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Mediating Effects of Foreign Direct Investment Inflows on Carbon Dioxide Emissions

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Abstract: In this research, the direct and indirect effects of foreign direct investment (FDI) inflows on carbon dioxide (CO_2) emissions in India are examined, covering the period from 1980 to 2014. To quantify the indirect outcome of the existence of FDI on CO_2 emissions, in this study, the three mediating channels of FDI are considered. The three broad mediating channels of FDI inflows are energy structure, industrial structure, and high-carbon technology, by which foreign direct investments affect India's carbon dioxide emissions. In this study, the unit root test, the Johansen cointegration, the Granger causality technique, and the seemingly unrelated regression (SUR) are used for the empirical analysis. The findings discover a process of cointegration in the long-run and reveal unidirectional causation between FDI inflows and CO_2 emissions. The outcomes of the SUR estimation indicate that all the mediating factors substantially contribute to the level of CO_2 emissions. In this paper, the findings reveal that FDI inflows affect the level of India's CO_2 emissions mainly via mediating factors compared to their direct effect. Finally, in this research, it is recommended that the concerned authorities should prioritize the redistribution of foreign direct investment from high carbon-intensive technologies to less carbon-intensive and cleaner technologies for India's carbonless and sustainable future.

Keywords: FDI; CO_2 emissions; mediating effects; SUR; Indian economy

JEL Classification: Q54; Q56; F23; C22

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1. Introduction

Climate change, greenhouse gases (GHGs), future energy, and carbon dioxide emissions are all attracting interest from industrialized, developing, and impoverished countries (Narayanan & 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 been diverted from its track of meeting the Paris Agreements (to restrict global warming to 1.5 °C),and climate change is faster and more robust than has been expected[1]. Further, the report highlighted that this diversion will cause severe consequences for hundreds of millions' food security, health, and threatens biodiversity. Thus, climate change has become a significant hurdle for accomplishing the United Nations' Sustainable Development Goals (SDGs) for global development. Besides, with due time, natural scientists have investigated the fact that carbon dioxide (CO_2) emissions are the leading factor in climate change due to an intensified greenhouse effect and the degradation of the atmospheric system (IPCC, 2014). Measuring this severity, the World Bank (2018) reported an 84.38% increase in CO_2 emissions from 1980 to 2014, which has awakened the world to this unexpected change in CO_2 emissions. Thus, to control the extreme climatic events, the melting of the Arctic sea ice, rising sea levels, 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 major causes of the increased CO_2 emissions (Muhammad & Khan, 2019). However, a trade-off occurs between environmental quality and higher economic prosperity. Growing economies have recently been significantly 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 concerns, making it an enormous task to fuel economic growth in an environmentally friendly manner (Sahu & Narayanan, 2010). As CO_2 emissions are a global pollutant, recent researchers have emphasized the globalization–environmental quality nexus. At the same time, internationalization is the prime factor in speeding up industrialization, so the higher the level of globalization, the higher the production, consumption, and deterioration inthe quality of the environment (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 unless the environmental impacts of globalization are considered, and CO_2 emissions will persist (Shahbaz et al., 2018). Several decades ago, researchers argued that an economy's environmental degradation would reduce with a subsequent acceptable amount of economic growth (Grossman & Krueger, 1995). This theory, popularly acknowledged as the environmental Kuznets curve (EKC), examines the different dimensions of the CO_2 emissions on the macroeconomic variables, which can be sub-divided into CO_2 emissions and economic growth (Y. Wang & He, 2019; Hargrove et al., 2019), CO_2 emissions and modernization (Yao et al., 2018), and CO_2 emissions and FDI inflows (Muhammad et al., 2021).

In recent years, there have been two distinct groups of studies in the findings on the association between CO_2 emissions and FDI inflows in recent years. On one side, a group of studies has asserted a favorable correlation between these two factors (Guzel & Okumus, 2020). It has principally emphasized the costs of the growth of any economy in terms of deterioration in environmental quality (Mohsen et al., 2024). This relationship is known as the 'pollution haven hypothesis' (henceforth the PHH). This implies that polluting units come from developed and more stringently environmentally regulated countries to developing and less environmentally regulated countries with high environmental pollution. On the other side, a group of studies by J. Huang et al. (2017), Seetanah et al. (2019), and Ehigiamusoe (2020) have highlighted a negative affiliation between these two and claimed that FDI could bring more advanced and energy-saving innovations from developed to underdeveloped countries; thus, helping the economies in building sustainable development. This relationship represents the opposite of the PHH hypothesis and is known as 'the pollution halo effect' (henceforth the PHHH). Examining affluent nations like Turkey, France, and Australia, alongside several emerging and developing countries, in the current research has emphasized a positive relationship and confirmed that FDI inflows weaken environmental quality (Jun et al., 2018; Rehman et al., 2021). Thus, this has supported the PHH hypothesis. Conversely, some studies have revealed a negative association between these two and validated the PHHH hypothesis (Nguyen et al., 2021).

Furthermore, Marques and Caetano (2020) pointed out that PHH occurs in developing countries. However, in recent times, the association between CO_2 emissions and

FDI remains unclear. Thus, further empirical investigation is needed to cross-check the direction and its nature over time. This vast body in the existing literature on this nexus mainly focuses on the direct linkage of CO_2 emissions (increase/decrease) and FDI inflows. Simultaneously, the existing studies have mostly 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 (Luigi et al., 2021). These three components of any economy's structure are the highly significant mediating channels to materialize any investment from abroad (Shen, 2018). To examine the effect of such mediating channels of FDI on CO_2 emissions, we follow Shen's (2018) study in the development of this paper. However, the research is currently limited to the Chinese economy's carbon productivity and cannot be extended or generalized to a growing democratic economy like India.

With significant historical data from 1980 to 2014, in this study, India is selected for the exploration of the direct and indirect impact of FDI in flows on CO_2 emissions. In this study, India was chosen for the following reasons. India's economy is among the world's fastest expanding economies (Chaturvedi, 2017) and is the most significant destination for FDI inflows in the globe, which touched USD 60.1 billion during 2016–17 (UNCTAD, 2018). At the same time, India is significantly vulnerable to the melting of the Himalayan glaciers' ice caps (Tewari, 2021); the region is susceptible to climate change and changes in the monsoon wind system. Simultaneously, the Carbon brief profile report, India (2019) indicated that India is the third-highest emitter globally, providing 3571 m tons of CO_2 emissions. The World Bank (2018) highlighted that "India could see \$1.2 tn 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 supplement environmental change that is likely to harm human health in growing economies like India (Prasad & Mishra, 2017). Moreover, Watts et al. (2018) indicated that the heat significantly damages the Indian agricultural output and work force by increasing CO_2 emissions and, ultimately, climate change. In relation to these conditions, the government of India has taken several initiatives to control CO_2 emissions and achieve net zero carbon dioxide emissions by 2070. Starting from the Paris Agreement, the economy is following the Nationally Determined Contribution (NDC) with a special focus on reducing carbon intensity by 45% by 2030. The economy is creating numerous carbon sinks by increasing the forest and tree coverage by 2030 and also targeted an increase in the share of renewable energy sources to 40% of installed electric power capacity by 2030; all these initiatives will help India to control greenhouse gases and maintain the temperature increase below 1.5 °C (MoEFCC, 2022; Invest India, 2024). However, the Climate Action Tracker (CAT) has assessed that India's measures for managing the climatic issues are insufficient. Therefore, the Indian government has to take further active policy measures to meet its net zero emission targets and control the economy of five trillion by 2025 (PIB, 2018; Climate Action Tracker, 2024). However, the government of India has taken initiatives to achieve its dual goal of economic growth and environment sustainability. The Indian economy is the fastest-growing global economy and provides opportunities for global investors to invest in pooled investment funds, sustainability-linked bonds, and green financing investments (Invest India, 2024; Kaushik et al., 2024). India has attempted to minimize the trade-off between FDI inflows (in billion USD) and CO_2 emissions (in million kilotons) but has not succeeded. The general pattern of FDI inflows and the seriousness of CO_2 emissions in India are visible in Figure 1. In the figure, it is clear that the economy receives a positive amount of FDI inflows over time, ultimately contributing to higher industrialization, urbanization, and economic growth. At the same time, it can be seen that the level of CO_2 emissions in India is also increasing over time, which is a direct cost of economic growth and might be an indirect effect of foreign investment. Thus, minimizing the uncertain climatic events and maintaining a balance between foreign investment and India's sustainable environment is necessary.

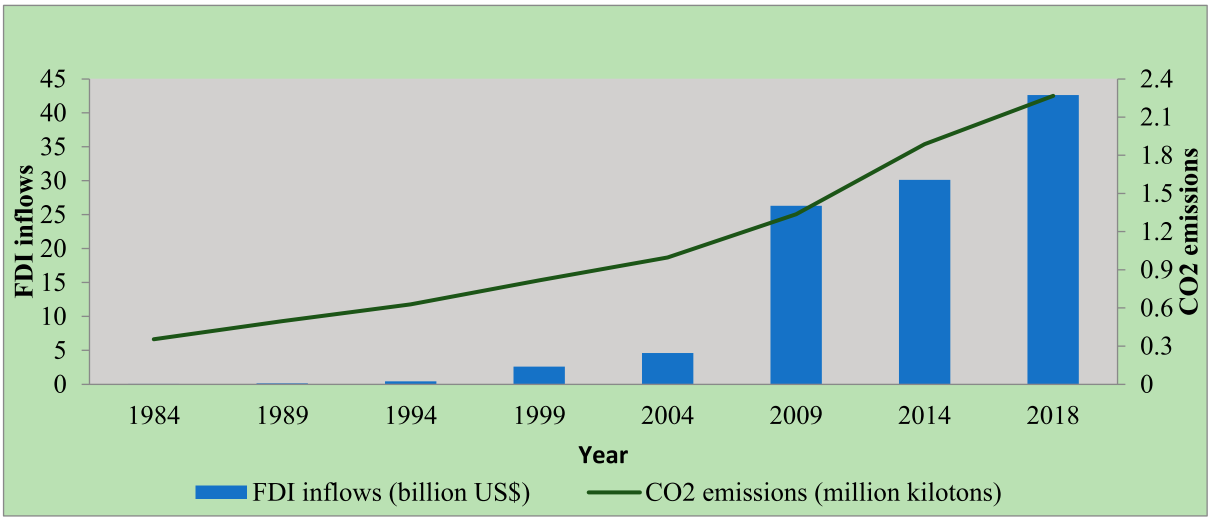

Figure 1. Trend of FDI inflows (in billion USD) and CO_2 emissions (in million kilotons) in India. Source: authors' compilation.

