

FDI Inflows – Green Indices – CO₂ Emissions in India: A Transitive Dependency Analysis

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ABSTRACT

Transitive dependency plays an important role in inferential statistics for data integrity and data consistency. After identifying and resolving, it can be structured efficiently and avoid prolixity and standardisation. This study liaisons between FDI, CO₂ emission and two sustainable green indices – S&P BSE Carbonex: Adherence of industries towards reduce threats arising from climate change and S&P BSE Greenex: Companies performance in terms of greenhouse gas (GHG) effusions with time span from 2010 to 2022. The methods used here to analyse the transitive dependency between FDI, S&P BSE Carbonex & Greenex and CO₂ emission includes Karl Pearson's Coefficient of Correlation and Simple Linear Regression using SPSS software. From the analysis, FDI inflows to developing countries like India with high concentration of energy-intake enterprises directing to consequential positive impacts on ecological deterioration in presence of wan environmental regulations as compared to developed countries.

Keywords: FDI, Stock, Emission, Regression and Transitive.

Mathematics Subject Classification: 91B80, 91B82, 62J05, 62H20.

Journal of Economic Literature (JEL) Classification: C10, G10, Q54.

1. INTRODUCTION

Statistical data are highly monotonous in nature (Cotofrei and Luchian, 1996). In order to acknowledge the scepticisms which suplicate for statistics, the information can be represented by aggregates of raw data; hence minimizing the amount of statistical data and pick out the ad rem variable steers to well grasping and improves in real-time outcomes (Kaliyadan and Kulkarni, 2019). In this regard, dependency estimation acquired much surveillance among academicians as well as practitioners over the last few decades (Ghosh, 1991).

The discovery of connections between variables are elementary to many statistical executions, e.g., Facet Selection (Peng, et al., 2005), Clustering (Nguyen, et al., 2013) or Outlier Detection (Keller, et al., 2012) and is a foremost concept in the statistical inference (Zhu and Shasha, 2002). To estimate the dependency on a given target, statistical methods such as the Pearson's Correlation Coefficient or Linear Regression are used in order to eliminate the logorrhoea by means of putrefaction (Shannon, 1948).

In statistical terminology, transitive dependency point out the interrelationship between two variables through an additional variable which acts as intercessor between two variables and is not necessary for regulating the relationship but is requisites to establish the relationship (Harrington, 2009). In context of FDI Inflows – S&P BSE Carbonex and Greenex – CO₂ emissions in India, many studies and researches have inquired the functional relationship between them; however there is still a lot of debate on it. There is a copious of literature surrounding the relationship between FDI, stock market and CO₂ emissions; however these literatures cumulatively propose three economic arguments:

1. Relationship between FDI Inflows and Stock Market Indices.
2. Relationship between Stock Market Indices and CO₂ Emissions.
3. Relationship between FDI and CO₂ Emissions.

Stock market is an effective medium of limn to describe the economic activity of a country and that also incorporates FDI, because it is considered to be more stable and secure due to its less prone to capital withdrawals and financial contagion (Rajapakse, 2018). There is a considerable amount of literature have been published on relationship between FDI and stock markets (Baker, et al, 2004; Adam and Tweneboah, 2008; Tsauroi, 2014 and Bakawdah and Tayachi, 2021). From the negative view points, due to inferior equity market in underdeveloped and institutionally weak countries, FDI becomes a proxy source for economic development (Hausmann and Fernandez-Arias, 2000), whereas, in developed countries, FDI creates an competitive atmosphere due to technological advancement, trade integration and employment generation (Claessens, et al., 2001).

In economically sound countries, the financial evolution is sharply correlated with its industrial stracture which leads to rise in CO₂ emissions (Xu, et al., 2017). So mitigating global warming requires coercions to focus on shrinking of CO₂ outflows basically arising from fossil fuels. According to financial statistics, to handle the problem of CO₂ emissions, it would be necessary to establish a negative correlation between stock market returns and carbon dioxide excretions (Chang, et al., 2020), which would stir up fiscal determinations and contribute to higher economic development (Xu and Li, 2023).

