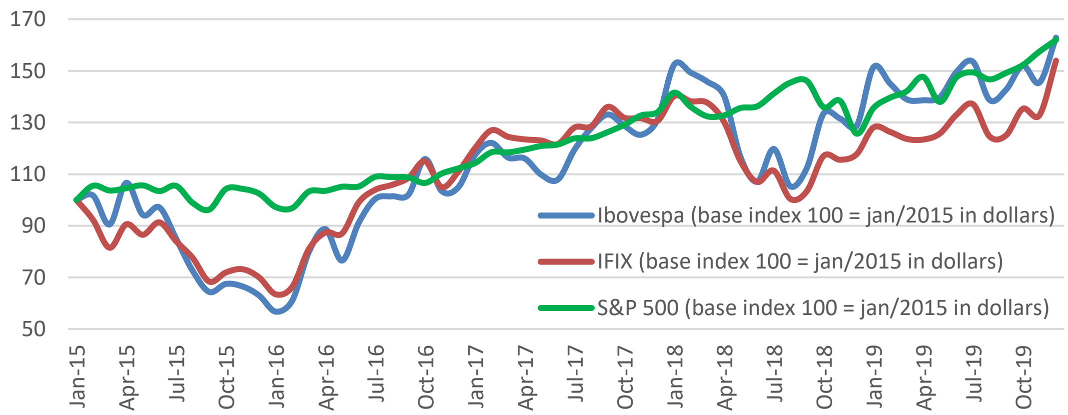
Figure 1. Evolution of Ibovespa and IFIX (January 2015 to December 2019)



Source: Economática.

In Figure 1, it is possible to observe the growing trend of both the Ibovespa and the IFIX between 2016 and 2018, with a relatively correlated movement. The bull movement was caused by the expectation of a resumption of economic growth. At the same time, in 2018, federal (president, senators, and federal deputies) and state (state governors and deputies) elections took place, and the liberalization of economic reforms was expected. The first reform, carried out in 2019, was the pension reform, which was even one of the government's campaign promises. The demonstration that the country would make progress in reforms, associated with the resumption of growth, promoted positive stimuli in the financial market.

Figure 2. Evolution of Ibovespa, IFIX e S&P 500 (January 2015 to December 2019)



Source: Economática.

For illustration purposes, Figure 2 shows, comparatively, an initial investment of US$100.00 in the Ibovespa, IFIX, and S&P 500 in January 2015 and evaluates the return on such investment until December 2019. According to Figure 2, the accumulated profitability was 62.84% on the Ibovespa, 53.94% on the IFIX, and 61.94% on the S&P 500. It is possible to perceive a relative convergence in terms of profitability in the period analyzed.

Specifically in relation to this research, the indices analyzed were the Ibovespa, which represents the stock market, and the IFIX, which represents the real estate market. In addition, monthly time series of selected macroeconomic and financial variables were collected from January 2015 to December 2019 based on the literature presented in the theoretical framework. The variables, with their respective sources and monthly frequency, are presented below:

i) Exchange rate: This corresponds to the nominal exchange rate expressed in R$/US$ extracted from the Central Bank of Brazil's database, represented by ER in this study.

ii) Inflation: Brazil's official inflation index, in the context of the inflation-targeting regime, is the Broad Consumer Price Index (IPCA), calculated by the Brazilian Institute of Geography and Statistics (IBGE). The series was extracted from the IBGE database and is represented by CPI.
iii) Interest rate: The basic interest rate of the Brazilian economy is the Selic rate, as mentioned above. The series, represented by IR, was also extracted from the Central Bank of Brazil's database.
iv) Industrial production: Industrial production was included to understand the behavior of the economy. It was used, as in other studies, as a proxy for the GDP and was extracted from the Central Bank of Brazil's database. The series is represented by IP.
iv) Oil price: One of the most important commodities in the world, represented by OIL, the Brent oil price series was extracted from Economática. Even though oil is one of the most important commodities today, it was considered as a financial variable because the prices have been affected more by financial issues than by the supply and demand for oil itself.
v) S&P 500 index: The S&P 500 index is the main index of the American stock market and a benchmark for the world market. It is represented by SP_500 and was extracted from the Economática database.
vi) Ibovespa: This is the main Brazilian stock index, represented by IBOV, and the closing price of the Economática database was extracted.
vii) IFIX: This is the benchmark index for real estate funds. It was represented in the survey by IFIX and also used the closing price of the Economática database.

