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The Interrelationship Between Foreign Direct Investment, Renewable Energy, Trade, And Carbon Emissions: Evidence From Indian Economy

[1]Dr. Amit Manglani, [2]Divya Nandini Sharma

[1]Associate Professor, [2]Research Scholar

[1]Department of Commerce,

[1]Guru Ghasidas Vishwavidyalaya, Bilaspur, Chhattisgarh, India

Abstract: Sustainability is an epicenter of concern for the world economy at present. Figures reveal that Green FDI, or foreign investment in ecofriendly avenues is among the largest categories of FDI for developed segment of the economy whereas the developing segment which also constitutes Indian Economy is currently moving towards sustainability. Thus, taking into consideration the challenges faced and factors positively affecting green economy growth pertaining to Indian Economy, this study seeks to draw an Ecological Sustainability nexus by studying the interrelationship between the variables; Foreign Direct Investment (FDI), Renewable Energy Consumption (REC) and Trade Openness (TO) with Ecological Sustainability (ES), i.e., Carbon Emissions. This analytical study makes use of Ordinary Least Square (OLS) regression, the study found an insignificant positive relationship between FDI and Ecological Sustainability. However, it has been found that a significant negative relationship exists between the REC and ES during the study period.

Keywords- Foreign Direct Investment, Renewable Energy, Indian Economy, sustainability, sustainable development

I. INTRODUCTION

The Global Risk Report mentions that the factors posing largest threats globally are climate change environmental factors (WEF, 2021). The present scenario can be characterised by increasing CO2 emissions and extreme changes in climatic condition. Apart from being a threat, it is the biggest challenge to be faced by the overall global economy because these changes negatively affect economy and overall living quality of people (Lahouel., 2021; Zafar et al., 2022) As a result of intensified climate change, there are hazardous shifts in climatic conditions that are unavoidable. Many developing economies are starting to plan to protect them from being sensitive towards these catastrophic shifts in climatic conditions. There are many strategies included in economy's planning with the objective of reducing extreme climatic conditions (Azam et al., 2021, 2022; Hunjra et al., 2022). Therefore, there is an increasing need for developing or the emerging economies to plan strategies to augment investment aimed towards sustainable development.

The insufficiency of investment is a basic hindrance in dealing with the challenges towards equitable and sustainable growth withing ecological sustainability framework. According to UNFCCC an investment of US$ 1.5 trillion is required by 2030 to implement and fulfil the motive of Paris Agreement. Along with an increasing income and demographic trends, easy availability of energy resources, increase in green finance is crucial to figure out the influence of increasing demand for energy in emerging economies. Many economies are starting to introduce and implement initiatives for green economy.

Green Finance, or green investment represents a novel concept related to the financial industry's role in addressing contemporary major challenges in a way that ensures the creation of value for both businesses and society, all while safeguarding the environment from harm (Thomson et al., 2021). Green investment encompasses financial structures such as blended financing, social responsibility factors, and green investment instruments that prioritize energy-efficient building design and construction techniques (Fayad et al., 2021). This concept has been an element of concern in recent years owing to its inclusion in causing increase in sustainable development. In simplified terms, it includes the financial activities and investments that support sustainable and environmentally friendly projects and initiatives. Sustainable development encompasses governmental strategies, corporate economic strategies, and efforts to preserve natural resources. Mawhinney (2008) highlights three essential pillars of sustainable progress, which include economic, ecological, and social development.

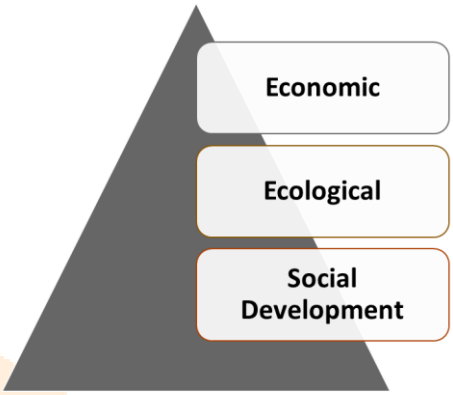

Figure 1 (Mawhinney, 2008)

The three aspects have been covered in this study through the five variables employed to establish the sustainability nexus.

