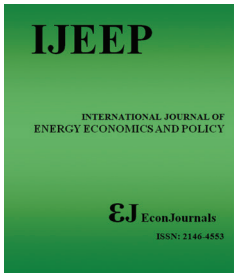

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The Dynamics of FDI Inflows, Economic Growth, Trade Openness and CO_2 Emissions in India: An ARDL Approach with Structural Breaks

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ABSTRACT

The present study empirically investigates the causal relationship among FDI inflows, economic growth, trade openness, and CO_2 emissions in India from 1980 to 2023, employing the autoregressive distributed lag (ARDL) approach. Unlike previous studies, the structural breakpoints are identified in the time-series data using the multiple breakpoint test to incorporate into the ARDL model. The cointegration test shows a significant long-term relationship between the variables. The error correction model with structural breaks reveals a bidirectional causation between the FDI inflows and trade openness, validating the long-term complementary relationship. However, there is no significant evidence of causation between FDI inflows and economic growth in the long run. Besides, the FDI-Growth nexus is bidirectional in the short run, with the impact of FDI on GDP growth being relatively modest. While GDP and trade contribute to CO_2 emissions, the study indicates no significant relationship between FDI inflows and CO_2 emissions in both the long and short run. The findings do not support the pollution haven hypothesis in the Indian economy. The study emphasizes the establishment of future-ready infrastructure for the green FDI inflows, rather than the FDI that primarily focuses on generating employment opportunities in the economy.

Keywords: Foreign Direct Investment, Economic Growth, Trade Openness, CO_2 Emissions, Autoregressive Distributed Lag Approach, India
JEL Classifications: C12, F21, F23

1. INTRODUCTION

Foreign direct investment (FDI) is widely acknowledged as a significant driver of economic growth and trade liberalization, particularly within emerging economies, due to greater financial and economic integration (Dinh et al., 2019). Neoclassical economists posit that increases in FDI inflows bolster economic growth by crowd-in domestic investment. It facilitates technological progress and capital accumulation, thereby improving efficiency. Endogenous growth theory further highlights that FDI enhances productivity through spillover effects. Additionally, FDI can promote domestic investment, generate employment opportunities, and encourage skills development and knowledge transfer (Solow, 1956; Romer, 1986; Grossman and Helpman, 1991). Nonetheless, the dependency theorists emphasize the potential risk that FDI could impede output growth by concentrating economic power in the hands of foreign entities, leading to profit repatriation and restricted reinvestment in host economies (Cardoso, 1977).

Moreover, the high economic growth attracts more FDI into the country (Markusen, 1995). A larger market size characterizes a higher GDP, increased per capita income, and a stable macroeconomic environment. Such conditions foster investor confidence in the potential for profit and return on investment.

FDI and trade openness exhibit substitute and complementary relations. The substitute and complementary relationship is referred to as horizontal FDI and vertical FDI, respectively. Vertical FDI involves firms leveraging advanced technologies alongside cheap resources in developing countries, primarily driven by cost considerations (Fonseca and Mendonça, 2016). Conversely, horizontal FDI occurs in advanced economies, motivated by market-seeking objectives (Kang, 2012). This distinction highlights the differing motivations behind these two types of FDI, with unique economic strategies in international trade. FDI occurs in a host country to leverage comparative advantages, subsequently enhancing trade flows through increased exports from the host country. Local Firms choose between export and FDI to enter foreign markets, and entry depends on transportation costs, trade barriers, and the host country's market demand. This investment often serves as a substitute for imports in the host country. Besides, it was established that absorptive capacity is critical for FDI inflows to influence trade openness positively (Tang and Zhang, 2016). Liberalized trade policy (tariff and non-tariff barriers) and favourable FDI policy can encourage foreign capital to support import substitution strategies (Su et al., 2018). In other words, trade liberalization positively influences FDI inflows by enhancing the investment environment, providing better market access, and lowering business barriers for foreign investors.

The nexus between FDI inflows, economic growth and trade openness has emerged as a pivotal area of inquiry in sustainable development. FDI can significantly lower pollution intensity in firms, particularly in lightly polluting industries and regions with better absorption capabilities (Wang and Liu, 2024; Chang et al., 2022). It often brings advanced technologies that improve resource efficiency and pollution management, contributing to better environmental outcomes. Besides, FDI improves environmental quality by introducing sustainable practices, supporting the Pollution Halo Hypothesis (Zhao and Peng, 2024). In contrast, the pollution haven effect states that developing countries may attract FDI, leading to increased pollution, as foreign firms exploit weaker environmental regulations, creating "polluted paradise" (Liu and Guo, 2023). Further, the impact of FDI varies significantly between developing and developed nations, with middle-income countries often experiencing increased pollution levels due to lax regulations (Zhao and Peng, 2024). Without robust environmental policies, the influx of FDI can lead to resource over-exploitation and environmental degradation (Ngoc et al., 2025).

On the theoretical arguments, the relationship between FDI, GDP, trade openness, and pollution remains complex and depends on which effect dominates the other effects. Given the necessity to address climate change, exploring the relationship between FDI inflows, economic growth, and trade openness in alignment with environmental quality is essential. This will provide significant insights into how the Indian economy can harness the economic advantages of FDI while reducing its environmental impacts. Furthermore, the Indian economy, characterized by limited capital and inadequate environmental regulations, predominantly depends on non-renewable energy sources like coal to attract FDI in energy-intensive and carbon-heavy sectors (Sarkodie and Strezov, 2019). This situation raises an empirical question: while FDI fosters economic growth and trade, it may also challenge and adversely affect the environmental quality of the Indian economy. Our study empirically investigates the causal nexus between FDI inflows, economic growth, and trade openness. Besides, it explores the effects of FDI inflows, economic growth, and trade openness on CO_2 emissions in India. This research contributes to the existing body of knowledge in multiple ways. Unlike other studies, it uses the ARDL approach with structural breaks that can handle variables with mixed integration orders (I[0] and I[1]), avoids pre-testing for unit roots, and can be used to estimate long run relationships even with small sample sizes. Incorporating structural breaks allows the model to account for potential shifts or changes between variables over time, leading to more accurate and robust results. Further, while earlier studies mainly concentrate on economic factors, this study integrates a key environmental variable (CO_2 emission) as a regressand, offering a broader framework to explore the dynamics of economic factors influencing environmental quality. Finally, this research carries considerable implications for both policymakers and investors. If FDI inflows are determined to increase CO_2 emissions without effective governance and policies focused on sustainability, it emphasizes the necessity for more stringent environmental regulations and incentives for green investments. On the other hand, if FDI inflows, economic growth, and trade openness are found to alleviate these environmental effects, it underscores the significance of aligning these factors with sustainability goals. Such insights could assist policymakers in formulating frameworks that optimize the economic advantages of FDI while reducing its environmental impacts. It also guides investors in identifying opportunities in the Indian economy that align with sustainable development.

The structure of this paper is as follows: Section 2 reviews the relevant literature. Section 3 introduces the data and methods. Section 4 presents the empirical results. Section 5 concludes the study and provides policy recommendations.

