International Journal of Finance, Economics and Business
Vol. 2, No. 4, December 2023, pp.301-312
e-ISSN: 2948-3883
DOI: 10.56225/ijfeb.v2i4.249

Original Article

Investigating the Market Efficiency of Socially Responsible Indices: Evidence from India

Anshika Goel [1,*] and Namita Sahay [1]

[1] Amity International Business School, Amity University, I3 Block GF Amity University Noida, Sector 125, Noida, India; nsahay@amity.edu (N.S.)
* Correspondence: goelanshika12@gmail.com (A.G.)

Citations: Goel, A. & Sahay, N. (2023). Investigating the Market Efficiency of Socially Responsible Indices: Evidence from India. *International Journal of Finance, Economics and Business*, *2*(4), 301-312.

Received: 8 August 2023 Accepted: 26 November 2023 Published: 31 December 2023

Abstract: Socially Responsible Indices allow investors to invest in those companies which are deemed to be socially responsible. These indices comprise those constituent companies screened and assessed for environmental, social and governance (ESG) criteria. This paper analyses the weak form of the Efficient Market Hypothesis (EMH) for socially responsible investment indices in India. The authors used the daily closing price of two indices, Carbonex and Greenex, from June 3, 2013, to December 31, 2022. This study conducted Augmented Dickey Fuller, normality, and autocorrelation tests to analyse the randomness of prices and test whether the future price can be predicted using the past price. The weak form theory of the efficient market hypothesis is violated if the returns are not random and dependent on past returns, thereby enabling investors to gain abnormal returns by extrapolating the past data. The research results suggest that the theory of weak form of efficient market hypothesis is valid for Carbonex and Greenex, which are the socially responsible indices of India. It implies that the future movement of returns for socially responsible investment indices in India cannot be predicted from past prices. Therefore, the opportunity to gain abnormal returns is not possible.

Keywords: Efficient market hypothesis; Environmental, social and governance; Socially responsible investment; Socially responsible indices.

1. Introduction

Capital markets are efficient only when they reflect all relevant information in determining stock prices. Therefore, the investors cannot earn abnormal returns and forecast the future price by analysing past price patterns. The efficient market hypothesis (EMH) proposed by Fama (1970) and Fama (1991) has three forms: the weak form, the semi-strong form and the strong form. The weak form of the efficient market hypothesis states that stock prices incorporate all publicly available past information. The weak form of the efficient market hypothesis states that all information, such as the past stock price history, trading data and volumes, are reflected in the stock price. Fama (1991) has extended the weak-form efficiency concept to involve the predictability of future returns using accounting variables. The semi-strong form of EMH states that the current stock price reflects and adjusts to all the available past information as well as any new public information. It prevents the possibility of attaining superior or abnormal returns using any trading strategy. The strong form of EMH asserts that stock prices adjust rapidly to account for public and private information (Maverick, 2020). However, Seyhun (1986) provided in his research that insiders can make superior returns through insider trading. This scenario affects the market participants' reaction to news and events, which can cause security prices to deviate. Therefore, the market sometimes becomes too volatile to be efficient since market participants are not consistently rational. Many studies have used the semi-strong form as the basis of their research; however, the current research focuses on studying the weak-form efficiency of socially responsible investment indices.

The weak form of the Efficient Market Hypothesis is very closely related to the random walk theory proposed by Fama & French (1995). The random walk theory assumes that price movements of publicly listed stocks are random and are not correlated with the previous prices because publicly listed stocks always mirror the latest information. It renders the effort to predict the future price for abnormal returns. However, when the stock market is inefficient, investors can predict the performance of a particular stock price by extrapolating price information from the past. One of the earlier studies by Kendall & Hill (1953) examined a pattern followed by stock prices that allow investors to extrapolate the future price movement of a stock based on the available information about the past. Market efficiency is important not only from the perspective of investors but also from the perspective of policymakers. Investors make their investment decisions based on past price information and current price information. For example, policymakers use stock market information to develop strategies to promote a country's development.

Different researchers have vastly investigated the weak form of EMH on various stock exchange markets. For example, Njuguna (2016) tested on the Nairobi Securities Exchange. Šonje et al. (2011) tested the Croatia and US stock markets. However, very few studies have been centred on socially responsible indices. Many of these studies have been conducted using statistical tests like run, autocorrelation, and unit root tests. These statistical tests have used historical closing prices of the indices for performing statistical tests. Socially Responsible Investing (SRI) is very similar to ethical or value-based investing (Sandberg et al., 2009). Though different investors hold different viewpoints on SRI, the basic concept underlies the desirable non-financial impact of such an investment. SRI integrates environmental, social and governance concerns into the investment process. The concept of SRI has become immensely important among investors in recent years. One of the biggest reasons for the increase in SRI investment is the focus towards CSR practices by the national and international level companies coupled with investor awareness towards environmental, Social and Governance criteria. This can result in increase in the number of SRI indices in developing countries. Hence, it becomes significantly important to test the efficiency of Socially Responsible Indices in developing countries which can create alternate investment avenues for portfolio managers who are interested in socially responsible investments to park their funds.

