CARBON REDUCTION AND SUSTAINABLE INVESTMENT: A WAY TO SUSTAINABLE DEVELOPMENT

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ABSTRACT

The present empirically examines the impact of five variables, namely Economic level, Population-level, Urbanization level, Industry proportion, Fossil fuel energy consumption, and Methane emission on Carbon intensity in India. It also evaluates the volatility and impact of news on asymmetric volatility of sustainable indices in the Indian stock market, S&P BSE CARBONEX, S&P BSE GREENEX, and S&P BSE 100 ESG against S&P BSE SENSEX as poxy for the market index. The data for the study was collected from the World Bank Database and the official website of the Bombay Stock Exchange. The study used OLS regression to evaluate the impact of five variables on Carbon intensity and econometrics tools like GARCH and EGARCH to measure the volatility and impact of the news. The study found that Economic level, Fossil fuel energy consumption, Population-level, urbanization level, and Methane emission have a significant positive impact on carbon intensity. There is a negative relationship between economic level and carbon intensity. The volatility of SENSEX is higher than that of sustainability indices. The study found that there is an asymmetric impact of positive and negative news on stock volatility, as parameter γ is negative and significant for all indices.

Contribution/ Originality: The study is very significant, as it provides new insight in to factors influencing carbon emission and the role of sustainable indices in the promotion of sustainable development in India. The findings of the study are important to investors, portfolio managers, financial advisers, and other stakeholders of the financial market interested in promoting sustainable investment.

1. INTRODUCTION

"Socially Responsible Investing, also known as sustainable, socially conscious, green or ethical investing, is any investment strategy which seeks to consider both financial return and social good" (Jain & Rohra, 2016). In recent years, the concept of Socially Responsible Investment has gained more popularity because of the increasing impact of global warming, climate change, environmental degradation, as a result, more investors making their investment by considering Environmental, Social, and Governance Factors (Tripathi & Bhandari, 2015). A socially responsible investor not only looks for return/wealth maximization but also encourages environmental, social, and governance practices of corporates, it has a long-term consequence on companies' financial performance (Jain & Rohra, 2016).

Nowadays, excessive emission of Green House Gas (GHG) leads to climate change and it has received wide attention among the national and international community. It is one of the major environmental threats to human survival (Wang, Su, & Li, 2018). For the first time, in December 1997, in Kyoto Japan, United Nations Framework Convention on Climate Change, establishes legally binding limits for industrialized countries on the emission of carbon dioxide and other Green House Gases, called the Kyoto Protocol (Breidenich, Magraw, Rowley, & Rubin, 1998). To make national and regional development paths more sustainable, climate policies should be constantly embedded with broader strategies as climate change is the larger challenge for sustainable development (Sathaye, Shukla, & Ravindranath, 2006). India's emission of Green House Gases is increasing with a large and growing population. Its impact on the Indian economy is severe, include sea-level rise, changes in monsoon, drought, flooding, and cyclone. All these have a serious impact on India's socio-economic development (Brenkert & Malone, 2005). The oil and gas industry, coal mining, livestock, rice cultivation, landfills, and wastewater treatment are the major Anthropogenic source of methane (Scarpelli et al., 2020). During 2000 and 2008, Co2 emissions due to the burning of fossil fuels have increased at an average annual rate of 3.4 percent compared with 1 percent during 1990 (Angila, 2017). In recent years, Global warming has become a serious issue for the regional and global environment. Burning of fossil fuel, clearing of forest and other human interventions causes rise in carbon dioxide (Bhardwaj, 2013). The global climate was changing in its full swing and the global financial crisis of 2008 brings the entire world to its toes (Sharma & Jasuja, 2020). India is among the fastest-growing economies of the world. India's GDP growth at an average rate of 5.40% during 1980-2005, along with the same India's electricity consumption also mover upward trend (Tiwari, 2011). This was the first time Carbon dioxide emissions in India fell by an estimated 30 million tons of CO2 during 2019-2020 Figure 2 in four decades (Tiseo, 2020).