Foreign direct investment has played the role of a key force behind economic integration and progress in today's global economy (Damgaard et al., 2020). It is a proven fact that foreign direct investment is a major factor in emerging nations' economic growth and development (Pricope, 2017). Foreign direct investment has been carrying more relevance in emerging nations including India in an effort to boost competitiveness, build infrastructure, and promote economic progress. FDI boosts recipient nations' economies by providing funding in capital, foreign exchange, technological spillovers, increased competition, and access to international markets (Mottaleb & Kalirajan, 2010). Additionally, it enables developing countries to cater to the investment requirements that surpasses the country's savings rate. This allows them to obtain foreign direct investment, or capital, from abroad and invest in priority industries in order to accelerate economic growth. On the contrary, green investment concentrates on funding environmentally conscious initiatives and enterprises. These financial frameworks guarantee that projects are intrinsically more energy-efficient than they would be otherwise by acting as a prior to new construction and design strategies. At the nexus of sustainable investing and foreign direct investment in emerging economies, there is a great deal of hope for both environmental sustainability and economic expansion.

The rising influx of FDI is a consequence of global economic developement and the movement of international capital. However, it is noteworthy to note that FDI contributes to higher levels of carbon emissions within host countries and contributes to an environmentally unfriendly atmosphere. As a result, FDI has a notably adverse impact on host nations.

Previous studies have explored the surge in FDI inflows, highlighting its potential to exacerbate environmental deterioration in developing nations. A recent study confirmed that FDI inflows lead to increased air pollution and contribute to CO2 emissions. It is proved by a number of studies that the pollution haven hypothesis amplifies overall CO2 emissions and worsens detrimental environmental degradation (Cole, 2004; Cole et al., 2011; Ur Rahman et al., 2019; Kheder and Zugravu, 2012; Rahman et al., 2021). Furthermore, certain research findings indicate that the increase in FDI has resulted in the reduction of carbon emissions in host nations. This positive effect is attributed to clean technology initiatives, improved financial development, and the promotion of an eco-friendly environment induced by FDI inflows.

Consequently, inflows of FDI are associated with a favorable and substantial influence on CO2 emissions (Nair-Reichert and Weinhold, 2001; Didas et al., 2015; Diaz and Moore, 2017; Destek M et al., 2018). Another recent study conducted by Huang et al. (2022) revealed that in the initial stages of FDI inflow, there may be an augmentation in carbon emissions. However, once a certain threshold level is reached, carbon

emissions start to decline as FDI inflow increases. Furthermore, recent investigations by Manoli and Weber (2016), Mahmood and Tariq (2020), Xie et al. (2020), and Li et al. (2022) have all demonstrated the adverse effect of FDI on CO2 emissions.

Increased economic expansion in emerging and developing economies results in higher energy consumption and carbon emissions. The tendency of developing countries to grow through fast industrialization damages the environment and increases air pollution (Sadiq et al., 2021). However, a number of studies depict the positive aspect of economic growth towards sustainability portrayed through Kuznets curve (EKC). In the initial phase, the major concern of an economy is augmenting its economic growth, thereby it represents an overly ambitious phase of an economy. This is the stage witnessing increase in carbon emissions and when these carbon emissions reach a peak, the economy controls it owing to clean energy (Grossman and Kruger, 1991). In this context, the current study contributes to the existing literature by deriving a nexus between Environmental Sustainability and FDI, Renewable Energy, Trade Openness and Economic Growth of the Indian Economy.

II. LITERATURE REVIEW

FDI plays a vital part in forming the global economic landscape, and the link of FDI with environmental responsibility and sustainability concerns has become a subject of increasing importance. As was indicated in the section before this one, FDI holds both positive and detrimental results for the ecological wellbeing of the host economy which can be better understood with the help of Pollution Haven Hypothesis and Pollution Halo Hypothesis. According to the pollution haven hypothesis, along with globalization, less developed and emerging countries attract more foreign investments through industrialization where environmental laws do not form the major point of concern. This results in increase in level of CO2 in the host economy. It's also caused due to the investor's comfort in investing in those destinations which have environmentally flexible regulations as compared to the rigid regulations in developed economies.