Financial markets offer investors alternative investment avenues and contribute to economic development. Singh (1997) notes that they provide a mechanism to boost the investor's savings and increase the quantity and quality of investment. Furthermore, Wuyts (2007) asserts that financial markets provide liquidity to the owners of assets, which can increase investors' willingness to participate in the stock market since they can buy and sell the securities at a lower cost. It contributes to the competitive price determination of various assets. The ability of the stock market to perform these roles, among several others, effectively determines whether it is efficient or not. The question of market efficiency is central to finance and has been debated heavily since the seminal paper (Fama, 1965). Although mixed reviews still exist today, most of the studies have shown a huge development in the efficiency of the stock market over the years. This growth has been associated with technological advancements enabling the security price to incorporate publicly available information quickly. Yang et al. (2008) observed this trend in their study on the Korea Exchange, showing that information is quickly reflected in the prices due to the development of communication, such as mobile technologies, high-speed internet, and worldwide broadcasting systems.

These studies, however, do not provide a promising picture of whether the stock markets are fully efficient or not but only point towards the increase in efficiency over the years. Despite this, investors are still able to generate abnormal returns. According to Antoniou et al. (1997), stock market efficiency holds a significant place as it allows the prices of securities to absorb all the available information in the market, giving perfect signals for the efficient allocation of capital. It creates the foundation of the Efficient Market Hypothesis because if it holds, it demonstrates that securities always trade at their intrinsic value. Therefore, an investor does not have the opportunity to make abnormal returns. It is to be noted that the Efficient Market Hypothesis relies on certain assumptions that do not reflect the real world, like the presence of perfectly competitive markets or rational investors who are risk-averse and profit maximisers. Lee et al. (2002) noted that the information and how the market participants react to it are important.

Many studies have tested the efficient market hypothesis for various stock market indices. Past studies have also tested EMH in sectorial indices. But, since ‘Socially Responsible Indices’ is a relatively new concept and still emerging in developing countries, not many studies have tested the concept of efficient market hypothesis for these indices. Based on the gap area identified above, the present study attempts to fill the gap in the existing literature by examining the applicability of the efficient market hypothesis to socially responsible indices in India. This paper contributes to the existing literature on EMH in several ways. For example, the data covers a very recent period up to 2022, which was not covered in the previous studies, and the conduct of the study is based on socially responsible investment indices, on which very few studies existed in the past. Many authors have explored the weak-form efficiency of different stock markets. However, this study has mainly focused on testing the weak market efficiency in socially responsible investment indices. It aims to add to the existing literature by conducting various statistical tests and time-varying techniques conducted on various financial markets. The significance of the study is that it explores the weak-form market efficiency in socially responsible investment indices. Since the EMH claims that it is highly unlikely for an investor to gain abnormal return through price prediction, this study will benefit the investors because it will assess one's ability to earn an abnormal return without necessarily investing in an asset with high risk.

The study aims to understand the nature of socially responsible indices by testing the randomness of daily market returns. Random stock returns are only possible when markets are efficient in their weak form. Hence, we check the random walk nature of these markets to test for weak form market efficiency. This study has tried to check whether the socially responsible indices are in the weak form of market efficiency or not and add to the existing literature. EMH uses past prices or returns to conduct the tests. As discussed earlier, market efficiency has three forms, but working on all three forms has certain limitations because of the unavailability of data to achieve the study's objectives. To measure the market return randomness, it is necessary to test weak form market efficiency. For testing the strong form of market efficiency, private or insider information, which is not readily available, is needed; hence, these tests are impossible.

Investors and traders need to evaluate securities in the financial markets, which can help form investment strategies for trading. Valuation of securities is also necessary to identify the behaviour of these markets. It is only possible if the respective markets' market efficiency status is known. This information is very important as it could potentially lead to arbitrage opportunities. Arbitrage is the simultaneous purchase and sale of the same or substantially similar security in two different markets at advantageously different prices. It does not require any capital, therefore bringing the investor risk-free profit.

A stock that a trader buys on a foreign stock exchange, the price of which has not yet been considered constantly fluctuating exchange rates, and which he sells on the local stock exchange. The trader could benefit from this difference as the stock price on the foreign exchange is undervalued compared to the price on the local exchange. When the markets are weak and inefficient, it is impossible to earn abnormal returns by buying the undervalued securities and selling them in the markets where they are overvalued. Therefore, a weak form market efficiency can lead to decisions related to buying and selling undervalued or overvalued securities at the right time.

2. Literature Review

There have been many studies in the past that have tested stock market efficiency in various countries and on several indices. However, very few studies focus on the market efficiency of socially responsible indices. The literature review is divided into four sections: firstly, it focuses on studies of weak-form efficiency, secondly, it includes those studies which accept the efficient market hypothesis, thirdly, those who reject the efficient market hypothesis and lastly it includes the studies on carbon efficiency.

