The impact of COVID-19 pandemic on South Asian Stock Markets: Test of EMH

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Abstract

Objective

The paper aims to investigate the pandemic's impact on the efficiency of capital markets in countries of South Asia. This study includes the stock markets of Pakistan (PSX), India (BSE), Bangladesh (DSE), and Sri Lanka (CSE).

Overview

The study analyzes the market efficiency of these stock markets before and during the COVID-19 global wave. The core objective of this research is to study the market efficiency of sample stock markets before and during the global pandemic. It has been hypothesized that the stock markets of South Asian countries are weak-form efficient.

Methodology

This research is conducted by using the daily secondary data collected from the stock indices of Pakistan (KSE), India (BSE), Bangladesh (DSE), and Sri Lanka (CSE) from August 2018 to July 2021. For the accomplishment of this research, different statistical tests have been used to check the efficiency of the capital markets. The tests include unit root for stationarity, serial correlation for autocorrelation, and variance ratio methodology for checking efficiency.

Findings

The results find the mixed confirmation of the hypothesis of efficiency. According to the results, we find that all capital markets were efficient before the global outbreak. Similarly, findings indicate that all financial markets exhibit weak efficiency daily during the global breakout of the pandemic (COVID-19). The findings also indicate that the prices of stocks are not independent.

Significance

This conclusion enables investors and market regulators to take action to create certain information in these economies, which in turn allows some stock returns to be predictable and creates chances for arbitrage and abnormal profits.

Keywords: COVID-19, South Asian countries; Stock Markets; efficiency

1. Introduction

The first report of the coronavirus was made in Wuhan, China, in December 2019 (WHO, 2020). Millions of people in nearly 300 nations were affected by this virus, which was spreading quickly over the globe (WHO, 2020). Soon after the COVID-19 epidemic left China and spread to other nations, further positive cases as well as millions of deaths were confirmed. The WHO officially recognized it as a worldwide epidemic a few months later. The COVID-19 pandemic has had a significant negative impact on the performance of financial markets and economies worldwide, with ripple effects felt across the board (Okorie and Lin, 2021). The ability of the stock market to affect all areas of the economy makes it a vital component of any nation. The stock market's efficiency is crucial during a worldwide shock because it informs investors about the financial market trading and strategic moves that affect profitability (Okorie and Lin, 2021).

1.1. Research Problem

Businesses worldwide are being forced into a total lockdown to contain the COVID-19 pandemic. The regular operations of enterprises are impacted during the lockdown, and people require resources for sustenance during this period (Okorie and Lin, 2021). Investors in the markets liquidated their positions to obtain those resources, and this volatility and stock price movement had an impact on the financial markets, leading to a shift in the efficiency of the stock markets. COVID-19 has a significant fractal contagion influence on the capital markets, as demonstrated by Okorie and Lin (2021). Researchers Ahmar (2020), Alber (2020), Ashraf (2020), Patsoulis (2020), Rahman et al. (2021), and others have also strongly indicated that COVID-19's impact on the capital markets, which are severely impacted during this pandemic.

1.2. Research Gap

Prior studies have been carried out in the stock markets of Asia. The comparative analysis of the market efficiency in South Asian stock markets before and during the pandemic is still lacking, despite the efforts of Sapkota and Madai (2020), Vasileiou (2020), Okorie and Lin (2021), and other highly afflicted economies. Consequently, this study closes this gap. The South Asian rising economies—Pakistan, Sri Lanka, Bangladesh, and India—are examined in this study. These markets have been chosen based on the magnitude of their respective markets. This paper's primary objective is to examine the sample stock markets' market efficiency both before and during the COVID-19 epidemic.

1.3. Objective of research

The primary goal of this research is to investigate the market efficiency of sample stock markets amid a global pandemic wave. Complete data was obtained from the market indices of Bangladesh (DSE), Sri Lanka (CSE), India (BSE), Pakistan (KSE), and Bangladesh (BSE) between August 2018 and July 2021. Afterward, the entire dataset is split into two sets: pre-COVID-19 (Aug 18 to Jan 2020) and post-COVID-19 (Feb 20 to Jul 21).

1.4. Significance of Research

The results of this study will be a valuable addition to the current weak form of the efficient market hypothesis, which is being studied in several South Asian nations. In addition to helping to support the execution of policies that will support the efficiency of the financial markets, this work aims to provide information to financial investors and regulators of the global capital markets, where institutional and individual investors will seek the benefits of diversity. Thus, this paper's goal is to examine the chosen capital markets' market efficiency and certainty during the global pandemic (COVID-19).

1.5. The Premise of EMH

EMH depends on the premise of information and the value of information. The information structure may forecast which event will happen. A message that has different values to different people, subject to the condition that;

- they can take action and
- what benefit will come out of this action

The same me be explained in equation 1

Value of information structure, v (n)

$$\boldsymbol{V(n) = \sum q(m) MAX \sum P(e)(m)\, U(a,e) - V(n_o)} \quad \textbf{[1]}$$

Where:
V (n) = value of information, m= no of time, p= probability, e= event, u= utility, a= action and n◦ = information as of today

Given this scenario, an optimal action may be exercised as depicted in equation 2.

$$\boldsymbol{MAX \sum P(e)(m)\, U(a,e)}$$

$$\boldsymbol{V(n_i) - V(n_o) = O} \quad \textbf{[2]}$$

If return follows random walk theory, the value of the underlying distribution does not change over time. Serial covariance between returns for any lag must be zero as equation 3 shows.

$$\boldsymbol{CoV(r_{j,t+1}, r_{jt}) = f_{rjt}[r_{jt} - E(r_{jt})][E(r_{jt+1} r_{jt}) - E(r_{j,t+1})] f(r_{jt})} \quad \textbf{[3]}$$

1. **Literature Review**

The global outbreak COVID-19 has shaken the worldwide economy. All the financial economies are responding to this outbreak, which results in an excessive loss (Aslam et al., 2020). Therefore, testing the influence of this pandemic globally is a hot topic for all researchers. There is fast-growing literature about the COVID-19 impact on the economies. Liu et al. (2020) analyzed the pandemic effect on the 21 leading capital markets. The authors used panel data analysis and the study proved that this pandemic badly impacted the financial markets of the leading economies.