2. LITERATURE REVIEW

2.1. FDI Inflows and Economic Growth Nexus

Numerous studies have explored the causal relationship between FDI inflows and economic growth in various countries and regions. Kurečić and Kozina (2017) examined the FDI-GDP relationship among EU15 member states from 1980 to 2014, found a positive correlation in most countries. The authors emphasized that FDI is a significant growth driver in less developed EU states. Using cointegration and the error correction model, Talwar and Srivastava (2018) examined the FDI-GDP nexus across countries at different stages of development—Bhutan, Ethiopia, India, Brazil, the USA, and the UK. The authors showed a long-term equilibrium relationship between FDI and GDP in Ethiopia, India, and the UK,

but not in Bhutan, Brazil, or the USA. The research concludes that the developmental effects of FDI differ based on the context of the specific country and suggests against excessive reliance on FDI for short-term growth. Mansoor and Bibi (2019) utilized ARDL approaches and causality tests to demonstrate that FDI positively influences economic growth in Pakistan, highlighting the need for stable exchange rates and supportive policies to sustain long-term growth. Verma (2020) analyzed FDI inflows on GDP per capita in India, China, the Philippines, and Vietnam and concluded that FDI enhances income growth through technological transfers. Li (2020) demonstrated that FDI contributes positively to economic growth in Shandong Province, China, advocating for strategies that enhance export activities and target FDI in industrial sectors.

Using the cointegration and the error correction model, Tanoe (2021) confirmed a positive long-term relationship between FDI and GDP in Sub-Saharan African nations. Taghiyev and Mahmud (2022) also identified a long-term relationship and a unidirectional causality from FDI to GDP in Azerbaijan, highlighting the liberalized foreign investment for economic development. Similarly, Angola (2022) found unidirectional causality from FDI to GDP in Zambia. Research conducted by Sabra (2021) in selected MENA (Middle East and North Africa) countries revealed a negligible but positive effect of FDI on GDP. The study highlights the need for institutional and structural reforms to enhance the growth benefits of foreign investment. Lingaiah (2021) and Begum et al. (2023) demonstrated a positive effect of FDI on GDP in India and Bangladesh, respectively. The study highlights the necessity for institutional reforms to attract foreign investment, which supports sustained development. Kumar (2023) found no significant relationship between FDI inflows and economic growth in Ethiopia. Besides, the analysis revealed a positive impact of FDI on GDP in 14 East African nations, suggesting that FDI is essential for regional growth. Bobek et al. (2024) reported a positive association between FDI and GDP in both China and India, highlighting the need to strengthen institutional frameworks to maximize the benefits of foreign investment. Xuan (2025) demonstrated a significant positive correlation between FDI and GDP in Germany, advocating for growth strategies driven by investment and support for innovations and sustainability initiatives.

Studies have also shown that economic growth often signals a favourable investment climate, increased market size, and business confidence, making a country more appealing to foreign investors. For instance, Kosztowniak (2016) demonstrated a bidirectional causation among FDI and GDP in Poland, with GDP exerting a more substantial impact on FDI. The study suggests that policy reforms should focus on enhancing employment growth, improving the quality of FDI inflows, and boosting domestic investments. Pečarić et al. (2021) established that GDP growth has a significant impact on FDI inflows in Croatia. Similarly, Anwar et al. (2023) found that GDP growth positively influences FDI inflows in the ASEAN-5 countries. The authors suggest that strong macroeconomic performance would attract more foreign investment. Recently, Güz et al. (2025) examined the factors affecting FDI inflows across 54 nations and confirmed a positive correlation between GDP and FDI. Their study indicates that high economic growth, institutional quality and liberal trade policies are needed to attract foreign capital.

FDI is often seen as a driver of economic growth, but some studies suggest that its impact on GDP can be negligible or even negative. Ramadhan et al. (2016) analyzed the effects of FDI inflows on economic growth in Mozambique and South Africa from 1996 to 2014. Utilizing the ordinary least squares (OLS) technique, the research indicated that FDI had a positive but insignificant effect in Mozambique. Besides, FDI was statistically significant but had a negative impact on GDP in South Africa. The authors suggest enhancing infrastructure sectors, business environment, and governance structures to attain long-term economic growth from foreign investment. Alvarado et al. (2017) investigated the impact of FDI inflows on GDP across 19 Latin American countries using panel data analysis. Their findings indicated that the effect of FDI on economic growth is not statistically significant however, this effect varies based on the developmental levels of the countries in the region. FDI shows a positive and statistically significant impact on output growth in high-income countries. Conversely, the effect is uneven and not statistically significant in upper-middle-income countries. In lower-middle-income countries, the impact of FDI is negative and statistically significant. Using cointegration and Granger causality tests, Al-Masbhi and Du (2020) indicated no causal nexus between FDI and GDP growth in Yemen. Employing time-series analysis and Artificial Neural Networks (ANNs) in a production function framework, Magazzino and Mele (2022) supported the neutrality hypothesis, suggesting no significant causal link between FDI and GDP in Malta during the study period.

2.2. FDI Inflows and Trade Nexus

Sun (1999) explored the impact of FDI on foreign trade in China using macroeconomic and firm-level analysis and found that foreign-invested enterprises (FIEs) played a significant role in trade expansion. Liu et al. (2001) applied panel data analysis from 1984 to 1998 and identified that FDI stimulate exports in China. Using panel data analysis, Jensen (2004) observed that the effect of FDI on trade was more moderate in the Central and Eastern European countries. Africano and Magalhães (2005) applied a gravity model to examine the causal nexus between trade flows and FDI inflows in Portugal. The results revealed that inward FDI boosted exports, especially within the EU. Kosekahyaoglu (2006) applied the Granger causality tests for Turkey and Central and Eastern European countries and confirmed a complementary FDI–trade relationship. Aizenman and Noy (2006) applied time-series analysis and Geweke decomposition. They found strong bidirectional causality between FDI and manufacturing trade—50% influence from FDI to trade and 31% in reverse. Similarly, Ghosh (2007) used panel data from 1970 to 1997 for developing countries and found that FDI was a stronger driver of trade openness than vice versa. Dash and Sharma (2011) used VAR and Granger causality tests. They found bidirectional causality between FDI and imports and unidirectional causality from exports to FDI, supporting export promotion to attract investment in India.

Anwar and Nguyen (2011) employed a gravity model for Vietnam and concluded that FDI had a robust positive effect on exports and imports, particularly post-crisis, urging for resilience-focused FDI

policies. For a panel of 36 developing countries, Liargovas and Skandalis (2012) found that trade openness significantly attracted FDI inflows. Belloumi (2015) applied ARDL bounds testing for Tunisia and confirmed long run cointegration among FDI, trade openness, and GDP, but no short run causality. The authors recommended policies that enhance absorptive capacity. Dash and Parida (2013) applied cointegration and the error correction model for India and found that services exports and FDI are mutually reinforcing, and both positively contributed to economic growth. Using the Hausman-Taylor estimator for Malaysia, Goh and Tham (2013) observed that inward FDI complements trade. For the emerging countries, Medvedev (2012) showed that preferential trade agreements significantly increase FDI flows. Frutos-Bencze et al. (2017) used dynamic panel models and found that FDI promotes export diversification in African economies, especially in low-tech sectors. Albulescu and Goyeau (2019) used gravity models for Central and Eastern European countries from 2000 to 2013 and found inward FDI had weaker effects on trade openness. Cantah et al. (2018) applied dynamic panel GMM to Sub-Saharan Africa and found that trade openness significantly boosts FDI inflows. The study suggests tariff reductions and liberal reforms. Pan and Chong (2023) performed social network analysis for the Belt and Road Initiative (BRI) countries and established that FDI significantly improved trade, especially in medium-tech exports post-BRI. The study recommends sector-specific coordination to sustain gains in the region.