The financial market makes a major contribution to economic and social development. It plays a significant role in the promotion of sustainable development by providing an opportunity to investors for investing in socially responsible portfolios (Patel & Kumari, 2020). The global benchmark for sustainability assessment was first introduced by Dow Jones Sustainability Indexes (DJSI) in 1999, which employ several criteria as climate change, energy spending, and green practices across all the capital markets in the world (Dinesh & Souza, 2021). Indian stock market introduced sustainability Indices called S&P BSE 100 ESG, S&P BSE CARBONEX and S&P BSE GREENEX for evaluating and promoting the sustainable performance of companies. The present study evaluates the volatility of sustainability indices in the Indian capital market, such as BSE 100 ESG, BSE CARBONEX, and BSE GREENEX against market index BSE SENSEX. It also measures the relationship between India's CO2 emission and Economic level, Population, Urbanization, Fossil fuel energy consumption, Industry proportion, and Methane emission. The rest of the paper is structured as follows. Section 2 present important literature in field of carbon emission, sustainable indices, and volatility of sustainable indices. Section 3 present the method and data source. Result and discussion were summarized in section 4, and last section conclude the paper.

2. LITERATURE REVIEW
2.1. Carbon Intensity and Economic Growth

Prior research provides extensive literature on carbon emission and economic growth. By examining the key factors influencing carbon intensity at both the national and regional levels, they proved that the economic level of activity was negatively correlated with carbon intensity on both national and regional levels (Wang, Zhang, & Liu, 2016). They provided the evidence for the role of economic development in China in promoting lower carbon intensity. There was a positive effect of urbanization on carbon intensity in China. Further study by Nag and Parikh (2000) evaluated the carbon emission from end-use of commercial energy by four major sectors namely, industry, transport agriculture, and commercial sector by using the Divisia decomposition technique. They concluded that overall growth in carbon emission intensity has been contributed mainly to energy intensity. Towards economic growth without emission growth, the role of urbanization and industrialization in India as well as in China (Wang

et al., 2018) comparatively analyses the decoupling effect of the economic growth from the carbon emission as well as its drivers. The study found that urbanization and industrialization had a significant impact on the economic growth of India and China.

2.2. Sustainability Indices

In recent years investors are interested to contribute to global sustainability in many ways. One of their initiative is by incorporating environmental, social and governance criteria to their portfolio (Souza, 2019). It helps to combine investors' social, ethical and ecological consideration with economic consideration (Jain, Sharma, & Srivastava, 2019). By investigating the influence of macro-economic variables namely, crude oil price, exchange rate, 10-year bond price, and non-farm payrolls on companies that integrate CSR activities and equity securities, by using GARCH model (Sariannidis, Giannarakis, Litinas, & Konteos, 2010). Further, Kathiravan, Selvam, Maniam, Venkateswar, and Sigo (2020) studied the impact of temperature in the top five cities of India, such as Bangalore, Chennai, Delhi, Kolkata, and Mumbai on BSE GREENEX index in India from 2009 to 2018 and found the significant impact of temperature on the performance of BSE GREENEX. Chen (2008) compared the green core competence, green product innovation performance, green process innovation and green image of Taiwanese large enterprises with small and medium enterprises in information and electronic industry found that the influence of all these variables of SME's was significantly less than those of large enterprises in Taiwan. While comparing the socially responsible stocks with other portfolios, socially responsible stocks portfolios are found higher return with lower during crisis and post-crisis (Tripathi & Bhandari, 2015). In contraction to this (Jain et al., 2019) found that sustainable indices and conventional indices are integrated and there is no significant difference in the performance between sustainable indices and conventional indices.

By analyzing the behavior of sustainability indices, such as BSE GREENEX and BSE CARBONEX, in respect to return a risk associated with market indices, such as BSE SENSE and BSE 500 (Patel & Kumari, 2020) found that BSE CARBONEX outperforms both market indices and BSE GREENEX outperforms SENSEX but is slightly lower than that of BSE 500. By comparing the performance of sustainability indices, the BSE CARBONEX is slightly outperforming the BSE GREENEX. Statman (2006) also added to the existing literature by evidence that the return of socially responsible indexes was generally higher than those of market index. By supporting to that, (Jain & Rohra, 2016) during post-crisis period, the socially responsible stocks outperform general stocks in terms of return. Kathleen, Walker, and Loo (2014) investigated the relationship between sustainability and disclosure and sustainability performance by using Ullmann's conceptual framework of corporate social responsibility and concluded that sustainability disclosure has a significant positive association with a firm's sustainability performance. Research by Hartmann, Perego, and Young (2013) attempts to link the emergent area of carbon control with fundamental theoretical and empirical issues in Management Accounting Control.

