Analysis of Stock Market Efficiency in Emerging Markets: Evidence from BRICS

Siva Kiran[1]
Prabhakar Rao.R[2]

Abstract
This study aims at examining the efficiency of stock returns of BRICS markets. Here we consider the daily data from 25th September 1997 to 31st March 2018. This study employs variance ratio tests for linear dependencies and BDSL test for nonlinear dependence. Further, the entire period of study is divided into sub-periods such as pre-crisis, crisis and post-crisis periods to understand the level of efficiency in different time periods. The results of variance ratio tests show that Brazil and China markets are weak-form efficient in all time periods while Russia and South Africa are a weak form efficient in the full period, crisis and post-crisis periods but not in pre-crisis period. With regard to Indian stock markets, the markets are found to be weakly efficient during pre-crisis and crisis period while market inefficiency is observed in full period and post-crisis period. However, the results of the nonlinear test show that all the BRICS markets are rejecting the random walk hypothesis due to the nonlinear dependence in all time periods of study.

Keywords: Weak form Efficiency, Variance ratio tests, BDSL test, BRICS Stock Markets

JEL Classifications: G10, G14, G15

1. Introduction

In recent times, the behavior of stock returns has become an interesting topic for discussion among researchers, investors, and regulators. The researchers want to know the movements of stock indices for prediction purposes, the investors take advantage of the imperfections present in the market in order to gain from arbitrage opportunities. On the other hand, regulators frame policies to increase the efficiency of the markets. The Efficient Market Hypothesis (EMH) formulated by Fama (1965, 1970) states that the current stock prices reflect all available

[1]Sri Sathya Sai Institute of Higher Learning, Puttaparthi-515134, AP, India, e-mail: kiran.akshaya@gmail.com
[2]Sri Sathya Sai Institute of Higher Learning, Puttaparthi-515134, AP, India, e-mail: rprabhakarrao@gmail.com

information at any given point of time. Hence, investors can earn only normal profits or zero economic profits on their investments, i.e. no investor can earn abnormal profits. Therefore, the historical information is not useful for predicting the prices (ineffective technical analysis[3]). This phenomenon is called the Random Walk Hypothesis wherein the successive price changes are independent or unrelated. In an inefficient market, investors can predict security's price movements thereby outperform the markets. The concept of the efficient market was first theorized by Bachelier (1900). Later on, the studies by Samuelson (1965), Fama (1965,1970), Ayadi and Pyun (1994), Areal and Armada (2002), Lock (2007), and Aymen and Adel (2013) have found that the markets are efficient. While few studies have found that the markets are inefficient as the dependence of successive day's market returns helps in predicting stock returns (see Poterba and Summers (1987), Richards A. J. (1995), Abraham et al (2002), M. R. Borges (2010), and Said and Harper (2015)). This inconsistency in the findings denotes that there is no consensus on the findings of studies in understanding the behavior of stock returns. The prime reason for the divergent findings is the use of several statistical tests with restrictive assumptions employed on the different frequencies of data (Gourishankar and Kamaiah (2010)).

In testing the market efficiency several statistical tests have evolved over a period of time. In early studies, researchers used the conventional serial correlation and run tests. As these techniques suffer from more restrictive assumptions they tend to be less efficient in identifying the patterns in the returns. To overcome this issue Lo and Mackinlay (1988) (LMVR) proposed individual variance ratio test. However, the major limitation of this variance ratio test is the problem of sample size distortions. Chow and Denning (1993) suggested a multiple variance ratio tests to address this size distortion problem of the individual variance ratio test. These tests can validate only linear dependencies in the return series. Granger and Anderson (1978) argued that the rejection of linearity in the series alone does not validate market efficiency as non-linearity might enable to predict future prices. Furthermore, the observational effect of Black Monday[4] in the early 1980s ignited the interest in capturing non-linear dependencies in the series. Brock, Dechert, Scheinkman, and LeBaron (BDSL, 1996) developed a test to examine the non-linear dependencies in the series.

