ARTHAVAAN
Volume 7, Issue 1, December 2024

10.71322/arthavaan.vol.7.issue.1.05

Empirical Investigation into Long Run and Causal Relationship Between Sustainability and Benchmark Indices in Indian Stock Market

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Abstract

Amidst the growing concern about climate change, many investors worldwide believe that adopting sustainable business practices has a positive impact on stock prices in the long run. In light of this, the present study explores the dynamic connectedness between the sustainability index and the benchmark equity market index in India. For this purpose, the two indices from the popular stock market in India, namely, the Bombay Stock Exchange, are selected. The BSE 100 ESG symbolizes the sustainability index, and the BSE 100 index represents a broader benchmark of the Indian equity market. The two indices are initially analysed along the risk and returns parameters using daily closing prices from 1 January 2018 to 30 September 2024, obtained from the Bombay Stock Exchange of India portal. The data set consists of 1672 observations covering six years and nine months. The study further examines the cointegrating and causal behaviour of the two indices. For modelling the intertwined dynamics of the two variables in the long run, the popular cointegration techniques, namely, the Engle-Granger and Johansen Cointegration methods, are applied. Further, the cause-effect relationship between the indices in the short run is investigated using the Granger Causality approach. The data is stationary at the first difference, I (1), as per the Augmented Dickey-Fuller (ADF) unit root test. The study results support cointegration between the ESG and BSE indices in the long run. However, no Granger causality exists between the two. The serial correlation, heteroskedasticity, and model stability diagnostic tests are performed satisfactorily. The research has theoretical as well as practical implications. It enriches the existing literature by providing empirical insights into the dynamic relationships between sustainability and stock market indices, focusing on the Indian market. The fund managers and investors engaged in pair trading in the stock market can make informed decisions using the cointegrating knowledge evidenced by this research. Further, lawmakers can use the findings to design or reframe the market policies to motivate businesses and investors for ESG-oriented investment

Keywords: *Cointegration, Sustainability, ESG 100 index, BSE 100 index, Causality*

1. Introduction

At present, sustainability is one of the most discussed and practiced concepts internationally among all the sections of society, viz. investors, businesses, researchers, environmentalists, and policymakers. The United Nations Brundtland Commission (1987) defined 'sustainability' as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." It aims to ensure that the needs of the three Ps i.e., people, planet, and profit, are balanced. To ensure sustainable development in future for the betterment of all, it is inevitable to pursue an integrated approach that deliberates on environmental

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and social issues while aiming at economic development. ESG is one of the significant steps to accomplish sustainable development goals to improve people's lives worldwide and protect them from the hazardous effects of climate change. ESG stands for environmental, social and governance. It is commonly called sustainability. The environmental issues refer to biodiversity, green energy, renewable energy, waste management, air pollution, water management and so on; social factors cover namely, inclusiveness, gender equality, human rights, working conditions and community relations; and governance factors relate to transparency in business reporting, the formation of the board of directors, ethical business practices and legal compliances. In a business context, ESG refers to a framework or a set of specific criteria that are applied to evaluate an organization's performance in terms of its impact on climate protection, social harmony and good governance practices. It can be said that ESG is a quantifiable measurement of a business practices sustainability in three areas, namely, environment, social and governance, based on well-defined metrics. Thus, sustainability is a broader concept that deliberates on the interdependence of environment, society, and economic factors holistically while ESG is one of the steps to accomplish it.

Further, besides the environmentalists and business communities, investors are also increasingly becoming more aware of climate protection. And many investors are sensitive to social and ethical issues too, particularly the young and educated ones belonging to middle and high-income groups. They are ready to sacrifice some returns in favour of ESG goals (Shrlber, Todd, 2023). They believe that corporates doing well on ESG criteria are less risky and better for the long term. Moreover, the financial investment preferences of younger generations: Gen-X and Millennials are changing as compared to Baby Boomers. Younger investors' choices are more inclined to invest in index funds, ETFs, hedge funds, ESG funds, and cryptocurrency (Hohwald, Sarlota, 2023). Thus, ESG, or commonly known as sustainability, is another dimension many investors consider while selecting investment securities, along with the traditional criteria of risk and returns. The investors opting for ESG investment, that is also commonly called socially responsible investment (SRI) or value investment, expect not only value from their investments in terms of risk and return parameters but also seek values for the benefit of the environment and society for the long term in the future.