2.1. Weak-Form Efficiency

Fama (1970) and Fama & French (1995) developed the Random Walk Hypothesis as a test for market efficiency. Due to this, previous research on market efficiency has included the Random Walk Hypothesis. Researchers like Fama et al. (1965) have used various statistical tests, such as run tests and serial correlation, to test the Random Walk Hypothesis. Many studies have examined the weak-form EMH after using the predictability power of variables such as firm size, dividends, and interest rates to test the Random Walk Hypothesis (Fama, 1991). Most of these studies focus on developed markets rather than developing markets. Developed markets and emerging markets share different characteristics. For example, the latter are classified by shallow trading, large price fluctuations, low liquidity, and uninformed investors who have access to unpredictable information (Angelovska, 2018). Studies conducted on both the developed and emerging markets are reported in the following sections. The number of studies conducted on the Random Walk Hypothesis and weak-form efficiency of emerging markets have increased significantly due to liberalisation in these economies. Angelovska (2018) tested the weak-form efficiency of the Macedonian stock exchange using daily returns on a sample spanning from January 4, 2005, to April 2, 2018. The researcher concluded that the Macedonian stock market is weak-form inefficient with the application of a random walk model and GARCH (1,1) model.

Tokić et al. (2018) examined the weak-form efficiency of the stock markets in Croatia, Serbia, Slovenia, and Slovakia using daily data from January 1, 2006 to January 31, 2016. The researchers conducted various tests, including serial correlation, ADF, runs, unit root, variance ratio, and a test of the January effect. The results confirmed that all markets were efficient in their weak form except Serbia, which provided mixed results and confirmed that it was not weak-form efficient. Sarkar (2019) tested the weak form of EMH using daily returns of the Bombay Stock Exchange and the National Stock Exchange in India from January 1, 2015, to December 31, 2018. Using the Kolmogorov- Smirnov Goodness of Fit, run test, ADF and Phillips Perron stationarity tests, the researcher concluded that the two stock exchanges are weak-form inefficient and, therefore, an investor can earn abnormal returns. Emenike & Kirabo (2018) investigated the Uganda Securities Exchange (USE) 's weak-form efficiency using daily prices from September 1, 2011, to December 31, 2016. The researchers applied linear serial dependence tests (Ljung-box Q tests and autocorrelation function) and nonlinear tests (autoregressive conditional heteroscedasticity Lagrange multiplier).

The results of the linear models showed that USE was weak form efficient. In contrast, the results of the non-linear models showed evidence against the weak-form efficiency of the USE, which concluded that non-linear models and fundamental analysis can help predict the USE's future returns. In contrast, linear models and technical analysis do not predict future returns. Hawaldar et al. (2017) tested the weak-form efficiency of individual stocks listed on the Bahrain Bourse from 2011 to 2015. The autocorrelation test, Kolmogorov-Smirnov Goodness of fit test, and runs test were conducted. They revealed mixed results with the Kolmogorov-Smirnov Goodness of fit test confirming that the market follows a random walk, the runs test revealing that the share prices of seven companies do not follow the random walk and the autocorrelation test revealing that share prices exhibiting low to moderate correlation. From these mixed results, the researchers highlighted that deciding whether the Bahrain Bourse is weak-form efficient is complicated.

2.2. Efficient Market Hypothesis

Kendall & Hill (1953) found that the stock index movement is random. Fama (1970) found sufficient evidence of a positive correlation between daily price changes and returns of common stocks. Still, this positive dependence was insufficient to refute the efficient markets hypothesis. Fama (1998) has found that market efficiency persists in the long run. Hassan & Girard (2011) found that the returns of the Dow Jones Islamic Market Index [DJIMI] are normally distributed, and the DJIMI has remarkable market efficiency. Shmilovici et al. (2003) found potential market inefficiency in ten international stock index series. Milunovich & Joyeux (2007) found that the spot and futures markets efficiently exchange information and jointly contribute to price discovery. Besides that, many studies reject the efficient market hypothesis in various stock markets. Lo & MacKinlay (1988) prove that stock prices do not follow random movements. A World Bank study found evidence of predictable stock market returns for twenty stock markets (Claessens et al., 1995). Gilbertson & Roux (1978) observed non-randomness in stock price behaviour and market inefficiency on the Johannesburg Stock Exchange. Singh (1997) found that the Indian Islamic stock index is not random. Dockery & Kavussanos (1996) rejected the existence of an efficient market hypothesis in the Athens stock market. Hamid et al. (2010) found no random walks in all Asia-Pacific countries and concluded that investors can benefit from profitable opportunities in these markets through the arbitrage process. Malkiel (2003) found that there is no market efficiency in the US stock market.

2.3. Carbon Efficiency

Daskalakis & Markellos (2008) studied the European market efficiency for carbon dioxide emission allowances and concluded that the behavior of the markets under consideration is inconsistent with the weak form efficiency. Miclăuş et al. (2008) examined the efficiency of carbon future market. The results are useful for emission-intensive companies, policymakers, risk managers, and active or passive investors in the emerging class of energy and carbon hedge funds. Singh (1997) conducted studies on carbon efficient indices.