In this paper, the following two broad research questions are addressed: first, does FDI inflow directly impact CO_2 emissions? Second, does FDI inflow have any substantial indirect effect on CO_2 emissions? In this research, we seek to determine the relationship between FDI and CO_2 emissions and verify both the "pollution halo" and "pollution haven" hypotheses. To analyze the indirect effects of FDI inflows on CO_2 emissions, in this study, the three mediating channels of FDI are considered of the energy structure, industry structure, and high-carbon technology of the Indian economy. In this study, energy used is considered in terms of the kg of oil equivalent to measure the energy structure. The industrial structure accounts for the whole industrial value-added as a crucial measure of value. The proportion of fossil fuel usage relative to overall energy consumption significantly contributes to carbon dioxide emissions from high-carbon technologies. The novelty of our research is two-fold. First, the mediating influence of FDI on CO_2 emissions is investigated, which assesses the indirect nexus between these two variables. However, while measuring the mediating effects of FDI, in this study, the mediating factors are assumed to be independent. Second, along with cointegration and Granger causality technique, the SUR model is employed to measure all equations together in a simultaneous framework. The outcomes of this research will contribute to the existing literature in several respects. In this study, the unexplored dimensions of FDI and CO_2 emissions will be illustrated through the mediating effects. This research will be helpful for policymakers, researchers, and academia to contextualize the relationship between FDI and CO_2 emissions in many dimensions. First, this study will help policymakers understand the direct relationship between FDI and CO_2 emissions; this will help the host country decide whether foreign investment should be approved depending on its contribution to the environmental quality. Second, the findings of mediating effects can also guide the host countries in deciding which route of foreign investment should be encouraged to increase the GDP and enhance the environmental quality. Third, this study's outcomes can also provide a comprehensive framework to analyze the impact of FDI on the Indian economy's GDP, urbanization, and environmental quality. Thus, this research could assess the contribution of foreign direct investments in achieving the sustainable development goals with a special focus on low-carbon development in India. Finally, this study will help academia and researchers to understand the mediating effects using the simultaneous regression models.

The remainder of this work is structured as follows. Section 2 provides a comprehensive assessment of the current theoretical and empirical literature. Section 3 delineates the data, variables, and methods. Section 4 outlines the empirical findings and analysis. The final section presents the conclusion and policy implications.

2. Review of the Literature

In this section, a detailed insight is provided into the theoretical and empirical literature on the FDI–environmental quality association and the effects of the mediating factors of FDI on CO_2 emissions.

2.1. Theoretical Literature

The preliminary premise highlights that the EKC theory associates economic advancement with environmental degradation. This hypothesis, proposed by Grossman and Krueger (1991, 1995), empirically demonstrated the association between environmental degradation and the economy's expansion. The researchers explained the nexus to illustrate that in an initial phase of economic growth, the pollution rate escalates, resulting in an increased amount of environmental degradation up to a specific point. Then, the sources of economic development press for a reduction in pollution levels and represent the 'inverted U-shaped' EKC hypothesis. In contrast, many existing studies on EKC in the literature have also revealed no significant relationship between these two (Stern, 2004). The argument for this might be due to the usage of inappropriate and weak econometric approaches.

The theoretical EKC approach of Grossman and Krueger (1995) has proposed three channels to describe the influence of FDI regarding CO_2 emissions, including scale, composition, and technique effects. The scale effect underlines that FDI promotes industrial production and increases energy demand, increasing CO_2 emissions in the destination 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 that high production will lead to a higher level of environmental deterioration (Pazienza, 2019). However, some of the new studies in the literature have suggested that environmental destruction will reach a limit due to the economy's advancement (Luigi et al., 2021). Similarly, Shahbaz et al. (2018) explained the structural effect on the economy's structure with energy intensity. Additionally, studies have demonstrated the effect of composition and explained the changes in industrial design and how they affect free-market policy (Pazienza, 2019). In contrast, the existing findings have argued that the composition effect in a free trade economy can be either undesirable or encouraging, contingent upon the nation's competitive edge and productive specialization (Cole & Elliott, 2003). The technique effect is centered on the dissemination of newer machinery via FDI. This 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 locative efficiency, the countries will update their technology and adopt the development of more energy-efficient technology. The technique effect is considered environmentally beneficial for all (Shahbaz et al., 2018; Pazienza, 2019). However, in our analysis, our prime objective is to disseminate the impacts of these three mediating factors of FDI inflows on CO_2 emissions for India but not to concentrate on the EKC hypothesis.

From these three channels, the theoretical literature has been extended. If the scale and the composition effect outweigh the technique effect, this creates the pollution haven hypothesis. Suppose the technique and composition effect overcomes the scale effect, then, the pollution halo effect is created (Pazienza, 2019; Shahbaz et al., 2018). The PHH and the PHHH effect are the two main hypotheses used to describe the relationship amid FDI inflows and pollution. The PHH hypothesis, pioneered by Pethig (1976), argued that multinational corporations (MNCs) relocate pollution-intensive industries to less stringently environmentally regulated countries from more stringent environmentally regulated countries. Supporting the above argument, C. 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. However, the PHHH hypothesis demonstrates a positive connection between FDI and the quality of the environment as it provides higher economic growth and environmentally friendly and cutting-edge technologies, enhancing the environmental quality (Dinda, 2004; Zarsky, 1999). This strengthens the idea that Heil and Selden (2001) and Grimes and Kentor (2003) have proposed, that FDI originating from advanced countries comes with advanced and greener technologies, enhancing both economic prosperity and environmental quality.

2.2. Empirical Literature

This section on the empirical literature covers four elements in the existing literature. The first element in Section 2.2.1 covers the relationship between CO_2 emissions and FDI inflows; the link between CO_2 emissions and mediating factors is presented in Section 2.2.2. In the third sub-section under this heading, Section 2.2.3, the affiliation between FDI inflows and the mediating factors is explained. Section 2.2.4 narrates the association between CO_2 emissions and other control variables, such as economic growth and urbanization, followed in Section 2.2.5 with the research gap and hypothesis.

2.2.1. CO_2 Emissions and FDI

A notable segment of the empirical studies in this dimension has examined the correlation between FDI and environmental quality. Within the existing literature, a number of studies have supported the PHH, while others have supported the PHHH. In between, only a few studies have supported either, while others have mentioned no significant effect between these two. Employing the ARDL bounds testing and VECM Granger causality technique, Salahuddin et al. (2018) revealed that the economy's expansion, increased electricity use, and FDI in Kuwait caused CO_2 emissions. Similarly, Lee (2009) showed that FDI induced CO_2 emissions in Malaysia. Gokmenoglu and Taspinar (2016) noted a two-way affiliation between these two in Turkey. Further, the existing findings in the case of Ghana evidence and support the PHH hypothesis (Solarin et al., 2017). The study used the ARDL method from 1980 to 2012, revealing a beneficial and substantial association between FDI and CO_2 emissions. A. Q. Khan et al. (2018) discovered that the usage of energy, degree of openness, FDI, and socio-economic–political internationalization substantially and positively impacted CO_2 emissions in Pakistan. However, urbanization and economic expansion considerably and negatively impact CO_2 emissions.

Using dynamic panel regressions on selected developed and developing nations, Singhania and Saini (2021) mentioned that FDI inflows significantly impacted environmental quality and evidenced a pollution haven hypothesis. Similarly, using the STVR and the SUR models for China's macro-economy from 1980 to 2017, Pu et al. (2020) revealed natural catastrophes occurring with financial and large-industrial growth. Following the earlier study applying the SUR technique, Zangoei et al. (2021) established a substantial and progressive relationship between FDI and emissions in selected emerging countries. Y. Huang et al. (2022) highlighted a substantial and positive association between FDI inflows and CO_2 emissions in selected G20 countries. Supporting this, Sreenu (2024) highlighted that FDI inflows are associated with increased CO_2 emissions in BRICS countries. However, the recent research of V. Boamah et al. (2023) revealed that FDI inflows have a two-way effect on CO_2 emissions depending on the nature of the investment in selected South African countries. On the contrary, the findings of Ren et al. (2024) established a positive relationship between FDI inflows and environmental quality. Their study revealed that FDI inflows negatively affected CO_2 emissions in G7 countries. This implied that FDI into developed countries is more environmentally friendly and positively contributes to a sustainable environment. However, the study of M. Khan et al. (2023) argued that the relationship between FDI inflows and CO_2 emissions depends on the level of education. If the economies have a higher level of education after a certain threshold, FDI inflows can reduce CO_2 emissions. In the context of India, Acharyya (2009), applying a cointegration technique, revealed a substantial association between FDI and CO_2 emissions. In addition, Rana and Sharma (2019) identified the existence of the pollution haven hypothesis in India. Their study further highlighted that FDI inflows cause economic prosperity through CO_2 emissions. In *contrast to the preceding* findings, C. Zhang and Zhou (2016) demonstrated that FDI could reduce CO_2 emissions in China. Similarly, using panel data from 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. Additionally, using the simultaneous equation method, Ayamba et al. (2019) revealed that FDI and environmental quality had a good connection from 1995 to 2016 in China. In the paper, it was argued that FDI brings the advantages of advanced technology and green production.

Further, the concluding findings of a meta-analysis of FDI on environmental pollution highlighted that FDI inflows significantly reduce environmental quality degradation (Demena & Afesorgbor, 2020). However, Kathuria (2018) highlighted that FDI has no role in influencing the emission levels in India; instead, it helps to progress the environmental quality. However, a recent study of Rej et al. (2024) highlighted that the impact of FDI inflows on CO_2 emissions depends on the positive and negative shocks; while the positive shocks have increased the emission levels, the adverse shocks have had no significant contribution to the level of emissions in India. Similarly, using firm-level Indian manufacturing data, Bagchi and Sahu (2024) have suggested that foreign investment can improve the environmental quality in India. Substantially, using the information for selected OECD countries and BRICS countries, Apergis et al. (2023) highlighted that FDI inflows from developed countries to developing countries show a positive contribution to environmental quality. Contrary to this, the study of Kayani et al. (2024) highlighted that FDI adversely impacts carbon dioxide emissions and enhances renewable energy in BRICS economies along with technological advancement. Conversely, Ansari et al. (2019) did not identify any significant linkage between FDI and emissions for selected countries. Instead, their study confirmed that energy usage is the major cause of the high level of CO_2 emissions in those countries.

2.2.2. CO_2 Emissions, Energy Consumption, Industry, and Fossil Fuel Consumption

The existing empirical studies concerning CO_2 emissions and energy consumption are well-explored. Using various econometric techniques such as ARDL cointegration, VECM causal techniques, and Westerlund and Pedroni cointegration estimations, studies include those of Saboori et al. (2014) for OECD countries, Saboori and Sulaiman (2013) for ASEAN countries, Yousefi-Sahzabi et al. (2011) for Iran, and Mirza and Kanwal (2017) for Pakistan. These studies have mentioned that the variables are highly inter-related, and that energy usage is a substantial cause of pollution. Supporting these studies, Mohsin et al. (2022) highlighted that energy consumption significantly contributes to CO_2 emissions in selected European and Central Asian countries. However, Bunnag (2023) did not found any significant relationship between these two in the case of Thailand. Limited studies, such as

Tiwari (2011), have empirically verified this nexus in the Indian context and highlighted that energy usage has a favorable and substantial influence on emissions. In contrast, Ouyang and Lin (2015), using the LMDI, highlighted that the industrial sector in China made a substantial contribution to CO_2 emissions while energy intensity helped to reduce the level of CO_2 emissions.

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 the threshold regression model, ARDL, VECM models, and non-linear ARDL cointegration techniques, Liu et al. (2016) for China demonstrated a favorable and considerable association between industrialization and CO_2 emissions. These studies have argued that with the 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 in a selection of 73 countries revealed that industrialization causes CO_2 emissions (Li & Lin, 2015). Supporting these, Parikh et al. (2009) showed a constructive and noteworthy connection between industrialization and CO_2 emissions. Further, the electricity sector is responsible for India's CO_2 emissions level. However, Dong et al. (2020) have argued that industrialization reduces CO_2 emissions through upgrading industrial units with advanced technology and new mechanisms. Thus, industrial structures can contribute to carbon mitigation and sustainable development.