The globalization and liberalization in the late '80s have helped emerging economies in attracting more capital flows from developed and other emerging economies. The economic and financial integration with the world economies coupled with the reforms are taken up by the emerging economies have brought a

[3] Using historical prices data to forecast the direction of prices
[4] The stock market crash of 1987

sea change in these economies and especially in their financial markets. Jim O Neil (2001) of Goldman Sachs carried out a study to understand the growth patterns of some developed and emerging economies. He observed that four countries, namely Brazil, Russia, India, and China together has the potential to grow at a faster rate. Thus the acronym BRIC was coined in 2001. Later in 2010 with South Africa joining this group - the new emerging economic order - BRICS was established. These five economies together contribute about 32% of global GDP (PPP). Not only in terms of its economy size, but also with regard to the financial sector the implementation of reforms has helped capital markets to experience a steady increase in size and volume. Capital market development indicators have shown significant improvement with a combined market capitalization of US$13 trillion and the value of stocks traded US$19 trillion, which accounts for 17% of world's market capitalization and 25% of the value of stocks traded as on 2017. The burgeoning BRICS market development indicators triggered interest in researchers to examine the behavior and informational efficiency of markets. Some researchers have carried out the studies to verify the informational efficiency of markets in each of these countries (see, for example, Regis Augusto Ely (2012) for Brazil, Said and Harper (2015) for Russia, Gupta and Sankalp (2017) for India, Andrea et al (2016) for China, Lumengo (2012) for South Africa).

Against this background, this study attempts to examine the market efficiency of BRICS stock markets. The present study contributes to the existing literature on the following aspects. First, the study extends to the most recent period, i.e. from 25th September 1997 to 31st March 2018. Second, to investigate the level of efficiency in varying time periods, the sample period is subdivided into Pre-crisis, during a crisis, and Post-crisis periods. Third, this study employs variance ratio tests Lo and MacKinlay (1988) and Chow-Denning (1993) for linear dependence and BDSL (1996) test for nonlinear dependence to examine the efficiency in BRICS stock markets.

The rest of the paper is organized as follows: A literature review is presented in section 2, followed by a description of the data and methodology in the third section. In section 4 we present the findings of this study. Section 5 ends the paper with a summary and conclusions.

2. Literature Review

In this section, we present a brief overview of the literature available in this area of research. Several empirical studies have been carried out to study the behavior of stock markets by employing the conventional techniques, namely autocorrelation test, and runs test. Fama (1965) used these techniques on the Dow Jones daily returns and found that the market is efficient. Later on, some studies have been

conducted to verify the market efficiency by using conventional tests such as correlation and run tests. However, Lo and Mackinlay (1988) showed that these tests are less efficient and proposed the most powerful variance ratio test and is widely known as Lo and Mackinlay variance ratio test (hereafter LMVR, 1988). They tested the random walk hypothesis for US stock indices and found that the markets are inefficient due to mean reversion in returns[5]. Using LMVR test Ayadi and Pyun (1994) observed that the Korean Stock Exchange (KSE) is a random walk market. Abraham et al (2002) studied the random walk and weak form efficiency of Gulf stock indices for the period of 1992-2008 and found that they are inefficient. By using the traditional parametric and nonparametric tests Areal and Armada (2002) showed that the Portuguese stock markets are weak form efficient. Buguk and Brorsen (2003) tested the efficient market hypothesis for the Istanbul Stock Exchange (ISE) using weekly returns and showed that it follows a random walk. To test the random walk on weekly returns of Taiwan stock market from 1990 to 2006, Lock (2007) applied the variance test and found that the markets move in a random walk. Even though the individual LMVR test is widely used for testing the random walk hypothesis Chow and Denning (1993) developed the multiple variance ratio tests to overcome the issue of sample size distortions from LMVR tests. Huber (1995) used the multiple variance ratio tests for the Austrian Stock Exchange and found that the markets are inefficient or don't have a random walk. Using multiple variance ratio and autoregressive fractionally integrated moving average (ARFIMA) test Ojah and Karemera (1999) showed that Latin American equity markets indices follow a random walk. To test the random walk hypothesis of stock returns in the Middle East markets, Smith (2007) by employing the multiple variance ratio tests found that Israeli, Jordanian and Lebanese markets follow a random walk while other markets showed no random walk. By applying the nonparametric variance ratio test in the Middle East and North African (MENA) markets Al-Khzali et al (2007) found that the MENA markets are weak-form efficient. In order to test a random walk phenomenon for 8 Asian emerging markets, Hoque et al (2007) employed two new VR tests, namely Wright's rank and Whang-Kim subsampling tests along with the variance ratio tests and found that among the Asian markets only Taiwan and Korea markets follow a random walk whereas other markets do not follow a random walk. Kim and Shamsuddin (2008) studied the behavior of advanced and secondary emerging markets for the period from 1990 to 2005. By employing multiple variance ratio tests they found that advanced emerging markets are efficient while the secondary emerging markets are inefficient. M. R. Borges (2010) used variance ratio tests and showed that the European equity markets are