2.3. FDI and Pollution Nexus

The impact of FDI inflows on environmental concerns has sparked a global discourse on sustainable development. Researchers have begun to examine how the influx of foreign capital can contribute to both the degradation and enhancement of environmental quality. Chen et al. (2022) analyzed provincial data in China using spatial econometric and threshold models. They found that FDI improved emission efficiency and water quality, refuting the pollution haven hypothesis, which states FDI can increase pollution in host countries, particularly those with weaker environmental regulations. The authors suggested the need to promote export-oriented and eco-innovative foreign capital inflows. Liu and Zhang (2022) employed firm-level data around the global financial crisis in China. They showed that FDI reduced air pollution, especially where trade openness and governance were strong, supporting the pollution halo hypothesis. Wang et al. (2021) performed spatial Durbin and panel threshold models and showed that FDI inflows improved emission efficiency and generated positive spatial spillovers. Bhujabal et al. (2021) demonstrated that FDI reduced emissions in Asia-Pacific countries.

While studies highlight that FDI significantly reduces emissions, a growing body of research reveals adverse effects of FDI towards emissions. Marques and Caetano (2022) applied a panel ARDL model to 15 OECD countries from 2005 to 2016 and found FDI inflows linked to rising emissions, recommending stricter environmental controls. Using threshold regression on 107 countries, Deng et al. (2022) found that FDI reduced pollution only below certain income thresholds, suggesting income-level-sensitive environmental policies. Ha and Nguyen (2021) employed the system GMM estimation on 86 developing countries and observed that FDI worsens pollution. Caetano et al. (2022) examined FDI in electricity and services sectors for the OECD countries and found improved energy efficiency in certain areas but overall increased pollution. Using spatial autoregressive analysis, An et al. (2021) reported an inverted "U-shaped" association between FDI and pollution in China. Bulus and Koc (2021) validated that FDI, GDP, energy use, and imports raised emissions in Korea, recommending expansion of green growth policies and stricter FDI regulation. For a panel of 105 developing economies, Kamal et al. (2021) confirmed that FDI and globalization increased CO_2 emissions. The authors recommended restructuring industrial sectors and implementing carbon-free macroeconomic policies. Using a semi-parametric STIRPAT model on the Chinese economy, Xu et al. (2020) found a positive association between FDI and SO_2 emissions. Huang et al. (2021) reported that FDI increased PM2.5 pollution in China. For Asian countries, Kisswani and Zaitouni (2021) found mixed evidence—FDI increased pollution in the Philippines (PHH) but negatively impacted Malaysia and Singapore. Mahmood (2025) applied a spatial durbin model in Latin America and found FDI had no significant environmental effect, though growth raised emissions. Chiriluș and Costea (2023) showed that CO_2 emissions influenced FDI inflows, with economic growth being the main pollution driver in Romania. Fu et al. (2023) confirmed the pollution haven hypothesis in central and western China. Nguyen et al. (2023) found that FDI increased pollution in ASEAN countries, validating the pollution haven hypothesis. Apergis et al. (2023) showed that bilateral FDI had mixed effects on emissions in BRICS. Wu and Wang (2023) found that FDI worsened air pollution in China and an inverted U-shape effect, especially in central and western regions. Xie and Zhang (2023) observed that global FDI raised haze pollution, but environmental regulation moderated the impact. Applying the Difference-in-Differences approach, Liu et al. (2025) showed that FDI lowered firm-level emissions in China. The authors recommended the FDI liberalized strategy to achieve growth with environmental sustainability.

The existing literature indicates that FDI significantly influences the economic growth of host nations; however, there exists a notable gap in research regarding its relationship with environmental pollution. The Indian economy has experienced substantial FDI inflows since implementing economic reforms, establishing itself as an attractive destination for such investments. Nonetheless, the impact of FDI on economic growth and trade in India remains contentious, with various studies producing conflicting evidence. Furthermore, the literature has predominantly concentrated on the economic advantages of FDI, such as output growth, trade, and spillover effects, while often neglecting the environmental consequences. This neglect is particularly alarming, as the increase in industrial activity concerning FDI inflows can result in increased pollution levels in India, complicating the evaluation of ecological footprint. On the methodological front, prior studies mainly used traditional econometric techniques without accounting for structural breaks, which can mislead results and obscure the underlying relationships between variables. It is essential to address these research gaps to formulate comprehensive policies that not only attract foreign investment but also protect environmental integrity, thereby ensuring sustainable development in the long run. The current study also employed robust least squares methods to validate the results.

3. METHODOLOGY

3.1. Data Sources

The study uses annual time series data from 1980 to 202. All necessary information is collected from the World Development Indicators (WDI) provided by the World Bank. Foreign Direct Investment (FDI) is measured as net foreign direct investment inflows as a percentage of GDP. Gross domestic product (GDP) is expressed in constant 2015 US dollars. Trade openness is the percentage of exports and imports relative to GDP. Following Sreenu (2022), Rana and Sharma (2020), and Bekun et al. (2024), pollution is represented by carbon dioxide (CO_2) emissions per capita. This reflects the total annual CO_2 emissions—among the six greenhouse gases recognized in the Kyoto Protocol—derived from the agriculture, energy, waste, and industrial sectors, standardized to carbon dioxide equivalent values and divided by the population of the economy.

3.2. Model Specification

To evaluate the stationarity of the time series data while accounting for structural breaks, the study employs the augmented dickey-fuller (ADF) test, including additive outliers (AO) and Innovative Outliers (IO) as outlined by Perron (1989). The ARDL approach is then used to investigate the long run and short run causal relationships among FDI inflows, GDP, trade, and CO_2 emissions. To ensure a robust ARDL analysis, the study identifies potential structural breaks in the time series data using the multiple structural breakpoint test developed by Bai and Perron (2003). Using a general-to-specific modelling framework, the ARDL method selects suitable lags to capture the data-generating process effectively. The ARDL bounds test is represented in Equations (5-8).

