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Testing of Market Efficiency of BSE GREENEX: An Empirical Analysis

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Abstract

According to the United Nations Principle for Responsible Investment, an investment in a non-ESG compliance company has 28% higher risk per annum as compared to an ESG compliance company. Such company has a positive relationship with the financial performance and the investors cannot outperform these stocks as the information about sustainability compliance is readily available in the market. This concept is of the Efficient Market Hypothesis. Employing a quantitative research design, this study considered 17 companies of BSE Green Index that has considerable ESG scores and extracted their daily, weekly and monthly data to examine and understand its stock return movement and to test whether it follows the Efficient Market Hypothesis. This study makes use of the various statistical tools such as the Run Test, Auto-correlation Function and the Unit Root Test. Summarising the results of run test, Auto-correlation Function and two-unit root test i.e., Augmented Dickey Fuller test and Philips-Perron, it statistically confirmed the findings that the daily, weekly and monthly stock return series of the 17 stocks of BSE Green Index do not obey the 'Random Walk Hypothesis' which is the key findings of the study and hence rejects all the three hypotheses of the study. Backing the empirical findings of this study, it would be rational to state that the concept of the Efficient Market Hypothesis does not hold good in the BSE Green Index of the Indian Stock Market and this finding would be very imperative to the investors concerned about their investment decisions with regard to sustainability practices.

Keywords: BSE-GREENEX, Efficient Market Hypothesis, ESG Scores, Indian Stock Market, Random Walk Model
JEL Codes: G10, G14

1. Introduction

The efficiency of capital market is an imperious concept to understand the operations of financial market. It presents the discussion on the operation and functioning of capital market especially the process of fundamental price generation (Arora, 2013). The capital market, where the investors fascinatingly pursue risk to earn higher profits (Potocki and Swist, 2015) gather as many as relevant resources regarding the price and return of respective stocks and use the same resources to predict its future movement (Dash, 2020). As such, the Efficient Market Hypothesis (EMH) simply states that it is impossible for the investors to outperform the capital market and this hypothesis was pioneered by Eugene Fama in 1970 as the 'theory of market efficiency'. Eugene Fama had discussed the theory of market efficiency but it was Bachelier (1990) who came up with the intrinsic concept of EMH that the stock price movement are independent, unrelated and unpredictable. The rationale behind EMH is that all the available information of the market is already reflected in the stock prices (Nelmida, 2020). In this particular kind of market, investors make the use of available market information to assess the past movement of a stock and can describe its current movement based on such past information and also predict its future movement (Bustanji, 2020).

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At present, where the world is heading towards the achievement of sustainability goals and sustainable development, the business and corporate houses have become more concerned about its sustainability practices and have started to focus towards the adoption of ESG principles (Raja, 2018). It is a corporate strategy that focuses on the three pillars of environment, social and governance (Kadam, 2019). But why ESG counts? The functioning of an organisation which is measured in the financial figures impacts its sustainability and of its society as well. So, it is inevitable that the sustainability, responsibility and ethical practices are evaluated in a similar fashion of its financial performance (Rahul, 2016).

According to the United Nations Principle for Responsible Investment (PRI), an investment in a non-ESG company has 28% higher risk per annum as compared to the investment made in company that has ESG principles compliance. So, a company following the ESG principles is believed to have a positive relationship with its financial performance while a company having no ESG compliance exhibit significant fall of the stock returns in short term. (CRISIL, 2021). This means that the available market information will be reflected in the stock prices as the company under the ESG compliance will have a positive relationship with the financial performance and the investors cannot outperform these stocks as the information about ESG compliance is readily available in the market. This concept is of EMH which states that all the available information of the market is already reflected in the stock prices and investors makes use of available market information to assess the past movement of a stock and can describe its current movement based on such past information and also predicts its future movement (Han *et al.*, 2019).

The EMH is a keystone in the financial theory which remains highly debated and a disputed topic as it advocates that the market listed stocks trade at their fair value on the stock market which makes it difficult for the investors to beat the market by purchasing an undervalued stock or by selling the stocks at a very high inflated price (Song *et al.,* 2021). Considering the ESG based investing, if EMH holds good in those stock prices that has a considerable ESG scores as reported by CRISIL ESG compendium 2021, one cannot outperform these stocks using expertise portfolio management nor through market timing. This is the rationale of the study.

The CRISIL ESG compendium 2021 has the ESG scores for 225 companies from different sectors and verification of the Efficient Market Hypothesis of each stock movement does not fall under the scope of this study. So, the study uses the companies listed in BSE Green Index (BSE-GREENEX) from different sectors and industry which has a considerable ESG score on CRISIL ESG compendium 2021 because the BSE Green Index primarily works within the framework of ESG investing incorporating other rapports like sustainability development goals, sustainable finance, green finance etc. (Sharma, 2022). Whenever the discussion on ESG investing is put forward, the Green Index inevitably enters the scenario because the investors are aware about its related concepts such as green transition, green policies, green parties which are the footings of Green Index developed by BSE. The study on the performance of index which is developed on its sustainability practices like BSE-GREENEX, BSE Carbonex etc., has been an emerging area of interest for many researchers. So, a need is felt for conducting an empirical study of the index based on sustainability practices of the Indian capital market i.e., BSE-Green Index (BSE-GREENEX). Thus, this study will verify whether the stock prices of the companies listed in BSE Green Index (BSE-GREENEX) having a considerable ESG scores follow EMH as such the objective of the study are –

- To examine and understand the daily, weekly and monthly stock return movement of BSE Green Index.
- To test whether the daily, weekly and monthly stock return of BSE Green Index exhibit weak form of efficiency.

2. Literature Review

The Efficient Market Hypothesis (EMH) still remains the disputed and debatable topic as several studies has presented mixed results due to timing difference and indices differences. Sufficient amount of literature has been reviewed for this study which has been discussed below.

