COVID-19 Pandemic and Speculative Behaviors: An Empirical Evidence of Stock Markets

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Abstract

The recent economic developments and outcomes have shown that the COVID-19 pandemic has been highly, but also negatively, correlated with financial markets and thus the financial system. This situation led to an increase in uncertainty and fragility in the economy. In this sense, this study aims to assess the speculative price behavior that occurred during the COVID-19 outbreak in the stock markets of 13 major countries. Daily data for the period between November 1, 2019 and October 23, 2020 are used to assess speculative price behavior. The empirical estimation strategy is based on the Supremum Augmented Dickey-Fuller (SADF) test and the Generalized Supremum Augmented Dickey-Fuller (GSADF) test. According to the estimation results, the SADF and GSADF test statistics show that the estimates are significant for the 13 specified stock market indexes. This empirical result shows that the COVID-19 pandemic has contagion effects on various types of financial markets, leading to bubble formation during the given sample period.

Key words: financial markets, COVID-19, speculative behaviors, bubbles, SADF, GSADF

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COVID-19 Salgını ve Spekülatif Davranışlar: Hisse Senedi Piyasalarından Ampirik Bir Kanıt

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Öz

Son yaşanan ekonomik gelişmeler ve sonuçlar COVID-19 pandemisinin finansal piyasalar ve dolayısıyla finansal sistem ile yüksek oranda ancak aynı zamanda olumsuz yönde ilişkili olduğunu göstermiştir. Bu durum ise ekonomide belirsizlik ve kırılganlığın artmasına neden olmuştur. Bu anlamda bu çalışma, 13 büyük ülkede COVID-19 salgınında ortaya çıkan spekülatif davranışların finansal piyasalar üzerindeki etkisinin olup olmadığını belirlemeyi amaçlamaktadır. Finansal piyasalarda spekülatif davranışların etkilerini değerlendirmek için 1 Kasım 2019 ile 23 Ekim 2020 arasındaki döneme ait günlük veriler kullanılmıştır. Ampirik tahmin stratejisi, the Supremum Augmented Dickey-Fuller (SADF) testine ve Generalized Supremum Augmented Dickey-Fuller (GSADF) testine dayalı olarak oluşturulmuştur. Tahmin sonuçlarına göre SADF ve GSADF test istatistikleri, verilen 13 borsa endeksi için tahminlerin istatistiki anlamlı olduğunu göstermektedir. Elde edilen bu ampirik sonuç, COVID -19 salgınının, verilen örnekleme döneminde balon oluşumuna yol açan farklı finansal piyasa türleri üzerinde bulaşıcı etkileri olduğu ortaya koymaktadır.

Anahtar sözcükler: finansal piyasalar, COVID-19, spekülatif davranışlar, balonlar, SADF, GSADF

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1. Introduction

Pandemic diseases, which caused many deaths, have been observed in history from the past to the present. A plague pandemic in the 14th century, Bleeding Fever in Mexico in the 16th century, cholera in the 19th century, SARS in the early 2000s, and Ebola and Swine Flu in recent years are just a few examples related to these deadly pandemics. The most recent addition to this chain of pandemic diseases is the COVID -19 or coronavirus pandemic, which first appeared in Wuhan, China, in December 2019 and was declared a pandemic by the World Health Organization on March 11, 2019 (Estrada et al. 2020). The coronavirus pandemic has caused many deaths worldwide and affected the entire world. In addition, the negative developments experienced around the world have profoundly affected social and cultural activities around the world.

The impact of the coronavirus pandemic negatively affected economic structures well as social and cultural activities. As a result of the uncertainty that emerged with the pandemic, global trade and supply chains were disrupted, while asset prices around the world suddenly felt (Ayittey et al., 2020, p. 473). The negative impact of the coronavirus on tourism, commodity trade, manufacturing, and transportation sectors was even more negative. For example, manufacturers such as General Motors, Nissan, and Renault decided to stop their production during this process (Zeren and Hızarcı, 2020, p. 79). In this context, if we consider the negative effects of the coronavirus brought by the current pandemic, a large-scale decline in production, fluctuations in the stock and foreign exchange markets represent an additional burden for national economies. More importantly, the problems that the pandemic has caused in financial markets have had a devastating impact on the real economy. This, in turn, has increased the likelihood that the macroeconomic system of economies will be disrupted and instabilities will arise.

Given the catchment area of the coronavirus and its speed of spread around the world, the impact of the virus on macroeconomic stability can be assessed from different angles. The first concerns the cost of the virus to national economies. The economic cost of the COVID -19 pandemic is that Boissay and Rungcharoenkitkul (2020) estimate that global GDP will shrink by an average of 4% in 2020 if the current situation persists. In other words, the pandemic is likely to lead to global output losses. According to IMF estimates (2020), the income losses of the global economy will be about 6%. From this point of view, it can be evaluated that the cost of the pandemic will exceed the cost of the crisis when compared to OECD economies, which shrank by 3% on average in the 2008 Global Crisis.

