International Journal of Sustainable Economy

ISSN online: 1756-5812 - ISSN print: 1756-5804
https://www.inderscience.com/ijse

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DOI: 10.1504/IJSE.2023.10050571

Article History:

Received:	18 April 2022
Accepted:	26 July 2022
Published online:	02 December 2023

Investigating the environmental Kuznets curve hypothesis and pollution haven hypothesis in India: an ARDL approach

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Abstract: The study examines the validity of the inverted U-shaped environmental Kuznets curve (EKC) hypothesis and pollution haven hypothesis (PHH) in India during the period 1970 to 2018. Adopting autoregressive distributed lag (ARDL) method, the study disproves the existence of the EKC by indicating a U-shaped curve between environmental degradation and the country's economic growth. Likewise, the relationship between environmental degradation and foreign direct investments confirms an invalid PHH in India. The non-existence of the two hypotheses has important implications on formulation, evaluation, and restructuring of the country's environmental, industrial and economic regulations. The study also considers industrialisation, population density and urbanisation as other regressors. Additionally, the causal relationships among the variables are explored in the study.

Keywords: carbon emission; economic growth; environmental degradation; environmental Kuznets curve; EKC; pollution haven hypothesis; PHH; autoregressive distributed lag; ARDL; India.

Reference to this paper should be made as follows: Gogoi, N. and Hussain, F. (2024) 'Investigating the environmental Kuznets curve hypothesis and pollution haven hypothesis in India: an ARDL approach', *Int. J. Sustainable Economy*, Vol. 16, No. 1, pp.16–44.

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1 Introduction

The modern economy has to make certain choices for achieving its growth and consider other important aspects at the same time. One of the most highlighted concerns in recent times has been the effect of economic growth on the preservability of the environment for future generations. Many argue that the development of an economy does not come cheap and the biggest cost of it is the degradation of the environment. When an economy decides or formulates industrial policies, trade regulations, economic measures, etc., it is very crucial to consider the safeguarding of the environment at each and every step (Iwami, 2001).

Economic growth has its significant impact on the environment by increasing the emission of carbon, both in the short-run and long-run (Osadume and University, 2021). On one hand, studies like Vidyarthi (2013) has reported that that carbon emission is positively correlated to economic growth and so is energy consumption in India; while on the other hand, Leal et al. (2018) conclude that economic growth increases the level of carbon dioxide (CO_2) intensity and this in turn, affects the gross domestic product (GDP) negatively in Australia. The cement and the construction industry play a vital role in a country's industrial development and economic growth. However, many studies have already discovered how both the industries can be a great threat for the environment around the world (Ren et al., 2012; Isaksson, 2016; Shrivastava and Shrivastava, 2017; Zeb et al., 2019). Further, Munir and Ameer (2018) found that achieving economic growth through trade openness and usage of technology indeed harms the environment by emitting sulphur dioxide (SO_2). It proves how difficult it is to achieve economic prosperity without causing any ill-effect on the environment. So, there is clearly a difficult situation for a country to balance economic growth alongside environmental safeguarding (Rai et al., 2019).

As a result, people have become very much concerned about environment friendly operations. To gain the attention of the stakeholders, businesses have started to become more transparent and stringent regarding their actions. Studies disclose that companies have started to voluntarily disclose facts regarding their carbon accounting systems, which has become a usual practice for many. Furthermore, the larger and high performing firms tend to be more visible about the same (Choi et al., 2013; Datt et al., 2019). It helps them build a better image in front of the investors and other significant stakeholders. In recent times, many countries have made it mandatory to make such disclosures in their Carbon Disclosure Project (CDP) reports. Moreover, the level of participation and transparency in terms of the carbon reports also depend on the environment related regulations of one's country. The carbon emission level significantly depends on the strictness of different policies and regulations. Based on the various economic parameters and the industrial structures, an economy has to decide what will be the most effective measures for the safety of its environment (Han et al., 2021). Mateo-Márquez et al. (2020) stated that companies receive higher CDP scores in voluntary carbon reporting disclosures when their host courtiers have more stringent and definitive climate related regulations.

Many firms have reconsidered their supply chain management, inventory management policies, transportation facility options, etc. to transform themselves into more environment friendly and less carbon emitting organisations (Das and Jharkharia, 2018). Significantly, a study from Turkey revealed that companies conducting sensitive environmental operations are more active and efficient in disclosing carbon-emitting statements (Kılıç and Kuzey, 2019). It proves how companies have become more concerned about their image in protecting the environment. Even India has set its targets to voluntarily reduce carbon emission levels without compromising the economic growth factors. However, achieving low-carbon growth for a country like India provokes a lot of challenges which the country has to tackle from the fundamental levels. Efficient climate policy formulation and their successful implementation in India involve a lot of key players including the government and various other institutions (Dutta et al., 2016).

