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Performance Analysis of Sustainable Responsible Companies: An Empirical Study of Indian Sustainability Indices

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***Abstract*— Sustainability practices by business are being priced and reflected in its market return. Hence the index constituting those companies based on its Environmental, Social and Governance parameters are of interest for researchers to analyse such index performance. The present study investigates the performance of such three Indian indices i.e., S&P BSE GREENEX, S&P BSE 100 ESG, and S&P BSE CARBONEX which are based on better ESG risk managing stocks. For this purpose, the study analyses the return behaviour of index and calculates Value at Risk to predict the return for post covid time. The results indicate that even with a turbulent market, ESG index performance is found to be comparatively stable. VaR prediction confirms the robustness of tested VaR models for prediction. Lastly, this study concludes that including sustainable activities into business practices not only attracts more profit but also makes financial market and economy stable..**

***Index Terms*— Sustainable investment, VaR, ESG index.**

I. INTRODUCTION

Scarcity of resources has led business entities to employ resources efficiently and smartly. Such careful use of resources makes corporate social responsibility and sustainability practices more relevant to the present day. Achieving sustainable development goals has become the primary motive for the firms which want to survive in the long term. Performance analysis of such firms also has attracted the interest of researchers all over the world. The achievement in terms of SDGs or according to ESG parameter are also being included into market return and hence a separate index based on ESG activities are developed in many economies. Indian stock exchange BSE (Bombay Stock Exchange) and NSE (National Stock Exchange) also has such sustainability indices. These indices consist of companies based on their ESG parameter. Subsequently, such indices performance attracts attention of researchers (Vadithala and Gattaiah (2021), Meher et. al. (2020), Jasuja, Jaya and Nautiyal (2021), Balasubramanian (2019), Konar and Mark (2001), Statman (200), Ortas et. al. (2014) Albertini (2007)). As world market has many sustainability indices to capture the performance of listed companies on ESG parameters, Bombay Stock Exchange (BSE), a leading Indian stock exchange, also has such the three ESG parameters-based indices i.e., S&P BSE GREENEX, S&P BSE 100 ESG, S&P BSE CARBONEX. These three Indices reflect the performance of companies based on its Environmental, Social and Governance (ESG) score (Lata & Kumar, 2021). The S&P BSE Greenex is designed to measure the performance of the top 25 “green” companies in terms of greenhouse gas (GHG) emissions, market cap and liquidity. The S&P BSE CARBONEX, the first index of its kind in India, tracks the performance of the companies within the S&P BSE 100 index based

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on their commitment to mitigating risks arising from climate change (Lata & Kumar, 2023). The index was created to address market demand for a sophisticated approach to portfolio management incorporating climate change risk and opportunity. The S&P BSE 100 ESG Index is designed to measure securities that meet sustainability investing criteria while maintaining a risk and performance profile similar to the S&P BSE 100. Primarily, BSE Greenex is a comprehensive index based on sustainability performance of all listed stock on Bombay Stock exchange, whereas the other two indexes i.e., BSE Carbonex and BSE 100 ESG exclude stocks based on their ESG performance.

The literature review suggest that there are few studies that have explored the performance of these three indices exclusively. Bhattacharya (2013) evaluates the performance of BSEGREENEX in comparison to the other two BSE indexes and also predicts return of these three indices for a short time period. This study confirms that there is additional financial reward for investors to invest in green stocks and BSE-GREENEX is found to be slightly more predictable other two indexes. Swalih & Vinod (2017) studies BSE Greenex listed stock for four years and predicts how safe are those stock for investing based on its Altman-Z score to assess corporate financial problems. Vanitha & Priyangha (2017) analyze the stock prices between the pre and post listing 110-day window periods for GREENEX on BSE listed companies. Their study suggests that better ESG performing companies outperform other companies in the long term. Patel & Kumari (2020) examines BSE Carbonex and BSE Greenex performance vis-à-vis other market index BSE Sensex & BSE 500. They conclude that there is similarity in performance of BSE Carbonex and BSE Sensex and BSE 500 whereas BSE Greenex slightly underperform than BSE Sensex and BSE 500. Kaur & Chaudhary (2022) employ Cointegration test, Vector Error Correction Model (VECM) and Variance Decomposition analysis to examine the relationship between BSE Carbonex and macro-economic variables. They conclude the existence of co0integreton between sustainable index BSE Carbonex and studies macro-economic variables. Sharma (2022) studies BSE Greenex performance for post-covid time. This study concludes the stability of index return over market return. Sharma et. al. (2023) assesses the impact of macroeconomic variables on Indian ESG based indices. Their study includes analysis of BSE Greenex & BSE Carbonex indexes. They conclude that apart from Wholesale Price Index other macro-economic variables i.e., Industrial Index, Real Effective Exchange rate, M3 and Crude oil price impacts both BSE Greenex and BSE Carbonex, whereas Wholesale Price Index only impacts BSE Greenex. Deshmukh et. al. (2022) examines impact of black swan events on sustainable index i.e., BSE Greenex and BSE Carbonex vis-à-vis market index i.e., BSE Sensex. They employed GARCH model to capture volatility of these three indices.