The impact of this outbreak has a diverse influence on different capital markets. Numerous studies have found that this pandemic has caused the financial crisis worldwide. During the pandemic the global capital market risks have risen dramatically Zhang et al., (2020). Recently, Waheed et al., (2020) found that stock exchange of Pakistan, gained a significantly positive returns, due to their timely government interventions during pandemic that secure shareholders from an absolute disaster for the capital market. Moreover, Baker et al., (2020) compared this outbreak to the previous outbreak of 1918–1919, 1957–1958, and 1968 and concluded that no previous pandemic disturbed the operation of financial markets as much as COVID–19 did. The study revealed the main reason that stock markets have responded more intensely to COVID-19, are the lockdown of the businesses and social distancing.

Şenol and Zeren (2020) analyzed that the pandemic of COVID-19 has significantly increased the financial risks around the globe. In a shorter period of time, the prices of the stock markets dropped, and the businesses lost their value. Indeed, during financial crises, it is essential to investigate the efficiency of the capital markets. Dias et al., (2020) studied the efficiency in the economies of China, France, Italy, Portugal, Germany, South Korea, and Spain. The result showed that the random walk hypothesis was not accepted in all market indexes. Topcu and Gulal (2020) discovered that the developing financial markets are gradually dropped and started to be fallen down by mid-April

The influence of coronavirus (COVID-19) has been the greatest in the emerging markets of Asia however the European emerging markets have faced the lowest impact. The different studies showed diversified results for different stock markets, some markets are largely influenced, and some are less influenced. However, in an Asian context, a genuine question has been raised about the COVID-19 effect on the efficiency of the capital market returns. Furthermore, the main investigating issue is which country has been affected more during the pandemic.

The market efficiency in developed markets have been tested by Rounaghi and Zadeh (2016), Sensoy and Tabak (2015), Shirvani and Delcoure (2016). Sensoy and Tabak (2015) revealed that all European capital markets had been affected by the 2008 financial crisis. These authors confirm that there was a significant impact on the economies of France, Greece and Spain during the sovereign debt crises of European. Rounaghi and Zadeh (2016) examined the Stock Exchange of London (LSE) with its comparison to the S&P 500, result revealed that both economies were financially healthy and efficient throughout the times of up and down. Shirvani & Delcoure (2016) investigated the efficiency of the 16 capital markets of OECD. The hypothesis of market efficiency was accepted and all markets were efficient. Hamid et al., (2017) studied the hypothesis of efficient market in developed and emerging markets. He tested 14 financial markets for the period 2004-2009. The researchers found that RWH was not accepted in region of Asia-Pacific.

Malafeyev et al., (2019) investigated the financial markets of India and China, authors revealed that RWH is not followed by the prices and these markets were inefficient. Caporale et al., (2020) dealt with the European financial markets (France, Germany, Italy, Spain and United Kingdom), the results confirm that all European indices were accepted the weak form assumption of market efficiency. Miloş et al., (2020) studied seven financial economies of CEE (Central and Eastern Europe). These researchers confirm a long-term correlation between the rates of return, thus the result revealed that all the capital markets were not efficient.

Theoretical framework and hypothesis development

Efficient market hypothesis:

In 90's the Efficient Market Hypothesis (EMH) had gained importance and was developed separately by Professor Paul A. Samuelson and Professor Eugene Fama. The emerging economies became a hot topic at that time. The emerging economies included the South Asian markets, after the crises of the currency of Asia. The eminence of these emerging markets brought out the fact that the assumption of efficient market was not factual for the South Asian capital markets. Therefore, the investment risks were higher. The theory suggests the comprehensive and quick flow of the information that is currently available in the market. EMH guarantees efficient performance and procedure in case of the financial markets, which in return impacts the operations and procedures of the working economy.

Fama and French (1988) proposed that the market is efficient if prices of stocks reflect all available data in the capital markets. This information covers not only the information that is available in the financial reports however it also reveals the social and political news, the economic affairs and other financial data. The EMH idea consider that how quickly the market reacts to the newly available data and have impact on the prices of the security.

Hypothesis Development:

When investors making decisions regarding to investment in the securities, they use information that they own. stock market information is disturbed by the environments' condition, however it is economic or not Syifaudin et al., (2020). The stock market efficiency is affected by many events and every event has different features. The COVID-19 outbreak has crushed all the sectors around the globe, whether it is health sector or economic. It is one of the unusual events that drastically disturbing the efficiency of the capital markets globally.

The EMH describes the reaction of security prices to the new information. Dias et al., (2020) tested COVID-19 influence on the capital markets of Europe China, and US and found out the mixed results about the hypothesis of efficient market. The assumption of random walk was not accepted in the case of Belgium, China, France, Germany, Greece, Portugal and USA but it was accepted in the case of Ireland and Spain. The finding also displays that prices of stock do not reveal all the data and the fluctuations that occur in the stock prices are not identically circulated. Based on the previous research findings, the hypotheses of this research are as follow:

Hypothesis:

(H_1): KSE is a weak form of efficient capital market.

(H_2): BSE is a weak form of efficient capital market.

(H_3): CSE is a weak form of efficient capital market.

(H_4): DSE is a weak form of efficient capital market.

Methodology

3.1. Data and Variables:

Information and data include time series secondary data collected from the stock indices of Pakistan (PSX), India (BSE), Bangladesh (DSE) and Sri Lanka (CSE) for a period of August 2018 to July 2021 on a daily basis. The closing values of the selected indices are used to calculate the returns.

Table 1. Selected countries and their indices

Country	Index
Pakistan	KSE-100
India	BSE-SENEX
Bangladesh	DSE-GEN
Sri Lanka	CSE-MPI

3.2. Statistical Models:

The tests that have been used to analyze the efficiency of stock markets includes the unit root rank-variance ratio that estimate if stock prices are following a random walk. Tests of Unit root are ADF and PP test and for evaluating the stationarity for returns series, Breusch-Godfrey serial correlation LM test is used for analyzing autocorrelation. The stability test was applied through auto regression (AR) model for each capital market.