The environmental Kuznets curve (EKC) and the pollution haven hypothesis (PHH) are widely leveraged by studies to understand the dynamics between economic growth and environmental degradation. EKC hypothesis argues that the economic growth has an adverse effect on the environment only to a certain extent and after crossing a certain threshold level, the economy no more harms the environment. The PHH on the other hand explains that economic development and environmental shelter may not go hand in hand. It describes that the developing countries having lax environmental regulations produce and export pollution-intensive goods comparatively more because the dirty industries are migrated from the developed countries due to their strict environmental policies. As a result, economic benefits through foreign investments lead to environmental degradation for the developing countries. Nonetheless, the researchers are still trying to argue the truthiness of both the hypotheses in real-life implications.

The study aims to empirically test the validity of the EKC and PHH in India during the period of 1970 to 2018. The review of literature in Section 2 of the study has thoroughly observed and considered the insights from previous studies. Section 3 describes the variables considered, their nature and the source of data. The methodology presented in Section 4 explains the empirical tests conducted for the study in detail. Section 5 then reports and discusses the empirical test results. Additionally, a robustness test has been performed and explained in Section 6. After confirming the empirical results, Section 7 offers the policy implications of the study in India. The conclusions part in Section 8 offers some suggestions considering the results in light of the Indian economy.

2 Review of literature

2.1 EKC hypothesis

The Kuznets curve is proved to be a significant concept for various economic sectors. With time, it has been developed for extensive usage. The Kuznets curve is named after Simon Kuznets. Initially, Kuznets (1955) formulated this curve to establish a relationship between economic growth and income inequality. The Kuznets curve hypothesis stated that the income inequality of the economy increases when the economy goes through the stages of prosperity in the beginning. However, the relationship changes after the economy reach a certain growth point. Beyond this point, the inequality in income slowly decreases as the economy continues to grow. As a result, the Kuznets curve represents an inverted U-shaped curve graphically.

Researchers have undertaken several studies to test the Kuznets curve hypothesis in the later periods. The curve led to the concept of the EKC hypothesis, which is still widely used for various studies related to the environment and economic growth (Bashir et al., 2021). Grossman and Krueger (1991) were the first to use the Kuznets hypothesis regarding the environmental aspect. The study was conducted in Mexico, and a relationship between trade liberalisations and economic degradation was shown in it. Panayotou (1993) was the first to name it as the 'EKC'. Dinda (2004) made another significant contribution by testing and establishing the inverted U-shaped relationship between multiple pollutants and economic growth, taking per capita income as its indicator. It was stated that the economic growth, i.e., rise in per capita income, increases the environmental pressure at an early stage. However, environmental degradation subsequently slows down in relation to the economy's advancement. Moreover, Beckerman (1992) also carried out a study concluding that a significant conflict exists between environmental preservation and economic growth in practicality.

The reason behind the inverted U-shaped EKC can be explained from different aspects. A significant study conducted by Grossman and Krueger (1995) have explained three fundamental possible reasons for the same. According to the study, the first reason may be the country's environmental laws and regulations. The developed countries usually implement more stringent policies to protect the environment, which is lacking in case of the developing and less developed countries. Secondly, with economic prosperity, the industries begin to innovate and use cleaner and more efficient technologies that bring down the country's pollution level. The third point explains that with time and the development of the economy, people become more aware of environment protection and preservation, encouraging them to use modern and eco-friendly technologies. Another study supports the same by stating that better policy formulation and their successful implementation can significantly bring down the level of pressure on the environment. In that case, attaining economic prosperity may be possible without degrading the environment (Panayotou, 1997). These reasons may help us explain why developed countries depict a clearer and more distinct inverted U-shaped curve in EKC hypothesis testing. On the other hand, the developing or less developed countries result in a less significant inverted U-shaped curve (Liu and Lai, 2021).

