International Journal of Business and Management; Vol. 18, No. 4; 2023
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

# A Behavioral Interpretation of Volatility Patterns in Brazilian Stock Market: Analysis of Pre and Post-COVID-19 Periods from 2019 to 2021

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Received: February 24, 2023 Accepted: April 10, 2023 Online Published: May 26, 2023

doi:10.5539/ijbm.v18n4p24 URL: https://doi.org/10.5539/ijbm.v18n4p24

**Abstract**

There has recently been an increasing number of new investors in the Brazilian stock markets, providing new asset allocation opportunities as well as challenges in terms of individual judgment and decision-making. The departure point of this paper is the conjecture that the Ibovespa (Brazilian stock exchange index) might reveal asymmetric volatility patterns during the January 2019 to February 2021 period that call for behavioral financial explanations. More specifically, this paper aims to subject this bold conjecture to an empirical test. It draws on a threshold autoregressive conditional heteroskedasticity (TARCH) model to investigate the existence of asymmetric reactions in the period under study. Our findings suggest that the traditional approach to finance fails to explain volatility patterns in the Brazilian stock market behavior, since they do not fit well with predictions based on the efficient market hypothesis. Inspired by Vasileiou's (2021) account of what occurred with the New York Stock Exchange during COVID-19, we then embark on a brief survey of the vast literature on applied behavioral economics and finance to provide an interpretation of the heuristics and biases that may be non-negligible mental mechanisms underlying the Ibovespa's detected asymmetric responses.

**Keywords:** behavioral economics, behavioral finance, volatility, Ibovespa index

## 1. Introduction

The efficient market hypothesis (EMH), which characterizes the traditional finance literature, is based on the premise that asset prices reflect the information available in the market, and, therefore, rational investors make decisions that optimize their returns and risks (Markowitz, 1952; Sharpe, 1964; Black and Scholes, 1973). However, economists and psychologists such as Herbert Simon and Daniel Kahneman have challenged the mainstream view of the unbounded rationality of economic agents in the context of decision-making under risk and uncertainty (Wong, 2020). Simon (1955) claims that there is a limit to human cognition, while Kahneman and Tversky (1979) point out that individuals make use of heuristics to economize on their computational capabilities that can systematically bias their probabilistic judgments and decision-making behaviors.

Since then, studies in behavioral economics and finance have identified and explained anomalies of investor behavior with economically relevant consequences, such as volatility patterns in financial markets that cannot be satisfactorily explained by the EMH-based literature (Illiashenko, 2017). In response to these puzzles, the behavioral approach has made important contributions to research and debate regarding finance in the real world. Shiller (1981) suggests that the EMH cannot be solely responsible for explaining the excessive volatility of assets. In the same vein, De Bondt and Thaler (1985) highlight the existence of overreaction behavior in the stock market, while Odean (1998) draws attention to investors´loss aversion, among other expected utility anomalies.

As a starting point for studies on behavioral finance in Brazil, Costa (1994) innovated by testing the hypothesis of overreaction in the Brazilian capital market during the period from January 1970 to December 1989, by comparing winning and losing portfolios (Correa and Panhoca, 2019; Milanez, 2003). Quite similarly, Agnol (2001) compared winning and losing portfolios with more recent data from 1986 to 2000 (See also, Milanez, 2003; Bonomo and Agnol, 2010).

The Brazilian stock exchange, despite its recent advances, remains less attractive and popular among investors than other countries. In Brazil, only 3,229,318 individuals invest in the stock market, which represents 3% of the

population. In the United States, a country that has a more mature and developed capital market, the number corresponds to 55% of the population (B3, 2020). However, from 2016 onwards, Brazil underwent a transition regarding economic variables, which intensified the number of Brazilian investors with a variable income. The country's basic interest rate – the Selic rate – was gradually reduced. The cycle of cuts, which began in November 2016, when the Selic rate was at 14.25% per year, resulted in a historic low of 2.00% per year in August 2020 (BACEN, 2020). Within the international context, there has been a period of low growth in the world economy, in addition to events such as the trade war between the US and China, including surcharges and accusations of currency manipulation by the Asian country, as well as the reduction of interest at global levels, with the aim of stimulating the economy. In 2019, the Brazilian pension reform was approved, which led to extra optimism and generated great expectations of sustained increase in the stock market index to the extent that the Brazilian government seemed to give credible signals of its commitment to an economic agent with fiscal austerity.

However, in 2020, Brazil and the world began to suffer from the consequences of the COVID-19 pandemic. Vasileiou (2021) highlights that the United States, to minimize the economic effects caused by the measures taken to contain the pandemic, provided monetary and fiscal stimuli. Similar measures were adopted by several countries, including Brazil, which had the lowest basic interest rate in history. Brazilian investors, until then used to high interest rates in fixed income investments combined with low volatility, began to search for other return options and look more closely at variable income. The data reveal a significant increase in investors since 2016 in the then Brazilian Mercantile and Futures Exchange (BMF) and Bovespa, since renamed the Brazil Stock Exchange (B3).

Such a change in investors´ behavior, who migrated part of their financial resources from a fixed income to a variable one, might have been influenced by the impact of social media on investment decisions (ANBIMA, 2020). Folk wisdom warns us that even when there is a large amount of information available in the market, it is not possible to say that investors always make optimal choices in the allocation of their resources. The literature on behavioral finance have collected strong evidence suggesting agents' bounded rationality, the asymmetric influence of perceived gains and losses on decision-making, among various cognitive heuristics and bias to which even experts are subject in the real world.

Given the volatility movements and their effects, to which the agents were exposed before and during the pandemic, the proposed task is to investigate actual investors´ behavior in the Brazilian stock market. More precisely, this paper draws on behavioral finance insights to detect choices that differ from the predictions offered by the traditional finance literature. To undertake our task, we aim to analyze the volatility of the Bovespa Index (Ibovespa) between January 2019 and February 2021 and go on to identify investors´behaviors that call for behavioral finance interpretations.