Table 1 presents the main descriptive statistics of the variables in the selected research period. It is possible to observe that the Ibovespa averaged approximately 70 thousand points, reaching a minimum value of 40,405 and a maximum value of 115,645. The IFIX presented a very close mean and median, around 2400 points. With regard to macroeconomic indicators, it is possible to verify that inflation was situated in the interval between deflation of 0.23% in one month and a rise of 1.32% in the month in which it reached its peak. The exchange rate averaged R$3.53/US$ over the period. Industrial production shows the cyclical nature of the Brazilian economy, oscillating between a monthly drop of over 13% in a single month and a rise of just over 9% in another. With respect to the price of oil, the average price was US$57.5/barrel, while the Brazilian interest rate had a monthly average of 0.78% per month; it is traditionally higher than international standards. In addition, the interest rate was high in the period, despite international liquidity, to keep inflation within the bands established by the inflation-targeting regime.

Table 1. Descriptive statistics of variables from 2015 to 2019

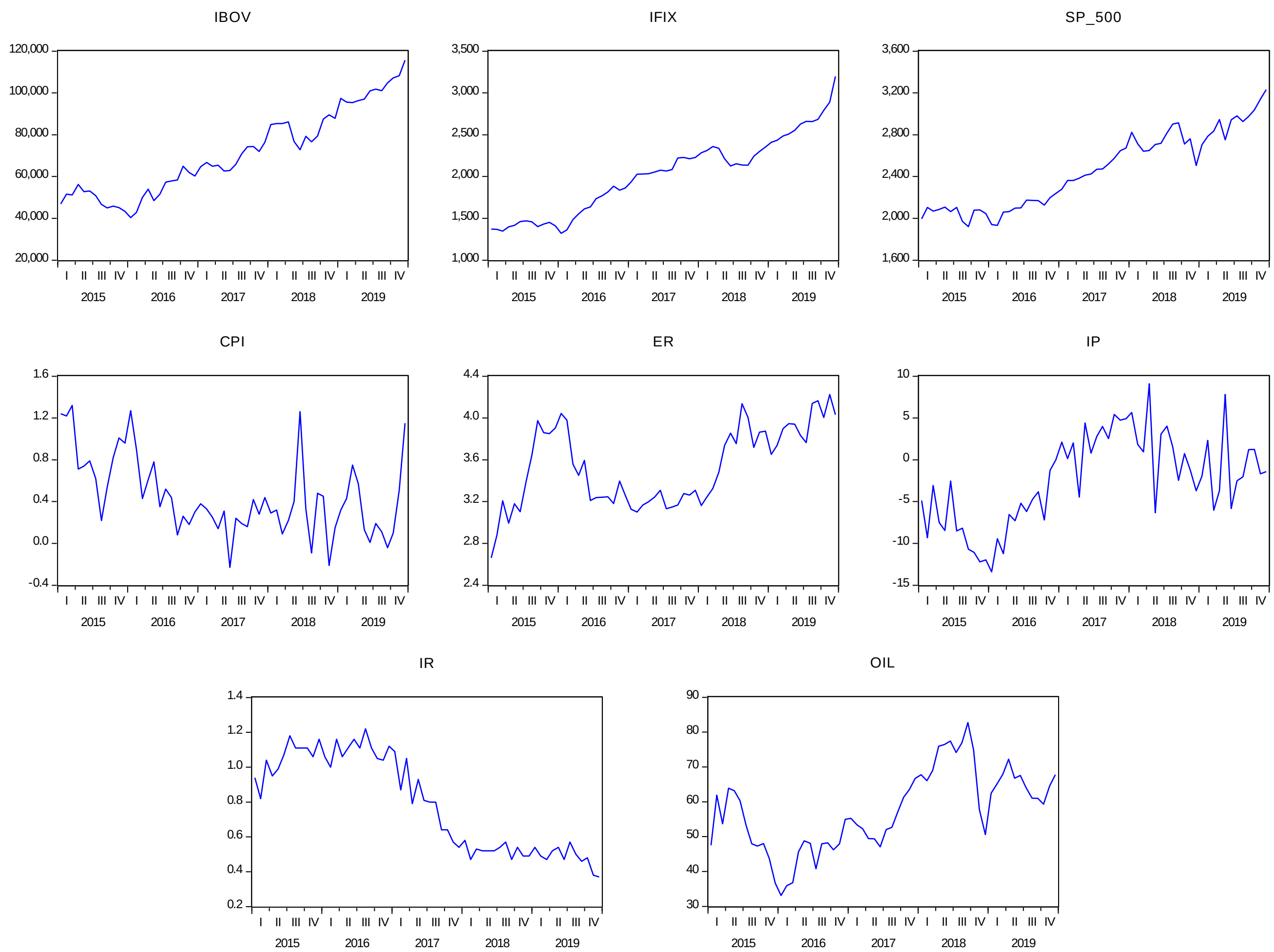
	IBOV	*IFIX*	*SP_500*	*CPI*	*ER*	*IP*	*OIL*	*IR*
Average	71.172	2.015	2.459	0,45	3,53	-2,41	57,51	0,78
Median	66.291	2.070	2.446	0,36	3,46	-2,25	57,36	0,80
Minimum	40.405	1.322	1.920	-0,23	2,66	-13,39	33,14	0,37
Maximum	115.645	3.197	3.230	1,32	4,22	9,08	82,72	1,22
Standard Deviation	20.229	464	365	0,37	0,38	5,45	11,62	0,27