By studying the relationship between environmental and financial performance (Cohen, Fenn, & Konar, 1997) found that investors who choose the environmental leaders in an industry-balanced portfolio were found to perform better than choosing the environmental laggards in each industry. McAleer and Pauwels (2007) showed mixed evidence concerning the effect of the short-run and long-run persistence of shocks to the return of sustainability index as well as the asymmetric effect of negative to positive shocks by applying GARCH model. By extending the existing literature, Goyal and Aggarwal (2014) investigated whether ESG stocks portfolios outperform the blue-chip stocks portfolios and the market portfolios in the Indian stock market and found significant evidence of the outperformance of ESG stock against blue-chip stock and market portfolios. Tripathia and Bhanadari (2012) studies the performance of green stocks in the Indian stock market, by differentiating the period into three sub-periods, such as pre-crisis, crisis, and post-crisis, and found that green stocks portfolios underperformed non-green stocks portfolios during the pre-crisis period, it significantly outperformed non-green stock portfolios and market portfolios during the crisis period. Volatility is the measure of risk in the financial market. Investors are concerned

about volatility while they make investment. Malik and Yadav (2020) investigated the presence of volatility symmetry in three sustainability indices in the Indian stock market, such as GREENEX, CARBONEX and ESG, by using econometric tools. The risk-return and volatility analysis of ESG index and broad market index, Sudha (2015) found that return of sustainability index is better than the return of broad market index and the volatility of ESG is less than other indices. Empirical investigation of response of ESG firm to bad news and good news (Sabhaghi, 2020) support the hypothesis that volatility of ESG firm is higher for bad news that good news and small sized ESG firm response to such news slower than large sized firms. A new diagnostic test of volatility asymmetry proposed by Engle and Ng (1993) provide new insight in to asymmetric volatility in the market.

The above literature shows that many studies were conducted in the field of carbon emission, sustainability indices, Socially Responsible Investment at the national and global level. In the case of India, there are only a few studies were conducted in this area. Majority of research was carried out to find out the performance of sustainability indices and comparison with market indices. Prior research has not investigated sustainable development in India by combining factors influencing carbon emission and the role of the capital market for promoting sustainable development in India. The present paper tries to evaluates the following objectives:

1. To evaluate the impact of economic level, Population, Urbanization, Industry added-value, Fossil fuel energy consumption on Carbon intensity in India.
2. To examine the extent of the volatility of sustainability indices and market index.
3. To measure the extent of the leverage effect among sustainability indices in the Indian stock market.

3. METHODOLOGY

3.1. Data and Source

The entire paper is divided into two sections. Section one discusses the relationship between CO_2 emission and Economic level, Population, Urbanization, Industry added value, and fossil fuel energy consumption. Section two deals with the role of the Indian stock market for promoting sustainable development by analyzing the volatility, and impact of news on sustainability indices and market index. S&P BSE 100 ESG, S&P BSE CARBONEX and S&P BSE GREENEX indices have been taken as the proxies for sustainable stock portfolios. S&P BSE SENSEX as the proxy for a general stock portfolio. The calculation is done based on the closing price of these indices. The daily closing price of indices was collected from the official website of BSE (www.bseindia.com) for the period from 2012 to 2020. The data of economic level, population, urbanization, industry added-value, fossil fuel energy consumption was collected from World Bank Database for the period 1990-2010. The study used econometrics tools like GARCH and EGARCH for analyzing the volatility and impact of news on volatility, for that EVIEW 8 is used. By using SPSS, OLS regression and Granger causality were used to evaluate the impact of different independent on carbon intensity and causal relationship between variables.

3.2. Model development

The following model is used to analyze the effect of economic factors on Carbon intensity using Eviews 8:

$$CI_{it} = \alpha + \beta_1 EL + \beta_2 PL + \beta_3 UL + \beta_4 ME + \beta_5 FFEC + \beta_6 IP + \varepsilon_{it} \qquad \text{(Model 1)}$$

Where CI is the carbon intensity, EL is the economic level, PL is the population, UL is the urbanization level, ME is the Methane emission, FFEC is the Fossil fuel energy consumption, and IP is the Industry proportion.