3.3. Return:

The formula that is used to calculate the return is;

$$r = lnY_t - lnY_{t-1} \quad [4]$$

3.4. Unit root

The Unit Root was applied to analyze the order series of integration. Different methods have been established for this purpose, one of the methods that is widely used is ADF (Augmented Dickey-Fuller), and this method requires that the unit root (Ho) null hypothesis is not accepted, in benefit of the stationarity alternative hypothesis. The formula of ADF test shows in the following equation:

$$\Delta y_t = \alpha_o + \alpha_1 y_{t-1} + \sum_{i=1}^{n} \alpha \Delta y_t + e_t$$

Where: Δ = 1st difference operator, y = data time series, t = time period, αo = constant value, n = number of lags and e = random error. Another method which is also suggested for the test of unit root is PP (Phillips and Perron, 1988), which is shown in the following equation:

$$\Delta y_t = \alpha_o + \alpha_1 y_{t-1} + e_t$$

3.5. Rank Variance ratio:

The variance ratio is applied to test the randomness in return series. It is used to access the autocorrelation between returns.

$$X_t = \mu + X_{t-1} + \epsilon_t$$

Where X_t = logarithm, μ = arbitrary motion parameter, P_t = price of an asset and ϵ_t = random error. The method of variance ratio test is implemented same as described by Lo and Mackinlay (1988), which is consistent with the estimator heteroscedasticity. As an example, nq+1 = observations, in which q is numeral which is higher than 1. Following equation can be defined as:

$$\hat{\mu} \equiv \frac{1}{nq} \sum_{k=1}^{nq} (X_k - X_{k-1}) = \frac{1}{nq} (X_{nq} - X_\circ)$$

$$\sigma_a^2 \equiv \frac{1}{nq} \sum_{k=1}^{nq} (X_k - X_{k-1} - \hat{\mu})^2$$

$$\bar{\sigma}_c^2(q) \equiv \frac{1}{m} \sum_{k=1}^{n} (X_{qk} - X_{qk-q} - q\hat{\mu})^2$$

Then:

$$m = q\,(nq - q + 1)\left(1 - \frac{q}{nq}\right)$$

The variance ratio test is given by the following equation:

$$\widehat{VR}\,(q) = \frac{\bar{\sigma}_c^2(q)}{\bar{\sigma}_c^2}$$

4. Results and Discussion:

Figure 1a illustrates the capital market indices progress overtime in prices (level) of India (BSE-SENSEX), Sri Lanka (CSE-MPI), Bangladesh (DSE-GEN) and Pakistan (KSE-100), in the period from 01-08-2018 to 30-07-2021 on a daily basis. There is a major decline in all of the capital markets during March, April, May, and June 2020. It is a challenging time, because of the global outbreak of COVID-19. It could be related to the uncertainty and pessimism of pandemic.

Figure 1a. Daily returns data of four capital markets, for the period of 01-08-2018 to 30-07-2021. (Full Sample)

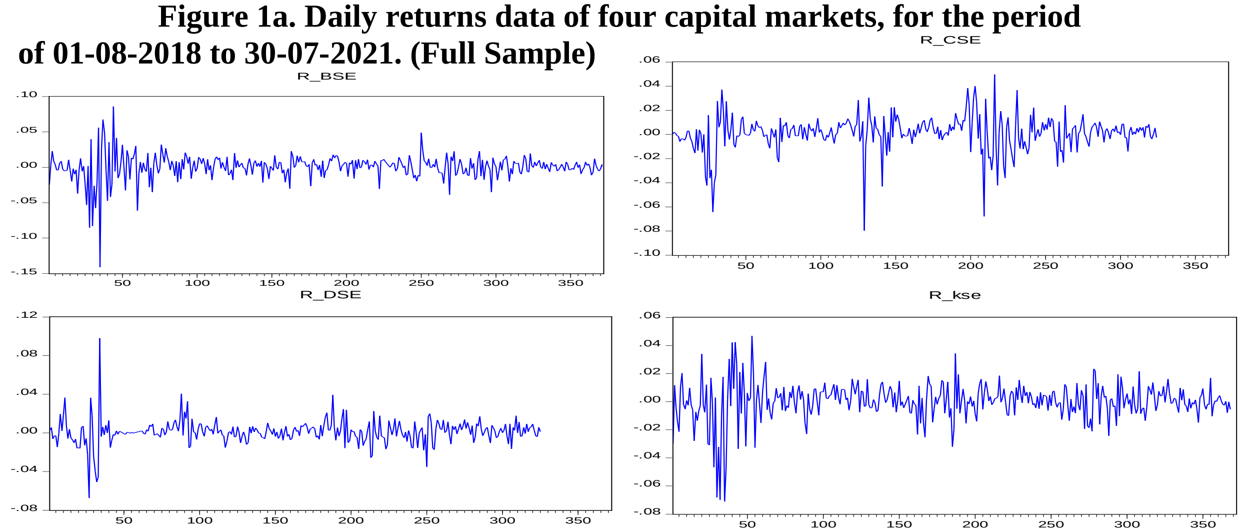


Figure 1b illustrates the pre-COVID capital market indices progress overtime in prices (level) of India (BSE- SENSEX), Sri Lanka (CSE-MPI), Bangladesh (DSE-GEN) and Pakistan (KSE-100), in the period from 01-08-2018 to 30-01-2020 on a daily basis before COVID-19. The stock market of India shows a declining trend which is because of their crashes of 2018 (in which Indian market is fell by 600 points in 2 days). The Sri Lanka stock market was down during 2019 Because of the economic collapses. We can also find a significant decline in Pakistan stock exchange in the month of august 2019 which is due to the worst blow amid tension with India. Overall, the evolution in these capital markets shows volatility in series.

Figure 1b. Evolution in levels pre- COVID Daily data of four capital markets, for the period of 01-08-2018 to 30-01-2020.