The COVID-19 pandemic has had a second impact on oil markets. While the price of oil was $50 at the beginning of March 2020, it has fallen to $20 due to low demand caused by the pandemic. Low oil prices have left the economies of OPEC countries such as Russia, Qatar, Azerbaijan, and Saudi Arabia vulnerable, especially where the economy is dominated by oil. In this context, the inability to control this process, which began with the COVID-19 pandemic, means that the risk of economic collapse due to oil prices in these countries remains.

The COVID-19 pandemic has shown its third impact on financial markets, which is the subject of this study. The COVID-19 pandemic has shown its impact on financial markets with the collapse of all world stock markets in March 2020. For example, on March 16, 2020, the Dow Jones Index fell 2977 points in one day, the largest collapse ever. The COVID-19 breakout created an environment of uncertainty for investors. This uncertainty led to huge losses in the stock markets. For example, while there was a 37% drop in the UK stock market, a 33% drop was observed in the German stock market. On the other hand, while there was a 48% decline in the Brazilian stock market, this decline was 38% in the Polish stock market. In Turkey, the stock market recorded a decline of 15% at the same time.

The globalization of financial markets is an inevitable and ongoing dynamic process that leads to more capital resources to support companies and individuals, more investment products and diversity, more opportunities, and greater complexity of risk and risk management issues (Račickas & Vasiliauskaitė, 2011, p. 1174). This causes the spread of market disruptions, which can be defined as financial contagion, from one country to another. In other words, financial contagion refers to the spread of adverse shocks that have the potential to trigger financial instability (Moser, 2003) (Pereira, 2018, p. 5). Increasing mixed relations between financial markets with the globalization process increase the likelihood that excessive volatility in one financial market will infect other markets. Increasing the probability of financial contagion leads to the formation of bubbles in financial markets by moving away from the fundamental values of financial asset prices. As stated in the studies on the formation of bubbles in the literature, the explosion of bubbles in financial markets always shows that there is a serious disruption in the financial markets. While in the case of positive bubbles in financial markets there is excessive demand formation, in the case of negative bubbles there is a disproportionate sale of financial assets. In the event of an explosion of bubbles, prices suddenly fall (Malkiel, 2010, p. 14).

In this context, this paper aims to determine whether the impact of financial contagion, which is a major topic of discussion in the international finance literature, occurred in the financial markets of 13 major countries during the COVID-19 outbreak. To this end, the study used daily data between November 1, 2019 and October 23, 2020, obtained from Yahoo Finance and the CBRT EDDS database. This study differs from similar studies in terms of its subject and method. For example, few studies focus on speculative pricing and timing in stock markets during the COVID-19 pandemic. The SADF and GSADF methods used in the study are another difference that sets it apart from others. The SADF and GSADF tests, which are used to detect speculative price behavior, allow bubbles to be predicted in advance thanks to their dynamic structure, as opposed to indirect methods, and provide more accurate results than standard econometric tests.

The paper considers the relevant literature and presents in Part 2 the results of previous studies related to the subject of this research. The following section (Part 3) summarizes the dataset and the empirical method in detail. Part 4 presents the empirical results using a predetermined empirical strategy. Part 5 contains a concluding remark.

2. Literature Review

There are limited studies in the literature (Shu et al., 2021; Song et al., 2022) regarding the effects of the COVID-19 pandemic, which emerged towards the end of 2019 and affected the whole world, on financial markets. The short time between the emergence of the pandemic and the feeling of its impact on financial markets and economic factors constitutes the limits of research in this field. At this point, this study is expected to make an important contribution to the literature.

Zeren and Hızarcı (2020) examined the effects of the COVID-19 outbreak on the stock markets of China, South Korea, Italy, France, Germany, and Spain. In the study conducted with the help of daily data for the period of 23 January 2020 - 13 March 2020, the effect of both the COVID-19-day total mortality rate and the COVID-19-day total number of cases on the stock markets through the Maki (2012) cointegration test. As a result of the study, it was found that total mortality rates and all stock market indices move together. In addition, it was found that the total cases showed a cointegration relationship with SSE, KOSPI, and IBEX35 and were not cointegrated with FTSE, MIB, CAC40, and DAX30.

Avşargil (2020) conducted a study to examine the disruptions and changes in the financial markets to show the changes in Bitcoin, West Texas Crude Oil, and Euro prices and the behavioral patterns of the COVID-19 pandemic between 03/04/2020-11/01/2018. /The results show that the averages changed significantly in terms of the pre- and post-pandemic series, and the change in WTI is a reason for the change in BTC, as well as a change in the price of WTI in the change in EUR. In addition, the Zivot-Andrews unit root test with structural break revealed that there was no structural break at the beginning of the COVID-19 pandemic for both WTI and BTC, and EUR.

In the study conducted by Contessi and De Pace (2020), they examined the effects of the COVID-19 outbreak on the stock markets of 18 selected countries in four regions (South-East Asia, Europe, Developed Economies, and Developing Economies) for the period 1 November 2019 - 31 May 2020. In the study, it was concluded that the recent pandemic had negative effects on the rapid crashes of the stock market.