The mentioned studies have explored the performance and/or relationship of BSE Greenex and BSE Carbonex vis-à-vis other market indexes or macro-economic variable but none of these studies has analyzed the performance all three BSE sustainability indices. This gap in literature has framed the research objective of the present study as the performance analysis of all existing sustainability BSE indices enables comments on viability of sustainable business activities in terms of financial return.

Hence, the present study investigates all the ESG based indices of Bomabay Stock Exchange performance by modelling risk with different Value at Risk (VaR) method. VaR calculation is employed to profile risk for investors. This study integrates results for index performance and VaR calculations to comment on overall evaluation of index.

II. RESEARCH METHODOLOGY

The study employs daily closing prices from January 2021 to December 2022 for analysis. This time frame is chosen to study the most recent impact on index performance after pandemic as 2021-22 is marked with declining phase of covid and return phase to normal market situation.

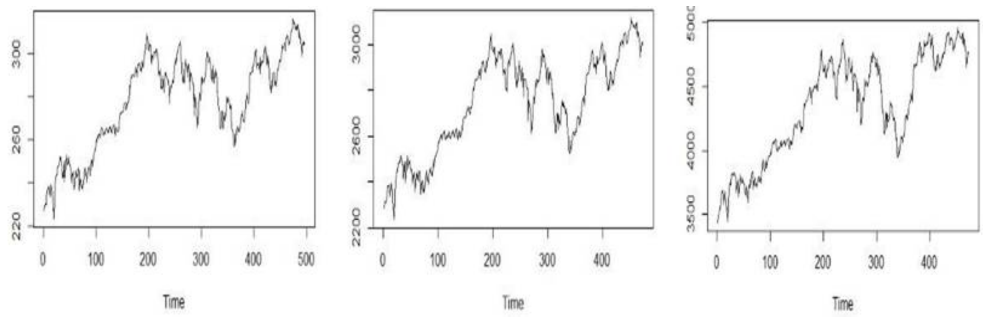

Figure 1 Close Price series (a) BSE 100 ESG (b) BSE Carbonex (c) BSE Greenex

Figure 1 and table 1 show the distribution properties of all three indices price series. It can be observed from the price chart of all three indices that it is not a normally distributed time series as a bell shaped curved can't be fit rather it has fat tail. Table 1 shows descriptive statistics of all three indices closing series. It is evident that Mean, Median and mode are found to be inequal and non-zero, and kurtosis and moment found to be negative for all three indices series data. Hence, the results presented in table 1 also confirm that the closing price of all three indices are not normally distributed. These three price-series are further converted into return series by taking log difference of two consecutive days. For remaining of the study, we use return series instead of price series for data analysis. These three return-series are further checked for normality, stationarity, and serial correlation. Based on time series properties of all three indices return series, the study fit Value at Risk (VaR) models to compare and analyze indices' performance.