2.4. Hypothesis

This study applies a classical framework for testing weak form market efficiency for the time series data of socially responsible indices using statistical tests including normality, autocorrelation, and unit root tests. The Jarque-Bera (JB) test is used to test the normality of the distribution. The results of skewness and kurtosis are also checked by JB test. So, the JB test is the test of the common hypothesis that the skewness S and the Kurtosis K are zero and three, respectively. The value of the Jarque-Bera statistic is calculated using the following equation:

$$\mathbf{JB = n\ [(\sqrt{b1})^2 / 6 + (b_2 - 3)^2 / 24]}$$

The conclusion can be based upon the probability value. If probability value is more than 0.05 at 5% significance level, the null hypothesis for normal distribution gets accepted and one can conclude that the observed series passes the normality test. The autocorrelation test determines the series correlation with itself. It measures the extent of linear dependence between observations separated by a time lag. It shows to what extent current values in the series are related to different lags in past data. For an efficient market, the null hypothesis states that there is no autocorrelation. The unit root test determines the stationarity of time series data and finds out whether a time series variable is stationary or not. The most used unit root tests are the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. For both tests, the null hypothesis states that there is existence of unit root.

Normality test, Stationarity test and autocorrelation for the time series are conducted using the return of the indices. The main objective of this study is to investigate whether the socially responsible indices, Carbonex and Greenex are random in nature or efficient in weak form. This study used four different methods that are, unit root tests, autocorrelation test, normality test and the descriptive statistics. Durbin Watson test and Breusch-Godfrey Serial Correlation LM test are used to check autocorrelation. Augmented Dickey Fuller Test is used to check the presence of unit root and therefore to assess whether the data is stationary or not. Using Jarque Bera test, normality of the data is checked. These methods were used to analyses the daily closing prices of the indices. These methods were used to test the different null and alternative hypotheses. The following null and alternative hypotheses were formulated for the study. Accordingly, the study's hypothesis is:

H10: Carbonex index is weak-form efficient.
H1a: Carbonex index is not weak-form efficient and not following the random walk.

H20: Greenex index is weak-form efficient.
H2a: Greenex index is not weak-form efficient and not following the random walk.

3. Materials and Methods

In the recent years, it has been observed that global investors have shifted their investment focus towards socially responsible investments. Hence, the present study proposed to analyse the randomness in returns of Socially Responsible Investment (SRI) Indices and to test the weak form of Efficient Market Indices in these indices. For that purpose, the study used Carbonex and Greenex as sample SRI Indices. The study is based on secondary data. The daily closing prices of the socially responsible indices (Carbonex and Greenex) are used for the study. The data is collected from the official website of Bombay Stock Exchange (BSE), India. Daily closing prices of the two indices are taken from June 3rd, 2013 to December 31st, 2022. In this study, Durbin Watson test and Breusch-Godfrey Serial Correlation LM test are used to check autocorrelation. Augmented Dickey Fuller Test is used to check the unit root and therefore to assess whether the data is stationary or not. Using Jarque Bera test, normality of the data is checked, and descriptive statistics gives the following parameters for return: mean median, skewness and kurtosis, and standard deviation for the time series data.

4. Results

The descriptive statistics shown below in table-1 describe the data characteristics for both the socially responsible indices – Carbonex and Greenex. The mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera statistics and probability value for Carbonex and Greenex samples are given below.

Table 1. Result of Descriptive Statistics

	Log (Carbonex Return)	Log (Greenex Return)
Mean	0.000203	0.000198
Median	0.000368	0.000372
Maximum	0.036099	0.034988
Minimum	-0.060632	-0.054667
Std. Dev.	0.004806	0.004787
Skewness	-1.353717	-1.081254
Kurtosis	21.132820	16.17823
Jarque-Bera	31133.99	16518.96
Prob.	0.000000	0.00000
Sum	0.452229	0.439418
Sum Sq. Dev.	0.051320	0.050921

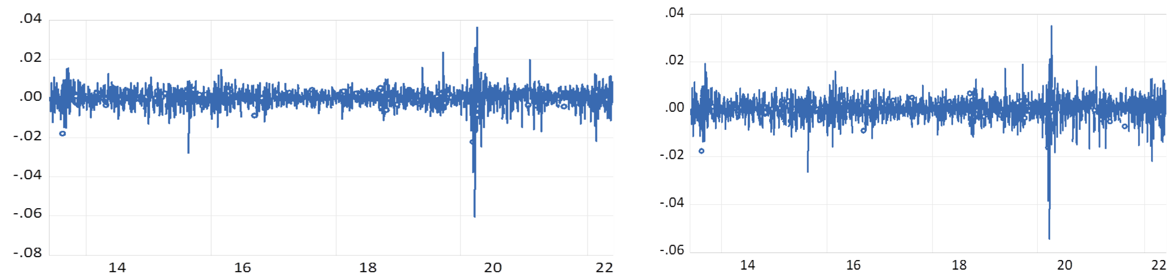
The sample size comprising of daily closing price, is of 2223 and 2223 observations for Carbonex and Greenex indices respectively. For both the indices, return has been calculated using the below formula:

$$Rt = Log(Pt / Pt-1)$$

Here, Rt represents log value of daily return at time t whereas Pt-1 and Pt represent daily closing prices of an asset at two consecutive days, t-1and t respectively. For the time series data, extreme values can be observed using descriptive statistics. Also, skewness, kurtosis and normality of the data can also be observed using descriptive statistics. The mean of Carbonex and Greenex is very small and close to zero i.e. 0.000203 And 0.000198 respectively Compared to Greenex, value of the standard deviation for Carbonex index was slightly higher. It is to be noted that the risk of Carbonex is higher than Greenex. The greater the market volatility, the higher the chances of high returns with higher risk. The unconditional standard deviation as measure of variation is quite small, 0.004806 for Carbonex index and 0.004787 for Greenex.