Sansa (2020) discussed the period of March 1, 2020 - March 25, 2020 in her study, which examined the impact of the COVID-19 outbreak on China and the US financial markets. As a result of the analysis, a positive and significant relationship was found between the number of cases and the Chinese and US markets.

In the study conducted by Cepoi (2020), the effects of the news about the COVID-19 outbreak on stock market returns were examined for the six countries most affected by the pandemic (USA, UK, Germany, France, Spain, and Italy) for the period 3 February 2020 - 17 April 2020. Daily returns of DJIA, FTSE 100, DAX, CAC 40, IGBM, and MIB were used as dependent variables in the study. As a result of the study, evidence was found that the news about

COVID-19 and the risk of contagion showed asymmetric dependence on stock market returns.

Bayraktar (2020) in his study examined the impact of the pandemic COVID-19 on manufacturing stocks BIST. According to the results of the study, it was found that manufacturing stocks whose stock returns are traded on BIST 100 have negative returns on average every day. The mentioned returns became more evident one day after the date of the announcement. The study found that BIST experienced a decline in parallel with the decline in world stock markets due to the impact of the pandemic on that day. In addition, the study found that price volatility was high, especially around the announcement date, in an environment of uncertainty caused by the pandemic.

Ali et al. (2020) examined the impact of the COVID-19 crisis on the volatility of financial markets. In this context, the daily prices and returns of the MSCI indices of the first nine countries affected by the COVID-19 Pandemic, namely China, the USA, England, Italy, Spain, France, Germany, Switzerland, and South Korea, as well as some regions such as the World, Europe (EU) and Asia were used. The study covers the period between January 1, 2020 - March 20, 2020. In the period specified in the study, it provides evidence that COVID-19 increases the level of uncertainty, causing high volatility in stock market returns, and that the markets are gradually deteriorating.

Yıldız and Aydın (2021) investigated the impact of the multi-layered COVID-19 pandemic on alternative financial instruments in Turkey using the EGARCH model. In this direction, the researchers tested the hypothesis that risk and risk-related volatility will increase and economic entities will seek a safe haven, with uncertainty in financial markets due to the uncertainty of when the pandemic will end. According to the results, it was found that volatility persisted in Bitcoin and the interest rate, while the duration of the shock in volatility in the gold market was low. At the same time, negative news was found to have a greater impact on stocks, gold, and interest rates, and positive news on dollars and bitcoin. It was found that the number of cases related to COVID-19 increased the volatility of stocks, gold, and interest rates, but did not have a significant impact on the dollar and bitcoin.

Baker et al. (2020) examined the impact of COVID-19 on the volatility of the U.S. stock market by comparing the COVID-19 pandemic with pandemics in previous periods. In the study, they found that the historical pandemics had a small impact on U.S. stock market volatility, but news of COVID-19 developments had a significant force on U.S. stock market movements on February 24, 2020. In addition to COVID-19 being a more severe disease in many ways, they argued that the greater interconnectedness of modern economies, easier access to information, and action against the COVID-19 outbreak produce more effective responses to current problems.

In the study conducted by Wang and Enilov (2020), the effect of the number of COVID-19 cases on the stock returns of international financial markets between February 17, 2020 and April 9, 2020 was analyzed with the help of Panel data for G-7 countries. As a result of the

analysis, it was found that there is a causality relationship between the number of cases and stock market returns in Canada, France, Germany, Italy, and the USA, whereas there is no such causality relationship in the UK and Japan.

Gürsoy et al. (2020) analyzed the relationship between the COVID-19 outbreak and financial indicators with the help of the Toda-Yamamoto (1995) causality test for the period between December 6, 2019 and March 10, 2020. In this context, while the SSEC index, which is the benchmark stock market of China, is considered as the dependent variable, Brent oil, Bitcoin, Gold, and VIX (Fear Index) data are used as independent variables. According to the results obtained from the study, a one-way causality relationship was found between the SSEC index and gold, and a two-way causality relationship between SSEC and VIX.

Çoban et al. (2020) investigated the impact of the COVID-19 Outbreak on Turkish financial markets with the help of the Toda-Yamamoto Causality Test. According to the results of the analysis, a statistically significant causality relationship was determined from the number of cases to the Euro and USD exchange rate. In addition, in the study, no causality relationship was found between the COVID-19 case numbers and the BIST100 index and gold prices.

Finally, studies investigating the formation of bubbles in different types of markets can also be found in the literature. Using the PSY test (GSADF), Gharib et al. (2021) point to the presence of boom periods in the crude oil and gold markets between 2010 and 2020. In particular, the COVID-19 period has shown the contagion effect in the bubbles in the two markets.