The remainder of this paper is organized as follows. Section 2 covers the theoretical framework with an emphasis on behavioral finance, from its earliest authors such as Simon (1955) and Kahneman and Tversky (1974) to the applications of these concepts in the capital market. Section 3 presents the methodology used. In Section 4, the results obtained and the patterns of investor choices regarding the B3 identified during the investigation period are analyzed according to the behavioral financial perspective. The final remarks are outlined in Section 5.

## 2. Theoretical Foundations

This section initially presents a history of behavioral economics and its segmentation in relation to behavioral finance. Subsequently, the main differences between traditional and behavioral finance are addressed. Finally, a review of the behavioral finance literature in the capital market is presented.

### *2.1 Behavioral Economics and Behavioral Finance*

It is worth highlighting the differences between behavioral economics and finance. The central premise of behavioral economics literature is that humans have bounded rationality. The main goal of behavioral economists is to provide models and theory with more psychologically realistic assumptions that improve the quality of the explanations and predictions of economic phenomena, such as consumption, saving, investment, and pricing.

Decision research emerged in the 1950s and Herbert Simon's contributions paved the way for the emergence of behavioral economics and finance. His account of bounded rationality challenged expected utility theory. Simon's (1955) criticism was based on evidence that suggests the existence of bounds on human cognition, since individuals do not have unlimited computational capacity to make judgments and decisions equivalent to what the benchmark of economic rationality - the principle of expected utility maximization - predicts. Simon (1990) provided an alternative decision perspective built on the limited rationality hypothesis that sheds extra light on actual people´s scarce attention, memory, and their difficulty with making choices built on expected utility decision criterion. In response to such a portrait of human rationality, the author admits that agents also base their decisions on emotions,

intuitions, and shared beliefs or norms. Furthermore, boundedly rational individuals simplify their judgments and decisions to deal with complex situations.

The initial research by Simon (1990) and the experimental contributions of Kahneman and Tversky enabled the evolution of behavioral economics, which is not characterized using a single methodology, but by a commitment to the integration of psychology, economics, and sociology to expand the fragile empirical basis of economics (Hursh, 1984). According to Costa et al. (2017), Kahneman, Tversky, and Hursh are extremely important for the field of behavioral economics since they came up with an empirically informed theory of decision under risk – prospect theory - that challenged expected theory and endorsed their view of bounded rationality. Furthermore, Kahneman and Tversky devoted a great deal of their careers to investigating heuristics, biases and anomalies that are very important for the field of behavioral finance (Costa et al., 2019).

Therefore, it is worth recognizing that the field of behavioral finance derives directly from behavioral economics, and essentially from the studies of Kahneman and Tversky in the 1970s and 1980s. The starting point of this field of knowledge can be defined as the study of errors in judgment and aspects of decision-making in financial investments (Tomer, 2007). During the 1980s, the work of Shiller (1981) stood out, with the author arguing that the volatility of the stock market is much greater than the traditional finance literature considers. In a similar vein, De Bondt and Thaler (1985) studied overreaction, which is an overestimation of new information by decision-makers.

*2.2 Traditional Finance and Behavioral Finance*

It is important to point out that the traditional economic theories inspired by the EMH were, over many years, the prevalent perspective for studies related to capital markets. As exponents of traditional theories, the portfolio theory developed by Markowitz (1952), the capital asset pricing models (CAPMs) by Sharpe (1964), and the model for options by Black and Scholes (1973) stand out.

The EMH is based on the premise that asset prices reflect available information. Fama (1970) defines an efficient market as one characterized by many rational agents, whose objective is to maximize profit through attempts to predict the future value of the price of securities. According to the author, a competitive environment allows them to reflect all the information available in the market, including their expectations about the future. In this case, the investor will make decisions based on the objective of maximizing results given his risk preferences.

According to this approach, there are three versions of market efficiency with prices that reveal the available information differently. In the weak form, the current price of an asset is the result of the previous price plus an expected return. In the semi-strong version of efficiency, the current price uses the concept of price from the weak form, in addition to available public information. The strong version of the efficient market, on the other hand, maintains that all information is still reflected in the price of an asset. As a result, no investor would achieve above-market returns.

It is worth mentioning the importance of the EMH for the field of finance. However, there have been numerous developments in capital markets that seem to challenge it empirically. Furthermore, supporters of the behavioral perspective applied to the financial universe emphasize that the judgments and decisions of real investors are influenced by pressures, beliefs and social norms that are not always well grounded in concrete market information.

In response to empirical anomalies, behavioral finance contributions draw inspiration from works such as Kahneman and Tversky (1979), Shiller (1981) and De Bondt and Thaler (1985) to argue that real-world investors employ heuristics to make quick choices that, in specific contexts, generate recurrently suboptimal or biased results.

However, the great reference for behavioral studies is the work of Kahnemann and Tversky (1979), who present the prospect theory as an empirically more relevant alternative to the expected utility theory, considered the benchmark of economic rationality. The authors argue that real-world lottery valuations reveal that risk attitudes and preferences depend on how individuals perceive decision-making contexts and alternatives in terms of relative gains and losses. Kahneman and Tversky provide empirical evidence that agents give greater weight to losses than to gains. As a result of what they call loss aversion, the utility function in prospect theory has a concave shape for gains and a convex one for losses.

Complementing the previous study, Kahneman and Tversky (1982) have found deviations in decision-making that contradict the hypothesis of full or unlimited rationality. To this end, they have carried out experimental studies whose results suggest that agents often underestimate or ignore statistical data, resorting to recent events or events to guide their choices under risk. The authors point out that the availability bias is related to the triggering of the frequencies of an event by the human being's inclination to remember similar events. Judgment distortion occurs because individuals tend to focus their attention on a single fact and not on the whole situation, because this single

fact is more present in their mind.