Studies have also discovered the empirical connection between the usage of fossil fuels and CO_2 emissions. Using the ARDL test for fifteen developing Asian countries, the empirical result of Hanif et al.'s (2019) paper demonstrated that such consumption causes higher emissions. Supporting these with the help of the ARDL-bound testing technique in Pakistan, they evidenced a long-term link between economic prosperity, usage of fossil fuels, FDI inflows, and CO_2 emissions. They revealed that fossil fuels, FDI, and the development of an economy cause CO_2 emissions. In contrast, employing the Toda–Yamamoto estimation technique for Iran, Lotfalipour et al. (2010) demonstrated that although GDP and energy consumption cause carbon emissions, fossil fuel consumption had no leading role in influencing the emission level.

2.2.3. 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, increasing production in the host country and raising energy consumption. Second, it might expand the production capacity with efficient energy use and enable efficient production technologies. It helps the production units' transit from dirty or relatively polluted companies to green energy structures. The earlier impact of FDI on energy consumption is well explained as the scale effect. Still, the latter signifies its reverse and implies the composition and technical impact during the production (Zhu et al., 2016). Similarly, many empirical studies with different econometric techniques like the Fourier ADL and ARDL test and the VECM Granger technique, Leitao (2015) in Portugal, Uzar and Eyuboglu (2019) in Turkey, Mavikela and Khobai (2018) in Argentina discovered that FDI provides an encouraging and substantial basis for the higher level of usage of energy. Energy-intensive investors' investments have shifted from more developed and environmentally stringent countries to less-regulated developing countries. In addition, Saint and Ajmi (2020) supported the existing findings and highlighted that FDI has a favorable and considerable impact on increasing energy consumption for 23 sub-Saharan Africa (SSA) countries. In contrast, Nepal et al. (2021), in the case of India, revealed a harmful link and mentioned that FDI had the significant potential to improve environmental quality by inducing energy efficiency. However, Sadorsky (2010) and Hubler and Keller (2010) highlighted that FDI does not significantly affect energy consumption in developing economies. A recent study of Irfan and Ojha (2023) analyzed how FDI inflows help diversify the energy structure in several countries.

Similarly, using data from 12 franc zone and 11 non-franc zone African countries, Ngouhouo and Ewane (2020) concluded that FDI has a major and beneficial impact on industrial progress within the franc zone. However, the results become undesirable in the non-franc zone. In addition, by applying various cointegration and causality techniques, Adejumo (2020) for Nigeria, and Dash and Parida (2013) for India demonstrated a significant link between FDI and industrialization. The argument represented that foreign direct investment inflows significantly upgrade industrialization and boost the economy's investment and development. A recent work of Ali et al. (2024) demonstrated that FDI inflows positively contribute to industrialization, and industrialization and foreign investment have an adverse impact on CO_2 emissions. In addition, Zangoei et al. (2021) explained that although countries have tried to find an alternative fuel source to moderate the dependency on fossil energy consumption, fossil fuels are a significant component in attracting FDI with environmental deterioration. Nevertheless, shifting the energy structure away from polluted fossil fuels to green sources remains difficult.

2.2.4. CO_2 Emissions, Economic Growth, and Urbanization

By employing the ARDL and Toda–Yamamoto test, Nkengfack and Fotio (2019) revealed a progressive and substantial energy and economic expansion impact on CO_2 emissions for Algeria, South Africa, and Egypt. Similarly, Jalil and Mahmud (2009) described that economic prosperity causes carbon dioxide emissions in the case of China. In supporting these, a systematic survey by Mardani et al. (2019) also revealed that economic growth has a substantial effect on CO_2 emission levels. However, Mosikari and Eita (2020) have indicated that economic prosperity in selected African economies favorably influences emissions at the early stages until a specific duration. Then, pollution can be controlled with high economic growth (Brahmi & Zouari, 2014). Their paper concluded that the urban population significantly contributes to improving environmental quality. In the recent study of Q. Wang et al. (2023), it was highlighted that the GDP per capita has a significant impact on FDI and CO_2 emissions. Similarly, using Panel ARDL models, Sikder et al. (2022) highlighted that GDP growth is associated with high levels of CO_2 emissions in selected developing countries. Similarly, the findings of Suhrab et al. (2023) stated that GDP makes a positive contribution to emissions. In the Indian context, using econometric techniques like the dynamic multivariate Toda–Yamamoto (TY) technique, ARDL, and VECM causality techniques, Rana and Sharma (2019) supported such a relationship in India.

Many empirical studies have scrutinized the linkages between urbanization and CO_2 emissions (Mohsen et al., 2023). Using various empirical techniques like ARDL, the VECM Granger causality technique, and the FMOLS technique, Al-Mulali and Ozturk (2015) in Europe demonstrated that urbanization is a significant factor in such emissions. Additionally, Franco et al. (2017) showed that urbanization has a greater significance in enhancing the standard of life while fostering economic expansion and significantly affecting the emission levels in India. In addition, Mahmood et al. (2020) supported the empirical results of this nexus for Saudi Arabia. Their paper demonstrated that urbanization positively and significantly contributes to CO_2 emissions. Using the Toda–Yamamoto non-causality methods, Salahuddin et al. (2019) highlighted a bidirectional association amid urbanization and emissions in South Africa. Similarly, using spatial econometric models, G. Zhang et al. (2018) demonstrated that population urbanization has a positive and large spillover effect on pollution in China. In addition, Sikder et al. (2022) showed that high-level CO_2 emissions contribute more to urbanization in selected developing countries (Mohsen et al., 2014). In addition, Suhrab et al. (2023) highlighted that urbanization positively affects CO_2 emissions. On the other hand, Y. Tang et al. (2022) demonstrated a U-shaped relationship between the level of emissions and the degree of urbanization in China. On the contrary, Shahbaz et al. (2016) mentioned that urbanization significantly caused CO_2 emissions and addressed a U-shaped association between urbanization and pollution in Malaysia. However, Singh et al. (2024) highlighted that urbanization has significantly reduced the level of carbon dioxide emissions in India but remains positive in the case of South Africa.

2.2.5. Research Gap and Hypotheses

Though there exists an extensive corpus of writing relating to the PHH and the PHHH hypothesis for the rest of the globe, there are only a few studies on India where the results are mixed and unclear. India is a growing economy, the largest FDI receiver, and is one of the world's highest emitting countries. To achieve a sustained equilibrium between FDI inflows and India's CO_2 emissions, the country must prioritize globalization and increase sustainable energy consumption and industrialization. Therefore, the issue requires further investigation. Though the existing studies mostly measure the direct nexus between FDI inflows and CO_2 emissions, there are fewer studies focusing on the indirect effects of FDI inflows[2]. It is further identified that hardly any existing study has attempted to determine the indirect impact of FDI on CO_2 emissions, considering its mediating channels. Thus, it is essential to also measure their indirect nexus. Though several studies have examined the association between CO_2 emissions, industrialization, energy usage, and fossil fuel consumption, hardly any studies have attempted to find the impact of high-carbon technology based on fossil fuels as the mediating factors of FDI inflows on carbon dioxide emissions in India. In this study, the indirect effect of FDI inflows on CO_2 emissions is considered through three mediating channels to minimize this gap. In this study, the following four hypotheses are presented:

H_1: *There exists a substantial association between FDI inflows and CO_2 emissions.*

H_2: *FDI inflows, energy structure, industrial structure, and carbon technologies are all linked in some way.*

H_3: *Energy structure, industrial structure, and carbon technologies significantly affect carbon dioxide emissions.*

H_4: *Inflows of FDI have a large mediating effect on CO_2 emissions.*

3. Empirical Framework

The data and variables are described in this section. It presents the methodology to demonstrate its relevance to the econometric methods of unit root test, cointegration test, the Granger causality technique, and the unrelated regression estimate to verify the abovementioned hypotheses.

3.1. Data and Variables

In this study, India's year-wise data are employed from 1980 to 2014. The sample duration is limited to 1980–2014 for two reasons. First, in 1980, India started its initial liberalization before 1990 (Panagariya, 2008). Second, the maximum limit is constrained up to 2014, depending upon the availability of CO_2 emission data in the World Bank data source. To maintain the consistency of all variables, data were collected from the World Development Indicators (WDIs) released by the World Bank. The primary dependent variable in our study is CO_2 emissions. CO_2 emissions are the commonly used indicator among other components to analyze the degree of environmental deterioration due to the long data availability period. Following Bakhsh et al. (2017), in this study, carbon dioxide emissions are considered as a significant dependent variable inour empirical analysis. The primary explanatory variable in our study is FDI inflows. Following Salahuddin et al. (2018),we measure FDI inflows as a portion of GDP in this estimation. The three important mediating variables are the energy structure (Wada et al., 2020), the industrial structure (Mahmood et al., 2020), and the high-carbon technology structure (Ali et al., 2024). The energy structure is represented in terms of energy usage. The industrial structure is represented as a proxy, and the industrial value is added to this study. Following Ali et al. (2024), our research uses fossil fuel consumption as a proxy to measure high-carbon technology.

To ensure our regression estimation results are free from a variable omission or are not affected by other unobservable factors, in our paper, two commonly influential factors of CO_2 emission are controlled, namely economic growth and urbanization (Rustemoglu & Andres, 2016; Mahmood et al., 2020). Similarly, the country's growth is considered with the GDP per capita and signifies the consequence of economic expansion on CO_2 emissions. Simultaneously, the economy's urban structure is a proxy of the growth in the urban population. During the estimation, all data are turned into the natural logarithm. In this paper, the CO_2 and FDI show the natural logarithm of carbon dioxide emissions and FDI inflows in their natural logarithmic form, respectively. ES indicates the natural logarithm of the energy structure of the economy, IS indicates the natural log of the industrial structure, and HCT shows the natural log of the high-carbon technology structure. The natural logarithm of gross domestic development (economic development) is captured through GDP, and URBAN shows the natural logarithm of the degree of urbanization in this paper. Table 1 lists all variables' measurements, definitions, 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 USD 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 USD)	WDI, WB	+/−
HCT	High carbon technology	Fossil fuel energy consumption (% of total energy)	WDI, WB	+/−
GDP	GDP per capita	GDP per capita (Constant 2010 USD)	WDI, WB	+/−
URBAN	Urban structure	The urban population (% of the total population) growth	WDI, WB	+/−

Note: '+' sign and '−' signs indicate positive and negative effects, respectively; the sign (+/−) means that impacts may be positive or negative. Source: authors' contribution.

3.2. Methodology

In this section, the unit root test, cointegration test, causality test, and seemingly unrelated regression equations are included. The unit root test is the first measure to ensure it is stationary before any time-series estimation. The previous research concentrated on the interaction between FDI and CO_2 emissions at the aggregate level, such as at the single country or cross-country level, to verify the equilibrium and causality (Singhania

& Saini, 2021; Nguyen et al., 2021) and it has been mentioned that detecting cointegration is the first step. After ascertaining the equilibrium or cointegration relationship, the second phase entails deciding on appropriate Granger causality (Pu et al., 2020). For the Granger causality technique, two strands of tests are available. The first aspect changes the test statistics but still does not distribute. It contains Toda and Yamamoto's (1995) and Dolado and Lütkepohl's (1996) modified Granger causality test, a simple method for calculating a Wald statistic by adding VAR delays to the conventional asymptotic distribution. Consequently, the following segment alters the distribution rather than the statistics. In the present study, the Granger causality technique is applied to survey the preliminary causal link age involving FDI and CO_2 emissions. Finally, in this study, the seemingly unrelated regressions (SURs) are applied considering the bootstrap causality and measure the bootstrap samples' structure.