3. Data and Empirical Methodology

3.1 Data

The purpose of this study is to determine whether the effects of financial contagion are statistically relevant during the COVID-19 outbreak in terms of different financial markets. In that vein, we use a daily dataset (5-day weeks) of 13 major stock market indices. These indices cover a large degree of capitalization levels accruing from the volume of total stock exchanges in the world and belong to economies that have been critically affected by the recent pandemic. One of the most important features of this study that distinguishes it from the others depends on the fact that it detects the presence of contagion effect of COVID-19 outbreak in the financial markets. In addition, it determines the exact period and its side-effects in which the contagion can occur in the financial markets in line with an ongoing emergence of potential financial instability. Besides those mentioned macro-based outcomes that we will be dealt with in the empirical part, the adopted SADF and GSADF procedure detects the dynamic structure of financial contagion by way of examining the instability migration across different stock markets. We consider the stock market indices for the two core classifications. The first one consists of this framework in terms of countries' income levels and the second evaluates it in the presence of their regional differences.

However, it should be noted that this classification does not matter in some sense if the social ingredients are ignored in the discussion of financial instability which might be occurred in different stock markets. The income-based classification of the sample selected stock market indices can be implied as follows:

1. High-Income Economies: *Australia* (S&P/ASX 200 Composite Index), *France* (Paris CAC-40 Index), *Germany* (DAX Price Index), *Hong Kong* (Hang Seng Composite Index), *Italy* (Milan COMIT 30 Index), *Korea Republic* (KOSPI-100 Index), *Spain* (Madrid SE IBEX-35 Index), *United Kingdom* (FTSE All-Share Index), and *United States of America* (Dow Jones Composite Average (Actual) Index);
2. Upper-Middle-Income Economies: *Brazil* (BOVESPA Index), *China* (Shanghai SE Composite Index), *Turkey* (BIST100 Index);
3. Lower-Middle-Income Economies: *India* (NSE-50 Index)

Besides the income-based classification, the second type of classification for the stock markets can be done in terms of countries' regional differences as follows:

1. East Asia and Pacific: *Australia* (S&P/ASX 200 Composite Index), *China* (Shanghai SE Composite Index), *Hong Kong* (Hang Seng Composite Index), and *Korea Republic* (KOSPI-100 Index);
2. Europe: *France* (Paris CAC-40 Index), *Germany* (DAX Price Index), *Italy* (Milan COMIT 30 Index), *Spain* (Madrid SE IBEX-35 Index), *Turkey* (BIST100 Index), and *United Kingdom* (FTSE All-Share Index);
3. North America: *United States of America* (Dow Jones Composite Average (Actual) Index);
4. Latin America: *Brazil* (BOVESPA Index);
5. South Asia: *India* (NSE-50 Index).

Table 1 presents selected descriptive statistics for 13 major stock market indices. As the statistical values indicate, the trends in stock market volatility are recognized across the economies and thus may not ensure a significant correlation with each other.

Table 1. Descriptive Statistics

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J-B	Obs.
Australia	6128	6039	7144	4546	603	-0.101	2.256	6.029	244
Brazil	98390	100369	119528	63570	13373	-0.529	2.471	14.24	244
China	3056	2984	3451	2660	210	0.331	1.729	20.84	244
France	5156	5007	6111	3754	613	0.123	1.915	12.58	244
Germany	12332	12832	13789	8441	1235	-1.294	3.694	73.05	244
Hong Kong	25396	24946	29056	21696	1617	0.414	2.314	11.69	243
India	10953	11305	12362	7610	1191	-0.824	2.484	30.33	244

Italy	20361	19782	25478	14894	2614	0.142	1.957	11.88	244
Korea Rep.	2136	2161	2443	1458	197	-0.887	3.693	36.73	243
Spain	7874	7274	10083	6107	1211	0.533	1.555	32.78	244
Turkey	1087	1099	1235	842	89	-0.709	3.034	19.69	235
UK	3575	3407	4258	2728	403	0.379	1.859	19.07	244
USA	8717	9073	9710	6100	799	-0.934	3.088	35.52	244

All series begins on November 1, 2019 and end on October 23, 2020. The fact that the speculative movements in the price formations in the financial markets caused by the COVID-19 pandemic were most intense in the selection of this period was effective. We apply our SADF and GSADF methods to the full samples. In parallel to the literature on COVID-19/asset pricing, we describe empirical findings in terms of the starting date as soon as possible that the World Health Organization (WHO) announced. Therefore, we do not adopt the starting date of empirical results as of January 1, 2020 in which Contessi and De Pace (2020) use this period – the day after the Wuhan Municipal Health Commission in China reports a cluster of cases of pneumonia in Wuhan, Hubei Province.

The major reason for not adopting this date to start the empirical examination depends on the case that the mentioned starting date with a given report in Wuhan is only an official statement but the cases were no longer dependent on that statement. In other words, the unofficial cases and their effects on various economic units are several which have been assumed from ourselves that started far away from the official reports. Therefore, we describe empirical results starting from November 1, 2019. With this in mind, the following subsection explains the basics of the empirical methods - namely SADF and GSADF.