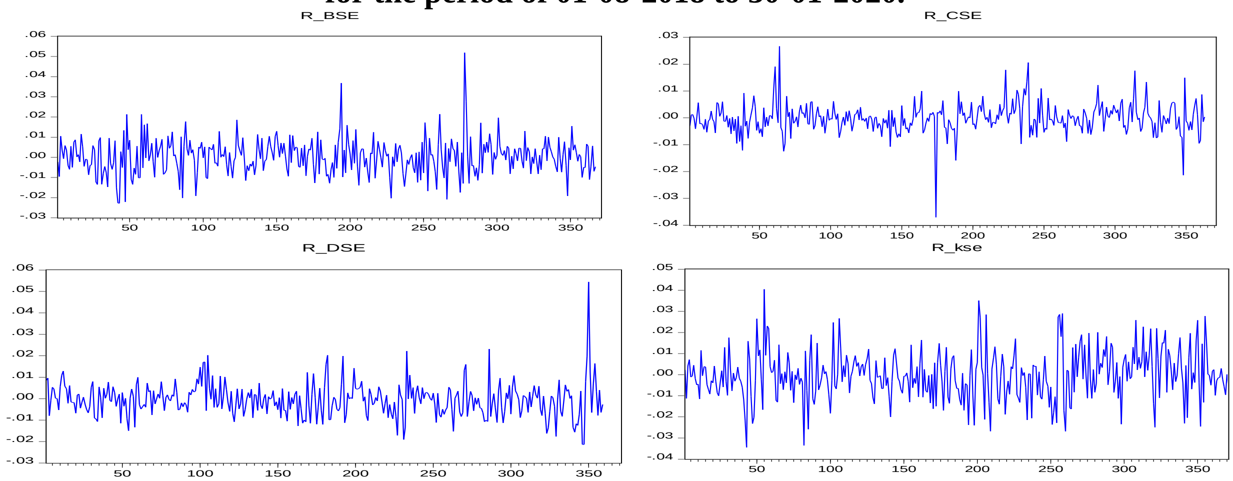
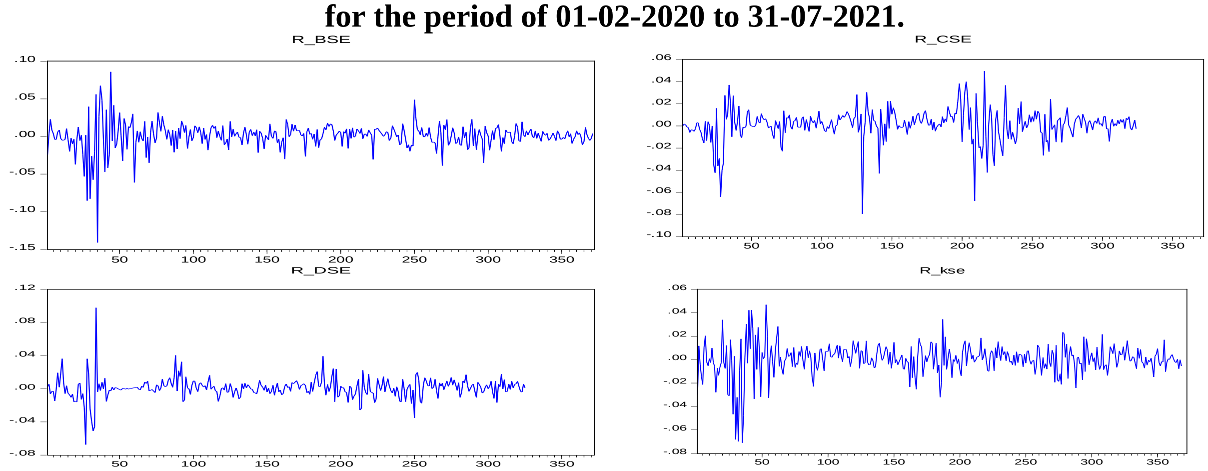


Figure 1c illustrates the capital market indices progress overtime in prices (level) of India (BSE-SENSEX), Sri Lanka (CSE-MPI), Bangladesh (DSE-GEN) and Pakistan (KSE-100), in the period from 01-02-2020 to 31-07-2021 on a daily basis. There is a major decline in all of the capital markets during March, April, May, and June 2020, it is a challenging time, because of the globally outbreak of COVID-19. It could be related to the uncertainty and pessimism of pandemic.

Figure 1c. Evolution in levels during- COVID Daily data of four financial markets, for the period of 01-02-2020 to 31-07-2021.



Descriptive Statistics and Unit Root Results:

The result of descriptive statistics and unit root of the capital market returns display in **Table 1a** to **1c** across different time periods that is complete data set, pre-COVID and during COVID-19. The descriptive statistics analysis permits us to validate that the rate of return on daily basis of all the stock markets have positive average. Table 1a shows that BSE has the highest standard deviation among all, for returns, the characteristics of asymmetry (skewness) are negative, with exception to the Bangladesh stock market (DSE). Moreover, the normality hypothesis of Jarque-Bera test is rejected (Ho) at a significance level of 1% for all four capital markets.

Table 1a: Four capital markets for the period of 01-08-2018 to 30-07-2021

	R_BSE	R_CSE	R_DSE	R_KSE
Mean	0.0005	0.0005	0.0003	0.0001
Median	0.0010	0.0004	0.0004	0.0002
Maximum	0.0859	0.0497	0.0980	0.0468
Minimum	-0.1410	-0.0796	-0.0674	-0.0710
Std. Dev.	0.0142	0.0108	0.0103	0.0126
Skewness	-1.6021	-1.2925	0.9169	-0.6521
Kurtosis	22.8881	13.7308	19.8852	7.3764
Jarque-Bera	12495.39***	3599.126***	8221.511***	642.1273***
ADF	-9.1619***	-21.3623***	-8.5325***	-23.4544***
PP-Test	-29.2775***	-21.9727***	-23.1896***	-23.8097***

Table 1b shows the descriptive statistics of pre-COVID situation. The mean return is negative with the exception of BSE which has a positive mean return in all four capital markets. The result shows that the KSE has the highest standard deviation among all markets, stating that KSE has the highest risk than other market under study. The asymmetry characteristic is positive, excluding Sri- Lankan market.

Table 1b: Four capital markets for the period of 01-08-2018 to 30-01-2020, pre-COVID

	R_BSE	R_CSE	R_DSE	R_KSE
Mean	0.0003	-0.0001	-0.0005	0.0000
Median	0.0003	-0.0002	-0.0001	-0.0005
Maximum	0.0519	0.0266	0.0545	0.0404
Minimum	-0.0228	-0.0370	-0.0214	-0.0344
Std. Dev.	0.0089	0.0056	0.0078	0.0119
Skewness	0.6410	-0.1501	1.1354	0.1737
Kurtosis	6.4849	10.6606	9.7036	3.4584
Jarque-Bera	206.25***	879.16***	749.34***	4.95***
ADF	-18.4138***	-16.4554***	-14.9148***	-16.4896***
PP-Test	-18.4673***	-16.4865***	-14.9092***	-16.4104***

Table 1c illustrates the descriptive statistics of all four markets for During-COVID scenario. All the four capital markets show positive mean returns as illustrated in **Table 1c**. The result depicted that BSE are risky markets among other markets under study. The characteristics of asymmetry

are negative, except the capital market of Bangladesh. The Bangladesh stock market have high degree of asymmetry.

Table 1c: Four capital markets for the period of 01-08-2018 to 30-07-2021, During- COVID

	R_BSE	R_CSE	R_DSE	R_KSE
Mean	0.0007	0.0010	0.0011	0.0003
Median	0.0019	0.0021	0.0013	0.0011
Maximum	0.0859	0.0497	0.0980	0.0468
Minimum	-0.1410	-0.0796	-0.0674	-0.0710
Std. Dev.	0.0180	0.0144	0.0125	0.0135
Skewness	-1.6684	-1.3068	0.6625	-1.2096
Kurtosis	17.3529	9.2732	17.7158	9.4055
Jarque-Bera	3365.68***	623.48***	2956.31***	718.87***
ADF	-5.9388***	-14.2362***	-5.2730***	-16.7569***
PP-Test	-21.2817***	-14.5595***	-16.4849***	-17.1773***

The overall descriptive statistics show that all stock markets i.e. BSE, CSE, DSE and KSE showed an upward trend, but the daily returns were low. Significant volatility was observed during the selected period. Interestingly there was low volatility before COVID, and distribution of returns was closer to what was expected in well-functioning markets. However, during covid the volatility in returns increased and that represents a decrease in market efficiency.