In an attempt to test the weak form efficiency using the daily data of Indian Stock Exchanges i.e., the National Stock Exchange and the Bombay Stock Exchanges for a period of last 5 years (1999-2004), Khan (2006) rejected the random walk hypothesis for both the Indian Stock Exchanges and found a negative auto-correlation in the daily data and an increasing deviation from normality with time. In the same year, Raj and Kumari (2006) attempted to study the existence of seasonal effect i.e., the January effect and the Monday effect and found that both the effects were not prevalent in Indian stock market but the study concluded that the market operates in the weak form of the EMH. Both the study i.e., Khan (2006) and Raj and Kumari (2006) contradict each other on the efficiency of the Indian stock market.

Using the daily and weekly closing data of the three stock indices i.e., CNX Defty, CNX Nifty and CNX Nifty Junior, Pandey (2003) made an attempt to investigate the efficiency of Indian stock market. Employing the run test and Auto-correlation Function (ACF) on the data of 6 years ranging from January, 1996 to June 2002. This study could not confirm the random walk hypothesis in the Indian Stock Market. Poshakwale (1996) using the daily Bombay Stock Exchange Index data for a period of 1987-944 also reported about the stock market of Indian exhibit market inefficiency. The very recent study by Sarkar (2019) attempted to test the weak form market efficiency of both the Bombay Stock Exchange and National Stock Exchange. For testing the weak form of market, the author used the Run Test, Auto-correlation Function (ACF), Kolmogorov-Smirnov Normality test and concluded the study stating that the Indian Stock Exchange is not efficient, not even in its weak form as their share prices do not reflect its available information in the market. The study further stated that the Indian Stock market provides a platform for the investors to earn abnormal profits by making the correct use of the past information. Ramkumar *et al.* (2014) had also arrived at the similar results. They incorporated five indices form Bombay Stock Exchange and five from National Stock Exchange. Using several analytical tools such as descriptive statistics, run-tests, auto-correlation, etc., the authors analysed the data of four years i.e., from April 2009 to March 2014 and concluded with the findings that neither of the five indices of the both Bombay Stock Exchange and National Stock Exchange were not weak form efficient. Mishra *et al.* (2009) implemented a very popular test to verify the Efficient Market Hypothesis on Bombay Stock Exchange and National Stock Exchange, which are the two major stock exchanges in India. They used two-unit root test *viz.,* the Phillips-Perron (PP) test and then the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root test and the findings of this study showed that the series were stationary having no unit root. This evidence supported the existing literature that the Indian stock market do not follow the random walk hypothesis and are not efficient even in its weak form. There are several other studies too that support the theory of Indian stock market being inefficient in its weak form like Hassan (2013) and Bisen and Pandey (2015) and others which signals the investors about the possibility of exploiting the loopholes of the market and extract abnormal profits through prediction of future movement of stock prices.

It is also noted that the literature on EMH provides mixed results as some study provide evidences that the Indian stock market do exhibit the random walk model and supports the Efficient Market Hypothesis. The study of Sharma and Kennedy (1977) was an interesting comparative study where they made a behavioural comparison between the leading indices of Bombay, London and New York for the data of 10 years (1963-73). They used the run test and the spectral analysis and the result of these tests confirmed that the securities listed in the Bombay Stock Exchange exhibit random walk and are weak-form efficient. Dhankar (1991) also used the run test with the serial correlation test to empirically test the random walk hypothesis in Indian stock market and confirmed the existence of random walk of share prices and concluded the study stating that the Indian stock market exhibit weak from of market efficiency. Again, using the run test and

Auto-correlation Function (ACF), Chavannavar and Patel (2016) examined the Nifty 20 Index and Nifty 50 stocks to examine weak form and semi strong form of market efficiency in the Indian Stock Market. This study reported that the movement of stock prices in Indian Stock Exchange are independent and there is no scope to predict the future prices of shares using its past information on its performance. A recent study by Kumar *et al.* (2020) in a similar attempt considered the 10 pharma stocks that had more than 20% of foreign investments (Biocon Limited, Cadila Healthcare, Cipla Limited, Dr. Reddy's Laboratories, Glaxo Smith Kline Global Corporate, Glenmark Pharma, Lupin Limited, Merck Limited, Pfizer Limited, Sun Pharmaceutical Industry). They conducted the run test and confirmed the existence of weak form of market efficiency in these pharma stocks but they conducted the study stating that the index returns were under the influence of insiders trading. Similarly, Zafar (2012); Patrick and Sushama (2011) and several other studies confirmed that the Indian stock market exhibits the weak form of market efficiency.

The existing literature of EMH has provided mixed results for the Indian stock market and this is because the studies were based on different time periods and for different stock indices of different sectors and industries. It is also understood that the literature on the EMH of several stock indices is available abundantly, but when it comes to green index or ESG investing - the literature is at the infant stage considering the fact the sustainable investment impacts the financial market. Past literature has analysed the performance of listed stocks in different indexes but this study will be exclusive in its own kind as it considers the performance analysis of BSE-GREENEX which assess its listed stocks on its sustainability practices like carbon performance etc. In this present era of ESG investing where the business and corporate houses have to concern about its sustainability practices, the current study explores this research gap by investigating the relationship between sustainability and the stock market by testing the EMH of the BSE Green Index (BSE GREENEX) that has considerable ESG scores reported in CRISIL ESG compendium 2021.

3. Research Hypothesis

In light of the literature and objective of the study, this study will test the following three hypothesis -

H1: The daily stock return is efficient in its weak form,

H2: The weekly stock return is efficient in its weak form,

H3: The monthly stock return is efficient in its weak form.

