Testing for Bubbles in the BRICS Stock Markets[*]

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ABSTRACT

In this study, we apply the generalized sup Augmented Dickey-Fuller (GSADF) test, a new recursive test proposed by Phillips et al. (2013) to investigate whether there exist multiple bubbles in the BRICS (Brazil, Russia, India, China and South Africa) stock markets, using monthly data on stock price-dividend ratio. Our empirical results indicate that there exist multiple bubbles in the stock markets of the BRICS. Further, the dates of the bubbles also correspond to specific events in the stocks markets of these economies. This finding has important economic and policy implications.

Keywords: Multiple bubbles; BRICS stock markets; GSADF test

JEL: C12, C15, G12, G15

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I. Introduction

This paper examines whether multiple bubbles exist in the BRICS (Brazil, Russia, India, China and South Africa) stock markets during the 1990 to 2013 period using a new test proposed by Phillips et al. (2013). Bubbles are observable economic phenomena. The term asset price bubble or speculative bubble is often used to describe persistent market overvaluation followed by market collapse (Reza, 2010). Bubbles arise when assets consistently sell at prices in excess of their fundamental value where the fundamental value is the amount of discounted future dividends and the price of the asset when it is sold in infinite future. Therefore, a bubble is the difference between an asset's fundamental value and its market price (Reza, 2010). Larsen (1997) noted that a bubble on an asset may arise when the market values an asset more because it has increased in value previously. Hence, the traders believe that since the value of the asset has increased before, it will pay off to hold it for a limited period of time. This would in general lead to a further increase in the asset price as the demand for it increases. This explanation emphasizes the self-fulfilling nature of expected future price changes based on the concept of 'resale optionality' (Jones, 2014). According to Noussair and Powell (2010) accurate information about the value of the assets is provided to investors when market prices of assets reflect their underlying fundamentals. This price information aligns investors' incentives to allocate their capital profitably with those decisions that increase overall efficiency in the allocation of capital. Therefore, the efficiency of an economy's allocation of resources can be affected by the extent of prices deviation from fundamentals.

Different series of theoretical set-ups for bubbles detection are presented in Thompson and Hickson (2006). However, bubbles manifest mainly in three different ways according to Jiménez (2011): first, naturally such as the bubble component on fiat money that appears due to confidence and convenience throughout agents transactions; second, due to informational monopolies, like when some big institutional traders have privileged information about a specific company, and they manipulate the market creating a specific company's stock price boom; and third, through the coalition of governments plus running elites, who together prepare and generate economic events that involve a major part of society. The occurrence of rational bubbles signifies that no long-run relationships exist between stock prices and dividends. Explosive behavior in asset prices can give rise to boom periods consequently leading to a misallocation of resources, distort investment patterns, and have serious repercussions in real economic activity (Pavlidis et al., 2014).

A vast amount of research has been devoted to investigating the presence of rational bubbles in stock markets (Diba and Grossman, 1988a, 1988b; Johansen, 1988; Johansen and Juselius, 1990; Crowder and Wohar, 1998; Barnett and Serletis, 2000; Bohl, and Henke 2003; Cuñado et al, 2005; Chang et al., 2007, Jahan-Parvar and Waters, 2010 among others). In order to determine whether stock prices and dividends are cointegrated, empirical studies have, employed cointegration techniques. Among the most widely employed is the Johansen cointegration test (Johansen, 1988; Johansen and Juselius, 1990), which is based on the linear autoregressive model and assumes that the underlying dynamics are linear. From a theoretical perspective, there is no sound reason to assume that economic systems are intrinsically linear (see, Barnett and Serletis, 2000). In fact, numerous studies have empirically demonstrated that financial time series, such as stock prices, exhibit nonlinear dependencies (see, Hsieh, 1991; Abhyankar et al., 1997). In addition, substantive evidence from the Monte Carlo simulations in Bierens (1997) has indicated that, inherent to the conventional Johansen cointegration framework, there is a misspecification problem when the true nature of the adjustment process is nonlinear and that the speed of adjustment varies with the magnitude of the disequilibrium.

A recursive method, supremum Augmented Dickey-Fuller (SADF) have also been proposed by Phillips et al. (2011) which can detect exuberance in asset price series during an inflationary phase. However, the Phillips et al. (2011) recursive method is especially effective when there is a single bubble episode in the sample data. This is examplified in the 1990s Nasdaq episode analyzed in Phillips et al. (2011) and in the 2000s U.S. house price bubble analyzed in Phillips and Yu (2011). Therefore, given the possibility of multiple bubbles within the same sample period, this study investigates whether multiple bubbles exist in the BRICS stock markets using a new test, generalized sup Augmented Dickey-Fuller (GSADF) test, proposed by Phillips et al. (2013). The major advantage of the approach is that it allows one to account for the nonlinear structure and break mechanisms while investigating the existence of multiple bubbles. To the best of our knowledge, this is the first study to test for bubbles in the BRICS stock markets. We utilize the GSADF test to investigate the existence of multiple bubbles in the BRICS stock markets given that emerging stock markets are generally characterized by higher volatility than developed economies markets (Kasman et al, 2009). These markets are also often marked by frequent and erratic changes which are usually driven by various local events than events of global importance (Aggarwal et al., 1999). Our empirical results indicate that multiple bubbles exist in the BRICS countries.

The paper is organized as follows: Section 2 briefly describes the theoretical framework and the econometric methodology proposed by Phillips et al. (2011) and Phillips et al. (2013). Section 3 presents the data used in our study, while Section 4 discusses the empirical results and some policy implications. Section 5 concludes the paper.