In India, however, ESG investing is an emerging concept gaining prominence gradually. Various market participants in the country have generated interest and started considering ESG factors while investing. The ESG investing culture is on the rising path in India as indicated by the fast-growing pace of nine active ESG funds in India, with aggregate AUM standing at about Rs. 9,986 Crores at present (Soni et al.; Hemanshi, 2024). Further, more ESG-inclined investment is estimated to be popular in India in the next few years, as per the study conducted by Avendus Capital. They projected that by the year 2051, ESG investments in India will reach approximately 34 percent of total domestic AUM moving along with India's Net Zero target for 2070. The driving force for such expected growth being spur in sectors, namely. green energy, green hydrogen, renewable energy, solar energy, climate technology and electric vehicles. (Source: www.avendus.com/India/newsroom)

The proliferating significance of ESG investing worldwide motivated us to investigate the sustainability scenario in Indian financial market. On other words, how does the sustainability index perform in comparison to the benchmark index on risks and returns criterioa; and how do they associate with each other in short- and long-term. To examine this hypothesis, we conducted a study in the past by considering the NSE 100 ESG index as representative of the sustainability index and the NSE 500 index as a market proxy of the Indian Economy. The prior study failed to identify any cointegration relationship in long-run between the ESG and market indexes pertaining to the National Stock Exchange (NSE). However, a short run bi-directional

casualty was identified between the indices in the (Sharma, N. & Shahani; R., 2022). After gathering the research outcome on this issue from our past study that was based on samples drawn from the NSE, we became curious to examine the same hypothesis by taking the samples from the oldest stock exchange of India i.e., the Bombay Stock Exchange (BSE). Hence, our encouragement to conduct this research is to explore if our past study results on the relationship between the ESG and market indices are similar when the indices pertain to different Indian stock markets.

The study has practical implications as the performance of the ESG index helps the impact investors and fund managers navigate and assess the companies' ESG risks against the ESG parameters. Further, a benchmark index reflects the market's overall performance as investors perceive it. To compare the performance of the two indices, in this study, we consider the sustainability index viz., the BSE 100 ESG Index that tracks the performance of the companies included in the BSE 100 index of the Bombay Stock Exchange (BSE) and also comply ESG criteria. As of October 31, 2024, there are 54 such companies in this index (source: www.asian index.co.in). This index was launched on October 26, 2017, hence, our study period in this research starts from January 1, 2018, until September 30, 2024. The BSE 100 index, a broad market index of BSE, is used as the benchmark index in this study. It is a barometer of Indian economy that reflects the financial health of the economy by tracking and measuring the 100 largest and most liquid companies within the domain of S&P BSE large and mid-cap (it was launched on January 1, 1986, with a base value of 100 points). Thus, BSE 100 is a benchmark index reflecting the performance of the Indian economy. While the index, BSE 100 ESG is skewed towards the firms with high score on positive impact on environment, society and governance. In other words, the ESG Index is structured to assess the performance of securities that satisfy the ESG criteria and also having a risk/reward profile analogous to that of its benchmark index , the BSE100.

Further, empirical evidence on the association or co-movement of the ESG and market indices is of interest to the individual investors, as well as to the organizations, and institutions engaged in financial securities investment and connected to the stock market. For exploring this relationship, we applied cointegration analysis which is an essential statistical tool to understand the dependence and the degree of association or linkages in the long run between different assets, stocks, commodities, financial markets and sub-markets. The notion of cointegration explains the situation when two or more variables follow random walks, which means each of them individually is nonstationary. However, there may exist a combination of such variables, which is stationary (Handbook of Statistics, 2020) (Source: www.sciencedirect.com). We substantiate this theoretical proposition by conducting an empirical investigation into the trend, patterns and relationship between the sustainability index and benchmark index in India by taking the sample from the BSE. Moreover, the knowledge of interlinkages of the two variables is significant for investors and fund managers to comprehend the spread dynamics in pair trading. And they can work on their portfolio strategy accordingly. Though many studies have examined the association between sustainability investment and stock markets, most of them focused on developed and other emerging markets, and there is not enough research work has been seen with focus on Indian markets. Furthermore, the available literature in the Indian market has generally considered the study variables from the National Stock Exchange, including the one by Shahani R. and Sharma N., (2023). This study aims to capture if the sustainability index and market index show cointegrating behaviour or not in the long run by using the sample from the different markets, i.e., the Mumbai Stock Exchange in India.

The rest of the paper is presented as follows: Section 2 reviews the concerned literature. Section 3 specifies research data, and methodology. Section 4 contains the data's distribution characteristics. Section 5 deals with methodology and testing hypotheses. Section 6

explains the study results. Finally, section 7 provides the conclusion and implications.

2. Literature Review

Plenty of research is conducted on sustainable investing evaluating along different dimensions, assets, indexes, and markets over varied periods using various techniques. Notably, there is no consensus on research findings when comparing the performance from sustainability investment to traditional investment.

Some studies focused on assessing whether investors achieve superior returns from ESG stocks compared to traditional investing. According to Alexander and Buchholz (1978), there was not any significant connection between the returns of the stock market and socially responsible stocks using CAPM approach. Similar results were noticed by Atz et al. (2023), who studied 1,141 peer-reviewed research and 27 meta-reviews that were published during the years 2015-2020 and concluded that returns obtained from ESG investing were not better than that from traditional investing. Likewise, Hornuf, L. and Yuksel, G. (2023), when evaluating the social responsible investing using meta-analysis, found that SRI neither underperformed nor outperformed the benchmark portfolio, on average. On the contrary, they noticed that global SRI portfolio performance was superior to regional sub-portfolios. Further, Torre, M.L. et al.'s (2020) study also did not support the view that companies with ESG scores report more alpha returns and lower volatility. They concluded this by examining the effect of ESG criteria on equity returns of the corporates from the Eurostoxx50 index during 2010 -2018.

