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MEDIATING EFFECTS OF FDI INFLOWS ON CARBON DIOXIDE EMISSIONS: EVIDENCE FROM INDIA

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ABSTRACT

This paper investigates the direct and indirect consequence of foreign direct investment (FDI) inflows on carbon dioxide (CO_2) emissions in India, covering1980 to 2014.To quantify the indirect outcome of FDI taking place CO_2 emissions, this study considers three mediating channels of FDI. The three broad mediating channels of FDI inflows are energy structure, industrial structure, and high-carbon technology, by which the foreign direct investments affect India's carbon dioxide emissions. The unit root test, the Johansen cointegration, the Granger causality, and the Seemingly Unrelated Regressionare used in this study for the empirical analysis. The findingsdiscovera long-run cointegrating link between FDI inflows and CO_2 emissions, as well as a one-way causality running from FDI to CO_2 emissions. The outcomes of the seemingly unrelated regression estimationindicatethat all the mediating factors significantly contributeto the carbon dioxide emissions level. The findings of this paper reveal that FDI inflows affect India's CO_2 emission level mainly by the mediating factors compared to its direct effect. Finally,thestudy suggests that the policymakersshouldprioritize the redistributionof foreign investment from high carbon-intensive technology to less carbon-intensive and cleaner technologies for a carbonless and sustainable future in India.

KEYWORDS

foreign direct investment, carbon dioxide emissions, mediating effects, cointegration, Granger causality, seemingly unrelated regression, Indian economy

INTRODUCTION

Climate change, greenhouse gases (GHGs), future energy, and carbon dioxide emissions are all attracting interest from industrialized, developing, and impoverished countries alike (Narayan, Sahu, 2016). As per the Future Earth and the Earth League report-2019 discussed at the Conference of Parties (COP) 25, the world has already diverted from its track to meet the Paris Agreements (to limit global

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warming to 1.5° C),and climate change is faster and more robust than it was expected[1]. Further, the report highlights that it will go to severe pain for hundreds of millions' food security and health;also threaten biodiversity. Thus, climate change becomes a significant hurdle to accomplishing the Sustainable Development Goals of the United Nations (SDGs) for overall global development.With due time, natural scientists investigated those carbon dioxide (CO_2) emissionsare the leading factor of climate change through a higher level of the greenhouse effect and the deterioration of the atmospheric system (IPCC, 2014). Measuring this severity,the World Bank (2019) has reported around an 84.38% increase in CO_2 emissions from 1980 to 2014 and awaked the world about such an unexpected change in CO_2 emissions. Thus, to control the extreme climatic events, melting of Arctic sea ice, rising sea level, and other long-term and irreversible changes, it is indispensable to maintain the CO_2 emissions level and increase environmental sustainability (Mardani et al., 2019).

For decades, studies have pointed out that heavy industrialization and high energy consumption are the prime cause of the increased CO_2 emissions (Muhammad, Khan, 2019). However, a trade-off exists between environmental quality and higher economic growth. In recent times, growing economies have been deeply involved in internationalization, industrialization, and energy consumption to achieve their economic growth target (Sabir et al., 2020).Furthermore, the global and local environmental challenges produced by the ever-increasing usage of fossil fuels have reignited worries, making it an enormous task to fuel economic growth in an environmentally friendly manner (Sahu, Narayan, 2010). As CO_2 emissionsarea global pollutant, recent researchers have emphasized the globalization-environmental quality nexus. At the same time, internationalization is the prime factor to speed up industrialization, so the higher the level of globalization, the higher the production, consumption, and deterioration of the environment quality (Bhat et al., 2018, Haider et al., 2019).

More specifically, according to the published studies, any initiatives by policymakers and government entities in developed and developing economies to optimize environmental quality will be ineffective in the long run until either the effects of globalization on the environment is accounted for CO_2 emissions (Shahbaz et al., 2018). Although a few decades ago, researchers argued that an economy's environmental degradationwould reduce after a threshold level of economic growth was achieved (Grossman, Krueger, 1991, 1995). This theory, popularly acknowledged as the Environment Kuznets Curve (EKC) hypothesis,is usually represented in an inverted U-shape.The well-known EKC examines the different dimensions of the CO_2 emissions on the macroeconomic variables, which can be sub-divided as CO_2 emissions and economic growth (Saboori et al., 2014, Wang et al., 2018, Wang, He, 2019, Hargrove et al., 2019), CO_2 emissions, and urbanization (Yao et al., 2018, Sharma, 2011), and CO_2 emissions and FDI inflows (Muhammad et al., 2021, Gokmenoglu, Taspinar, 2016).

Research results on the association between CO_2 emissions and FDI inflows have been twofold in recent years. On the one hand,a group of studies argued a positive relationship between these two factors (Guzel, Okumus, 2020, Opoku, Boachie, 2020, Omri et al., 2014, Shahbaz et al., 2015**,** 2019, Abdouli et al., 2018) and mainly emphasized the cost of economic growth in terms of environmental degradation.This relationship is commonly known as the 'pollution haven hypothesis (henceforth the PHH).'This hypothesis implies that polluting units come from developed and more stringent environmentally regulated countries to developing and less environmentally regulated countries with high environmental pollution. On the other side, a group of studies by Huang et al. (2017), Seetanah et al. (2019), and Ehigiamusoe (2020) have highlighted a negative affiliation between FDI and CO_2 emissions and claimed that FDI could bring more advanced and energy-saving innovations from developed to underdeveloped countries economies;so helpsthe economy to build sustainable development.

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[1] A global temperature rises to 1.5^0 C, i.e., above the pre-industrial levels, could be reached already in 2030, instead of 2040, as is the mean projection of IPCC.

This relationship explains the opposite of the PHH hypothesis and is well known as 'the pollution halo effect (henceforth the PHHH).'Considering developed countries such as Turkey, France, Australia, and several emerging and developing countries such as Mexico, Brazil, India, China, and Pakistan in existing studies (Jun et al., 2018, Shahbaz et al., 2018, Rehman et al., 2021, Nasir et al., 2019) have emphasized a positive relationship and confirms FDI inflows deteriorates the environmental quality. Thus, thissupports the PHH hypothesis. On the other side, considering a set of 30 OECD economies, MINT nations, G6 economies, and a collection of Sub-Saharan African countries, including Malaysia and Chinagroup of studies (Acheampong et al., 2019, Balsalobre-Lorente et al., 2019, Nguyen et al., 2021) have revealed a negative association between these two and validated the PHHH hypothesis.

Furthermore, Marques and Cantano (2020) pointed out that the pollution haven hypothesis occurs merely for poor and middle-income nations and remainedabsent for high-income countries when looking at a different group of countries. However, in recent times the relationship between CO_2 emissions and FDI remains unclear and needs further empirical investigation to cross-check the direction and their nature over time. Going further, thisvast body of existing literature on this nexus mainly focuses on the direct nexus of CO_2 emissions (increase/decreases) and FDI inflows.

Simultaneously, the existing studies mostly have ignored the indirect association between these two, which primarily accounts for an economy's different structures and components, such as industrial structure, energy consumption, and carbon technology. These three components of any economy's structure are the highly significant mediating channels to materialize any form of investment from abroad (Menghan, 2018). To examine the effect of such mediating channels of FDI on CO_2 emissions, we follow Menghan's (2018)study to develop this paper. However, the research limited the Chinese economies' carbon productivity and cannot extend or generalize to a growing democratic economy like India.

With significant time data spanning the years 1980 to 2014, this study selects India to explore the direct and indirect impact of FDI inflows on CO_2 emissions. This is because of the following reasons; India's economyis among the world's fastest expanding (Chaturvedi, 2017) and the hottest destinations of FDI inflows in the globe (Ibrahim, Muthusamy, 2014). As per the UNCTAD report (2018), India's gross FDI touched the US $ 60.1 billion during 2016-17; its average growth performance has grown from 0.8 percent of domestic GDP during the global financial crisis to 1.3 percent of the same post-crisis period. Extending further, India ranks top 100 clubs on ease of doing business and ranks first in the green-field investment (Chaturvedi, 2017).

However, India is significantly vulnerable to the melting of the Himalayan glaciers[1] ice caps; the region is susceptible to climate change and changes to the monsoon.Simultaneously,the Carbon Brief Profile Report (2019) indicates that India is third-largest emitter in the worldandcontributing 3,571m tonnes of CO_2emissions,i.e., increased over threefold since 1970.According to World Bank (2018), "India could see $1.2tn of lost GDP, plus lower living standards for nearly half of its population by 2050, compared to a scenario with no climate change".In addition, carbon dioxide emissions supplementenvironmental change that is likely to harm human health for growing economies like India (Prasad, Mishra,2017). Moreover, Watts et al. (2018) mentioned that India's agriculture and its agricultural workforce are significantly hurt by the heat resulting from growing carbon emissions and, ultimately, climate change.The trend of FDI inflows and the severity of CO_2 emissions in India can be well noticedin Figure

[1] On February 7, 2021 the most recent disaster witnessed in India when a glacier broke after a heavy avalanche in the Joshimath area of Uttarakhand's Chamoli district. The environmentalist claiming that the incident was induced by climate change and highlights the negative consequence of human activities on the environment (Tewari 2021).

1. Thus, it is necessary to minimize the uncertain climatic events and balance between foreign investment and the sustainable environment of India.