Skewness results for both the series show that they are skewed negatively. A negatively skewed or left-skewed distribution has more values concentrated on the right tail while the left tail of the distribution graph is longer. Skewness values are not zero for both indices which means all the rates of returns are not symmetric. The negative skewness of the series may indicate frequent small gains and a few large losses for the investor. However, the skewness is more for Carbonex. The kurtosis for different returns is 21.13282 and 16.17823. They are greater than three, which implies that all stock returns exhibit the fat tail characteristic. Furthermore, the Jarque-Bera statistic shows us that a higher value depicts the non-normality of returns. Figure-1 and Figure-2 below show the return for both the indices, Carbonex and Greenex respectively.

Even though NPL has no significant effect on stock return, it is still mandatory for each bank to maintain its NPL ratio so that it does not exceed the 5% requirement. Banks need to increase public trust in the independent directors not only to meet formal requirements, but also to make their presence can influence the bank's performance. Each bank is advised to have a continuously increasing ROA in order to increase stock return and attract new investors. Even though CAR is generally having good impact for bank capital, each bank should be wiser in determining the portion of CAR because a high CAR does not always guarantee the efficiency and effectiveness of bank performance. It can be detrimental to the bank if the CAR becomes idle fund. Banking in ASEAN countries should manage CAR better, so that a high CAR is able to have a positive effect on bank stock return, especially Indonesia with a CAR that exceeds 20%. Banking in Thailand should lower NPL because the ratio is the highest compared to Indonesia and Malaysia. Malaysian banks are suggested to increase Return on Assets as this factor has a positive and significant impact on bank growth. Among the other two countries, Malaysia has the lowest ROA with a moderate predicate. For future researchers, better to add other variables, such as LDR, NIM, ROE, or external variables such as exchange rates. Good Corporate Governance should be replaced with other factors in the form of financial ratios so that they can further influence stock return.



(a) **(b)**

Figure 1. (a) Return for Carbonex and (b) Return for Greenex

4.1. Autocorrelation Test

4.1.1. Durbin Watson

The results of Durbin Watson test are shown in the following tables. Table-2 reflects the Durbin Watson statistic for Carbonex which is 1.999 and table-3 reflects the Durbin Watson statistic for Greenex which is 2.00. The Durbin Watson statistic for both the indices is 2 which provide an inference that there is no autocorrelation. Hence, the null hypothesis is accepted which states that there is no first order autocorrelation. The Hypotheses for the Durbin Watson test are:

H0: there is no first order autocorrelation.
H1: there is existence of first order autocorrelation.

Table 2. Result of Durbin Watson Statistic for Carbonex

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000230	0.000102	1.985918	0.047200
L_Carbonex_Return (-1)	0.006208	0.021224	0.292487	0.769900
R-squared	0.000039	Mean dependent var		0.000204
Adjusted R-squared	-0.000412	S.D. dependent var		0.004807
S.E. of regression	0.004808	Akaike info criterion		-7.836232
Sum squared resid	0.051316	Schwarz criterion		-7.831096
Log likelihood	8708.054000	Hannan Quinn crit.		-7.834357
F-statistic	0.085549	Durbin-Watson stat		1.999830
Prob(F-statistic)	0.769941			

Table 3. Result of Durbin Watson Statistic for Greenex

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000194	0.000102	1.912073	0.056000
L_Greenex_Return(-1)	0.016997	0.021222	0.800927	0.423300
R-squared	0.000289	Mean dependent var		0.000198
Adjusted R-squared	-0.000161	S.D. dependent var		0.004788
S.E. of regression	0.004789	Akaike info criterion		-7.844246
Sum squared resid	0.050907	Schwarz criterion		-7.839110
Log likelihood	8716.958000	Hannan Quinn crit.		-7.842371
F-statistic	0.641484	Durbin-Watson stat		2.000108
Prob(F-statistic)	0.423260			

Table 4. Result of Durbin Watson Statistic for Greenex

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000194	0.000102	1.912073	0.056000

L_Greenex_Return(-1)	0.016997	0.021222	0.800927	0.423300
R-squared	0.000289	Mean dependent var		0.000198
Adjusted R-squared	-0.000161	S.D. dependent var		0.004788
S.E. of regression	0.004789	Akaike info criterion		-7.844246
Sum squared resid	0.050907	Schwarz criterion		-7.839110
Log likelihood	8716.958000	Hannan Quinn crit.		-7.842371
F-statistic	0.641484	Durbin-Watson stat		2.000108
Prob(F-statistic)	0.423260			

4.1.2. Breusch-Godfrey Serial Correlation LM Test

Table-4 shows the output of Serial Correlation LM Test. The probablity Chi-square value is 0.9892 for Carbonex and 0.9354 for Greenex. Since both the probability chi-square values are more than 0.05 at two lags, therefore, the null hypothesis is accepted which states that there is no serial correlation up to 2 lags. Null Hypothesis for Serial Correlation LM Test which is to be tested:

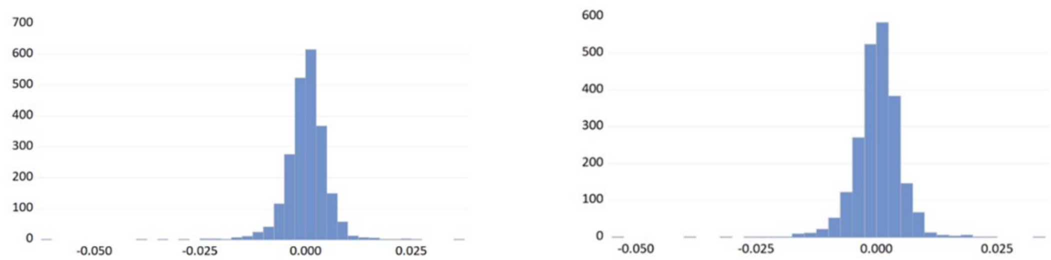
H0: No serial correlation up to 2 lags.
H1: Serial Correlation exists.

Table 5. Serial Correlation LM Test

	Carbonex	Greenex
F-statistic	0.010797	0.066659
Observed R-squared	0.021632	0.13355
Prob. F(22218)	0.9893	0.9355
Prob. Chi-Square(2)	0.9892	0.9354

4.2. Test for Normality of the Indices

Figure 2 (a) and (b) depict the normality test for Carbonex and Greenex respectively. One can conclude that the time series data is highly non-normal (asymmetric), which is also confirmed by the Jarque-Bera test both the series exhibit negative skewness and high positive kurtosis. These values represent the situation that the distributions of the series have a long-left tail and are leptokurtic.



(a) **(b)**

Figure 2. (a) Normality Test for Carbonex and (b) Normality Test for Greenex

The Jarque-Bera (JB) statistic rejects the null hypothesis of normal distribution at the 5% significance level for both series. This confirms the general norm that stock returns are not normally distributed and are negatively or positively skewed. The probability value for both the indices is less than 0.05 at 5% level of significance, therefore, rejecting the normality assumption.

4.3. Augmented Dickey-Fuller (ADF) Test

The subsequent research on market efficiency used a new methodology known as unit root test for testing the randomness in stock prices. This methodology was developed by Dickey and Fuller in the year

1981 and it examines the stationarity of the time series data. A series with existence of unit root is said to be non-stationary indicating non-random walk by the stock market. The most used test for examining the existence of unit root is the Dickey-Fuller test. It provides evidence regarding the random walk nature of stock indices. Therefore, it is also carried out as a test of weak form market efficiency. The standard Dickey-Fuller (DF) test is suitable for a series generated by a first-order autoregressive process, AR(1). Then, the hypotheses to be tested are:
H0: $\rho = 0$ (Non-stationary or existence of unit root)
H1: $\rho < 0$ (Stationary or no unit root)

The results of the Augmented Dickey-Fuller (ADF) test for both the socially responsible indices are given in table-5 below. ADF test has been done both at level and by taking first difference. In line with the results obtained, the sample series is stationary both at level and when its first difference is taken. In other words, we can say that the series has no unit root, thus rejecting the null hypothesis. Values of the Augmented Dickey-Fuller test statistic for daily returns of Carbonex and Greenex were -46.82329 and -46.32082 respectively. These values were less than the test critical values at 1%, 5% and 10% level which indicated that both the sample indices experienced stationarity during the study period. These results also showed that the probability values of the two sample indices were below the significant level of 0.05. Therefore, we reject the null hypothesis NH02: the daily returns of Carbonex and Greenex have existence of unit root or are non-stationary during the sample period. Thus, concluding that returns of both the indices are random in nature.

Table 6. Result of Augmented Dickey-Fuller Test

	Carbonex	**Greenex**
Augmented Dickey-Fuller test statistic	-46.82329	-46.32082
Prob.	0.0001	0.0001
Critical Values:		
1% level	-3.433096	-3.433096
5% level	-2.862639	-2.862639
10% level	-2.567401	-2.567401

The autocorrelation test results reveal that the Durbin Watson statistic for Carbonex is 1.999 and for Greenex, it is 2.00. The Durbin Watson statistic for both the indices is 2 which helps to make an inference that autocorrelation does not exist. Hence, null hypothesis of no first order autocorrelation is accepted. The output of the Breusch-Godfrey Serial Correlation LM Test shows that the probability Chi-square value is 0.9892 for Carbonex and 0.9354 for Greenex. Since, both the probability chi-square values are more than 0.05 at two lags, therefore, the null hypothesis is accepted that there is no serial correlation up to 2 lags. While testing data stationarity, values of the Augmented Dickey-Fuller test statistic come out to be -46.82329 and -46.32082 for daily returns of Carbonex and Greenex respectively. The reported values are less than the test critical values at 1%, 5% and 10% level which indicates that both the sample indices showed stationarity during the study period. The probability values of the two sample indices were also found to be less than the significant value of 0.05. Thus, concluding that returns of both the indices are random in nature.