There are many other studies to have researched the EKC hypothesis. Each of them has concluded their findings, whether in support or against the validity of the same. One of the studies stated that the existence of EKC might not be significant in every economy. Its validity may vary from country to country, depending on which growth stage they are going through (Bader and Ganguli, 2019). A study has concluded that foreign finance and economic growth do show an inverted U-shaped curve as suggested by the EKC hypothesis (Alshubiri and Elheddad, 2020). Another study, validating the EKC hypothesis in terms of countries with different income levels, has accepted its true presence in all the observed cases. Although, the researchers stated that the curve was more evident in high-income panel, when compared to the middle and low-income panel (Nasreen and Anwar, 2015). Another research on the ASEAN countries proved that the EKC hypothesis is true and valid. To do so, the relationship between economic growth and the emission of methane (CH_4) was tested (Adeel-Farooq et al., 2021). Other recent studies have also validated this hypothesis and established the inverted U-shaped curve between environmental pollutants and economic growth (Andreoni and Levinson, 2001; Kim, 2013; Li et al., 2014; Hua and Boateng, 2015; Koshta et al., 2021).

However, there have been researches denying the truthiness of EKC hypothesis by pointing out its various weaknesses in a real economic scenario. These studies have somewhat expressed their doubts about the existence of this inverted U-shaped curve (Spangenberg, 2001; Arnaut and Lidman, 2021; Minlah et al., 2021). Pata and Caglar (2021) also reveal no true EKC hypothesis in terms of relationship between environment pollutants and income levels in China's economy. Again, another study empirically concludes that economic growth cannot lead to environmental sustainability as expressed in the EKC hypothesis. The researchers have tested this in the context of Brazil, China, India, Norway, Canada and the USa (Pata and Aydin, 2020).

It is not necessary that the existence of the EKC hypothesis can be proved in every economy. Different countries may be going through different levels of development. Their environmental policies or methods to measure environmental degradation may vary and so can be their point of turn where the economic growth starts to improve the environment alongside (Zapata and Paudel, 2009). The process of testing the validity of EKC hypothesis itself has become a very difficult and complex task. With time, new variables and indicators for environmental performance and economic growth have been introduced in various studies. It makes the whole scenario even more challenging to land on a concrete conclusion (Leal and Marques, 2020). Nevertheless, the importance of EKC hypothesis can never be ignored in the research world. Many policies have been formulated and technologies have been implemented to ensure both sustainability and economic growth simultaneously, by studying the nature of this curve. Its significance can never be doubted in modern times, especially for environmental economics.

To confirm the existence of the EKC, researchers have been using various models throughout the years. Apart from the widely used traditional practices, few studies have tried to introduce different and new methodologies for validating the hypothesis. The literature infers that most studies have considered CO_2 emission levels to measure an economy's environmental degradation level. However, Jha and Murthy (2003) have argued that CO_2 emission level alone fails to quantify an economy's level of environmental degradation. Thus, they have developed an environmental degradation index (EDI) by considering and aggregating the effects of six related indicators. The study uses the human development index (HDI) in place of the other commonly used economic growth indicators such as income level, GDP level, and so on (Jha and Murthy, 2006). By developing the EDI and HDI for 174 countries, the study validates an inverse N-shaped global EKC. The same results are further supported by Jha and Murthy (2004) when a consumption-based global EKC model was formulated by using EDI and HDI. The empirical results of the study state that high-consumption countries are considered the most significant contributors to the EDI.

Moreover, Narayan and Narayan (2010) have also suggested a simple and unique approach to test whether the EKC is present in an economy or not. Here, the degree of income elasticity on CO_2 emission level is observed to confirm the hypothesis. If the long-run income elasticity is lower than that of the short-run, it indicates a reduction in CO_2 emission levels over the years and proves the truthiness of the EKC hypothesis for a particular region or an economy. The study finds that the EKC is present only in the Middle Eastern and South Asian regions in the globe. Saboori et al. (2016) have used the same approach to empirically test the EKC hypothesis in ten Organization of Petroleum Exporting Countries (OPEC). By comparing the long-run and short-run coefficients, the study finds that a valid EKC was present only in six observed countries. Aung et al. (2017) have executed similar methodologies in Myanmar and found that the hypothesis is not valid between CO_2 emission levels and its GDP. However, the EKC was proved to be valid when the CO_2 emission levels were replaced by nitrous oxide (N_2O) and CH_4. The long-run coefficient values were smaller than that of the short-run in these two cases.