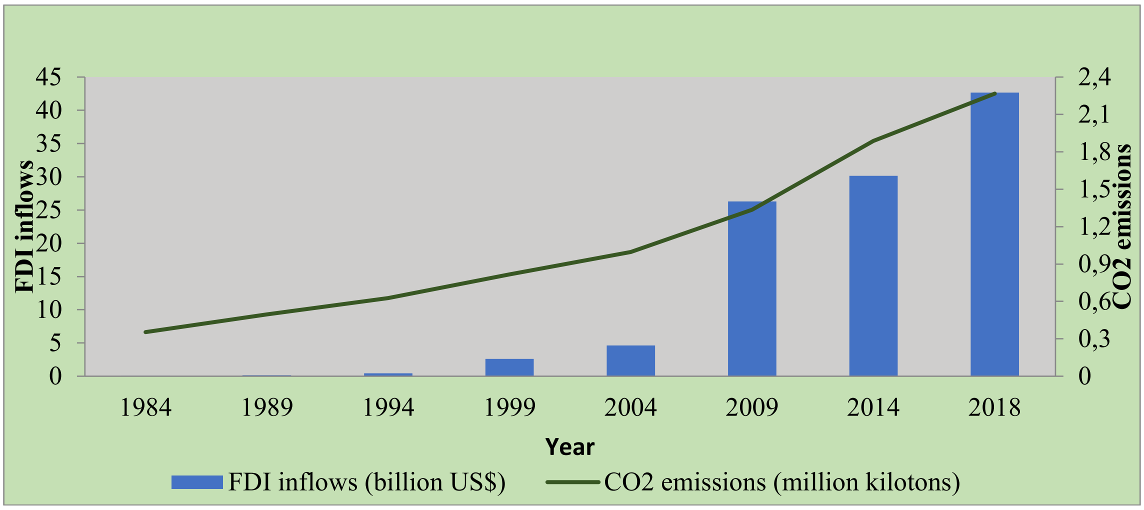

Figure 1. Trend of FDI inflows and CO_2 emissions in India
Source: Authors' compilation

This paper attempts to deal with two broad research questions: first, does FDI inflow directly impact CO_2 emissions? Second, does FDI have any significant indirect effect on CO_2 emissions? To investigate the affiliation between FDI inflows and CO_2 emissions, our paper aims to verify both the "pollution halo"and"pollution haven" hypotheses.To examine the indirect consequence of FDI inflows and CO_2 emissions, we consider three mediating channels of FDI: energy structure, industry structure, and high-carbon technology of the Indian economy. This study has considered energy use in terms of the kg of oil equivalent to measuring the energy structure. The industrial structure accounts for the total industrial value-added as a significant measure to value it. The consumption of fossil fuels as a percentage of total energy consumption is considered as multiple transmitters of carbon dioxide emissions for the high-carbon technology.The novelty of our research lies two-fold. First, we examine the mediating effect of FDI on CO_2 emissions which measures the indirect nexus between these two variables. However, during the measurement of the mediating effects of FDI, this study assumes the mediating factors are independent of each other. Second, along with cointegration and Granger causality,the research employs the SUR model to measure all equations together in a simultaneous framework.

LITERATURE REVIEW

This section provides a detailedinsightinto theoretical and empirical literature on FDI-environmental quality nexus and the effects of mediating factors of FDI on CO_2 emissions.

The initial hypothesis that emphasizes the Environmental Kuznets Curve (EKC) theory links economic development and environmental deterioration. The EKC hypothesis of Grossman and Krueger (1991, 1995) empirically revealed the link between environmental deprivation and economic growth. The researcher explained the nexus such that in an initial phase of economic growth, the rate of pollution increases, thus a higher level of environmental degradation up to a specific point and thenafter the economic evolvementsurges with the reduction of pollution level and signifies the 'inverted U-shaped'

EKC hypothesis.In contrast, many existing studies on EKC literature also revealno significant relationship between these two (Stern, 2004). The argument for that this might be due to the usage of inappropriate and weak econometric approaches.

Based on Grossman and Krueger's (1991, 1995) theoretical EKC approach, literature hasproposed three channels todescribe the influence of FDI on CO_2 emissions in terms of scale, composition, and technique effects. The scale impactunderlines that foreign direct investmentpromotes industrial production and increases energy demand,subsequentlyincreasing carbon dioxide emissions in the host nations (Pao, Tsai, 2011). It becomes a threat to the environment as the pollution level is positively associated with the scale of its economy. It is due to the rise in the production of that economy; high production will primeto a higher level of environmental deterioration (Pazienza, 2019). However, some new literature suggests that environmental destruction due to the economy's advancement will reach a limit. Then a turning point started, and environmental quality improvement started (Gill et al., 2018).The structural effect explains the economy's structure with energy intensity (Shahbaz et al., 2018). It is also identified as the composition effect and explains the changes in industrial design and how it affects free-market policy (Pazienza, 2019). It is argued that with the help of free-market policy,an economy can boost its environmentally profitable investment and encourage the allocative efficiency of resources among economies (OECD, 2001).

In contrast, Cole and Elliott (2003) have argued that the composition effect in a free trade economy can be undesirable or encouraging as it depends on the country's competitive advantage and productive specialization. The technique effect is based on the dissemination of introduction of newer machinery via FDI. The effect indicates that the present production technique's emission level determines the cost per unit of items produced. A free market can liberally invest in neighboring countries,and with the allocative efficiency, the countries will update their technology and adopt the development with more energy-efficient technology. The technique effect is assumed to be environmentally beneficial for all (Shahbaz et al.,2018; Pazienza, 2019). However, in our analysis, our prime objective is to analyzethe effects of these three mediating factors of FDI inflows on CO_2 emissionsfor India but not to examine the EKC hypothesis.

From these three channels, the theoretical literature has been extended. If the scale effect and the composition effect outweigh the technique effect, it creates the pollution haven hypothesis. Suppose the technique and composition effect overcomes the scale effect, the pollution halo effect (Pazienza, 2019, Shahbaz et al., 2018). The PHH and the PHHH effect are the two main hypotheses accustomedto describe the link between FDI and environmental pollution. The PHH hypothesis pioneered by Pethig (1976) argued that multinational corporations (MNCs) relocate pollution-intensive industries to less stringent environmental regulated countries from a more stringent environmental regulated country. Supporting the above argument, Zhang and Zhou (2016) revealed that MNCs are driven to shift their heavy and polluting activities to nations with more permissive environmental legislation to minimize regulatory compliance expenses in their home nation. On the other side, the PHHH hypothesis demonstrates a positive connotation between FDI and quality of environment with higher economic growth and provides environmentally friendly and cutting-edge technologies, enhancing environmental quality (Dinda, 2004, Zarsky, 1999). To strengthen the idea that Heil and Selden (2001) and Grimes and Kentor (2003) have argued that FDI coming from the advanced countries are with advanced and greener technologies, thus increasing economic growth on the one side and the environmental quality on the opposite point.

The empirical literature covers four-part of existing literature. The first part covers the CO_2 emissions and FDI inflows;the link between CO_2 emissions and mediating factors are presented in the second section. The third part of this literature section explains the affiliation between FDI inflows and the mediating factors. The final sub-section of this section narrates the association between CO_2 emissions and other control variables such as economic growth and urbanization, following up with the research gap and hypothesis.

CO_2 emissions and FDI

To date,a significant number of empirical studies have discussed the relationship between FDI and environmental quality. In the existing literature, many studies support the PHH while others support the PHHH. In between, few studies have either supported both,while others mentioned no significant effect between these two. Employing the Autoregressive Distributed Lag (ARDL) bounds testing and Vector Error Correction Model (VECM) Granger causality techniques, Salahuddin et al. (2018) revealed that CO_2 emissions are caused by economic expansion, increased electricity use, and FDI in the short and long termin Kuwait. Similarly, Lee (2009) showed that FDI Granger causes CO_2 emissions in Malaysia in the short run. Gokmenoglu and Taspinar (2016) notified a bidirectional affiliation between carbon dioxide emissions and FDI, energy ingestion, and CO_2 emissions in Turkey's case.

Further, Solarin et al. (2017) for Ghana evidence and supportthe PHH hypothesis. The study used the ARDL method from 1980 to 2012 and revealed a favorable and substantial link amid FDI and CO_2 emission. Khan et al. (2018) found that energy consumption, financial development, trade, FDI, and economic, social, and political globalization had a significant and positive effect on carbon dioxide emissions in Pakistan during 1971-2016. However, urbanization, economic expansion, and innovation have a considerable adverse impact on carbon dioxide emissions. A recent paper by Singhania and Saini (2021) using dynamic panel data estimations for 21 developed and developing countries mentioned that FDI inflows significantly impact environmental quality and evidence a pollution haven hypothesis. Similarly, applying empirical techniques such as the Dynamic Ordinary Least Squares, the Fully Modified OLS, the System- GMM estimation, as well as forecasting approaches for a set of G6 countries from 1978 to 2014. Nguyen et al. (2021) revealed a very beneficiall ink between FDI and CO_2 emissions.

In addition, applying similar techniques (except the system-GMM), Nasir et al. (2019) revealed that in the ASEAN-5 countries, FDI and CO_2 emissions are highly co-integrated over time. Using the structural vector autoregressive and the seemingly unrelated regression models for China's macro economy from 1980 to 2017, Pu et al. (2020) revealed natural disaster losses economic and the macro-industry development. Following the earlier study by applying the SUR technique, Zangoei et al. (2021) established a substantial and progressive relation amid FDI and carbon dioxide emissions in the case of 14 developing countries during 1986-2016. In the context of India, Acharyya (2009), applying a cointegration technique, has revealed a positive association between FDI and CO_2 emissions. In addition, Rana and Sharma (2019), apply ingyearly time-series data during the period 1982-2013, identified the existence of the pollution haven hypothesis in India. This study further highlighted that FDI inflows cause economic growth through carbon dioxide emissions.