Descriptive statistics show the mean, median, skewness, kurtosis, and normality of the data. The mean of Carbonex and Greenex is very small and nearly zero i.e. 0.000203 And 0.000198 respectively Value of the standard deviation for Carbonex index is more compared to Greenex indicating slightly higher volatility. Skewness results for both the series indicate that they are skewed negatively. Skewness values are not zero for both indices which means that all the rates of returns are not symmetric. However, the skewness is slightly more for Carbonex. The kurtosis for different rates of returns is greater than three indicating that stock returns have the fat-tail characteristic. Normality test reveals that both the series are not normal since the probability value for both the indices is less than 0.05 at 5% level of significance. Jarque-Bera (JB) statistic rejects the null hypothesis of normal distribution at the 5% level of significance for both Carbonex and Greenex. The above stated statistical tests have revealed that there are no possibilities of earning abnormal returns by extrapolating past prices of both the socially responsible indices – Carbonex and Greenex. Both are found to be efficient in the weak form and therefore, no extra income can be earned.

5. Conclusion

Since the inception of stock markets, capitalising on market inefficiencies has been the objective of many professional investors. Over the past couple of years, various research has been conducted to examine the weak form of Efficient Market Hypothesis with the use of various statistical tests. Research papers have mainly focused on the weak form of the EMH due to the data availability for testing. This study focused on testing the weak-form of the EMH for socially responsible indices – Carbonex and Greenex. This research was carried out to explore the empirical evidence of weak-form efficiency. To achieve this, four different statistical tests were applied (Durbin Watson test and Breusch-Godfrey Serial Correlation LM test, Augmented Dickey Fuller Test, Jarque Bera test.) to Carbonex and Greenex for the period June 3rd, 2013, to December 31st, 2022. Stock market efficiency explains the extent to which stock prices reflect all available information in the market. Therefore, one can perform fundamental analysis by relying on this information to design a trading strategy for guaranteed returns. Our analysis from various tests conducted helps in making a conclusion that both the socially responsible indices, Carbonex and Greenex are weak form efficient and exhibit randomness in their returns. These results show that there is no way to generate additional income by extrapolating past prices of both indices since both indices are efficient in the weak form and therefore abnormal returns are not possible.

Exceptional returns are only possible when markets are inefficient, and it is possible for the investor to foresee future prices using past price information. A new set of findings may show varied results if the time period used is different or different socially responsible indices are taken. Other additions might include checking EMH through weekly and monthly analysis. Also, the effect of global financial shocks can be studied in this time period. The present study adds to the existing literature on market efficiency by examining randomness in socially responsible investment indices in India. Therefore, we provide a brief discussion of the results on the random walk hypothesis or the weak form efficiency, thereby providing a general overview of this study. Future studies can focus on making a comparison between socially responsible indices of developed and developing countries in view of the efficient market hypothesis, which will be helpful in finding out whether economic development has any connection with the market efficiency of their respective indices.

Author Contributions: Conceptualisation, A.G. and N.S.; methodology, A.G.; software, A.G.; validation, N.S.; formal analysis, A.G. and N.S.; investigation, A.G.; resources, A.G.; data curation, N.S.; writing—original draft preparation, A.G. and N.S.; writing—review and editing, A.G. and N.S.; visualisation, A.G.; supervision, N.S.; project administration, N.S.; funding acquisition, A.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to thank Amity International Business School, Amity University, India, for supporting this research and publication. We also thank the reviewers for their constructive comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

References

Angelovska, J. (2018). Testing Weak Form of Stock Market Efficiency at the Macedonian Stock Exchange. *UTMS Journal of Economics*, *9*(2), 133–144.

Antoniou, A., Ergul, N., & Holmes, P. (1997). Market Efficiency, Thin Trading and Non-linear Behaviour: Evidence from an Emerging Market. *European Financial Management*, *3*(2), 175–190. https://doi.org/10.1111/1468-036X.00038

Claessens, S., Dasgupta, S., & Glen, J. (1995). Return Behavior in Emerging Stock Markets. *The World Bank Economic Review*, *9*(1), 131–151. https://doi.org/10.1093/wber/9.1.131

Daskalakis, G., & Markellos, R. N. (2008). Are the European carbon markets efficient. *Review of Futures Markets*, *17*(2), 103–128.

Dockery, E., & Kavussanos, M. G. (1996). Testing the efficient market hypothesis using panel data, with application to the Athens stock market. *Applied Economics Letters*, *3*(2), 121–123. https://doi.org/10.1080/135048596356834

Emenike, K. O., & Kirabo, J. K. B. (2018). Empirical evaluation of weak-form efficient market hypothesis in Ugandan securities exchange. *Journal Of Contemporary Economic And Business*, *5*(1), 35–50.

Fama, E. F. (1965). The behavior of stock-market prices. *The Journal of Business*, *38*(1), 34–105.