3.2.1. Unit Root Test

To determine if the time series included in this investigation is stationary, it is prudent to per forma stationary test. In this work, the augmented Dickey–Fuller (ADF) test (1981) and the Phillips–Perron (PP) test (1988) are used to ascertain the stationary features of this research. The ADF test screens for unit roots while allowing residual correlation. Simultaneously, the ADF test addresses more intricate models compared to the Dickey–Fuller test (1979). The investigation incorporates intercept (α) and trend (T) with a lag order of one to identify the unit root issue. The ADF test is predicated on the subsequent equation, as follows:

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

where Δ denotes a 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 serial correlation. However, the complexity lies in the ADF test as it is prone to produce a high rate of type-1 error if not managed carefully (Naz et al., 2019). We employed the PP test and managed the type-1 error to maintain the protection from this ADF limitation. Utilizing the ADF methodology, Phillips and Perron (1988) introduced a unit root test that addresses the issues of heteroscedasticity and serial correlation. In addition, to remove the serial correlation, it provides rank to the residuals, and the equation of the PP test is as follows:

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

The null assumption is dismissed in this instance, indicating that the series is stationary. In this study, automatic lag length selection is utilized in the residuals through the Akaike Information Criterion (AIC).

3.2.2. Cointegration Test

Cointegration is a time-series econometric feature and a prerequisite for any long-term equilibrium relationship among various factors, and in this study, the Johansen cointegration technique of Engle and Granger (1987) is used to assess the long-run link amid FDI inflows and CO_2 emissions. The Johansen (1988) cointegration test will be used in our research to check the collaborative flow between these two variables. This method provides the two tests of trace (J_{Trace}) and max-Eigen value (J_{Max}). The trace and the max-Eigen statistical values are used (Johansen, 1988; Johansen & Juselius, 1990). The max-Eigen statistical value test is preferred (K. B. Boamah et al., 2018). The reason is that the max-Eigen test has greater power than the trace-Eigen test (Johansen & Juselius, 1990).

Two statistical values of the Johansen cointegration test can be represented mathematically by Equations (3) and (4), as follows:

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

$$J_{Max}(K+1) = -Tln(1-\lambda_{K+1}) \tag{4}$$

Here, K is the cointegrating vector, while T represents the sample size. The jth most significant canonical correlation is presented in λ_j. The criterion for rejecting the null hypothesis is based on asymptotic critical values at a 5% significance level, mostly accessible through econometric software tools.

3.2.3. Granger Causality

Verifying the enduring relationship link between CO_2 emissions and FDI inflows does not end once the research has confirmed it. The long-term relationship between variables is inadequate for a definitive judgment regarding two-time series (Granger, 1969). Thus, our objective's next logical step is to check for any causal connection between these two variables when the time series is cointegrated (Rahman & Kashem, 2017). In this study, the Granger (1969) framework is followed to examine this nexus. Following Wen and Dai (2020), we used the Granger causality technique between our variables in an enhanced VAR framework. Granger causality provides the opportunity intended for both unidirectional and bi-directional causality. However, our prime motive is to check whether FDI inflows cause CO_2 emissions in India.

3.2.4. SUR Regression

In this research, the impacts are examined of the mediator variables of FDI inflows on CO_2 emission. For simplicity, in this study, a single-step multiple mediator model is followed for the analysis of the internal mechanism of FDI inflows affecting India's carbon emission levels. One approach to measuring such an effect is the apparently unrelated regression equations.

The SUR method is a multivariate regression technique. According to Zellner (1962), SUR is helpful when several equations seem irrelevant, but a secret and significant relationship exists between them. 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). However, Bartels et al. (1996) applied the SUR technique to cross-section units such as household expenditure on gas and electricity. Further, Fernández 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, seasonal, and cycles, known as structural time-series models. This model is widely used in time-series analysis (Engle, 1978; Gersch & Kitagawa, 1983; Harvey & Durbin, 1986). In these studies, the unobserved components in each time series are permitted to be contemporaneously associated with each other to quantify them in multivariate structural models. Extending further, Pu et al. (2020) have addressed that the SUR is favorable for estimating a model when the time-series data have[3] fewer variables, and there is a correlation between the error terms of the dependent variables (M. A. Khan et al., 2014). The SUR model is a set of FGLS, considered either a simplified version of the general linear model or a generalization of the simultaneous equation regressions.

Thus, this model helps measure the equations' jointers and the associated covariance. The empirical analysis accounts for the following model specifications:

$$CO_{2,t} = \alpha + cFDI_t + u_t \quad (5)$$

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

$$CO_{2,t} = \gamma + c' lnX_t + \sum_{i=1}^{3} b_i M_{i,t} + u\prime_t \quad (7)$$

where α, β_i, γ are the intercepts; u, u_i and u' are residual errors, and time is denoted as t; FDI_t is the independent factorand implies FDI inflows; the dependent variable is presented in $CO_{2,\ t}$ and shows the CO_2 emissions; M_i comprises the mediator variables where M_1 is the 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 effect of FDI inflows; a_i is the effect of FDI inflows on M_i; b_i is the effect of M_i of CO_2 emissions, after controlling the influence of X; $a_i b_i$ is the specific indirect effect of FDI inflows on CO_2 emissions via M_i. The direct effect of FDI inflows on emissions after controlling the mediators is presented with c' and $\sum_{i=1}^{3} b_i M_i$ is the total mediation effect.

4. Empirical Results and Discussion

4.1. Summary Statistics

The summary statistics are presented in the original form of the variables in Table 2. This empirical analysis is based on 35 observations. The average value of carbon dioxide emissions is about 1.136 units, while their maximum value is about 1.292 units, the lowest value is 1.010 units, and the standard deviation (SD) is 0.089 units. The average amount of FDI is 0.800, and the SD is 0.889. Its maximum value is about 3.620 units; the lowest score is 0.002. The average energy structure, industrial structure, and high-carbon technology score are 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 highest and lowest values of the energy structure lie between 636.570 and 286.164. The industrial structure has the highest and lowest values of 611.834 and 77.641, respectively. Similarly, the higher value of HCT is 73.576, and the lowest value stands at 39.383. The average GDP is 833.321, the SD is 356.818, the upper value is 1640.181, and the lowest is 422.904. URBAN's average size and SD values are 2.839 and 0.369, respectively. At the same time, the highest and lowest values of URBAN are 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.

4.2. Correlation Results

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

The correlation and covariance results for the FDI inflows and mediating factors are reported in Table 3. This indicates that FDI negatively correlates with CO_2 emissions; however, its *p*-values indicate that it is insignificant in affecting CO_2 emissions. The three mediating factors of FDI have also shown a negative association with the dependent variable, where all variables remain significant at a 5% significance level except high-carbon technology. GDP per capita has shown an adverse association with carbon dioxide emissions and remains substantial at a 1% significance level. The urban factor positively correlates with the dependent variable but is insignificant. Based on the findings, it is worth noting that there is a substantial beneficial link between FDI inflows and ES, FDI inflows and IS, and FDI inflows and HCT. Table 3 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 results noted that IS and HCT have a beneficial and substantial correlation. Similarly, the correlation findings also highlighted that three mediating factors are positively and significantly associated with GDP but possess a negative but significant association with urbanization. The correlation between GDP and URBAN has shown a negative and significant association. It 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.

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 the significant level at 5% and 1% significance levels, respectively.

4.3. Unit Root Results

The ADF and PP unit root test results with intercept and trend and 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 the variables are stationary at a level with intercept and trend. However, the PP test also reveals that some are non-stationary at levels with intercept except HCT. The PP test shows that 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, in both test cases, all variables become stationary in their first difference with intercept and trend.

Table 4. ADF and PPunit 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 parentheses.

The ADF and PP unit root test findings give a stable conclusion of the stationary level at the first difference, allowing the cointegration analysis to be conducted in this study.

4.4. Cointegration Test Result

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

The cointegration test outcomes for CO_2 emissions and FDI inflows reveal a fairly long cointegration link between these variables in India's case. This outcome is in line with the expectations for India of Salahuddin et al. (2018), C. F. Tang and Tan (2015), and Acharyya (2009). This implies that the long-term FDI inflows can affect the level of CO_2 emissions either positively or negatively in India. Thus, policymakers need to understand the causal direction of FDI inflows toward emissions while establishing a regulatory framework to assess FDI approval in India.

Table 5. Cointegration test results.

Test Form (c, t, p)	Statistics Value	5% Critical Value	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)	Eigenvalue	Hypothesized No. of CE (s)
			Trace Statistics			
(1, 0, 1)	15.791 **	15.494	h = 0	h ≠ 0	0.303	None
(1, 1, 1)	27.156 **	25.872	h = 0	h ≠ 0	0.502	None
(0, 0, 1)	21.538 ***	12.321	h = 0	h ≠ 0	0.391	None
			Max-Eigen statistic			
(1, 0, 1)	4.608 **	3.841	h = 0	h ≠ 0	0.138	At most 1
(1, 1, 1)	20.229 **	19.387	h = 0	h ≠ 0	0.213	None
(0, 0, 1)	6.126 ***	11.224	h = 0	h ≠ 0	0.392	None

Note: 'h' represents the cointegration rank; '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"; ***, ** indicates 1% and 5% significance level, respectively. Source: authors' calculation.

4.5. Granger Causality Test Result

Once the cointegration results are obtained, this investigation must examine the causal relationship between FDI inflows and CO_2 emissions. Thus, the next step of our paper is to examine whether FDI inflows cause carbon emissions in India. Our estimation applies the Granger (1969) causality test to explore this relationship for this study's variables.

Table 6 shows that in two cases, i.e., lag one and lag two, our results show that FDI inflows positively cause CO_2 emissions. This implies that one unit change in FDI demonstrated a 3.47 unit change in CO_2 emission at the first lag and a 2.553 unit change at the second lag. In other words, FDI has a favorable and consistent effect on CO_2 emission levels in the sample country. This result is consistent with Salahuddin et al. (2018), Acharyya (2009), and Lee (2009) and supports the PHH. These results mean that FDI also influences the increasing carbon dioxide emission levels. Thus, it is important to understand its importance on foreign investment policies for those coming on the direct route. As the findings support that the current FDI inflows are increasing without environmental safeguards, it is high time for the economy to screen the FDI mechanism and assess its contribution to environmental quality through different mediating channels.

Table 6. Granger causality test results.

Lag Order	F Statistics	*p*-Values	No. of Observations
1	3.47 *	0.072	34
2	2.553 *	0.095	33
3	2.155	0.118	32
4	1.296	0.302	31
5	1.076	0.404	30

Source: authors' estimation. Note: * presents significant results at a 10% significance level.

4.6. SUR Regression Result

This calculation will examine how FDI inflows affect carbon dioxide emissions with different mediating factors. In this research, the SUR method is followed to verify the multiple effects of FDI inflows. Table 7 displays the OLS findings and the results of the SUR model. Model 1 gives the OLS model estimation. Models 2–4 provide 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 results.

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: the parenthesis values are the robust standard errors. ***, **, and * present the significance level at 1%, 5%, and 10%, respectively.

In Table 7, model 1 shows that the total effect on the carbon emission levels is beneficial and consistent. The OLS measurement of FDI demonstrates a0.014 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 result is consistent with Shahbaz et al. (2018) for France. This outcome aligns with Acharyya's (2009) previous findings and imply the existence of the PHH hypothesis in India's case. The empirical results demonstrate that one unit change in economic development offers a significant negative effect of −0.398 units on CO_2 emissions. This finding supports the recent literature (Z. Wang et al., 2018). 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). This implies that urbanization can improve the quality of the environment 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, in our study, the SUR estimators are employed.