TABLE 1. DESCRIPTIVE STATISTICS

	BSE 100 ESG	**BSE CARBONEX**	**BSE GREENEX**
Mean	277.8615	2741.4795	4341.4682
Standard Error	0.9839	9.8030	18.4792
Median	283.9100	2782.8350	4411.8700
Mode	290.1800	2601.0000	#N/A
Standard Deviation	21.9133	213.4254	402.3215
Sample Variance	480.1908	45550.3963	161862.5539
Kurtosis	-0.8065	-1.0048	-1.1109
Skewness	-0.4983	-0.3486	-0.3592
Range	92.5700	878.2800	1520.7000
Minimum	223.2700	2234.7900	3434.5500
Maximum	315.8400	3113.0700	4955.2500
Sum	137819.2800	1299461.2800	2057855.9200
Count	496.0000	496.0000	496.0000

III. DATA ANALYSIS & FINDINGS

Results of data analysis for employed research methodology are explained in this section. The statistical tests for normality, serial correlation, stationarity, ARCH effect, value at risk calculation and back-testing employed in the present study is described as follows:

A. Stationarity of data

The analysis starts with checking the stationarity of data to ensure the reliability of results. The study employs ADF Test (Augmented Dickey Fuller test) which is a popular statistical test to check if a data is stationary or not. Table 2 summarizes the results of the stationarity test at 95% confidence level. Evidently the results confirm the stationarity of data for all three indices return series.

TABLE 2. ADF TEST

	BSE 100 ESG	**BSE CARBONEX**	**BSE GREENEX**
P Value	0.01	0.01	0.01
Null Hypothesis	Non stationary	Non stationary	Non stationary
Decision	Reject	Reject	Reject

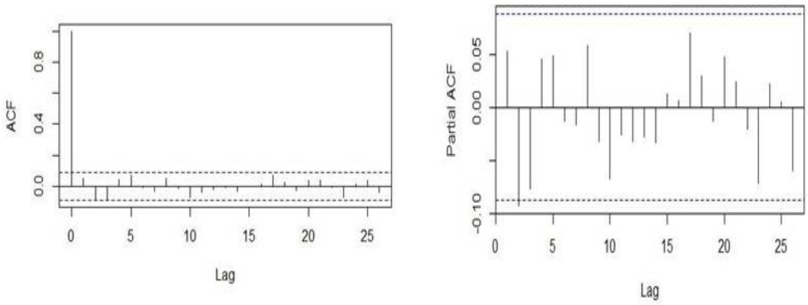

Figure 2 (a) ACF & PACF of BSE 100 ESG

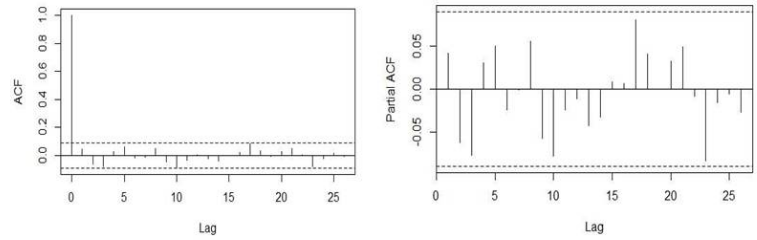

Figure 3 (b) ACF & PACF of BSE Carbonex

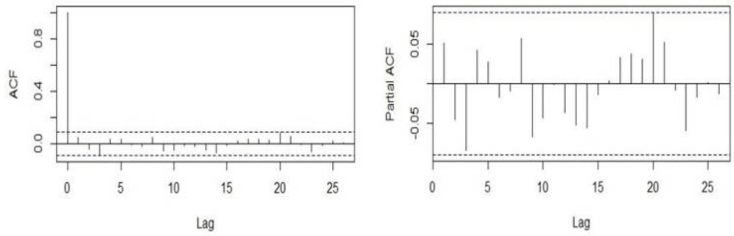

Figure 4 (c) ACF & PACF of BSE Greenex

The study also calculates Autocorrelation (ACF) and Partial-autocorrelation (PACF) plot to detect stationarity in all three return series data. Figure 2 (a), Figure 2 (b) and Figure 2 (c) show autocorrelation plot for BSE 100 ESG, BSE Carbonex and BSE Greenex. It can be observed from ACF plot of all three indices that return series is stationary at higher lag. Hence, at lag one return series can be stationary. Partial-autocorrelation (PACF) plot for all three-return series does not have unit root that also confirms the stationarity of data at higher lag. Hence, ACF and PACF plot indicates that all three return time series are stationary.