In contrast, Ashwin, N.C. et al. (2016) identified that stocks of the 157 corporates that were included in the Dow Jones Sustainability Index (DJSI) and practiced ESG criteria, generated higher returns, and they were less volatile comparable to their peers belonging to the same industry but not listed in DJSI; and ESG factor affected each industry differently. Ouchen's A. (2022) study also supported the similar evidence. He empirically evaluated the volatility in the ESG portfolio and compared it with benchmark portfolio volatility. He examined returns (based on daily data) of the ESG portfolio "MSCI USA ESG Select" against the market portfolio "S&P 500" returns during the period 2005-2020 using the Markov-switching GARCH approach, including and excluding the COVID-19 period in the time series. They identified that the ESG portfolio reflected less volatile behaviour than the benchmark portfolio.

Interestingly, Kabderian Dreyer, J. (2023) observed inconsistent results as their study neither supported underperformance nor superior performance on account of pursuing ESG practices. They investigated the influence of ESG oriented strategies on stock prices of the corporates in the US market over the period 2000 - 2020. Based on risk-adjusted returns, they concluded that the ESG brand did not result in significant influence on the financial performance.

At country-level comparison, Moosawi, S., & Segerhammar, L. (2022) examined the cause-effect relationship between the ESG assets and traditional benchmarks by using the GARCH model and the Spillover approach for both returns and volatility. They identified that the country-level ESG indices were more interlinked than other assets. And country-level ESG indexes were spillover transmitter to a greater extent to the MSCI world ESG and equity indices, gold, currency, and crude-oil.

Further, the literature examined the cost of SRI and the influence of negatively screened investment strategy on financial performance. Adler and Kritzman (2008) found that investors of sustainable funds had to sacrifice returns somewhere between 0.17-2.4 % due to restrictions imposed on investment in certain sectors' stock, often called sin stocks. The constrained environment also led to greater volatility caused by enhanced sensitivity to systematic risk. Another Mousa, M. et al. (2022) examined the impact of COVID-19 on equity market performance during March 2019 and March 2021 in the Arab region and also compared

the reactions of ESG and equity stocks during the COVID-19 pandemic period using GARCH and non-linear ARDL models. They concluded that in the ESG market the pandemic shock was short lived without affecting much of its performance. Moreover, while comparing socially responsible mutual funds with conventional funds, Hamilton S. et al. (1993) identified that former funds did not outperform the latter. Rather the performance of SRI funds was similar to that of the traditional funds.

One of the latest studies on ESG index performance by Kossentini, Hager, et al. (2024) showed that the Emerging Market (EM) Europe ESG leaders index was less volatile in comparison to the benchmark index based on static analysis. Meanwhile, based on the dynamic analysis they found that Capital Asset Pricing Model (CAPM) alpha and beta were time sensitive. Based on the rolling window (annual) analysis, they concluded that the FM Europe ESG Leaders index outperformed the benchmark by being less risky and yielding better performance.

Thus, numerous studies have deeply explored financial performance and sustainability, SRI investing, and meta-analyses on corporate social responsibility and ESG funds performance. However, the extant literature provides largely diverse and somewhat inconsistent results. The inconclusiveness may be due to different methodologies, geographical locations, sample choices, and timeframes. Interestingly, the industry research by investment firms, bankers or sell-side analysts often presents a positive influence of ESG practices on financial performance of the corporates. For instance, a study on "ESG from A to Z: a global primer" by Bank of America and Merrill Lynch (2019) and "ESG Investing" by J.P. Morgan (2016) identified a positive correlation between ESG and performance. Whereas academic research generally found a negative correlation.

Furthermore, most of the research comes from developed stock markets and some focus on developing economies and interlinkages between these markets. In India, the sustainability movement is in the air and evolving rapidly, providing a vast ground for research on ESG-related issues, including investment aspect. Hence, more empirical studies in the Indian context are required to expedite ESG culture in India among businesses and investors for the betterment of the future for all. This study is an attempt in this direction and intends to contribute to the existing literature by serving further empirical evidence on interlinkages between ESG and market indices in India. While further continuing our research on the issue we considered the data sample from another stock market to test if the findings confirm in the Indian market.

3. Research Data and Methodology

The study initiates with the research question: How does the returns on sustainability index correlate with benchmark index in the long run in Indian market? And does any causal relationship exist between the two indices? In light of such research questions, the aim of this study is to identify and investigate the cointegrating behaviour and the causal relationship between the ESG index and equity index in India financial market. For this research, data set comprise of the two samples taken from the Bombay Stock Exchange (BSE), viz., BSE 100 ESG index and BSE 100 index. The former representing the sustainability index and the latter is the proxy of market index. Data of the study consist of daily closing price of the two indices downloaded from the BSE website spanning over the period 1 Jan. 2018 to 30 Sep. 2024 (Source: www.bseindia.com).

To accomplish the research objectives, we considered the following hypotheses:

(1) H0: No cointegration between the ESG and BSE index in long run.