From FDI and CO₂ emission nexus, it is found that, there are two channels where FDI affects the environment through CO₂ emission. Firstly, the shifting of contaminated industries from developed countries with strict environmental mandate as a proxy of FDI to under developed countries with remiss ordinance and have a rise in CO₂ emission (Acharyya, 2009; Mutafoğlu, 2012; Muhhammad, et al., 2015 and Demena and Afesorgbor, 2020). Secondly, FDI can ameliorate front country's environment by initiating technological spillovers which reduces CO₂ emissions (Asghari, 2013; Şahinöz and Fotourehchi, 2014; Tang and Tan, 2015 and Öztürk and Öz, 2016).

So, the primary objectives of the existing studies are to examine the impact of FDI on stock markets and CO₂ emissions. From the above discussion, estimating statistical dependencies between FDI Inflows, S&P BSE Carbonex and Greenex and CO₂ emissions is a prominent topic in the theory of statistical ecology in terms of climate change and protection of the environment. Identifying the dependent features between FDI inflows, S&P BSE Carbonex and Greenex and CO₂ emissions is commentative to entente with high magnitude and assists to extract the characteristics with relevant features for the assignment (Zebari, et al., 2020).

The remaining structure of the article proceeds as follows. Section 2 emphasises on Objective of the Study, Section 3 describes the Research Methodology: Type and Duration of Data, Sample Selection and Statistical Tools and Techniques. In Analysis and Interpretation: Descriptive Statistics, Correlation Analysis and Linear Regression are analysed in Section 4. Finally, Section 5 concludes the paper with References in Section 6.

2. OBJECTIVE OF THE STUDY

Based on literature review, FDI inflows are directly link to stock markets and CO₂ emissions. Also stock market indices are both positively and negatively correlated with CO₂ emission. In Indian context, there is no study, which determines the nexus relationship between FDI, two sustainable green indices: S&P BSE Carbonex and S&P BSE Greenex index and CO₂ emissions due to fossil fuel consumption from various sectors. Hence there is need to know whether the FDI inflows directly influence on CO₂ emissions or influence through S&P BSE Carbonex and S&P BSE Greenex.

3. RESEARCH METHODOLOGY

The entire paper is divided into three sections.

- Section one discusses the relationship between FDI and S&P BSE Carbonex and S&P BSE Greenex index.
- Section two deals with the relationship between S&P BSE Carbonex and S&P BSE Greenex index with CO₂ emissions and
- Section three emphasises the impact of FDI on CO₂ emission.

3.1. Type and Duration of Data

The present study is based on secondary data and a descriptive research approach has been adopted from the period from 2010 to 2022.

3.2. Sample Selection

The significant driving factor of current research is to study the transitive dependency between FDI inflows-two sustainable green indices- CO₂ emissions in India. Data on FDI Inflows (INR ₹ in Crores) to India are collected from the DIPP Fact Sheets of Department for Promotion of Industry and Internal Trade under the Ministry of Commerce and Industry, Govt. in India. Whereas, two sustainable green indices, S&P BSE Greenex and S&P BSE Carbonex (INR ₹) are gathered from the official website of Bombay Stock Exchange (www.bseindia.com). Closed stock price is choosen for this study because it reflects all the activities of the entire index and historical CO₂ emissions (Mt CO₂/yr) from fossil fuel combustion from all the sectors (Agriculture, Building, Fuel Exploitation, Industrial Combustion, Power Industry, Process and Transport) are collected from <https://www.statista.com>.

3.3. Statistical Tools and Techniques Applied

The descriptive statistics, Karl Pearson's Coefficient of Correlation and Simple Linear Regression are the tools for the analysis of data using the Statistical Package for Social Sciences (SPSS).

4. ANALYSIS & INTERPRETATION

According to UNCTAD's annual survey of investment trends reports, global FDI inflows cut down by 18% to US \$ 1.35 trillion in 2012. In the same time, the Indian economy also experienced its slowest growth and also scuffled with perils related to high inflation. As a result, FDI inflows to India declined 37.08% as compared to 2011. But, in 2013, for the first time ever, developing countries took the lead in attracting FDI, as compared to developed countries and the amount of FDI inflows into India in terms of INR was 147517.74 Crores and then it had increased to 189107.13 crores in the year 2014. In the same line, the S&P BSE Carbonex and Greenex increases at 31.28% and 31.49% respectively. In terms of CO₂ emission, there was an increase up to 7.64% in 2014 and occupied 4th position in terms of six largest emitting countries/regions.

