BMIJ
ISSN: 2148-2586

bmij (2021) 9 (4):1286-1299
doi: https://doi.org/10.15295/bmij.v9i4.1889
Research Article

An empirical comparison of stock market bubbles

Borsa balonlarının ampirik karşılaştırılması

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Submitted: 14/07/2021

Revised: 13/09/2021

Accepted: 15/11/2021

Online Published: 25/12/2021

Citation: Korkmaz, Ö., & Bari, B., & Adalı, Z., An empirical comparison of stock market bubbles, bmij (2021) 9 (4): 1286-1299, doi: https://doi.org/10.15295/bmij.v9i4.1889

Abstract

Financial asset bubbles occur due to systematic and continuous differences between fundamental and market values. Due to high growth periods and foreign capital inflows, bubbles are also seen in stock market indexes, especially in emerging market economies. This study analyzes the existence of bubbles in BIST100, IDX COMPOSITE, BOVESPA, MDEX, NIFTY 50, SHANGAI, and S&P 500 stock markets for the period 2009:01-2021:06. RADF, SADF, and GSADF tests are applied to detect bubbles on stock market closing prices. In addition, the emergence and demise dates of the bubbles are determined by employing the date-stamping method. The GSADF test gives more effective results and determines bubbles with different durations in all stock markets, except the S&P 500. The results reveal that the most inefficient market is IDX COMPOSITE, and S&P 500is the most efficient market. The analysis includes the S&P 500, the world's most liquid and most prominent stock market, for comparison. In this respect, bubbles occur more in emerging market exchanges. The findings also confirm the validity of the rational bubble law.

Keywords: Financial Asset Bubbles, Stock Market Indexes, RADF Test, SADF Test, GSADFT Test

Jel Codes: C31, G10, G17

Öz

Finansal varlık balonları bir varlığın temel değeri ile piyasa değeri arasında oluşan sistematik ve sürekli farklar sonucu ortaya çıkar. Benzer balonlar borsa endekslerinde de görülür. Özellikle yükselen piyasa ekonomilerinde büyüme dönemleri ve yabancı fon girişleri sonucu balon etkisi oluşabilir. Bu çalışmada BIST100, IDX COMPOSITE, BOVESPA MDEX, NIFTY 50, SHANGAI ve S&P 500 borsalarında 2009:01-2021:06 dönemi için balonların varlığı incelenmektedir. Bu amaçla borsa kapanış fiyatları kullanılarak RADF, SADF, and GSADF testleri uygulanmaktadır. Ayrıca, date-stamping yöntemi yardımıyla balonların ortaya çıkma ve sönme tarihleri incelenmektedir. GSADF testinin daha etkin sonuçlar verdiği dikkate alındığında S&P 500 hariç tüm borsalarda farklı süreye sahip balonların varlığı tespit edilmektedir. Sonuçlar karşılaştırıldığında en etkin olmayan piyasanın IDX COMPOSITE olduğu görülmektedir. S&P 500 ise en etkin işleyen piyasadır. Dünyanın en likit ve en büyük borsası olan S&P 500 karşılaştırma amacıyla analize dahil edilmektedir. Sonuçlara genel olarak bakıldığında yükselen piyasa borsalarında balonların daha fazla oluştuğu görülmektedir. Bulgular aynı zamanda rasyonel balon yasasının geçerliliğini de doğrulamaktadır.

Anahtar Kelimeler: Finansal Varlık Balonları, Borsa Endeksleri, RADF Test, SADF Testi, GSADF Testi

JEL Kodları: C31, G10, G17

Introduction

Many studies have investigated the finance literature of rational bubbles in stock markets across the last three decades. According to Chan et al.'s (1998) rational bubble law, investors expect stock prices to continue to rise, and rational expectation reveals the rational bubble law. The rational bubbles mean that the long-run relationship between stock prices and their dividends disappear or an increase in stock prices motion over the extended periods but the bubbles resulting from an increase in asset prices unexpectedly explode because of experienced specific events. As the number of firms and individuals participating in profit speculation increases, rational behavior turns into behavior defined as madness or bubble. A bubble rises in prices for a certain period before a violent collapse, while a prolonged negative bubble is defined as a collapse. However, bubbles can be denoted as a divergence between an asset's market value and fundamental value (Kırkpınar, Erer, and Erer, 2015:22). Financial bubbles consist of asset price bubbles and speculative bubbles (Kindleberger, 1991:155). There are several determinants inducing asset price bubbles. Low-interest rates, a dramatic increase in demand for a product, bottlenecks in a particular stock in the market can contribute to the formation of bubbles. However, speculative bubbles result from forms caused by sheer speculation, and the financial fundamentals do not support asset inflation (Dwyer and Hafer, 2013:5).

Furthermore, various definitions are provided by different researchers. For example, Santoni (1987) indicates that stock prices deviate from those consistent with fundamentals, and the deviation is called a bubble. Asset price bubbles are based on price inflation formed by investors because of an increase in the flock of an appropriate asset class. There are also some features indicated by Santoni (1987) that a bubble means the systematic and continuous accelerating and deviation asset prices from intrinsic asset values. Blanchard and Watson (1982) underline that those bubbles are a deviation from the core values measured values of expected cash flows. Moreover, Reza (2010) also claims that stock market bubbles are cognitive biases formed by emotional investing, causing higher prices regardless of rational reflection and fundamentals. It can also be defined that the bubbles refer to the persistent market overvaluation accompanied by the market collapse.