H1: Yes, there is cointegration between the two in the long run.

(2) H0: No causality relation between the ESG index and BSE index in short run.

H1: Yes, there is causality relation between the two in the short run.

Methodology:

Research methodology consists of developing a model and testing it for cointegration and causal relationships between the returns on ESG and Market index.
Initially a simple regression model was formulated as below:

$$Ret_{Bse_t} = \beta_1 + \beta_2\, Ret_{Esg_t} + \mu_t \ \ldots (1)$$

It was improved to satisfy the model diagnostics and the final model developed is as below:

$$Ret_{Bse_t} = \beta_1 + \beta_2\, Ret_{Esg_t} + \beta_3\ Ret_{Esg_{t-1}}$$

$$+ \beta_3\, Ret_{Bse_{t-1}} + \beta_4\, Ret_{Bse_{t-2}} + \mu_t \ \ldots (2)$$

The long run association between the returns from the two indices: ESG index and market index is examined by applying two popular tests on the model viz., Engle Granger and Johansen cointegration methods. While the Granger causality test in VAR (Vector Autoregressive) is applied to examine the linkages between the two variables in short run. Before proceeding on statistical analysis, a summary statistic of the distributions is computed to comprehend the characteristics of the collected dataset and presented in Table1 below. And stationarity test of both the time series is checked by employing a famous unit root test, viz., Augmented Dickey-Fuller (1984) Test. Finally, model diagnostics tests: no serial correlation, no heteroscedasticity of residuals and stability are also performed.

4. Distribution Characteristics

4.1 Descriptive statistics

This section summarises the statistical characteristics of the data sets with the help of central tendency, dispersion and the patterns of distribution. And present the comparative assessment of the two-time series, i.e. Returns on the BSE 100 Index and BSE 100 ESG index. For this, daily closing prices of the indices have been transformed into the log returns by using the formula: $\ln\left(\frac{P_t}{p_{t-1}}\right)$, where refers to the daily closing price of index on day 't', whereas, is daily closing price of same index on day 't-1' .The price data have been transformed to returns series to facilitate comparison between the variables along various parameters as displayed in Table 1.

Table 1: Statistical Description of Daily Returns of the BSE and ESG indices

Statistics	BSE Index	ESG Index
Mean	0.000547	0.000565
Std. Dev.	0.011201	0.011345
C.V.=σ / μ	20.47715	20.07965
Skewness	-1.646872	-1.468008
Kurtosis	25.15027	23.27718
Jarque-bera	34915.76	29227.48
JB (Prob.)	0.00000	0.00000
Observations	1671	1671

Source: Author's computation using 'EVIEWS' software.

Table 1 shows that the daily average return on ESG index (μ = 0.000565) is slightly higher than BSE index (μ = 0.000547). But it is accompanied with little higher risk (σ = 0.01135) than in case of BSE index (σ = 0.01120). It points out that investors in India consider ESG little riskier investment. Interestingly, another metrics of dispersion, coefficient of variation (σμ that adjusts returns for associated risk measures risk-return trade off slightly in favour of ESG index as the difference is not major. The coefficient of variation (σ/μ) for ESG index (C.V. = 20.08) is a bit lower in comparison to BSE index (C.V. = 20.48). Thus, the results of measures of central tendency and dispersion, indicates that ESG investing is slowly gaining acceptance among investors in Indian securities market. The distribution characteristics of both the series show that they are negatively skewed and have fatter tails as indicated by higher Kurtosis value (>3) than in case of normal distribution. Finally, the JB Normality test: *JB* = { + }, where 'n' is the number of observations, 'S' is the

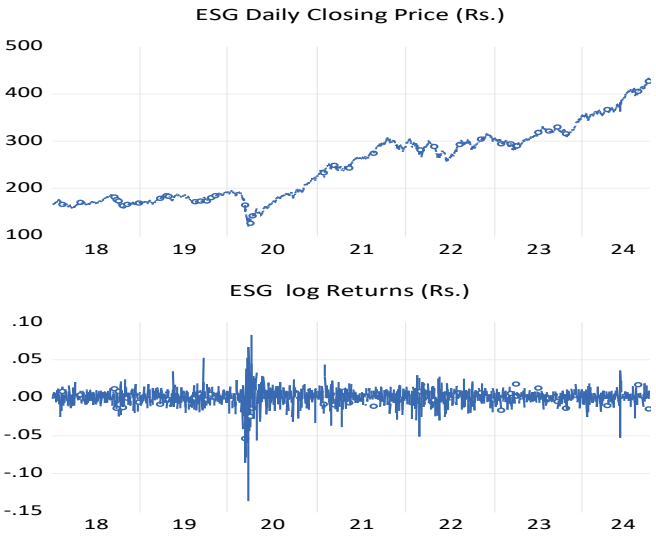
skewness and 'K' is the Kurtosis; also confirms that the series are not normally distributed. It reveals a larger impact of outliers, especially during COVID-19 period.