In contrast to the preceding findings, Zhang and Zhou (2016) demonstrated that FDI could reduce CO_2 emissions in China.Similarly, using panel data of 280 selected Chinese cities during 2003-2012, Ning and Wang (2018) revealed that FDI brought positive environmental knowledge externalities and improved China's environmental quality. Similarly, using the simultaneous equation method, Ayamba et al. (2019) have also revealed that FDI and environmental quality have a good connectionfrom 1995 to 2016 in China. This paper argued that FDI has the advantage of advanced production technology, green production, positive pollution control, and environmental conditions. Thus China should encourage such inward FDI for more economic growth industrial structure.

Further, the concluding findings of a meta-analysis of FDI on environmental pollutions highlighted that FDI inflows significantly reduce the environmental quality degradation (Demena, Afesorgbor, 2020). In addition, using first- and second-generation panel econometric techniques for central and Eastern European (CEE) economies, Christoforidis and Katrakilidis (2021) demonstrated an inverted U-shaped connection concerning FDI and carbon dioxide emissions. The argument lies that in the initial stage, with an upturn in energy consumption, the emissions level raises but with a surge in economic growth, the level of emissions reduces. However, Kathuria (2018) highlighted that FDI has no role in influencing the pollution level in India; instead, it helps to progress the environmental quality.

Similarly, Ansari et al. (2019) have not found any significant association between FDI and CO_2 emissions for 29 countries over 1994-2014. Instead, the study confirmed that energy consumption is the prime cause of the high level of CO_2 emission in those countries. Supporting these findings, Ghazouani (2021), after applying the bootstrap ARDL bounds test method, mentioned no significant association between FDI inflows and emission levels in Tunisia from 1980 to 2016. To investigate the role of renewable energy use, foreign direct investment and growth of economy in moderating and mediating carbon dioxide emissions with annual time series data from 1975-2016 in Pakistan, Naz et al. (2019) found that the FDI inflows have a substantial advert effect on CO_2 emissions. The inclusion of moderating and mediating effects resultsin the positive impact of renewable energy trends towards anadverseimpact on the environmental quality, i.e., a negative externality.

CO_2 emissions, energy consumption, industry, andfossil fuel consumption

The existing empirical studies concerning CO_2 emission and energy consumption are well-explored. Using various econometrics techniques such as Fully Modified Ordinary Least Squares regression, ARDL cointegration, VECM causal techniques, Westerlund and Pedroni cointegration estimations Saboori et al. (2014) for OECD countries, Saboori and Sulaiman (2013) for Association of Southeast Asian Nations (ASEAN) countries, Pao et al. (2011) for Russia, Yousefi-Sahzabi et al. (2011) for Iran, Mirza and Kanwal (2017) for Pakistan and Behera and Dash (2017) for South and Southeast Asian (SSEA) regions have explored the impact of energy consumption on CO_2 emissions. All these studies have mentioned that the variables are highly interrelated and that energy consumption substantially causes pollution. The existing literature has highly focused that primary energy consumption, especially fossil fuel consumption have significantly affected CO_2 emissions, thus leading to GHGs in these areas. Similarly, these findings are also supported in developed country cases like the US (Danish et al. 2020). However, limited studies (Tiwari, 2011) have empirically verified this nexus in the Indian context and highlighted that energy usage has a favorable and substantial influence on CO_2 emissions. In contrast, Ouyang and Lin (2015), using the Logarithmic Mean Divisia Index (LMDI), highlighted that China's industrial sector substantially contributed to CO_2 emission while energy intensity helps to reduce the level of CO_2 emission.

Similarly, recent studies have explored the empirical literature on industrial development and its influence on CO_2 emissions in different countries. Employing other econometrics such as threshold regression model, ARDL, VECM models, and non-linear ARDL cointegration techniques, Dong et al. (2019) for 14 developed economies, Liu and Bae (2018) and Liu et al. (2016) for China, Ullah et al. (2020) in Pakistan and Mahmood et al. (2020) in Saudi Arabia have demonstrated a favorable and considerable association between industrialization and CO_2 emissions.

These studies argued that with colossal destruction of resources, high energy consumption, and heavy transportation in production activities, industrialization causes higher CO_2 emissions. At the same time, adopting the STRIPAT framework on a balanced panel dataset of 73 countries Li and Lin (2015) revealed that industrialization causes CO_2 emissions. Supporting these, Parikh et al. (2009) showed a constructive and noteworthy connection between industrialization and carbon dioxide emissions. Further, the electricity sector is responsible for India's carbon dioxide emissions. However, Dong et al. (2020) have argued that industrialization helps in the reduction of CO_2 emissions through upgrading industrial units with advanced technology and new mechanisms. Thus industrial structure can contribute to carbon mitigation and sustainable development.

Studies also discovered the empirical connection between fossil energy consumption and carbon dioxide emissions. Using the ARDL test, covering the time of 1990-2013 for fifteen developing Asian countries, the empirical result of Hanif et al.’s (2019) paper demonstrated that consumption of fossil fuels causes a significant level of CO_2 emissions. Supporting these with the help of ARDL bound testing technique, Ali et al. (2020a) evidenced a long-term link amid economic development, fossil fuel consumption, inward FDI, and carbon dioxide emission from 1975 to 2014 in Pakistan. Further, Ali et al. (2020b) also verified the same nexus for Pakistan, Bangladesh and India. They revealed that fossil fuel, FDI, and development of an economy cause CO_2 emissions. In contrast, employing the Toda-Yamamoto estimation technique for Iran, Lotfalipour (2010) demonstrated that although GDP and energy consumption causes carbon emission, fossil fuel consumption did not have any leading role in influencing the emission level.

Industry, energy consumption, fossil fuel consumption, and FDI

According to Dinda (2004) and Ghani (2012), FDI has two effects on energy usage. First, FDI induces investment, leading to increased production in the host country and raising energy consumption. Second, it might expand the production capacity with efficient energy useand enable efficient production technologies. It helps the production units transit from dirty or relatively polluted companies to clean-energy structures. The earlier effect of FDI on energy consumption has well explained as the scale effect. Still, the latter signifiesits reverse and implies the composition and technical impact during the production process (Zhu et al., 2016).

A recent empirical investigation of three income groups: low, middle, and high, covering the period 1970-2008 by Omri and Kahouli (2014) have highlighted that FDI is a significant cause of energy usage in all cases. Similarly, many empirical studies with different econometrics techniques like Fourier ADL and ARDL test and VECM Granger, Leitao (2015) in Portugal, Uzar and Eyuboglu (2019) in Turkey, Mavikela and Khobai (2018) in Argentina have discovered that FDI has an encouraging and substantial basis of the higher level of energy consumption.

The energy-intensive investor’s investment shifted from the more developed and environmentally stringent country to less regulated developing countries. In addition, Saint and Ajmi (2020) also supported the existing findings and highlighted that FDI has a favorable and considerable result of increasing energy consumption for 23 Sub-Sharan Africa (SSA) countries. In contrast, Mielnik and Goldemberg (2000) and Salim et al. (2017) for China, Nepal et al. (2021), and Pao and Tsai (2011) for India revealed a harmful link between FDI and energy consumption. The findings of this paper mentioned that FDI had the significant potentiality to improve environmental quality by inducing energy efficiency. However, Sadorsky (2010) and Hubler and Keller (2010) highlighted no considerable effect of FDI on energy consumptionin developing economies.

Similarly, using 12 franc zone and 11 non-franc zone African countries data, Ngouhouo and Ewane (2020) resulted that FDI has a substantialand beneficial impact onindustrial development within the franc zone, however, the results become undesirable in the non-franc zone. In addition, applying various cointegration and causality techniques, Adejumo (2020) for Nigeria, Dash and Parida (2013) for India, and Gui-Diby and Renard (2015) for 49 African countries demonstrated a significant link amid FDI and industrialization. The argument followed that foreign direct investmentin flows significantly upgrade industrialization and boost the economy's investment and development.

At the same time, the existing studies have examined the empirical nexus between FDI inflows and fossil fuel energy. In addition, Al-Mulali and Ozturk (2015) and Zangoei et al. (2021) explained that although countries have tried to find an alternative fuel source to moderate the dependency on fossil energy consumption and mentioned fossil fuel assignificant component to attract FDI at the cost of the quality of environment. However, it remains critical to shift the energy structure away from traditional fossil fuels and toward renewable sources. That to transfer from a low energy technology enterprise tomore advanced and clean technology in the production process (Irfan et al. 2020).

CO_2 emissions, economic growth, and urbanization

There are several empirical research on the relationship between economic growth and CO_2 emissions. For example, by using ARDL and Toda-Yamamoto test, Nkengfack and Fotio (2019) revealed a progressive and substantial impact of energy usage and growth of the economy on CO_2 emissions for Algeria, Egypt, and South Africa. In addition, Wang et al. (2019) and Jalil and Mahmud (2009) described that economic development is the primary determinant of carbon dioxide emissions in China. Supporting these, a systematic survey by Mardani et al. (2019) has also revealed economic growth as a significant factor to affect the CO_2 emissions level. However, employing a non-linear panel smooth transition regression (PSTR) estimation technique, Mosikari and Eita (2020) for selected African countries have also highlighted that economic growth affects environmental pollution positively in the early stage after a certain period of pollution can be controlled with high economic growth.