To measure the extend of leverage effect, the following model is used:

$$log(h_t) = \lambda + \sum_{j}^{q} \alpha_j \left| \frac{U_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{j=1}^{q} \gamma_j \frac{U_{t-j}}{\sqrt{h_{t-j}}} + \sum_{j=1}^{p} \delta_i log[h_{t-j}] \qquad \text{(Model 2)}$$
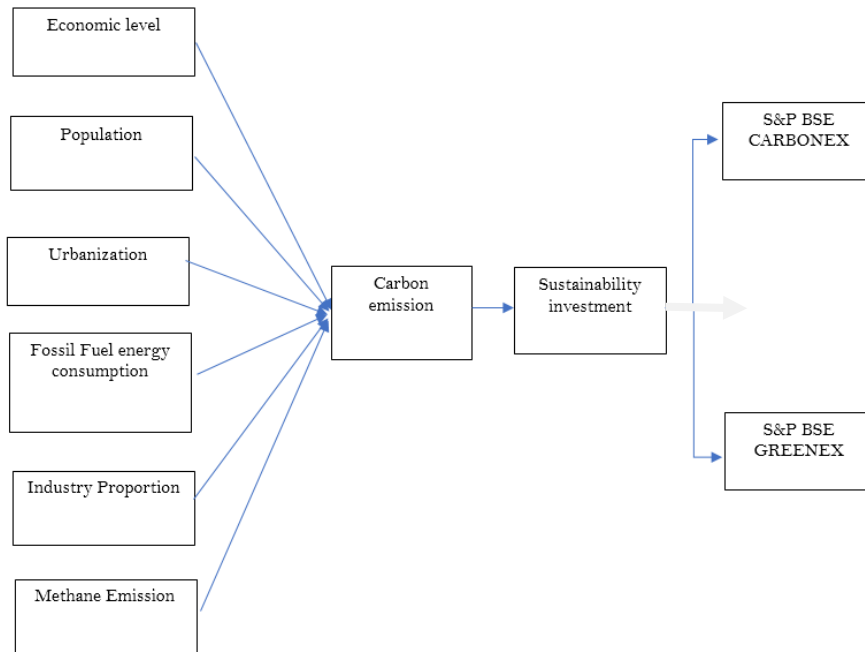
Figure-1. Explains the theoretical model of the study. Which contains the variables of the study, and establish relationship between them. The independent variables of the study include Economic level, Population, Urbanization, Fossil Fuel Energy Consumption, Industry Proportion, and Methane emission. The dependents and carbon emission and performance of sustainability indices in the Indian Capital Market.

3.3. Explanation of Variables

The definition of the variable in the theoretical model summarized in Table 1.

Table-1. Variable summary.

Symbol	Variables	Definition
CI	Carbon Intensity	Carbon emission per unit of GDP
UL	Urbanization Level	Urban population proportion of Total population
PL	Population Level	Total Population
EL	Economic level	GDP per capita
IP	Industry Proportion	Industry added-value in proportion to GDP
FFEC	Fossil fuel energy consumption	Fossil fuel energy consumption proportion of total energy consumption
ME	Methane Emission	Methane emission (kt of CO_2 equivalent)

4. RESULT AND DISCUSSION

4.1. Impact of Economic Level, Population, Urbanization, Industry added-value, Fossil Fuel Energy Consumption on Carbon Intensity in India

The result of OLS regression summarized in Table 2, shows that regression analysis is significant for Economic level ($\beta = -0.961$, $P<0.05$), Fossil fuel energy consumption ($\beta = 2.153$, $P<0.05$), Population-level ($\beta = -2.736$, $P<0.05$), Methane emission ($\beta = 1.202$, $P<0.05$), and Urbanization ($\beta = 2.901$, $P<0.05$). At the same time Industry proportion do not show significant effect on carbon emission (P-value>0.05). The value of R-squared and Adjusted R-squared shows, how much percent of change in the dependent variable is explained by the independent variable. Here the value of R-squared is 99 percent, it is very reliable to say that 99 percent of change in Carbon intensity explained by all the independent variables.