B. Serial Correlation

The study employs the Box-Pierce test to detect serial autocorrelation in return time series at 95% confidence level for different lags. This test analyses the time series to know whether or not errors are independently and identically distributed (i.e. white noise) or does serial autocorrelations exist in the errors or whether residuals of time series are non-zero. Table 3 summarizes the results of serial correlation test. It is found that all three return time-series is serially correlated.

TABLE 3. BOX-PIERCE TEST

	BSE 100 ESG	**BSE CARBONEX**	**BSE GREENEX**
P Value	0.2394	0.3634	0.2604
Null Hypothesis	No serial correlation	No serial correlation	No serial correlation
Decision	Do not reject	Do not reject	Do not reject

C. Normality of data

Jarque-Bera test is used to check normality of data. It checks whether the kurtosis is higher than 3 and mean, median and mode is 0 for data or not which ultimately a test for checking whether time series is normally distributed or not. Table 4 summarizes the results of this test that confirms that at 0.05 significance level all three return time-series are found to be not normally distributed. Therefore, any statistical test which assumes data to be normally distributed can’t be employed for such time series.

TABLE 4. JARQUE-BERA TEST

	BSE 100 ESG	**BSE CARBONEX**	**BSE GREENEX**
P Value	2.20E-16	2.20E-16	2.20E-16
Null Hypothesis	Normal distribution	Normal distribution	Normal distribution
Decision	Reject	Reject	Reject

D. Value At Risk

Value at risk (VaR) calculates the maximum losses with given probability which can occur over a certain time period. Hence, VaR can be seen as the value loss that should not be exceeded for that certain time period given the confidence level. VaR also consider the magnitude of loss if actual losses exceed the expected loss. Therefore, VaR can be seen as a parameter which helps investors to take investment decision and also signifies the health of given stock or index. The present study employs historical simulation VaR, Parametric VaR and Extreme Value Theory VaR model as explained below:

Historical Simulation

There are different types of methods for value at risk calculation. Each such method has sets of assumptions also. As none of the three time-series has been tested as normally distributed, the study employs the historical simulation method for VaR calculation which does not assume data to be normally distributed. The simulation is run for different confidence intervals i.e., 95% and 99% for all three indices time series.

TABLE 5.HISTORICAL SIMULATION

BSE 100 ESG			BSE CARBONEX		BSE GREENEX	
Alpha	95%	99%	95%	99%	95%	99%
VaR_HS	18.2054089	29.48445	31.79729	16.297264	18.6642	34.0516

Parametric VaR

Both return series of indexes are not normally distributed. Hence, mean and variance equation of series can't be modelled based on normality assumptions. Literature suggests that GARCH model adequately captures the properties of not normally distributed time series, hence GARCH model can be employed to calculate VaR for these series as well (Balkema & Laurens 1974). Before employing the GARCH model, both return series are checked for volatility clustering and ARCH effect.

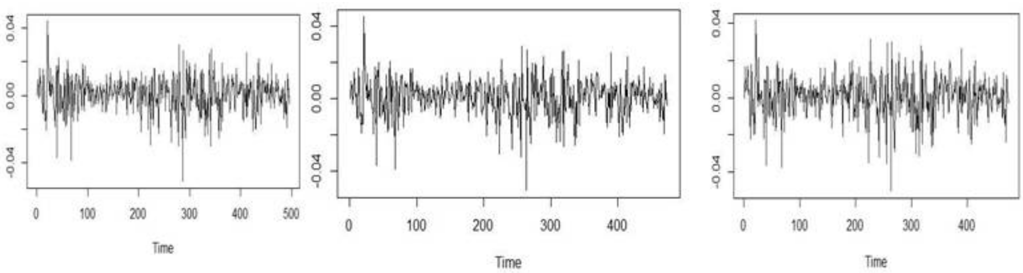

Figure 3. Volatility Clustering (a) BSE 100 ESG , (b) BSE Carbonex , (c) BSE Greenex