Emerging markets, characterized by rapid industrialization and urbanization, have become the core points for green investment (Cohen & Winn, 2007). These areas are becoming more and more dedicated to sustainable development as they recognize the serious environmental problems brought on by rapid growth (Eckstein & Kuenzel, 2017). FDI in emerging markets is driven by the desire to tap into their vast economic potential. Sustainability of the environment and the function of sustainable finance have garnered increasing attention in the previous years as the global community grapples with the pressing need to address climate change and environmental degradation. Green Finance, as stated previously, refers to financial products, investments, and strategies that prioritize environmental sustainability while delivering financial returns.

FDI flows in the past few years into emerging markets have exhibited a strong correlation with green investment (Dinu, 2020). Multinational corporations are motivated by the potential to establish sustainable practices, access renewable energy resources, and satisfy the increasing demand for environmentally-safe goods and services on a worldwide scale (Li et al., 2016).

FDI can either exacerbate or mitigate CO2 emissions specific to the industries it invests in and the environmental regulations in the host country. Kivyiro and Arminen (2014) found that FDI inflows often lead to increased CO2 emissions, especially in energy-intensive industries. In contrast, Balsalobre-Lorente et al. (2018) observed that FDI can help transfer cleaner technology and management practices, reducing emissions.

There are various arguments regarding how foreign direct investment (FDI) affects carbon emissions. According to some studies, foreign direct investment (FDI) may raise CO2 emissions, particularly in developing countries (e.g., Ren et al., 2021; Boamah et al., 2023). This is because FDI may result in a shift of polluting industries to developing nations, where environmental laws are often less stringent (Mujtaba & Jena, 2021). Few further studies have also discovered that FDI can lead to reduced CO2 emissions, particularly in developed countries (Pazienza, 2019; Saqib et al., 2023). This is because FDI can bring with it new technologies and cleaner production methods (Zhu et al., 2016; Huang et al., 2017; Wang et al., 2019). FDI's general influence on CO2 emissions likely depends on a numerous factor, including the type of FDI, the destination country, and the regulations pertaining to the environment.

The connection between Economic expansion and Carbon emissions is well-established. As nations become wealthier, they often utilize more energy, which can result in more CO2 emissions. The Environmental Kuznets Curve (EKC) hypothesis is a well-known theory that postulates a nonlinear link between economic expansion and environmental degradation, including CO2 emissions. (Grossman & Krueger, 1995). As per the EKC theory hypothesizes, industrialization and increased energy use cause a rise in environmental deterioration during the early phases of economic development. However, as economies reach a certain level of revenue, environment witnesses less degradation due to use of more efficient

technologies, environmental policies, and shifts in production. Early empirical evidence for the EKC came from studies like Shafik and Bandyopadhyay (1992) and Grossman and Krueger (1995), which demonstrated an inverse U-shaped trend line linking GDP per capita and CO2 emissions. While the Kuznets Curve hypothesis has gained attention, it is not without critiques and challenges. Some researchers argue that the EKC is overly simplistic and may not universally apply to all countries and environmental indicators (Selden & Song, 1994). There have been observations of inconsistencies in the Kuznets Curve relationship between countries, indicating that variations in institutional quality, technical advancement, and energy sources are responsible for the curve's varying shape (Pao & Tsai, 2011).

An increasing corpus of research, nevertheless, also raises the possibility that this relationship is fading. This is a result of nations making larger investments in energy-efficient and renewable energy technology.

Trade openness, defined as a country's integration into the global economy through exports and imports, has been linked to economic growth. A higher degree of trade openness can lead to increased economic productivity and income (Dollar, 1992). Trade openness can attract FDI, stimulating economic growth (Smarzynska and Wei, 2001). Trade liberalization's capacity to encourage economic expansion has effects on renewable energy usage and CO2 emissions as well. Trade openness can also influence CO2 emissions in several ways. Increased trade can lead to greater transportation and energy consumption, potentially increasing emissions (Lorente et al., 2019). Additionally, trade can affect the composition of production, with industries in trade-intensive countries producing more emissions (Andersson et al., 2015). Nevertheless, trade openness can also facilitate the transfer of cleaner technologies and expertise, potentially leading to emissions reductions.