II. Theoretical Framework and Econometric Methodology

Based on the Campbell et al. (1997), Cuñado et al. (2005), and Koustas and Serletis (2005), our model of the net simple return on a stock is defined as follows:

$$SR_{t+1} = \frac{P_{t+1} - P_t + D_{t+1}}{P_t} = \frac{P_{t+1} + D_{t+1}}{P_t} - 1, \tag{1}$$

where SR_{t+1} denotes the stock return in period $t+1$ and D_{t+1} is the dividend in period $t+1$. Taking the mathematical expectation on Eq. (1), based on information available at time t, and rearranging terms, we can obtain:

$$P_t = E_t\left[\frac{P_{t+1} + D_{t+1}}{1 + SR_{t+1}}\right]. \tag{2}$$

We can solve Eq. (2) forward k periods and obtain the following semi-reduced form:

$$P_t = E_t\left[\sum_{i=1}^{k}\left(\frac{1}{1+SR_{t+i}}\right)^i D_{t+i}\right] + E_t\left[\left(\frac{1}{1+SR_{t+k}}\right)^k P_{t+k}\right]. \tag{3}$$

To yield a unique solution to Eq. (3), we assume that the expected discounted value of the stock in the indefinite future converges to zero:

$$\lim_{k\to\infty} E_t\left[\left(\frac{1}{1+SR_{t+k}}\right)^k P_{t+k}\right] = 0. \tag{4}$$

Based on the convergence assumption, we can get the fundamental value of the stock as the expected present value of future dividends:

$$F_t = E_t\left[\sum_{i=1}^{\infty}\left(\frac{1}{1+SR_{t+i}}\right)^i D_{t+i}\right]. \tag{5}$$

If we get out of the convergence assumption, then Eq. (4) can lead to an infinite number of solutions and any one of which can be written in the following form

$$P_t = F_t + B_t \quad \text{where} \quad B_t = E_t\left[\frac{B_{t+1}}{1+SR_{t+1}}\right]. \tag{6}$$

Here, the additional term B_t is called a "rational bubble", in the sense that it is entirely consistent with rational expectations and the time path of expected returns. Diba and Grossman (1988b) also define a rational bubble to be a self-confirming divergence of stock prices from market fundamentals in response to extraneous variables. If the nonstationarity of dividends account for the nonstationarity of stock prices, then stock prices and dividends are cointegrated. The null hypothesis of rational bubbles can be tested by testing for the cointegrating relationship between dividends and stock prices. A cointegrating relationship between dividends and stock prices is inconsistent with rational bubbles. Understandably, the stationarity of the dividend-price ratio would also imply the same.

However, in the econometric literature, identifying a bubble in real time has proven to be a huge challenge. Econometric techniques suffer from finite sample bias. For example, conventional unit root and cointegration tests may be able to detect one-off exploding speculative bubbles but are unlikely to detect periodically collapsing bubbles. In other words, efforts to identify significant warning signs of future stock price bubbles have been impeded by the necessity to spot multiple starting and ending points. The reason is that conventional unit root tests are not well equipped to handle changes from I(0) to I(1) and back to I(0). This makes detection by cointegration techniques harder, due to bias and kurtosis (Evans, 1991).[1]

[1] Using the standard Johansen (1988) trace and maximum eigen value tests, we found that the null of no cointegration was rejected for Brazil, China and South Africa, while no cointegration could be detected for Russia and India. Given the possibility of nonlinearity in the data generating process of the stocks and dividends and structural breaks in the long-run relationship between these two variables leading to

Recently, an innovative and persuasive approach to identification and dating multiple bubbles in real time has been pioneered by Phillips and Yu (2011) and Phillips et al. (2013). The idea is to spot speculative bubbles as they emerge, not just after they have collapsed. Their point of departure is the observation that the explosive property of bubbles is very different from random walk behaviour. Correspondingly, they have developed a new recursive econometric methodology for interpreting mildly explosive unit roots as a hint for bubbles. Considering the typical difference of stationary *vs* trend stationary testing procedures for a unit root, we usually restrict our attention to regions of 'no more than' a unit root process, i.e. an autoregressive process where $\delta \leq 1$. In contrast, Phillips and Yu (2011) model mildly explosive behaviour by an autoregressive process with a root δ that exceeds unity but is still in the neighbourhood of unity. The basic idea of their approach is to calculate recursively right-sided unit root tests to assess evidence for mildly explosive behaviour in the data. The test is a right-sided test and therefore differs from the usual left-sided tests for stationarity. More specifically, consider the following autoregressive specification estimated by recursive least squares

$$x_t = \mu + \delta x_{t-1} + \sum_{j=1}^{J} \phi_j \Delta x_{t-j} + \varepsilon_t \quad . \tag{7}$$

The usual H_0: $\delta = 1$ applies, but unlike the left-sided tests which have relevance for a

parameter instability, we checked for the robustness of the results from the Johansen (1988) tests by also implementing the Autoregressive Distributed Lag (ADL) test for threshold cointegration, proposed by Li and Lee (2010), as the test can simultaneously investigate nonlinearity and cointegration. The test detected nonlinear cointegration between dividends and stock prices for BRICS. Thus, taking the Johansen (1988) and Li and Lee (2010) cointegration tests together, there seems to be evidence that there exist no rational bubbles in the equity markets of these countries. However, as indicated not much reliance can put on conventional cointegration-based tests as they are not capable of detecting explosive bubbles when they manifest periodically collapsing behavior in the sample. The details of these results are available upon request from the authors.

stationary alternative, Phillips and Yu (2011) have H_a: $\delta > 1$, which, with $\delta = 1 + c / k_n$, where $c > 0$, $k_n \to \infty$, and $k_n / n \to 0$, and these allow for their mildly explosive cases.