4.2 Graphic representation

Initially to comprehend the pattern and structure of data, we visualised the data time series through plotting a line graph of both the variables: ESG and BSE indices in daily closing price as well as log returns as below.

Figure 1:

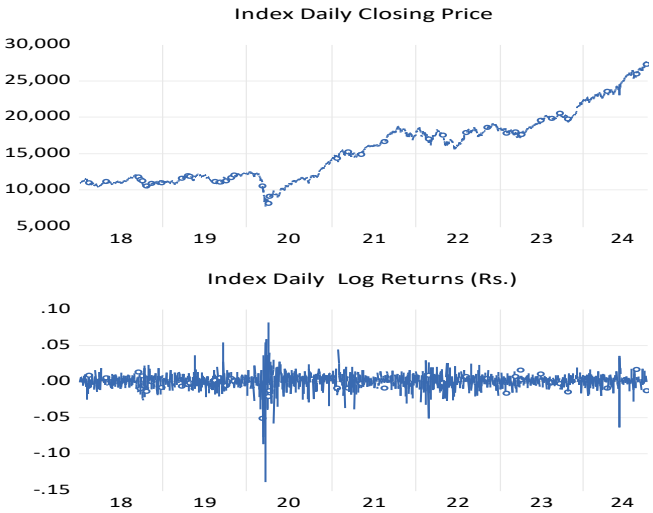
Daily Price and Returns series of ESG index



Source: Author's computation using 'EVIEWS' software

Figure 1:

Daily Price and Returns series of BSE index



Source: Author's computation using 'EVIEWS' software

The first graph in Fig. 1 and 2 show that daily closing price series of both the indices are reflecting overall increasing trends over time except with major downfall during COVID-19 period. And it appears that mean of the closing price distribution of both the variables is non-constant over the period reflecting non-stationary series. However, the second graphs in both figures presenting the daily log return series for both the variables show the mean reverting tendency of the data indicating stationarity of the return series. The impact of covid-19 is quite visible from the sharp fall of the price series and high spikes of return series in case of both the indices.

5. Results and Discussions

5.1 Unit Root Test:

Before to build the model and analyse the time series, we checked if each series is stationary. For this a unit root test was done using Augmented Dickey-Fuller (ADF) method. The Null hypothesis is that the data has a unit root (non-stationary) against the alternative hypothesis that the data is stationary. The ADF test results are shown in Table 2 as below:

Table 2: Augmented Dickey-Fuller Test Statistics (Unit Root Test)

Stationarity Test (Constant, Linear Trend)	BSE index Close Price (₹)		ESG Index Close Price (₹)	
	Level	First Difference	Level	First Difference

H0: Data is Non-Stationary / Presence of Unit Root H1: Data is Stationary/ No Unit Root	1. Coefficient 'P' Values	0.8786	0.0000*	0.7303	0.0000*
	2. Table Results	-1.3354	-16.7669	-1.7461	-16.8977
	3. Null H (Accepted/ Rejected)	Accepted	Rejected	Accepted	Rejected
	4. Critical Value at 5%	-3.4125	-3.4125	-3.4125	-3.4125

Source: Author's computation using 'EVIEWS' software. (Criterion: AIC)

Table 2 shows that in case of the BSE index time series the coefficient p-value (0.88) is close to one indicating likely presence of a unit root. Similarly, the coefficient p-value (0.73) for ESG index distribution is close to one, again indicating the likely presence of a unit root. The results fail to reject the null hypothesis suggesting the series is non-stationary at level, in case of both the variables. However, at first difference in case of satisfies the test of stationary as the coefficient p-value closer to zero results in the rejection of the null. Thus, ADF test concludes that both the time series are stationary at first difference, I (1) paving the way for further analysis.

5.2 Engle Granger Co-integration Test

Initially we applied Engle Granger co-integration method (1987) to explore the long run association between the two indices. It is commonly called the test of residuals involving two steps: in the first step, we generate residuals from linear regression equation of the two variables and then apply ADF unit root test on the residual's equation. The null hypothesis (Ho) of this test considers no cointegration among the residuals.

Table 3: Co-integration Test Results: Engle Granger Method

Dependent Variable	Tau-statistics	Prob.	z-statistics	Prob.	Result
ESG Index Returns	-14.13481	0.0000*	-2612.596	0.0000*	Null Hypothesis rejected
BSE Index Returns	-9.596252	0.0000*	-1893.600	0.0000*	

Note: (1) Null Hypothesis: Series are not cointegrated. (2) Lag Criterion: AIC. (3) Number of observations: 1671. (4) Source: Author's computation using 'EVIEWS' software.

Table 3 presents both Tau- and Z-statistics for ESG and BSE indices along with the probability values signifying the rejection of the null hypothesis. Hence, this method concludes that both the indices are cointegrated in the long run.

5.3 Johansen Co-integration Test

We further employ another cointegration method using Johansen approach to assess the long-run association between the ESG and BSE indices with assumed hypotheses as below:

H0: No long-run linkages between the ESG and BSE indices.

H1: long-run linkages exist between the ESG and BSE indices.

This is a VAR based technique and consider all variables endogenous and does not require assumptions. The results are presented in Tabe 4.