$$\Delta InFDI_t = \beta_0 + \sum_{i=1}^{m}\delta_1\Delta InFDI_{t-i} + \sum_{i=1}^{n}\delta_2\Delta InGDP_{t-i} + \sum_{i=1}^{n}\delta_3\Delta InTRADE_{t-i} + \beta_1 InFDI_{t-i} + \beta_2 InGDP_{t-i} + \beta_3 InTRADE_{t-i} + \lambda_1 D_{1t} + \lambda_2 D_{2t} + \lambda_3 D_{3t} + \varepsilon_t \quad (1)$$

$$\Delta InGDP_t = \beta_4 + \sum_{i=1}^{m}\delta_4\Delta InFDI_{t-i} + \sum_{i=1}^{n}\delta_5\Delta InGDP_{t-i} + \sum_{i=1}^{n}\delta_6\Delta InTRADE_{t-i} + \beta_5 InFDI_{t-i} + \beta_6 InGDP_{t-i} + \beta_7 InTRADE_{t-i} + \lambda_4 D_{4t} + \lambda_5 D_{5t} + \lambda_6 D_{6t} + \lambda_7 D_{7t} + \varepsilon_t \quad (2)$$

$$\Delta InTRADE_t = \beta_8 + \sum_{i=1}^{m}\delta_7\Delta InFDI_{t-i} + \sum_{i=1}^{n}\delta_8\Delta InGDP_{t-i} + \sum_{i=1}^{n}\delta_9\Delta InTRADE_{t-i} + \beta_9 InFDI_{t-i} + \beta_{10} InGDP_{t-i} + \beta_{11} InTRADE_{t-i} + \lambda_8 D_{8t} + \lambda_9 D_{9t} + \varepsilon_t \quad (3)$$

$$\Delta InCO_{2t} = \beta_8 + \sum_{i=1}^{m}\delta_7\Delta InFDI_{t-i} + \sum_{i=1}^{n}\delta_8\Delta InGDP_{t-i} + \sum_{i=1}^{n}\delta_9\Delta InTRADE_{t-i} + \sum_{i=1}^{n}\delta_9\Delta InCO_{2t-i} + \beta_9 InFDI_{t-i} + \beta_{10} InGDP_{t-i} + \beta_{11} InTRADE_{t-i} + \beta_{12} InCO_{2t-i} + \lambda_8 D_{8t} + \lambda_9 D_{9t} + \lambda_{10} D_{10t} \quad (4)$$

The variables FDI, GDP, TRADE, and CO_2 represent net foreign direct investment inflows, gross domestic product, trade openness, and carbon dioxide emissions per capita, respectively. The dummy variables D1 through D13 indicate the existence of structural breaks in the time series data. Each dummy variable takes the zero value before the break period and one after. The FDI has three key breakpoints: 1986 (D_1), 1994 (D_2), and 2006 (D_3). The GDP characterizes four breakpoints: 1987 (D_4), 1993 (D_5), 2004 (D_6), and 2014 (D_7). Trade openness has two key breakpoints: 1992 (D8) and 2002 (D9). The CO_2 emissions have four significant breakpoints: 1987 (D10), 1997 (D11), 2006 (D12), and 2012 (D13).

The above ARDL bounds test equations provide the following long run form of the ARDL estimates:

$$InFDI_t = \alpha_1 + \rho_1 InFDI_{t-1} + \rho_2 InGDP_{t-i} + \rho_3 InTRADE_{t-i} + \varepsilon_t \quad (5)$$

$$InGDP_t = \alpha_2 + \rho_4 InFDI_{t-1} + \rho_5 InGDP_{t-i} + \rho_6 InTRADE_{t-i} + \varepsilon_t \quad (6)$$

$$InTRADE_t = \alpha_3 + \rho_7 InFDI_{t-1} + \rho_8 InGDP_{t-i} + \rho_9 InTRADE_{t-i} + \varepsilon_t \quad (7)$$

$$InCO_{2t} = \alpha_3 + \rho_7 InFDI_{t-1} + \rho_8 InGDP_{t-i} + \rho_9 InTRADE_{t-i} + \rho_{10} InCO_{2t-i} + \varepsilon_t \quad (8)$$

Besides, the short run estimates of the ARDL-error correction model takes the following form:

$$ln\Delta FDI_t = \gamma_1 z_{t-1} + \sum_{i=1}^{p-1}\sigma_1 ln\Delta FDI_{t-i} + \sum_{i=1}^{p-1}\sigma_2 ln\Delta GDP_{t-i} + \sum_{i=1}^{p-1}\sigma_3 ln\Delta TRADE_{t-i} + \lambda_1 D_1 t + \lambda_2 D_2 t + \lambda_3 D_3 t + \varepsilon_t \quad (9)$$

$$ln\Delta GDP_t = \gamma_2 z_{t-1} + \sum_{i=1}^{p-1}\sigma_4 ln\Delta FDI_{t-i} + \sum_{i=1}^{p-1}\sigma_5 ln\Delta GDP_{t-i} + \sum_{i=1}^{p-1}\sigma_6 ln\Delta TRADE_{t-i} + \lambda_4 D_4 t + \lambda_5 D_5 t + \lambda_6 D_6 t + \lambda_7 D_7 t + \varepsilon_t \quad (10)$$

$$ln\Delta TRADE_t = \gamma_3 z_{t-1} + \sum_{i=1}^{p-1}\sigma_7 ln\Delta FDI_{t-i} + \sum_{i=1}^{p-1}\sigma_8 ln\Delta GDP_{t-i} + \sum_{i=1}^{p-1}\sigma_9 ln\Delta TRADE_{t-i} + \lambda_8 D_8 t + \lambda_9 D_9 t + \varepsilon_t \quad (11)$$

$$ln\Delta CO_{2t} = \gamma_4 z_{t-1} + \sum_{i=1}^{p-1}\sigma_{10} ln\Delta FDI_{t-i} + \sum_{i=1}^{p-1}\sigma_{11} ln\Delta GDP_{t-i} + \sum_{i=1}^{p-1}\sigma_{12} ln\Delta TRADE_{t-i} + \sum_{i=1}^{p-1}\sigma_{13} ln\Delta CO_{2t-i} + \lambda_{10} D_{10} t + \lambda_{11} D_{11} t + \lambda_{12} D_{12} t + \lambda_{13} D_{13} t + \varepsilon_t \quad (12)$$

Where γz_{t-1} represents the error correction term. υs are the short run parameters. To assess the stability of the estimated ARDL models, we use the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMQ) plots. In addition, the study applied the robust least squares method to validate the long run and short run nexus between FDI inflows, economic growth, trade openness and CO_2 emissions.

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

Table 1 shows the descriptive statistics for the selected variables. The average real GDP was USD 1190 billion with a median of USD 855 billion. The range between the maximum (USD 3220 billion) and minimum (USD 271 billion) real GDP values highlights that the Indian economy exhibits significantly higher levels of transformation and structural changes during the study period. A standard deviation of USD 8670 billion implies the variation in the economic performance. FDI inflows had recorded an all-time high of 3.6% of the GDP. However, it is observed that the average net FDI inflows as a percentage of GDP are recorded as <1%, with a median of 0.77%. Standard deviation (0.88%) shows lesser variability in the FDI inflows to the output. Trade openness has a mean of 31.29%, indicating the average level of integration with global trade. The maximum contribution of trade towards GDP was 55.79%. The high standard deviation (14.67%) suggests significant variability in the contribution of trade towards the economic output, potentially due to differences in economic growth prospects, trade regimes or institutional frameworks. The rapid industrial growth and urbanization have led to increased energy consumption. The average per capita CO_2 emissions were approximately 1.10245 metric tons per person. The highest recorded emissions were 2.05496 metric tons, still lower than the global average of approximately 4.8 metric tons. These circumstances highlight the urgent need for sustainable energy practices in India to support economic and infrastructure development. Moreover, the growing demand for energy and industrial growth driven by FDI may increase per capita emissions, raising significant questions about sustainable economic practices.