Phillips and Yu (2011) argue that their tests have discriminatory power, because they are sensitive to the changes that occur when a process undergoes a change from a unit root to a mildly explosive root or *vice versa*. This sensitivity is much greater than in left-sided unit root tests against stationary alternatives. But this is not all. As we know bubbles usually collapse periodically. Therefore, conventional unit root tests have limited power in detecting periodically collapsing bubbles. In order to overcome this shortcoming, Phillips and Yu (2011) have suggested using the supremum (sup) of recursively determined Augmented Dickey-Fuller (ADF) *t*-statistics. The estimation is intended to identify the time period where the explosive property of the bubble component becomes dominant in the stock price process. The test is applied sequentially on different subsamples. The first subsample contains observations from the initial sample and is then extended forward until all observations of the complete sample are included in the tests. The beginning of the bubble is estimated as the first date when the ADF *t*-statistic is greater than its corresponding critical value of the right-sided unit root test. The end of the speculative bubble will be determined as the first period when the ADF *t*-statistic is below the aforementioned critical value.

Following Phillips et al. (2011) we can calculate a sequence of ADF tests. Let $\hat{\delta}_\gamma$ denote the OLS estimator of δ and $\hat{\sigma}_{\delta,\gamma}$ the usual estimator for the standard deviation of $\hat{\delta}_\gamma$ using the subsample $\{x_1, x_{2,} ... x_{[\gamma T]}\}$. Denoting the fractional window size of the regression by r_w, defined by $r_2 - r_1$ and by r_0 the fixed initial window set by the user and assuming for simplicity a sample interval of [0,1] (i.e. normalizing the original sample by *T*). The SADF test depends on repeated estimation of the ADF model on a forward expanding sample sequence and the test is obtained as the sup value of the corresponding ADF statistic sequence. The window size, r_w, expands from r_0 to 1; so that r_0 is the smallest sample window width fraction and 1 is the largest window fraction (the total sample size) in the recursion. The starting point r_1 of the sample sequence is fixed at 0; so the end point of each sample (r_2) equals r_w, and changes from r_0 to 1. The ADF statistic for a sample that runs from 0 to r_2 is denoted by $ADF_0^{r_2}$. The forward recursive ADF test of H_0 against H_a is given by

$$SADF(r_0) = \sup_{r_2 \in [r_0, 1]} \{ADF_0^{r_2}\}, \qquad (8)$$

where $ADF = \frac{\hat{\delta}_t - 1}{\hat{\sigma}_{\delta t}}$. Here the ADF statistic is computed for the asymmetric interval $[r_0, 1]$. In most applications, our r_0 will be set to start with a sample fraction of reasonable size. However, one limitation of the SADF test is that the starting point is fixed as the first observation of the sample. This implies that in the presence of two bubbles, the second bubble may not be detected if it is dominated by the first bubble. Therefore, Phillips et al. (2011) also apply a rolling version of the SADF test, where the starting window moves over the sample. However, the size of the starting window is still fixed, which limits the power of the test.

Phillips et al. (2013) have suggested employing the 'generalised' supADF (GSADF) test as a dating mechanism. The GSADF diagnostic is also based on the idea of sequential right-tailed *ADF* tests, but the diagnostic extends the sample sequence to a more flexible range. Instead of fixing the starting point of the sample, the GSADF test changes the starting point and ending point of the sample over a feasible range of windows. In other words, the subsamples used in the recursion in the GSADF test are much more extensive (i.e covers a larger number of subsamples) than those of the

SADF test. More so, in addition to varying the end point of the regression r_2 from r_0 (the minimum window width) to 1, the GSADF test allows the starting point r_1 to change within a feasible range, i.e. from 0 to $r_2 - r_0$. This extra flexibility on the estimation windows results in substantial power gains in comparison to the SADF. Moreover, the test is consistent with multiple boom-bust episodes within a given time series (Pavlidis et al., 2014). The GSADF statistic is defined to be the largest ADF statistic over all feasible ranges of r_1 and r_2. The test statistics is denoted by $GSADF(r_0)$:

$$GSADF(r_0) = \sup_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_1]} \{\mathrm{ADF}_{r_1}^{r_2}\}. \quad (9)$$

Phillips et al. (2013) demonstrate that the moving sample GSADF diagnostic outperforms the SADF test based on an expanding sample size in detecting explosive behaviour in multiple bubble episodes and seldom gives false alarms, even in relatively modest sample sizes. The reason is that the GSADF test covers more subsamples of the data and has greater window flexibility. The generalized SADF test (GSADF) is able to detect potential multiple bubbles in the data and thus overcomes the weakness of the SADF test.

Similar to the SADF procedure, if the null hypothesis of no bubbles is rejected in the GASDF test, a second step is implemented to consistently date-stamp the starting and ending points of this (these) bubble(s). The starting point of a bubble is defined as the date, denoted as T_{re} (in fraction terms), at which the backward sup ADF (BSADF) sequence crosses the corresponding critical value from below. Similarly, the ending point of a bubble is defined as the date, denoted as T_{fe} (in fraction terms), at which the backward sup ADF sequence crosses the corresponding critical value from above.