Source: Own elaboration based on calculations made in the econometric package.

Figure 3 shows the behavior of the variables between 2015 and 2019. It is possible to observe, in addition to the positive evolution of the Ibovespa, the IFIX, and the S&P 500, the trajectory of the other macroeconomic and financial variables. The change in the level of the Brazilian interest rate after the drop started in 2016 is noteworthy, and it is comparable with the drop in inflation. At the same time, industrial production was recovering after the 2014–2016 recession but still showed occasional declines in the subsequent period. From an international point of view, oil prices followed an upward trend from 2016 to 2018, and the exchange rate, which involves internal and external determinants, appreciated in 2016, with a new devaluation process from 2018.

Specifically in relation to the Ibovespa and IFIX indices, relevant growth is apparent from 2016 to 2019, motivated by the drop in interest rates and the relative control of inflation, in addition to the end of the recession. It is in this context that the impacts of macroeconomic variables on the Ibovespa and the IFIX were analyzed comparatively using a vector autoregressive (VAR) model.

Figure 3. Evolution of variables in the period 2015-2019



Source: IBGE, Banco Central do Brasil and Economática.

Gujarati (2019) stated that the VAR model uses two or more time series simultaneously, an approach that is appropriate for the purposes of this research. According to Vartanian (2010), one of the main applications of the VAR model concerns the use of impulse response functions, that is, the behavior of a variable when another one suffers a shock (impulse) at the same time t, advancing to another period, at t+1, t+2, and so on. In this sense, impulse response functions were used as a result of the estimation of the model as they allow the comparative evaluation of the effects of shocks on macroeconomic and financial variables. The algebraic form of the VAR can be described as follows:

$$y_t = A_1 \, y_{t-1} + \ldots A_N \, y_{t-N} + Bx_t + \mathcal{E}_t \qquad (1)$$

where
y_t = endogenous variable vector
x_t = exogenous variable vector
$A_1 + \ldots + A_N$ and B = matrices of coefficients to be estimated
$\mathcal{E}_t$ = self-correlated innovation vector

Generally, when estimating a VAR model, all the variables are considered as endogenous, although it is possible to include exogenous variables in the model. Lien and Luo (1994) asserted that the VAR model excludes the possibility of two or more series being cointegrated. To solve the problem, the VEC model (VAR model with error correction), when carrying out the error correction, considers the equilibrium relationships of the variables in the long run and therefore takes into account the existence of cointegration between the variables. In this context, with the error correction mechanism in the VAR model, Maysami and Koh (2000) stated that the VEC model produces more efficient estimators of cointegrating vectors. Another advantage of using VAR/VEC models is that they do not require a priori assumptions, which usually occur when one of the model's regressors is correlated with the error, generating endogeneity problems. To decide between the VAR model and the VEC model, it is necessary to analyze the series for stationarity and apply cointegration tests. According to Gujarati (2019), the VAR model requires the time series to be stationary. If the individual variables of the VAR are not stationary but cointegrated, the VAR can be estimated taking into account the error correction term, obtained from the cointegration relationship, which results in the estimation of a VEC model.