The SUR technique simultaneously provides the results for four models (models 2–5) in Table 7. Model 2 demonstrates coefficient a_1, i.e., the direct impact of FDI on energy structure is 0.107 at the 1% significance level. Similarly, 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 consistent with Saboori et al. (2014) and A. Q. Khan et al. (2018). This implies that energy consumption has significantly pushed the emissions line upward. Since a_1 and b_1 are substantial, the indirect effect through the energy structure is crucial, $a_1b_1 = 0.092$. This implies that FDI inflows use higher energy in terms of kg of oil use. It can be assumed that this might burden India's transportation sector heavily[4]. This highly energy-intensive sector 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 with renewable energy or less intensive resources. It needs high investment in energy-consuming sectors and demands serious action to build an unfavorable connection between energy resources and environmental quality through FDI. This is possible with the advancement of adaptive, less energy-intensive technologies.

Similarly, model 3 represents the coefficient $a_{2,}$ which is 0.315, where a_2 presents the direct effect and shows that FDI makesan important contribution to increasing the industrial structure by increasing the production value. This result supports the earlier findings of Adejumo (2020), Dash and Parida (2013), and Gui-Diby and Renard (2015), which emphasized the direct and upward relationship between FDI inflows and industrial development. In other words, these papers claimed that FDI boosts industrialization and modernizes the economy with new investment and growth. Similarly, model 5 shows that the coefficient of b_2 is significant and has a negative value (−0.716), which indicates that CO_2 emissions have been adversely affected by the industrial structure. These findings are supported by Lin et al. (2017). This indicates that with environmentally 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 positively influences 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 the third mediating factor (high-carbon technology) coefficient values is 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 in the inflow of FDI would be beneficial. This implies that an increase in FDI inflows significantly affects the promotion of high-carbon technology. This result is consistent with the earlier empirical findings of Zangoei et al. (2021). This demonstrates that developing countries use more fossil fuel energy to generate economic growth from foreign investment.

At the same time, the mediating factor coefficient value b_3 is 1.250 and remains significant at a 1% level. The interpretation indicates that the rise in consumption of fossil resources (Brahmi & Luigi, 2022) as a percentage of total energy can significantly increase India's carbon emission levels. This finding follows Mert and Bölük (2016) and Ahmad et al. (2016). The findings in these studies revealed that economic development, fossil fuel, and CO_2 emissions have a positive and strong correlation. Thus, the high-carbon technology indirect impact is substantial, where $a_3b_3 = 0.110$. From this result, it can be inferred that India's FDI inflows favorably influence fossil fuel consumption and the adoption of high-carbon technology. Thus, investment through FDI in fossil fuel-intensive units generates rising carbon emissions in India. These results can be verified with the previous findings of Pao and Tsai (2011), who suggested that nations with fossil energy-oriented FDI inflows should shift their paradigm to more eco-friendly investments 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 influence of FDI inflows on CO_2 emissions, $c' = 0.014$ in model 5. This indicates that in addition to the three mediating variables, other factors may impact this mechanism, where FDI can influence India's carbon dioxide emission levels.

Table 8 presents the mediating factors that significantly affect carbon emission levels. The bootstrap test results show that the individual and the combined indirect impact of FDI inflows on CO_2 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 levels. However, the combined mediating effect shows an undesirable consequence of FDI inflows on CO_2 emissions. This suggests that FDI inflows in India are not directly deteriorating the environmental quality offered as the OLS estimators in model 1. Instead, different mediating channels help to improve the environmental quality. This finding is in keeping with Kong's (2021) past research. This implies a positive and sustainable economy with high FDI inflows and improved environmental quality.

Table 8. Bootstrap test results.

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.

Finally, the findings demonstrate that the total mediation effect of FDI inflows is significant and accounts for the overall proportion of 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 diagram (see Figure 2).

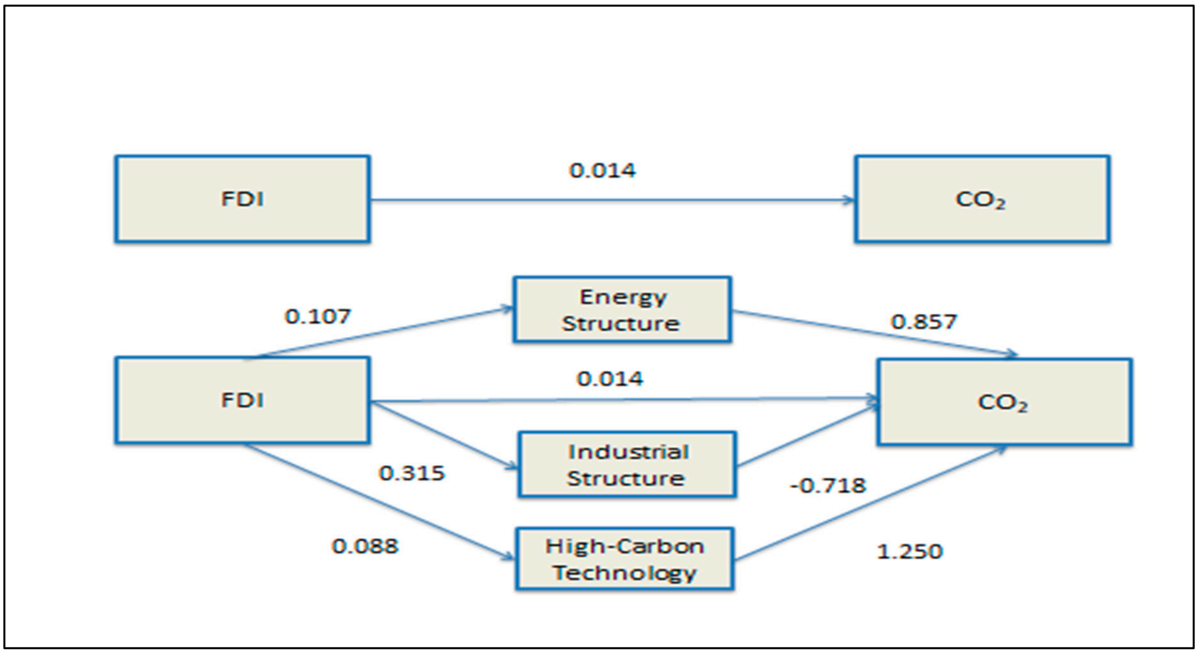

Figure 2. The direct and indirect effect of FDI inflows on CO_2 emissions. Source: authors' calculation.

This figure (Figure 2) provides the flow directions of FDI inflows influencing CO_2 emissions directly and indirectly. The OLS regression findings are shown in the first part, and the impact on carbon emissions is also presented. Throughout the second part, the figure provides 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, in this study, an indirect effect of FDI inflows on CO_2 emissions is highlighted after verifying its cointegration and unidirectional causal relationship from foreign direct investment inflows to carbon dioxide emissions in India. The novelty of this study lies in its investigation of the mediating effects of FDI inflows on emissions. With the apparently unrelated regression application, our study enables us to find the relationship between FDI and CO_2 emissions, energy structure, industrial structure, fossil fuel consumption, and the effect of these three mediating channels of FDI on CO_2 emissions. The findings also demonstrate that the two control variables in the first model are negative and significant. This implies that economic growth and urbanization have reached a threshold, and environmental awareness and energy-efficient technology have helped to reduce CO_2 emissions. This result follows those of Z. Wang et al. (2018) and Yao et al. (2018). These findings have several theoretical and practical implications concerning future studies and policy suggestions and are further elucidated in the next section.

5. Conclusions and Policy Implication

In this paper, research is covered on FDI inflows and environmental quality in India. The analysis focused on the FDI inflow's direct and indirect impact on CO_2 emissions in the presence of three mediating channels. In this research, extensive time-series data are accounted for over a 35-year period. In this study, the ADF and the PP unit root test, the Johansen cointegration test, the Granger causality test, and the SUR method are used for the 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 employed the Johansen cointegration test, which shows that these two have a long-term association. Then, this research applied the Granger causality and evidenced a one-way causation from FDI to CO_2 emissions. In this study, the effect is estimated using the SUR technique to examine the mediating effects of FDI inflows. As per the SUR estimates, the mediating effect of FDI inflows on India's carbon dioxide emissions is greater than the direct impact. The findings also show that foreign investors who invest through FDI in India are highly energy-intensive and consume significant amounts of oil. At the same time, our results evidenced that foreign investment in India is significantly fossil fuel-intensive and produces more carbon emissions with high-carbon technologies. This result supports the pollution haven theory in 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, the impact of FDI inflows on CO_2 emissions depends on redistributing investments across the structures. Thus, in this study, several theoretical and practical implications are identified that can be used as a road map for researchers, industrial agents, policymakers, and government.

In this paper, the debate is highlighted between the "pollution haven" and "pollution halo" effects by synthesizing the question of determining whether FDI inflows are favorable or unfavorable for the quality of the environment. From the cointegration findings, it is suggested that as FDI inflows and CO_2 emissions have long-term associations in India, policymakers must prepare a regulatory framework that simultaneously considers both the environmental impact and the FDI project approval decisions. Then, the policymakers should consider the unidirectional causation of FDI inflows to CO_2 emissions. In this situation, the government and the policymakers should encourage the "green FDI" and investors to switch to advanced environmentally friendly technologies and practices with a high potential for reducing CO_2 emissions in India. The findings of this estimation control the mediating effects and explain that part of FDI inflows is invested in the energy-intensive and fossil fuel sectors. This further contributes to emissions and might provide polluting industries with a less environmentally friendly approach for investing in India. This indicates a 'capital flight' of polluted units from a highly regulated and high-production cost economy to India. However, the results also revealed that FDI in industrial sectors significantly boosts the industrial outcome. At the same time, the SUR estimates revealed that investment in the industrial sector is energy-efficient (Esposito et al., 2023) and helps control emissions. It is further noted that the net SUR bootstrap result shows that FDI inflows create a "pollution halo" in India after comprising the adverse effect of FDI inflows on the environment. Therefore, our findings suggest that studies should control the heterogeneous consequences of FDI inflows and its adverse outcomes on the sustainable environment. In this paper, some practical implications are also suggested for the industrial units. As FDI inflows in the industrial sector help to create 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 priorities, the Indian government and reputed industrial CEOs should encourage programs like "Mission Innovation (MI)" to formulate a new and more "transformative innovation policy (TIP)", as mentioned by Carayannis et al. (2022) in the case of the US in 2015. This program aims to make clean energy accessible and generate more sustainable jobs and investment opportunities for enterprises.

A concrete policy implication of this study is explained in the following section. Being the most prominent global growing country, India needs more foreign investment to grow and develop faster. Thus, similar to Singhania and Saini (2021), our research suggests that government intervention with clear environmental disclosures by establishing stringent regulations is essential for reducing the direct volume of carbon emissions and GHG levels. Therefore, to achieve 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, a promotion of all measures may be encouraged at the macro and micro levels, with tax exemptions for cleaner units. Like Zhu et al. (2016), our research suggests that 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 more carbon dioxide. At the same time, MNCs should follow a strict disclosure index on environmental quality within the host country (Esposito & Brahmi, 2023). This will pressure domestic units to improve their environmental quality and stay more competitive in the world market (RobecoSAM, 2019). Simultaneously, as India is a renewable energy source, it may encourage production units to invest more in using solar, wind, and bio-fuel energy instead of fossil fuels. 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.