In financial markets, more specifically in stock exchanges around the world, movements of high volatility occur in certain assets or indexes, whether of overvaluation or extreme devaluation, which are not satisfactorily explained by traditional theories. Behavioral finance suggests some justifications for these events, as will be demonstrated in the next section.

*2.3 The Application of Behavioral Finance in the Financial Market*

Barberis (2013) organized the field of behavioral finance into three areas of applied studies: the pricing of financial assets, investor decision-making, portfolio choice and investment managers' behavior. Shefrin and Statman (1994) consider that despite these three areas, the focus of studies on behavioral finance centers on issues associated with the decision-making of agents and their effects on the market (Statman, 1999).

Behavioral finance suggests a complementary approach to the finance perspective, anchored in the EMH. For the mainstream, it is not possible for an operator or agent to obtain better results than the market. Furthermore, asset price distortions do not survive in a competitive environment with rational agents. However, episodes or periods of high market volatility can be considered pieces of empirical evidence contrary to the view that individuals in the market are fully rational and have unlimited arbitrage gains (De Long et al., 1990).

Shiller (1981) criticizes the EMH and emphasizes that the excessive volatility of the capital markets can also be an indication of the agents' limited rationality. This is an indication that agents are limitedly rational. The promise of the behavioral finance approach is to offer a broader and deeper understanding of patterns of behavior in real markets. The next section presents and discusses contributions from behavioral economics relevant to understanding financial market puzzles.

*2.4 Evidence of Anomalies in Choices Under Risk and Uncertainty*

Rubinstein (2001) has compiled evidence of phenomena that can be explained by behavioral finance. Some of the following empirical regularities, considered to be expected utility anomalies, deserve to be highlighted, especially for the impacts they generate on asset prices. They are: (a) overconfidence, (b) availability and loss aversion, (c) representativeness, (d) overreaction, and (e) the herding effect.

Lichtenstein and Fischhoff (1977) define individual investor confidence as an investor's ability to make predictions about future scenarios with some accuracy. Overconfidence occurs when this ability is overestimated by the investor. Statman, Thorley, and Vorkink (2006) have found evidence of behavioral patterns that reveal overconfidence on the part of New York Stock Exchange (NYSE) investors. According to them, overconfidence behavior leads investors to operate excessively, thus incurring higher costs that can threaten the profitability of their portfolios. Griffin, Nardari, and Stulz (2007) studied 46 countries and found that investor overconfidence bias manifests itself more frequently when capital markets have exhibited high returns in the recent past.

Kahneman and Tversky (1979) explain the availability heuristic by drawing attention to the fact that boundedly rational individuals make probabilistic judgments and inferences based on the vivid information that is freshest in their memory, often disregarding objectively collected statistical data. An example of this is the overestimation of unlikely catastrophic events, such as the risk of dying in an air disaster. In a study evaluating the forecasts of financial analysts for the performance of companies, Lee, O'Brien, and Sivaramakrishnan (2008) conclude that in periods of growth, the forecasts were more optimistic than the data. Likewise, in periods of recession or economic crisis, forecasts were more pessimistic than presented by the data.

When analyzing data relating to the transactions of a major brokerage firm in the United States, Odean (1998) identifies that some investors have a loss aversion. The author refers to this result as the disposition effect and interprets it as favorable evidence for the format of the value function of prospect theory, since individuals attribute much more weight to losses than to relative gains and, as such, are averse to losses. Representativeness is a mental shortcut that influences the judgments of individuals in the capital and financial markets. Such a heuristic manifests itself once there are contexts in which choices result from judgments based on stereotypes. Van Hulle, Vanthienen, and De Bondt (1993) study stock price predictions, finding that ordinary investors make stock buying and selling decisions based on what they deem to be a representative pattern of asset price performance. According to the researchers, some agents showed optimism in relation to a stock simply because they observed the price's uptrend. They also note this in relation to falling stocks. Investors, when verifying the downward trajectory of the shares, revealed pessimism.

Barberis, Shleifer, and Vishny (1998) view overreaction as a behavioral response empirically observed in the stock market. The authors argue that, in certain contexts, investors exhibit an overreaction to news, regardless of whether it is positive or negative or whether it is related to the impact on the company's cash flow. Overreaction patterns

remain an anomaly for the traditional finance literature. In De Bondt and Thaler's (1985) pioneering study of overreaction, the authors collect data on stock prices on the NYSE during the years 1926 to 1982. The work examines the impact that news, specifically negative news, had on investors' decisions. De Bondt and Thaler conclude that the initial losses implied overreactions. However, the distortions were corrected after a certain period.

Costa (1994) analyzes the hypothesis of overreaction in the Brazilian capital market based on the analysis of monthly returns of 121 companies traded on B3. The methodology used, like De Bondt and Thaler (1985), identifies the superior performance of a portfolio of losing stocks when compared to one of winning stocks. The author finds evidence of the overreaction of investors in relation to the performance of stocks with an uptrend (to the detriment of those with low recent performance). Herd behavior is defined as the action of an individual in repeating the strategy used by a group or majority. This results from the human tendency to imitate the choices made by others and to justify their behavior on the basis that individual mistakes are more frequent than those made by a group of people. According to Costa (2009), the herd effect is related to the fragile belief that a group cannot be wrong. Agents learn that when a large group is unanimous in their judgment, they are likely to be correct (Costa 2009, p. 18).