In a hypothetical system with two variables and a cointegration equation, the cointegration equation has the following algebraic form:

$$y_{2,t} = B\, y_{1,t} \qquad (2)$$

with the following VEC model:

$$\Delta y_{1,t} = a_1\,(y_{2,t-1} - B\, y_{1,t-1}) + e_{1,t} \qquad (3)$$

$$\Delta y_{2,t} = a_2\,(y_{2,t-1} - B\, y_{1,t-1}) + e_{2,t} \qquad (4)$$

The right side of equations 3 and 4 reflects the error correction term, which is equal to zero in the long-term equilibrium, but y_1 and y_2 can adjust in the short term to the long-term equilibrium relationship according to the speed of adjustment of the endogenous variables given by coefficients a_1 and a_2.

Table 2. Dickey-Fuller Unit Root Test

Variable	*Lags*	*Constant*	*Trend*	*Test Statistics*	*P-Value*
IBOV	6	Yes	Yes	-3,52	0,04
IFIX	1	No	No	-1,10	0,93
SP_500	0	Yes	Yes	-3,09	0,11
CPI	0	Yes	No	-3,91	0,01
ER	3	Yes	No	-2,17	0,50
IP	3	No	No	-1,09	0,92
OIL	1	Yes	Yes	-2,90	0,16
IR	3	No	No	-1,09	0,92

Source: Own elaboration based on calculations carried out in the Gretl econometric package

In this context, to determine which model (VAR or VEC) to use initially, a unit root test was applied to the variables. The results obtained from the Dickey and Fuller unit root test, one of the most frequently used tests in the literature, can be seen in Table 2. According to the test results, only the IBOV and CPI variables do not have a unit root. The other variables have a unit root and are therefore non-stationary. In this case, the cointegration tests must be carried out to evaluate the estimate using a VEC model. For the purposes of this study, two models were estimated: one with the Ibovespa series and the other economic and financial variables and the other with the IFIX series and the same economic and financial variables.

As mentioned, in the presence of a non-stationary series, which can be cointegrated, the VEC model must be estimated. Thus, after detecting non-stationarity, the presence of cointegration must be evaluated, and the Johansen (1988) cointegration test is the most commonly used test for this purpose. To perform the cointegration test, however, it is necessary to select the appropriate number of lags, and accordingly the statistical criteria of Akaike (1974) and Schwarz (1978) were calculated. It is important to include the appropriate number of lags in the model; after all, the greater the number of lags, the greater the number of parameters to be estimated, which will result in a loss of degrees of freedom in the estimation process. In this context, simulations were carried out with different lag criteria, which also resulted in different numbers of cointegration equations, and the best model for each of the variables, IFIX and Ibovespa, can be chosen from the results presented, respectively, in Table 3 and Table 4.

Table 3. Selection of the number of lags and number of cointegration equations - Ibovespa

Lags	*Cointegration equations*	*Log likelihood*	*Akaike*	*Schwarz*
1	1	344.90	-9.49	-6.99
2	4	458.50	-10.44	-4.67
3	4	499.40	-10.33	-2.74

Source: Own elaboration based on calculations made in the econometric package.

Estimates were made considering the possibilities of models with one, two, and three lags, the results of which are reported in Tables 3 and 4 for the Ibovespa and the IFIX, respectively. The estimates aimed to define the optimal number of lags to be used according to the Akaike and Schwarz penalty criteria. According to Akaike's criterion, the ideal number of lags in the case of the Ibovespa model is two, but, according to Schwarz's criterion, the ideal model is the one that uses only one lag. In this context, according to the use of the criterion of parsimony, the model with one lag was selected for the case of the Ibovespa, which in turn presented a cointegration equation.

Table 4. Selection of the number of lags and number of cointegration equations - IFIX

Lags	*Cointegration equations*	*Log likelihood*	*Akaike*	*Schwarz*
1	3	400.62	-10.43	-6.95
2	5	468.94	-10.31	-4.04
3	3	485.96	-10.35	-3.26

Source: Own elaboration based on calculations made in the econometric package.