ADF and PP methods have been to examine the presence of stationarity in the data. **Table 2a to 2c** displays the results at level intercept and with intercept and trend.

Test critical values: 1%: -3.4391, 5%: -2.8653, 10%: -2.5688

Table 2a, 2b and 2c illustrates the results of ADF and PP that in all four financial markets, the unit root null hypothesis (Ho) in return series cannot be accepted on a daily basis for complete period as well as pre COVID, post-COVID19 period. The test statistics show the p-values of BSE, CSE, DSE and KSE are 0.0000 on a daily return of all the financial markets. Therefore, we can summarize that the return series of indexes with intercept and with intercept & trend are stationary at levels. The analysis shows that all capital markets under study are weak form inefficient and do not follow the assumption of random walk during 2018-2021.

Variance Ratio Test:

Variance ratio test methods have been used to examine the weak form of efficiency in returns of all four capital markets. The market shows weak efficiency if past returns do not predict future returns. **Table 3a to 3c** displays the results of variance ratio test on daily frequency for complete, before and after global pandemic. The result shows statistically significant probability values i.e. < 0.05 for joint as well as different lags (2, 4, 8 and16 days). Therefore, the null hypothesis can be rejected, and it can be said that **all capital markets are also weak from efficient** because past returns seem to predict future returns.

Table 3a: Variance Ratio Test Results on Daily Frequency:

Variance Ratio Test of BSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		3.8397	738	0.0005
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.4530	0.1425	-3.8397	0.0001
4	0.2299	0.2332	-3.3030	0.0010
8	0.1173	0.3238	-2.7260	0.0064
16	0.0647	0.4584	-2.0405	0.0413

Variance Ratio Test of CSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		4.6005	708	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5933	0.0919	-4.4237	0.0000
4	0.2918	0.1539	-4.6005	0.0000
8	0.1687	0.2183	-3.8076	0.0001
16	0.0862	0.3049	-2.9969	0.0027

Variance Ratio Test of DSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		3.6202	683	0.0012
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.6203	0.1292	-2.9389	0.0033
4	0.2665	0.2026	-3.6202	0.0003
8	0.1565	0.2668	-3.1614	0.0016
16	0.0769	0.3631	-2.5424	0.0110

Variance Ratio Test of KSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		7.3659	738	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5811	0.0569	-7.3659	0.0000
4	0.2872	0.1089	-6.5447	0.0000
8	0.1524	0.1721	-4.9254	0.0000

16	0.0732	0.2511	-3.6907	0.0002

*Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of freedom

Table 3b: Variance Ratio Test Results on Daily Frequency- pre COVID period:

Variance Ratio Test of BSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		6.5444	366	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5075	0.0753	-6.5444	0.0000
4	0.2556	0.1348	-5.5223	0.0000
8	0.1422	0.1972	-4.3488	0.0000
16	0.0643	0.2705	-3.4587	0.0005

Variance Ratio Test of CSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		4.2112	362	0.0001
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5475	0.1074	-4.2112	0.0000
4	0.2921	0.1695	-4.1776	0.0000
8	0.1363	0.2217	-3.8965	0.0001
16	0.0709	0.2849	-3.2613	0.0011

Variance Ratio Test of DSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		4.953989	358	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5075	0.0753	-6.5444	0.0000
4	0.2556	0.1348	-5.5223	0.0000
8	0.1422	0.1972	-4.3488	0.0000
16	0.0643	0.2705	-3.4587	0.0005

Variance Ratio Test of KSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		6.1488	370	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.6176	0.0622	-6.1488	0.0000
4	0.3038	0.1133	-6.1427	0.0000
8	0.1662	0.1739	-4.7944	0.0000
16	0.0759	0.2504	-3.6897	0.0002

*Probability approximation using studentized maximum modulus with parameter value 4

Table 3c: Variance Ratio Test Results on Daily Frequency- during COVID period:

Variance Ratio Test of BSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		3.247697	371	0.0046
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.4431	0.1715	-3.2477	0.0012
4	0.2258	0.2804	-2.7612	0.0058
8	0.1145	0.3892	-2.2753	0.0229
16	0.0677	0.5512	-1.6915	0.0907

Variance Ratio Test of CSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		3.7253	323	0.0008
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5994	0.1128	-3.5530	0.0004
4	0.2980	0.1884	-3.7253	0.0002
8	0.1795	0.2672	-3.0703	0.0021
16	0.0954	0.3736	-2.4214	0.0155

Variance Ratio Test of DSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		2.7321	324	0.0249
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5957	0.1729	-2.3384	0.0194
4	0.2620	0.2701	-2.7321	0.0063
8	0.1499	0.3543	-2.3996	0.0164
16	0.0769	0.4822	-1.9142	0.0556

Variance Ratio Test of KSE

Joint Tests		**Value**	**Df**	**Probability**
Max |z| (at period 2)*		5.0811	367	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.5538	0.0878	-5.0811	0.0000
4	0.2778	0.1706	-4.2322	0.0000
8	0.1456	0.2718	-3.1439	0.0017
16	0.0743	0.3980	-2.3258	0.0200

*Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of freedom

Serial Correlation:

The following section displays the results of serial correlation for all four capital markets, for complete, before & after global pandemic. The test for serial correlation Breusch-Godfrey Serial

Correlation LM Test is used. This test identifies a relationship between past and future returns that potentially violates the weak form of efficiency assumption that is movement in past returns do not predict future returns.

The results in **Table 4a** display the serial correlation for the return of daily frequency for all four capital markets. The Ho of this test is that there is no serial correlation. The Obs*R-squared probability value is higher than a significant value (0.05 or at 95% significance), therefore we accept our Ho and conclude that there is no serial correlation in returns series of all three capital markets, except BSD where probability value is almost 0.05, which means in BSE there is serial correlation at 95% confidence level but not at 99% significance level.