Although the investigation for detecting rational bubbles seems to be a contemporary and exciting topic in the literature, there are three primary approaches for detecting the bubbles' presence. According to Brooks and Katsaris (2003), testing for bubbles, excess volatility, and the cointegration of dividends and prices comprise the three approaches. However, they also suggest that the analysis of the stationary and cointegration seem to be the best analytical methods to examine the validity of a long-run connection between actual prices and fundamental variables. Although these methods and the studies have been the product of the three decades, the world has experienced various bubbles over history. Indeed, some of the bubbles have changed the thought of the economic theory and even shaped the countries' hegemony. Their effects and causes triggering the bubbles have continued to be discussed in the literature. For example, Zeren and Yilanci (2019) and Yanık and Aytürk (2011) state that The Tulip Bubble in the Netherlands (1637), the Mississippi Bubble (1927), Estate and the Stock Bubbles in the Asian Countries (1992-1997), the Dot-Com Bubble in the USA (1990), the Mortgage Housing Bubble in the USA (2008-2012), and the Greek Government Debt Crisis (2011) can be presented as the most significant bubble examples in history.

In the literature, bubbles are categorized and explained through three different perspectives. The first perspective is a dimension that emphasizes external and internal views to clarify the causes of the bubbles. According to the first perspective, internal bubbles are based on bubbles associated with the sources of an effective market. Changes in market factors and external bubbles are induced by the market participant's expectations on the futures of the market. In the first dimension, inefficiencies in bubbles resulting from imperfect and heterogeneous information are also determined as different types of bubbles. For example, some market participants have knowledge based on the overvaluation of asset prices. Therefore, they forestall to sell the overvalued assets, which induces the dramatic fall in the asset prices in which other market participants with less awareness about the markets are shocked and want to shuffle off the assets before the more decline in the asset prices happen (Boucher, 2003: 7).

Furthermore, the second dimension considers that bubbles are rational and irrational. According to this view, rational bubbles are created by rational expectations, whereas irrational bubbles are induced by the irrational thoughts and behavior of the market participants. Final categorization considers the bubbles as explosive properties and non-explosive bubbles. Non-explosive bubbles seem to be foam but are not flammable, while the explosive features of the explosive bubbles are high (Yuhn, Kim, and Nam, 2015:265; Zeren and Yilanci, 2019:83). Among the classifications of the bubbles, the rational and irrational bubbles have important appearances to explain the behavior of the market participants. The market participants invest stock conscious of the asset over-valued concerning the rational bubbles. Still, the market participants evaluate the course, fundamentals of the market and endeavor to determine the chance of procuring profits. On the other hand, an irrational bubble occurs in stocks invested by market participants at inflated prices regardless of market fundamentals. As a result, investors engage in a price demand war to win the stock (Dwyer and Hafer, 2013:5; Salge, 2012:3).

The bubble growing up can be classified as several stages in the light of the theoretical frameworks introduced by Calverley (2004) and Aliber and Kindleberger (2011). The first stage is the available and suitable economic and financial environment for investors. It is called displacement, changing the investment environment and providing a new investment opportunity. The financial or technological innovation, low-interest rates for borrowing, sound economic performance, the end of a war or conflict can be defined as the first stage. If the economic and political environment is strong enough, this new environment induces an economic boom and generates new investment areas. New and former participants flooding the new area and extant investment areas leads to increased asset prices. Still, the rates of asset price acceleration are generally observed as a low rate.

Moreover, the second stage plays a considerable role in generating the bubbles' structure. The optimistic and sound environments resulting from the events in the first stage are also experienced in the second stage. Still, the new phenomenon occurs, and it is observed as a significant culprit which induces the bubbles. The recent phenomenon is called euphoria or mania, representing the changing behavior and attitude of the market participants. At the second stage, strong market performances are expected as endlessly forward, and investors continue to invest in asset price, which creates the skyward course in the asset accelerates' the price. Still, even though investors know that a bubble exists, they seem confident that there is a reasonable opportunity to sell their holdings at a more substantial price in the future. In the second stage, herd behavior also plays a vital role in expanding the bubbles. An infinite number of new investors enter the market to achieve profits offered by a sound economic environment. Developing market participants leads to dramatically accelerating asset prices, strengthening the optimism that asset prices will continue to accelerate (Blanchard and Watson, 1982:299). The final stage is occurred by some unfavorable economic and financial environment which later changes the mood of the investors. Investors' expectations are adversely affected due to the decline in economic performance, the emergence of political and financial shocks, and the tendency of more prominent market participants to sell, increasing the selling pressure in financial markets. Sales acceleration leads to push-down asset prices, leading to the bubbles' burst and collapse. Panic phase comprising rising in financial distress, bankruptcies, and a shrinking in lending, the rise in uncertainty worse the effects of the explosion of the bubbles in the economy.

This study examines the bubbles in the stock market indexes of countries with different economic structures. Thus, it focuses on efficient markets and rational expectations in the stock markets of other countries with economic development levels. For this purpose, the empirical part clarifies the presence of bubbles using three different tests. Our study contributes to the literature regarding the period of data, usage of other methods, and comparison of various stock exchanges. The rest of the paper is designed as follows. Section 2 reviews the empirical literature. Section 3 introduces data and methodology. Section 4 presents empirical results. Lastly, section 5 concludes the study and provides main findings and policy recommendations.

Literature review

Investigating asset bubbles has been one of the most comprehensive literature since the asset pricing model was developed by Lucas (1978). Its popularity has been continued by improving econometric techniques and introducing new assets. Indeed, the process of investigating asset bubbles has moved parallel with the improving econometrics techniques against the former study's methods. Some pioneer studies have emerged during the 1980s and 1990s. Shiller's (1981) study is a seminal study that uses a variance bounds test to distinguish rational bubbles. Later, Diba and Grossman (1985) use Dickey-Fuller (DF) test to detect the bubbles in the US market, and the analysis poses that there is no existence in the US market. Phillips and Yu (2009) also underline that the DF unit root statistics diverge to negative infinity, decreasing the methods' efficiency. Regarding some drawbacks indicated by researchers, Phillips, Wu, and Yu (2011) introduce the detection methods by developing a forward recursive right-tailed DF test.