Formally, the estimates of the bubble periods based on the GSADF test are defined by:[2]

$$\hat{r}_e = \inf_{r_2 \in [r_0,1]} \left\{ r_2 : BSADF_{r_2}(r_0) > cv_{r_2}^{\beta_T} \right\} \tag{10}$$

$$\hat{r}_f = \inf_{r_2 \in [\hat{r}_e,1]} \left\{ r_2 : BSADF_{r_2}(r_0) < cv_{r_2}^{\beta_T} \right\}, \tag{11}$$

where, $cv_{r_2}^{\beta_T}$ is the 100(1- β_T)% critical value of the sup ADF statistic based on [T_{r2}] observations. The $BSADF(r_0)$ for $r_2 \in [r_{0,}1]$, is the backward sup ADF statistic that relates to the GSADF statistic by noting that:

$$GSADF(r_0) = \sup_{r_2 \in [r_0,1]} \left\{ BSADF(r_0) \right\} . \tag{12}$$

III. Data

In this paper, we use the monthly stock price and dividend for the BRICS for our empirical study. The data is obtained from Global Financial Database (GFD). Due to data availability, we have different starting periods for each country. Brazil starts from 1990.1; Russia starts from 1997.9; India starts from 1990.7; China starts from 1995.1; and South Africa starts from 1995.6. All the countries end at 2013.2. We use an initial window size of 36 to start off the recursive estimation. Following the study of Phillips et al. (2013), we also use stock price-dividend ratio for our analysis. If we look at the top panel of Figs 1-5, we can see the plots of stock price-dividend ratio for the BRICS stock markets and there might be evidence of multiple bubbles in all five data series. These results motive us to empirically investigate whether there are multiple bubbles in the BRICS stock markets using the SADF and GSADF tests proposed by Phillips et

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2 For further details about both SADF and GSADF tests, interested readers can refer to Philips and Yu (2011), Philips et al. (2011), and Philips et al. (2013). Also an Eviews add-in by Caspi (2013) can help in the practical implementation.

al. (2011) and Phillips et al. (2013), respectively.

IV. Empirical Results and Policy Implications

Tables 1-5 report the empirical results for both SADF and GSADF tests. We find that based on the GSADF test, the null hypothesis of no bubble is rejected for all the BRICS countries, while it is rejected for Brazil and South Africa only based on the SADF test..[3] Phillips et al. (2013) demonstrate that the moving sample GSADF diagnostic outperforms the SADF test based on an expanding sample size in detecting explosive behaviour in multiple bubble episodes and seldom gives false alarms, even in relatively modest sample sizes. The reason is that the GSADF test covers more subsamples of the data. Based on this argument, we can conclude that there is evidence of multiple bubbles in the BRICS stock markets.

To locate specific bubble periods, we compare the backward SADF statistic sequence with the 95% SADF critical value sequence, which were obtained from Monte Carlo simulations with 2,000 replications. Fig. 1-5 display results for the date-stamping strategy over the period for each of the BRICS countries. We can see that there is evidence of bubble during the subprime crisis period for almost all the BRICS countries.

If we look at Fig. 1, there is evidence of another bubble which occurred in the early period of our sample size, specifically during 1992-1994 for the Brazilian stock market. The presence of a bubble around this period may be partly explained by the immediate after effect of the first stock market liberalization in Brazil which took off in May 1991

[3] Recall that nonlinear cointegration test detected a long-run relationship between dividends and stock prices for BRICS, and hence, suggested that there exist no rational bubbles in the equity markets of these countries. We believe that this result is because of the fact that ADL threshold test of cointegration allows for only one regime change, and is likely to have low power just like the SADF test, when in fact multiple bubbles exist over the sample.

(Arouri et al., 2010).

Fig. 2 indicates that there is evidence of another bubble during the middle of 2005 for Russia. During 2005, the Russian stock rose by 83 percent and by the first two months of 2006, it gained 30.5 percent, a record rise compared to other world markets over the same period and this was attributed to the influx of foreign pension funds and Russian oil revenues (Daily News, 2006).

For India, there is a short bubble during the end of 1999 period. This bubble is likely due to the spillover of the 1997-2000 dot-com bubble. During this period, the technology industry began embracing the entire world and India's stock markets started showing signs of hyper-activity. Moreover, it coincided with the period when Ketan Parekh, a former stockbroker based in Mumbai was accused of being involved in engineering the technology stocks scam in India's stock market in 1999-2001 (FLAME, 2011).[4]

Regarding China, we find that there is evidence of 2 bubbles during 2007-2008 subprime crisis periods. The additional bubbles detected could be due to the Chinese stock market bubble in 2007 when the SSE Composite Index of the Shanghai Stock Exchange tumbled 9% from unexpected selloffs, the largest drop in 10 years, triggering major drops in worldwide stock markets (Wikipedia, 2014).

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[4] Interestingly, the GSADF test did not detect the sudden rise of the price-dividend ratio in June 2004 and the collapse thereof in July 2004 as a bubble. The stock prices collapsed in May 2004 more due to political reasons with the then ruling coalition government (National democratic Alliance) loosing in the national assembly election. This resulted in an even sharper decline in the dividends in june, 2004, but the stock markets started to recover from July onwards causing the dividends to increases as well, and the price-dividend ratio to come back to the levels observed in April, 2004. Further details on the events during this period can be found at: http://indiatoday.intoday.in/story/probe-into-2004-sensex-crash-reveals-a-bigger-lacuna-in-the-indian-stock-market/1/193578.html. We also conducted the analysis for India using natural logarithms of the price-dividend ratio and our results were qualitatively similar. Complete details of these results are available upon request from the authors.