[5] Laura Spierdijk et al(2012)

inefficient. Aymen and Adel (2013) studied the impact of financial liberalization on informational efficiency in 13 emerging markets and found that the financial liberalization improved the efficiency of these markets. Yang et al (2015) examined the efficiency of Mexico, Indonesia, South Korea and Turkey (MIST) utilizing Fourier transformation and showed that the markets are efficient. Geoffrey Ngene et al (2017) examined whether stock prices in 18 emerging markets follow random-walk in the presence of single and multiple structural breaks employing Phillips-Perron test. The results found that in single break test 16 markets rejected the random walk hypothesis and in multiple breaks 14 markets showed the random walk process. Assaf and Charif (2017) used the variance ratio test to investigate the random walk hypothesis in the MENA equity markets and showed that MENA markets are weak-form efficient.

With regard to each of the BRICS stock markets, several studies were conducted to examine the efficiency of markets using the traditional parametric, nonparametric tests. In the case of stock market efficiency in Brazil, using variance ratio tests on Latin American equity markets Urrutia (1995) showed that the markets do not follow a random walk while the runs test showed that markets are efficient. Grieb and Reyes (1999) employed variance ratio tests on Brazil and Mexico markets and found that Brazil markets are efficient. Karemera et al (1999) tested for random walk in emerging equity markets using multiple variance ratio tests and found that Brazil market follows a random walk. Using conventional serial correlation test on Brazil equity markets Capobianco et al (2002) found that the markets follow a random walk. Regis Augusto Ely (2012) investigated the market efficiency in five sectoral indices of Brazil markets. The results of variance ratio tests indicate that except industrial sector all other sectors considered for the study showed a random walk in their returns. With reference to the Russian stock market, Natalia Abrosimova et al (2002) examined weak form efficiency using the autocorrelation and variance ratio tests and found that the markets are efficient. MC Gowan (2011) by employing a serial correlation test found that the Russian stock market is a weak form efficient. Said and Harper (2015) employing autocorrelation and the variance ratio test showed that the Russian market is not efficient. With reference to Indian stock markets, there exist several studies such as Sharma and Kennedy (1977) confirmed that the Indian market follows a random walk. A similar result was found by Barua (1981, 1994), Amanulla and Kamaiah (1996,1998), Mitra (2000), Chawla et al (2006), Gupta (2014). Conversely, studies by Poshakwale (2002), Chaudhuri and Wu (2003), Ahmed et al (2006), Rakesh Gupta and Parikshit (2007), Anil k Sharma and Neha (2011), Hiremath and Kamaiah (2010, 2012) Hiremath and Jyoti (2014), Gupta and Sankalp (2017) found markets are not efficient. As for stock market efficiency in China, studies are conducted by Liu et al (1997), Darrat and Zhong (2000), Lee et

al (2001), Lock (2007), Charles and Darne (2008), Fifield and Jetty (2008), Kian-Ping Lim et al (2009), Lim and Brooks (2009) supported weak form efficiency of Chinese markets. On the other hand, Lima and Tabak (2004), Seddighi and Nian (2004), Andrea and Marianna (2016) observed the dependence in a return series of Chinese markets which implied that markets are inefficient. In the case of South Africa, Mc Millan and Thupayagale (2008) found that the African markets do not follow a random walk while Smith et al (2002) and Lumengo (2012) showed that South African markets are efficient.