Along with these improved techniques, many studies have used this method to shine the bubbles in the asset market. Despite the dynamic criticism for the econometric methods in the relevant literature, various techniques have been continued to apply to detect the bubbles. Yuhn, Kim, and Nam (2015) indicate that the bubbles in the S&P occur during the Mortgage Housing crisis, whereas the bubbles in the NASDAQ are found during Black Monday and the Housing Crisis. Some studies are using the

Markow regime-switching model to determine the bubbles. Ahmed, Rosser, and Uppal (2010) administer a study for 27 developing countries, and the result affirms that the presence of the bubble was detected for 22 countries from 1990-2006. Al-Anaswah and Wilfing (2011) confirm the bubbles in the United States, Japan, Brazil, Malaysia, and Indonesia.

RADF, SADF, and GSADF have been the leading econometric methods relevant literature. For example, Korkos (2014) investigates whether the bubbles' validity exists in S&P 500 index employing ADF, RADF, SADF, and GSADF tests. The empirical evidence detected two bubbles in 2008-2012. Moreover, Chang and Gupta (2014) analyze the bubbles in the BRICS stock market through GSADF on data belonging to share prices and the profit share distribution ratios. Their results affirm that the bubbles have happened in specific periods. Finally, Arshanapalli and Nelson (2016) apply the SADF and GSADF tests to investigate the bubbles in S&P 500 index over 1960 - 2014. Their result emphasizes that GSADF detects two bubbles in 1974 and 1987, whereas the SADF rejects the existence of the bubbles.

Furthermore, Chang and Cai (2016) focus on Shanghai markets and detect six bubbles in the specific events related to politics and financial markets. Liaqat, Nazir, and Ahmad (2019) study whether bubbles exist in various industrial sectors operating in the Pakistan Stock Exchange. Monthly data covering 2007- 2016 is considered, and GSADF is employed in the investigation. The empirical evidence confirms that the validity of the bubbles holds for the KSE-100 index and several industrial sectors except for Investment, Chemical, and Textile Spinning sectors. Chang et al. (2016) employ the GSADF test to detect multiple bubbles in BRICS countries. The test result indicates that bubbles hold for almost all the BRICS countries during the subprime crisis. For India, a short bubble occurring during the 1999 period is detected. The bubble is explained through the spillover of the 1997-2000 dot-com bubble. Two bubbles during the 2007-2008 subprime crisis are determined concerning China. As for Brazil, a bubble was detected in 1992-1994. This period is characterized as financial liberalization in Brazil. Afsar and Kisava (2018) also notice the evidence of the bubble and crashes on the BRICS countries' financial markets exercising ADF, RADF, SADF, and GSADF for 2000-2016. The subsequent unit root tests reach a shred of evidence that the bubbles occur in the different time intervals in the BRICS countries. Escobari, Garcia, and Mellado (2017) account for Latin American equity markets and the link between S&P 500 and considered regions' equity markets employing SADF and GSADF tests. As a result of the analyses, it is identified that there is a strong connection between bubbles detected in the S&P500 and bubbles in the equity markets in the region. However, the Latin Americans market bubbles happened before the United States during the 2008 financial crisis. Therefore, the duration of the bubble in the Latin American markets has a more extended period.

Bago, Sourati, Ouédraogo, Ouédraogo, and Dembélé (2019) use South Africa share prices monthly data covering January 1960 -July 2019, and three bubbles are detected in the light of evidence reached from the GSADF test. First, the international oil crisis in 1979 and the 2008 global financial crisis are two crucial events creating bubbles in South Africa. This implication refers to the exogenous shocks playing a considerable role in the presence of the bubbles. Second, Almudhaf (2018) analyzes the Indonesian Stock Market in predictability, price bubbles, and efficiency. The GSADF test result indicates bubbles during 1988-90 and 2007-2008. Finally, Szulczyk, Cheema, and Holmes (2018) researched the rational speculative bubbles in Asian stock markets involving China, Indonesia, Malaysia, and six Asian countries. The result of the GSADF applied on monthly data confirms the explosive process except for the Malaysian market. However, The SADF and GSADF employed weekly show no bubbles in China, Indonesia, and Malaysia.

There are various studies to test the existence of bubbles in the Turkish stock market with the help of employing different econometric methods. For example, Tasci and Okuyan (2009), Yu and Hasan (2010), and Yanık and Ayturk (2011) employ duration tests, while Ogut et al. (2009) uses Artificial and Neural Networks and Support Machine. Parvar and Waters (2010) and Bozoklu and Zeren (2013) examine cointegration. These studies find no evidence for bubbles in the Turkish stock market before 2013s. In parallel with international literature, GSADF and SADF techniques have become popular to examine the validity of the bubbles in the Turkish stock market. For example, Kırkpınar, Erer, and Erer (2015) search for bubbles in BIST 100 and some sectors indices by employing the right-tailed unit root test, SADF, and GSADF test on data spanning 1990-2015. The empirical evidence demonstrates that rational bubbles do not exist in BIST 100 and the sector indices considered in the study. Korkmaz et al. (2016) examine the effect of bubbles in alternative investment instruments on the BIST 100 index return volatility for the period 2002:1-2016:5. SADF and GSADF test results find that the increases in gold and dollar exchange rates, which are alternative investment instruments, increase the volatility of the BIST 100 index. In contrast, the bubbles in the gold prices reduce the volatility of the BIST 100 index. Cagli and Mandaci (2017) apply a model-based recursive flexible window algorithm to detect the presence of the bubble in twenty-one BIST sectors indices. The evidence poses that the company of the bubbles holds for the BIST broad market indices and various sector indices. Citak (2019) investigates the existence of the bubble in twenty-four sectoral stock price indexes in the BIST. The results report that twenty sectors stock prices index is not suffering from bubbles. In contrast, bubbles are detected in BIST Insurance, Holding and Investment, and Information Technology.