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, *25*(2), 383–417. https://doi.org/10.2307/2325486

Fama, E. F. (1991). Efficient Capital Markets: II. *The Journal of Finance*, *46*(5), 1575–1617. https://doi.org/10.1111/j.1540-6261.1991.tb04636.x

Fama, E. F. (1998). Market efficiency, long-term returns, and behavioral finance. *Journal of Financial Economics*, *49*(3), 283–306. https://doi.org/10.1016/S0304-405X(98)00026-9

Fama, E. F., & French, K. R. (1995). Size and Book-to-Market Factors in Earnings and Returns. *The Journal of Finance*, *50*(1), 131–155. https://doi.org/10.1111/j.1540-6261.1995.tb05169.x

Fama, E. F., Kenneth, R. F., David, G. B., & Rex, S. (1965). *Financial Analysts Journal*. Random Walks in Stock Market Prices.

Gilbertson, B. P., & Roux, F. J. P. (1978). Some further comments on The Johannesburg Stock Exchange as an efficient market. *Investment Analysts Journal*, *7*(11), 21–31. https://doi.org/10.1080/10293523.1978.11082609

Hamid, K., Suleman, M. T., Ali Shah, S. Z., & Imdad Akash, R. S. (2010). Testing the weak form of efficient market hypothesis: Empirical evidence from Asia-Pacific markets. *International Research Journal of Finance and Economics*, *58*, 121–133. https://doi.org/10.2139/ssrn.2912908

Hassan, M. K., & Girard, E. (2011). Faith-based ethical investing: the case of Dow Jones Islamic indexes. *Networks Financial Institute Working Paper*, *19*(4), 1–41.

Hawaldar, I. T., Rohit, B., & Pinto, P. (2017). Testing of weak form of efficient market hypothesis: evidence from the Bahrain Bourse. *Investment Management and Financial Innovations*, *14*(2), 376–385.

Kendall, M. G., & Hill, A. B. (1953). The Analysis of Economic Time-Series-Part I: Prices. *Journal of the Royal Statistical Society. Series A (General)*, *116*(1), 11–34. https://doi.org/10.2307/2980947

Lee, W. Y., Jiang, C. X., & Indro, D. C. (2002). Stock market volatility, excess returns, and the role of investor sentiment. *Journal of Banking & Finance*, *26*(12), 2277–2299. https://doi.org/10.1016/S0378-4266(01)00202-3

Lo, A. W., & MacKinlay, A. C. (1988). Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test. *Review of Financial Studies*, *1*(1), 41–66. https://doi.org/10.1093/rfs/1.1.41

Malkiel, B. G. (2003). The Efficient Market Hypothesis and Its Critics. *Journal of Economic Perspectives*, *17*(1), 59–82. https://doi.org/10.1257/089533003321164958

Maverick, A. (2020). *Henry J. Raymond and the New York Press for Thirty Years*. BoD–Books on Demand.

Miclăuş, P. G., Lupu, R., Dumitrescu, S. A., & Bobircă, A. (2008). Testing the efficiency of the European carbon futures market using event-study methodology. *International Journal of Energy and Environment*, *2*(2), 121–128.

Milunovich, G., & Joyeux, R. (2007). *Testing market efficiency and price discovery in European carbon markets*.

Njuguna, J. (2016). Testing the efficient market hypothesis on the Nairobi Securities Exchange. *Investment Management and Financial Innovations*, *13*(3), 75–83.

Sandberg, J., Juravle, C., Hedesström, T. M., & Hamilton, I. (2009). The Heterogeneity of Socially Responsible Investment. *Journal of Business Ethics*, *87*(4), 519–533. https://doi.org/10.1007/s10551-008-9956-0

Sarkar, R. (2019). Testing Weak Form Of Efficient Market Hypothesis (EMH): Empirical Evidence From Leading Stock Exchanges In India. *International Journal on Recent Trends in Business and Tourism*, *3*(3), 64–69.

Seyhun, H. N. (1986). Insiders' profits, costs of trading, and market efficiency. *Journal of Financial Economics*, *16*(2), 189–212. https://doi.org/10.1016/0304-405X(86)90060-7

Shmilovici, A., Alon-Brimer, Y., & Hauser, S. (2003). Using a stochastic complexity measure to check the efficient market hypothesis. *Computational Economics*, *22*, 273–284.

Singh, A. (1997). Financial Liberalisation, Stockmarkets and Economic Development. *The Economic Journal*, *107*(442), 771–782. https://doi.org/10.1111/j.1468-0297.1997.tb00042.x

Šonje, V., Alajbeg, D., & Bubaš, Z. (2011). Efficient market hypothesis: is the Croatian stock market as (in) efficient as the US market. *Financial Theory and Practice*, *35*(3), 301–326.

Tokić, S., Bolfek, B., & Peša, A. R. (2018). Testing efficient market hypothesis in developing Eastern European countries. *Investment Management & Financial Innovations*, *15*(2), 281–291.

Wuyts, G. (2007). Stock market liquidity: Determinants and implications. *Review of Business and Economics*, *52*(2), 279–316.

Yang, J.-S., Kwak, W., Kaizoji, T., & Kim, I. (2008). Increasing market efficiency in the stock markets. *The European Physical Journal B*, *61*(2), 241–246. https://doi.org/10.1140/epjb/e2008-00050-0