Some studies have also assessed the EKC's nature by applying the decoupling method. Tapio (2005) discussed the importance of the decoupling method to achieve a more realistic picture of any phenomenon. He explained that if we want to study the environmental efficiency of the transport sector in Finland, considering only the CO_2 emission levels will fail to portray its actual picture. The increase in the volume of vehicle engines on the road is also an essential factor for the same. So, it is better and safer to improve a decoupling index considering both the overall transport emission levels and the transport volume growth to attain a more concrete scenario. Likewise, Lv et al. (2021) have used decoupling analysis by integrating it with the EKC hypothesis. The study develops a decoupling index between China's CO_2 emission levels and value added in its manufacturing industry. The results conclude that the EKC hypothesis is valid in China's manufacturing industry. Another study by Wang et al. (2021) has employed Tapio (2005) elastic decoupling analysis to test the EKC in the cities of China. A decoupling index was introduced between municipal solid waste generation and per capita GDP in China. By evaluating a cubic equation form, the results report that an N-shaped curve was found instead of the traditional EKC. It indicates that the observed cities in China fail to improve their environmental conditions.

Again, Jia et al. (2009) have used the stochastic estimation of environmental impacts by regression on population, affluence and technology (STIRPAT) model and partial least square (PLS) methods to determine the crucial drivers of ecological footprints in Henan Province, China. Additionally, the study reports an invalid EKC in Henan by considering the results of both the tests conducted.

There have been arguments about the existence of EKC hypothesis in Indian economy also. Several studies have been conducted by researchers and have found different results. A study found that EKC hypothesis is present in Indian context when the relationship between renewable energy and CO_2 emission was tested. Renewable energy can be expensive and may harm the environment initially. Although with time, the government can take measures to flatten the EKC and achieve economic growth without degrading the environment further (Sinha and Shahbaz, 2018). Another study stated that CO_2 emission increases when income of the economy increases in the initial period. However, after attaining the turnover point, increase in income brings down the level of CO_2 emission (Sehrawat et al., 2015). Managi and Ranjan (2008) also documented a true EKC hypothesis between income of the Indian states and their environmental productivity. It was empirically found that the developed states are able to reduce the environmental deterioration faster than the low-income level states. Again, a valid EKC was established by researchers between nuclear energy consumptions in India and its pollution density (Danish et al., 2021). Some other studies have also supported the existence of EKC in India by analysing the relationship between economic growth and various environment pollutants (Kanjilal and Ghosh, 2013; Tiwari et al., 2013; Solarin et al., 2017; Usman et al., 2019).

Nevertheless, a study has been conducted by considering the nitrogen dioxide (NO_2) emission levels in 139 Indian cities. The cities were divided into three income level stratums (high, medium and low level) and considering them, the EKC hypothesis was tested by two models, i.e., electricity consumption model and petroleum consumption model. In case of the industrial areas, it was found that the inverted U-shaped EKC hypothesis was evidently visible only in high income-level cities using electricity model. Moreover, the hypothesis was empirically present in both the models in case of high income-level residential areas. The rest of the cases showed either a linear or an inverted N-shaped relationship (Sinha and Bhattacharya, 2016). Another study was carried on with the same stratums and models by considering SO_2 emission levels in the same 139 Indian cities. The results showed that only the high income-level industrial areas have a valid and empirically proved EKC hypothesis in both the electricity consumption and petroleum consumption models (Sinha and Bhattacharya, 2017).

However, there are some results that reveal an opposite scenario. Earlier, it has been documented that India's economic growth and carbon emission have a non-causality relationship in the long-run (Ghosh, 2010). Govindaraju and Tang (2013) also found no long-term relationship among energy consumption, economic growth and environmental development. Asumadu-Sarkodie and Yadav (2019) discovered a U-shaped curve as opposed to the EKC hypothesis and proved its non-existence in India. It implied that India's industrialised economy encourages environmental degradation. The same has been proved in another study testing the impact of energy consumption, export variety and foreign direct investment (FDI) on pollution increase. The study concluded that the EKC hypothesis is invalid in India (Adamu et al., 2019). Similarly, Alam et al. (2016) have empirically denied the existence of the EKC for CO_2 emissions in India. Another interesting study has established an N-shaped curve in India representing the relationship between its CO_2 emission levels and per capita GDP. It implies that the EKC hypothesis may not be very prominent in India (Pal and Mitra, 2017).

The previous studies have directed that the validity of the EKC hypothesis is still arguable and lies in a grey area. There are studies defending the EKC hypothesis in India and disagreeing with the same. As a result, it is essential to know and confirm whether the hypothesis is valid in the country or not because it has crucial industrial and environmental policy implications. To confirm the same, the following hypothesis is formed:

H_1 There exist a significant inverse U-shaped relationship between economic growth and environmental degradation in India.