Data and methodology

We investigate the presence of bubbles in closing prices of selected stock markets using monthly datasets for the period 2009:01-2021:06. Stock market indices in the data set were chosen from different developed countries. The aim here is to examine the existence of stock market bubbles in countries with other economic structures. In addition, the S&P 500 index is included in the data set for comparison purposes. Table 1 presents the descriptions for the variables. Descriptive statistics are available in the appendix. Ethics committee permission is not required as the variables used in the study were obtained from databases.

Table 1: Description of the Variables

Variables	Description
BIST100	Borsa İstanbul Stock Exchange Index
BOVESPA	Brazil Stock Exchange Index
IDX COMPOSITE	Indonesia Stock Exchange Index
MDEX	Malaysia Derivatives Exchange Index
NIFTY 50	India Stock Exchange Index
SHANGAI	Shanghai Stock Exchange Index
S&P 500	Standard & Poor's Index

Data Source: investing.com

We employ right-tailed unit root tests for detecting and date-stamping stock market bubbles: Rolling augmented Dickey-Fuller (RADF), Supremum-ADF (SADF), and Generalized SADF tests. We perceive a time series denoted as $\{y_t\}_{t=1}^{T}$ and null hypothesis tests, which means whether y_t follows Autoregressive Model AR (1) containing unit root within all samples. However, an alternative hypothesis refers that y_t moves as at least AR (1) process for some subsample (Harvey, Leybourne, and Sollis, 2013: 3). Phillips, Wu, and Yu (2011) introduce the PWY test to identify rational bubbles by employing recursive Dickey-Fuller (DF) tests. This test statistic is presented as follows in Harvey, Leybourne, and Sollis (2013: 4):

$$PWY = supDF_{\tau} \qquad (1)$$
$$\tau \in [\tau_0, 1]$$

In Equation (1), DF_{τ} refers to the standard Dickey-Fuller test (t-ratio on $\hat{\phi}$) for Ordinary Least Squared (OLS) regression estimation:

$$\Delta y_t = \hat{a} + \hat{\phi}_{PWY} y_{t-1} + \hat{\varepsilon}_t \qquad (2)$$

For this estimation in Equation (2), the subsample period is $t = 1 \ldots, \lfloor \tau T \rfloor$ and DF_{τ} is as below:

$$DF_{\tau} = \frac{\hat{\phi}_{PWY}}{\sqrt{\hat{\sigma}^2_{PWY} / \sum_{t=2}^{\lfloor \tau T \rfloor} (y_{t-1} - \bar{y}_{\tau})^2}}$$

where $\bar{y}_{\tau} = (\lfloor \tau T \rfloor - 1)^{-1} \sum_{t=2}^{\lfloor \tau T \rfloor} y_{t-1}$ and $\hat{\sigma}^2_{PWY} = (\lfloor \tau T \rfloor - 3)^{-1} \sum_{t=2}^{\lfloor \tau T \rfloor} \hat{\varepsilon}_t^2$. Therefore, The PWY test statistic is the supremum of a sequence of forwarding recursive figures with a minimum sample length $\lfloor \tau_0 T \rfloor$.

In the left-tailed unit root tests, the presence of non-stationary series makes an appropriate hypothesis formulation difficult, which induces the results to become more sensitive towards model specification. Because parameters take diverse positions under both null hypotheses, the existence of unit root and alternative hypothesis indicates stationarity (Phillips, Wu, and Yu, 2014:320). Nevertheless, right-tailed unit root tests play an influential role in determining slightly exploding series. Moreover, Diba and

Grossman (1988) executed right-tailed unit root tests for precisely sampled data to detect financial bubbles. Phillips, Wu, and Yu (2011) claim that performing right-tailed unit tests to recursive subsamples. Formulating regression models and hypotheses becomes more of an issue in both left-tailed and right-tailed unit root tests (Phillips, Wu, and Yu, 2014:321). Furthermore, SADF introduced by Phillips, Wu, and Yu (2011) test is one of the right-tailed unit root tests. SADF test is associated with the recursive opinion of the ADF model, and it is procured as sub value of the ADF statistic sequences. Right-tailed unit root tests indicate asymptotic properties linked to the regression model and the null hypothesis. The following autoregressive model is estimated by employing least squares as in Phillips, Wu, and Yu (2011: 206):

$$x_t = \mu_x + \delta x_{t-1} + \sum_{i=1}^{j} \phi_i \Delta x_{t-i} + \varepsilon_{x,t}\ , \varepsilon_{x,t} \sim NID\ (0, \sigma_x^2) \qquad (3)$$

In Equation (3), j is the first-difference operator's transient lag-order. We test the null hypothesis $H_0 : \delta = 1$ versus the alternative hypothesis $H_1 : \delta > 1$. The model in Equation (3) is repeatedly calculated, progressing one observation at each trial in recursive regression and gives rolling ADF (Phillips, Wu, and Yu, 2011: 207-208):

$$ADF_r \Rightarrow \frac{\int_0^r \widetilde{W} dW}{\left(\int_0^r \widetilde{W}^2\right)^{1/2}} \qquad (4)$$