The result of Granger causality supports the result of regression analysis (Table 3) The economic level, Methane emission, Fossil fuel energy consumption, Population-level, and urbanization level granger cause carbon intensity (prob<0.05). Whereas industry proportion do not granger cause to carbon intensity. There is a bi-

dimensional causal relationship between population-level and Carbon intensity. Whereas other variables show a unidimensional causal relationship with Carbon Intensity.

Table-2. OLS Regression.

Variable	Coefficient	Std. Error	Prob.
EL	–0.961	0.203	0.003
FFEC	2.153	0.919	0.034
IP	1.908	0.061	0.098
ME	1.202	0.913	0.001
PL	2.736	0.729	0.002
UL	2.901	1.608	0.029
R-squared	0.998	Durbin-Watson stat	1.812
Adjusted R-squared	0.998		

Notes: C= carbon intensity; EL=economic level; PL=population level; UL=urbanisation level; ME=methane emission; FFEC=fossil fuel energy consumption; IP= industry proportion.

Table-3. Granger Causality.

H₀: X does not granger cause to Y	CI	EL	FFEC	IP	PL	UL	ME
CI							
F statistics	-	0.602	2.031	2.388	4.928	1.370	1.287
Prob	-	0.081	0.168	0.128	0.044	0.085	0.306
EL							
F statistics	-3.803	-	7.377	1.919	1.018	4.155	6.370
Prob	0.047	-	0.006	0.183	0.009	0.031	0.010
FFEC							
F statistics	1.315	1.444	-	0.057	1.865	4.496	0.373
Prob	0.024	0.1048	-	0.944	0.191	0.031	0.694
IP							
F statistics	0.489	1.287	3.876	-	7.598	5.051	4.177
Prob	0.622	0.306	0.045	-	0.005	0.022	0.037
PL							
F statistics	4.994	6.029	1.812	4.882	-	1.160	1.530
Prob	0.023	0.012	0.199	0.026	-	0.341	0.250
UL							
F statistics	2.661	4.635	3.930	3.949	1.160	-	5.407
Prob	0.014	0.028	0.044	0.043	0.341	-	0.018
ME							-
F statistics	5.229	0.256	1.958	0.212	3.209	1.349	-
Prob	0.020	0.777	0.177	0.810	0.071	0.291	

Note: CI= Carbon Intensity, EL = Economic Level, FFEC = Fossil Fuel Energy Consumption, IP = Industry Proportion, PL = Population Level, UL = Urbanization Level, ME= Methane Emission.

4.2. Volatility and Impact of News on Volatility of Sustainability Indices

Volatility is the degree of variability in return over time. It is measured by standard deviation of logarithmic return. To measure the time-varying volatility of return, use ARCH (Engle & Ng, 1991). An extend version of ARCH called Generalised ARCH known as GARCH was also introduced. Asymmetric models of GARCH capture the asymmetric response of volatility towards positive and negative news/ shock called EGARCH (Exponential GARCH) and GJR GARCH (Glostan Jagannathan and Runkle GARCH) and TGARCH. Volatility when price decline (negative news/information) is higher than that of volatility when price rises (positive news/information).

For measuring the volatility and extent of leverage effect among sustainability indices and market index, the sample period ranges from 30/01/2011 to 30/01/2020. The daily closing price of indices are collected from official websites of BSE.

The rate of return was calculated by taking the logarithmic difference of price of two successive periods.

$$r_1 = log_e \left[\frac{P_1}{P_{t-1}} \right] = log_e[p_t] - log_e[P_{t-1}]$$

The variance specification of the EGARCH model as follows, in which variable $\frac{U_t-j}{\sqrt{ht-j}}$ captures the relative size of the shock, $\left|\frac{Ut-j}{\sqrt{ht-j}}\right|$ captures the relative magnitude of shock.

$$log(ht) = \lambda + \sum_{j}^{q} \alpha_j \left|\frac{Ut-j}{\sqrt{ht-j}}\right| + \sum_{j=1}^{q} \gamma_j \frac{Ut-j}{\sqrt{ht-j}} + \sum_{j=1}^{p} \delta \, ilog[ht-j]$$