In the financial market, herd behavior highlights the individual propensity to follow the actions of other investors, regardless of whether the action has rational or irrational motivation (Nagy, 2017), which is pointed out as one of the reasons for high volatility movements in the markets. According to Cipriani and Guarino (2008), financial crises can be linked to the herd effect. In a crisis environment, in which the fundamentals are fragile, there is a greater chance of agents operating in an unbalanced way. They find evidence of contagion between asset prices in different markets, showing that this contagion can detach the price from its fundamental value. Unfortunately, behavioral finance studies in the Brazilian financial market are few. This paper aims to contribute towards filling this gap and to inspire new research informed by behavioral finance.

## 3. Methodology

This research is mainly based on the analysis of the behavior of the Ibovespa through an econometric volatility threshold generalized autoregressive conditional heteroskedasticity (TARCH) model, which in turn originated from the heteroskedastic conditional autoregressive models (ARCH and GARCH). The ARCH model was initially proposed by Engle (1982). In this model, the conditional variance is a function of the sample variances. However, this model needed many parameters to be properly adjusted. Thus, the GARCH model was developed by Bollerslev (1986), who proposed a generalization of the ARCH model, inserting the lag variance of the model, to make the model more parsimonious than its predecessor. A few years later, Zakoïan (1994) developed the TARCH model, which distinguishes the impact of good and bad news on volatility. The seminal references for the TARCH model are the research of Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993). In this context, the model has the following representation:

$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{l=1}^{r} \gamma_i \varepsilon_{t-l}^2 D_{t-l} \quad (1)$$

Where

$$D_t = \begin{cases} 1, & if \ \varepsilon_t < 0 \\ 0, & if \ \varepsilon_t \geq 0 \end{cases}$$

The TARCH model is, as previously mentioned, an expansion of the GARCH model plus the threshold order (last part of the expression), in addition, of course, to the dependence of the conditional variance of the past values ($\sigma^2_{(t-j)}$) and the squares of the residuals past ($\varepsilon^2_{(t-i)}$). In the TARCH model, good news ($\varepsilon_{(t-l)}>0$) and bad news ($\varepsilon_{(t-l)}<0$) have different effects on the conditional variance. Complementarily, the impact is considered asymmetric when $\gamma_i \neq 0$. Good news has an impact captured by $\alpha_1$ and bad news has an impact of $\alpha_1 + \gamma_i$. Thus, when the coefficient $\gamma_i$ is positive, it is possible to affirm that bad news increases volatility more and that there is, therefore, a leverage effect.

The EGARCH (Exponential Generalized Autoregressive Conditional Heteroscedasticity) model is an alternative to the TARCH (Nelson, 1991). Both have the same aim to identify whether the negative and positive shocks on volatility have the same weight. Given that the TARCH model has been used more extensively lately in the literature on finance and estimates made by EGARCH and TGARCH are similar, this paper opted for it (Petrică & Stancu, 2017).

More precisely, the TARCH model was used to examine whether there is an asymmetry between positive and negative shocks on Ibovespa volatility in the period studied (January 2019 to February 2021). The time frame for the analysis is justified by understanding relevant political and economic events with great impact on the Brazilian stock market. The second part of President Donald Trump's term in the United States and the trade war between

the United States and China, in addition to the coronavirus pandemic that began in March 2020, stand out as international events. The first two years of Jair Bolsonaro´s government, the rupture of the Brumadinho dam and the approval of the pension reform in 2019 should be highlighted, as being that of a candidate more aligned with a policy of fiscal austerity (Silva, 2018).

Monetary policy during this period is also noteworthy. In January 2019, the country's basic interest rates – the Selic rates – were at 6.5% per year and had remained stable since the cycle of cuts started in November 2016. As of July 2019, with stability in inflation, the expansionary monetary policy combined with the effects of the pandemic in 2020 led the interest rate to a historic low of 2% per year in August 2020. This reduction implied the migration of investors from fixed income investments to a variable income in search of higher returns. The Brazilian investor, until then used to high remuneration in fixed income investments combined with low volatility, began to search for other return options, taking a closer look at variable income. Since 2016, data show a significant increase in investors on the Brazilian Stock Exchange (B3).

Table 1. Total number of taxpayers' ID numbers (CPFs) registered in the Brazilian stock exchange

| Year | Total of Brazilian taxpayers' ID numbers |
|---|---|
| 2016 | 564.024 |
| 2017 | 619.625 |
| 2018 | 813.291 |
| 2019 | 1.681.033 |
| 2020 | 3.229.318 |

To obtain an idea of the growth in the number of investors in B3 (Brazilian stock exchange) in 2016 there were 564,000 taxpayers' ID numbers (CPFs) registered on the exchange. In 2019, the number was already over 1.5 million investors, surpassing 3 million individuals in 2020, as shown in Table 1. In addition to the increase in the number of investors, there was an expansion of portfolio diversification on the part of these investors. In 2016, 17% of investors had only a single asset in their portfolios, while 50% had more than five assets. At the end of 2019, these figures were 10% for investments in a single asset and 63% for investments in more than five assets (B3, 2020). Finally, the study period deserves to be highlighted because, after reaching the historic maximum of 119,527 points on January 23, 2020, it presented a severe drop of 46.8% in less than two months due to the pandemic.