We defines three subsample period (r_0, r_1, r_2) as a fraction of the original sample period is { $t = 0, \ldots, T$ }. The first fraction for the smallest subsample is r_0, and it is employed to initialize computation for the test statistic. The second fraction r_1 is the starting point for the subsample, while the third fraction r_2 is the endpoint for the subsample SADF test statistic is repeated estimation of Equation (3). Following Phillips, Wu, and Yu (2011), r_0 refers to the width of the minimum sample, r_1=0 is the starting point, and r_2=1 is the endpoint for the range of subsample. SADF test statistic is as below:

$$sup_{r\in[r_0\ ,1]} ADF_r \Rightarrow sup_{r\in[r_0\ ,1]} \frac{\int_0^r \widetilde{W} dW}{(\int_0^r \widetilde{W}^2)^{1/2}} \qquad (5)$$

GSADF test relies on a rolling approach and SADF test, while GSADF is based on various forward growing sequences from the starting point. However, GSADF's subsamples are extensive value than SADF. Furthermore, the GSADF test allows for starting point "r_1" to modify within a possible sequence by replacing the finish point "r_2" which moving from "r_0" to "1". Therefore, GSADF states the most prominent ADF statistic over all possible sequences of r_1 and r_2, and GSADF is formulated as follows (Phillips, Wu, and Yu, 2011: 207; Phillips, Wu, and Yu, 2013: 10-11):

$$GSADF\ (r_0) \equiv sup_{r_2\in[r_0\ ,1]\ ,\ r_1\in[0, r_2\ -\ r_0]} \left\{ADF_{r_1}^{r_2}\right\} \qquad (6)$$

In Equations (4), (5), and (6), $W(\cdot)$ poses Standard Brownian motion, and $\widetilde{W}(r)$= W(r)-$\frac{1}{r}\int_0^1 W$ refers to reduced Brownian motion (Phillips, Wu, and Yu, 2011: 206-207).

Empirical findings

The bubbles in selected stock index closing prices were investigated using RADF, SADF, and GSADF tests. These test statistics are compared to the 95% critical value calculated by the Monte Carlo simulation with 10000 replications for each observation. Table 2 presents the test results.

Table 2: RADF - SADF - GSADF Results

	RADF	SADF	GSADF
BIST100	-0.2747 (0.6199)	-0.5386 (0.4343)	0.0086 (0.6419)
BOVESPA	0.0080 (0.3949)	-0.3047 (0.2996)	0.0080 (0.6424)
IDX COMPOSITE	1.5516*** (0.0055)	-1.0024 (0.7046)	1.5610** (0.0173)
MDEX	0.0804 (0.3450)	-0.5502 (0.4407)	0.0802 (0.5867)
NIFTY50	-0.1124 (0.4872)	-1.4566 (0.8888)	0.3653 (0.3800)
SHANGAI	1.8377*** (0.0022)	0.7434** (0.0246)	3.0913*** (0.0001)
S&P500	-0.5046 (0.7834)	-0.4495 (0.3601)	-0.4115 (0.8880)
	CV		
99%	-0.1548	1.0009	1.6971
95%	-0.8057	0.5057	1.2104
90%	-1.1336	0.2228	0.9587

Notes: ***, ** and * refer the significance level at 1%, 5% and 10%, respectively. CV shows the critical value of the tests.

The results in Table 2 show price bubbles in selected stock indices for IDX COMPOSITE and SHANGAI. In other words, bubbles were detected on the SHANGAI and IDX COMPOSITE stock exchanges at 5% and 1% significance levels. In order to see the dates when the bubbles appeared, date-stamping results are given in Figures 1-7 throughout the entire period. The middle (red) horizontal lines show the critical values calculated at the 95% confidence interval in these graphs. The gaps in which the blue lines exceed the red lines are considered when determining when the bubbles appear.