4.2. Unit Root Test

The modified Dickey-Fuller unit root test was employed to evaluate the stationarity properties of the selected variables. This unit root test incorporates dummy variables for structural shifts using the additive outlier (AO) and innovative outlier (IO) models. The AO model captures immediate shocks, while the IO model accounts for gradual effects. The results of the breakpoint unit root test are depicted in Table 2.

Table 1: Descriptive statistics

Statistics	FDI (% of GDP)	GDP (Billion US$)	TRADE (% of GDP)	CO_2 emissions Percapita
Mean	0.97698	1190	31.2954	1.10245
Median	0.77633	855	28.2047	0.94883
Maximum	3.62052	3220	55.7937	2.05496
Minimum	0.00258	271	12.2192	0.44166
Standard deviation	0.88808	8670	14.6721	0.48056

The results reveal that the macroeconomic variables, viz. FDI, GDP, openness and CO_2 emissions are stationary at first differences I(1) under the innovative outlier (IO) model. The variables, except FDI inflows, are stationary at the first differences under the additive outlier (AO) model. The variable FDI is stationary at level form I(0). Hence, the variables are either stationary at the first differences or the mix of order of integration warrants applying the ARDL approach to examine the causal nexus between FDI, economic growth, trade openness and CO_2 emissions.

4.3. Structural Break Analysis

Unlike previous studies, the structural breakpoints are identified for the selected variables using a multiple breakpoints test to incorporate into the ARDL model. The breakpoint test results are shown in Table 3. The FDI has three key breakpoints: 1986, 1994, and 2006. The breakpoint in 1986 signifies the beginning of economic reforms and a growing acceptance of foreign investment in India. The breakpoint in 1994 is noted for a marked increase in FDI inflows, aligning with the rollout of various economic reforms designed to liberalize foreign investment policies in the early 1990s. By 2006, India saw a considerable rise in FDI inflows, which was a notable increase compared to earlier years, leading India to surpass the United States and become the second-largest recipient of FDI across the globe.

Table 2: Unit root test with a breakpoint

Variables	Level	Break	First difference	Break
	t-statistics		t-statistics	
Innovative outlier (IO) model				
FDI	−4.160076 (0.1088)	1991	−8.771753* (<0.01)	1985
GDP	−0.935078 (0.9983)	2003	−9.128514* (<0.01)	2020
TRADE	−2.414985 (0.9231)	1988	−6.009992* (<0.01)	2015
CO_2	−1.918526 (0.9864)	2005	−9.883910* (<0.01)	2020
Additive outlier (AO) model				
FDI	−4.210050*** (0.0956)	1991	−9.258539* (<0.01)	1983
GDP	−1.166812 (0.9952)	2021	−6.766148* (<0.01)	1991
TRADE	−2.335635 (0.9403)	1988	−6.141844* (<0.01)	2011
CO_2	−4.092289 (0.1273)	2000	−6.184903* (<0.01)	2022

* and *** denote significance at 1% and 10%, respectively. Figures in brackets are *P* values

Table 3: Bai-Perron multiple structural breaks test

Variable	Break test	F-statistic	Critical value	Break
FDI	0 versus 1	189.5509*	8.58	1994
	1 versus 2	15.42604*	10.13	2006
	2 versus 3	14.00221*	11.14	1986
	3 versus 4	1.682758	11.83	
GDP	0 versus 1	138.0916*	8.58	2004
	1 versus 2	31.56483*	10.13	1993
	2 versus 3	52.77716*	11.14	2014
	3 versus 4	13.99169*	11.83	1987
	4 versus 5	0.000000	12.25	
TRADE	0 versus 1	193.3081*	8.58	2002
	1 versus 2	57.31279*	10.13	1992
	2 versus 3	10.74916	11.14	
CO_2	0 versus 1	123.0946*	8.58	1987
	1 versus 2	56.06102*	10.13	1997
	2 versus 3	30.25810*	11.14	2006
	3 versus 4	13.56280*	11.83	2012
	4 versus 5	2.852629	12.25	

*Denotes significance at 1% level

The GDP characterizes four breakpoints: 1987, 1993, 2004, and 2014. The breakpoint in 1987 indicates that it was a crucial time for significant structural shifts in GDP growth. It highlights a marked change in GDP growth during 1987 and 1993, attributed to the effects of economic reforms (Wallack, 2003; Choudhury, 2014). Additionally, the test identifies a breakpoint in 2004, linked to a rise in real GDP. The GDP had reached approximately 2 trillion in 2014, showcasing India's resilience, innovation, and growing global stature.

The trade openness has two key breakpoints, namely 1992 and 2002. In 1992, India embarked on a significant transition towards trade liberalization as part of broader economic reforms, shifting from a controlled and regulated economy to a more market-driven one. This process included reducing trade barriers such as tariffs, licensing restrictions, and import duties and replacing the import licensing system. India's exports have experienced significant growth throughout 2002. The strategies to enhance exports included several impactful measures to ensure a consistent rise in India's export figures. These measures feature the elimination of quantitative restrictions, except for a few sensitive items designated for export through state trading enterprises, a farm-to-port strategy for the export of agricultural goods, a particular emphasis on cottage industries and handicrafts, along with increased support for states in terms of export-related infrastructural development. This trade recovery occurred despite a struggling global economy, sharply decreased investment inflows, significant fluctuations in currency exchange rates, diminished business confidence, heightened restrictions on international trade transactions meant to mitigate risks from terrorism, and escalating geopolitical tensions. The CO_2 emissions show four breakpoints, namely 1987, 1997, 2006 and 2012. In 1987, the per capita CO_2 emissions stood at 0.61 tons per person. Despite being lower than those of numerous developed countries, it has risen due to population growth and increased economic activity. By 1997, India's per capita CO_2 emissions had climbed to 0.88 metric tons, primarily driven by economic expansion and industrialization throughout the 1990s. The per capita CO_2 emissions reached 1.11 tons in 2006. The industrial sector was the second largest contributor to CO_2 emissions, accounting for approximately 26% of India's total emissions, following the energy sector. By 2012, India's total CO_2 emissions had escalated to 2 billion tons, positioning it as the fourth largest emitter globally, behind China, the United States, and the European Union. The per capita CO_2 emissions stood at 1.6 metric tons per person in 2012. Though the total emissions are considerable, the per capita emissions remain relatively low compared to other developed nations.

4.4. ARDL Bounds Cointegration Test

Before applying the ARDL bounds cointegration test, it is essential to determine the appropriate lag length for FDI, GDP, trade and CO_2. The results are presented in Table 4. The optimal lag length criteria indicate that the preferred lag length for the ARDL approach is one. Consequently, the ARDL model was estimated, and the results are shown in Table 5. The calculated values of the F-statistics exceeded the critical values at the 1% significance level for the FDI and GDP equations, and at the 5% level for the trade equation. Therefore, we reject the null hypothesis of no cointegration, confirming a long run relationship between FDI inflows, economic growth, and trade openness. These findings align with the results reported by Bhasin and Gupta (2017). When CO_2 is considered the dependent variable, the calculated F-statistic surpasses the upper bound critical value at the 10% significance level. This finding leads us to reject the null hypothesis of no cointegration, concluding that there is a long run relationship among the variables.