The increasing trend for all the four variables: total FDI inflows into India, S&P BSE Carbonex, S&P BSE Greenex and total CO₂ emissions had increasing trend up to 2016. But due to two major decisions: Demonetization and GST on economic policy had a severe impact on Indian economy and changes in the FDI limits in various sectors and had reduced. Thereafter the total FDI inflows increased to 353558.38 Cr by the end of financial year 2019. But, there is a consistency in return of S&P BSE Carbonex and Greenex over the period of time.

CO₂ emissions due to carbon dioxide and other greenhouse gases plunged 9.83% in 2020 due to restricted global mobility including social distancing measures and restrictions on transportation and negatively impacted firm's productivity via increasing operation costs, decreasing revenue and cash flow challenges and have a decline of 1.22% FDI in 2021. After the pandemic, the growth is largely driven by the high growth in demand for power with new renewable capacity with increased FDI and ultimate increasing trend in S&P BSE Carbonex and Greenex.

4.1. Descriptive Statistics

The descriptive statistics quantified that, S&P BSE Carbonex has the mean of Rs. 1873.66 with S.D of Rs. 665.23 and the range was Rs. 1974.35 with Rs. 1027.55 as minimum and Rs. 3001.90 as maximum values.

Table 1: Descriptive Statistics before log transformation

SI No	Variables	Mean	S.D.	Variance	Skewness	Kurtosis
1	Total FDI Inflows	308272.31	96057.97	9227133922.35	-0.17	-0.51
2	S&P BSE Carbonex	1873.66	665.23	442536.47	0.64	-0.66
3	S&P BSE Greenex	2961.75	995.14	990302.47	0.93	-0.03
4	Total CO ₂ Emissions	2398.28	186.44	34759.33	-0.05	-0.73

Similarly, S&P BSE Greenex has the mean of Rs. 2961.75 with S.D of Rs. 995.14 and the range was Rs. 3052.94. The average CO₂ emission from 2013 to 2022 was 2398.28 Mt with S.D. 186.44. On the same time, on an average Rs. 308272.31 crore FDI that had come to India during 2013 to 2022.

As it can be seen from the Table 1 that, FDI Inflows and total CO₂ emissions have a negative skewness, whereas, S&P BSE Carbonex and Greenex have positive skewness (Mac Gillivray, 1992). Similarly, Kurtosis value of all variables are said to be Platykurtic and have a flatter peak and thinner tails compared to a normal distribution (Westfall, 2014).

To deals with the problems, the log transformation, possibly, the most prominent among others to transform skewed data to approximately conform to normality and a constant variance for linear modeling is used and the result are reported in Table 2 (Hall, 1992).

Table 2: Descriptive Statistics after log transformation

Statistics	Total FDI Inflows	S&P BSE Carbonex	S&P BSE Greenex	Total CO ₂ Emission
Skewness	-0.49	0.48	0.38	-1.40
Kurtosis	-0.11	-1.68	-1.44	2.29

After carefully observed, it is noticed that, the log-transformation does not reduce the skewness. In fact, applying the transformation make the distribution more skewed than the original data (Gonzalez-Blanks, et al., 2020). But the graphical representation from Q-Q plot technique indicates that, the data set possible came from normal distribution and the points forming a line that's roughly straight (Wilk and Gnanadesikan, 1968 and Meloun and Miličák, 2011).