This paper concluded that the urban population has a significant contribution to improving the environmental quality. In the Indian context, using econometrics techniques like the dynamic multivariate Toda-Yamamoto (TY) technique, ARDL, and VECM causality techniques, Rana and Sharma (2019), Ahmad et al. (2016), and Kanjilal and Ghosh (2013) proven that energy use has a large impact on CO_2 emissions in India. In contrast, Ghosh (2010) found no causal association between CO_2 emissions and economic growth in India utilizing ARDL bounds testing, Johansen-maximum Juselius's likelihood process in multivariate, and causality techniques.

A vast body of empirical literature has scrutinized the connection between urbanization and CO_2 emissions. Using various empirical techniques like ARDL, VECM Granger causality, FMOLS technique Shahbaz et al. (2014) incase of UAE and Al-Mulali et al. (2015) for Europe demonstrated that urbanization is a significant factor to create CO_2 emissions. Similarly, Franco et al. (2017) also showed that urbanization has a better level of significance in the quality of life while promoting economic growth and significantly affecting the emission level in India. In addition, Neli et al. (2012) argued that structural changes of India from rural to urban life are highly associated with heavy industrialization in urban centers and are responsible for increased energy use and emissions. Mahmood et al. (2020) supported the empirical results in this nexus for Saudi Arabia.

The paper demonstrated that urbanization positively and significantly contributes to CO_2 emissions. Using Toda-Yamamoto non-causality methods, Salahuddin et al. (2019) highlighted a bidirectional association amid urbanization and carbon dioxide emissions in the case of South Africa. Similarly, Zhang et al. (2018) found that population urbanization has a positive and large spillover effect on CO_2 emissions in China using spatial econometric models. However, using the Bayer-Hanck combined cointegration and VECM Granger causality, Shahbaz et al. (2016) have mentioned that urbanization significantly granger caused the CO_2 emissions and addressed a U-shaped association amid urbanization and CO_2 emissions in Malaysia. It implies that at the early stage of urbanization, carbon dioxide emissions decrease, but after a threshold level, it increases CO_2 emissions.

Research gap and hypotheses

Though there is a large body of literature on the PHH and the PHHH hypothesis for the rest of the globe, there are few studies on India, where the results are mixed and unclear. Therefore, it requires further investigation. The existing studies mostly measure the direct nexus amid foreign direct investment inflows and carbon dioxide emissions. There is hardly any study that attempts the indirect effect of FDI on CO_2 emissions considering the mediating effects of FDI. However, India is a growing economy, the largest FDI receiver, and one of the high emitter countries. To achieve a long-term balance between foreign direct investment inflows and India's CO_2 emissions, the country must prioritize globalization, increased energy consumption investment, and industrialization. It is essential to measure their indirect nexus too. Though several studies are in the relationship amongst CO_2 emissions, industrialization, energy usage and consumption of fossil fuel, no studies have attempted to examine the effect of high-carbon technology based on fossil fuels as the mediating factors of FDI inflows on carbon dioxide emissions in India's case. Our research considers the indirect effect of foreign direct investment inflows on carbon dioxide emissions through three mediating channels to minimize this gap. The following assumptions are proposed in order to investigate both the direct and indirect effects of FDI inflows on CO_2 emissions:

- H1: There exists a substantialassociationamongstforeign direct investment inflows and CO_2 emissions.
- H2: FDI inflows, energy structure, industrial structure, and carbon technologies are all linked in some way.
- H3: Energy structure, industrial structure, and carbon technologies significantly affect carbon dioxide emissions.
- H4: Inflows of FDI have a large mediating effect on CO_2 emissions.

EMPIRICAL FRAMEWORK

The data and variables are described in this section. It presents the methodology to demonstrateits relevance of the econometric methods, namely, unit root test, cointegration test, Granger causality, and seemingly unrelated regression estimate to verify the hypotheses mentioned above.

Data and Variables

The current study makes use of India's annual time-series data from 1980 to 2014. The sample duration is limited to 1980-2014 because of two reasons. First, 1980 is when India started its initial liberalization before 1990 (Panagariya, 2008). Second, the upper limit is restricted up to 2014,depending upon the availability of CO_2 emission data in the World Bank data source. To maintain all variables' consistency, we collected dataas ofthe World Development Indicators (WDI) released by the World Bank. The primary dependent variable of our study is CO_2 emission.CO_2 emission is the commonly used indicator among other components to measure the degree of environmental degradation due to its long data availability period. Following the study by Bakhsh et al. (2017), we have considered the carbon dioxide emissions (kg per 2010 US$ of GDP) as a significant dependent variable of our empirical analysis.

The primary explanatory variable of our study is inward foreign direct investment. Following Salahuddin et al. (2018), we measure FDI inflows are as a portion of gross domestic product (GDP) in this estimation. The three important mediating variables are energy structure (Wada et al., 2020, Shahbaz et al., 2016, Danish et al., 2020), the industrial structure (Mahmood et al.,2020, Zhang, Zhou, 2016), and the high carbon technology structure (Ali et al., 2020a, Ali et al., 2020b). The energy structure is dignifiedin energy usage (kg of oil equivalent per capita). The industrial structure is proxied with industry (including construction) value added (constant 2010 US$) in our study. Following Ali et al. (2020b), our research takes fossil fuel consumption (% of total energy usage) as a proxy to measure the high carbon technology.

To ensure our regression estimation results are free from a variable omission or not affected by other unobservable factors (Li et al., 2020), our paper controls two commonly influential factors of CO_2 emission, namely economic growth and urbanization (Rustemoglu, Andres, 2016, Mahmood et al., 2020, Parikh et al., 2009). The growth of the economy is considered with the GDP per capita (constant 2010 US$) and signifies the consequence of economic expansion on CO_2 emission. Simultaneously, the economy's urban structure (degree of urbanization)is proxied with the growth of the urban population (% of the total population).

During the estimation, all data is turned into the natural logarithm. In this paper, the CO_2 indicates the natural logarithm of carbon dioxide emissions, and FDI shows FDI inflows in its natural logarithm form. ES indicates the natural log of the energy structure of the economy, IS indicates the natural log of industrial structure, and HCT shows the natural log of high-carbon technology structure. The natural log of gross domestic development (economic development) is captured through GDP, and URBAN shows the natural log of the degree of urbanization in this paper.

Table 1 lists all variables, together with their measurement, definition, sources, and predicted indications.

Table 1 Description of variables, sources, and expected signs

Variables	Description	Representation	Source	Signs
CO_2	CO_2 emission	Carbon dioxide (CO_2) emissions (kg per 2010 US$ of GDP)	WDI, WB	+/-
FDI	FDI inflows	Foreign Direct Investment, net inflows (% of GDP)	WDI, WB	+/-
ES	Energy structure	Energy use (kg of oil equivalent per capita)	WDI, WB	+/-
IS	Industrial structure	Industry (including construction), value added (constant 2010 US$)	WDI, WB	+/-
HCT	High carbon technology	Fossil fuel energy consumption (% of total energy)	WDI, WB	+/-
GDP	GDP per capita	GDP per capita (Constant 2010 US$)	WDI, WB	+/-
URBAN	Urban structure	The urban population (% of the total population) growth	WDI, WB	+/-

Note: + ve sign and is –ve signs indicate positive and negative effects, respectively; the sign (+/-) means that impacts depend on the measurement scale.

Source: Authors' compilation

METHODOLOGY

This section includes the unit root test, co-integration test, causality test and the seemingly unrelated regression equations. The unit root test is the first measure to ensure stationarity before any time-series estimation. Following the previous research concentrated upon the interaction between FDI and carbon dioxide emissions at the aggregate level, such as single country or cross-country level,to verifythe equilibrium and causality (Salahuddin et al., 2018, Lee, 2009, Gokmenoglu, Taspinar, 2016; Solarin et al., 2017, Singhania, Saini, 2021, Ayamba et al., 2019, Nguyen et al., 2021), have mentioned that detecting cointegration is the first step.

After ascertaining the equilibrium or cointegration relationship, the second phase entails deciding on Granger causality that is appropriate (Pu et al., 2020). For Granger causality, two strands of tests are available. The first aspect changes the test statistics but still not distribution. It contains Toda and Yamamoto (1995), Dolado and Lutkepohl's (1996) modified Granger causality test, a simple method for calculating a Wald statistic by adding VAR delays to the conventional asymptotic distribution.

The modified Granger causality test can be applied to a variety of regardless of whether they are stationary or not. As a result, pre-testing for integration and cointegration is not essential as long as the process's maximal order of integration is less than the VAR system's lag number. However, Shukur and Mantalos (2000) discovered that a modified version of the Granger-causality test underperforms, especially in small samples, using Monte Carlo experiments; consequently, an alternative is required.

Therefore, the second strand changes the distribution instead of the statistics. It uses standard Wald statistics while substituting an empirical bootstrap distribution obtained through bootstrap simulation for the non-standard distribution. The present study applies the Granger causality to survey the preliminary causal linkage involving FDI and CO_2 emissions. In the final step, our study applies the seemingly unrelated regressions (SUR) considering the bootstrap causality and measures the bootstrap samples' structure. At the same time, the SUR is more suitable when all regressors are assumed to be exogenous, and it produces comparatively reliable estimates.