Adopting renewable energy sources is essential for tackling climate change and reducing CO2 emissions, as evidenced by research showing a correlation between lower CO2 emissions and increasing consumption of renewable energy (Lund and Mathiesen, 2015). The cost-effectiveness and accessibility of renewable energy sources, such as wind, solar, and hydropower, have increased, facilitating countries' shift away from fossil fuels (EIA, 2021).

Trade openness, economic growth, carbon dioxide (CO2) emissions, foreign direct investment (FDI), and the use of renewable energy sources are all significant variables that influence a nation's capacity to maintain both its environment and its economy. Trade openness, economic growth, CO2 emissions, foreign direct investment (FDI), and renewable energy consumption (REC) all have intricate and varied relationships with one another. A steadily increasing amount of research has been done on this subject, but the results are often at odds and flexible. The current study examines the statistical relationship between environmental sustainability and TO, REC, FDI, and economic growth in the Indian economy.

III. OBJECTIVE OF THE STUDY

The current study examines five factors in total, including trade openness, foreign direct investment, green financing, and economic development with carbon emissions as indicators of environmental sustainability. The variables that are dependent and the independent variables (ES) are included in the empirical estimation. From India's post-reform period of 1995 to 2020, the dependent variables comprise Green Finance (REC), Trade Openness (TO), Economic Growth (EG), and Foreign Direct Investment (FDI). From 1995 to 2020, India's annual figures were sourced from the World Development Indicators.

IV. RESEARCH METHODOLOGY

Methods:

Using the ordinary least square regression method, one could evaluate the independent variables' ability to explain the dependent variable and investigate the relationship between ecological sustainability, as measured by CO2 emissions, and trade openness, economic growth, foreign direct investment, renewable energy consumption, and trade. The linear regression model estimated that is applied is as follows:

$$ES_t = \propto + \beta_1 EG_t + \beta_2 FDI_t + \beta_3 REC_t + \beta_4 TO_t + \varepsilon_t$$

Where ‘t’ refers to the time in the year, ‘β’ coefficient measures the slope of independent variables, and ‘Ɛ_t’ is the random variable disturbance term.

4.1 Description of Variables

Since Landenberg (2014) provided a general explanation of green investment in terms of renewable energy consumption, we measured green financing as a percentage of renewable energy consumption. Additionally, as indicated in Table 1, the current study examined trade openness (export plus import of goods and services, % GDP), GDP (annual growth), environmental pollution (metric tons of CO2 emissions per capita), and net inflow (% GDP) as indicators of foreign direct investment.

Table 1: Description of Variables

Variable	Denotation	Measurement of Variables
Environmental Sustainability	ES	CO2 emissions metric tonnes per capita
Foreign Direct Investment	FDI	Foreign Direct Investment inflows % of GDP
Green Finance	REC	Renewable Energy Consumption % of total energy consumption
Trade Openness	TO	Imports and Exports % of GDP
Economic Growth	EG	The growth rate in GDP annual (in percentage)

4.2 Summary Statistics:

Table 2 shows the various statistical behaviour of the variables and shows there is no big gap in between the mean and median values of each variable. The probability value of the EG is less than 0.05, which means the null hypothesis is rejected implying that the economic growth is not normally distributed during the study period. However, FDI, REC, ES and TO are normally distributed during the study period.