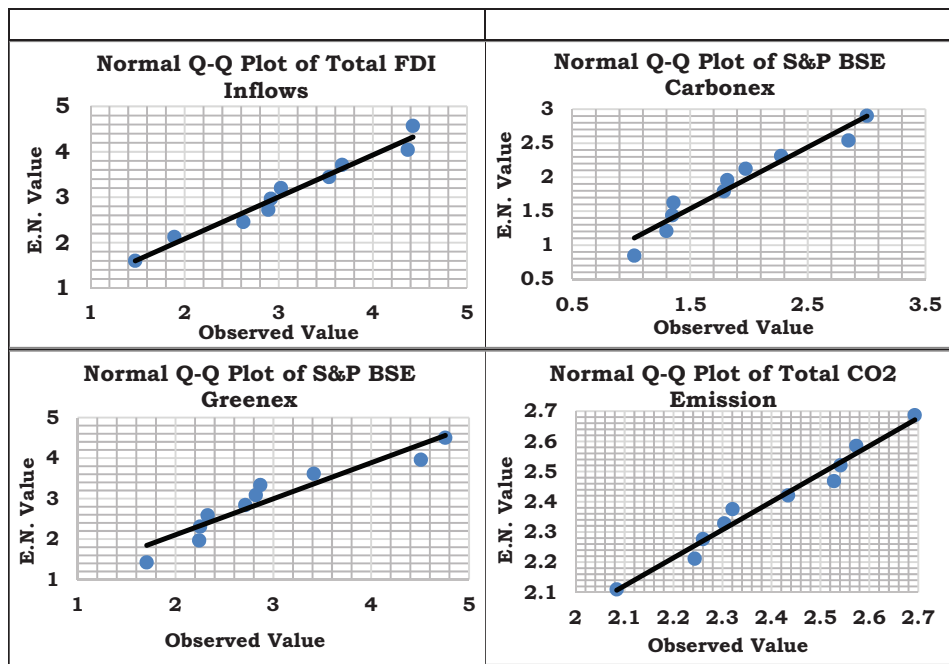


Figure – 1: Q-Q Plot

4.2. Correlation Analysis

Pearson's ρ is the most popular used measure of statistical dependence and gives a complete characterization of dependence in transitive dependency analysis (Tjøstheim, et al., 2022).

Correlation coefficients between FDI Inflows, S&P BSE Carbonex and S&P BSE Greenex and CO₂ Emissions and their significance values have been reported in Table 3. The results show a strong and significant correlation between total FDI inflows and S&P BSE Carbonex and Greenex with coefficient values 0.845 and 0.807 respectively. Similarly, the correlation between S&P BSE Carbonex and Greenex with CO₂ emissions – 0.809 and 0.774 means, investing in carbon reducing industries for climate change (S&P BSE Carbonex) has several precedence as compared to investing in GHG effusion industries (S&P BSE Greenex). On the other hand, the moderate correlation coefficient between CO₂ emissions and FDI inflows (0.654) indicates, FDI inflows to developing countries like India leading to significant positive effects on environmental humiliation in presence of weak environmental armistices (Singhania and Saini, 2021).

Table 3: Correlations Matrix

Correlation Analysis		Total FDI Inflows	S&P BSE Carbonex	S&P BSE Greenex	Total CO ₂ Emission
Total FDI Inflows	Pearson Correlation with Sig. (2-tailed)	1.000			
S&P BSE Carbonex		0.845** (0.002)	1.000		
S&P BSE Greenex		0.807** (0.005)	0.989** (0.000)	1.000	
Total CO ₂ Emission		0.654* (0.040)	0.809** (0.005)	0.774** (0.009)	1.000

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

4.3. Linear Regression

Regression analysis is helpful to identify trends, estimate future values and manage risk by analyzing historical data and making informed predictions based on relevant factors (Petropoulos, et al., 2022).

4.3.1. Total FDI Inflows and S&P BSE Carbonex & S&P BSE Greenex

The Regression model used here to show, whether changes observed in the S&P BSE Carbonex and Greenex are associated with changes in the FDI inflows and predict the effects of the FDI Inflows on the above two indices (Ord, et al., 2017).

Table 4: Model Summary, Coefficients and ANOVA (Model 1 & 2)

Model		Unstandardized Coefficients		t	Sig.	R ²
		B	S.E			
1	(Constant)	197.039	271.635	0.725	0.483	0.753
	Total FDI Inflows	0.005	0.001	5.787	0.000	
2	(Constant)	522.493	443.294	1.179	0.263	0.706
	Total FDI Inflows	0.008	0.002	5.139	0.000	
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4650060.811	1	4650061.811	33.484 ^A	0.000
	Residual	1527631.163	11	138875.560		
	Total	6177691.974	12			
2	Regression	9767888.492	1	9767888.492	26.410 ^B	0.000
	Residual	4068447.343	11	369858.849		
	Total	13836335.835	12			

Note: Dependent Variables: A-S&P BSE Carbonex & B-S&P BSE Greenex.

b. Predictors: (Constant), Total FDI Inflows (INR in Crores).

The F-value is high (33.484 for S&P BSE Carbonex and 26.410 for S&P BSE Greenex) and their significance value is 0.00 at 5% level of significance and represents goodness of fit of these models (Levin, et al., 2009). The coefficient sign of total FDI inflows is as per theoretical prediction and has positive influence on S&P BSE Carbonex and Greenex.