Table 4: Co-integration Test Results using Johanson Methodology

(A) Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistics	0.05 Critical value	Prob.	Result
No co-integration exists	249.3803	15.49471	0.0000*	Null Hypothesis Rejected
One co-integration	105.1697	3.841465	0.0000*	

Note: (1) Model: Linear Deterministic Trend but no Intercept. (2) Lag interval: 1 to 13. (3) N= 1657 after adjustments. (4) Source: Author's computation using 'EVIEWS' software

(B) Unrestricted Co-integration Rank Test (Max Eigen Value)

Hypothesized No. of CE(s)	Max Eigen Statistic	0.05 Critical value	Prob.	Result
No co-integration exists	144.2105	14.26460	0.0000*	Null Hypothesis Rejected
One co-integration	105.1697	3.841465	0.0000*	

Note: (1) Model: Linear Deterministic Trend but no Intercept. (2) Lag interval: 1 to 13. (3) N= 1657 after adjustments. (4) Source: Author's computation using 'EVIEWS' software

(c) Normalised Cointegrating Coefficients (Long run results)	
BSE Index	ESG index
1.0000	Coefficients: -0.940419
	S.E.: (0.01000)
	Z-Statistics: {94.0419}

Source: Author's computation using 'EVIEWS' software

Table 4 presents the two cointegrating equations; None: No cointegration, at the most one: no cointegration at the most one (at 5% significance level). The 'p' values for both the equations in case of the Trace as well as the Max Eigen Value tests are less than 0.05 revealing the results are significant and rejects the null hypothesis. Hence this test results also supports the presence of long-run equilibrium between the two indices. Further, the normalised cointegrating coefficient results show that in long run ESG index has a positive impact on the BSE index, on average, ceteris paribus. And, the coefficients are found statistically significant at 1% level of significance (Z-statistic: 94.04, p-value< 0.0001).

5.4 VAR Causality Test

After identifying the co-movement of the ESG and BSE indices over the long period. We try to capture if the cause-effect relationship exists between these indices in the short run. For this, we apply the test of Granger causality that is based on Vector Autoregression (VAR). Though VAR based model incorporates the lagged (past) values of an endogenous variable as well as the past (lagged) values of the other variables and an error term. And. it does not require prior assumptions of the model. However, this test is sensitive to the variable's lag order. Hence, first we determine the optimal lag order as presented in Table 5 below and then employ the Granger causality method showing its results in the following table.

Table 5: Lag Order Selection Criteria for VAR Model

Lag	FPE	AIC	SIC	HQ
0	2.88e-10	-16.29212	-16.28557*	-16.28970*
1	2.88e-10	-16.29396	-16.27430	-16.28667
2	2.87e-10	-16.29548	-16.26272	-16.28334
3	2.88e-10	-16.29188	-16.24601	-16.27487
4	2.88e-10	-16.29296	-16.23398	-16.27109
5	2.85e-10	-16.30213	-16.23005	-16.27998
6	2.83e-10	-16.31157	-16.22638	-16.27928
7	2.81e-10	-16.31572	-16.21743	-16.27928
8	2.80e-10	-16.32081	-16.20942	-16.27951
9	2.79e-10	-16.32301	-16.19851	-16.27685
10	2.79e-10	-16.32408	-16.18648	-16.27306
11	2.78e-10	-16.32847	-16.17776	-16.27259
12	2.79e-10	-16.32438	-16.16057	-16.26365
13	2.76e-10*	-16.33474*	-16.15782	-16.26914
14	2.76e-10	-16.33370	-16.14368	-16.26325
15	2.77e-10	-16.33179	-16.12866	-16.25648
16	2.77e-10	-16.33037	-16.11414	-16.25020
17	2.78e-10	-16.32880	-16.09946	-16.24378
18	2.76e-10	-16.33379	-16.09134	-16.24390
19	2.77e-10	-16.33134	-16.07579	-16.23659
20	2.77e-10	-16.33080	-16.06216	-16.23121

Source: Author's computation using 'EVIEWS' software

Table 5 details the optimal lag order as per the four criteria: Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Criterion. We considered the optimal lag order 13 as suggested by both the FPE and AIC criteria for our VAR based models of causality and cointegration.

Table 6: Pairwise Granger Causality Test Results

Null Hypothesis	Observations	'F'(Computed)	Probability	Result
ESG index returns does not cause BSE index returns	1658	1.69287	0.0564	Fail to reject Null Hypothesis
BSE index returns does not cause ESG index returns	1658	1.47370	0.1197	Fail to reject Null Hypothesis