The descriptive statistics for the sample are summarized in Table 4. The mean return of SENSEX is 10.20, ESG is 6.322, GREENEX is 7.677 and CARBONEX is 7.19, which indicate that the mean return of BSE SENSEX is higher than that of BSE CARBONEX and BSE GREENEX. The standard deviation is 0.29 for SENSEX, 0.231 for ESG, 0.26 for GREENEX, and 0.301 for CARBONEX (variability in return is slightly higher for CARBONEX than other two indices). Stock returns of all indices are negatively skewed (-0.090, -0.374, -0.421, and -0.177). The return of all the indices distributions are platykurtic. The Jarque Bera probability value is less than 0.05 for all indices, which indicates that the null hypotheses of normality can be rejected for all four indices, concluding that the series under refrence are non normal. The unit root result using Augmented Dickey-Fuller test at level indicates that the data is stationary.

Table-4. Descriptive Statistics of stock indices.

	Sensex	Greenex	Carbonex	BSE 100 ESG
Mean	10.20	7.677	7.195	6.322
Std. Dev.	0.297	0.266	0.301	0.231
Skewness	-0.090	-0.421	-0.177	-0.374
Kurtosis	1.927	1.935	1.811	5.903
Jarque-Bera	122.16 ***	190.62 ***	158.92 ***	201.20 ***

Note: P values *** indicate significance at 1% level.

The result of volatility and leverage effect of sustainability indices and market index were shown in the Table 5 summarises that, the parameter α and δ is significant for all indices. The volatility of all indices is sensitive to market events (BSE SENSEX=0.1847 and P<0.05), (BSE 100 ESG =0.1259 and P<0.05) (BSE GREENEX =0.1412 and P<0.05), and (BSE CARBONEX =0.1272 and P<0.05). The leverage effect γ are negative and significant for all indices (-0.317672 for SENSEX, -0.1920 for ESG, -0.360052 for GREENEX and -0.341921 for CARBONEX. Which indicate that negative shock creates more volatility than positive shock of the same magnitude. Volatility of declining market is higher than that of volatility of rising market.

Table-5. Result of GARCH and EGARCH.

Parameter	S&P BSE Sensex	S&P BSE Greenex	S&P BSE Carbonex	S&P BSE 100 ESG
λ	-0.3176 (0.002)**	-0.3600 (0.012)**	-0.3419 (0.010)**	-1.0143 (0.000)**
α	0.1847 (0.001)**	0.1412 (0.021)**	0.1272 (0.032)**	0.1259 (0.0206)**
γ	-0.1043 (0.010)**	-0.0818 (0.001)**	-0.0984 (0.000)**	-0.1920 (0.000)**
δ	0.9761 (0.021)**	0.9726 (0.004)**	0.9731 (0.000)**	0.9058 (0.000)**

Note: P value ** indicate significance at 5% level.

Table-6. Granger causality of stock return.

H₀= X does nor granger cause to Y	BSE Sensex	BSE Carbonex	BSE Greenex	BSE 100 ESG
BSE SENSEX				
F statistics	-	0.0336	0.1280	0.1340
Prob	-	0.9669	0.8799	0.6701
BSE CARBONEX				
F statistics	0.1658	-	0.1070	0.1307
Prob	0.8472	-	0.8985	0.5012
BSE GREENEX				
F statistics	0.0981	0.5577	-	0.0821
Prob	0.9065	0.5725	-	0.6211
BSE 100 ESG				
F statistics	0.0822	0.6045	0.1203	-
Prob.	0.6700	0.4675	0.6041	-

Table 6 summarizes the result of Granger causality of sustainability indices and broad market index. The probability value is significant for all the indices. So, we cannot reject the hypotheses. There is no causal relationship between return of BSE 100 ESG, BSE CARBONEX, BSE GREENEX, and BSE SENSEX.

5. CONCLUSION

The present evaluates the factors influencing Carbon emission in India and the volatility of sustainable indices against the market index of BSE. For measuring carbon intensity, we take Economic level, Population-level, Urbanization level, Industry proportion, Fossil fuel energy consumption, and Methane emission as independent variables. S&P BSE CARBONEX, S&P BSE GREENEX as proxies of sustainable indices, and S&P BSE SENSEX as a proxy for market index. By using OLS regression the study found that Economic level, Fossil fuel energy consumption, Population-level, urbanization, and Methane emission have a significant impact on carbon intensity. Except economic level, all other variables show significant positive impact on carbon emission. The level of carbon emission increases as the level of Fossil fuel energy consumption, Population-level, urbanization, and Methane emission increases.