Unit root test

To know whether the time series implemented in our study is stationary, it is wise to go for a stationarity test. To determine the research's stationary properties,this paper applies the Augmented Dickey-Fuller (ADF) (1981) test and Phillips-Perron (PP) (1988) unit root test. The ADF test screens for unit roots while allowing for serial correlation in the residual. Simultaneously, the ADF test has the advantage of tackling the more complex models over the Dickey-Fuller test (1979). The study has taken both intercept (α) and Trend (T) having intercept with at lag order of one to detect unit root problem. The ADF test is based on the following equation:

$$\Delta Y_t = \alpha + \gamma T + \delta Y_{t-1} + \beta_1 \Delta Y_{t-1} + \cdots + \beta_m \Delta Y_{t-m} + \mu_t \qquad \text{..........(1)}$$

where:

Δ – denotes difference operator;

μ_t – denotes residual term at time t;

Y_t – denotes time series variable and $\Delta Y_{t-1} + \cdots + \Delta Y_{t-m}$ is used to correct the problem of serial correlation.

However, the complexity lies with the ADF test as it is prone to produce a high rate of type-1 error if not handled carefully (Naz et al.2019). We employ the PP test together and handle the type-1 error to keep safe from this ADF limitation. Based on the ADF methodology, Phillips and Perron (1988) proposed a unit root test, which deals with the problem of heteroscedasticity and serial correlation. The method of PP test estimates non-augmented Dickey-Fuller test of equation (1) by ignoring $\Delta Y_{t-1} + \cdots + \Delta Y_{t-m}$.

In addition, to remove the serial correlation, it provides rank to the residuals, and the equation of the PP test is as follows:

$$\Delta Y_t = \alpha + \gamma T + \delta Y_{t-1} + \mu_t \qquad \ldots\ldots\ldots..(2)$$

The null hypothesis in both ADF and PP tests of non-stationarity is measured by the t-statistic with critical values computed by MacKinnon (1991). The null hypothesis is rejected in this case, implying that the series is stationary. This work employs the automatic lag length selection in the residual using the Akaike Information Criterion (AIC).

Cointegration test

Co-integration is a time series econometric feature and a prerequisite for any long-run equilibrium relationship among multiple variables. If each series is non-stationary, two variables are cointegrated; yet, a linear combination is stationary (Engle, Granger, 1987). Using the Johansen cointegration technique, this study examines the long-run link between FDI and CO_2 emissions.The Johansen cointegration test can be implemented to check cointegration only if all the sequences are in the equal order (Engle, Granger, 1987). In addition, this test can be useful if the variables are of first order integrated, i.e. variables are not stationary at their level but become stationary after their first differencing (Boamah et al., 2018).

If this condition exists, the Johansen (1988, 1991) cointegration test will be used in our research, to check the collaborative flow between these two variables. This method provides two tests: Trace (J_{Trace}) and Max-eigenvalue (J_{Max}). Here, the Trace and the Max-Eigen statistic values are used (Johansen1988, Johansen, Juselius1990). The Max-Eigen statistic value test is preferred (Boamah et al., 2018). The reason lies inthe Max-Eigen test having greater power thanthe Trace-Eigen test (Johansen, Juselius, 1990). Two statistical values of the Johansen cointegration test can be represented mathematically by Eq. 3-4 as follows:

$$J_{Trace}(K) = -T \sum_{j=K+1}^{m} \ln(1-\lambda_j) \qquad \ldots\ldots.(3)$$

$$J_{Max}(K+1) = -T\, ln(1-\lambda_{K+1}) \qquad \ldots\ldots.(4)$$

Here K implies the number of cointegrating vectors, and T is the sample size. λ_j is the most significant canonical correlation. The null hypothesis of trace test that there are r cointegration vectors against the alternative of n cointegration vectors. On the opposite side, the Max-Eigen test exams the null hypothesis of r cointegration against the alternative hypothesis of r+1 cointegrating vectors. These null hypotheses' rejection criterion depends on the asymptotic critical values at a 5% significance level and is available mainly by econometric software packages. There is no cointegration among the variables if the null hypothesis cannot be rejected at the given critical value.

Granger causality

The work of verifying the long-run link between CO_2 emissions and FDI inflows does not end once the study has established it. The long-run association between variables is insufficient to provide a concrete conclusion between two-time series (Granger, 1969). Thus, our objective's next logical footstep is to check for any causal connection among these two variables when the time series is cointegrated (Rahman, Kashem, 2017). The study follows the Granger (1969) framework to examine this nexus. Following Wen and Dai (2020), we used the Granger causality between our variables inan enhanced VAR framework. Granger causality provides the opportunity intended for both unidirectional (whether CO_2 emissions cause FDI inflows or FDI inflows cause CO_2 emissions) and bi-directional causality (both become the cause of each other). However, our prime motive is to check do FDI inflows cause CO_2 emissions in India?

SUR regression

This research looks into the impacts of the mediator variables of FDI inflows on CO_2 emission. When more than one or more variables achieve the independent variable's influence on the dependent variable, more variables are referred to as mediator variables (M) (Wen, Ye, 2014). For simplicity, the study follows single-step multiple mediator models to analyze the internal mechanism of FDI inflows affecting India's carbon emission level. One approach to measuring such an effect is the seemingly unrelated regression equations.

The SUR method is a multivariate regression technique and is commonly known as Zellner's method for estimating the model's parameters. According to Zellner (1962), SUR is helpful when several equations seem irrelevant, but a secret and significant relationship exists between them[1]. The reasons might be as follows:

1) some coefficients should be the same or equal to zero;
2) throughout the whole equations the error terms or residuals are interconnected;
3) standard independent variables are used (Zellner, 1962).

In the foundational work of Zellner, the approach was applied to firm-level investment data collected annually for 20 years. In any modelling endeavour including pooled data, it remained a popular option. More specifically, the model makes it easy to continue with the data's cross-section, time-series characterisation, but what makes the data unique is that it has two dimensions (Fiebig, 2001).

However, Bartels et al. (1996) applied the SUR technique to cross-section units such as household expenditure on gas and electricity. Extending further Fernandez and Harvey (1990) reported that the SUR model is helpful when dealing with models that are directly modeled in terms of components of interest, such as trends, seasonals, and cycles, which are known as structural time series models. This model is widely used in time series analysis (Engle, 1978, Gersch, Kitagawa, 1983, Harvey, Todd, 1983, Harvey, Durbin, 1986) in these articles, the unobserved components in each of the individual time series are permitted to be contemporaneously associated with each other to quantify them in multivariate

[1] The Breusch-Pagan/ Cook-Weisberg test our samples have no heteroscedasticity issues with an insignificant chi-square distribution (chi-square = 0.02 and p-value = 0.8869) The Breusch-Godfrey LM test established the existence of a correlation among the variables in our dataset (chi-square = 6.356 and p-value = 0.0117), thus justifying the use of the SUR to estimate equations (5) to (7).

structural models,. These models are made to deal with a group of time series that, while not directly related, are influenced in similar ways.

In recent times, many studies have used this technique in environment and energy literature. For example, Alataş (2020) has applied this regression to examine the relationship among the elasticity of substitution between four inputs such as capital, labor, energy, and materials at the aggregate level for Germany from 1978 to 2005. Bello et al. (2020) employed the econometrics techniques of seemingly unrelated regression using data information from 1988 to 2016 to demonstrate the elasticity of substitution between hydropower and the principal non-renewable fuels of natural gas and coal used in generating electricity in Malaysia. In addition, Pan et al. (2020) have used the SUR method to study the impact of FDI on energy efficiency in China from 2003 to 2016 at the national and province levels.

The implication behind this application lies in the method that takes account of the error term correlations across equations in the estimations and allows us to obtain more precise and efficient coefficient estimates than the ordinary least squares (OLS) estimator. Another reason for the SUR approach is that it is more suitable when all regressors are assumed to be exogenous; it produces more reliable estimates. Extending further, Pu et al. (2020) have addressed that the seemingly unrelated regression is suitable for estimating a model when the time series data have fewer variables, and there is a correlation between the error terms of the dependent variables.

Therefore, this method is helpful to estimate the system's parameters, accounting for contemporaneous correlation in the errors across equations (Khan et al., 2014). The SUR model is a set of feasible generalized squares with a particular form of the variance-covariance matrix. As a result, this model is considered as either a simplified version of the general linear model or a generalisation into the simultaneous equations model, with the right-hand side regressors set to be the endogenous variable. Thus, this model helps measure the equations' jointness and the covariances associated with this.The empirical analysis accounts for the following model specification:

$$\mathrm{CO}_{2,t} = \alpha + cFDI_t + u_t \qquad ..(5)$$

$$M_{i,t} = \beta_i + a_i X_t + u_{i,t} (i = 1,2,3) \qquad ......(6)$$

$$\mathrm{CO}_{2,t} = \gamma + c' lnX_t + \sum_{i=1}^{3} b_i M_{i,t} + u'_t \qquad ..(7)$$

where:

α, β_i, γ – are the intercepts,

u, u_i and u′ – are residual errors, and

t – shows the time,

FDI_t – is the independent variable and implies FDI inflows, and

$\mathrm{CO}_{2,t}$ – is the dependent variable and shows the CO_2 emissions,

M_i – comprise the mediator variables where M_1 is energy structure, M_2 is the industrial structure, and M_3 is the economy's high-carbon technology.

In equation (5), we include economic growth and urbanization as two control variables:

c – is the total impact of FDI inflows on CO_2 emissions,

a_i – is the impact of FDI inflows on M_i. b_i is the effect of M_i of CO_2 emissions, after controlling the influence of X, a_ib_i – is the specific indirect effect of FDI inflows on CO_2 emissions via M_i, c' – is the direct effect of FDI inflows on CO_2 emissions after controlling the mediators. $\sum_{i=1}^{3} b_i M_i$ is the total mediation effect.