TABLE 6. ARCH-LM TEST

	BSE 100 ESG	BSE CARBONEX	BSE GREENEX
P Value	0.002755	0.002895	8.69E-05
Null Hypothesis	no ARCH effects	no ARCH effects	no ARCH effects
Decision	Reject	Reject	Reject

Figure 3 (a), Figure 3 (b) and Figure 3 (c) show volatility clustering for all three indices' return series and table 6 shows whether ARCH effect is present in time series or not. As per ARCH-LM test, the null hypothesis of no ARCH effect is rejected for all indices return series. Hence, all three series can be modelled with GARCH model as volatility clustering and ARCH effect is present.The next step is to fit the appropriate GRACH model. The statistical test reveals that standard GARCH model can't be fit as the effect of good and bad news are not symmetrical to all three indices return series. Hence, we employ ARMA-EGARCH Model to fit mean and variance equation for computing parametric Value at Risk which capture asymmetrical effect of good and bad news on time series. The study assume that the non-normality of data can be accommodated with conditional mean returns, by employing following ARMA (1,1) model

$$r_t = a_0 + a_1 r_{t-1} + e_t + m_1 e_{t-1} \quad (1)$$

Where, $a_1$is parameters, r_{t-1} are lagged returns. For variance calculation, the conditional variance h_t follows EGARCH (^{1,1}) model as explained by Nelson 1991 is employed:

$$log\ h_t = \omega + \alpha_1\varepsilon_{t-1} + \gamma_1|\varepsilon_{t-1}| + \beta_1\ log\ h_{t-1} \quad (2)$$

Equation 2 EGARCH model is tested with Student-t distribution instead of normal distribution. Table 7 summarizes the result of estimated parameter from equation 1 and 2. For BSE 100 ESG, except parameter of mean function i.e., α_0, α_1 and m_1, all parameters are found statistically significant at 95% confidence level. For

BSE Carbonex index, in mean function only α_1 and in variance all parameters are found statistically significant at 95% confidence level. Lastly, for BSE Greenex, only parameters of variance function are found statistically significant at 95% confidence level.

TABLE 7. PARAMETER ESTIMATES FOR THE ARMA-EGARCH (1,1)

	BSE 100 ESG	BSE CARBONEX	BSE GREENEX
α_0	0.000424	0.000384	0.00034
α_1	-0.122591*	-0.078411	0.06998
m_1	0.277303	0.230739*	0.06697
ω	-0.777427*	-0.751376*	-0.92807*
α1	-0.249923*	-0.251045*	-0.22000*
β1	0.916417*	0.919175*	0.89762*
γ1	0.114914*	0.125538*	0.14255*

Extreme Value Theory-Value at Risk (EVT-VaR)

The descriptive statistics of price series show negative kurtosis and moments for all three price series which confirms negatively skewed data. This negative skewness also confirms fat tail of distribution. Traditional VaR models on such time series tend to underestimate the real risk observed on the markets. Hence, risk modelling with extreme events seems to be perfect for such time series risk modelling. One of such risk models is EVT theory. The EVT relates to the asymptotic behavior of extreme observations of a random variable. It provides the fundamentals for the statistical modelling of rare events and is used to compute tail-related risk measures. There are two different but related ways of identifying extremes in real data over a certain time horizon. One is Block Maxima method and the other is Peak over Threshold (POT) method. This study employs

PoT method for EVT modelling as block maxima method is not suited for financial time series because of volatility clustering (Figure 4 (a), (b) and (c)). The POT method identifies extreme observations that exceed a high threshold u and specifically models these 'exceedances' separately from non-extreme observations. A rule of thumb is that u should be approximately equal to the 95th percentile of the empirical distribution. The present study also fixes value of u in this way only.