Very few studies are conducted on BRICS markets to study market efficiency. Camelia (2012) tested weak-form market efficiency for five U.E emerging markets and BRIC emerging markets and found that all the markets are not efficient during the study period. Karamchandani et al (2014) employed Hurst exponent to study the efficiency of BRIC stock markets and found that all the four markets have more predictability indicating these markets are inefficient. Tiwari and Kyophilavong (2014) used Wavelet-based unit root tests to check whether the BRICS stock markets follow the random walk and observed that except for Russian market, all the other markets do not follow random walk during the study period. Conversely, Mobarek and Fiorante (2014) using individual and multiple variance ratio tests found that BRIC stock markets are efficient. Robert (2016) study found that the BRIC stock markets exhibit weak-form market efficiency.

It is evident from the above literature that the efficiency of markets is time-dependent. Also, the efficiency results heavily rely on the type of tests that have been used for testing the market efficiency of the respective stock markets. Hence, there is a need to test the efficiency for different periods by employing appropriate tests.

3. Data and Methodology

This study uses the daily returns of BRICS stock markets calculated from closing prices for the period 25th September 1997 to 31st March 2018. The stock indices selected are BOVESPA (Brazil), MICEX (Russia), SENSEX (India), SSE (China) and JSE (South Africa). It is also perceived that the markets are inherently volatile and sensitive to the information available domestically and externally at a given time period. It is also evident from the literature that the behavior of markets is highly time-dependent. Therefore, to analyze the behavior of these emerging markets before, during and after the US financial crisis of 2008, the entire time period is divided into three sub-periods. So, the study considers; Sub-period I as Pre Crisis period from 25th September 1997 to 29th June 2007; Sub-period II as Crisis period from 2nd July 2007 to 29th May 2009 and Sub period III as Post Crisis

period from 1st June 2009 to 30th March 2018. The closing prices data for Brazil, Russia, India, and China are obtained from the Yahoo finance and South Africa prices are obtained from the Wallstreet Journal site. The asset returns are calculated from the closing prices using formula $R_t = \log\left(\frac{p_t}{p_{t-1}}\right) \times 100$ Where p_t and p_{t-1} are the closing prices at period (t) and (t-1) respectively.

4. Methodology

Here we present some testing procedures of weak form efficiency of stock markets. In this study, we employ parametric tests, namely Lo and Mackinlay (1988) individual variance ratio test, Chow-Denning (1993) multiple variance ratio test for testing the linear dependence and BDSL (1996) which is a non-parametric test for nonlinear dependence in the return series of BRICS stock markets.

Lo and MacKinlay (1988) individual variance ratio test:

In order to test the weak form efficiency, Lo and MacKinlay (1988) proposed a variance ratio test under the assumption of homoscedasticity i.e. constant variance. (see, Campbell et al (1997)). The test statistic is given by

$$Z_1(q) = \sqrt{nq}\,\bar{M}_r(q)\left(\frac{2(2q-1)(q-1)}{3q}\right)^{\frac{-1}{2}} \approx N(0,1) \ldots\ldots(1)$$

Similarly, Z-statistic under heteroscedasticity assumption is computed as:

$$Z_2(q) = \sqrt{nq}\bar{M}_r(q)[V(q)]^{-\frac{1}{2}} \approx N(0,1) \ldots\ldots(2)$$

Chow and Denning (1993) Multiple Variance Ratio Test:

The random walk hypothesis necessitates the variance ratios of all investment horizons are equal to one and the test has to be done jointly over the time horizons. This procedure further leads to size distortions. To overcome this issue, Chow and Denning (1993) proposed a multiple variance ratio tests. The decision regarding the null hypothesis is according to the maximum absolute values of the individual variance ratio statistics of Lo and MacKinlay (1988). The variance ratio estimates are the maximum test statistic of the Lo and MacKinlay (1988) individual variance ratio test. Unlike the individual variance ratio test where the standard normal critical values are used for significance, multiple variance ratio tests uses Studentized Maximum Modulus (SMM) critical values. The test statistics are defined as

$$Z_1^*(K) = Max_{1\le i\le K}|Z_1(q_i)| \ldots\ldots(3)$$
$$Z_1^*(K) = Max_{1\le i\le K}|Z_1(q_i)| \ldots\ldots(4)$$

$Z_1(q), Z_2(q)$ are computed as in (1) and (2)

In which (q_i) are the different aggregation intervals for $\left\{\frac{q_i}{i} = 1,2,\dots,m\right\}$. The rejection of the null hypothesis is based on the maximum absolute value of the individual variance ratio test statistic.

Test for Non-Linearity: BDSL (1996) test

For a random walk hypothesis, one of the required assumptions is the (in)dependence among the return series. In order to check the linear or non-linear independence of the stock returns, we employ Brock-Dechert-Scheinkman-LeBaron(BDSL)test. It is a nonparametric test with the null hypothesis that the series is independently and identically distributed against an unspecified alternative Brock et al (1991).

The BDSL statistics, W, is given by

$$W_N(e,T) = |C_n(e.T) - C_l(e,T)^N| \times \sqrt{\frac{T}{S_N}(e,T)} \dots\dots (5)$$

where S_N (e, T) is the standard deviation of the correlation integrals. The test is able to locate many types of nonlinearity, nonstationarity, and deterministic chaos. If the null hypothesis is rejected, one can say that the time series is nonlinearly dependent.

5. Empirical Analysis

In order to examine the weak-form of market efficiency for each of the markets at various investment horizons like 2, 5, 10, we have carried out Lo and Mackinlay (1988) individual variance ratio tests for each return series at all time periods. The individual variance test results are presented in Table 1.

Table 1 Results of individual variance ratio tests

Full Period							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Lo-Mac	Z1	2	1.333	6.403*	5.342*	1.595	4.312*
		5	1.158	3.400*	2.200*	1.713	2.179*
		10	2.522*	1.340	0.929	1.837	0.327
	Z2	2	0.654	2.457*	3.194*	1.098	2.458*
		5	0.574	1.383	1.346	1.180	1.289
		10	1.303	0.588	0.581	1.278	0.219

Pre-Crisis Period							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Lo-Mac	Z1	2	2.061*	6.329*	3.258*	0.834	4.951*
		5	0.204	4.105*	1.941	1.037	4.834*
		10	1.053	1.992	1.379	0.915	3.223*
	Z2	2	0.973	2.528*	1.987*	0.629	2.490*
		5	0.100	1.793	1.276	0.771	2.665*
		10	0.548	0.967	0.965	0.693	1.964
Crisis Period							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Lo-Mac	Z1	2	0.471	0.086	2.145*	0.077	1.064
		5	1.791	0.177	0.206	0.136	0.566
		10	1.946	0.282	0.316	0.210	1.132
	Z2	2	0.367	0.070	1.845	0.068	0.914
		5	1.231	0.152	0.170	0.127	0.462
		10	1.307	0.251	0.257	0.197	0.900
Post Crisis Period							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Lo-Mac	Z1	2	0.587	0.021	2.811*	1.902	0.493
		5	0.938	0.472	1.403	1.460	2.130*
		10	1.488	1.028	0.119	1.590	2.885*
	Z2	2	0.499	0.014	2.491*	1.194	0.420
		5	0.779	0.336	1.203	0.889	1.781
		10	1.266	0.770	0.101	0.981	2.423*

*denotes the level of significance at 5% level

The empirical results under the assumption of homoscedasticity (Z1) show that in the full period Brazil at lag 10, Russia at 2 and 5 day lag, India and South Africa at lag 2 reject the weak form efficiency. In the pre-crisis period Brazil at 2 days, Russia and South Africa in 2, 5 and 10 day lag, India in 2 days lag show that the markets are not efficient. During the crisis period, India in 2 days lag, in post-crisis period India at 2 lags and South Africa at 5 and 10 days lag show that the markets are inefficient.