3.2 Empirical Methodology

A bulk of studies on financial instability and the detection of financial bubbles are particularly based on the use of cointegration and standard unit-root testing methods which of those are assumed as indirect procedures at all. However, the limitations of these indirect methods should be also mentioned to make further analyses in terms of the countries exhibiting inconsistent financial structures and having different stock market foundations. Therefore, the current methodology we use in the empirical analysis also takes into account the counterarguments and theoretical criticisms based on these indirect methods to identify whether bubbles occur in stock markets by using a novel econometric procedure developed by Phillips et al. (2011) as the SADF test method and by Phillips et al. (2015) as the GSADF test method. In other words, the statistical detection of financial contagion evolves around a right-tail variation of the Augmented Dickey-Fuller (ADF) test and subjects to the following test equation represented in Equation (1):

$$y_t = \mu + \delta y_{t-1} + \sum_{i=1}^{\rho} \phi_i \, \Delta y_{t-i} + \varepsilon_t \qquad (1)$$

where y_i is a stock market index; μ is an intercept; ρ is the maximum number of lags; and ε_t is a disturbance term.

To determine speculative bubbles and their occurrence, the Supremum ADF (SADF) test is used as a right-handed unit root test developed by Phillips et al. (2011), which is a standardized extended Dickey-Fuller (ADF) test. Homm and Breitung (2012) found that this test, as well as other tests using similar procedures, has excellent performance. SADF is essentially based on the replication assumption of the standardized ADF test. The SADF test is determined as the lower value of the ADF statistical sequence and is obtained by estimating equality in equation number 1 with minimum squares. (Philips et al. 2015).

$$x_t=\mu_x+\delta x_{t-1}+\sum_{j=1}^{j} \emptyset j_j \Delta x_{t-j}+\varepsilon_{x,t}\,,\varepsilon_{x,t} \sim NID(0,\sigma_x^2) \quad (2)$$

For several given values of J in Eq. 2, ND shows the independent and normal distribution, and H_0:$\delta=1$ zero hypothesis and H_{01}:$\delta>1$ alternative hypothesis is formed in SADF right-tailed unit root test. At each passing one observation is increased in recursive regressions in sample data and as a result it can be estimated recursively using sub-sets.

$$sup_{r\epsilon[r_0,1]} ADF_r \rightarrow sup_{r\epsilon[r_0,1]} \frac{\int_0^r \widetilde{W} dW}{(\int_0^r \widetilde{W}^2)^{1/2}} \quad (3)$$

Equation number 3 shows the W standard Brownian motion and $\widetilde{W}(r) = W(r) - \frac{1}{r}\int_0^1 W$ the minimized Brownian motion. (Philips et al., 2011: 206-207). In the case where more than one bubble occurs in the literature, Phillips et al. (2015), taking into account criticisms of the statistical power reduction of the SADF test, developed the generalized GSADF unit root test to compensate for the shortcomings of the SADF test. Specifically, the estimation of the GSADF unit root test method approaches the nonlinear structures and structural breaks that extend over a long period of time in parallel with the use of the iterative flexible estimation of the regression from which the standard ADF test is obtained in the empirical process. Therefore, the GSADF unit root test procedure performs statistically better than unit root tests such as supremum ADF (i.e., SADF) and standard ADF in terms of providing more consistent and accurate results when conditions are open to the occurrence of different financial bubbles (Phillips et al., 2015). Although the GSADF unit root test depends on the recursive operation of the ADF test in subsamples, it is referred to as the largest ADF test because it is much larger than other right-justified unit root tests. To measure the GSADF test statistics, the iterative regression equation labeled No. 1 should be estimated in the initial stage of the analysis. This is also adopted from Eq. (1) where the null and alternative hypotheses are $H_0 : \delta = 1$ and $H_1 : \delta \neq 1$, respectively. The original sample interval of *T* daily observations is ranged in [0,1]. The ordinary least squares estimate of δ over the sample $[r_1, r_2] \subseteq [0,1]$ is expressed as δ_{r_1,r_2}. On behalf of ρ (i.e., the maximum lag length), r_1 and r_2 are included in the equation to represent the starting and ending points of the sub-sample so that repetitive regression estimates can be done, respectively. In that vein, the corresponding *ADF* test statistic can be denoted as follows ADF_{r_1,r_2} where r_w is equal to r_2-r_1 and is called the (fractional) window size of the regression (Contessi and De Pace, 2020:

3). The *GSADF* test emerges from a recursive method in which *ADF* test statistics are estimated over windows that yield a forward-moving and spreading sample. Hence a given test equation is measured over the various sample at each iteration and thereby compute an *ADF* test statistic. So, the test statistic obtained by the employment of the *GSADF* testing procedure is assumed as the supremum of ADF_{r_1,r_2} over all potential overlapping windows. In essence, $GSADF\ (r_0) = \sup\left\{ADF_{r_1,r_2}\right\}$ where $r_2 \epsilon [0,1]$, $r_1 \epsilon [0, r_2 - r_1]$, and r_0 denotes the smallest sample window width fraction (10%) and 1 expresses the largest window width fraction in the recursion (Contessi and De Pace, 2020, p. 3; Phillips et al., 2015, p. 1049). All in all, Eq. (4) represents the general equation form of the *GSADF* test in the framework of the above-mentioned theoretical context in the following manner:

$$\Delta y_t = \tilde{\alpha}_{r_1,r_2} + \tilde{\beta}_{r_1,r_2} y_{t-1} + \sum_{i=1}^{\rho} \tilde{\psi}_{r_1,r_2} \Delta y_{t-i} + \tilde{\varepsilon}_t \quad (4)$$