Given a high threshold u, the probability distribution of excess value of x over threshold u is defined by

$$F_u(y) = \Pr(X - u \le y \mid X > u) = \frac{F(y+u) - F(u)}{1 - F(u)} \quad (3)$$

Setting $x = y + u$ for $x>u$, we have the following representation

$$(x) = [1 - F(u)]F_u(y) + F(u) \quad (4)$$

A theorem by Balkema and De Haan (1974) and Pickands III (1975) shows that for a sufficiently high threshold u, the distribution function of the excess may be approximated by the generalized pareto distribution (gpd) because as the threshold gets large, the excess distribution $f_u(y)$ converges to the gpd. The gpd in general is defined as

$$G_{\xi\psi}(y) = 1 - (1 + \frac{\xi y}{\psi})^{-1/\xi}, \text{ if } \xi \neq 0$$

$$= 1 - \exp^{-y/\xi}, \text{ if } \xi = 0$$

Where $\xi = 1/\alpha$ is the shape parameter, α is the tail index, and ψ is the scale parameter.

For $x > u$, where ξ and ψ can be estimated by the method of maximum likelihood. For a given probability $q > f(u)$, the tail quantile can be obtained by inverting the tail estimation formula above to get [16].

$$VaR_q = x_q = u + \frac{\psi}{\xi}\left[\left(\frac{1-q}{k/n}\right)^{-\xi} - 1\right] \quad (7)$$

Since VaR is an extreme quantile, it is equivalent to x-quantile. Table 8 shows parameter estimated of GPD fit for EVT VaR and value of EVT-VaR for two quantiles i.e., 99% and 95% for all three sustainability indices of BSE.

EVT VaR for all calculated quantiles are found to be higher for BSE Greenex compared to BSE 100 ESG & BSE Carbonex. Whereas EVT-VaR @ 95% is lower for BSE Carbonex vis-à-vis BSE 100 ESG & BSE Greenex and EVT-VaR @99% is lower for BSE 100 ESG in comparison to BSE Carbonex & BSE Greenex.

E. Back-testing; Likelihood Ratio Test

The robustness of any VaR model can only be confirmed with back-testing result of applied model. Therefore, to check the robustness of AR-EGARCH model, the present study employs the unconditional coverage test proposed by Kupiec, 1995. For every $t+1$ day return forecasting, variable I_{t+1},is used to indicate the exceedance of calculated VaR value by comparing the $V\hat{a}R_q{}^{t+1}$with the r_{t+1} by following equation:

$$I_{t+1} = \begin{cases} 1, if\ r_{t+1} < V\hat{a}R_q^{t+1} \\ 0,\ otherwise \end{cases}$$

TABLE 8 EVT ESTIMATES

	S&P BSE 100 ESG		BSE CARBONEX		BSE GREENEX	
Alpha	95%	99%	95%	99%	95%	99%
	18.21	29.5	31.797	16.297	18.6642	34.0516
u	16.6	16.6	18.106	18.106	18.295	18.295
b	32.53	32.5	32.532	32.532	32.5316	32.5316
x	0.436	0.44	0.4362	0.4362	0.43625	0.43625
n	495	495	495	495	495	495
n_u	24	24	24	24	24	24
VaR	15.6	80.8	12.72	83.151	20.0526	97.7565
ES	72.54	187	66.257	191.19	79.1181	216.951
Likelihood	-91.4	-91	-75.714	-75.71	-95.1302	-95.1302

The unconditional coverage test examines whether the realized value at risk equals to calculated value at risk. This comparison of realized and calculated VaR tests if the variable I_{t+1}follows an *iid* Bernoulli process with parameters p; where p stands for VaR's theoretical coverage rate α. The unconditional coverage likelihood ratio test follows a χ^2distribution with one degree of freedom and is calculated with following equation:

$$LR_{uc} = 2\log\left[\frac{(1-p)^{T_0}\, p^{T_1}}{(1-T_1/T)^{T_0}(T_1/T)^{T_1}}\right] \sim \chi^2\ \mathbf{(1)}$$

where $_0$ and T_1 are the number of zeros and ones, respectively in the violation sequence.