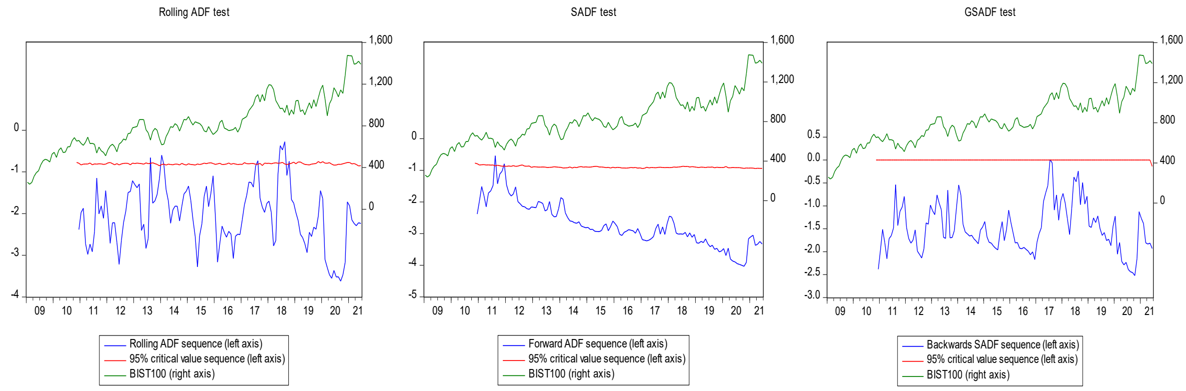

Figure 1: RADF, BSADF, and GSADF for BIST100

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

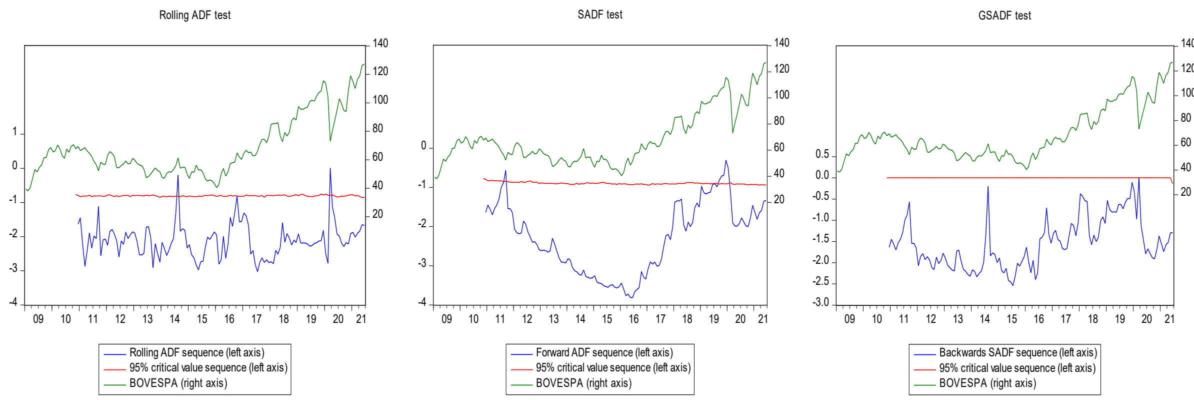

Figure 2: RADF, BSADF, and GSADF for BOVESPA

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values coming from Monte Carlo simulations with 10000 replications.