Table 4: Optimal lag length selection criteria

Lag	LR	FPE	AIC	SIC	HQ
0	--	0.006734	3.513069	3.645029	3.559127
1	283.9241*	1.56e−06*	−4.859561*	−4.331721*	−4.675330*
2	7.377285	2.02e−06	−4.613950	−3.690230	−4.291547
3	4.881467	2.84e−06	−4.301698	−2.982099	−3.841123
4	10.32501	3.17e−06	−4.250612	−2.535133	−3.651864
5	6.319413	4.20e−06	−4.066582	−1.955224	−3.329662
6	4.076028	6.37e−06	−3.806349	−1.299110	−2.931255
7	12.44328	5.50e−06	−4.195155	−1.292037	−3.181889
8	5.571005	7.94e−06	−4.201610	−0.902612	−3.050171

*Indicates lag order selected by the criterion

Table 5: ARDL bounds test for cointegration

Dependent variable	F-statistic	Significance level (%)	I (0)	I (1)
F_{FDI} (FDI | GDP TRADE)	7.35539*	10	2.63	3.35
		5	3.10	3.87
		1	4.13	5.00
F_{GDP} (GDP | FDI TRADE)	7.08617*	10	2.63	3.35
		5	3.10	3.87
		1	4.13	5.00
F_{TRADE} (TRADE | FDI GDP)	5.95133*	10	2.63	3.35
		5	3.10	3.87
		1	4.13	5.00
F_{CO2} (CO_2 | FDI GDP TRADE)	3.51934*	10	2.37	3.20
		5	2.79	3.67
		1	3.65	4.66

*Denotes significance at 1% level. I (0) shows the lower critical bound values, and I (1) represent the upper critical bound values

4.5. ARDL-ECM Approach

After establishing the cointegrating relationship among the variables of interest, the study examines the long- and short run coefficients using the ARDL-ECM approach. This model further assesses the speed at which the variables adjust. The long run and short run estimates from the ARDL model are presented in Tables 6 and 7, respectively. The analysis in Table 6 indicates that, when normalized for FDI, trade openness has a positive and significant effect on FDI inflows in the long run. A 1 unit increase in trade openness would lead to a 1.30 unit increase in FDI inflows at a 10% significance level. Trade liberalization attracts foreign investors by providing larger markets, reducing entry barriers, and creating a more stable trade policy environment. Furthermore, the positive and significant coefficient of trade openness in equation (6) shows that a 1 unit increase in trade openness leads to a 0.92 unit increase in GDP. This supports the traditional trade-led growth theory (TLG) and suggests that trade liberalization policies in India have positively influenced economic growth. The estimated coefficients in equation (7) indicate that FDI inflows and GDP have a significant impact on trade openness. A 1 unit increase in FDI inflows is associated with an approximate 0.12 unit increase

Table 6: Long run ARDL model estimates

Variables	LFDI Eq. [5]	LGDP Eq. [6]	LTRADE Eq. [7]	LCO_2 Eq. [8]
	Coefficient	Coefficient	Coefficient	Coefficient
LFDI	--	−0.055004 (0.12019)	0.120001* (0.031825)	−0.020271 (0.041313)
LGDP	−0.454180 (0.44531)	--	0.383722* (0.074277)	0.306938*** (0.180255)
LTRADE	1.298621*** (0.74597)	0.915767*** (0.47893)	--	0.228127 (0.188402)
C	4.905133 (11.5022)	24.49146* (1.48201)	−7.142876* (2.069431)	−9.382313 (4.592288)

* and *** denote significance at 1% and 10%, respectively. Figures in brackets are standard errors

Table 7: Short run ARDL model estimates

Variables	ΔLFDI Eq. [9]	ΔLGDP Eq. [10]	ΔLTRADE Eq. [11]	ΔLCO_2 Eq. [12]
	Coefficient	Coefficient	Coefficient	Coefficient
ΔLFDI	--	0.011810** (0.00551)	0.013318 (0.01763)	−0.002366 (0.00509)
ΔLGDP	6.283762** (2.70250)	--	0.275678 (0.33076)	0.660610* (0.126901)
ΔLTRADE	0.383862 (1.04139)	0.063730 (0.05234)	--	0.117844** (0.046018)
D_1	1.231003* (0.28458)	--	--	--
D_2	1.678243* (0.38684)	--	--	--
D_3	0.511117** (0.23417)	--	--	--
D_4	--	0.023212*** (0.01192)	--	--
D_5	--	0.019966*** (0.01069)	--	--
D_6	--	0.018735*** (0.01076)	--	--
D_7	--	0.045251* (0.01545)	--	--
D_8	--	--	0.117340* (0.04123)	--
D_9	--	--	0.159499* (0.05658)	--
D_{10}	--	--	--	0.217566* (0.04967)
D_{11}	--	--	--	0.219333* (0.04631)
D_{12}	--	--	--	0.338827* (0.05312)
D_{13}	--	--	--	0.478405* (0.05040)
Z_{t-1}	−0.863389* (0.15258)	−0.077654* (0.01396)	−0.273639* (0.07643)	−0.189504* (0.06470)
B-G LM test	0.588750 [0.4484]	0.595499 [0.4460]	0.466536 [0.4992]	0.595601 [0.5578]
ARCH-LM test	0.000130 [0.9910]	0.011325 [0.9158]	0.090429 [0.7652]	1.169342 [0.2860]
RESET test	0.836136 [0.3671]	0.022667 [0.8813]	0.672719 [0.4178]	0.086413 [0.7708]

*, ** and *** denote significance at 1%, 5% and 10%, respectively. Standard errors are in parentheses, and *P* values are in bracket

in trade. This highlights that FDI promotes trade by integrating domestic firms into global value chains, fostering export-oriented production, and providing access to international markets. Furthermore, the results reveal that a 1 unit increase in GDP would lead to a 0.38 unit increase in trade. This outcome is consistent with proponents of the growth-led trade (GLT) hypothesis, which posits that economic growth drives trade expansion due to the increased capacity of the economy to produce and consume a greater variety of goods and services. The long run analysis shows that FDI and trade have a complementary relationship, positively influencing each other in the long run. Trade liberalization creates a favourable environment that encourages FDI inflows by reducing barriers to both trade and investment. The influx of FDI significantly enhances trade volumes, as foreign companies engage with local markets, introduce innovative products, and expand their supply chains. Furthermore, the analysis shows a bidirectional positive long-term causality between GDP growth and openness, indicating that openness fosters economic growth and vice versa.

The long run estimates show no long-term causal relationship between FDI inflows and economic growth. Similarly, the coefficient for FDI is negatively associated with CO_2 emissions, but this relationship is statistically insignificant. This does not support the pollution haven hypothesis. Trade openness also has no significant impact on carbon emissions in India. The coefficient of GDP is positive and statistically significant at 10%, implying that a 1 unit increase in GDP leads to CO_2 emissions by 0.30 units. This suggests that increases in GDP contribute to higher CO_2 emissions in India. It is also evident that the long-term nexus between trade and economic growth supports both the trade-led and growth-led trade hypotheses, signifying that economic growth and trade openness reinforce each other.