TABLE 9 (A). BACK-TESTING BSE 100 ESG INDEX

	alpha	Kupiec Chi-squared	p-value
VaR HS@95%	95%	1.02	31%
	99%	26.22	0%
VaR_HS@99%	95%	31.83	0%
	99%	0.90	34%
P-VaR@95%	95%	0.02	88%
	99%	38.43	0%
P-VaR@99%	95%	11.83	0.06%
	99%	4.01	5%
EVT@95%	95%	0.43	51%
	99%	52.04	0%
EVT@99%	95%	NA	NA
	99%	NA	NA

Tables 9(a), Tables 9(b), and Tables 9(c) show statistics of unconditional coverage test for different quantiles i.e., 95% and 99%. For BSE100 ESG index, the result suggests that at 95% quantile, VaR-HS@ 95%, P-VaR@95% and EVT-VaR@95% models are significant whereas at higher quantile of 99%, VaR-HS@ 99%, P-VaR@99% models are found to be statistically significant.

Back-testing result of BSE Carbonex, at 95% quantile only P-VaR@95% found to be statistically significant and at 99% quantile, all VaR models @99% are found to be statistically significant. As per table 9 (c) for BSE Greenex, at 95% quantile, all 95% VaR models are robust and at 99% quantile, all 99% VaR models are robust. The back-testing results suggest that P-VaR model outperforms other VaR model in return prediction for all three indices.

IV. SCOPE & IMPLICATIONS OF THE STUDY

This study has employed Historical simulation, ARMA-EGARCH and EVT model to be fitted for Value at Risk. As time series are found to be not normally distributed, one can employ other methods for value at risk calculation including GARCH, EWMA etc. as model specification to forecast return. We suggest modelling two stage conditional EVT VaR to return forecast. The present study used unconditional coverage test for back-testing VaR model. The unconditional coverage test is not free from some limitation as this test does not properly characterize the behavior of the model in the presence of clustering. Therefore, it calculates the correct number of violations, but those violations may occur in clusters. Hence, we suggest employing another likelihood ratio rest i.e., the test of independence and the test of conditional coverage suggested by Christoffersen 1998. A comparative study of market indices and other sustainability indices from India such as NIFTY ESG Index, NIFTY 100 ESG Sector Leader Index and NIFTY 100 Enhanced ESF Index and other countries' sustainability indexes can also be investigated for further research. This study indicates that there is low risk and positive performance for index consists of stocks based on its ESG activities. Hence, it can be concluded that integrating sustainable development goals into common business practice brings profit and is necessary for the long run survival of business.

TABLE 9 (B). BACK-TESTING BSE CARBONEX

	alpha	Kupiec Chi-squared	p-value
VaR HS@95%	95%	0.00	96%
	99%	41.71	0%
VaR_HS@99%	95%	11.83	0%
	99%	4.02	5%
P-VaR@95%	95%	0.78	38%
	99%	54.11785	0%
P-VaR@99%	95%	10.55485	0.12%
	99%	4.470141	3.5%
EVT@95%	95%	0.07	80%
	99%	45.07	0%
EVT@99%	95%	42.26215	0%
	99%	4.732978	3%

TABLE 9 (C). BACK-TESTING BSE GREENEX

	alpha	Kupiec Chi-squared	p-value
VaR HS@95%	95%	0.00	96%
	99%	41.71	0%
VaR_HS@99%	95%	11.83	0%
	99%	4.02	5%
P-VaR@95%	95%	0.78	38%
	99%	54.11785	0%
P-VaR@99%	95%	10.55485	0.12%
	99%	4.470141	3.5%
EVT@95%	95%	0.07	80%
	99%	45.07	0%
EVT@99%	95%	42.26215	0%
	99%	4.732978	3%

V. CONCLUSION

The findings of the study conclude that all three sustainability specialized indices have good return predictability. Back-testing result suggests at higher level of confidence i.e., 99%, tested VaR models are robust. Such results also indicate the efficiency of market to absorb the shock efficiently. Hence, it can be concluded that the stocks which have a higher score of managing ESG risks are overall performing better. This also stipulated that there is a positive correlation between ESG risk management and overall risk management. The result of the present study also confirms that the need to include sustainable finance as common business practice for enhanced performance of index and stocks is a must. S&P BSE 100 ESG, S&P BSE Carbonex and S&P BSE Greenex performance analysis confirms that there is financial incentive to include ESG investing practices by companies. Though a comparative studies and further exploration of data will provide more insight on such index performance. This study results also advocates the better and clear public policy for ESG investing in India because energy efficiency and clean energy investment is not a future business activity but the present business activity.

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