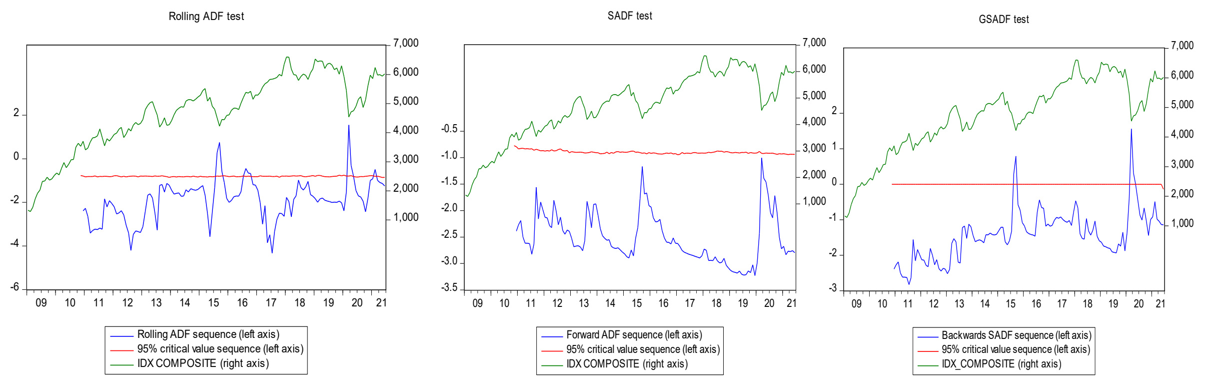

Figure 3: RADF, BSADF, and GSADF for IDX COMPOSITE

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

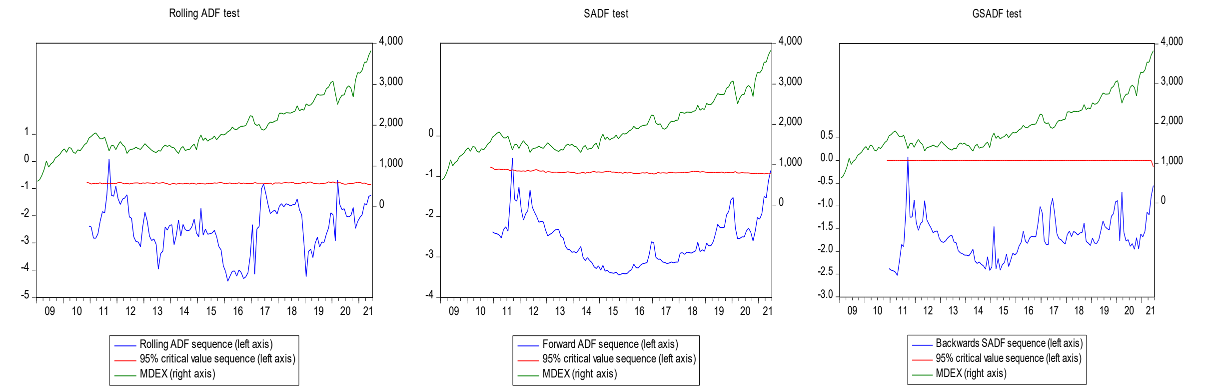

Figure 4: RADF, BSADF, and GSADF for MDEX

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

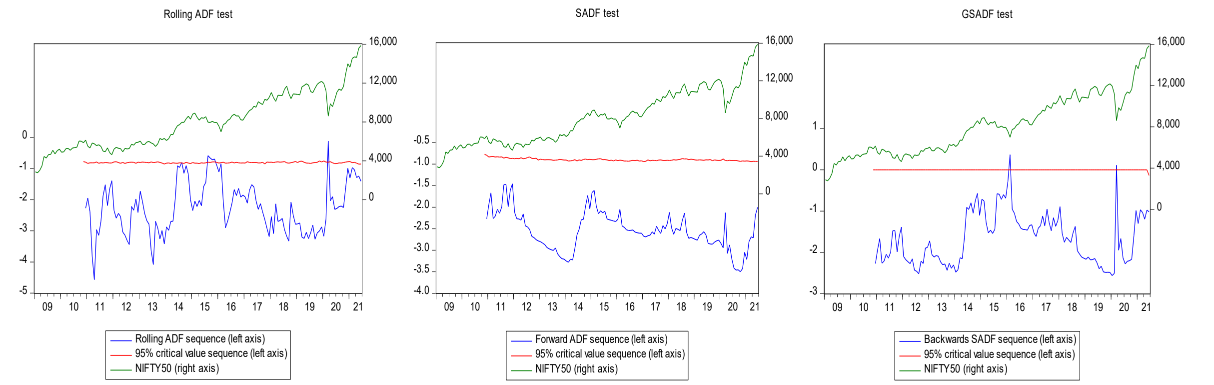

Figure 5: RADF, BSADF, and GSADF for NIFTY50

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

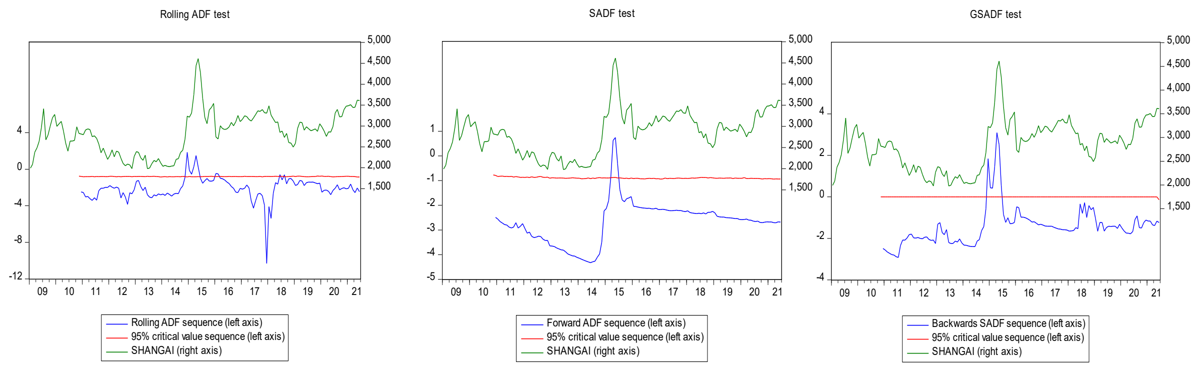

Figure 6: RADF, BSADF, and GSADF for SHANGAI

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

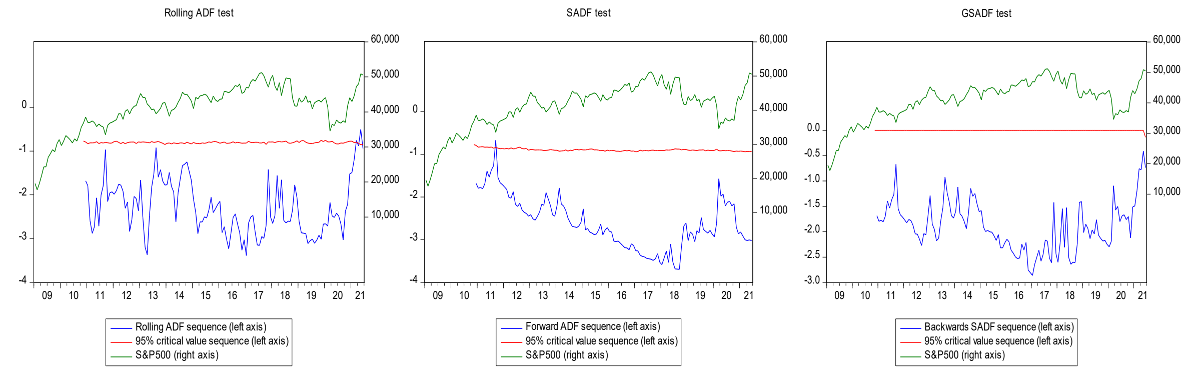

Figure 7: RADF, BSADF, and GSADF for S&P500

Notes: The sample spans from January 2009 to June 2021, with the total number of observations being 150. The RADF, SADF, and GSADF follow Phillips, Wu, and Yu (2015) with the 95% critical values calculated by Monte Carlo simulations with 10000 replications.

Considering the date stamping results given in Figure 1-7, the period(s) in which the blue lines exceed the red line are presented in Table 3.

Table 3: Bubble Dates

	RADF	**SADF**	**GSADF**
BIST100	2013M08 2014M01-2014M02 2018M04-2018M09	2011M07-2011M09 2011M12	2017M08
	RADF	**SADF**	**GSADF**
BOVESPA	2017M07-2017M08 **2020M03-2020M04**	2011M08-2018M10 **2019M07-2020M02**	**2020M03**
	RADF	**SADF**	**GSADF**
IDX COMPOSITE	2015M07-2015M11 **2020M02-2020M05** **2021M01-2021M03**	-	2015M08-2015M10 **2020M02-2020M05**
	RADF	**SADF**	**GSADF**
MDEX	2011M07-2017M10 217M06 **2020M03-2020M04**	2011M09-2011M10 2021M05-2021M06	2011M09
	RADF	**SADF**	**GSADF**
NIFTY50	2014M08 2015M08-2015M12 **2020M02-2020M03**	-	2016M01-2016M03 **2020M03**
	RADF	**SADF**	**GSADF**
SHANGAI	2014M11-2015M05 2016M01-2016M03 2018M06-2018M08	2015M03-2015M05	2014M11-2015M06
	RADF	**SADF**	**GSADF**
S&P500	**2021M03-2021M05**	-	-

Note: Dates are determined by taking into account the date-stamping results.

RADF results indicate that multiple bubbles are formed in the BIST100, BOVESPA, IDX COMPOSITE, NIFTY50, SHANGAI, and MDEX indexes, while it detects the presence of a single bubble in the S&P 500 index. According to the SADF results, different bubbles were formed in the BIST100, BOVESPA, MDEX, and SHANGAI indices. However, GSADF results seem to be more effective in detecting bubbles. The GSADF results see bubbles in different periods in all stock markets, except S&P 500. Our results differ from Szulczyk, Cheema, and Holmes (2018) and update Almudhaf (2018). We reach different results for Turkey and the opposite findings of Kırkpınar, Erer, and Erer (2015). Our empirical findings point to increasing bubbles in the relevant stock market indices in recent years. In this sense, it contributes to the literature.