All in all, Eq. (4) is estimated repeatedly for multiple sub-samples by using sub-sets with a future date; thus, the sub-samples are originated where the starting points change dynamically at r_1 which differs from the zero points in case of estimating the *GSADF* unit-root test. The next sub-section summarizes the empirical findings based on the SADF and *GSADF* unit-root testing method to measure the financial contagion whether it is statistically significant throughout the emergence of COVID-19 across 13 major stock market indices.

4. Empirical Findings

The study aims to determine whether there are bubbles in the stock markets based on the stock market indices of 13 major countries. Therefore, the main objective of the study is to determine the contagion of the COVID-19 outbreak on the financial markets. For this purpose, in the GSADF test used to determine the presence of bubbles and when the bubbles occur in the stock market, a Monte Carlo simulation with 2000 replications for each observation was used. The estimation results obtained are given in Table 1. The graphs of the GSADF test by income group are shown in Figure 1, Figure 2, and Figure 3.

Table 2. The GSADF and SADF Test Statistics

	GSADF Test Statistic	*SADF Test Statistic*
Australia (S&P/ASX 200 Composite Index)	2.966 (0.00)	2.966 (0.00)
Brazil (IBOVESPA Index)	2.603 (0.00)	2.603 (0.00)
China (Shanghai SE Composite Index)	3.620 (0.00)	0.648 (0.03)
France (Paris CAC-40 Index)	4.005 (0.00)	3.965 (0.00)
Germany (DAX Price Index)	3.540 (0.00)	3.487 (0.00)
Hong Kong (Hang Seng Composite Index)	1.064 (0.08)	0.875 (0.01)
India (NSE-50 Index)	3.072 (0.00)	3.072 (0.00)
Italy (Milan COMIT 30 Index)	3.903 (0.00)	3.872 (0.00)
Korea Republic (KOSPI-100 Index)	3.662 (0.00)	3.577 (0.00)
Spain (Madrid SE IBEX-35 Index)	4.589 (0.00)	4.589 (0.00)

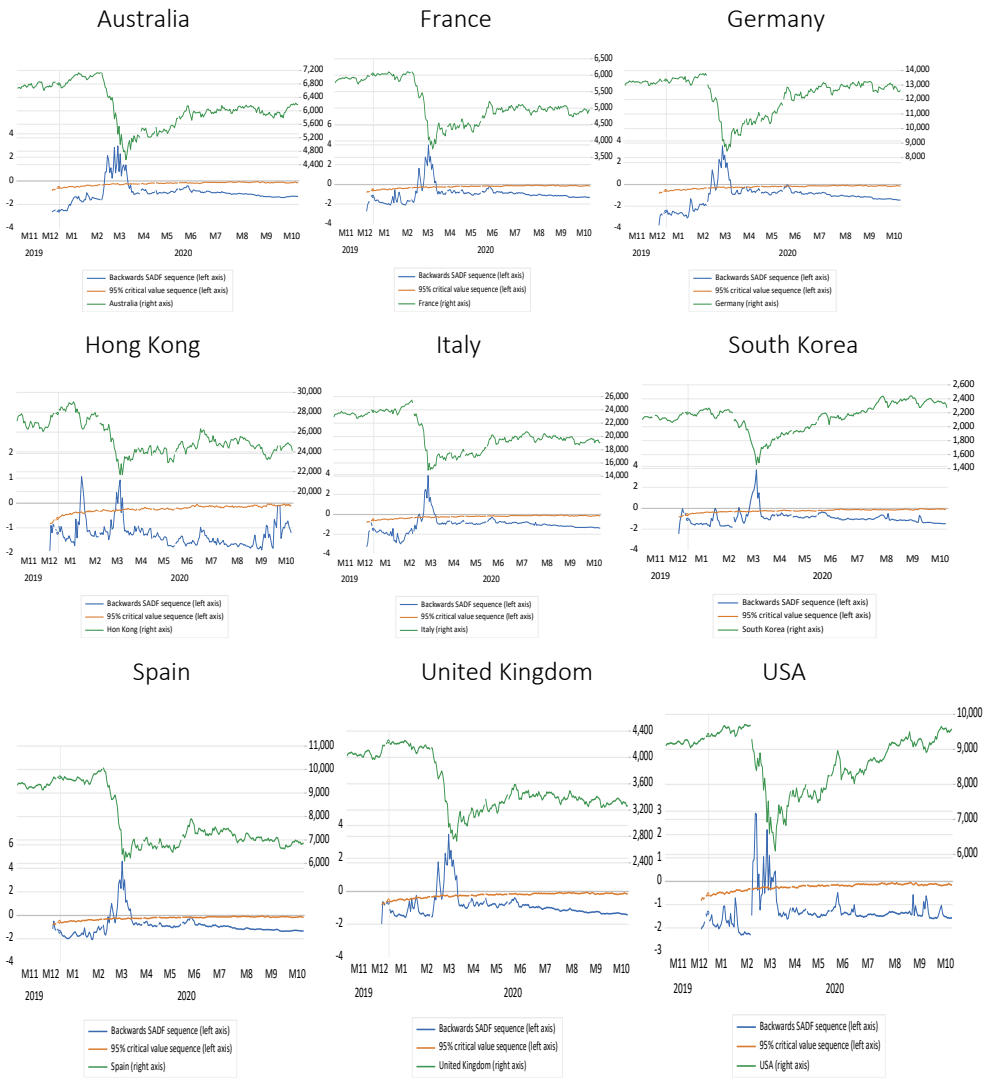
Turkey (BIST100 Index)	1.944 (0.00)	1.902 (0.00)
UK (FTSE All-Share Index)	3.455 (0.00)	3.445 (0.00)
USA (Dow Jones Composite Average (Actual) Index)	2.901 (0.00)	2.901 (0.00)