4. Data and Methodology

Employing a quantitative research design to empirically test the EMH of BSE Green Index, this study considered 17 companies out of the 20 companies of BSE Green Index having a considerable ESG scores as per CRISIL ESG compendium 2021 (see Table 1). The basis of selection of 17 companies is the mean ESG scores. These 17 companies have ESG scores on or above the mean ESG scores of 44 and the companies listed in BSE Green Index with ESG scores on or above mean score of 44 make a total of 17 companies. The study then extracted their daily, weekly and monthly closing prices from the index of BSE for a period of 5 years starting from 01/01/2015 to 31/12/2019 as the study wanted to analyse the very recent data available on the performance of indices but did not want to include the COVID-19 pandemic period in India. So, the study found it sensible to take the data for 5 years starting from 01/01/2015 till 31/12/2019 which would clearly exclude the COVID-19 pandemic period in India.

The daily, weekly and monthly return is calculated as follows-

$$R_t = \text{Log}\,(P_t / P_{t-1}) \quad \ldots\ldots (1)$$

where R_t is the stock return at time 't', Ptis the closing stock price at time 't' and P_{t-1} is the closing stock price at time 't-1'.

Table 1. Companies of BSE Green Index and their respective ESG scores

Company	Series Name	Sector	ESG Score
Bajaj Finance Ltd.	Fina	Financial	66
Bajaj Finserv Ltd.	Fins	Financial	65
Cipla Ltd.	Cipla	Pharma	62
Dr. Reddy's Laboratories Ltd.	Red	Pharma	63
HDFC. Ltd.	Hdf	Financial	72
Hindustan Unilever Ltd.	Hul	FMCG	63
ICICI Bank Ltd.	Ici	Financial	70
Info Edge (India) Ltd.	Info	Internet	63
Larsen & Toubro Ltd.	Lt	Capital Goods	67
Mahindra & Mahindra Ltd.	Mm	Auto OEM	68
Tata Motors Ltd.	Tata	Auto OEM	62
Bharat Electronics Ltd.	Bel	Capital Goods	51
Sun Pharmaceutical Industries Ltd.	Sunpha	Pharma	44
Hindalco Industries Ltd.	Hindal	Metals	60
Pidilite Industries Ltd.	Pidilite	FMCG	59
Maruti Suzuki India Ltd.	Maruti	Auto OEM	60
Power Grid Corporation of India Ltd.	Powerg	Power	60

Source: CRISIL ESG Compendium 2021.

Using the stock returns data, the following tests were used to test the weak form of market efficiency or to test the Efficient Market Hypothesis:

Kolmogorov-Smirnov Goodness of Fit Test is a non-parametric test statistic to verify whether the stock return conforms to any defined theoretical distribution. Using this test, we check the randomly selected daily, weekly and monthly stock return following the normal distribution or not. The Kolmogorov-Smirnov Goodness of Fit Test verifies the null hypothesis that the series conforms to normal distribution and the conclusion can be drawn based on the computed probability value (p-value) where the p-value higher than 0.05 implies the acceptance of null hypothesis that the series is normally distributed.

Auto-correlation Function (ACF) remains one of the most widely used parametric test for testing the EMH. It is a test to check the relationship between the stock return at time 't' with the stock return from the same stock at time 't-1' i.e., the relation between return of

Table 2. Test of normality

Series	Daily Return		Weekly Return		Monthly Return	
	Kolmogorov-Smirnova		Kolmogorov-Smirnova		Kolmogorov-Smirnova	
	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.
Fina	.070	.000	.069	.005	.099	.200
Fins	.061	.000	.054	.067	.059	.200
Cipla	.058	.000	.066	.008	.074	.200
Red	.068	.000	.090	.000	.101	.200
HDF	.436	.000	.136	.000	.174	.000
HUL	.050	.000	.041	.200	.066	.200
ICI	.064	.000	.069	.004	.086	.200
Info	.068	.000	.061	.021	.062	.200
Lt	.066	.000	.066	.007	.065	.200
Mm	.042	.000	.069	.005	.082	.200
Tata	.060	.000	.063	.015	.085	.200
Bel	.055	.000	.064	.011	.066	.200
Sunpha	.059	.000	.104	.000	.061	.200
Hindal	.033	.004	.041	.200	.062	.200
Pidilite	.068	.000	.074	.001	.077	.200
Maruti	.062	.000	.078	.001	.106	.092
Powerg	.037	.001	.065	.009	.067	.200
Liliefors Significance Correction.						

Source: Author(s)

current period and return from immediate previous period. The ACF portrays the pattern of auto-correlation in the random series and also the degree to which the series is related with its lag figure and shows whether the auto-correlation differs from zero significantly. For the EMH, the null hypothesis of zero auto-correlation exists. The Ljung-Box Q-statistic (Q-stats) also test the EMH null hypothesis that the auto-correlation (ρ_k) are zero (ρ_k=0) for all the levels of computed lags.

Run Test is a non-parametric test or a distribution free test which does not require the data to be normally distributed nor demands homogeneity of the data in the series. It is one of the mostly used tests in the EMH. The Run Test is for the testing the null hypothesis of series being a random variable or the movement of stock returns being random which would confirm the random walk movement of the series under study. The decision can be made on the basis of probability value or p-value (sig.) and if such value is higher than 0.05 i.e., at 5% level of significance, the null is accepted to state that the stock return movement is random in nature in the period under consideration.

Unit Root Test is used to check whether the time series i.e., the stock return in this study are whether stationary or non-stationary. This study uses the Augmented Dickey-Fuller test (ADF test) and the Phillips-Perron (PP) test to check the stationarity of the time series. The existence of unit root in the time series forms the null hypothesis of both the unit root test (i.e., the ADF test and PP test) and the EMH demands the series to be non-stationary or the series to be a random walk.