EMPIRICAL RESULTS AND DISCUSSION

Descriptive Statistics

The descriptive statistics of our variables are presented in their original form in Table 2. This empirical analysis is based on 35 observations. The statistics show that the average value of carbon dioxide emissions is about 1.136 units, while its maximum values are about 1.292 units, the minimum value is 1.010 units, the standard deviation is 0.089 units. The mean value of FDI is 0.800, and the standard deviation is 0.889 units. Its maximum value is about 3.620 units, and the minimum value is 0.002. The mean value of energy structure, industrial structure, and high-carbon technology is 413.111, 257.341, and 59.252.

At the same time, the standard deviation values of these three variables are 98.090, 163.739, and 9.948 units, respectively. The maximum and minimum value of the energy structure lies between 636.570 and 286.164. The maximum and minimum value of the industrial structure lies at 611.834and 77.641, respectively. Similarly, the maximum value of HCT is 73.576, and the minimum value stands at 39.383. The mean value of GDP is 833.321, the standard deviation is 356.818, while the maximum value is 1640.181, and the minimum value is 422.904. The mean and standard deviation value of URBAN is 2.839 and 0.369, respectively. At the same time, the maximum and minimum value of URBAN is 3.889 and 2.329, respectively.

Table 2. Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
CO_2	35	1.136	0.089	1.01	1.292
FDI	35	0.800	0.89	0.003	3.620
ES	35	413.112	98.091	286.164	636.570
IS	35	257.340	163.739	77.641	611.834
HCT	35	59.252	9.949	39.383	73.577
GDP	35	833.321	356.818	422.904	1640.181
URBAN	35	2.839	0.369	2.329	3.889

Source: Authors' calculation

Correlation results

Before the mediating effect analysis, the study correlatesthe dependent variable CO_2 emissions, the prime independent variable FDI inflows with its mediating factors, and the control variables.

Table 3. Correlation results of FDI inflows with its mediating factors

	CO_2	FDI	ES	IS	HCT	GDP	URBAN
CO_2	1.000						
FDI	-0.248 (0.150)	1.000					
ES	-0.391** (0.020)	0.861*** (0.000)	1.000				
IS	-0.415** (0.013)	0.898 *** (0.000)	0.989*** (0.000)	1.000			
HCT	-0.180 (0.301)	0.907*** (0.000)	0.938*** (0.000)	0.959*** (0.000)	1.000		
GDP	-0.456*** (0.006)	0.879*** (0.000)	0.993*** (0.000)	0.997*** (0.000)	0.941*** (0.000)	1.000	
URBAN	0.058 (0.742)	-0.829*** (0.000)	-0.906*** (0.000)	-0.900*** (0.000)	-0.958*** (0.000)	-0.886*** (0.000)	1.000

Source: Authors' calculation

Note: ** and *** indicate that the correlation coefficients are significant at 5% and 1 % significance levels, respectively.

The correlation and covariance results for FDI inflows and mediating factors are reported in Table 3. Thisindicates that FDI negatively correlates with CO_2 emissions; however, its p-values indicate it is insignificant to affect CO_2 emissions. Three mediating factors of FDI have also shown a negative association with the dependent variable, where all variables remain significant at a 5% level of significance except high carbon technology. GDP per capita has shown anadverse association with carbon dioxide emissions and remains substantial at a 1% significance level. The urban factor positively correlates with the dependent variable; however, it is insignificant. Based on the findings, it is worth noting that there is a substantial beneficial link between FDI and ES, FDI and IS, and FDI and HCT.

Table 3 also illustrates a favorable and considerable link between per capita GDP and FDI. However, URBAN presents a negative association with FDI but remains insignificant. The correlation analysis also shows that IS and ES are correlated positively and significantly. Finally, the result noted that IS and HCT havea positive and significant correlation.At the same time, the correlation results also highlighted that three mediating factors are positively and significantly associated with GDP but possess a negative but significant association with urbanization. The correlation result of GDP with URBAN has shown a negative and significant association.This can be noted that all the correlation coefficients of mediating factors are significant at a 1% level with FDI inflows. All three factors show a positive association with FDI inflows requiring further attention for empirical investigation regarding CO_2 emissions.

Unit root results

The ADF and PP-unit root test are used in the study to check stationarity, which is the initial stage in our empirical estimation. The ADF and PP-unit root test results with intercept and trend & intercept are shown in Table 4. The ADF results show that all variables remain non-stationary at a level with intercept except HCT. Similarly, none of our variables are stationary at a level with intercept and trend, according to the ADF test results.However, the PP-test also reveals that most variables are non-stationary at levels with intercept except HCT. Unlike the ADF test, the PP-test shows that all the variables are non-stationary at the level with intercept and trend except the HCT. In Table 4, the ADF result exhibits that all the variables become stationary at the first difference with intercept except the ES. However, all variables become stationary in their first difference with intercept and trend. Similar to the ADF first difference test, the PP-test results reveal that all variables become stationary after their first difference with intercept and intercept and trend.

Table 4. ADF and PP-unit root test results

Variables	Level		First Difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
ADF Test Statistics				
CO_2	-0.087 (0.670)	-0.137 (0.674)	-0.959 (0.000)	-1.016 (0.000)
FDI	-0.089 (0.643)	-0.479 (0.123)	-1.400 (0.000)	-1.401 (0.001)
ES	0.028 (0.999)	0.003 (0.995)	-0.602 (0.111)	-0.947 (0.001)
IS	0.004 (0.986)	-0.270 (0.173)	-0.719 (0.003)	-0.734 (0.011)
HCT	-0.054 (0.000)	-0.108 (0.134)	-0.521 (0.052)	-1.008 (0.000)
GDP	0.021 (1.000)	-0.074 (0.916)	-0.884 (0.000)	-1.097 (0.000)
URBAN	-0.076 (0.329)	-0.272 (0.131)	-0.677 (0.003)	-0.709 (0.013)
Phillips-Perron Test Statistics				
CO_2	-0.087 (0.623)	-0.137 (0.685)	-0.959 (0.000)	-1.016 (0.000)
FDI	-0.089 (0.746)	-0.479 (0.123)	-1.114 (0.000)	-1.114 (0.000)
ES	0.028 (0.999)	0.003 (0.989)	-0.812 (0.000)	-0.947 (0.000)
IS	0.004 (0.984)	-0.186 (0.495)	-0.719 (0.004)	-0.733 (0.016)
HCT	-0.053 (0.000)	-0.108 (0.096)	-0.598 (0.002)	-1.008 (0.003)
GDP	0.021 (1.000)	-0.073 (0.979)	-0.884 (0.000)	-1.097 (0.000)
URBAN	-0.096 (0.117)	-0.246 (0.138)	-0.677 (0.004)	-0.709 (0.018)

Source: Authors' calculation

Note: p-values are in parenthesis.

The ADF and PP-unit root test results give a stable conclusion of stationary at the first difference for all the variables in this study during 1980-2014. As the CO_2 emissions and FDI inflows follow the single integer of the same order, this study can carry out the cointegration analysis. Similar finding have also obtained in the existing studies with Acharyya (2009) and Tang and Tan (2015) and suggested a cointegration test to investigate the long-run association between FDI inflows and CO_2 emissions in India and Vietnam.

Cointegration test result

The Johansen test is preferred to see any long-run, steady, and balanced link between CO_2 emissions and FDI inflows in India over the study period. The cointegration test results are shown in Table 5.

Table 5. Cointegration test result

Test Form (c, t, p)	Statistics value	5% critical value	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)	Eigenvalue	Hypothesized No. of CE (s)	Conclusion
Trace Statistics							
(1, 0, 1)	15.791**	15.494	h=0	h≠0	0.303	None*	Cointegration relationship exists

(1,1, 1)	27.156 **	25.872	h=0	h≠0	0.502	None*	Cointegration relationship exists
(0,0,1)	21.538***	12.321	h=0	h≠0	0.391	None*	Cointegration relationship exists
Max-Eigen statistic							
(1, 0, 1)	4.608**	3.841	h=0	h≠0	0.138	At most 1*	Cointegration relationship exists
(1, 1, 1)	20.229**	19.387	h=0	h≠0	0.213	None*	Cointegration relationship exists
(0, 0, 1)	6.126***	11.224	h=0	h≠0	0.392	None*	Cointegration relationship exists

Source: Authors' calculation

Note: 1. h represents the cointegration rank. 2. In the test form (c, t, p), "c=0" means no constant, "c=1" means a constant; "t=0" means no trend and "t=1" means having a trend; p represents the lagged rank. 3. ***, ** indicates 1% and 5% level of significance, respectively.

The cointegration test outcomes for CO_2 emissionsand FDI inflows revealthat the trace statistic and max-eigenvalue tests are substantial at a 5 percent critical level. After rejecting the null hypothesis, the trace statistics, and maximum eigenvalue tests,the investigation uncovers a fairly long cointegration link between these two variables in India's case.This outcome is in line with expectations with Salahuddin et al. (2018) for Kuwait, Solarinet al. (2017) for Ghana,Tang and Tan (2015) for Vietnam,and Acharyya (2009) for India. Thus the cointegration results indicate that FDI inflows and CO_2 emissions have a reasonablylong association.

Granger causality test result

This study needs to investigate the causal association between FDI inflows and CO_2 emissions once the cointegration result is obtained. Thus,the next step of our paper is to examine whether FDI inflows cause carbon emission or not inthe case ofIndia. Our estimation applies the Granger causality (1969) test to explore this relationship for this study's variables. The lag-order, the F-statistics, and the p-values are used in the test.