Table 4a- Serial Correlation Test Results for Daily Data of Four Markets:
Daily Data of BSE Market

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	2.3377	Prob. F(2,734)	0.0973
Obs*R-squared	4.6711	Prob. Chi-Square(2)	0.0968

Daily Data of CSE Market

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.4662	Prob. F(2,704)	0.6276
Obs*R-squared	0.9364	Prob. Chi-Square(2)	0.6261

Daily Data of DSE Market

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	3.0010	Prob. F(2,679)	0.0504
Obs*R-squared	5.9847	Prob. Chi-Square(2)	0.0502

Daily Data of KSE Market

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.8434	Prob. F(2,734)	0.4307
Obs*R-squared	1.6921	Prob. Chi-Square(2)	0.4291

Table 4b- Serial Correlation Test Results for Daily Data of Four Markets-Pre-COVID:
Daily Data of BSE Market – pre COVID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.5124	Prob. F(2,362)	0.5995
Obs*R-squared	1.0333	Prob. Chi-Square(2)	0.5965

Daily Data of CSE Market – pre COVID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.6521	Prob. F(2,358)	0.5216
Obs*R-squared	1.3140	Prob. Chi-Square(2)	0.5184

Daily Data of DSE Market – pre COVID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	3.7733	Prob. F(2,354)	0.0239
Obs*R-squared	7.4725	Prob. Chi-Square(2)	0.0238

Daily Data of KSE Market – pre COVID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	1.0685	Prob. F(2,366)	0.3446
Obs*R-squared	2.1477	Prob. Chi-Square(2)	0.3417

Table 4c - Serial Correlation Test Results for Daily Data of Four Markets-Post-COVID:
Daily Data of BSE Market – during COCID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	1.5752	Prob. F(2,73)	0.2139
Obs*R-squared	3.1856	Prob. Chi-Square(2)	0.2034

Daily Data of CSE Market – during COCID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.3962	Prob. F(2,68)	0.6744
Obs*R-squared	0.8294	Prob. Chi-Square(2)	0.6605

Daily Data of DSE Market – during COCID period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.9301	Prob. F(2,69)	0.3994
Obs*R-squared	1.9163	Prob. Chi-Square(2)	0.3836

Daily Data of KSE Market – post COCID19 period

Breusch-Godfrey Serial Correlation LM Test:			
Ho: no serial correlation			
F-statistic	0.2874	Prob. F(2,73)	0.7511
Obs*R-squared	0.6015	Prob. Chi-Square(2)	0.7403

Structural Stability Test Results:

CUSUM and CUSUM Square test analyzes the stability of a model used to analyze stock market indices in four South Asian capital markets (BSE - India, CSE - Sri Lanka, DSE - Bangladesh, KSE - Pakistan) across three time periods: complete data set (Figure 2a), pre-COVID (Figure 3a), and during-COVID (Figure 4a). This test identifies the potential changes in between the actual data and predictions by the mode.

Figures 2a, 3a and 4a all show that line of CUSUM is lying between 5 % significance level, so the model is said to be stable by using CUSUM test for all the four capital markets.

Figure 2a. Structural stability test (CUSUM Test) for the stock index BSE, CSE, DSE & KSE, for the period of 01-08-2018 to 30-07-2021.

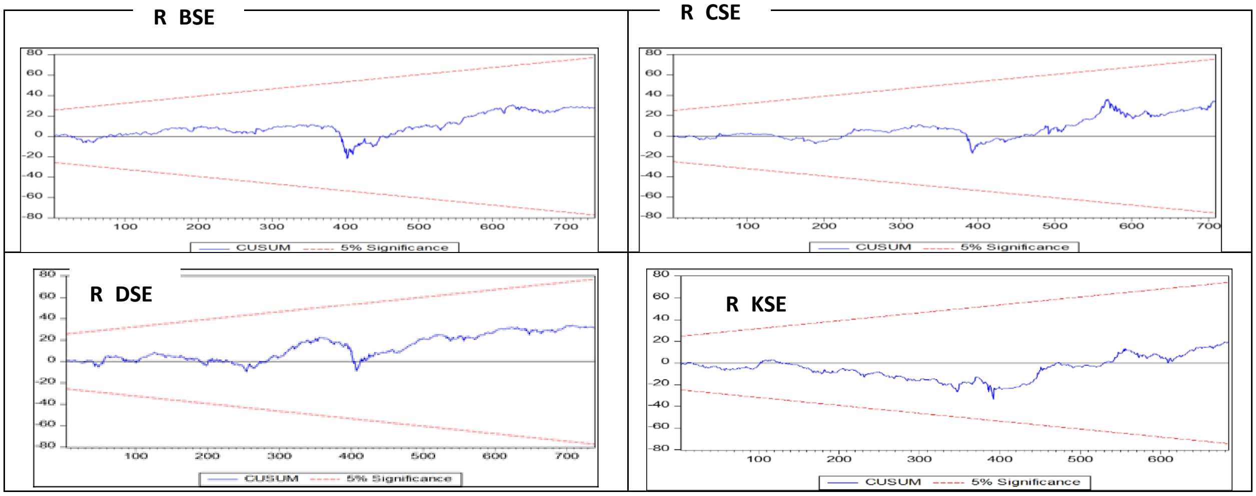


Figure3a. Structural stability test (CUSUM Test) for the stock index BSE, CSE, DSE & KSE, for the pre-COVID period 01-08-2018 to 31-01-2020