2.2 Pollution haven hypothesis

Another popular concept associated with the EKC hypothesis is the PHH. Many studies have discussed that the EKC hypothesis is more evident in the developed or high-income level countries. It is because they are able to successfully bring down the level of environmental pollutants after a certain point of economic growth. One of the reasons of this emission reduction may be explained by the PHH. It is observed that the developed countries with more stringent environmental policies transfer the pollution-intensive industries to the environmentally lax regulated developing countries. As a result, the pollution level is reduced or controlled in the developed countries by shifting the same burden to the developing and less developed countries (Cole, 2004). This process of pollutant emission transfer is the key concept in the PHH.

The concept of PHH was first introduced by Pethig (1976). He rightly pointed out that the developing countries usually enjoy a comparative advantage in producing environment-intensive goods to trade them for economic benefits. However, the countries may have to forgo welfare decisions if such goods are produced without considering suitable environmental controls and protections. Moreover, Walter and Ugelow (1979) also support by stating that developing countries do implement lenient environmental regulations to attract pollution-intensive production investments from developed countries. The degree of permissiveness is subjective according to a country's own standards and targets.

The validity of PHH depends on the various environmental policy instruments and the industries involved in Zheng and Shi (2017). The existence of the PHH is also heavily subjected to the economic state of the countries and the nature of their various sectors

(Zhang and Wang, 2021). That is why empirical studies are not able to universally accept this hypothesis. Nonetheless, there have been many studies arguing the validity of PHH over the time and some researchers have even confirmed mixed findings. A study was conducted to test whether FDI inflows degrade the quality of the environment in developing countries or not. An empirical analysis was undertaken for the same in terms of the BRICS countries. The results showed a mixed effect in case of Brazil and Russia. For China and South Africa, the effect of FDI inflow was rather positive and advantageous for their environmental aspects. On the other hand, the same had an adverse effect on the environment of India. The same findings were pointed out by Khan et al. (2020) when the PHH was empirically established in the context of India and Pakistan in contrast to China. In China's case, FDI inflow was considered to be an improvement factor for the quality of its environment.

Cole (2004) has confirmed the PHH even though it may exist for a shorter period of time in certain industries or regions. Singhania and Saini (2021) tested the PHH in 20 countries and empirically found that the existence of the hypothesis is much more evident in developing countries. Another study also confirms the PHH by concluding that the environmental policies have a significant effect on FDI decisions. To be more precise, the volume of FDI inflows in production sectors is more for countries with permissive environmental regulations (Yoon and Heshmati, 2021). There are several other researches which have empirically presented the validity of PHH in different regions and sectors (Mani and Wheeler, 1998; Silva and Zhu, 2009; Hille, 2018; Shen et al., 2019; Duan et al., 2021).

However, van Beers and van den Bergh (1997) pointed out that the strictness of environmental regulations does not necessarily increase the import volume of a country. Rather, a negative relationship was established between the two variables. Likewise, some other studies have also opposed to the PHH through empirical analysis. Antweiler et al. (2001) surprisingly found that a free trade economy may actually help in bettering the environment. Kearsley and Riddel (2010) found that neither trade openness nor dirty industrial product imports are correlated with the increased pollution level. Thus, the study has rejected the PHH due to very weak and insignificant relations between the variables. A study on EU countries documented very weak evidence for PHH only in some footloose and dirty industries. They rather found a clearer indication of Porter hypothesis which explains that stringent environmental regulations result in cleaner and more environment friendly innovations in technologies for the country (Martínez-Zarzoso et al., 2016). There have been lots of other studies which have proved that HPP is not acceptable for all economies (Birdsall and Wheeler, 1993; Tobey, 2001; Shao et al., 2019; Nathaniel et al., 2020).

The PHH is considered to be a very crucial concept for all economies. It helps in safeguarding one's environmental conditions by showing how economic policies can significantly affect one's environment. The PHH has the potential to explain the shortcomings of various trade and environmental regulations of a country and maintain a good and harmless balance between them.

Correspondingly, the viability of PHH in India has been proved to be somewhat debatable. Yilanci et al. (2020) have confirmed the hypothesis in India. It was empirically documented that FDI inflow harms the environmental aspects of the country through ecological footprint and carbon footprint. Khan et al. (2020) also discovered the same results stating that FDI inflows adversely affect the ecological footprints and thus, approves the truthiness of PHH in India. Another study explains that FDI helps in improving India's economic growth granted that it also causes decline in environmental quality. The study suggests to improve more stringent and safer environmental policies in India as the country may have already become a pollution haven for outsiders (Rana and Sharma, 2019). However, one of the studies presents an opposite picture and denies the argument that PHH is valid for India. It reports that despite being a developing country with relatively reluctant emission authorisation, India is actually involved in exporting less volumes of dirty goods and more of environment-friendly and clean products (Dietzenbacher and Mukhopadhyay, 2007). Sawhney and Rastogi (2015) have stated that India has still not turned into a pollution haven even though various dirty industries are still functioning in the country.