Finally, for South Africa, if we look at Fig. 5, there is evidence of another bubble during 2005-2006 period. The 2005-2006 bubble component in South Africa can be attributed to the influx of investors into South African assets (especially equities), which bid up their prices, not only in the form of higher rand prices of equities but also in the form of an appreciation of the currency (Frankel et al., 2008). Overall, our results indicate that multiple bubbles did exist in the BRICS countries. This is overwhelmingly confirmed by the GSADF test especially.[5]

The existence of bubbles has some implications on the economy. The effects of bubbles can vary depending on different factors and the outcome might be distinct as well for every single agent. Bubbles can harm an economy, but it may simply generate a strong temporary deviation from a price tendency, or it could even benefit the economy (Jiménez, 2011). However, there is empirical clear evidence that every single bubble generates a redistribution of wealth, directly or indirectly, among the various agents in the economy and can retard economic growth for future generations (Tirole 1985; Jiménez, 2011). Bubbles might also lead to economic distortions as well as financial and real economy instability, and have effects on current output growth, aggregate spending and expected inflation (Roubini, 2006a). Consistent with this, Misati and Nyamongo (2012) noted that monetary policy cannot completely ignore information from the stock market as this information can be used to predict the direction of the business cycle.

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[5] As a robustness check, we also conducted an additional bubbles test estimated recursively based on a long memory method that is implemented in a fractional integration framework, following Cunado et al., (2005, 2007). We started with a subsample of 36 observations and recursively estimated the long-memory parameter, as in the GSADF test, until the end of the sample. Overall, the findings from the long memory approach are consistent with those from GSADF test in that it supports the existence of multiple bubbles in BRICS stock markets. Complete details of these results are available upon request from the authors.

The monetary and fiscal policy authorities in the BRICS economies can learn some lessons from the negative impacts of the .com and the securitization bubbles especially on the middle class. These bubbles generated a clear redistribution of wealth from the middle class –which ended up increasing its debts by almost 50% on average- towards the ruling-elites, generated an almost immediate unemployment of 10% on average, implied a bailout of more than $800Billions just in the U.S, more than doubled the national debt, and plunged world western economies into severe recessions (Jiménez, 2011) that is still been somewhat experienced today. Since excessive bubbles can lead to economic and investment distortions that are dangerous and likely to trigger bubble bursts with severe real and financial consequences, the need for optimal monetary policy cannot be overstressed (Roubini, 2006a, 2006b) Moreover, the need for adopting fiscal policy rules that secure a sound medium-term orientation of fiscal policies while leaving adequate short-term flexibility has been advocated by Jaeger and Schuknecht (2007). However, they noted that the success of such fiscal policy rules hinges largely on credibly containing expenditure growth and preventing tax cuts during the "high temptation phases" toward the end of a prolonged boom and at the onset of bust phases in asset prices. Further, the role of economic transparency in guiding inflation expectation of the economic agents is highlighted by de Mendonça and Filho (2007). This improves information quality and hence reduces the likelihood of bubble formation.

Following these arguments, we are of the opinion that both monetary and fiscal policies are relevant for curtailing stock price bubbles given that our study is able to detect the presence of multiple bubbles. However, caution needs to be taken when implementing such policies to avoid a longer lasting negative impact on the economy. Macroprudential policies may equally be useful.

V. Conclusions

This study investigates whether there exist multiple bubbles in the BRICS stock markets using a new test, GSADF proposed by Phillips et al. (2013). Our empirical results based on the GSADF test statistic indicate that there exist multiple bubbles in the BRICS countries, which is not shown in previous studies. However, based on the SADF test which is considered to have lower power than the GSADF test, the null hypothesis of no bubbles is rejected for Brazil and South Africa only. Using the graphical evidence, the study was able to date stamped the periods in which bubbles appear in the different stock markets though the strength of these bubbles differ across markets and seem to be stronger for Brazil, Russia and South Africa.

Evidence of multiple bubbles in the BRICS stock markets has important policy implications. Stock prices bubbles can have positive, negative, or zero sum effects. However, empirical evidence from previous studies shows that bubbles generate a redistribution of wealth and can have negative financial and real consequences. Therefore, some expansionary monetary and fiscal policies are required in the BRICS context since these are the most efficient and effective under a bubble burst scenario. Soaring asset prices can lead to increase in aggregate demand which puts upward pressure on inflation. Therefore the monetary authority may wish to stabilize prices by tightening monetary policy as asset prices rise and easing it as asset prices fall. Also given that bubbles could arise due to agency problems caused by information asymmetry which consequently leads to mispricing of asset values by the market, the need for public policy action cannot be overstressed. This can be in the form of improved transparency and/or public information which could reduce information asymmetry and uncertainty about the economic environment thereby strengthening markets and reducing the probability of asset mispricing. The use of macroprudential tools such as credit constraints, credit-to-GDP ratio monitoring, countercyclical capital requirements, higher margin requirements, principal-agent contract design reforms, and implementation of financial benchmarks among others may also be effective for addressing bubbles.