The implications of the results have a broader scope for future research. Firstly, research can be undertaken for other countries or at the country level, considering this set of macroeconomic variables. Secondly, studies should investigate other mediating channels of FDI inflows while considering their environmental effects. Next, this study can be extended to verify such nexus at a more disaggregate level such as regional or districts, industries, or firm levels. Finally, the future research can encourage case studies for specific industries to change their competitiveness and competency. Therefore, this research will help researchers and policymakers choose where to invest in FDI inflows and generate more benefits with a good environmental quality.

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Notes

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

2 The three mediating channels of FDI inflows are energy structure, industry structure, and high-carbon technology of the Indian economy.

3 The VIF values support the existence of multicollinearity in some cases (particularly in the case of high-carbon technology, and FDI, GDP, and urbanization with the mediating channels). However, it is essential to note that multicollinearity does not impact the cointegration results, as the cointegration and Granger causality estimations take the lag and differentiated values into account and not analyzed at the levels (Engle, 1978; Gujarati & Porter, 2009), so multicollinearity is less likely to pose any significant issues. Moreover, using the SUR method also helps to control such issues, provides robust estimates, and mitigates the potential influence of multicollinearity on the estimates (Fiebig, 2001). In addition, the Breusch–Pagan/Cook–Weisberg testing of our samples showno heteroscedasticity issues with an insignificant chi-square distribution (chi-square = 0.02 and p-value = 0.8869). The Breusch–Godfrey LM test confirmed that there is 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)–(7).

4 The high dependency on the oil market means the Indian economy is also highly volatile with respect to crude oil prices, that plays a significant role in its macro-economic policies relating to the inflation rate, trade deficit, and overall stability of economic growth (Das, 2023). Therefore, it is essential for India to diversify its investments (domestic and foreign)with alternative energy sources to achieve stable and sustainable economic prosperity.

References

Acharyya, J. (2009). FDI, growth and the environment: Evidence from India on CO_2 emission during the last two decades. *Journal of Economic Development*, *34*, 43–58. [CrossRef]

Adejumo, A. V. (2020). Foreign direct investment-led industrialization: Any direction for spillovers in Nigeria? *Journal of Co-Operative and Business Studies*, *5*, 839–861. [CrossRef]

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption, and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy*, *96*, 131–143. [CrossRef]

Ali, M., Awe, E. O., Mohammed, S., & Isah, K. (2024). Industrialization, fdi inflow and climate change in Africa: A scenario analysis. *Chinese Journal of Urban and Environmental Studies*, *12*, 2450003. [CrossRef]

Al-Mulali, U., & Ozturk, I. (2015). The effect of energy consumption, urbanization, trade openness, industrial out put, and the political stability on the environmental degradation in the MENA (Middle East and North African) region. *Energy*, *84*, 382–389. [CrossRef]

Ansari, M. A., Khan, N. A., & Ganaie, A. A. (2019). Does foreign direct investment impede environmental quality in Asian countries? A panel data analysis. *OPEC Energy Review*, *43*, 109–135. [CrossRef]

Apergis, N., Pinar, M., & Unlu, E. (2023). How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries. *Environmental Science and Pollution Research*, *30*, 14680–14692. [CrossRef] [PubMed]

Ayamba, E. C., Chen, H., Musah, A.-A., Ruth, A., & Osei-Agyemang, A. (2019). An empirical model on the impact of foreign direct investment on China's environmental pollution: Analysis based on simultaneous equations. *Environmental Science and Pollution Research*, *26*, 16239–16248. [CrossRef]

Bagchi, P., & Sahu, S. K. (2024). The conundrum of porter hypothesis, pollution haven hypothesis, and pollution halo hypothesis: Evidence from the Indian manufacturing sector. *Clean Technologies and Environmental Policy*, 1–13. [CrossRef]

Bakhsh, K., Rose, S., Ali, M. F., Ahmad, N., & Shahbaz, M. (2017). Economic growth, CO_2 emissions, renewable waste and FDI relation in Pakistan: New evidences from 3SLS. *Journal of Environmental Management*, *196*, 627–632. [CrossRef]

Bartels, R., Fiebig, D. G., & Plumb, M. H. (1996). Gas or electricity, which is cheaper? An econometric approach with application to Australian expenditure data. *The Energy Journal*, *17*, 33–57. [CrossRef]

Boamah, K. B., Du, J., Boamah, A. J., & Appiah, K. (2018). A study on the causal effect of urban population growth and international trade on environmental pollution: Evidence from China. *Environmental Science and Pollution Research*, *25*, 5862–5874. [CrossRef] [PubMed]

Boamah, V., Tang, D., Zhang, Q., & Zhang, J. (2023). Do FDI inflows into African countries impact their CO_2 emission levels? *Sustainability*, *15*, 3131. [CrossRef]

Brahmi, M., & Luigi, A. (2022). Governance of abundant natural resources, mining and energy, and their economic impacts on developing countries: Theoretical controversies. *International Journal of Public Sector Performance Management*, *12*, 275–314. [CrossRef]

Brahmi, M., & Zouari, S. (2014). TIC, innovations et impact sur l'analyse concurrentielle: LeaderFirme du Bassin Minier Tunisien. *International Journal of Innovation and Applied Studies*, *10*, 195–217. Available online: https://issr-journals.org/xplore/ijisr/0010/001/IJISR-14-230-05.pdf (accessed on 1 October 2014).

Bunnag, T. (2023). Analyzing short run and long run causality relationship among CO_2 emission, energy consumption, GDP, square of GDP, and foreign direct investment in Environmental Kuznets Curvefor Thailand. *International Journal of Energy Economics and Policy*, *13*, 341–348. [CrossRef]

Carayannis, E. G., Draper, J., & Crumpton, C. D. (2022). Reviewing fusion energy to address climate change by 2050. *The Journal of Energy and Development*, *47*, 1–46. Available online: https://www.jstor.org/stable/27188912 (accessed on 26 October 2024).

(2019). *Carbon brief profile report, India*. Available online: https://www.carbonbrief.org/the-carbon-brief-profile-india/ (accessed on 14 March 2019).

Chaturvedi, A. (2017). *Consolidated FDI policy circular* (No.5(1)/2017-FC-1). Department of Industrial Policy and Promotion, Government of India, D/oIPPF.

Climate Action Tracker. (2024). *Policies and action against fair share insufficient*. Available online: https://climateactiontracker.org/countries/india/policies-action/ (accessed on 10 October 2024).

Cole, M. A., & Elliott, R. J. R. (2003). Determining the trade environment composition effect: The role of capital, labor and environmental regulations. *Journal of Environmental Economics and Management*, *46*, 363–383. [CrossRef]

Das, R. (2023). *Crude oil prices: The fuel driving India's economic growth?* Available online: https://www.goodreturns.in/news/impact-of-crude-oil-prices-on-indias-economy-gen-1312921.html (accessed on 15 January 2024).

Dash, R. K., & Parida, P. C. (2013). FDI, services trade and economic growth in India: Empirical evidence on causal links. *Empirical Economics*, *45*, 217–238. [CrossRef]

Demena, B., & Afesorgbor, S. K. (2020). The effect of FDI on environmental emissions: Evidence from a meta-analysis. *Energy Policy*, *138*, 111192. [CrossRef]

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological Economic*, *49*, 431–455. [CrossRef]

Dolado, J. J., & Lütkepohl, H. (1996). Making Wald tests work for cointegrated VAR systems. *Econometric Reviews*, *15*, 369–386. [CrossRef]

Dong, J., He, J., Li, X., Mou, X., & Dong, Z. (2020). The effect of industrial structure change on carbon dioxide emissions: Across-country panel analysis. *Journal of Systems Science and Information*, *8*, 1–16. [CrossRef]

Ehigiamusoe, K. U. (2020). The drivers of environmental degradation in ASEAN and China: Do financialdevelopment and urbanization have any moderating effect? *The Singapore Economic Review*, *68*, 1671–1714. [CrossRef]

Engle, R. F. (1978). Estimating structural models of seasonality. In *Seasonal analysis of economic time series* (pp. 281–308). NBER.

Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, *1*, 251–276. [CrossRef]

Esposito, L., & Brahmi, M. (2023). Value creation through innovation: Renewable energy community. In M. Joshi, M. Brahmi, L. Aldieri, & C. V. Herhey (Eds.), *Exploring business ecosystems and innovation capacity building in global economics* (pp. 315–330). IGI Global. [CrossRef]

Esposito, L., Brahmi, M., & Joshi, M. (2023). The importance of innovation diffusion in the renewable energy sector. In M. Joshi, M. Brahmi, L. Aldieri, & C. V. Herhey (Eds.), *Exploring business ecosystems and innovation capacity building in global economics* (pp. 283–302). IGI Global. [CrossRef]

Fernández, J., & Harvey, A. (1990). Seemingly unrelated time series equations and a test for homogeneity. *Journal of Business & Economic Statistics*, *8*, 71–81.

Fiebig, D. (2001). *Seemingly unrelated regression, in companion in theoretical econometrics*. Blackwell Publishing Ltd.

Franco, S., Mandla, V. R., & Rao, K. R. M. (2017). Urbanization, energy consumption and emissions in the Indian context A review. *Renewable and Sustainable Energy Reviews*, *71*, 898–907. [CrossRef]

Gersch, W., & Kitagawa, G. (1983). The prediction of time series with trends and seasonality's. *Journal of Business & Economic Statistics*, *1*, 253–264.

Ghani, G. M. (2012). Does trade liberalization effect energy consumption? *Energy Policy*, *43*, 285–290. [CrossRef]

Gokmenoglu, K., & Taspinar, N. (2016). Turkey The relationship between CO_2 emissions, energy consumption, economic growth and FDI: The case of Turkey. *The Journal of International Trade & Economic Development*, *25*, 706–723. [CrossRef]

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, *37*, 424–438. [CrossRef]

Grimes, P., & Kentor, J. (2003). Exporting the greenhouse: Foreign capital penetration and CO? Emissions 1980? 1996. *Journal of World-Systems Research*, *9*, 261–275. [CrossRef]

Grossman, G., & Krueger, A. (1991). *Environmental impacts of a north American free trade agreement*. National Bureau of Economic Research. [CrossRef]

Grossman, G., & Krueger, A. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*, 353–377. [CrossRef]

Gui-Diby, S. L., & Renard, M.-F. (2015). Foreign direct investment in flows and the industrialization of African countries. *World Development*, *74*, 43–57. [CrossRef]

Gujarati, D., & Porter, D. (2009). *Basic econometrics* (5th ed.). TataMcGraw-HillEducation. Available online: http://dspace.kottakkalfarookcollege.edu.in:8001/jspui/bitstream/123456789/3846/1/Basic%20Econometrics%20(%20PDFDrive%20).pdf (accessed on 15 October 2024).

Guzel, A. E., & Okumus, İ. (2020). Revisiting the pollution haven hypothesis in ASEAN-5 countries: New insights from panel data analysis. *Environmental Science and Pollution Research*, *27*, 18157–18167. [CrossRef]

Haider, S., Adil, M. H., & Ganaie, A. A. (2019). Does industrialization and urbanization affect energy consumption: A relative study of India and Iran. *Economics Bulletin*, *39*, 176–185.