5. Results and Discussion

At prior, the normality of the series is checked using the Kolmogorov-Smirnov Goodness of Fit Test for testing the null hypothesis of the series conforming to normal distribution. The series under the study are daily, weekly and monthly stock returns for a period of 5 years starting from 01/01/2015 to 31/12/2019. The

Table 3. Run Test

Series	Daily Return			Weekly Return			Monthly Return		
	No. of Runs	Z	Sig.	No. of Runs	Z	Sig.	No. of Runs	Z	Sig.
Fina	18	-34.09	0.000	4	-15.81	.000	6	-6.56	.000
Fins	8	-34.67	0.000	6	-15.56	.000	4	-7.09	.000
Ipla	50	-32.27	0.000	20	-13.82	.000	12	-5.01	.000
Red	19	-34.03	0.000	9	-15.18	.000	5	-6.84	.000
Hdf	2	-24.76	0.000	4	-15.81	.000	2	-7.55	.000
Hul	10	-34.55	0.000	4	-15.81	.000	2	-7.61	.000
Ici	27	-33.52	0.000	11	14.88	.000	7	-6.17	.000
Info	34	-33.07	0.000	12	-14.73	.000	6	-6.52	.000
Lt	30	-33.41	0.000	18	-14.07	.000	6	-6.58	.000
Mm	51	.32.120	0.000	27	-12.85	.000	13	-4.58	.000
Tata	16	-34.19	0.000	8	-15.30	.000	6	-6.56	.000
Bel	33	-32.99	0.000	11	-14.77	.000	7	-6.068	.000
Sunpha	22	-33.86	0.000	10	-15.06	.000	6	-6.489	.000
Hindal	12	-34.42	0.000	6	-15.54	.000	2	-7.547	.000
Pidilite	6	-34.77	0.000	2	-16.06	.000	2	-7.548	.000
Maruti	14	-34.33	0.000	8	-15.31	.000	4	-7.030	.000
powerg	14	-34.27	0.000	6	-15.51	.000	6	-6.419	.000
Test Value = Mean.									

Source: Author(s)

result of the test of normality has been presented in Table 2 below:

The result of Kolmogorov-Smirnov Goodness of Fit Test shows that the daily stock return series are not normally distributed as the null hypothesis is rejected for all series at 5% level but the monthly stock return series are normally distributed as the null hypothesis is accepted at 5% level of significance. In the weekly return series, the series of Fins, Hul and Hindal are normally distributed and the remaining other series in the weekly return are not normally distributed.

Since the data set has both normally distributed as well as not-normally distributed series, the study uses run test as a distribution free test and Auto-correlation Test as a parametric test to verify whether the series follows the EMH. The result of run test to test the randomness of stock return movement has been presented in Table 3 below:

The null hypothesis of the run test is that the movement of the data in the series i.e., stock return in our case is random and the result of the run test in the above Table 3 clearly depicts that the null hypothesis is rejected for all the series in daily, weekly and monthly stock returns. This provides the evidence that the movement of stock return is not random and does not follow the random walk model.

The study then presents the result of Auto-correlation Function (ACF) and the Ljung-Box Q-statistics in Table 4 and Table 5 respectively.

Result of Daily Series: The Ljung-Box Q-statistic which tests the null hypothesis that all ρ_k's are zero ($\rho_k = 0$) was computed for a total of 16 lags where the series of fina, fins, hdf, ici, lt, cipla, hul, tatas, bel, sunpha, hindal and maruti is insignificant at 5% level for all the levels of lag but the series of 'red' is insignificant from lag 4 to lag 15, series of 'info' is insignificant up to lag 2 and series of 'mm' is insignificant up to lag 14, 'pidilite' is insignificant in all with exception in lag 7, 8, 9, 11 and 15, 'powerg' is insignificant except in lag 3, 4, 5 and 6.

So, the value of ρ_k (auto-correlation) at various lags of all the series hovers around zero (Bhaumik, 2015) which resembles a stationary process (Gujurati, 2004). Thus, the findings through the Auto-correlation

Table 4. Auto-correlation Function (ACF)

	fina			Fins			cipla		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	-.001	.000	.007	.029	-.036	-.002	-.056**	-.034	-.223
2	.003	-.024	-.258**	-.010	.051	-.232	-.015	.004	.162
3	-.016	-.100	-.033	.009	-.001	.018	-.018	-.066	-.229
4	-.033	.081	-.142	-.018	.088	-.129	.021	-.024	.011
5	.023	.011	-.052	-.031	.067	-.139	-.005	-.056	-.214
6	-.056**	.102	-.014	-.049	.012	.063	.014	-.004	.098
7	-.008	.023	-.096	-.004	-.043	-.081	.001	.019	-.198
8	-.008	-.120	-.109	.010	-.138**	-.073	-.051	.005	.141
9	.021	-.100	-.057	.039	.002	.179	-.003	.011	.080
10	.040	.013	.183	.027	-.137	.134	.031	.053	.152
11	-.020	-.060	.091	.003	-.016	-.044	.031	.073	-.126
12	-.043	-.001	-.045	-.004	.004	.049	-.016	-.051	.053
13	.031	-.096	.168	-.007	-.075	.014	.021	-.124**	-.118
14	-.059**	-.042	.082	-.034	.082	-.170	-.053	-.079	-.058
15	-.029	-.033	-.015	-.025	-.135**	-.024	-.020	.059	.025
16	.019	-.014	.031	.081*	-.058	.102	.014	-.092	.019