For the case of the IFIX, the results of which are reported in Table 4, both the Akaike and the Schwarz criterion indicated that the model with a lag was the best model since the lowest possible values were found in both: -10.43 and -6.95. In the case of the IFIX model, the estimate with one lag resulted in three cointegration equations. In this context, a VEC model with one lag and three cointegration equations was estimated. This is because the use of non-stationary series in econometric estimates, according to Vartanian (2010), requires the identification of the spurious regression problem, highlighted by Granger and Newbold (1974). In this sense, it may be necessary to adjust the behavior of variables and correct errors in the VAR model. Thus, the model need to be tested to identify possible cointegration vectors. One way to identify the existence of cointegration is to perform the Johansen (1988) cointegration test, which serves to estimate the presence and number of cointegration vectors. The null hypothesis of the test is that there is no cointegration vector, the alternative hypothesis being that there is at least one cointegration vector. Thus, the cointegration test is necessary to identify the number of cointegration equations that are present in the relationship between the model variables. One of the possible ways of interpreting the results is based on trace statistics. In this context, the results of the cointegration test can be seen in Tables 5 and 6.

Table 5. Cointegration test - Model with Ibovespa

Cointegration equations	*Eigenvalue*	*Trace Statistic*	*Critical Value 5%*	*P-Value*
None*	0.711282	162.9895	125.6154	0.0000
Almost 1	0.442761	90.93578	95.75366	0.1025
Almost 2	0.369573	57.01962	69.81889	0.3381
Almost 3	0.239736	30.26087	47.85613	0.7056
Almost 4	0.129637	14.36364	29.79707	0.8196
Almost 5	0.097032	6.310617	15.49471	0.6588
Almost 6	0.006713	0.390694	3.841466	0.5319

Source: Own elaboration based on calculations made in the econometric package.

The results of the cointegration test for the model that considers the Ibovespa, observed in Table 5, indicate the presence of a cointegration equation since the trace statistic reveals the rejection of the null hypothesis of the absence of a cointegration vector at the 5% significance level. The Johansen cointegration test therefore ensures that the VEC model, which includes the error correction term, is the best model according to the presence of non-stationarity in some variables and in the presence of a vector of cointegration.

Table 6. Cointegration test - Model with IFIX

Cointegration equations	*Eigenvalue*	*Trace Statistic*	*Critical Value 5%*	*P-Value*
None*	0.651623	165.4927	125.6154	0.0000
Almost 1*	0.438252	104.3334	95.75366	0.0113
Almost 2*	0.392602	70.88466	69.81889	0.0410
Almost 3	0.275864	41.96755	47.85613	0.1596
Almost 4	0.226107	23.24652	29.79707	0.2342
Almost 5	0.113627	8.379875	15.49471	0.4257
Almost 6	0.023580	1.384052	3.841466	0.2394

Source: Own elaboration based on calculations made in the econometric package.

The results presented in Table 6 reflect the number of cointegration equations of the model for the IFIX. In this case, the Johansen cointegration test revealed the presence of three cointegration equations since it is possible to reject the absence of up to two cointegration equations at the 5% significance level. In addition, it is not possible to reject the absence of three cointegration equations according to the critical value of the trace statistic. Thus, the amount of cointegration vectors obtained in the test must be used to estimate the model. From the estimate, the impulse response functions can be obtained, making it possible to compare the trajectory of shocks in macroeconomic and financial variables on the Ibovespa and on the IFIX, which can be seen in the next section.