The studies fail to conclude whether India is a pollution haven or not. The PHH validity can imply how the foreign countries perceive India's industrial and environmental regulations and whether they take advantage of the same. The PHH confirmation can identify if any measures or changes are required to be implemented in that aspect. To find out the same, the following hypothesis is formulated:

H_2 There exist a significant positive relationship between FDI inflow and environmental degradation in India.

3 Data and variables

3.1 Variable description

The study is based on secondary data for Indian economy. Time series data (annual) for the period of 1970 to 2018 has been considered. The choice of the period is conditional on the availability of information. All information on variables has been collected from World Bank Open Data.

The study has carefully chosen the indicators as per the requirements to test the EKC and PHH in India. GDP per capita is considered to be one of the most commonly used indicators for economic growth. Various studies have used the same as an independent variable for testing EKC hypothesis (Bertinelli and Strobl, 2005; Maddison, 2006; Xu, 2018; Mania, 2020). Likewise, per capita emission of CO_2 is also widely used as a dependent variable to test the truthiness of the EKC in a country or economy (Heerink et al., 2001; He and Richard, 2010; Fernández et al., 2012; Lawson et al., 2020). CO_2 is one of the most common forms of air pollution. An increase in carbon emission level owing to greater consumption of energy causes air pollution and adds to environmental degradation.

CO_2 emissions per capita have been a key measure for environmental degradation in testing the PHH as well (Sun et al., 2017; Zhang et al., 2017). Again, the FDIs is also a crucial independent variable to test whether its inflows have turned an economy into PHH or not (Feridun et al., 2006; Liu et al., 2018; Sarkodie and Strezov, 2019).

Moreover, previous researches have already verified that variables like industrialisation (Sharmin and Tareque, 2018; Hettige et al., 2000; Du and Xie, 2020), population density (Shen, 2006; Apergis and Ozturk, 2015) and urbanisation (Torras and Boyce, 1998; Heerink et al., 2001) have their significant effect on the quality of the environment. Thus, these variables are taken as explanatory variables for this study.

In a nutshell, to test the two hypotheses of the study, the chosen indicators and variables have been shown in Table 1.

Table 1 List of variables

Variable	*Indicator*	*Abbreviation*	*Nature*
Environmental degradation	CO_2 emission per capita	CO_2	Dependent variable
Economic growth	Log of GDP (constant LCU)	ln*GDP*	Explanatory variable
Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	*FDI*	Explanatory variable
Industrialisation	Log of manufacturing value added (constant LCU)	ln*MVA*	Explanatory variable
Population density	Log of population density (people per sq. km of land area)	ln*POP*	Explanatory variable
Urbanisation	Urban population (% of total population)	*UPOP*	Explanatory variable

Source: Authors' compilation

3.2 Data source

The data on most of the variables are available for the period of 1960–2020 on World Bank Open Data. However, the FDI indicator is only available from 1970 to 2020 and the CO_2 emission measures are available only for 1960 to 2018. Thus, to keep the uniformity of time period across all the variables, the timeline has been chosen from 1970 to 2018. It ensures that data for all the variables are available for the chosen timeline.

4 Methodology

4.1 Unit root test

Unit root test is often used to check whether stationarity exists in variables or not for time series empirical studies. For this study, augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) and Phillips-Perron (PP) test (Phillips and Perron, 1988) are used for the same.

Sometimes, it may happen that a single unit root test does not provide the accurate or actual results regarding the stationarity of the variables. To ensure the robustness of the tests, both ADF and PP tests have been selected. If both the tests show the same results, the data's stationarity or non-stationarity will not be questionable. In both the tests, the null hypothesis states that the time series variable has a unit root, i.e., it is non-stationary.

The ADF and PP unit root tests are performed considering Schwarz information criterion (SIC) for the study. The SIC is one of the most widely used criterion in unit root tests to select the optimal lag length.