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Table 1 The SADF test and the GSADF test - Brazil

	SADF	GSADF
Test statistic	**27.781*** **	**27.781*** **
	Finite sample critical values	
90%	1.393	1.796
95%	1.770	1.993
99%	2.205	2.508

Note: Critical values of both tests are obtained from Monte Carlo simulation with 2000 replications (sample size 278 - (1990.1 - 2013.2)). The smallest window has 36 observations.

Table 2 The SADF test and the GSADF test - Russia

	SADF	GSADF
Test statistic	0.676	**2.829*** **
	Finite sample critical values	
90%	0.719	1.717
95%	1.008	1.857
99%	1.169	2.585

Note: Critical values of both tests are obtained from Monte Carlo simulation with 2000 replications (sample size 186 – (1997.9 - 2013.2)). The smallest window has 36 observations.

Table 3 The SADF test and the GSADF test - India

	SADF	GSADF
Test statistic	-0.392	**2.283** **
	Finite sample critical values	
90%	1.243	2.027
95%	1.483	2.220
99%	1.871	2.404

Note: Critical values of both tests are obtained from Monte Carlo simulation with 2000 replications (sample size 272 – (1990.7-2013.2)). The smallest window has 36 observations.

Table 4 The SADF test and the GSADF test - China

	SADF	GSADF
Test statistic	0.351	**4.433*** **
	Finite sample critical values	

90%	1.258	1.615
95%	1.565	1.756
99%	2.081	2.080

Note: Critical values of both tests are obtained from Monte Carlo simulation with 2000 replications (sample size 218 – (1995.1 - 2013.2)). The smallest window has 36 observations.

Table 5 The SADF test and the GSADF test – South Africa

	SADF	GSADF
Test statistic Test statistic	**2.526*** **	**2.588*** **
	Finite sample critical values	
90%	1.021	1.750
95%	1.452	1.861
99%	1.702	2.135

Note: Critical values of both tests are obtained from Monte Carlo simulation with 2000 replications (sample size 213 – (1995.6 – 2013.2). The smallest window has 36 observations.

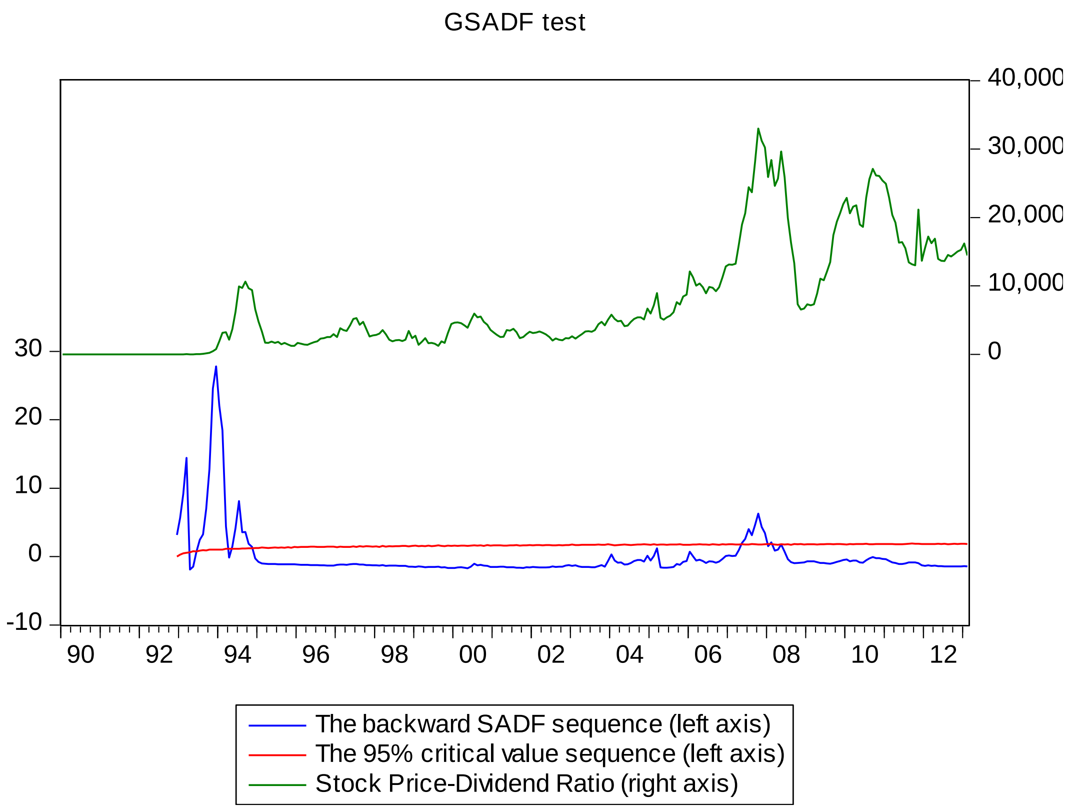

Fig. 1: Date-stamping bubble periods in the Brazil price-dividend ratio: the GSADF test.