Note: ( ) refers to the probability values of the variables. Critical values for GSADF statistics are 1.010, 1.227 and 1.726 for 10%, 5% and 1% significance levels, respectively. Critical values for SADF statistics are 0.260, 0.533, and 0.949 for 10%, 5% and 1% significance levels, respectively.

The SADF and GSADF test statistics reported in Table 2 were found to be statistically significant for 13 stock market indices selected based on the income groups of the countries under study. Our results are consistent with Contessi and De Pace (2020). In other words, this result shows empirical evidence of bubble formation in stock prices. Thus, it was found that the concerns raised by the COVID-19 pandemic that started in China and quickly spread around the world were transmitted to the financial markets of all the selected countries in the study. As can be seen from the empirical evidence obtained, the bubble collapses caused by COVID-19 in the financial markets of all income groups, in other words, their explosions cause serious disruptions in the financial markets.

Figure 1 shows whether speculative behavior occurred in the equity markets of the high-income group during the COVID-19 outbreak. In this sense, Figure 1 depicts that a bubble formed in the stock markets of the high-income group of economies. Accordingly, the negative bubble formation occurred in the high-income group countries between the end of February and the end of March, except in Hong Kong. In other words, the financial instability caused by the COVID-19 outbreak peaked during this period and stock market indices in high-income countries collapsed. However, there is a difference due to the geographical characteristics of Hong Kong. Namely, the instability that occurred in Hong Kong as a result of the restrictions imposed by China on the cities of Wuhan and Hubei on January 24, 2020 was quickly reflected in Hong Kong. For this reason, it can be observed that the first negative bubble formed in Hong Kong at the end of January 2020. With the declaration of the pandemic around the world on March 11, 2020, a second bubble formation is observed in Hong Kong. Therefore, the COVID-19 outbreak in Hong Kong stock markets shows contagion in two different periods and simultaneous bubble formation with other high-income countries is observed.

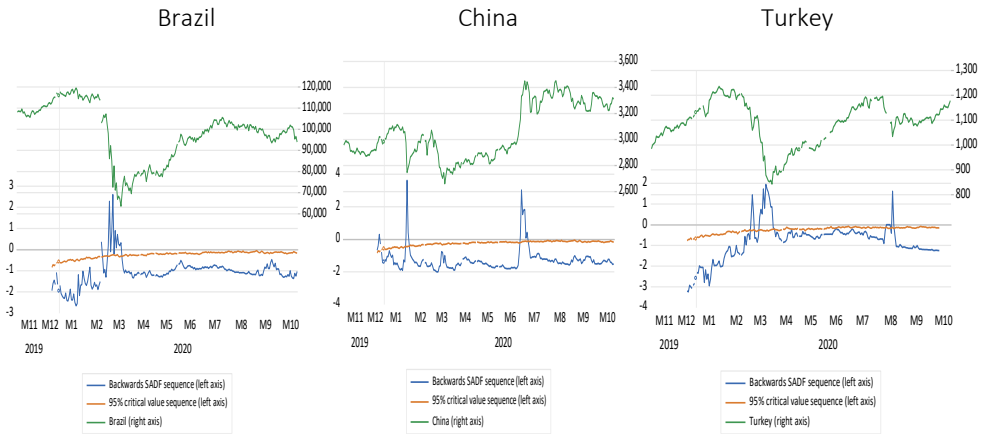
Figure 1. The GSADF Test Results for High-Income Economies



The GSADF form shown in Figure 2 shows the test results of the countries belonging to the group Upper-Middle-Income Economies. According to the figure, it can be observed that COVID-19 has caused a negative bubble in the Brazilian and Turkish stock markets. The uncertainty in the financial markets, especially due to the announcement of the global pandemic on March 11, 2020, was effective in the formation of this bubble. As a result of the contagion effect of the sharp declines observed in all world stock markets on March 16, 2020,