Results of heteroscedasticity (Z2) show that Russia, India, and South Africa markets at 2 lags in full period while in the pre-crisis period, Russia, Indian markets at 2 days

lag, the South African markets at all lags reject the weak form efficiency. During the pre-crisis period Russia and India in 2 days, South Africa at all lags while in post-crisis period India at two lags and South Africa in 10 lags show that the markets are inefficient. Both homoscedasticity (Z1) and heteroscedasticity (Z2) results confirm that China markets are efficient in all time periods of the study. From this, we observe that the results are mixed at various holding periods which may be due to the limitation of size distortions. To overcome this we employed a multiple variance ratio tests proposed by Chow and Denning (1993). The results of the test are presented in Table 2. Here we give the maximum homoscedastic (Z1) and heteroscedastic (Z2) robust test statistics of LMVR test.

Table 2 Results of Multiple variance ratio tests

Full Period							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Chow-Denning	CD1	2,5,10	2.522*	6.403*	5.342*	1.837	4.312*
	CD2	2,5,10	1.303	2.457	3.194*	1.278	2.458
Pre-Crisis							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Chow-Denning	CD1	2,5,10	2.061	6.329*	3.258*	1.037	4.951*
	CD2	2,5,10	0.973	2.528*	1.987	0.771	2.490*
Crisis							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Chow-Denning	CD1	2,5,10	1.946	0.580	2.114	0.210	1.132
	CD2	2,5,10	1.307	0.251	1.845	0.197	0.914
Post Crisis							
Test	Statistic	Holding Periods	BOVESPA	MICEX	SENSEX	SSE	JSE
Chow-Denning	CD1	2,5,10	1.488	0.936	2.811*	1.902	2.885*
	CD2	2,5,10	1.266	0.770	2.491*	1.194	2.423

*denotes the level of significance at 5% level

From table 2, we see that under the assumption of homoscedasticity (CD1) Brazil, Russia, India, and South Africa markets are inefficient in full period that is from 25th September 1997 to 31st March 2018. Also, Russia, India, and South Africa during the pre-crisis period, while the post-crisis period India and South Africa

markets are not efficient. Under the heteroscedasticity (CD2) assumption, the only Indian market is found to be inefficient. In the pre-crisis period, Russia and South Africa, during the post-crisis period India rejects the weak form market efficiency. However, in both tests (CD1 and CD2), China markets found to be efficient in all time periods of the study as its calculated values are less than the critical value (2.49). It is important to note that all the markets are found to be efficient during the crisis period. Here we can notice that the individual variance ratio tests (Z1 and Z2) and heteroscedasticity (CD2) of multiple variance ratio test reject the market efficiency for the same markets, this may be due to the robustness of the Chow - Denning test under the assumption of heteroscedasticity (CD2). From table 1 and table 2 it is also observed that during the crisis period all the markets are efficient from Lo and MacKinlay and Chow-Denning tests.

As the variance ratio tests can only indicate whether the series is linearly (in)dependent, thus it is necessary to test for nonlinear (in)dependence in the series. In order to test the nonlinear (in) dependence in the series, we applied the BDSL non-linearity tests at embedding dimensions (M = 2, 4, 8, 10) and at epsilon values (E = 0.5, 1, 1.5, 2). The results of the BDSL test on the return series are reported along with the p-values in parentheses are reported in table 3.