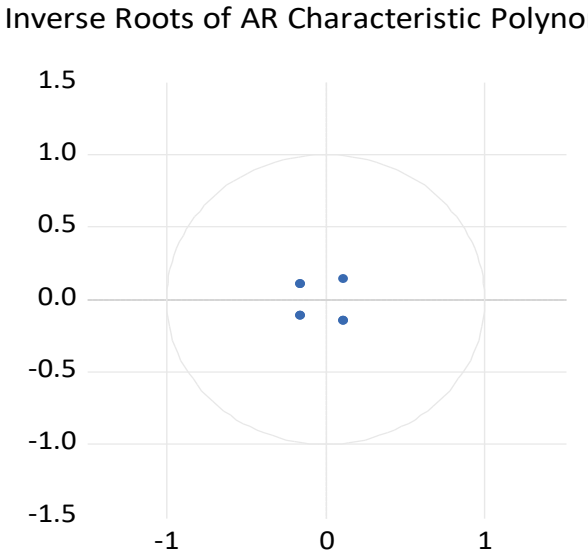
Note: (1) Lag Determination Criterion: Akaike Information Criterion (AIC). (2) No. of Lags=13. (3) Source: Author's computation using 'EVIEWS' software.

Table 6 presents the two null hypotheses of Pairwise Granger Causality Test: (1) H0: Returns on ESG index does not cause Returns on BSE index. (2) H1: Returns on BSE index does not cause Returns on ESG index. The computed probability values for both the hypotheses is greater than the p-value (0.05) at 5% significant level. Hence, the results suggest that there is no short-term causality effect between the two indices. In other words, in short run neither ESG index causes variability in BSE index returns nor the BSE index returns effect the ESG index returns in short.

5.5 VAR Model Stability test

We test the stability of the VAR model by constructing an inverse root of AR characteristic plot as shown below:

Fig. 3: VAR model stability test



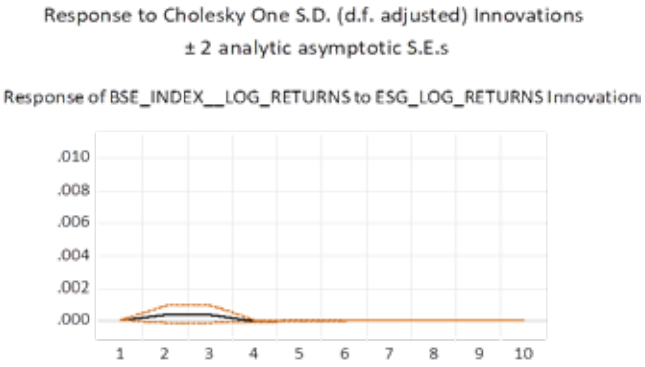
Source: Author's computation using 'EVIEWS' software

Fig.3 depicts that all the characteristic roots are within the circle in the area ± 1 clearly demonstrates the stability of the VAR model.

5.6 VAR Impulse Response

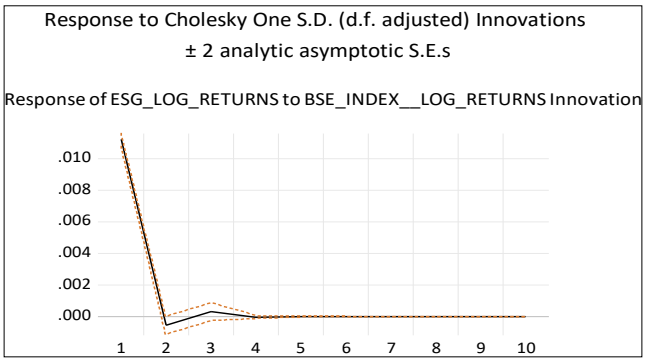
Now in fig 4 and 5 we present the plots constructed under impulse function with the objective to explain how the VAR models' dependent variable reacts to a unit shock (1 S.D.) applied to the other variable.

Fig.4: Impulse response of Index to ESG



Source: Author's computation using 'EVIEWS' software

Fig.5: Impulse response of ESG to index



Source: Author's computation using 'EVIEWS' software

Fig. 4 shows that a positive shock to ESG leads to a slight positive response to BSE, but it quickly dies out in one or two days. And Fig. 5 reflects that a unit shock in BSE leads to sharp negative decline in one day, but it rises soon and stabilises immediately in next day or two at the most. It concludes that the shock fades away shortly and does not persist reflecting that ESG investors do not get panic for long for shocks in BSE as they have short term memory to these impulses.

5.7 No Serial Correlation (BGLM Test)

Independence of the error term is one of the key assumptions of the linear regression model. Hence, we check our model for satisfying this assumption, i.e. if the residuals from our regression model are serially correlated or not. For this, we apply the Breusch-Godfrey serial correlation test in the residuals of our linear regression equation. The null hypothesis of the

test states that there is no autocorrelation in the residuals of the regression model.