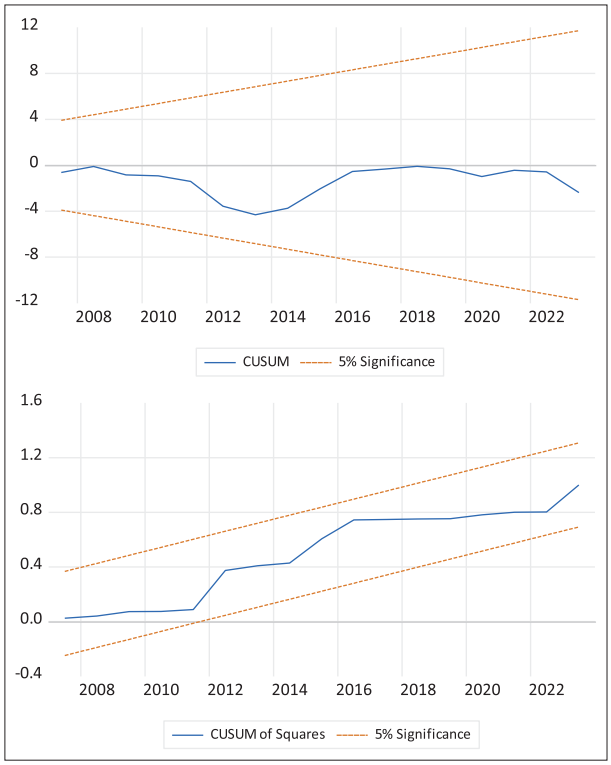
The short run estimates in Table 7 demonstrate that the coefficient of GDP has a positive and significant effect on FDI at the 1% level. A 1% increase in GDP results in approximately a 6.28% increase in FDI inflows, assuming other factors remain constant. Moreover, the coefficient for FDI shows a positive and modest effect on GDP at the 10% level. A 1% rise in FDI inflows leads to a 0.01% increase in GDP. The analysis reveals a bidirectional short-term causality between FDI inflows and GDP growth, indicating that FDI inflows contribute towards economic growth and vice versa. Besides, the analysis identifies no short-term causality between FDI inflows and trade in India. Moreover, the short run estimates establish that while the coefficient of FDI is negatively associated with CO_2 emissions, the effect is statistically insignificant, invalidating the pollution haven hypothesis. The coefficient of GDP and trade is positive and statistically significant. This implies that a 1% increase in GDP and trade increases CO_2 emissions by 0.66% and 0.11%, respectively. Thus, it is evident that economic growth and trade activity substantially contribute to higher carbon dioxide

emissions in the short run. Besides, the trade openness does not appear to contribute to FDI inflows or GDP growth.

The error correction coefficient (zt-1) in equation (9) indicates that approximately 86% of the deviation from the long run equilibrium in FDI inflows is restored in the following year. Similarly, equations (10) and (11) show that 0.07% and 0.27% of the deviation from the long run equilibrium in GDP and trade openness, respectively, is corrected after 1 year. In addition, equation (12) reveals that 18% of the deviation from the long run equilibrium in CO_2 emissions is restored. These findings confirm a stable long-term association among the variables, with short-term deviations gradually adjusting toward equilibrium. Furthermore, the results indicate that the dummy variables incorporated into the ARDL estimates to account for structural breaks significantly influence the dynamics of FDI inflows, GDP, trade openness, and CO_2 throughout the study period.

The diagnostic tests applied to validate the ARDL estimates include the Breusch-Godfrey (B-G LM) test for autocorrelation, the ARCH test for conditional heteroscedasticity, and the RESET test for model misspecification. The corresponding probability values of the F-statistics for each model are >0.05. Therefore, we cannot reject the null hypothesis, which means we accept our null hypothesis of no serial correlation, no heteroscedasticity, and the model is correctly specified. For the stability test, the CUSUM and CUSUMSQ plots for the estimated ARDL models with FDI, GDP, trade openness, and CO_2 as dependent variables are displayed in Figures 1-4, respectively. The plots demonstrate that the CUSUM and CUSUMSQ statistics lie within the 5% critical bounds, indicating that both the short- and long run coefficients of the selected ARDL models are stable.

Figure 1: Plot of cumulative sum (CUSUM) and cumulative sum square (Department variable: Foreign direct investment)



4.6. Robustness Check

To ensure robustness, Table 8 presents the results of a robust least squares method using M-estimation to examine the short run and long run relationship between FDI inflows, GDP, and trade

Figure 2: Cumulative sum (CUSUM) and cumulative sum square (Department variable: Gross domestic product)

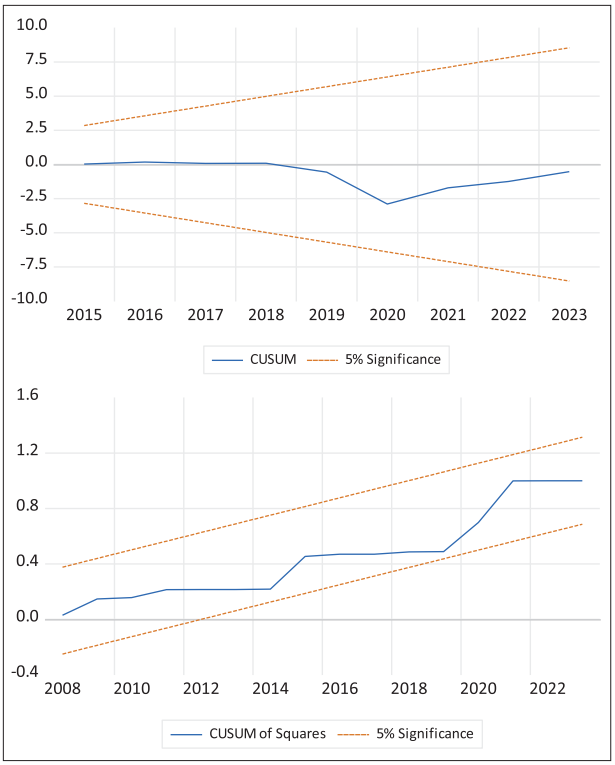


Figure 3: Cumulative sum (CUSUM) and cumulative sum square (Department variable: TRADE)