	red			Hdf			hul		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	.080*	-.028	-.178	.000	-.022	-.129	-.035	.026	.038
2	.023	-.049	.103	.002	-.122**	-.200	-.014	-.068	-.170
3	-.003	-.016	-.047	.000	-.020	-.061	-.003	-.077	-.129
4	-.019	-.111	-.082	-.001	-.057	-.137	.064**	.050	.062
5	.000	-.061	.033	.000	.022	.125	-.025	.000	.136
6	-.016	-.003	-.112	-.001	.054	-.001	-.019	.054	.046
7	-.011	-.011	-.049	-.002	-.098	.092	.007	.000	-.094
8	-.037	-.088	.136	.000	-.052	-.077	-.005	-.003	-.109
9	-.018	.039	-.064	.003	-.018	-.037	-.031	-.088	-.041
10	.018	.011	-.032	.001	.058	.063	-.022	-.103	-.047
11	.065**	.100	-.077	.002	.017	-.135	.011	.072	.134
12	-.047	.014	.041	.000	-.054	.091	-.023	.046	-.019
13	.018	-.043	.094	.001	-.026	-.002	.004	-.073	.018
14	-.048	.008	.010	-.001	-.052	-.113	-.005	-.044	.080
15	-.024	-.025	.068	.003	-.101	.055	-.018	-.046	.000
16	-.076*	-.029	.059	-.004	.033	.057	.025	-.024	-.100

	ici			Info			It		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	.018	-.122**	-.115	.020	-.202*	-.157	.019	.004	.113
2	-.007	.011	-.082	-.041	-.003	-.163	-.048	.034	-.247**
3	-.005	-.108	.114	-.10*	-.054	.035	.018	-.059	.072
4	-.059**	.044	-.116	-.06**	-.041	-.050	-.022	-.012	.025
5	-.054	-.123**	.014	-.020	.064	-.032	-.010	.046	-.138
6	-.022	.071	.122	-.030	.020	.186	-.015	.065	-.061
7	.014	-.043	.153	-.014	-.080	-.089	.017	-.097	-.109
8	-.023	-.052	-.058	.017	.076	.047	.004	-.111	-.217
9	.010	-.057	.014	-.005	-.076	.045	.023	.004	.043
10	.028	.065	.006	-.039	-.087	-.050	-.017	.001	.256**
11	-.012	.017	.044	.015	.008	.103	.008	-.009	.026
12	-.003	.104	.053	.028	-.083	-.030	-.013	.068	-.110
13	-.017	-.035	-.204	-.010	.030	-.053	.011	-.065	.007
14	-.039	.071	.094	.000	.056	.150	-.055	.114	.034
15	-.042	-.027	.077	-.045	.004	.098	.013	-.060	-.168
16	.030	.052	-.080	-.016	.018	-.177	-.004	.130	.051

	mm			Tata			bel		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	-.038	.009	-.030	.009	.087	-.003	.032	.025	-.239
2	.006	-.076	-.173	-.014	.066	.008	-.046	.040	-.025

3	-.008	-.090	-.021	.021	-.133**	-.182	-.034	-.069	.126
4	.020	-.009	.158	-.025	-.074	-.043	.033	-.062	-.019
5	-.027	.041	-.049	-.045	.019	-.007	-.013	-.147*	.241
6	.000	.027	-.043	.070**	.088	.049	-.020	-.045	-.094
7	.036	.025	.078	.033	.121**	-.065	.060**	-.030	.005
8	-.020	-.039	-.161	-.040	-.113	-.004	-.001	.002	-.034
9	-.024	-.185*	-.025	.051	.023	.229	-.004	-.101	-.115
10	.022	.090	.185	-.009	-.031	.048	.046	.153**	.147
11	.000	-.013	.023	.014	.017	-.122	.015	.019	-.070
12	-.066**	.066	-.178	.001	.011	-.166	-.018	.148	-.105
13	-.089*	-.019	.020	.006	-.038	-.188	-.026	-.003	-.124
14	.032	-.088	.008	-.066**	-.054	.148	-.035	.061	-.065
15	-.043	-.032	-.105	.012	.026	.032	.030	-.176*	-.031
16	.038	.127**	-.108	-.004	.061	.048	-.052	.033	.063

	sunpha			Hindal			pidilite		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	.032	-.010	-.150	-.033	-.009	-.110	.041	-.084	-.110
2	-.012	-.072	-.055	-.015	.059	.206	-.027	.051	-.312**
3	-.031	-.039	-.177	.020	-.086	.138	-.010	-.011	.089
4	.010	-.078	-.013	.033	-.054	-.014	-.041	-.054	.152
5	-.001	-.031	-.095	-.031	.005	.284**	.005	-.053	-.180
6	-.003	.121**	-.043	-.028	-.043	-.003	-.066**	-.042	-.156
7	-.017	-.037	.143	.025	.094	-.099	-.054	-.047	-.055
8	.035	-.059	-.042	-.024	-.045	.167	.042	-.086	.011
9	-.024	.058	.151	.029	.031	-.186	.029	-.009	.035
10	-.032	-.037	-.060	.013	.027	-.012	.017	-.097	.016
11	-.029	.053	-.073	.023	.064	-.008	-.049	.021	.065
12	.007	-.050	-.023	-.056**	.212*	-.297**	.009	.006	-.004
13	.023	-.122**	-.175	.022	-.078	.204	.014	-.037	.066
14	.004	-.043	.104	-.017	.038	-.220	.000	-.054	-.036
15	-.011	-.084	-.073	-.008	-.039	.000	-.059**	.044	.083
16	-.028	-.071	.028	.026	.139**	.038	.018	.080	-.042

	maruti			Powerg		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	.052	.000	.052	-.049	-.083	-.217
2	-.020	.025	-.175	-.026	-.058	-.084
3	-.007	.019	-.017	-.080*	.074	.072
4	.032	.003	.141	.004	-.123**	.070
5	-.060**	.073	-.076	-.021	.037	-.082
6	-.008	.045	.090	-.022	.014	.063
7	.024	-.002	-.068	-.028	-.100	.097

8	-.027	-.010	-.059	-.006	-.068	-.021
9	.006	-.035	.049	-.009	-.075	-.168
10	.011	-.066	.191	.045	.021	.193
11	.015	-.045	-.004	-.023	.108	-.067
12	-.017	-.112	-.145	.013	-.010	-.095
13	-.002	.160*	-.114	-.012	-.056	.044
14	.020	-.069	.094	.024	.126**	-.043
15	-.010	-.067	-.038	.016	.020	-.087
16	.001	.074	-.017	.006	-.004	.069

Source: Author(s).