Table 6. Granger causality test result

Lag order	**F statistics**	**p-values**	**No. of observations**	**Conclusion**
1	3.47*	0.072	34	FDI inflows cause CO_2 emissions
2	2.553*	0.095	33	FDI inflows cause CO_2emissions
3	2.155	0.118	32	FDI inflows do not cause CO_2emissions
4	1.296	0.302	31	FDI inflows do not cause CO_2emissions
5	1.076	0.404	30	FDI inflows do not cause CO_2emissions

Source: Authors' calculation

Note: * indicates 10 % level of significance

From Table 6, it is shown that in two cases, i.e., at lag one and lag two,our results show that FDI inflows positively cause CO_2 emission at a 10 percent significance level. This implies that one unit change in FDI demonstrated 3.47 unit changes in CO_2 emission at the first lag and 2.553 unit changes at the second lag. In other words, FDI has a favorable and consistent effect on CO_2 emission levels in India. This result is in line with previous researchofSalahuddin et al.(2018),Acharyya(2009), Lee (2009) and supports the pollution haven hypothesis in Kuwait, India, and Malaysia, respectively.These results mean that FDI is also influencing the increasing carbon dioxide emissions level.

SUR regression result

This calculation will look at how FDI inflows affect carbon dioxide emissions with different mediating factors.Thisresearch follows the seemingly unrelated regression model to check the multiple effects of FDI inflows. This helps control the error terms between the different equations, which might be correlated (Menghan2018). Table 7 displays the OLS estimates and the results of the SUR model.Model 1gives the OLS model estimation.Model 2-4 provides the impact of FDI on the mediating variables,and Model 5 presents the mediating effect of FDI on CO_2 emissions.

Table 7. SUR regression result

Dependent Variables →	**Model 1 CO_2**	**Model 2 ES**	**Model 3 IS**	**Model 4 HCT**	**Model 5 CO_2**
Independent Variables↓					
FDI	0.014* (0.013)	0.107*** (0.0106)	0.315*** (0.026)	0.088*** (0.007)	0.014** (0.006)
ES					0.856*** (0.144)
IS					-0.716*** (0.064)
HCT					1.246*** (0.096)
GDP	-0.398*** (0.040)				
URBAN	-0.956*** (0.113)				
R-squared	0.790	0.741	0.807	0.823	0.883
Adj. R-Squared	0.770				
F-statistics or Chi^2 -statistic	38.93***	100.40***	146.49***	162.04***	264.50***
No. of Observations	35	35	35	35	35

Source: Authors' calculation

Notes: 1. Model 1 presents the OLS estimates. 2. Model 2, Model 3, and Model 4 correspond to equation (6) containing variable M_1 (energy structure), M_2 (industrial structure), and M_3 (high-carbon technology). 3. The parenthesis values are the robust standard errors. 4. *** and ** indicate significance at 1% and 5 %, respectively. 5. Because the intercepted item has no substantial meaning in the mediating effect analysis, it is omitted here.

Table 7 Model 1 shows that the total effect on the carbon emission level is beneficial and consistent. The OLS measurement of FDI demonstrates a 0.014 unit change due to one unit change in FDI. This shows that FDI significantly affects carbon emission levels in India due to direct investment from abroad. This finding is supported by previous literature of Shahbaz et al. (2018) for France. This outcome aligns with Acharyya's (2009) previous findings and implies the PHH hypothesis's existence in India's case. The regression results also show a harmful and substantial effect of economic expansion and urbanization on carbon dioxide emissions. The empirical result demonstrates that one unit change in economic development offers a significant negative effect of -0.398units on CO_2 emissions. This finding supports the recent literature (Wang et al., 2018). This means that increased economic expansion has no negative impact on environmental quality;instead, it improves sustainability.Similarly, the coefficient of urbanization also highlights a significant negative effect of -0.956 units on CO_2 emissions. This outcome supports the existing literature (Yao et al., 2018). It implies that urbanization can improve environment quality with eco-friendly techniques and environmental awareness in urban India.

However, the OLS regression is limited to explaining the effect of the mediating channels on CO_2 emissions. Thus, our study employs the SUR estimators. The SUR technique provides four models (Model 2-5) results simultaneously in Table 7. Model 2 demonstrated coefficient a_1, i.e., the direct impact of FDI on energy structure is 0.107 at the 1% level of significance. This result is reliable with Pao and Tsai (2011), where the findings highlighted a bidirectional relationship between FDI and CO_2 emissions. At the same time, Model 5 can identify coefficient b_1, i.e., the direct effect of energy structure on carbon dioxide is 0.856, which is still considerable at 1%. This is in line with the recent research (Pao et al., 2011, Ozturk, Acaravci, 2013, Saboori et al., 2014, Khan et al., 2018).

This implies that energy consumption has significantly contributed to pushing up the emissions line upward. Since a_1 and b_1 are significant, the mediation effect through the energy structure is substantial, which is a_1b_1= 0.092. This implies that FDI inflows use higher energy in terms of kg of oil use. It can be assumed that this might be a heavy burden on India's transportation sector. This sector is highly energy-intensive and has become one of India's significant contributors to CO_2 emissions. Therefore, India's government must take immediate measures to reduce the energy intensity in oil consumption and substitute for renewable energy or less intensive resources. It needs high investment in energy-consuming sectors and demands serious actions to build an unfavorable connection between energy resources and environmental quality through FDI. It can be possible with the advancement of adaptive, less energy-intensive technologies.

Similarly, Model 3 represents the coefficient a_2 is 0.315 at a 1% level of significance, where a_2 implies the direct effect of FDI on the industrial structure. This shows that FDI inflow has a significant role in increasing the industrial structure by increasing the industrial value-added. This result supported the earlier findings of Adejumo (2020), Dash and Parida (2013), and Gui-Diby and Renard (2015). It emphasized the direct and upward relationship between FDI inflows abroad and industrial development. In other words, these papers claimed that FDI boosts industrialization and modernizes the economy with new investment and growth.

At the same time, the coefficient of b_2 in Model 5 shows a significant and a negative value (-0.716) which implies that CO_2 emissions are adversely affected by the industrial structure. This finding stands in contrast with the earlier literature by Liu and Bae (2018),Ullah et al. (2020), and Mahmood et al. (2020). The findings of these existing studies revealed a positive association between industrial activities and economies' emission levels. However, our results supported the recent literature by Lin et al. (2017), Dong et al. (2020), and Ghazouani (2021). They argued that with environment-friendly and energy-efficient technologies and skilled workers, industries could reduce environmental degradation and help countries sustain their economies. Thus the mediating effect of industrial structure is substantial with a value of a_2b_2= -0.226.

This illustrates that while FDI inflows have a beneficial direct influence on the industrial structure, the industrial structure harms CO_2 emissions. The implication is that FDI inflows increase the value-added of industries by introducing innovative technologies and environmentally friendly methods; thus, the industrial sector improves India's environmental quality. The direct impact of FDI on third mediating factor (high-carbon technology) coefficient values are shown in Model 4. The coefficient value demonstrates that a_3 is 0.088, which becomes statistically relevant at the 1% level. This means that an uptick inthe inflow of FDI would be beneficial. This implies that an increase in FDI inflows significantly affects promoting high-carbon technology.

These findings are supported with the earlier empirical findings of Lindmark (2002) and Zangoei et al. (2021). These papers demonstrated that developing countries generate economic growth from inward foreign investment by using more fossil fuel energy. At the same time, the mediating factors coefficient value b_3 is 1.250 and remains significant at a 1% level. The interpretation lies thatthe rise in consumption of fossil resources as a percentage of total energy can significantly increase India's carbon emission level. This finding is in accordance with Mert and Boluk (2016), Ali et al. (2020a) and Ali et al. (2020b), Ahmad et al. (2016).The findings of these studies revealed that economic development, fossil fuel, and CO_2 emissions have a positive and strong correlation. Thus the high-carbon technology mediation effect is significant with a value of a_3b_3= 0.110.

From this result, it can be assumed that India's inflows favorably influence the fossil fuel consumption and adopt a high-carbon technology. Thus investment through FDI in fossil fuel-intensive units generates a rising amount of carbon emissions in India.These results can be verified with the previous findings of Pao and Tsai (2011) and suggested that nations with fossil energy-oriented inward FDI should shift their paradigm to more eco-friendly investment and control the level of emissions without compromising their economic growth. Along with the significant three mediating coefficients, our SUR model presents a substantial direct effect of FDI on carbon emission is $c^{'}$=0.014 in Model 5. This indicates that in addition to the three mediating variables, other mediators may play a role in this mechanism by which FDI affects India's carbon dioxide emission level.

Then the bootstrap test is used to examine the individual mediation effect and the total mediation effects. The single-step multiple mediator models are tested using the non-parametric percentile bootstrap method and the biased-corrected non-parametric percentile bootstrap method.

Table 8. Bootstrap test result

Mediation effect	**Observed coefficient**	**95% confidence interval**	**95% biased confidence interval**	**Conclusion**
a_1b_1	0.092	(0.051, 0.133)	(0.054, 0.134)	Significant
a_2b_2	-0.226	(-0.302, -0.150)	(-0.308, -0.165)	Significant
a_3b_3	0.110	(0.083, 0.138)	(0.083, 0.137)	Significant
$a_1b_1+a_2b_2+a_3b_3$	-0.024	(-0049, 0.001)	(-0.053, -0.005)	Significant

Source: Authors' calculation

Table 8 presents the mediating factors that significantly affect carbon emission levels. The bootstrap test results show that the individual and the combing indirect impact of FDI inflows on carbon emissions are substantial. While the individual mediating effect of the energy structure and the high carbon technology positively impacts CO_2 emissions, the industrial structure negatively affects India's emission level. However, the combined mediating effect shows anundesirable consequence of FDI on carbon emissions. This suggests that FDI inflows in India are not directly deteriorating the environment quality offered as the OLS estimators in Model 1. Instead, it helps to improve the environmental quality with different mediating channels. This findings is in keeping with Kong's past research (2021). This implies a positive and sustainable economy with high FDI inflows and improved environmental quality.