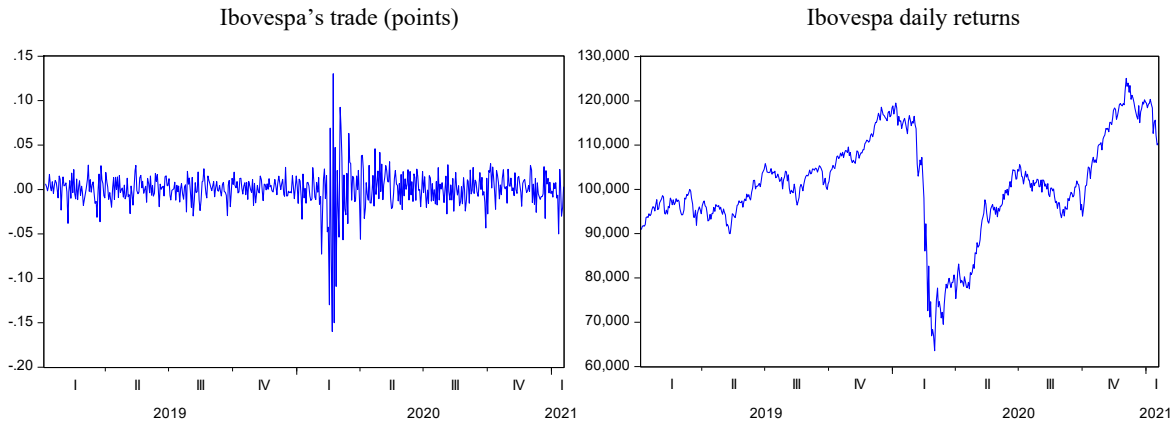


Figure 1. Ibovespa stocks in points and daily returns (Jan. 2019 to Feb. 2021)

This piece of research used data from the daily closing of the Ibovespa, the main stock index in the Brazilian market, between January 2019 and February 2021, totaling 535 observations. The Ibovespa index is composed of the shares of several companies with greater liquidity, traded on the Brazilian stock exchange. It corresponds to about 80% of the number of trades and the financial volume of the Brazilian capital market. The data were extracted from the Bloomberg platform. Figure 1 depicts the evolution of the index in the period in points and the daily return. As can be seen, the Ibovespa showed a positive evolution between January 2019 and January 2020 (graph on the left in points) when, after reaching a historical peak, it faced a vertiginous fall in the first quarter of 2020, with the first cases and deaths from the coronavirus in Brazil and the lockdown measures imposed by state

governments. The graph on the right shows the Ibovespa's daily return, calculated by applying the logarithmic difference to the Ibovespa data in points, and it is possible to observe, in addition to the various volatility clusters, an atypical increase in volatility in the first quarter of 2020, with variations which reached 15% in some trading sessions.

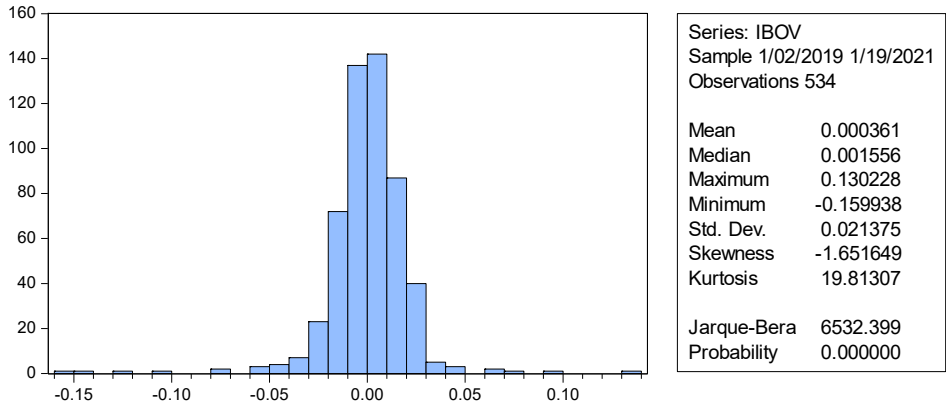


Figure 2. Histogram of Ibovespa's returns (Jan. 2019 to Feb. 2021)

Source: Own elaboration based on Bloomberg data.

The histogram of returns, shown in Figure 2, suggests that the distribution is leptokurtic, as is typical of financial series. This can be observed in other works, such as those by Wang and Hsu (2006), Otuki et al. (2008) and Nogueira and Kobunda (2019). The Jarque-Bera statistic confirms the absence of a normal distribution in the data and the kurtosis coefficient confirms the fact that the distribution has a heavy tail (long tail). According to the literature, conventional econometric models that assume normal data distribution cannot be applied in these cases. For such cases, heteroskedastic conditional autoregression models (ARCH, GARCH, etc.) are the most suitable.

Table 2. Descriptive statistics

| | **Ibovespa (points)** | **Ibovespa daily returns** |
|---|---|---|
| *Average* | 101024.8 | 0.00 |
| *Median* | 100724.0 | 0.00 |
| *Maximum* | 125076.6 | 0.13 |
| *Minimum* | 63569.60 | -0.16 |
| *Standard Deviation* | 11262.19 | 0.02 |
| *Asymmetry* | -0.484082 | -1.65 |
| *Kurtosis* | 3.503989 | 19.81 |
| *Jarque-Bera* | 26.55709 | 6532.399 |
| *P Value* | 0.00 | 0.00 |
| *Sample* | 535 | 534 |

Regarding the descriptive statistics, it is worth noticing the significant amplitude of the Ibovespa during this period, which stood between 63 thousand points and 125 thousand points, with an average of around 101,000 points. Volatility is a very present feature. As shown in Table 2, the index even offered returns that ranged from 16% (negative) to 13% (positive). This means that in a single day the stock index lost 16%. Following the presentation of the methodology and data used in the estimation, the next section will aim to present the results of the econometric model and the discussion, based on the literature on behavioral finance. With the realization that positive and negative shocks are asymmetrical, as well as the possibility of the leverage effect, elements of the behavioral finance theory will be sought to explain the behavior of investors in relation to shocks in the Brazilian stock market index (Ibovespa).