Table 5. Ljung-Box Q-Statistics

	fina			Fins			cipla		
	Daily	**Weekly**	**Monthly**	**Daily**	**Weekly**	**Monthly**	**Daily**	**Weekly**	**Monthly**
1	.000	.000	.003	1.053	.337	.000	3.830	.313	3.192
2	.011	.158	4.349	1.174	1.022	3.507	4.127	.316	4.909
3	.344	2.819	4.424	1.284	1.022	3.528	4.543	1.468	8.372**
4	1.718	4.577	5.787	1.677	3.076	4.653	5.073	1.619	8.381
5	2.390	4.607	5.970	2.836	4.274	5.982	5.108	2.456	11.54**
6	6.316	7.409	5.983	5.859	4.314	6.263	5.351	2.461	12.203
7	6.400	7.551	6.639	5.882	4.806	6.728	5.353	2.555	14.98**
8	6.475	11.435	7.494	5.996	9.982	7.117	8.528	2.561	16.43**
9	7.024	14.168	7.735	7.922	9.983	9.490	8.541	2.593	16.902
10	9.055	14.211	10.249	8.849	15.121	10.839	9.695	3.370	18.65**
11	9.536	15.206	10.890	8.862	15.189	10.988	10.862	4.849	19.87**
12	11.822	15.207	11.048	8.880	15.194	11.180	11.168	5.568	20.098
13	13.021	17.736	13.312	8.942	16.750	11.196	11.694	9.850	21.217
14	17.335	18.225	13.867	10.362	18.601	13.572	15.191	11.590	21.490
15	18.349	18.528	13.886	11.140	23.709	13.621	15.676	12.576	21.542
16	18.822	18.580	13.966	19.373	24.641	14.515	15.921	14.963	21.573

	red			Hdf			hul		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	7.934*	.203	2.034	.000	.129	1.056	1.489	.172	.090
2	8.590**	.850	2.719	.003	4.056	3.622	1.727	1.404	1.967
3	8.603**	.922	2.866	.003	4.168	3.862	1.740	2.984	3.076
4	9.031	4.186	3.316	.004	5.041	5.117	6.756	3.662	3.334
5	9.031	5.183	3.389	.005	5.169	6.169	7.542	3.662	4.600
6	9.342	5.186	4.268	.005	5.951	6.169	7.986	4.450	4.747
7	9.499	5.220	4.440	.012	8.538	6.758	8.045	4.450	5.374
8	11.206	7.302	5.777	.012	9.259	7.183	8.078	4.452	6.230
9	11.622	7.712	6.078	.027	9.347	7.284	9.238	6.553	6.352
10	12.044	7.743	6.156	.028	10.274	7.581	9.846	9.438	6.516
11	17.263	10.514	6.610	.032	10.356	8.968	9.997	10.863	7.893
12	20.036	10.572	6.740	.032	11.152	9.615	10.630	11.437	7.922
13	20.457	11.094	7.447	.034	11.342	9.616	10.647	12.928	7.948

14	23.277	11.113	7.455	.036	12.080	10.646	10.684	13.456	8.469
15	24.014	11.293	7.843	.046	14.908	10.894	11.086	14.056	8.469
16	31.27**	11.524	8.136	.063	15.211	11.173	11.877	14.215	9.322

	ici			Info			It		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	.397	3.94**	.854	.482	10.74**	1.574	.437	.004	.818
2	.456	3.980	1.294	2.541	10.74**	3.299	3.265	.306	4.782
3	.481	7.097	2.152	15.127*	11.51**	3.381	3.683	1.235	5.124
4	4.797	7.618	3.057	20.429*	11.96**	3.552	4.264	1.273	5.165
5	8.467	11.6**	3.071	20.910*	13.04**	3.623	4.383	1.834	6.469
6	9.053	13.0**	4.110	21.996*	13.15**	6.045	4.660	2.967	6.732
7	9.312	13.52	5.784	22.233*	14.88**	6.612	5.007	5.524	7.577
8	9.978	14.27	6.029	22.605*	16.45**	6.769	5.027	8.842	11.007
9	10.105	15.15	6.045	22.630*	18.02**	6.921	5.681	8.846	11.146
10	11.078	16.31	6.047	24.475*	20.09**	7.110	6.058	8.846	16.068
11	11.258	16.38	6.198	24.748*	20.11**	7.922	6.140	8.868	16.122
12	11.269	19.35	6.418	25.70**	22.01**	7.991	6.338	10.140	17.072
13	11.613	19.69	9.758	25.82**	22.262	8.213	6.481	11.316	17.076
14	13.516	21.11	10.47	25.82**	23.145	10.061	10.305	14.942	17.171
15	15.729	21.31	10.96	28.33**	23.150	10.856	10.510	15.935	19.522
16	16.846	22.06	11.51	28.64**	23.243	13.538	10.528	20.700	19.745