Finally, the results demonstrate that the total mediation effect of FDI inflowsare significant and accounts for the overall proportion of the carbon dioxide in the Indian economy, which accounts for around 82.8 percent in India; thus, it can visualize the necessity of the proper structural distribution and its utilization of FDI inflows in India. The above analysis can be shown in a path of the diagram (see Figure 2).

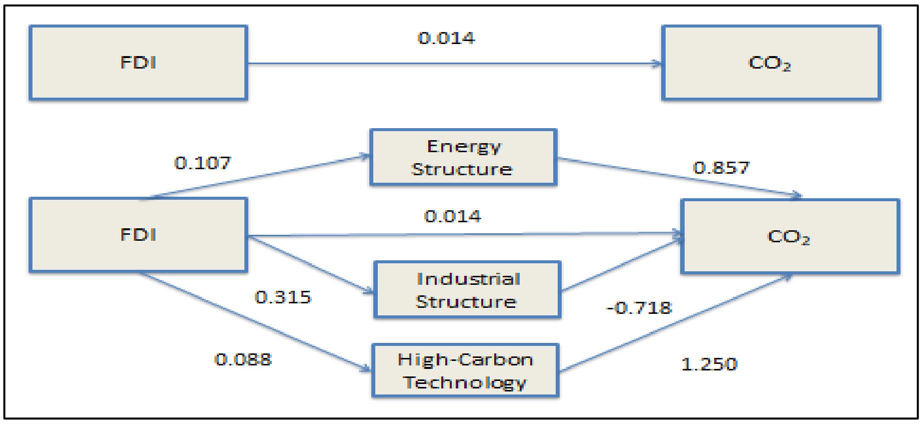

Figure 2. The direct and mediating effect of FDI inflows on CO2 emission
Source: Authors' calculation

Figure 2 gives the path chart of FDI inflows affecting carbon emissions directly and indirectly. The first part of the figure shows the OLS regression results and shows the entire impact on carbon emissions. Throughout the second part, the figure gives the mediating effect of FDI inflows by energy structure, industrial structure, and high carbon technology on the CO_2 emission level of India.

In summary, this study highlighted an indirect effect of FDI inflows on CO_2 emissions once after verifying its long-run cointegration and unidirectional causal relationship from inward foreign investment to carbon dioxide emissions in India. However, the existing studies have well explored the relation amid FDI inflows and CO_2 emissions (Acharyya, 2009, Rana, Sharma, 2019, Pu et al., 2020, Zangoei et al., 2021) and found a positive association and supported the theoretical pollution haven hypothesis. Similar findings can also prove while interpreting the direct relationship between FDI inflows and carbon dioxide emissions in this paper. In contrast, a set of existing studies (Zhang, Zhou, 2016, Ning, Wang, 2018, Ayamba et al., 2019) have revealed a negative linkage among them, and it was materialized in the bootstrap result in the SUR model.

The novelty of this study lies with its investigation of mediating effects of FDI inflows on emissions. With the application of the seemingly unrelated regression, our study enables us to find out the relationship between FDI on CO_2 emissions, energy structure, industrial structure, fossil fuel consumption, and the effect of these three mediating channels of FDI on CO_2 emissions. However, the existing studies (Mirza, Kanwal, 2017, Ullah et al., 2020, Dong et al., 2020, Ali et al., 2020a) have revealed the relationship considering these variables for a different group of countries focused on the direct associations. The findings also demonstrate that the two control variables in the first model are negative and significant. This implies economic growth and urbanization have reached a threshold, and environmental awareness and energy-efficient technology together helped to reduce CO_2 emissions. This result is in accordance with Wang et al. (2018) and Yao et al. (2018) and inconsistent with Jalil, Mahmud (2009), Mardani et al. (2019), Shahbaz (2014), and AI-Mulali et al. (2015). These findings have several theoretical and practical implications concerning future studies and policy suggestions and can be better understood in the next section.

CONCLUSION AND POLICY IMPLICATION

The research on FDI inflows and environmental quality in India is covered in this paper. The analysis focused on the FDI inflow'sdirect and indirect impact on CO_2 emissions in the presence of mediating channels. This research accounts an extensive time-series data for 35 years. We use the ADF and the PP-unit root test, the Johansen cointegration test, the Granger causality test, and the SUR method for empirical analysis. After giving a brief of variables with descriptive statistics, our research found that FDI inflows and CO_2 emissions are stationary at the same integer. Our research employs the Johansen cointegration test shows that these two have a long-term association. Then this research applies the Granger causality and evidences a one-way connection from FDI to CO_2 emissions.

To examine the mediating effects of FDI inflows, we estimate using the SUR technique. According to the SUR estimates, the mediating effect of FDI inflows on India's carbon dioxide emissions is greater than the direct impact. High-carbon technology and energy structure coefficient are positive in the mediating channels of FDI inflows. This shows that foreign investors invest FDI in India are highly energy-intensive with high oil consumption. At the same time, our result evidenced that foreign investment in India is significantly fossil fuel-intensive and produces more carbon emissions with high-carbon technologies. This resultbacks up the pollution haven theoryin the internationalization and environmental quality nexus. However, the industrial structure's mediating influence demonstrates an inverse link between FDI inflows and CO_2 emissions. This result contrasts the energy structure and the carbon technology, supporting the recent environmental and internationalization nexus mentioned in the pollution halo effect. Therefore, FDI inflows on CO_2 emissions depend on redistribution across the structures. Thus, this study has several theoretical and practical implications that can be used as a road map for the researcher, industrial agents, policy makers, and government.

The findings of this paper contribute to the debate between "pollution haven" and "pollution halo" effects by synthesizing the existing relation between FDI inflows and carbon dioxide emissions and determining whether FDI is favourable or unfavourable for the quality of the environment. The findings of our estimation control the mediating effects and explain that part of FDI inflows is invested in the energy-intensive and fossil fuel sector. This further contributes to emissions and might provide polluting industries with a less environment-friendly approach to invest in India. This indicated a 'capital flight' of polluted units from a highly regulated and high production cost economy to India to use its cheap labor supply and enjoy the less stringent environmental regulations.

However, the results also revealed that FDI inflows in industrial sectors significantly boost the industrial outcome. At the same time, the SUR estimates revealed that investment in the industrial sector is energy efficient and helps control emissions. It is further can be notified that the net SUR bootstrap result shows that FDI inflows create a "pollution halo" in India after comprising the negative effect of FDI on the environment. Therefore our findings suggest dealing with the theoretical ambiguity about the FDI-environment nexus; studies should control the heterogeneous effect of foreign investment and its consequence on the environment. This paper has also suggested some practical implications for the industrial units. As FDI inflows in the industrial sector are helping for a sustainable environment, industrial entities can increase their competency and attract more FDI.

At the same time, the industrial sector can boost the economy for more output and employment sustainably. Considering its priority Indian government and reputed industrial chairs should encourage programs like "Mission Innovation (MI)" to formulate new and more "transformative innovation policy (TIP)," as mentioned by Carayannis et al. (2022) in the case of the US in 2015. This program's primary goal is to make clean energy more accessible and generate more sustainable jobs and investment opportunities for enterprises.

Thus, the implications of the results have a broader scope for future research. Firstly, research can undertake for other countries or at cross country level considering this set of macro-economic variables. Secondly, studies can further investigate other mediating channels of FDI inflows while considering their effect on the environment. Next, this study can extend to verify such nexus at a more dis-aggregate level such as region or districts, industry or firm level. Finally, future research can encourage case studies for specific industries to change their competitiveness and competency. Therefore, this research will help the researchers and policymakers choose where to invest the FDI inflows and generate more benefits with good environmental quality. A concrete policy implication of this study can be explained in the following section.

Being the most prominent growing country globally, India needs more foreign investment to grow and develop faster. Thus, similar to Singhania and Saini (2021) our research suggests government intervention with clear environmental disclosures by establishing stringent regulations is essential to reduce the direct volume of carbon emissions and reduce greenhouse gas (GHGs) levels. Though the government of India has taken many initiatives (such as a target of by 2030, emissions linked with each unit of economic output will be reduced by 33-35 percent compared to the 2005 levels, the National Electricity Plan (NEP)-2018 and also the National Action Plan on Climate Change (NAPCC) in 2008) to curb the climate change effects nationally and globally, some measures are still necessary to achieve a sustainable India.

Therefore to achieve the COP26's "net zero" emission target by 2070 and attain sustainable development, India needs to encourage the ability to cut emissions and complement the best use of resources. Thus, an incentivized policy may be proposed at the macro and micro level with tax exemptions to the cleaner units. Similar to Zhu et al. (2016), our research suggests the government may impose strict legal and non-legal barriers to control various production units' energy consumption. For example, a carbon tax can be imposed on those production units emitting a higher level of carbon dioxide. At the same time, MNCs should follow a strict disclosure index on environmental quality within the host country. This will pressure the domestic units to improve their environmental quality to stay more competitive in the world market (RobecoSAM2019). Simultaneously, as India is a source of renewable energies, it may encourage the production units to invest more by using solar energy, wind energy, and biofuel energy instead of fossil fuel energy. Thus, India should improve its economic performance and enable further FDI inflows with efficient energy use and the latest eco-friendly technologies to achieve a cleaner and sustainable environment.

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