4.2 Autoregressive distributed lag bounds test

The autoregressive distributed lag (ARDL) method is widely used to check the cointegration between variables in time series data (Pesaran et al., 2001). The test is applicable if the unit root tests show that the variables are integrated either at I(0) or I(1). The ARDL test can empirically quantify the effects of one variable on another by considering other explanatory variables at the same time. If the data conforms to all the assumptions for performing the test, ARDL can be used to test whether cointegration exists or not among the dependent and explanatory variables of the study. The test can give the results to check whether any significant relationship exists among the variables. The statistical results of the variables can quantify the effects of the regressors on the dependent variable. Likewise, the coefficient of the regressors can imply the degree of impact, if any. The ARDL bounds test can signify the relationships between variables in the short-run and long-run periods. Moreover, to conduct the ARDL bound test, vector autoregression (VAR) lag order selection criteria have been used to determine the optimal lag length. The VAR model is performed considering the Akaike information criterion (AIC) and SIC. The standard ARDL equation considering the variables of this study will be,

$$\begin{aligned}\Delta(CO_2)_t &= \alpha_0 + \beta_1 (CO_2)_{t-1} + \beta_2 \ln GDP_{t-1} + \beta_3 \ln GDP_{t-1}^2 + \beta_4 \ln MVA_{t-1} \\ &+ \beta_5 \ln POP_{t-1} + \beta_6 UPOP_{t-1} + \beta_7 FDI_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta(CO_2)_{t-i} \\ &+ \sum_{j=1}^{q} \alpha_{2j} \Delta \ln GDP_{t-j} + \sum_{k=1}^{r} \alpha_{3k} \Delta \ln GDP_{t-k}^2 + \sum_{l=1}^{s} \alpha_{4l} \Delta \ln MVA_{t-l} \\ &+ \sum_{m=1}^{t} \alpha_{5m} \Delta \ln POP_{t-m} + \sum_{n=1}^{u} \alpha_{6n} \Delta UPOP_{t-n} + \sum_{h=1}^{v} \alpha_{7h} \Delta FDI_{t-h} + \mu_t\end{aligned} \quad (1)$$

In the above equation, α_0 is the intercept value of the equation and μ_t is the error term. *GDP*, GDP^2, *MVA*, *POP*, *UPOP* and *FDI* represents gross domestic product, gross domestic product square, manufacturing value added, population density, urbanisation and foreign direct investments, respectively. To remove large variations in the values, natural log of *GDP*, GDP^2, *MVA* and *POP* are used. The null hypothesis for the ARDL bounds test is:

$H_o \quad \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7.$

The above equation of the null hypothesis represents that there exists no significant cointegration among the variables. The alternative hypothesis is that at least one β-value is non-zero, i.e., any one $\beta \neq 0$. It means that a significant cointegration is present among the variables. After implementing equation (1), the F-test value is observed, comparing it to the lower bounds and upper bounds critical values (Pesaran et al., 2001). The F statistic value represents the joint significance level of coefficients of the lagged variables. There may be three cases depending on the value of the F-test:

- If the F-test value is more than the upper bound critical values, it allows to reject the null hypothesis, i.e., a cointegration relationship exists among the variables.
- If the F statistic value lies between the upper bound and lower bound critical value, the result is inconclusive, i.e., there is lack of evidence to comment whether cointegration exists or not.

- If the F-test value is lower than the lower bound critical value, there lies no cointegration among the variables, i.e., the null hypothesis is accepted.

Once the cointegration is established with empirical evidence, the long-run relationship between the dependent variable and regressors is observed. To do so, the following equation is formulated and tested:

$$(CO_2)_t = \vartheta_0 + \vartheta_1 \ln GDP_t + \vartheta_2 \ln GDP_t^2 + \vartheta_3 \ln MVA_t + \vartheta_2 \ln POP_t + \vartheta_6 FDI_t + \theta_t \quad (2)$$

Here, the λ_i represents the coefficient of the long-run effects of the regressors on the dependent variable. The curve derived from the above equation will have an inverted U-shape only if $\lambda_1 > 0$ and $\lambda_2 < 0$.