Table 2: Descriptive Statistics of ES, EG, FDI, REC and TO

	ES	EG	FDI	REC	TO
Mean	1.212808	6.060909	1.468768	40.49962	38.73067
Median	1.151980	7.102806	1.511796	40.46000	40.41249
Maximum	1.795595	8.845756	3.620523	49.54000	55.79372
Minimum	0.765190	-5.831053	0.472645	32.57000	21.92949
Std. Dev.	0.355663	2.973679	0.770425	6.203826	11.15154
Skewness	-0.236575	-2.561957	0.776198	0.051935	-0.122055
Kurtosis	1.485625	10.84446	3.396372	1.340849	1.755443
Jarque-Bera	2.726968	95.10582	2.780965	2.993867	1.742553
Probability	0.255768	0.000000	0.248955	0.223815	0.418417
Sum	31.68901	157.5836	38.18798	1052.990	1006.998
Sum Sq. Dev.	3.162410	221.0692	14.83887	962.1863	3108.921
Observations	26	26	26	26	26

Source: EViews result by Authors

V. OLS REGRESSION ANALYSIS

Table 3 represents the interrelationship between CO2 emissions, FDI, Economic Growth, Renewable Energy Consumption and ES (Ecological Sustainability) using log differences of variables during the study period. The significant value of EG is 0.3715 which is greater than 0.05, which means the EG has no significant influence on ES. Similarly, the significant value of FDI is 0.8518 which posits that FDI has no significant influence on ES. On the other hand, the significant value of REC is 0.0013 which is less than 0.05, which means the null hypothesis is rejected and REC has a significant relationship with ES but a negative impact. This implies that an increase in Renewable Energy Consumption can decrease CO2 emissions. The significant value of TO is 0.4357 which is less than 0.05, thereby showing that Trade Openness also has no significant relationship with ES. The R2 is 0.46 which represents Renewable Energy Consumption explaining the ecological sustainability of 46% during the study period in India. Durbin-Watson statistic is 1.99 and the value is between 1 and 4, closer to the best fit value of 2, the value is nearer to zero autocorrelation which means the assumed model is fit.

Table 3: Regression analysis with ES as dependent variable and EG, FDI, REC and TO as independent variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017004	0.006492	2.619027	0.0169
DLNEG	0.013259	0.014486	0.915318	0.3715
DLNFDI	-0.003251	0.017163	-0.189387	0.8518
DLNREC	-1.023570	0.272808	-3.751986	0.0013
DLNTO	0.045913	0.057653	0.796370	0.4357
R-squared	0.465874	Mean dependent var		0.034529
Adjusted R-squared	0.353427	S.D. dependent var		0.028487
S.E. of regression	0.022907	Akaike info criterion		-4.531721
Sum squared resid	0.009970	Schwarz criterion		-4.286293
Log likelihood	59.38066	Hannan-Quinn criteria.		-4.466609
F-statistic	4.143040	Durbin-Watson statistic		1.998927
Prob(F-statistic)	0.014031			

Source: EViews result by Authors

5.1 Residual Diagnostic

5.1.1 Serial Correlation

Table 4 shows the probability value of F-statistic is 0.4125 and is greater than 0.05, which means null hypothesis is accepted and found no autocorrelation within the model.

Table 4:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.933232	**Prob. F(2,17)**	**0.4125**
Obs*R-squared	2.374326	Prob. Chi-Square(2)	0.3051

5.1.2 Heteroscedasticity

The robustness of OLS output is checked by using the Heteroscedasticity test. The Hypothesis is:

H_0: No Heteroscedasticity

H_1: Presence of Heteroscedasticity

Table 5 shows the F-statistic significant value is 0.63 which is greater than the value at 5% level of significance, means there is the presence of homoscedasticity in the model.

Table 5:

Heteroscedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.642362	**Prob. F(4,19)**	**0.6389**
Obs*R-squared	2.858984	Prob. Chi-Square(4)	0.5817
Scaled explained SS	1.252950	Prob. Chi-Square(4)	0.8693

5.1.3 Variance Inflation Factor Analysis

Variance Inflation Factor (VIF) analysis is a diagnostic tool used to detect multicollinearity in a linear regression model. Variance inflation factor is used to measure how much the variance of the estimated regression coefficient is inflated if the independent variables are correlated. The value of Centered VIF in this study is less than 10 which implies that the independent variables are not correlated to each other.

Table 6:

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	4.22E-05	1.927965	NA
DLNEG	0.000210	1.730174	1.722667
DLNFDI	0.000295	1.552088	1.523859
DLNREC	0.074424	1.968451	1.031723
DLNTO	0.003324	1.304641	1.222813

5.1.4 Residual Normality

Figure 2 depicts the residual normality test of variables together. The significant value of residuals is 0.69 which is greater than the value of 0.05, which means the null hypothesis is accepted and the residuals are normal.