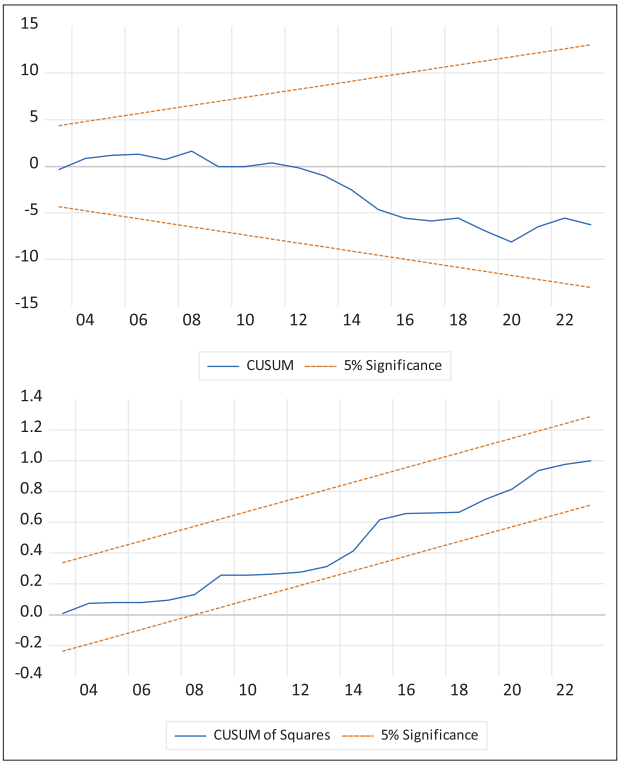
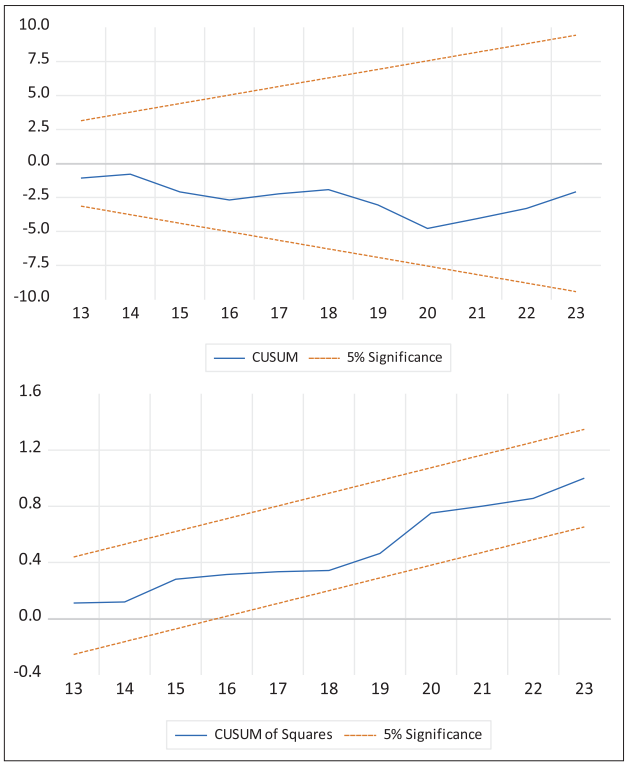


Table 8: Robust least squares based on M-estimation

Long run estimates				
Variables	**Department variable: LFDI**	**Department variable: LGDP**	**Department variable: LTRADE**	**Department variable: LCO_2**
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
LFDI	--	0.053280 (0.061054)	0.047969* (0.017847)	0.012944 (0.010397)
LGDP	0.307061 (0.347839)	--	0.425312* (0.041653)	0.569382* (0.027763)
LTRADE	2.375744* (0.514325)	1.106642* (0.210699)	--	−0.014370 (0.048740)
C	−17.13139** (8.032063)	23.85378* (0.750737)	−8.412771* (1.160487)	−15.61489* (0.666968)
Short run estimates				
Variables	**Department variable: ΔLFDI**	**Department variable: ΔLGDP**	**Department variable: ΔLTRADE**	**Department variable: ΔLCO_2**
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
ΔLFDI	--	0.008677** (0.004077)	0.017307 (0.020449)	−0.002089 (0.006529)
ΔLGDP	5.699172*** (3.192120)	--	0.397475 (0.551487)	0.642405*(0.175600)
ΔLTRADE	0.998569 (0.970740)	0.006228 (0.033437)	--	0.078838***(0.042419)
C	0.405502** (0.200694)	0.061801 (0.002924)	0.002610 (0.034884)	−0.003265 (0.011055)

*, ** and *** denote significance at 1%, 5% and 10%, respectively. Figures in brackets are standard errors

Figure 4: Cumulative sum (CUSUM) and cumulative sum square (Department variable: CO_2)



openness. This robust regression approach based on M-estimation provides dependable parameter estimates even in the presence of structural breaks (Yang et al., 2019). The long run estimates indicate that trade openness positively influences FDI inflows at a significance level of 1%. Similarly, FDI inflows have a positive impact on trade openness at a 1% significance level, confirming a bidirectional relationship between the FDI inflows and trade in the long run. Furthermore, the findings suggest that GDP leads to trade openness and vice versa at a 1% significance level, reinforcing the bidirectional causality among economic growth and trade openness in India. While economic growth significantly increases CO_2 emissions, it is evident that neither FDI nor trade openness has a significant long-term impact on CO_2 emissions. These findings validate the results from the ARDL long run estimates.

The short run analysis reveals that GDP positively influences the FDI inflows at a 5% significance level. The FDI inflows are positive, but have a modest impact on GDP at a 10% significance level. Hence, the feedback relationship between the FDI inflows and economic growth is validated, with the effect of FDI on GDP being modest. Besides, this analysis shows no short-term causality between trade and FDI inflows and trade and economic growth. The analysis reveals that the FDI inflows do not have a significant relation with the CO_2 emissions, while economic growth and trade activity significantly increase the emissions. These findings validate the results from the ARDL short run estimates.

5. CONCLUSION

The study empirically examines the causal nexus between FDI inflows, economic growth, trade openness and CO_2 emissions in India. The ARDL bounds test confirms the long run association between the variables. The results indicate a bidirectional causation between trade openness and FDI inflows in the long run, validating the complementary relationship. This suggests that increased trade openness attracts FDI inflows and, in turn, FDI enhance trade openness. As a result of specialization, greater trade openness stimulates foreign investment. Multinational companies seek goods that can be produced more cost-effectively in India, making it advantageous for them to establish operations in the market to leverage its comparative advantages. The increase in FDI inflows fosters the transfer of technology and innovative products for export, facilitating access to global markets.

The analysis on the FDI-GDP linkage shows no significant evidence of causation between FDI inflows and economic growth in the long run. Furthermore, the FDI-GDP nexus is bidirectional in the short run, with the impact of FDI on GDP growth being relatively modest. It is also to be noted that the FDI-GDP ratio remains below 1%. Although FDI inflows significantly contribute to foreign trade

in the long run, the country must enhance its attractiveness as an investment destination to promote economic growth. The study recommends that the Indian economy implement targeted reforms that adapt to changing global conditions and foster an environment that encourages investors to commit long-term capital. India should further liberalize key sectors by establishing an investor-friendly policy framework and addressing challenges related to infrastructure, bureaucratic delays, regulatory complexities, and sector-specific issues. Notably, it is vital to ensure stability and transparency in tax regulations.

While GDP and trade contribute to CO_2 emissions, the study indicates no significant relationship between FDI inflows and CO_2 emissions in either the long or short run. The findings refute the hypothesis of a pollution haven in the Indian economy. The study recommends that while achieving economic growth and foreign trade, mitigating carbon emissions through effective environmental management regulations is crucial. Governments should actively promote green trade, which prioritizes exchanging environmentally sustainable goods and services. This initiative could include the implementation of reduced tariffs as a compelling incentive. Furthermore, the study suggests governments need to enhance investment in renewable energy projects and develop infrastructure equipped for future demands, thereby reducing emissions associated with economic activities. Moreover, it is essential to prioritize green FDI over projects that merely generate employment opportunities in the economy.

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