## 4. Results and Discussion

As presented in the previous section, a TARCH model was estimated with the objective of identifying the presence

of asymmetric shocks, that is, verifying whether negative shocks have a greater effect on volatility than positive shocks. The estimation results can be seen in the following table:

Table 3. Results of the TARCH model

| Variable | Coefficient | Standard error | Z statistic | Prob. |
|---|---|---|---|---|
| C | 0.000876 | 0.000623 | 1.404522 | 0.16 |
| **Variance equation** | | | | |
| $\alpha_0$ | 0.000016 | 3.25E-06 | 5.053380 | 0.00 |
| $\alpha_i$ | 0.019856 | 0.028695 | 0.691975 | 0.49 |
| $\gamma_i$ | 0.208579 | 0.041116 | 5.072945 | 0.00 |
| $\beta_j$ | 0.809953 | 0.026280 | 30.82008 | 0.00 |

According to Table 3, the coefficient $\gamma_i$ _is statistically significant. The statistical significance of the coefficient $\gamma_i$ suggests that negative shocks have a greater effect on volatility than positive shocks for the Ibovespa in the analyzed period. In addition, the fact that the coefficient in question is positive indicates the leverage effect. The leverage effect, as previously mentioned, implies that negative shocks increase volatility more than positive shocks, which is one of the signs of overreaction.

Figure 3 presents the conditional standard deviation and the conditional variance estimated from the TARCH model. It is possible to identify, in both the case of the standard deviation and the conditional variance, that there was a significant increase in volatility in the first quarter of 2020, because of the effects of the COVID-19 pandemic. At the same time, it is also possible to observe other periods in which volatility increased, albeit to a lower degree than that observed by the effects of the pandemic. The periods of volatility will be analyzed below through the lens of behavioral finance.

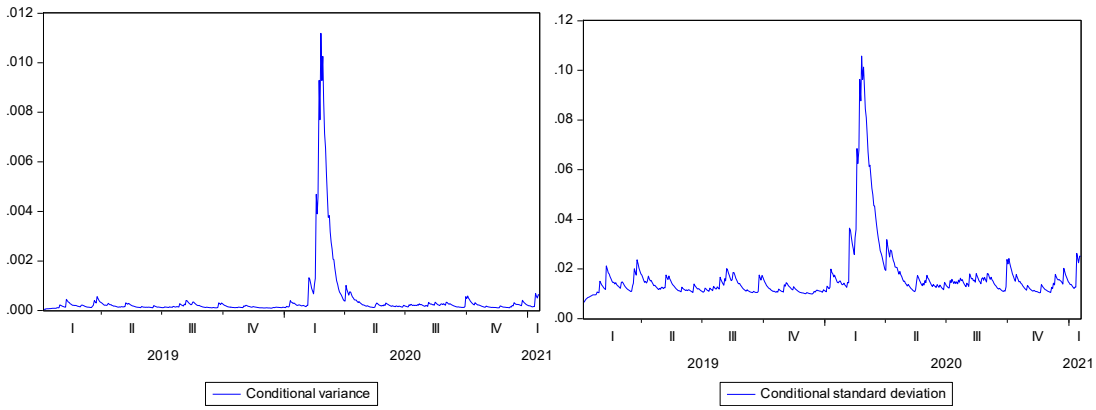


Figure 3. Conditional standard deviation and variance

The TARCH model identified asymmetry in the positive and negative shocks for the period studied. The detected asymmetries suggest that the EMH does not satisfactorily explain anomalies in the Brazilian stock market. Rather, the empirical findings that negative shocks have a greater impact on stock market volatility than positive gains make a good case for prospect theory, which is the behaviorally informed explanation of decision under risk.

Inspired by De Bondt and Thaler (1985), Odean (1998) and Vasileiou (2021), this paper goes on to draw on behavioral finance items to provide interpretations of some investors´ choices made in the Brazilian stock market. To carry out the foregoing task, it focuses on episodes just like the Bolsonaro´s as well as Biden´s presidential election, the COVID-19 pandemic and some economic measures taken to manage the public health crisis that influenced investors´ decision-making behaviors and the performance of the Brazilian stock market during the period 2019–2021. They all challenge the unbounded rationality and the efficient market hypotheses. More precisely, it discusses some investment decision contexts in which stock market prices and investors´ choices did not seem to be fully rational or reflect all the available information. Rather, they call for similar behavioral financial accounts to those made by Ali, Alam, and Rizvi (2020), Ashraf (2020) and Vasileiou (2021).

The year 2019 started very promising for the Brazilian stock exchange. The victory of Mr. Jair Bolsonaro, who presented himself as a pro-market reformist candidate, increased somehow investors´ optimism (Silva, 2018). Bolsonaro´s presidential campaign promised a classical liberal economic agenda, which included structural reforms, privatizations, and proposals to reduce public spending capable of generating an atmosphere of enthusiasm for the that year. The Brazilian Chamber of Deputies approved of the pension system reform on August 7, 2019. Under the above institutional settings, judgment and decision-making among stock market investors seemed to have been influenced by availability heuristics since their choices depended on the favorable environment they saw at that moment. In addition, individuals might have also drawn on the representativeness heuristics to make their decisions, since many investors believed that the pro-market environment would be representative of very positive prospects for the stock exchange performance.

There is evidence that Brazilian investment choices in 2019 revealed a confirmation bias, which is often discussed in the behavioral finance literature. Confirmation bias occurs when the individual selects only the information that supports their choices and disregards contrary evidence and divergent opinions (Langer 1975). Investors who show such bias overestimate the information that corroborates their beliefs and disregard the random events that have an impact on the price of assets (Glaser & Weber, 2007). Brazilian investors underestimated important pieces of information about the future of the Brazilian economy like the Central Bank's index of economic activity (IBC-Br). The latter is taken as a preview of gross domestic product (GDP) and at that time it estimated economic activity retractions in six of the 12 months of 2019. Investors in the B3 stock exchange made choices based on the optimistic premise that the Brazilian economic performance would be better, regardless of the available information suggesting a different macroeconomic scenario than they expected to. Brazilian investors judgments and decisions focused instead on positive information in tune with their optimistic expectations, such as the approved pension reform, prospects of a bullish market and Bolsonaro´s promises of market-oriented structural reforms. The foregoing mental shortcuts partly explain increased individuals´ participation in the Brazilian stock market and why the IBOVESPA index appreciated 31.58% in 2019 and for the first time passed the historic mark of 100,000 points. Yet the Brazilian GDP grew by only 1.2% according to data from The Brazilian Institute of Geography and Statistics (IBGE, 2020).