According to the RADF, SADF, and GSADF test results in Table 2, while there is no bubble in all stock markets, the date-stamping analyzes in Figure 1-7 give the dates when the bubbles occurred and deflated. The results underline that Monte Carlo simulations significantly contribute to dating accuracy. Furthermore, since the SADF and GSADF distributions are not standardized, the predictions are improved thanks to the critical values provided by the Monte Carlo simulations. Harvey, Leybourne, and Whitehouse (2020) state that another vital advantage of the Monte Carlo procedure is that it can determine whether each bubble that occurs results in being extinguished or whether standard market behavior is restored when the bubble ends.

Conclusion

Financial bubbles are continuous and systematic price differences between the market value and the fundamental value of financial assets. A bubble raises prices for a certain period before a sharp collapse, and a long-term negative bubble is defined as a collapse. Financial bubbles are caused by psychological and emotional factors such as rumor, irrational investors, overconfidence, asymmetric information, herd behavior, overreaction, investor sentiment, and feedback. Bubbles are effective in financial markets and are closely related to financial crises. For example, the financial crisis in the United States in 2007 demonstrated the importance of detecting bubbles. Therefore, market decision-makers and investors must detect and analyze bubbles. In addition, the efficiency of the markets where bubbles are formed decreases.

This study investigates the existence of bubbles in BIST100, BOVESPA, IDX, COMPOSITE, MDEX, NIFTY50, SHANGAI, and S&P 500 stock markets for the period spanning from 2009:01-2021:06. The reasons for the determined period are examining the stock markets index after the 2008 Global financial crisis. Within this purpose, RADF, SADF, and GSADF tests were employed using stock market closing prices. The test statistics of the tests confirmed the existence of bubbles in IDX COMPOSITE and SHANGAI. In other explanations, bubbles are designated on the SHANGAI and IDX COMPOSITE stock exchanges at 5% and 1% significance levels. Moreover, when the date sampling results achieved by all tests were considered, all stock markets had historical bubbles during the considered period. The findings reveal that the periods, durations, and numbers of historical bubbles differ. According to RADF's historical bubbles results, the multiple historical bubbles hold for all selected stock markets. However, SADF presented the existence of historical bubbles for BIST100, BOVESPA, MDEX, and SHANGAI, while the presence of the historical bubbles was detected for all countries' stock markets except for S&P500. As a result of the dates' historical bubbles, emerging stock markets prevailing in the study had been exuberant during the considered periods. Moreover, the result indicated that SHANGAI indexes encountered historical bubbles that continued for seven months due to RADF and GSADF, respectively. As a result, emerging countries' stock indexes provided abnormal profits regarding investors' sight. Investors can gain extraordinary profits from IDX COMPOSITE and SHANGAI indexes, but they should be aware of the bubbles due to the test. When evaluated from investors' point of view, the results show that the efficiency of emerging markets is low. What is noteworthy here is that these markets are susceptible to foreign capital inflows. Therefore, bubbles can adversely affect stock prices for both domestic investors and companies.

The evaluation of the historical bubbles dates provides insight information for evaluating the economic situations that occurred during the periods. Regarding the dates presented in historical bubbles, there are some standard periods. Shared periods are relevant to COVID-19 pandemic outbreaks and the implementation of economies package for mitigating the effects of the pandemic. The monetary expansions and the fiscal package of FED and ECB have caused enormous funds around the world, and some of the funds have flowed to emerging countries because of their higher interest rates policy. The growth periods of emerging market economies also cause bubbles to appear. It is also understood that the duration of the historical bubbles did not prevail for the long in most of the stock market indexes. Nevertheless, the SHANGAI index is the market that experienced the most prolonged duration of historical bubbles, continuing approximately eight months.

For further studies, we suggest examining the relationship between periods of bubble formation and global capital flows. In addition, the effects of the monetary expansions of the FED on the stock markets of developing countries are also remarkable. Therefore, it is also recommended to increase the frequency of the data set and examine it under different periods.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The author(s) has (have) no conflict of interest to declare.

Grant Support:

The authors declared that this study has received no financial support

Author Contributions:

Idea/Concept/Design: **Ö.K., B.B., Z.A.** Data Collection and/or Processing: **B.B., Z.A.** Analysis and/or Interpretation: **Ö.K.,** Literature Review: **B.B., Z.A.**, Writing the Article: **Ö.K., B.B., Z.A.** Critical Review: **Ö.K., B.B.**, Approval: **Ö.K., B.B., Z.A.**

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Appendix

Appendix A: Descriptive Statistics of Data Set

	BIST100	BOVESPA	IDX_COMP	MDEX	NIFTY 50	S&P 500	SHANGHAI
Mean	817.4763	68.79455	4708.502	40842.84	8060.727	1900.181	2836.472
Median	786.5950	62.80600	4857.705	42627.52	7959.575	1708.355	2892.470
Maximum	1476.720	127.2560	6605.630	51210.48	15860.35	3831.840	4611.740
Minimum	240.2700	38.18300	1285.480	17752.18	2763.650	624.9000	1979.210
Std. Dev.	251.9193	20.81895	1246.916	6694.364	2855.296	642.1724	511.8818
Skewness	0.372363	1.013029	-0.699756	-1.091770	0.490705	0.842319	0.352372
Kurtosis	3.204523	3.122000	2.950743	4.344420	2.526547	3.234289	3.401435
Jarque-Bera	3.727790	25.74870	12.25663	41.09571	7.420760	18.08062	4.111332
Probability	0.155067	0.000003	0.002180	0.000000	0.024468	0.000119	0.128008
Sum	122621.5	10319.18	706275.3	6126426.	1209109.	285027.2	425470.8
Sum Sq. Dev.	9456035.	64580.86	2.32E+08	6.68E+09	1.21E+09	61445414	39041422
Observations	150	150	150	150	150	150	150