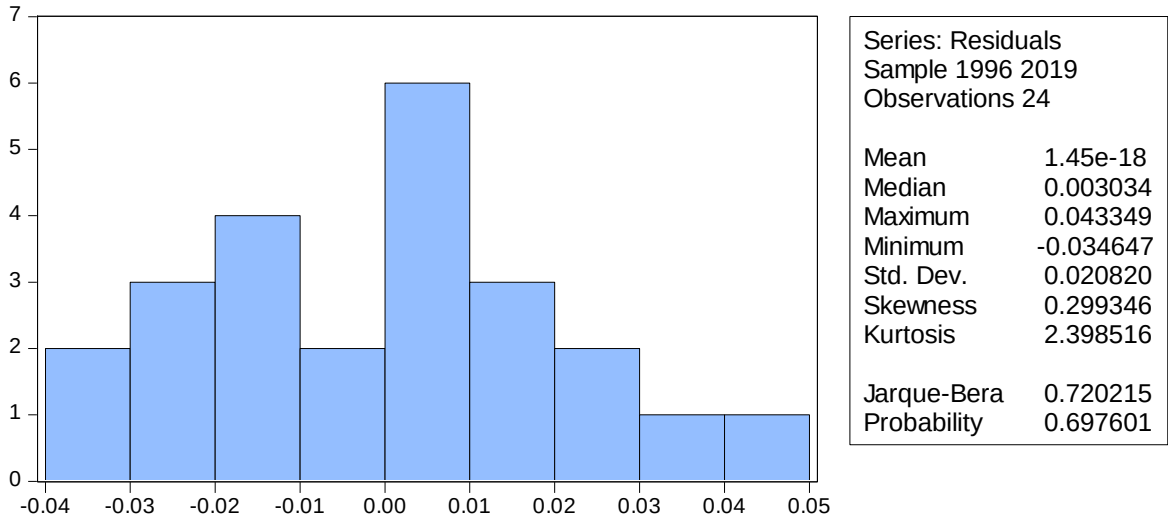

Figure 2: Histogram of residuals and Jarque-Bera Test

VI. SUMMARY AND CONCLUSION

The objective of the empirical analysis is to determine how the Indian economy's use of renewable energy, trade openness, economic growth, and foreign direct investment relate to each other. From the perspective of the environment of view, ecological sustainability is believed to be facilitated by trade openness, economic growth, the use of renewable energy, and foreign direct investment. However, using the OLS linear regression model, the study found that, over the course of the study period, Foreign Direct Investment had a positive but negligible impact on Ecological Sustainability in India. However, during the study period in India, Renewable Energy Consumption had a significant negative influence on Ecological Sustainability. The outcome of the study concluded that the insignificance of Foreign Direct Investment also points out towards the shortage of investments towards green endeavors in Indian Economy. In the pretext of the negative relationship existing between FDI and Carbon Emissions, an increased Foreign Direct Investment more focused towards green initiatives can cause reduction in carbon emissions. The consumption of renewable energy has been found to be directly related to carbon emissions, indicating the need to limit the use of renewables in order to meet the Sustainable Development Goals for the Indian economy. Trade openness and economic growth have been found to be negatively related to carbon emissions, which is evident from a theoretical perspective as demonstrated by the Kuznets Curve, which shows that the more development, the more environmental deterioration that occurs. The government should take more action to encourage green investments. Ecologically focused initiatives towards maintaining and improving environmental quality and promotion of eco-friendly investment avenues is a must for the Indian Economy to be able to achieve its sustainability targets.

VII. LIMITATIONS OF THE STUDY

The current study has considered only four factors to determine the empirical relationship with Ecological Sustainability which can be expanded towards more relevant factors. This study is majorly concerned with establishing the relationship between Ecological Sustainability and FDI, Economic Growth, Renewable Energy Consumption and Trade Openness of Indian Economy. Further studies can also carry out co-integration study of these variables in the context of Indian Economy and different regional integrations.

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