At the beginning of 2020, there was an expectation that the pro-market measures would remain a government credible commitment, given the approval of the Brazilian pension system reform. The market revealed confidence about the progress of tax and administrative reforms, in addition to privatizations. The first trading session of the year had 118,573 points and was still fueled by optimism on January 23, the index reached its peak of the semester of 119,527 points. However, infections generated by the coronavirus, which started in late 2019 in China, reached several other countries in the first months of 2020. The World Health Organization (WHO) declared a public health emergency in January 2020 and its general director, Tedros Adhanom Ghebreyesus, declared COVID-19 as a pandemic on March 11$^{th}$, 2020. Due to the lack of effective treatment and the high transmissibility of the disease, several countries adopted lockdown measures or restrictions on movement to slow down contamination in the population and reduce the risk of collapse of their health systems. Such measures directly impacted economic activities. The world economy contracted by approximately 3.5%. During that period, the effects of the economic downturn hit financial markets intensely at a time when the stock markets of some countries, such as the United States and Brazil, were at historic highs. In the United States, for example, the declaration of a pandemic negatively impacted the performance of the Standard and Poor's (S&P) 500 index (Vasileiou, 2021). The American index fell by 28.52% in the period between March 4 and March 23, 2020. In Brazil, in less than a month, the index was devalued by more than 40% and the circuit breaker was activated six times. Such drastic fluctuations in the Brazilian stock exchange market behavior inspire the conjecture that individual choices are influenced by emotional as well as social thinking.

Movements such as the one that occurred in the Ibovespa on March 2020 allow for an interpretation of the so-called herd effect. Carmo (2005) considers that herding behavior occurs when an individual investor´s decision is influenced by investments made by other people. One of the justifications for this behavior is the reduction of cognitive dissonance, a conflict faced by agents when faced with situations in which their premises or beliefs are wrong. In other words, an investor can believe in a rise in the stock market, based on fundamentals, but the vertiginous downward movement makes her change her mind. Sanches (2013) points out that, in moments of herd effect, imitation of another's investment behavior makes an individual ignore her own analyses and market perceptions. To Lakonishok, Shleifer, and Vishny (1992), the herd effect occurs in the financial market when the actions of agents converge in the same direction, whether downward or upward. The individual investor assumes that herd behavior points in the right direction. In this case, the individual simply follows the majority decision, taking a shortcut in decision-making without the critical analysis to understand the reasons for that behavior. Right

after the WHO declaration of the COVID-19 pandemic and Brazilian government´s ambiguous responses to deal with the health and economic crises resulting from the pandemic itself individual investors turned out to revise their optimistic expectations about financial markets in the first quarter of 2020 and changed their portfolio choices based on what institutional investors were doing in Brazil and worldwide. This partly explains why after reaching the historic maximum of 119,527 points on January 23, 2020, the Brazilian stock market exchange index on March 23, 2020, achieved its lowest performance of the year, reaching 63,569 points: an impressive drop of 46.8% in less than two months.

Bazerman (2002) argues that the availability heuristic sheds light on the fact that probability judgments are based on the ease with which one can remember the likelihood of a given event. The occurrence of a phenomenon which emotionally impacted the individual will be more available in their memory and, therefore, they may (mistakenly) infer that it is more likely. The availability heuristic seems to have influenced the decisions of the Brazilian stock exchange investor, who was frightened by negative information such as the devaluation of the real, the increase in the number of COVID-19 cases, unfavorable economic forecasts, and the effects of restrictions on business operations. This may explain why many investors in the Brazilian stock exchange felt uneasy about what the future could bring and made selling decisions that somehow explain the fall of the Ibovespa.

Shiller (2020) claims that the worse the economic fundamentals and available economic forecasts, the more difficult the task of explaining the rapid recovery stock movement in the US. We go on to argue that the same line of behavioral reasoning applies to the Brazilian stock market in Brazil during the pandemic. The trajectories of Ibovespa as well as the S&P 500 index do challenge traditional financial theory and call for a psychologically informed explanation. The scenario of severe uncertainty underlying investor judgment and decision-making signaled that individuals could face greater losses if they opted for portfolios with assets traded on the stock exchange. In theory, the perception of a highly risky financial environment would push some individuals away from the stock market. However, that is not what happened.

Shiller (2020) offers an interpretation informed by the behavioral approach to the rapid recovery of the American stock market. According to him, the interest rate cuts, and other measures adopted by the US government until March 23, 2020, had not improved investor sentiment. However, the decision-making context changed with the introduction of a bold program to establish credit lines and incentives. The entire financial package promised by the US government could reach $2 trillion. People were not guaranteed an economic aid plan before the public announcements, but investors had already quickly returned to the US stock market. To him, investors´ financial choices might have been influenced by the memory of the US government intervening in 2009 to prevent a worsening of the financial crisis. If this is so, it makes sense to partly explain that stock exchange trade behavior is also influenced by the availability as well as the representativeness heuristics. Quite similarly to the US government, Brazilian authorities felt the political and economic pressure to manage COVID-19 and embarked on active monetary and fiscal policies that made investors to form expectations that the federal government would go on with market interventions to avoid a severe recession and liquidity crisis. Such features of the macroeconomic environment framed investors´ risky attitudes and partly explain the increase of investors´ interest in the Brazilian stock market.