Hanif, I., Raza, S. M., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil fuels, foreign direct investment, and economic growth have triggered CO_2 emissions in emerging Asian economies: Some empirical evidence. *Energy*, *171*, 493–501. [CrossRef]

Hargrove, A., Qandeel, M., & Sommer, J. (2019). Global governance for climate justice: Across national analysis of CO_2 emissions. *Global Transitions*, *1*, 190–199. [CrossRef]

Harvey, A., & Durbin, J. (1986). The effects of seatbelt legislation on British road casualties: A case study in structural time series modeling. *Journal of the Royal Statistical Society: Series A (General)*, *149*, 187–210. [CrossRef]

Heil, M., & Selden, T. (2001). International trade intensity and carbon emissions: Across-country econometric analysis. *The Journal of Environment & Development*, *10*, 35–49. [CrossRef]

Huang, J., Chen, X., Huang, B., & Yang, X. (2017). Economic and environmental impacts of foreign direct investment in China: Aspatial spillover analysis. *China Economic Review*, *45*, 289–309. [CrossRef]

Huang, Y., Chen, F., Wei, H., Xiang, J., Xu, Z., & Akram, R. (2022). The impacts of FDI inflows on carbon emissions: Economic development and regulatory quality as moderators. *Frontiers in Energy Research*, *9*, 820596. [CrossRef]

Hubler, M., & Keller, A. (2010). Energy savings via FDI? Empirical evidence from developing countries. *Environment and Development Economics*, *1*, 59–80. [CrossRef]

Invest India. (2024). *India's carbon market revolution: Balancing economic growth with climate responsibility*. Available online: https://www.investindia.gov.in/team-india-blogs/indias-carbon-market-revolution-balancing-economic-growth-climate-responsibility (accessed on 17 July 2024).

IPCC. (2014). *Climate change 2014: Synthesis report*. Available online: https://www.globalchange.gov/reports/ipcc-climate-change-2014-synthesis-report (accessed on 21 September 2022).

Irfan, M., & Ojha, R. K. (2023). Foreign direct investment inflows and energy diversification in emerging seven economies: Evidence from a panel data analysis. *International Journal of Emerging Markets*, *18*, 5545–5564. [CrossRef]

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. *Energy Policy*, *37*, 5167–5172. [CrossRef]

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*, 231–254. [CrossRef]

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—With applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*, 169–210. [CrossRef]

Jun, W., Zakaria, M., Shahzad, S. J. H., & Mahmood, H. (2018). Effect of FDI on pollution in China: New insights based on wavelet approach. *Sustainability*, *10*, 3859. [CrossRef]

Kathuria, V. (2018). Does environmental governance matter for foreign direct investment? Testing the pollution haven hypothesis for the Indian States. *Asian Development Review*, *35*, 81–107. [CrossRef]

Kaushik, P., Mohsen, B., Shubham, K., & Pooja, K. (2024). The predictive grey forecasting approach for measuring tax collection. *Journal of Risk and Financial Management*, *17*, 558. [CrossRef]

Kayani, U. N., Nasim, I., Aysan, A. F., & Iqbal, U. (2024). Emerging trends of carbon emissions and foreign direct investment: Accounting for ecological footprints, renewable energy, globalization, and technological innovations in BRICS. *Environmental Science and Pollution Research*, *31*, 41586–41599. [CrossRef] [PubMed]

Khan, A. Q., Saleem, N., & Fatima, S. T. (2018). Financial development, income inequality, and CO_2 emissions in Asian countries using STIRPAT model. *Environmental Science and Pollution Research*, *25*, 6308–6319. [CrossRef] [PubMed]

Khan, M., Rana, A. T., & Ghardallou, W. (2023). FDI and CO_2 emissions in developing countries: The role of human capital. *Natural Hazards*, *117*, 1125–1155. [CrossRef] [PubMed]

Khan, M. A., Khan, M. Z., Zaman, K., & Arif, M. (2014). Global estimates of energy growth nexus: Application of seemingly unrelated regressions. *Renewable and Sustainable Energy Reviews*, *29*, 63–71. [CrossRef]

Kong, S. (2021). Environmental cost of energy consumption and economic growth: Can China shifts some burden through financial development? An asymmetric analysis. *Environmental Science and Pollution Research*, *28*, 25255–25264. [CrossRef] [PubMed]

Lee, C. G. (2009). Foreign direct investment, pollution and economic growth: Evidence from Malaysia. *Applied Economics*, *41*, 1709–1716. [CrossRef]

Leitao, N. C. (2015). Energy consumption and foreign direct investment: A panel data analysis for Portugal. *International Journal of Energy Economics and Policy*, *5*, 138–147.

Li, K., & Lin, B. (2015). Impacts of urbanization and industrialization on energy consumption/CO_2 emissions: Does the level of development matter? *Renewable and Sustainable Energy Reviews*, *52*, 1107–1122. [CrossRef]

Lin, S., Wang, S., Marinova, D., Zhao, D., & Hong, J. (2017). Impacts of urbanization and real economic development on CO_2 emissions innon high income countries: Empirical research based on the extended STIRPAT model. *Journal of Cleaner Production*, *166*, 952–966. [CrossRef]

Liu, Y., Huang, J., & Zikhali, P. (2016). The bitter sweet fruits of industrialization in rural China: The cost of environment and the benefit from off farm employment. *China Economic Review*, *38*, 1–10. [CrossRef]

Lotfalipour, M. R., Falahi, M. A., & Ashena, M. (2010). Economic growth, CO_2 emissions, and fossil fuels consumption in Iran. *Energy*, *35*, 5115–5120. [CrossRef]

Luigi, A., Mohsen, B., Chen, X., & Concetto, P. V. (2021). Knowledge spillovers and technical efficiency for cleaner production: An economic analysis from agriculture innovation. *Journal of Cleaner Production*, *320*, 128830. [CrossRef]

Mahmood, H., Alkhateeb, T. T. Y., & Furqan, M. (2020). Industrialization, urbanization and CO_2 emissions in Saudi Arabia: Asymmetry analysis. *Energy Reports*, *6*, 1553–1560. [CrossRef]

Mardani, A., Streimikiene, D., Cavallaro, F., Loganathan, N., & Khoshnoudi, M. (2019). Carbon dioxide (CO_2) emissions and economic growth: A systematic review of two decades of researchfrom 1995 to 2017. *Science of the Total Environment*, *649*, 31–49. [CrossRef] [PubMed]

Marques, A. C., & Caetano, R. (2020). The impact of foreign direct investment on emission reduction targets: Evidence from high and middle income countries. *Structural Change and Economic Dynamics*, *55*, 107–118. [CrossRef] [PubMed]

Mavikela, N., & Khobai, H. (2018). *Investigating the link between foreign direct investment, energy consumption and economic growth in Argentina*. Available online: https://mpra.ub.uni-muenchen.de/83960/ (accessed on 21 October 2022).

Mert, M., & Bölük, G. (2016). Do foreign direct investment and renewable energy consumption affect the CO_2 emissions? New evidence from a panel ARDL approach to Kyoto Annex countries. *Environmental Science and Pollution Research*, *23*, 21669–21681. [CrossRef] [PubMed]

Mirza, F. M., & Kanwal, A. (2017). Energy consumption, carbon emissions and economicgrowth in Pakistan: Dynamic causality analysis. *Renewable and Sustainable Energy Reviews*, *72*, 1233–1240. [CrossRef]

MoEFCC. (2022). *India's long-term low-carbon development strategy.* Ministry of Environment, Forestand Climate Change, Government of India. Available online: https://moef.gov.in/uploads/2022/11/Indias-LT-LEDS.pdf (accessed on 21 October 2022).

Mohsen, B., Bruna, B., Karambir, S. D., Luca, E., & Anna, P. (2024). From manuretomega watts: Navigating the sustainable innovation solution through biog as production from lives tock waste for harnessing green energy for green economy. *Heliyon*, *10*, e34504. [CrossRef]

Mohsen, B., Espisoto, L., Anna, P., Karabir, S. D., Shruti, A., Giri, A. K., & Loan, N. T. (2023). The role of greener innovations in promoting financial inclusion to achieve carbon neutrality: An integrative review. *Economies*, *11*(7), 194. [CrossRef]

Mohsen, B., Zouari, S., & Magali, R. (2014). L'industrie minière et ses effets écologiques. État socio-économique et environnemental dans le bassin minier Tunisien. *Collection EDYTEM, Cahiers de géographie, Impacts Environnementaux et Sociétaux*, *17*, 109–120. [CrossRef]

Mohsin, M., Naseem, S., Sarfraz, M., & Azam, T. (2022). Assessing the effects of fuel energy consumption, foreign direct investment and GDP onCO_2 emission: New data science evidence from Europe & Central Asia. *Fuel*, *314*, 123098.

Mosikari, T. J., & Eita, J. H. (2020). CO_2 emissions, urban population, energy consumption and economic growth in selected African countries: A Panel Smooth Transition Regression (PSTR). *OPEC Energy Review*, *44*, 319–333. [CrossRef]

Muhammad, B., & Khan, S. (2019). Effect of bilateral FDI, energy consumption, CO_2 emission and capital on economic growth of Asia countries. *Energy Reports*, *5*, 1305–1315. [CrossRef]

Muhammad, B., Khan, M. K., Khan, M. I., & Khan, S. (2021). Impact of foreign direct investment, natural resources, renewable energy consumption, and economic growth on environmental degradation: Evidence from BRICS, developing, and global countries. *Environmental Science and Pollution Research*, *28*, 21789. [CrossRef]

Narayanan, K., & Sahu, S. K. (2016). Effects of climate change on the house hold economy and adaptive responses among agricultural house holds in the eastern coast of India. *Current Science*, *110*, 1240–1250.

Naz, S., Sultan, R., Zaman, K., Aldakhil, A. M., Nassani, A. A., & Abro, M. M. Q. (2019). Moderating and mediating role of renewable energy consumption, FDIinflows, and economic growth on carbon dioxide emissions: Evidence from the robust least square estimator. *Environmental Science and Pollution Research*, *26*, 2806–2819. [CrossRef] [PubMed]

Nepal, R., Paija, N., Tyagi, B., & Harvie, C. (2021). Energy security, economic growth and environmental sustainability in India: Do FDI and trade openness play a role? *Journal of Environmental Management*, *281*, 111886. [CrossRef] [PubMed]

Ngouhouo, I., & Ewane, E. I. (2020). The effects of foreign direct investments on industrialization: A comparative approach between the Franc and the non-Franc zone. *Asian Journal of Economic Modelling*, *8*, 123–132. [CrossRef]

Nguyen, D. K., Huynh, T. L. D., & Nasir, M. A. (2021). Carbon emissions determinants and forecasting: Evidence from G6 countries. *Journal of Environmental Management*, *285*, 111988. [CrossRef]

Ning, L., & Wang, F. (2018). Does FDI bring environmental knowledge spillovers to developing countries? The role of the local industrial structure. *Environmental and Resource Economics*, *71*, 381–405. [CrossRef]

Nkengfack, H., & Fotio, H. K. (2019). Energy consumption, economic growth, and carbon emissions: Evidence from the top three emitters in Africa. *Modern Economy*, *10*, 52–71. [CrossRef]

Ouyang, X., & Lin, B. (2015). An analysis of the driving forces of energy related carbon dioxide emissions in China's industrial sector. *Renewable and Sustainable Energy Reviews*, *45*, 838–849. [CrossRef]

Panagariya, A. (2008). *India: The emerging giant*. Oxford University Press.