	mm			Tata			bel		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	1.758	.022	.057	.103	1.977	.001	1.232	.162	3.590
2	1.805	1.557	2.008	.342	3.148	.005	3.822	.581	3.630
3	1.883	3.724**	2.038	.875	7.849	2.196	5.233	1.859	4.659
4	2.356	3.748	3.724	1.620	9.320	2.321	6.591	2.878	4.684
5	3.248	4.192	3.887	4.094	9.420	2.325	6.792	8.699	8.625
6	3.248	4.392	4.015	10.209	11.500	2.493	7.304	9.236	9.230
7	4.867	4.560**	4.452	11.521	15.470	2.790	11.709	9.483	9.231
8	5.359	4.966**	6.325	13.551	18.965	2.791	11.710	9.485	9.314
9	6.089	14.320**	6.372	16.762	19.110	6.675	11.728	12.258	10.273
10	6.684	16.537**	8.959	16.870	19.366	6.850	14.336	18.655	11.882
11	6.684	16.580	9.002	17.123	19.443	8.001	14.628	18.757	12.253
12	12.027	17.784	11.493	17.125	19.479	10.174	15.024	24.819	13.101
13	21.984	17.880	11.526	17.165	19.888	13.001	15.896	24.821	14.319
14	23.266	20.052	11.532	22.549	20.693	14.788	17.451	25.867	14.656
15	25.547**	20.331	12.453	22.737	20.884	14.871	18.548	34.551	14.737
16	27.385**	24.844	13.450	22.753	21.928	15.064	21.963	34.864	15.072

	sunpha			Hindal			pidilite		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	1.268	.027	1.424	1.355	.023	.762	2.092	1.871	.767
2	1.454	1.403	1.617	1.633	.951	3.492	2.981	2.549	7.004**
3	2.643	1.817	3.668	2.146	2.934	4.737	3.115	2.580	7.519
4	2.757	3.442	3.679	3.522	3.727	4.750	5.230	3.361	9.059
5	2.759	3.694	4.284	4.680	3.734	10.211	5.262	4.110	11.262**
6	2.769	7.620	4.409	5.625	4.242	10.211	10.582	4.583	12.939**
7	3.143	7.988	5.844	6.380	6.618	10.904	14.252**	5.171	13.148
8	4.645	8.937	5.969	7.072	7.176	12.891	16.463**	7.155	13.157
9	5.373	9.865	7.634	8.128	7.431	15.418	17.484**	7.176	13.244
10	6.604	10.231	7.902	8.332	7.626	15.429	17.864	9.749	13.263
11	7.675	11.015	8.311	9.009	8.741	15.434	20.837**	9.870	13.583
12	7.743	11.717	8.353	12.935	21.134**	22.262**	20.941	9.879	13.585
13	8.413	15.866	10.782	13.517	22.827**	25.571**	21.185	10.265	13.927
14	8.428	16.381	11.658	13.889	23.238	29.480**	21.185	11.074	14.030
15	8.580	18.350	12.104	13.976	23.656	29.480**	25.537**	11.612	14.605
16	9.562	19.751	12.171	14.799	29.070**	29.604**	25.960	13.383	14.751

	maruti			Powerg		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly
1	3.362	.000	.170	2.992	1.814	2.957
2	3.859	.167	2.139	3.801	2.713	3.414
3	3.926	.260	2.158	11.665*	4.183	3.753
4	5.168	.262	3.484	11.690**	8.241	4.079
5	9.665	1.674	3.871	12.216**	8.616	4.539
6	9.752	2.208	4.429	12.808**	8.667	4.812
7	10.437	2.209	4.752	13.763	11.346	5.477
8	11.341	2.239	5.001	13.803	12.587	5.507
9	11.389	2.571	5.176	13.908	14.137	7.573
10	11.528	3.762	7.897	16.384	14.257	10.337
11	11.815	4.320	7.899	17.043	17.449	10.674
12	12.173	7.792	9.529	17.255	17.476	11.368
13	12.176	14.846	10.562	17.423	18.355	11.520
14	12.657	16.188	11.272	18.161	22.795	11.669
15	12.780	17.433	11.391	18.483	22.907	12.295
16	12.782	18.968	11.414	18.535	22.911	12.703

Source: Author(s)

Function (ACF), and Ljung- Box Q-statistic it can be concluded that the series is a stationary process and do not obey the random walk model.

Result of Weekly Series: The Ljung-Box Q-statistic which tests the null hypothesis that all ρ_k's are zero ($\rho_k = 0$) was computed for a total of 16 lags where the series of fina, fins, cipla, red, hul, lt, mm, sunpha, pidilite, maruti, and powerg is insignificant at 5% level for all the levels of lag but the series of 'ici' is insignificant at all lag level except at lag 1, 5 and 6, series of 'info' is insignificant from lag 13 only, series of 'mm' is insignificant at all level except at lag 3, 7, 8, 9 and 10, bel is insignificant up to lag 9 and in lag 11, 'hindal' is insignificant at all lag level with exception in lag 12, 13 and 16.

So, the value of ρ_k (auto-correlation) at various lags of all the series hovers around zero (Bhaumik, 2015) which resembles a stationary process (Gujurati, 2004). Thus, the findings through the Auto-correlation Function (ACF), and Ljung-Box Q-statistic can be concluded that the series is a stationary process and do not obey the random walk model.

Result of Monthly Series: The Ljung-Box Q-statistic which tests the null hypothesis that all ρ_k's are zero ($\rho_k = 0$) was computed for a total of 16 lags where the series of fina, fins, red, hdf, hul, ici, info, lt, mm, tata, bel, sunpha, maruti and powerg is insignificant at 5% level for all the levels of lag and the series of 'cipla' is not insignificant at lag 3, 5, 7, 8, 10 and 11, 'hindalco' is significant at lag 12, 13, 14, 15 and 16 and 'pidilite' is insignificant in all lags except in Lag 2, 5 and 6.

So, the value of ρ_k (auto-correlation) at various lags of all the series hovers around zero (Bhaumik, 2015) which resembles a stationary process (Gujurati, 2004). Thus, the findings through the Auto-correlation Function (ACF) and Ljung-Box Q-statistic can be concluded that the series is a stationary process and do not obey the random walk model.

To make the findings more robust, the study further applies the unit root test for checking the stationarity of the data series and as far as the EMH is concerned, The series should exhibit a random walk movement or a non-stationary process. The result of the unit root test has been depicted below. Table 6 shows the result of Augmented Dickey Fuller (ADF) test and Table 7 shows the result of Philips-Perron test.