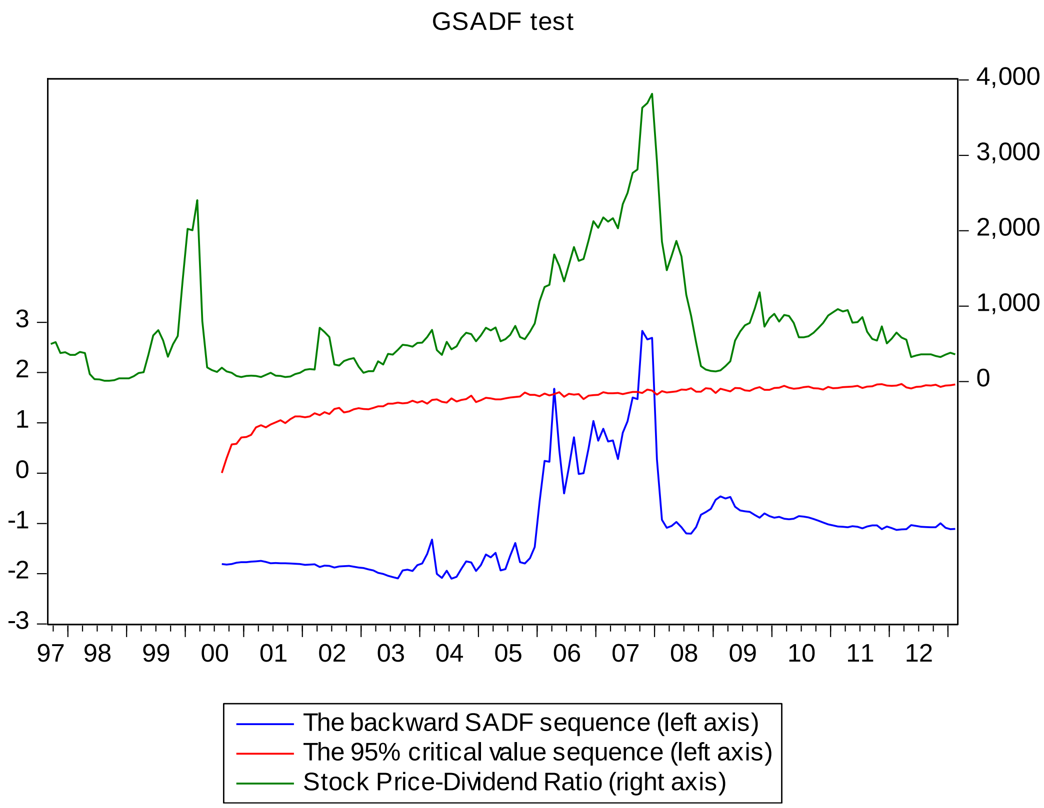

Fig. 2: Date-stamping bubble periods in the Russia price-dividend ratio: the GSADF test.

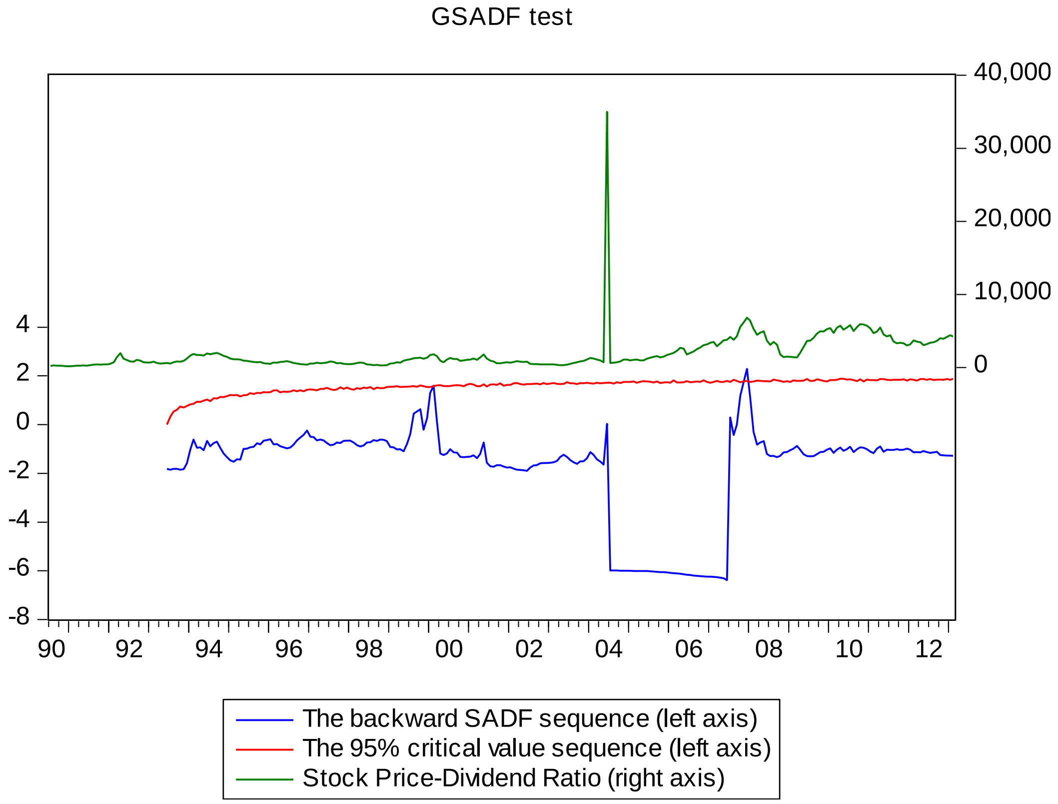

Fig. 3: Date-stamping bubble periods in the India price-dividend ratio: the GSADF test.