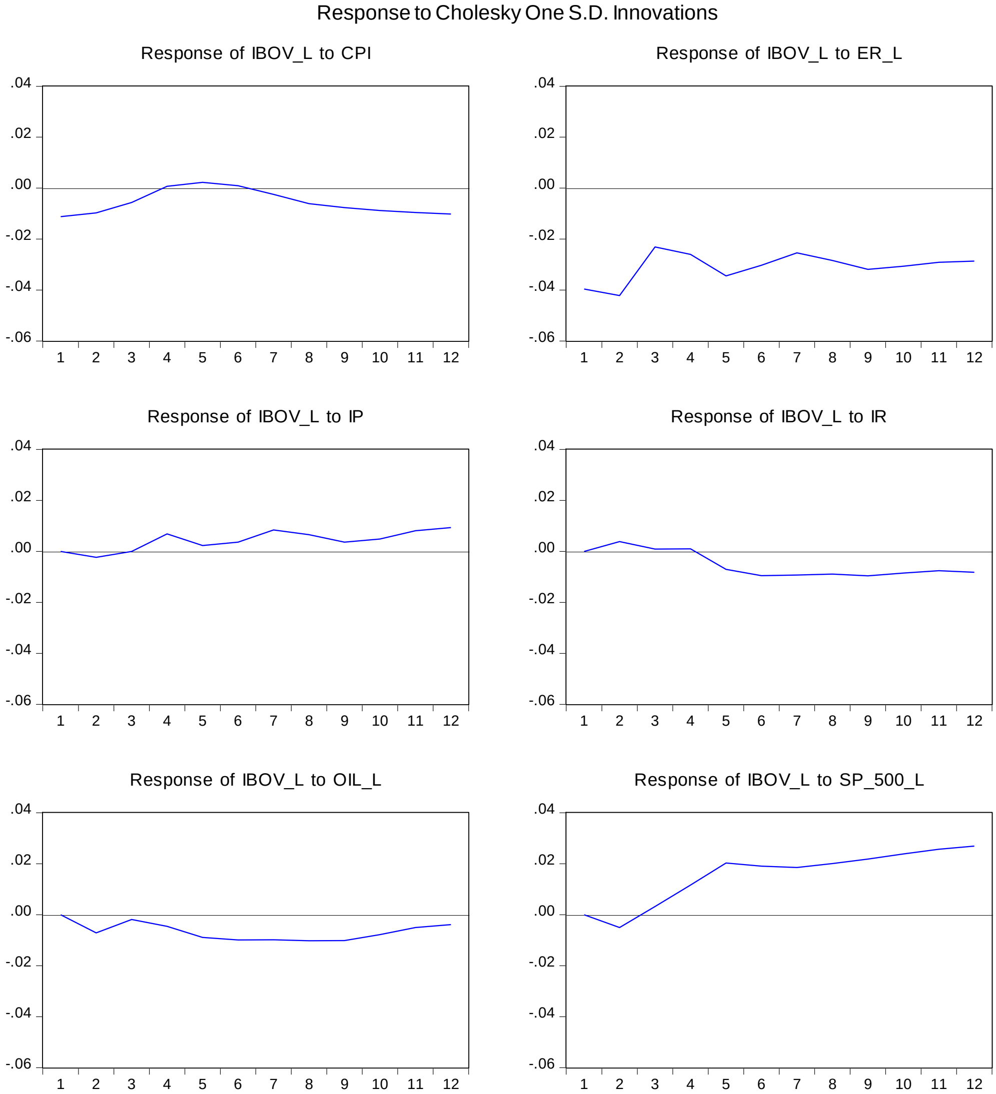
4. Results and Discussion

The recurrent analysis of the results of an autoregressive vector model is performed using impulse response functions. An impulse response function shows the trajectory of a variable, over the months, after a hypothetical shock in another variable or even in the variable itself. This study used generalized impulse response functions (IRFs), which solve the problem of possible distinct IRFs according to the ordering of the variables adopted, traditionally based on Cholesky decomposition.

Figures 2 and 3 show the impulse response functions of shocks in macroeconomic and financial variables on the Ibovespa and the IFIX, respectively. The blue line represents the reactions of the Ibovespa and the IFIX over the months after a hypothetical shock in each of the macroeconomic and financial variables. The period selected for visualization in the graphs was 12 months after the shock, which appears on the horizontal axis of each graph. To reduce the variance and consequently solve the heteroskedasticity problem, the series of the Ibovespa, the IFIX, the S&P 500, the exchange rate, and the oil prices were transformed using logarithms.

In Figure 4, the Ibovespa initially responds negatively to shocks in inflation, becoming slightly positive between month 4 and month 6 and returning to negative until the end of the period. With respect to the exchange rate, it is notable that an exchange rate shock (devaluation of the real) negatively affects the Ibovespa. With regard to industrial production, it is possible to see a positive relationship with the Ibovespa since an increase in industrial production provokes a positive reaction from the Ibovespa. The interest rate, in turn, influences the Ibovespa negatively. Although there is a slightly positive reaction in the first months, it is possible to notice that, after the fourth month, the Ibovespa starts to have a negative reaction to an increase in interest rates. Another negative effect comes from a hypothetical oil price shock. When the price of oil increases, it exerts negative impacts on the trajectory of the Ibovespa. The S&P 500 affects the trajectory of the Ibovespa positively, despite a slightly negative effect in the second month. The results obtained in this work are similar to those reported in the study by Pimenta Júnior and Higuchi (2008), in which the Ibovespa reacts with greater significance to a proven impulse in the exchange rate.