The economic level has a negative impact on carbon emission. The result confirms the findings of Wang et al. (2016) as they proposed that economic level negatively correlated with carbon intensity. Economic level, Methane emission, Fossil fuel energy consumption, Population-level, and urbanization-level granger cause carbon intensity. Whereas industry proportion do not granger cause to carbon intensity. The mean return of BSE SENSEX is higher than that of BSE 100 ESG, BSE CARBONEX and BSE GREENEX. It is contradicting with the result of Sudha (2015) in that study researcher proposed that the return of ESG index is higher than that of broad market index. While evaluating the volatility and leverage effect, the volatility of SENSEX is higher than that of ESG, CARBONEX and GREENEX. The market index is more sensitive to market events than sustainable indices. The leverage effect γ is negative and significant for all indices. The presence of asymmetric response of volatility to positive and negative news/shock is highly significant for all indices. This result support the findings of Sabhaghi (2020). By reducing carbon emission and promoting sustainable investment helps the Indian economy to achieve sustainable development.

The present study has some relevant implications for investors, financial advisers, portfolio managers, financial analysts, corporate executives, and other stakeholders. It will help investors to compare sustainable indices with market index, and to make better investment decision. It is important for portfolio managers and financial advisers to obtain more insight regarding sustainable indices and it help them to provide better advices to investors.

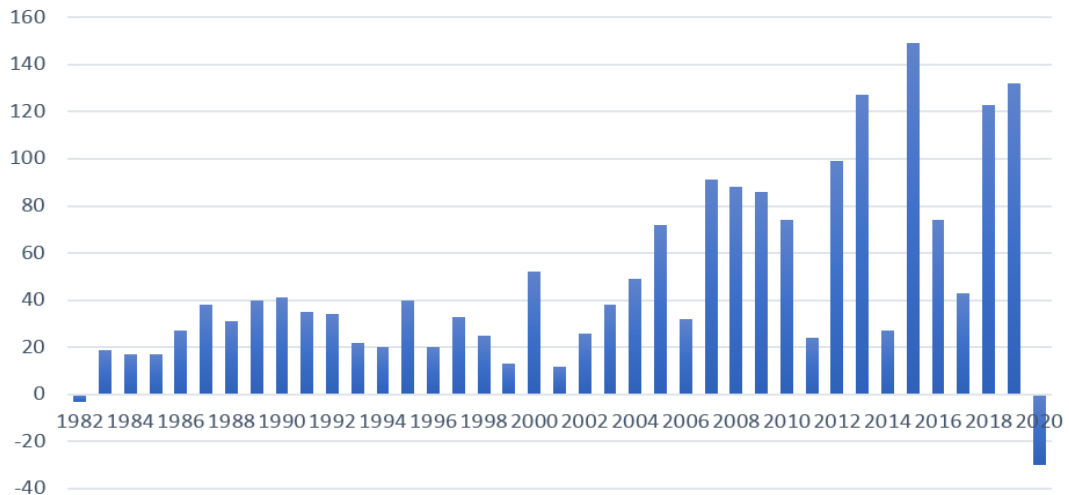## Annual emission change in million tonnes of CO2

Figure-2. Annual Emission change in CO₂ in Million tonnes.

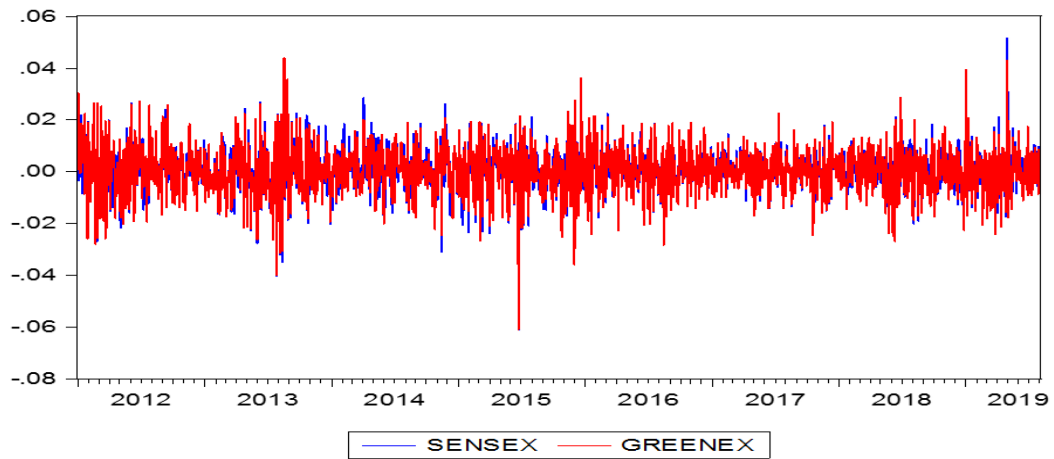**Source:** World Bank Database.