4.3.2. S&P BSE Carbonex & S&P BSE Greenex and CO₂ Emissions due to Fossil Fuel Consumption.

To explore the relationship between S&P BSE Carbonex and Greenex and CO₂ emissions, regression analysis is significant for S&P BSE Carbonex ($\beta = 0.336$, $P < 0.05$) and S&P BSE Greenex ($\beta = 0.219$, $P < 0.05$).

Similarly, the value of R-squared 0.705 for S&P BSE Carbonex and 0.672 for S&P BSE Greenex and it is very reliable to say that, 70.50 percent of change in CO₂ emissions explained by S&P BSE Carbonex and 67.20 percent of change in CO₂ emission explained by S&P BSE Greenex (Harrel, 2015).

Table 5: Model Summary and Coefficients (Model 3 & 4)

Model		Unstandardized Coefficients		t	Sig.	R ²
		B	S.E			
3	(Constant)	1722.551	117.279	14.688	0.000	0.705
	S&P BSE Carbonex	0.336	0.066	5.124	0.000	
4	(Constant)	1700.532	130.317	13.049	0.000	0.672
	S&P BSE Greenex	0.219	0.046	4.752	0.001	

Note: Dependent Variables: CO₂ emissions

Independent Variable: S&P BSE Carbonex & S&P BSE Greenex.

4.3.3. Total FDI Inflows and CO₂ Emissions due to Fossil Fuel Consumption.

To establish the relationship between India's overall CO₂ emissions at the national level (represented by a combination of CO₂ emission from various sectors) and actual amount of FDI (represented by FDI inflows into various sectors into country) the following regression equation can be established.

$$\text{CO}_2 \text{ Emission} = \alpha + \beta (\text{Total FDI Inflows}) + \varepsilon$$

From the below table, the regression analysis is significant for total FDI Inflows ($\beta = 0.002$, $P < 0.05$) and consistent and concluded that 64.8 percent of change in CO₂ emission described by total FDI Inflows (Field, 2013).

Table 6: Model Summary and Coefficients (Model 5)

Model		Unstandardized Coefficients		t	Sig.	R ²
		B	S.E			
5	(Constant)	1737.552	129.871	13.388	0.000	0.648
	Total FDI Inflows	0.002	0.000	4.495	0.001	

Note: Dependent Variables: CO₂ emissions due to fossil fuel

Further, the Parameter, $\beta = 0.002$ indicating that for every 1 Crore increase in FDI, India's overall carbon emissions will increase by 20,000 Mt.

5. CONCLUSION

This paper used transitive dependency analysis approach to investigate whether FDI have any impact on two sustainable green stock returns and is a cause for changes in CO₂ emissions or FDI is directly correlated with CO₂ emission based on the correlation and linear regression analysis to determine cause and affect relationship in context of India.

The strong significant relationship between total FDI inflows and S&P BSE Carbonex and Greenex signifies influence of FDI inflows on S&P BSE Carbonex and S&P BSE Greenex and changing prospective on green economic development with social obligations and responsible investing. The positive correlation between S&P BSE Carbonex and Greenex with CO₂ emission indicates environment-conscious industrialists should increase the use of renewable energy with green technology innovation to ensure sustainable economic development without environmental degradation. On the other hand, the moderate correlation coefficient between CO₂ emissions and FDI inflows indicates, FDI inflows to developing countries like India from developed countries with high concentration of energy-intensive industries leading to significant positive effects on environmental deterioration due to feeble sustainable practices.

From the above functional relationship (In Statistical terminology, Correlation or Regression) between FDI-Green Indices – CO₂ emission: A transitive dependency exists with following functional dependency pattern:

FDI Inflows → S&P BSE Carbonex and S&P BSE Greenex and

S&P BSE Carbonex and S&P BSE Greenex → CO₂ Emissions;

Therefore, FDI Inflows → CO₂ Emissions.

Here, Transitive dependencies take their name from the transitive property in mathematics, which states that if $a > b$ and $b > c$, then $a > c$. This study provides a new perspective in environmental economics with expecting FDI can contribute to a cleaner environment for sustainable development, especially if foreign investments come with cleaner technologies with better management practices and use energy-efficient and cleaner production processes to developing countries like India.

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