Table 3 Results of BDSL test

Full Period	Stock Return	M=2, E=0.5	M=4, E=1	M=8, E= 1.5	M=10, E= 2
	BOVESPA	7.76(0.00)	16.44(0.00)	31.47(0.00)	38.78(0.00)
	MICEX	19.46(0.00)	37.83(0.00)	93.17(0.00)	113.04(0.00)
	SENSEX	15.7(0.00)	27.93(0.00)	50.27(0.00)	52.25(0.00)
	SSE	9.19(0.00)	20.6(0.00)	37.39(0.00)	40.27(0.00)
	JSE	12.59(0.00)	23.75(0.00)	37.34(0.00)	38.25(0.00)
Pre Crisis	BOVESPA	8.50(0.00)	13.12(0.00)	20.54(0.00)	24.45(0.00)
	MICEX	13.27(0.00)	24.86(0.00)	64.16(0.00)	89.28(0.00)
	SENSEX	11.42(0.00)	18.00(0.00)	29.53(0.00)	32.08(0.00)
	SSE	4.88(0.00)	11.05(0.00)	18.19(0.00)	20.20(0.00)
	JSE	6.77(0.00)	12.36(0.00)	19.19(0.00)	20.42(0.00)
Crisis	BOVESPA	0.76(0.41)	3.31(0.00)	4.99(0.00)	6.83(0.00)
	MICEX	5.18(0.00)	10.14(0.00)	34.69(0.00)	56.57(0.00)
	SENSEX	3.25(0.00)	7.24(0.00)	38.20(0.00)	38.09(0.00)
	SSE	0.86(0.38)	2.99(0.00)	8.88(0.00)	7.09(0.00)
	JSE	2.74(0.00)	10.89(0.00)	21.47(0.00)	28.07(0.00)
Post Crisis	BOVESPA	0.70(0.48)	5.08(0.00)	9.62(0.00)	11.76(0.00)

Full Period	Stock Return	M=2, E=0.5	M=4, E=1	M=8, E= 1.5	M=10, E= 2
	MICEX	5.87(0.00)	12.64(0.00)	21.18(0.00)	22.80(0.00)
	SENSEX	3.55(0.00)	8.01(0.00)	13.87(0.00)	14.42(0.00)
	SSE	4.86(0.00)	10.93(0.00)	18.52(0.00)	19.64(0.00)
	JSE	5.73(0.00)	11.12(0.00)	16.15(0.00)	16.31(0.00)

(P values are in parenthesis)

The results of BDSL test show that the stock returns of all the BRICS markets have nonlinear and chaotic behavior for all time periods of study except for Brazil and China during crisis period at lag 2 and only in Brazil in post-crisis at lag 2.

From the above empirical analysis, the variance ratio tests, namely Lo and MacKinlay and Chow-Denning test show that market efficiency is time-varying and there is no uniformity in the results. However, BDSL test revealed that there is a nonlinear dependence in all the periods of the BRICS markets. This confirms that the markets are markets inefficient during the study period.

6. Summary & Conclusions

Market efficiency is one of the key concepts of financial economics studies. In this study, the efficiency was tested for the five important emerging market economies, namely Brazil, Russia, India, China and South Africa (BRICS) by considering the daily data from 25th September 1997 to 31st March 2018. Further, the data is subdivided into three periods; pre-crisis, during a crisis and post-crisis periods to understand the behavior of these markets in all these periods with respect to efficiency. We employed the parametric (Lao and MacKinlay (1988) individual variance ratio and Chow and Denning (1993) multiple variance ratio test) and non-parametric (BDSL (1996)) tests to verify the linear and nonlinear (in) dependence in the return series.

The empirical analysis of variance ratio tests, Lao and MacKinlay (1988) and Chow and Denning (1993) showed that market efficiency is varying during a choice of time periods of the study. However, the non-parametric BDSL (1996) test revealed that markets are inefficient in all the time periods. Thus, we can conclude that the BRICS stock markets are inefficient during this period of the study.

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