Figure-3. Compares the return series of BSE GREENEX against S$P BSE SENSE. The variability return series of BSE SENSEX is higher than that of BSE GREENX.
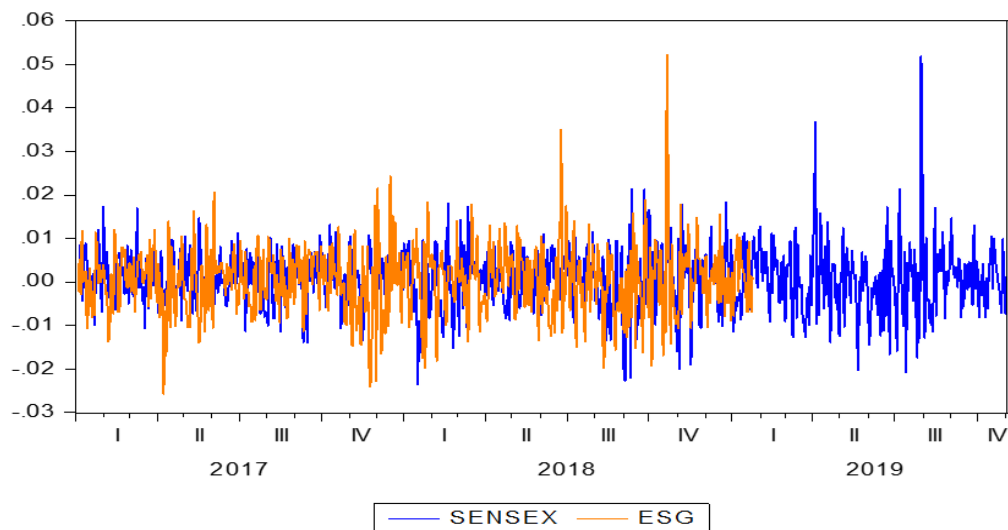

Figure-4. Compares the return series of BSE 100 ESG against S$P BSE SENSEX. The variability in return series of BSE 100 ESG is lower than that of BSE SENSEX for the sample period.
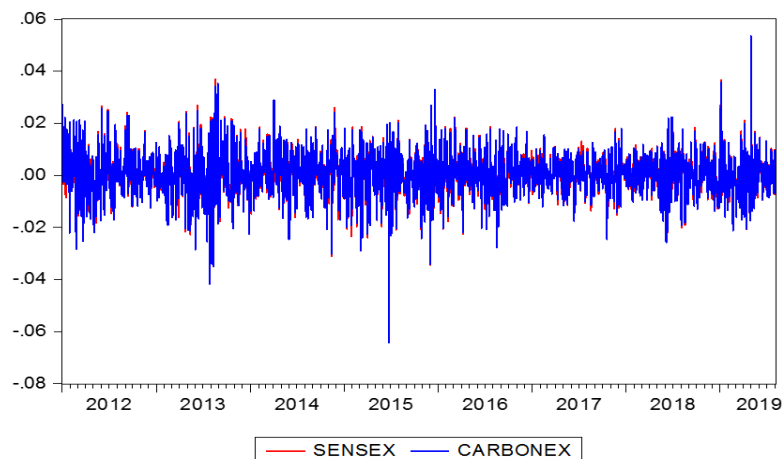
Figure-5. Trend line return series of BSE SENSEX and BSE CARBONEX shows that, the variability in CARBONEX is higher than that of BSE SENSEX.

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