It is worthwhile to stress that the Ibovespa's index upward movements took place at a time when the number of cases of Brazilians infected with COVID-19 was growing exponentially. Vasileiou (2021) found a similar pattern in his study of the US stock market based on the S&P 500 index. Again, the abovementioned investment choice behaviors cannot be satisfactorily understood by the traditional finance literature. Our interpretation for such a Brazilian stock market rally along with the rise in COVID-19 confirmed cases and deaths is that investors´ decisions were strongly influenced by their understanding that Bolsonaro's government would intervene in the markets to avoid a financial crisis information, regardless on the available information about the severity of the health scenario and its high burden to public debt. Brazilian stock market investors´ neglect of available information to guide their financial decisions cannot fit well with the EMH.

The second half of 2020 started with less uncertainty than the second quarter of 2020. There were signs that the number of severe cases of COVID-19 would fall, after the peaks of the first half. In addition, there had been great efforts made by Pfizer, Moderna, AstraZeneca and others to develop an effective vaccine to fight the coronavirus.

The 2020 presidential election in the United States turned out to be an important political event with economic relevance that might have influenced investors´ understanding of financial prospects and therefore their financial decision-making behavior. On November 9, Joe Biden was declared the winner of the election. The Chicago Board Options Exchange's Volatility Index (VIX index), an indicator of the volatility of options on the S&P 500 stocks, saw an increase in volatility in the pre-election period. Similarly, the Ibovespa index seemed to suggest a case of

overreaction, which shows the descriptive value of behavioral finance (De Bondt & Thaler, 2005). After the end of the American election, the Ibovespa index rose from 95,979 points to 125,076 on January 8, 2021, achieving an appreciation of 30.32% in the period.

Brazilian vaccination program against COVID-19 started on January 17, 2021. Such an intense appreciation of the Ibovespa in such a short period suggests the effect of overreaction, as was observed in the electoral period. Despite the vaccination program in the US, the second wave of the pandemic seems to have influenced the decisions of investors in the Brazilian stock market. The Ibovespa soon showed a downward trajectory again. Such movement allows for the interpretation that investors´ behavior may have been affected by the representativeness heuristic. That being the case, behavioral finance seems to be a useful analytical framework to explain actual financial choices in the real world of boundedly rational agents.

## 5. Final Remarks

This article attempted to provide an empirical (econometric) investigation of whether positive and negative shocks in the Ibovespa index volatility from January 2019 to February 2021 were asymmetric. Its starting point of the work was the conjecture that asymmetry would indicate the empirical relevance of the Kahneman and Tversky (1979) ´s prospect theory, the behaviorally informed explanation of decision under risk. The time frame for the analysis was justified by considering relevant political and economic events that had a great impact on the Brazilian stock market, especially in relation to the period prior to the beginning of the COVID-19 pandemic, as well as the period that involved the volatility of the Brazilian stock market and world during the pandemic. The findings of the proposed TGARCH model corroborates our hypothesis that negative shocks in the Brazilian stock market have a greater effect on volatility than positive shocks.

Furthermore, the econometric study allowed us to identify the leverage effect. The latter highlights that negative shocks increase volatility more than positive shocks, which is also known in behavioral financial literature as overreaction. The abovementioned results drew our attention to the fact that the Brazilian stock exchange behavior in the period under scrutiny could not be satisfactorily explained by the traditional financial literature. Ibovespa investors seem to have reacted more intensely to negative shocks, undoing their positions by selling assets, probably at a loss, in a scenario of falling stock values. The increased volatility in a bearish scenario of the Brazilian stock exchange during the pandemic put some individuals away from Ibovespa due to non-rational psychological and social factors. We acknowledge that the proposed model did not accommodate political and economic factors which might play an important role in explaining the Brazilian stock exchange volatility. Yet given the focus on the current paper, the task of estimating more comprehensive models is left for future research.

To claim that behavioral financial insights improve understanding of the Brazilian stock exchange investment decisions in the period under study, we drew on the literature on cognitive and affective heuristics and biases to provide an interpretation of behavior patterns before and after Covid-19 that shed extra light on the fact that financial decisions among investors of the Ibovespa deviated from the EMH and provided exemplary cases of bounded rationality. Ibovespa investors underestimated information about Covid-19 before March 2020 and instead focused their attention on what they regarded as favorable information about the Brazilian future economic growth trajectory under Bolsonaro´s administration. Their behavior patterns suggest that boundedly rational agents make judgments and decisions based on anchoring, availability, and representativeness heuristics. In tune with Vasileiou (2020), we also propose that herding, availability, and representativeness mental heuristics also explain why investors in the Brazilian stock exchange made optimistic buying decisions despite the increase of number of COVID 19 cases and deaths. Among boundedly rational investors´ attention and memory are scarce resources and they might have appealed to narrowly framed information about American and Brazilian government interventions to neutralize risks of a financial crisis to justify their B3 investment choices. One lesson to be drawn is that a broader understanding of the actual functioning of the stock market is necessary, given the fact that negative shocks must be prevented from resulting in more intense movements of sales than positive shocks, which certainly increases the loss of market participants who are fully unaware of the possibility of temporary losses. Another lesson is that it does pay off to draw attention to theoretical and empirical insights from behavioral finance and its promise to provide mechanistic explanations of anomalies and puzzles of the Brazilian economy. Despite the vast literature worldwide, there is fertile room for new behavioral financial studies that dig deeper into cognitive, emotional, and social mechanisms underlying real-world investors in the Brazilian financial markets before and during the pandemic.

## Acknowledgements

The authors are grateful to Mackpesquisa research fund from Mackenzie Presbyterian University of Sao Paulo for financial support and to the IJBM´s anonymous reviewers for their very useful suggestions.

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