Pao, H.-T., & Tsai, C.-M. (2011). Multivariate Granger causality between CO_2 emissions, energy consumption, FDI and GDP: Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36*, 685–693. [CrossRef]

Parikh, J., Panda, M., Ganesh-Kumar, A., & Singh, V. (2009). CO_2 emissions structure of Indian economy. *Energy*, *34*, 1024–1031. [CrossRef]

Pazienza, P. (2019). The impact of FDI in the OECD manufacturing sector onCO_2 emission: Evidence and policy issues. *Environmental Impact Assessment Review*, *77*, 60–68. [CrossRef]

Pethig, R. (1976). Pollution, welfare, and environmental policy in the theory of comparative advantage. *Journal of Environmental Economics and Management*, *2*, 160–169. [CrossRef]

Phillips, P., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*, 335–346. [CrossRef]

PIB. (2018). *Vision of a USD5 trillion indian economy*; Press Information Bureau, Government of India, Ministry of Commerce & Industry. Available online: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1549454 (accessed on 20 September 2022).

Prasad, M., & Mishra, T. (2017). Low carbon growth for Indian iron and steel sector: Exploring the role of voluntary environmental compliance. *Energy Policy*, *100*, 41–50. [CrossRef]

Pu, C., Liu, Z., Pan, X., & Addai, B. (2020). The impact of natural disasters on China's macro-economy. *Environmental Science and Pollution Research*, *27*, 43987–43998. [CrossRef]

Rahman, M. M., & Kashem, M. A. (2017). Carbon emissions, energy consumption and industrial growth in Bangladesh: Empirical evidence from ARDL cointegration and Granger causality analysis. *Energy Policy*, *110*, 600–608. [CrossRef]

Rana, R., & Sharma, M. (2019). Dynamic causality testing for EKC hypothesis, pollution haven hypothesis and international trade in India. *The Journal of International Trade & Economic Development*, *28*, 348–364. [CrossRef]

Rehman, A., Radulescu, M., Ma, H., Dagar, V., Hussain, I., & Khan, M. K. (2021). The impact of globalization, energy use, and trade on ecological footprint in Pakistan: Does environmental sustainability exist? *Energies*, *14*, 5234. [CrossRef]

Rej, S., Nag, B., & Hossain, M. E. (2024). Foreign direct investment, income inequality and pollution reduction: Policy trilemma for India. *Social Indicators Research*, *174*, 221–248. [CrossRef]

Ren, X., An, Y., He, F., & Goodell, J. W. (2024). Do FDI inflows bring both capital and CO_2 emissions? Evidence from non-parametric modeling for the G7 countries. *International Review of Economics & Finance*, *95*, 103420.

RobecoSAM. (2019). *The sustainability yearbook 2019*. SAM. Available online: https://www.robeco.com/docm/docu-robecosam-sustainability-yearbook-2019.pdf (accessed on 21 September 2021).

Rustemoglu, H., & Andres, A. R. (2016). Determinants of CO_2 emissions in Brazil and Russia between 1992 and 2011: A decomposition analysis. *Environmental Science & Policy*, *58*, 95–106. [CrossRef]

Sabir, S., Qayyum, U., & Majeed, T. (2020). FDI and environmental degradation: The role of political institutions in South Asian countries. *Environmental Science and Pollution Research*, *27*, 1–10. [CrossRef] [PubMed]

Saboori, B., & Sulaiman, J. (2013). CO_2 emissions, energy consumption and economicgrowth in Association of Southeast Asian Nations (ASEAN) countries: A cointegration approach. *Energy*, *55*, 813–822. [CrossRef]

Saboori, B., Sapri, M., & Baba, M. B. (2014). Economicgrowth, energy consumption and CO_2 emissions in OECD (Organization for Economic Co-operation and Development's) transport sector: A fully modified directional relationship approach. *Energy*, *66*, 150–161. [CrossRef]

Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, *38*, 2528–2535. [CrossRef]

Sahu, S. K., & Narayanan, K. (2010). Decomposition of industrial energy consumption in Indian manufacturing: The energy intensity approach. *Journal of Environmental Management & Tourism*, *1*, 22.

Saint, A. S., & Ajmi, A. N. (2020). Causality relationship between energy consumption, economic growth, FDI, and globalization in SSA countries: A symbolic transfer entropy analysis. *Environmental Science and Pollution Research*, *27*, 44623–44628. [CrossRef]

Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissionsi n Kuwait. *Renewable and Sustainable Energy Reviews*, *81*, 2002–2010. [CrossRef]

Salahuddin, M., Gow, J., Ali, M. I., Hossain, M. R., Al-Azami, K. S., Akbar, D., & Gedikli, A. (2019). Urbanization globalization CO_2 emissions nexus revisited: Empirical evidence from South Africa. *Heliyon*, *5*, e01974. [CrossRef] [PubMed]

Seetanah, B., Sannassee, R. V., Fauzel, S., Soobaruth, Y., Giudici, G., & Nguyen, A. P. H. (2019). Impact of economic and financial development on environmental degradation: Evidence from small island developing states (SIDS). *Emerging Markets Finance and Trade*, *55*, 308–322. [CrossRef]

Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., & Jabran, M. A. (2016). How urbanization affects CO_2 emissions in Malaysia? The application of STIRPAT model. *Renewable and Sustainable Energy Reviews*, *57*, 83–93. [CrossRef]

Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics*, *74*, 843–857. [CrossRef]

Shen, M. (2018). Multiple mediation effects of foreign direct investment on China's carbon productivity. *China-USA Business Review*, *17*, 23. [CrossRef]

Sikder, M., Wang, C., Yao, X., Huai, X., Wu, L., Yeboah, F. K., Wood, J., Zhao, Y., & Dou, X. (2022). The integrated impact of GDP growth, Industrialization, energy use, and urbanization onCO_2 emissions in developing countries: Evidence from the panel ARDL approach. *Science of the Total Environment*, *837*, 155795. [CrossRef]

Singh, G. J., Singh, P. K., & Lal, P. (2024). Dynamic Approach to Study Relationship Among Carbon Dioxide Emissions, Urbanization, and Economic Growth in BRICS Countries. *Journal of the Knowledge Economy*, 1–18. [CrossRef]

Singhania, M., & Saini, N. (2021). Demystifying pollution haven hypothesis: Role of FDI. *Journal of Business Research*, *123*, 516–528. [CrossRef] [PubMed]

Solarin, S. A., Al-Mulali, U., Musah, I., & Ozturk, I. (2017). Investigating the pollutionhaven hypothesis in Ghana: An empirical investigation. *Energy*, *124*, 706–719. [CrossRef]

Sreenu, N. (2024). Analysing FDI inflow effects on CO_2 emissions: A comparative study of OECD and BRIC nations with PHH and PHE models. *International Journal of Energy Sector Management*, *19*, 80–100. [CrossRef]

Stern, D. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, *32*, 1419–1439. [CrossRef]

Suhrab, M., Soomro, J. A., Ullah, S., & Chavara, J. (2023). The effect of gross domestic product, urbanization, trade openness, financial development, and renewable energy on CO_2 emission. *Environmental Science and Pollution Research*, *30*, 22985–22991. [CrossRef] [PubMed]

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy*, *79*, 447–454. [CrossRef]

Tang, Y., Zhu, H., & Yang, J. (2022). The asymmetric effects of economic growth, urbanizationandde industrialization on carbon emissions: Evidence from China. *Energy Reports*, *8*, 513–521. [CrossRef]

Tewari, S. (2021). *Chamoli glacier burst: It is time to learn from our mistakes.* Down to Earth. Available online: https://www.downtoearth.org.in/blog/climate-change/chamoli-glacier-burst-it-is-time-to-learn-from-our-mistakes-75419 (accessed on 7 February 2021).

Tiwari, A. K. (2011). Energy consumption, CO_2 emissions, and economic growth: Evidence from India. *Journal of International Business and Econom*, *12*, 85–122. [CrossRef]

Toda, H., & Yamamoto, T. (1995). Statistical inference in vector auto-regressions with possibly integrated processes. *Journal of Econometrics*, *66*, 225–250. [CrossRef]

UNCTAD. (2018). *World investment report 2018*. Available online: https://unctad.org/publication/world-investment-report-2018 (accessed on 21 October 2022).

Uzar, U., & Eyuboglu, K. (2019). Is foreign direct investment an engine for energy consumption? An empirical investigation for Turkey. *Environmental Science and Pollution Research*, *26*, 28092–28105. [CrossRef]

Wada, I., Faizulayev, A., Khademolomoom, A. H., & Alzubi, A. (2020). Energy use, real ou t put growth, FDI, energy intensity and CO_2 emission: The case of Kazakhstan. *Journal of Public Affairs*, *22*, e2300. [CrossRef]

Wang, Q., Yang, T., Li, R., & Wang, X. (2023). Reexamining the impact of foreign direct investment on carbon emissions: Does per capita GDP matter? *Humanities and Social Sciences Communications*, *10*, 1–18. [CrossRef]

Wang, Y., & He, X. (2019). Spatial economic dependency in the Environmental Kuznets Curve of carbon dioxide: The case of China. *Journal of Cleaner Production*, *218*, 498–510. [CrossRef]

Wang, Z., Zhang, B., & Wang, B. (2018). The moderating role of corruption between economic growthand CO_2 emissions: Evidence from BRICS economies. *Energy*, *148*, 506–513. [CrossRef]

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H., & Costello, A. (2018). The 2018 report of the Lancet Count down on health and climate change: Shaping the health of nations for centuries to come. *The Lancet*, *392*, 2479–2514. [CrossRef] [PubMed]

Wen, H., & Dai, J. (2020). Trade openness, environmental regulation, and human capital in China: Based on ARDL cointegration and Granger causality analysis. *Environmental Science and Pollution Research*, *27*, 1789–1799. [CrossRef] [PubMed]

World Bank. (2018). *Climate change could force over 140 million to migrate within countries by 2050: World bank report*. Available online: https://www.worldbank.org/en/news/press-release/2018/03/19/climate-change-could-force-over-140-million-to-migrate-within-countries-by-2050-world-bank-report (accessed on 19 March 2018).

Yao, X., Kou, D., Shao, S., Li, X., Wang, W., & Zhang, C. (2018). Can urbanization processand carbon emission abatement be harmonious? New evidence from China. *Environmental Impact Assessment Review*, *71*, 70–83. [CrossRef]

Yousefi-Sahzabi, A., Sasaki, K., Yousefi, H., & Sugai, Y. (2011). CO_2 emission and economic growth of Iran. *Mitigation and Adaptation Strategies for Global Change*, *16*, 63–82. [CrossRef]

Zangoei, S., Salehnia, N., & Mashhadi, M. K. (2021). A comparative study on the effect of alternative and fossil energy consumption on economic growth and foreign direct investment in selected countries using SUR approach. *Environmental Science and Pollution Research*, *28*, 19799–19809. [CrossRef]

Zarsky, H. (1999). Halos and spaghetti: Untangling the evidence about foreign direct investment and the environment. *Foreign Direct Investment and the Environment*, *13*, 47–74.

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association*, *57*, 348–368. [CrossRef]

Zhang, C., & Zhou, X. (2016). Does foreign direct investment lead to lower CO_2 emissions? Evidence from a regional analysis in China. *Renewable and Sustainable Energy Reviews*, *58*, 943–951. [CrossRef]

Zhang, G., Zhang, N., & Liao, W. (2018). How do population and land urbanization affect CO_2 emissions under gravity center change? A spatial econometric analysis. *Journal of Cleaner Production*, *202*, 510–523. [CrossRef]

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quintile regression. *Economic Modeling*, *58*, 237–248. [CrossRef]

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