With the null hypothesis of the series having a unit root, the result of both the unit root tests i.e., Augmented Dickey Fuller test and the Philips-Perron test indicates that all the series of daily, weekly and monthly stock returns included in the study is statistically significant at 5% level to infer that the series has no unit root or the series are stationary which means that the series does not follow a random walk.

Summarising the results, the Run Test, the Auto-correlation Function and the two Unit Root Test i.e., Augmented Dickey Fuller test and the Philips-Perron

Table 6. Augmented Dickey Fuller test

	Daily Return		Weekly Return		Monthly Return	
	t-statistics	Prob.*	t-statistics	Prob.*	t-statistics	Prob.*
Bajaj finance	-35.03393	0.000	-16.05	.000	-7.655499	0.000
Bajaj finserv	-34.01515	0.000	-16.64	.000	-7.664633	0.000
CIPLA	-37.02434	0.000	-16.61	.000	-9.733598	0.000
Dr Reddy	-32.31243	0.000	-16.51	.000	-9.063710	0.000
HDFC	-3.180138	0.021	-16.41	.000	-8.594178	0.000
HUL	-36.24910	0.000	-16.30	.000	-8.186276	0.000
ICICI	-34.38760	0.000	-18.22	.000	-8.543311	0.000
InfoEdge	-34.32831	0.000	-19.70	.000	-8.848287	0.000
LT	-34.36166	0.000	-15.99	.000	-6.961128	0.000
Mahindra	-36.35808	0.000	-15.91	.000	-7.799550	0.000
Tatamotors	-34.69459	0.000	-14.64	.000	-7.783594	0.000
BEL	-33.92419	0.000	-15.76	.000	-9.745005	0.000
SunPha	-33.90565	0.000	-16.21	.000	-8.915988	0.000
Hindal	-33.19447	0.000	-16.22	.000	-8.510222	0.000
Pidilite	-33.59250	0.000	-17.65	.000	-7.794005	0.000
Maruti	-33.22788	0.000	-16.08	.000	-7.223263	0.000
PowerG	-36.78838	0.000	-16.08	.000	-9.517209	0.000

Source: Author(s)

*MacKinnon (1996) one sided p-values.

Table 7. Philips Perron test

	Daily Return		Weekly Return		Monthly Return	
	t-statistics	Prob.*	t-statistics	Prob.*	t-statistics	Prob.*
Bajaj finance	-35.06787	0.000	-16.05	.000	-9.232447	0.000
Bajaj finserv	-34.00194	0.000	-16.64	.000	-7.919977	0.000
CIPLA	-37.04035	0.000	-16.69	.000	-9.827666	0.000
Dr Reddy	-32.31772	0.000	-17.07	.000	-9.063710	0.000
HDFC	-3.180138	0.021	-16.85	.000	-10.74958	0.000
HUL	-36.24946	0.000	-16.40	.000	-8.211817	0.000
ICICI	-34.61349	0.000	-18.53	.000	-8.546740	0.000
InfoEdge	-36.22815	0.000	-20.30	.000	-9.270541	0.000
LT	-34.36436	0.000	-15.99	.000	-6.939390	0.000
Mahindra	-36.35713	0.000	-15.98	.000	-7.834558	0.000
Tata motors	-34.69325	0.000	-14.61	.000	-7.784359	0.000
BEL	-33.90969	0.000	-15.88	.000	-9.797260	0.000
SunPha	-33.89112	0.000	-16.40	.000	-11.98269	0.000
Hindal	-36.18822	0.000	-16.23	.000	-8.476181	0.000
Pidilite	-33.64803	0.000	-17.61	.000	-9.055595	0.000
Maruti	-33.18720	0.000	-16.09	.000	-7.218222	0.000
PowerG	-37.51045	0.000	-16.09	.000	-9.517209	0.000

Source: Author(s)

test has statistically confirmed with the findings that the daily, weekly and monthly stock return series of the 17 stocks of BSE Green Index has considerable ESG scores and do not obey the 'Random Walk Hypothesis' or 'Efficient Market Hypothesis' and hence rejects all the three hypothesis of the study (H_1, H_2, and H_3) as reported above. The findings also stand in line with the studies of Poshakwale (1996); Pandey (2003); Khan (2006) and Sarkar (2019).

6. Conclusion

There are evidences all around the globe about few investors who could outperform the market excellently and have added enormous wealth to their net worth. Such evidences are in India as well. Further, having a very limited scope, this paper undertook an investigation on one of the stock indexes *i.e.,* the BSE Green Index and studied 17 stocks out of a total of 20 stocks from the index. Extracting daily, weekly and monthly data from BSE for a period of 5 years (01/01/2015-31/12/2019) and employing statistical test like Run Test, Auto-correlation Test and Unit Root Test, this paper concludes its analysis stating that the companies under the BSE Green index do not follow the 'Random Walk Hypothesis'. Also, based on the literature survey of the 'Efficient Market Hypothesis' and backing the empirical findings of this study, it would be rational to state that the concept of random walk and the Efficient Market Hypothesis which was pioneered in 1970's Ph.D. dissertation by Eugene Fama does not hold good in the BSE Green Index of the Indian Stock Market.

The findings of this study would be very imperative to the investors concerned about their investment decisions with regard to sustainability practices. It showed the pattern of daily, weekly and monthly stock return movement as whether it walks randomly or not. It even portrayed whether the previous stock return has effect on the future stock returns through auto-

correlation test and justified the unit root problem as well. These results would be useful to the analysts where they can further apply more advanced statistical tools keeping these results as the footings of new research avenue. The results also concern all the stakeholders of ESG investing and sustainability practices as it throws a light on how the BSE-GREENEX which is developed on the base of sustainability has performed in the Indian capital market.

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