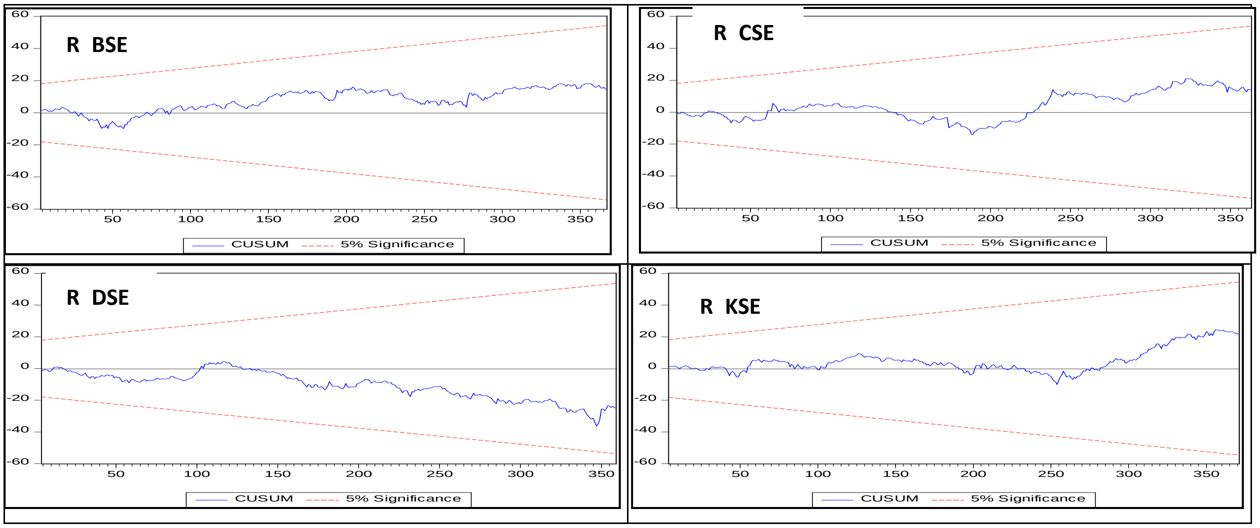
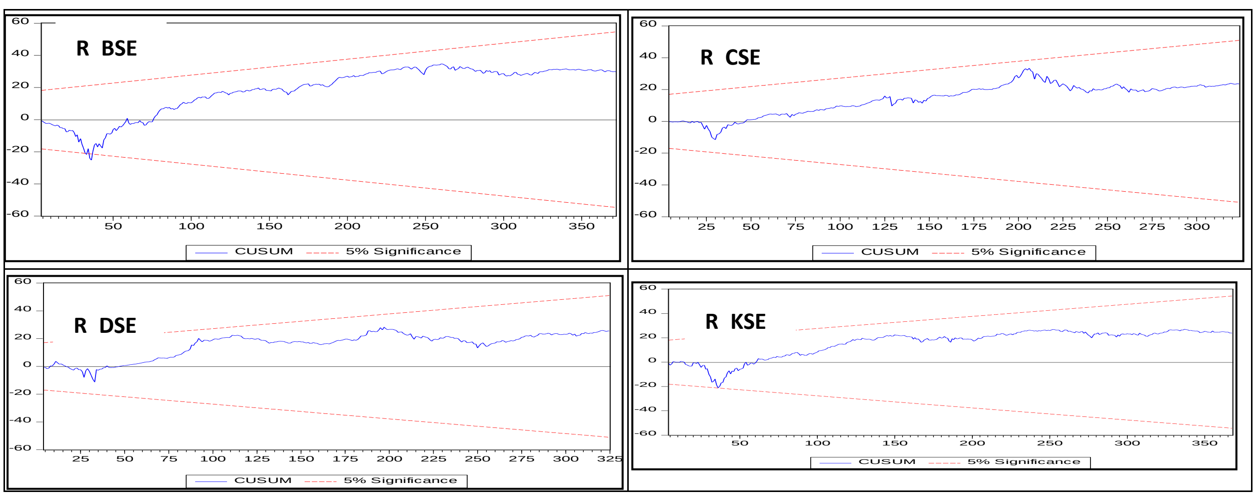


Figure 4a. Structural stability test (CUSUM Test) for the stock index BSE, CSE, DSE & KSE, during-COVID period 01-02-2020 to 31-07-2021



Structural stability test – CUSUM Square Test

CUSUM Square test is used to examine the stability of the model. It provides a more sensitive measure of potential instabilities in the model by focusing on the squared deviations from the expected values. Figures 2b, 3b and 4b provides the CUSUM Square test results of the three stock markets BSE, CSE, DSE and KSE across three time periods: complete data set, pre-COVID, and during-COVID.

Unlike CUSUM test explained in figures 2a, 3a and 4a, the CUSUM squared tests highlights the potential instability in the parameters of the model parameters for stock markets across all three periods: Figure 2b suggest the period of instability for BSE, CSE, and DSE during the complete period. with the exception of KSE as the CUSUM Square line is almost lie between the 5%

significance level so overall we can say that this model is only stable for majority of study period in Pakistani capital market. Figure 3b shows that in the pre-COVID time, all stock markets except DSE remained unstable. While during COVID-19 only CSE showed stability while all rest of the markets remained unstable, reflecting the impact of COVID-19. It can be said that CSE relatively remained stable across all periods suggesting that the model might have captured the dynamics of this market more effectively.

Figure 2b. Structural stability test (CUSUM Square Test) for the stock index BSE, CSE, SE & KSE, for the period of 01-08-2018 to 30-07-2021.

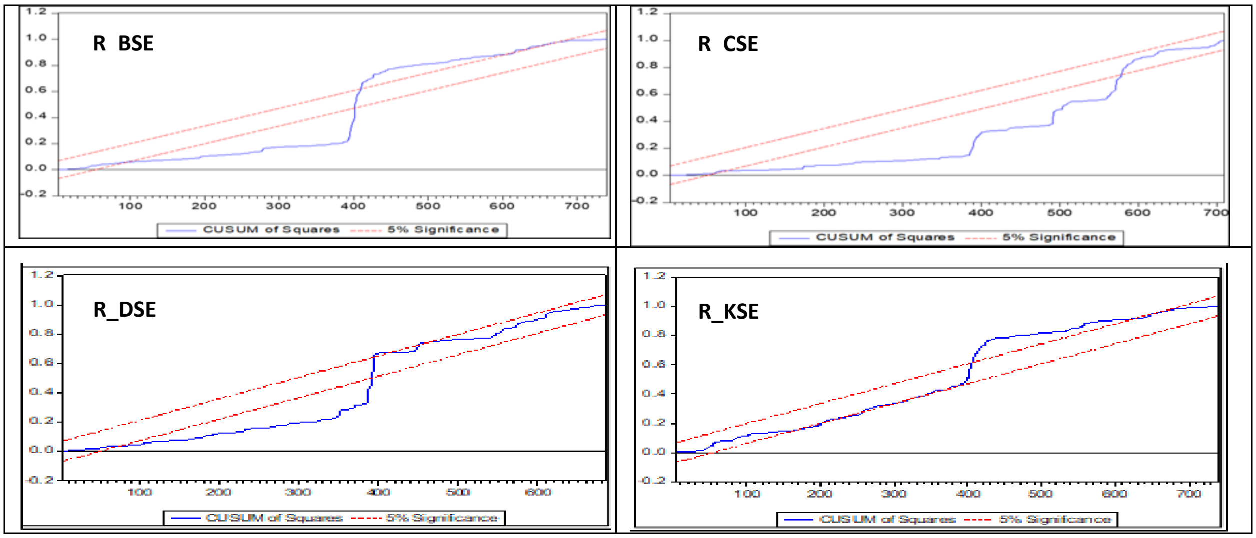


Figure3b. Structural stability test (CUSUM Squared Test) for the stock index BSE, CSE, DSE & KSE, for the pre-COVID period 01-08-2018 to 31-01-2020.