Figure 4 – Ibovespa's response to shocks in macroeconomic and financial variables

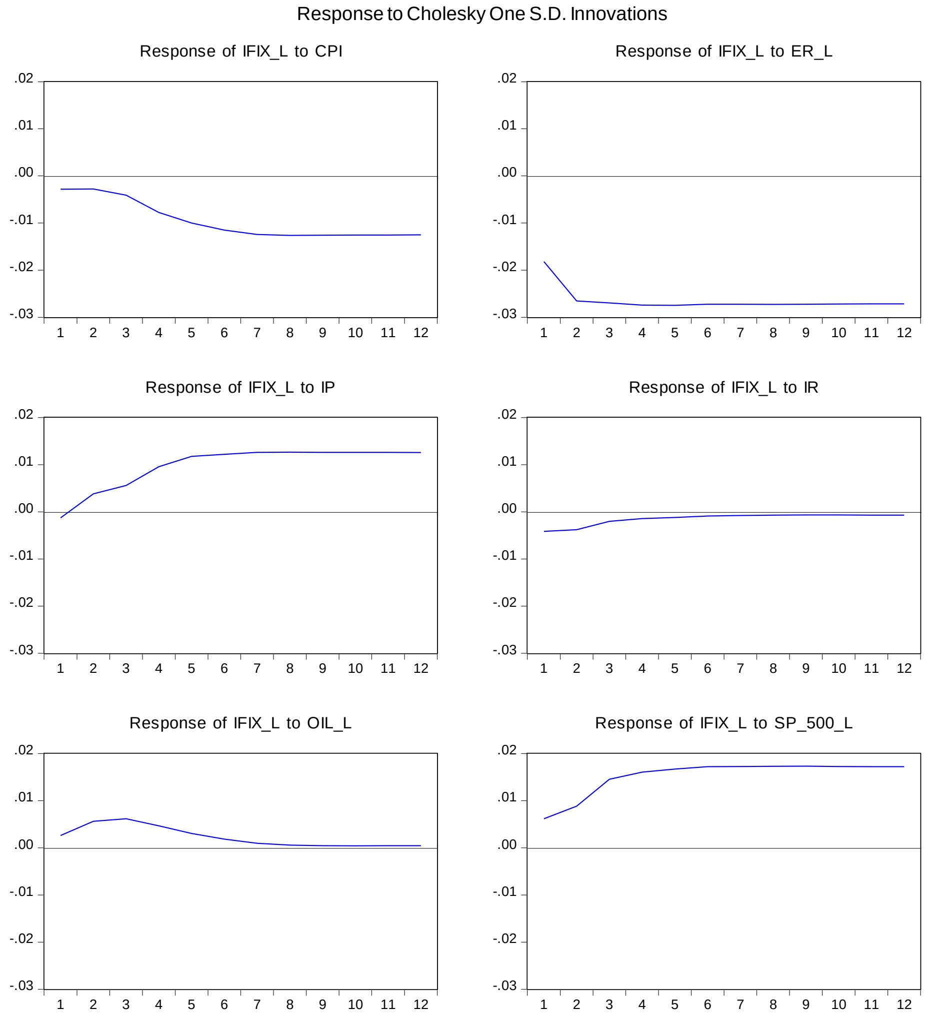


Source: Self elaboration.

The results found in the IRFs also converge with those obtained by Grôppo (2006), who, when using the VEC model, identified negative impacts of the interest rate on the Ibovespa and of the exchange rate on the stock index. According to Vartanian's (2012) analysis, the Brazilian stock index reacted positively to commodity price shocks (which include oil prices but are more comprehensive) as well as to exchange rate depreciation. A divergence was observed here regarding the impacts of commodities versus oil prices as the present study identified a negative effect of the oil price on the Ibovespa. In another analysis, Bilson et al. (2001), when studying the countries of Latin America, Europe and Asia, highlighted the importance of the impacts of both industrial production and interest rates on stock returns in emerging markets.

In relation to the model that evaluated the impacts of macroeconomic and financial variables on the IFIX, the IRFs of which are shown in Figure 3, it was possible to verify some similarities and divergences in relation to the shocks in the Ibovespa. From the point of view of inflation and the exchange rate, one can see practically the same effects: a rise in inflation or devaluation of the exchange rate promotes a fall in the IFIX, in the same way as in the Ibovespa. With regard to industrial production and the interest rate, the effects of shocks on the IFIX are also similar to those on the Ibovespa. The IFIX increases in the face of a shock (increase) in industrial production and decreases in response to an increase in the interest rate. The difference in behavior between the IFIX and the Ibovespa arises in the face of a shock in oil prices. When an oil price shock occurs, the Ibovespa shows negative reaction dynamics while the IFIX has a positive reaction. Finally, in response to a shock in the S&P 500, the IFIX shows a positive response, as does the Ibovespa.