Table 7: Breusch-Godfrey Serial Correlation LM Test Results

Null Hypothesis: No Serial correlation				Result
F-statistic	1.357719	Prob. F (2,1662)	0.2575	Fail to reject Null Hypothesis
Obs*R-squared	2.722428	Prob. Chi-square (2)	0.2563	

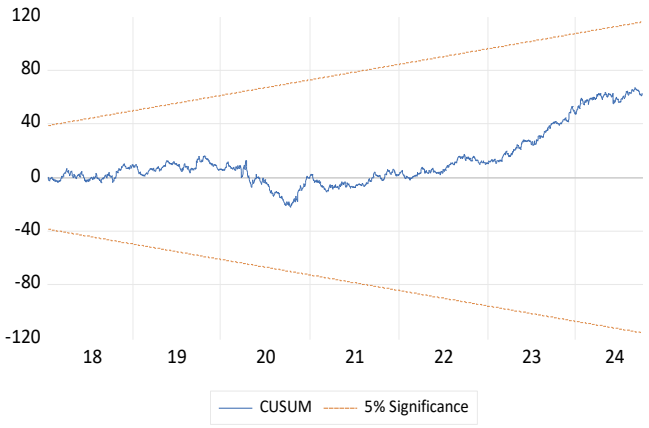
Source: Author's computation using 'EVIEWS' software

Table 7 presents that probability of F-statistics (0.2575) is greater than p-value (.05) at 5% significance level. The test results fail to reject the H-not and concludes that no serial correlation is found among the residuals of the regression model. Thus, the BGLM test results supports that the model coefficients are efficient, and model can be used for predictive values.

5.8 Model Stability (Cusum Test)

We perform the Cumulative Sum (CUSUM) test (with forward direction) to examine the model stability i.e., if the regression coefficients are stable over time. The null being regression coefficients are stable.

Figure 6: CUSUM Test Results



Source: Author's computation using 'EVIEWS' software

Figure 6 presents the V- mask CUSUM graph. It displays (Cusum statistics shown on Y-axis) that the CUSUM series lies within the critical lines (at significance level: .05) and does not cross the decision intervals. This indicates that the process mean is stable. Therefore, results fail to reject the null hypothesis of stable regression coefficients. It concludes that our model is efficient as parameter estimates are unbiased.

5.9 Homoscedastic Residuals (Harvey Test)

The homogeneity of residuals is examined for the model using Harvey method to ensure the variance among the residuals is constant across the sample. The H0: Residuals are homoscedastic as against the H1: Residuals are heteroskedastic.

Table 8: Result of Heteroskedasticity: Harvey Test

F-statistic	0.382500	Prob.F(4,1664)	0.8213
Obs*R-squared	1.533189	Prob. Chi-Square (4)	0.8207
Scaled explained SS	1.682215	Prob. Chi-Square (4)	0.7939

Source: Author's computation using 'EVIEWS' software

Table 8 displays findings of residuals diagnostic test about their homoskedasticity. As the probability of F-statistic (0.8213 > 0.05) and Chi-Square (0.8207 > 0.05) are not significant. Hence the results again fail to reject the null hypothesis. The Harvey test satisfies that no heterogeneity among the residuals of the model ensuring that model results are valid.

6. Conclusions and Implications

Worldwide, the investing community's rapidly growing awareness and sensitivity towards environmental, social, and governance issues necessitate continuous empirical research in the field of sustainability. Hence, the study aims to identify the interlinkages and causal relations between the two indexes over the short- and long run. This study analyses the performance of sustainability index represented by ESG index against one of the major benchmark indices in the Indian securities market, viz. BSE 100 Index in Bombay Stock Exchange. We first examine the risks-returns profile of these indexes and later develop a regression model and tests for prerequisites and diagnostics. It is observed that

the BSE index yielded almost similar returns but lower risk in comparison to the ESG index. It reveals that the ESG index has not delivered a performance superior to that of the BSE index. So, risk-averse investors may still prefer traditional stocks. ESG may not be an attractive choice among investors. However, a slightly lower coefficient of variation (risk-adjusted return) in favour of the ESG index gives an encouraging signal for sustainability investing among ESG-conscious investors. The study identified that the returns on two indices are cointegrated in the long run. However, the two indices have no causal relationship in the short run. The results are in sharp contrast to our previous study, which examined the cointegration and causal relationship between the NSE 100 ESG and NSE 500 market index in the National Stock Exchange of India. And no cointegrating relationship between returns from the NSE 100 ESG index and the NSE 500 index was established. However, the earlier study found short-run causality between the study variables. It indicates that ESG investing is not equally popular among all investors in India. It concludes that the sustainability concept is still in an emerging stage in the Indian economy, unlike in the developed markets where investment in ESG stocks is generally favoured by investors. Further, this research also provide evidence in line with past literature that no firm conclusion can be stated about the superior performance of the ESG investing while comparing with traditional investing.

The study results have practical implications for investors, professionals and legal institutions. The knowledge of cointegrating behaviour between the ESG and market indices is important for investors and fund managers, particularly those interested in BSE stock exchange companies, in understanding the spread dynamics in pair trading and designing their portfolio strategy accordingly and can take the positions to buy the low and sell the high. Further, the research findings can be especially helpful for index arbitrageurs and sustainability-conscious investors, who prefer index habitats and pursue passive portfolio strategies in index funds. Policymakers can also use empirical evidence of cointegration between the ESG and market indices when formulating sustainability-encouraging strategies.

The research is limited to the two index variables from the Mumbai Stock Exchange. Future research can cover a broad spectrum by considering different sustainability indices, such as green energy and green bonds, and comparing them with other stock indices in India and emerging markets.

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