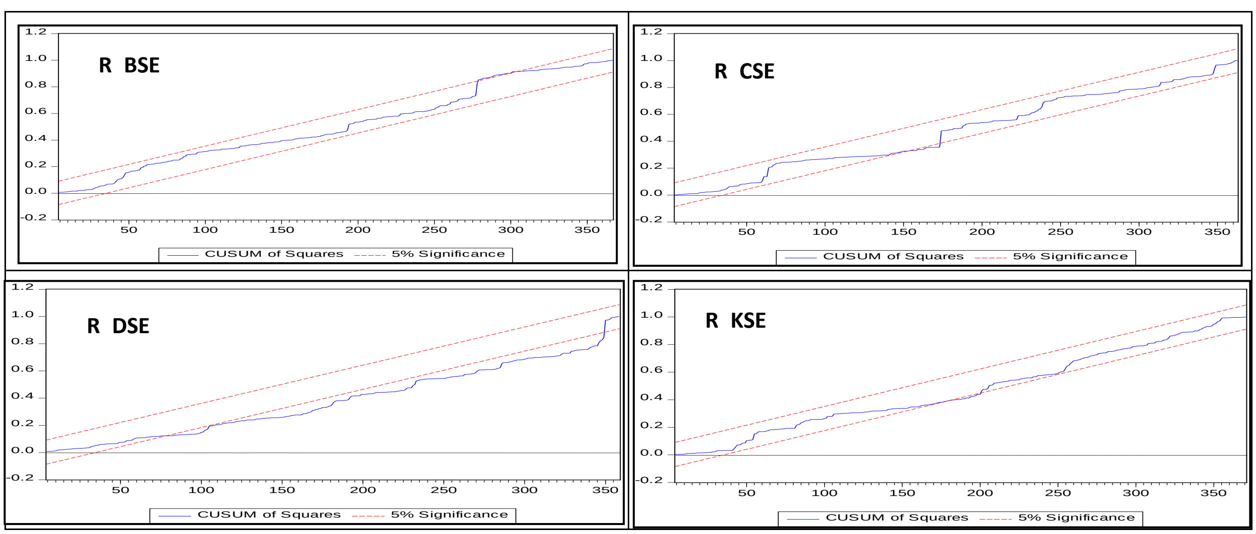
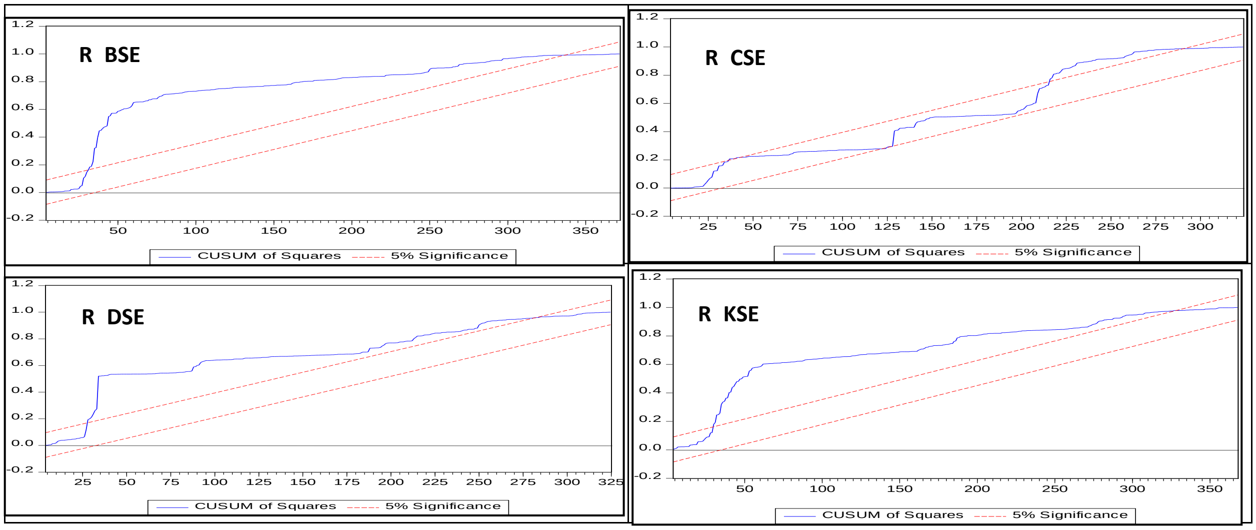


Figure 4b. Structural stability test (CUSUM Squared Test) for the stock index BSE, CSE, DSE & KSE, during-COVID period 01-02-2020 to 31-07-2021.



CONCLUSION:

The main results outline concludes that there is a major decline in all of the capital markets during March, April, May, and June 2020, during the major challenging time of the globally outbreak of COVID-19. It could be related to the uncertainty and pessimism of investors during the pandemic. The descriptive statistics analysis permits us to validate that the rate of return on daily basis of all the stock markets have positive average. The result shows that BSE has the highest standard deviation among all, for returns, the characteristics of asymmetry (skewness) are negative, with exception to the Bangladesh stock market (DSE). Moreover, the normality hypothesis of Jarque-Bera test is rejected (Ho) at a significance level of 1% for all four capital markets. The result from unit root tests both ADF & PP tells us that, the return series of indexes with intercept and with intercept & trend are stationary at levels.

Consistent with Nisar and Hanif (2012), Mehla and Goyal (2012), Caporale et al., (2020), Dias et al., (2020) and Miloş et al., (2020), the analysis shows that all capital markets under study are weak form inefficient and do not follow the assumption of random walk. Our results are consistent with the results of Waheed et al., (2020), showing that stock exchange of Pakistan, gained a significantly positive returns.

The statistical result of rank variance ratio test explains that the hypothesis of RW is not accepted in the Indian capital market. Thus, the (Ho) is not accepted as well because the probability-value is lower than 0.05, hence all markets are weak form efficient for three daily data sets (complete, before & after COVID. The results from Breusch-Godfrey serial correlation LM test explain that there is no evidence of existence of serial correlation in all four capital markets for complete, before and after COVID outbreak. As far as stability is concern all four markets the AR(1) model is stable when tested from CUSUM test, but generally not stable when tested from CUSUM Square test. In the end all four hypotheses of testing weak form of efficiency hypothesis are accepted by using rank-variance ratio test. These conclusions help the regulators of markets and investors to take steps to make certain information in these economies, subsequently returns of some stocks can be predictable and generating opportunities for abnormal earnings and for arbitrage.

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