Figure 5 – IFIX's response to shocks in macroeconomic and financial variables



Source: Self elaboration.

The results found in the analysis of macroeconomic and financial shocks on the IFIX are similar to those presented by Frade (2015), who identified a significantly negative response to the interest rate impulse in the real estate fund market, represented by the IFIX, which was also found in the present study. In general, differences in intensity were identified between the shocks in the macroeconomic and financial variables on the IFIX and the Ibovespa, but the sense of the shocks was quite similar in the two cases, with the exception of oil price shocks. Shocks in inflation, in the exchange rate (devaluation of the real), and in the interest rate promoted a negative trajectory in the dynamics of the Ibovespa and the IFIX, while shocks in industrial production resulted in a positive trajectory both in the IFIX and in the Ibovespa. The divergence occurred with an oil price shock, which resulted in a fall in the Ibovespa and a rise in the IFIX. Finally, a shock to the S&P 500 provoked a positive response from both the Ibovespa and the IFIX.

5. Final Considerations

This study sought to analyze the influence of macroeconomic and financial variables on the stock and real estate markets, represented by the Ibovespa and the IFIX, respectively, with a comparative analysis between 2015 and 2019. The comparative analysis allowed us to determine whether there is a possibility of diversification between the Ibovespa and the IFIX in the face of macroeconomic and financial shocks. As a methodology, the research used the vector with error correction (VEC) econometric model, which allowed a comparative analysis of the effects of shocks on the variables through the impulse response function. Due to the fact that several series used in the estimation were non-stationary, as verified by the unit root tests, the VEC model was applied instead of the VAR. The results indicated that the Ibovespa and the IFIX have relatively similar behavior in response to macroeconomic and financial shocks. Before the estimation, the research initially sought, through a review of the literature, to identify the variables that most positively or negatively influence the Ibovespa and the IFIX.

Using the VEC model, which was necessary due to the presence of non-stationary series, two models were estimated: one with the Ibovespa and the macroeconomic and financial variables and the other with the IFIX instead of the Ibovespa. The results obtained through the impulse response function showed that there were intensity differences between the shocks in the macroeconomic and financial variables on the IFIX and the Ibovespa, but the sense of the shocks was quite similar, with the exception of shocks in the oil prices. Shocks in inflation, in the exchange rate (devaluation of the real), and in the interest rate promoted a negative trajectory in the dynamics of the Ibovespa and the IFIX, while shocks in industrial production resulted in a positive trajectory both in the IFIX and in the Ibovespa. The divergence occurred with an oil price shock, which resulted in a fall in the Ibovespa and a rise in the IFIX. Finally, a shock in the S&P 500 promoted a positive response in both the Ibovespa and the IFIX.

Given the relative convergence between the IFIX and the Ibovespa, it is possible to affirm, based on the data analyzed in the period from 2015 to 2019, that the possibility of diversification between the Ibovespa and the IFIX does not exist given the fact that the macroeconomic and financial variables exert similar effects on the two indices, refuting the hypothesis initially formulated that it would be possible, from investors' perspective, to diversify between the two markets. The only exception occurred with an oil price shock, which resulted in different trajectories, as mentioned above. This fact deserves further investigation and constitutes one of the limitations of the research. Another limitation to be considered is the period of temporal delimitation of the research. As the Brazilian economy suffered a severe recession between 2014 and 2016, the extension of the analysis period to the past is compromised by the fact that the weak economic activity affected the trajectory of the two indexes even with changes in other variables, such as the interest and exchange rates. In 2020, the COVID-19 pandemic had a very strong impact on the trajectory of all the variables, which even changed the historical relationship between them. Thus, as a suggestion for future studies, it would be relevant to reestimate the model with the inclusion of a time series with a greater number of post-pandemic observations. Another important task is to deepen the investigation of the divergence between the Ibovespa and the IFIX in the face of an oil price shock. Given their relevance, such issues can be included in the future research agenda as important topics.

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