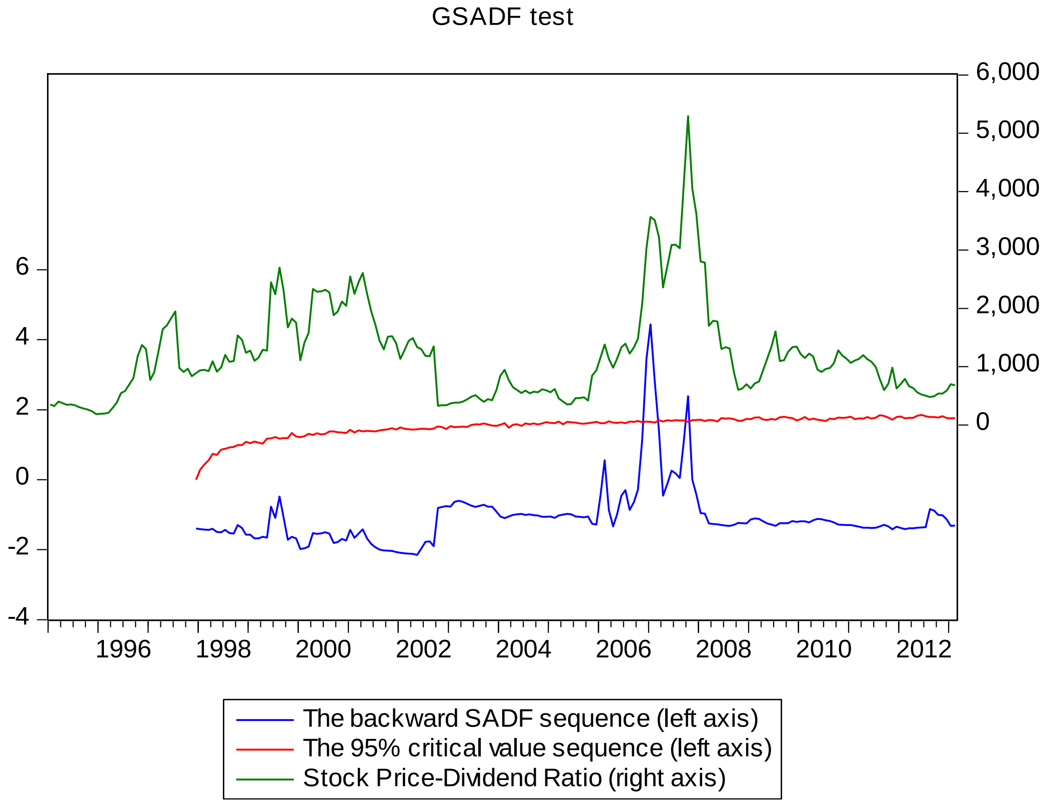

Fig. 4: Date-stamping bubble periods in the China price-dividend ratio: the GSADF test.

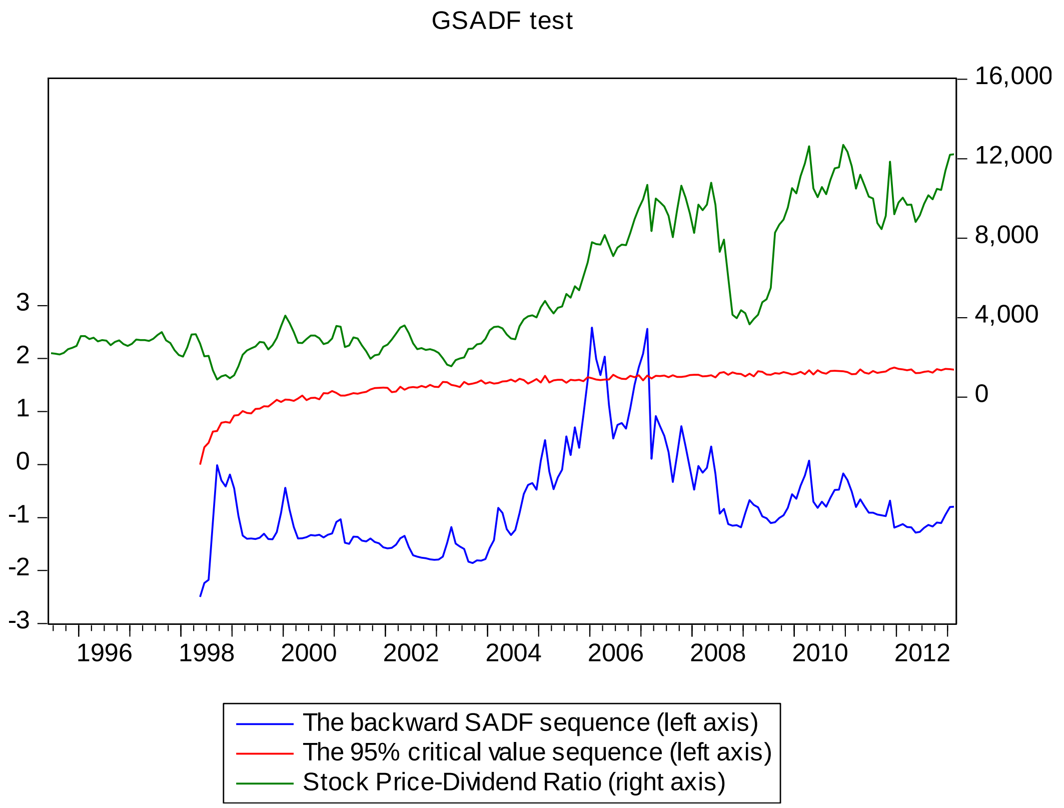

Fig. 5: Date-stamping bubble periods in South Africa price-dividend ratio: the GSADF test.