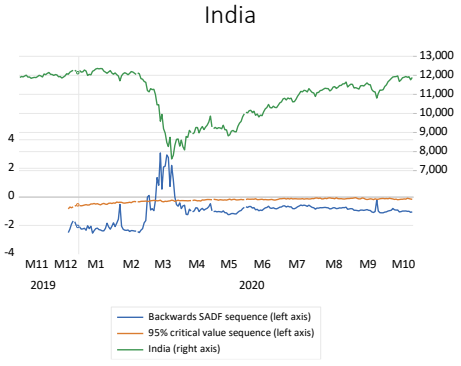
financial instability in both countries peaked during the period from March 18 to 25, 2020. In other words, the contagion effect of the COVID-19 outbreak reached its highest level during this period. On the other hand, in China, the center of the pandemic, the bubble formation occurred after the restrictions imposed on January 24 were reflected in the financial markets. Therefore, as the test results show, financial instability in China peaked in late January 2020. However, as China entered a recovery phase, the Chinese stock market experienced a positive bubble formation in late June 2020 and early July.

Figure 2. The GSADF Test Results for Upper-Middle-Income Economies



Finally, the bubble in the stock market of India, which is included in the groups of Lower-Middle-Income Economies, occurred in a similar period to the countries selected in the study after the COVID-19 pandemic was announced as a pandemic worldwide. Therefore, the period from March 13, 2020 to March 26, 2020 has been identified as the peak of financial contagion in the Indian stock market.

Figure 3. The GSADF Test Results for Lower-Middle-Income Economies



5. Concluding Remarks

The liberalization of financial systems and the globalization of capital markets have expanded financial services and improved the allocation of resources. At the same time, this has increased the size of significant financial cycles. These cycles paved the way for dramatic fluctuations in the prices of financial assets, the amplification of the business cycle, and the formation of bubbles, and even led to the culmination of crises in financial markets. Therefore, it is important to understand more about the impact on the economy and financial markets by carefully analyzing the bubble formation and financial contagion in financial markets.

In this context, this study aims to determine whether the stock market indices of 13 major countries caused financial contagion during the COVID-19 outbreak. To this end, an attempt was made to determine the presence of bubbles in these financial markets and when they occur in the event of bubbles. This was estimated using the SADF and the GSADF test used in the study and Monte Carlo Simulation with 2000 replications for each observation. According to the estimation results obtained, the SADF and the GSADF test statistics were found to be statistically significant for 13 stock market indices selected for the study. This result shows empirical evidence that the COVID-19 pandemic has contagion effects on financial markets and causes bubble formation. Therefore, the evidence obtained in this study has provided important insights into the development and spread of the contagion of the COVID-19 pandemic to financial markets. In other words, during the period discussed, financial contagion and uncertainty that spread to countries in all income groups, starting from China, caused bubble formation. As can be seen from the evidence obtained, it was observed that financial contagion first spread to Hong Kong stock markets, especially starting in China. After the COVID-19 outbreak was declared a pandemic, empirical evidence of bubble formation was obtained across the entire sample of stock market indices in the study. In other words, the increased financial instability due to the COVID-19 outbreak led to the collapse of the stock market indices.

Although these global devaluations have gradually entered a balancing process with the liquidity provision practices of all central banks, particularly the US Federal Reserve, the uncertainties of investors for the future persist. These uncertainties undoubtedly include not only the problems caused by the coronavirus pandemic, but also the vulnerabilities left behind by the 2008 Global Crisis, the high levels of corporate and personal debt, and the fact that they cannot be overcome by central bank liquidity policies. From this point of view, it can be predicted that if the course of the COVID-19 pandemic is not brought under control, the risk of disruption and destabilization of the financial system will continue.

So that, given the empirical evidence obtained in this study, the coronavirus pandemic still has the potential to be a financial pandemic, as it not only has a negative impact on financial

markets but is also a pandemic caused by the global health crisis. For this reason, countries should aim to mitigate the impact of the COVID-19 pandemic through monetary, fiscal, and financial policies as a result of all the developments experienced. Once the rise of the pandemic is under control, it is of great importance that they aim for a stable, sustainable recovery process by learning lessons from the pandemic. In such a case, it seems possible to overcome the "financial pandemic" and prevent financial contagion.

Ethical Statement Information of the Article Titled As "COVID-19 Pandemic and Speculative Behaviors: An Empirical Evidence of Stock Markets"

	This study has been prepared in accordance with the values of "Research and Publication Ethics"
Acknowledgement	Article is not reproduced from any paper or thesis.
Conflict of Interest Statement	Not any.
Author Contributions	In the study titled "COVID-19 Pandemic and Speculative Behaviors: An Empirical Evidence of Stock Markets"; Emrah DOĞAN (50%): Introduction, empirical analysis, and conclusion sections. Onur ÖZDEMİR (%30): Data set and method sections. Başak ÖZARSLAN DOĞAN (%20): Abstract, literature review sections.
Support	If the study was supported by an institution.
Ethics Committee Certificate Of Approval	Ethics Committee Permission is not required.
Scale Permission	Scale Permission is not required.

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