Once the long-run cointegration is established, the ARDL test can be used to check the short-run dynamics. The ARDL short-run model is also called the error correction model (ECM). The most crucial part of the short-run model is the error correction term (ECT). The significance of the ECT and its coefficient value is tested through the model. Ideally, a significant coefficient value of ECT lies between the range of 0 and –1. In that case, the ECT coefficient depicts the speed of adjustment to restore the long-run equilibrium. The equation for the ECM is as follows:

$$\begin{aligned}\Delta(CO_2)_t &= \gamma_0 + \sum\nolimits_{i=1}^{p} \gamma_{1i} (CO_2)_{t-1} + \sum\nolimits_{j=1}^{q} \gamma_{2j} \Delta \ln GDP_{t-j} + \sum\nolimits_{k=1}^{r} \gamma_{3k} \Delta \ln GDP_{t-k}^2 \\ &+ \sum\nolimits_{l=1}^{s} \gamma_{4l} \Delta \ln MVA_{t-l} + \sum\nolimits_{m=1}^{t} \gamma_{5m} \Delta \ln POP_{t-m} + \sum\nolimits_{n=1}^{u} \gamma_{6n} \Delta UPOP_{t-n} \\ &+ \sum\nolimits_{h=1}^{v} \gamma_{7h} \Delta FDI_{t-h} + \theta ECT_{t-1} + \pi_t.\end{aligned} \quad (3)$$

4.3 Diagnostic tests

To ensure that all the assumptions for conducting the ARDL test are fulfilled and the equation model fits all the criteria, specific diagnostic tests are performed. A histogram normality test can be undertaken using the Jarque-Bera model to ensure that residual values are normally distributed. The null hypothesis of this test is that the data is normally distributed. The serial correlation LM test is also performed considering the null hypothesis that no serial correlation exists in the dataset. Likewise, the Breusch-Pegan-Godfrey (heteroscedasticity) test is performed using the null hypothesis, which states that no heteroscedasticity exists. Also, the CUSUM test and CUSUMSQ tests are considered for testing the stability of the long-run and short-run parameters. The residual diagnostic tests help in strengthening the model and ensure that conclusions are reliable.

4.4 Partial least square structural equation model

The partial least square structural equation model (PLS-SEM) is a technique that researchers have been using to establish relationships between latent variables. PLS-SEM can simultaneously accommodate multiple indicators for multiple latent variables and infer causal relationships (Wang et al., 2021; Manley et al., 2021). Additionally, it provides a graphical representation of all the variables for easy understanding. The study uses PLS-SEM to determine if a causal relationship is present from economic growth to environmental degradation in India, considering multiple indicators at once.

To test the causality, data from the World Bank Open Data has been chosen in the context of India. The timeline is considered from 1990 to 2018 to maintain the uniform availability of all the observed indicators. This study observes two latent variables: economic growth and environmental degradation. The former latent variable is provided with four indicators and three indicators for the latter.

As mentioned earlier, the GDP has always been the most commonly used indicator for economic growth. Moreover, past studies have already established that FDIs (Yao and Wei, 2007; Wu et al., 2020), exports (Rangasamy, 2009; Kalaitzi and Cleeve, 2017) and life expectancy (Azomahou et al., 2009; He and Li, 2020) can determine economic growth. All four indicators are considered to represent the economic growth for the PLS-SEM test. CO_2 emissions have been taken to measure environmental degradation as stated earlier. In addition, nitrous oxide (Shaheen et al., 2020; Majeed et al., 2021) and methane (Scheutz et al., 2009; Leytem et al., 2017) emissions have also been chosen to indicate the same. Table 2 gives a summary of all the latent variables and their indicators that are assessed for this study.

Table 2 Variables and indicators (for PLS-SEM)

Latent variable	*Abbreviation*	*Indicators*	*Abbreviation*
Economic growth	EG	Gross domestic product per capita (constant LCU)	EG1
		Foreign direct investments, net inflow (% of GDP)	EG2
		Exports of goods and services (% of GDP)	EG3
		Life expectancy at birth, total (years)	EG4
Environmental degradation	ED	CO_2 emissions (kt)	ED1
		Nitrous oxide emissions (thousand metric tons of CO_2 equivalent)	ED2
		Methane emissions (kt of CO_2 equivalent)	ED3

Source: Authors' compilation

The Cronbach's alpha is obtained to assess the composite reliability of the model. Any value greater than 0.70 is a good mark for this test. The composite reliability tests the internal consistency of the variables. A higher composite reliability value indicates higher consistency. The average of variance extracted (AVE) indicates the amount of variance captured by a construct concerning the amount of variance due to any measurement error. Any value more than 0.50 is acceptable in this regard. On the other hand, the standardised root mean square residuals (SRMR) reflect the difference between observed correlation and the model implied correlation matrix. The rule of thumb states that its value should be between 0 and 0.08.

5 Empirical results

5.1 ADF and PP unit root tests

Table 3 reports the results of the ADF and PP unit root tests. All variables except UPOP are stationary at I(1), which is confirmed by both the tests. Here, only UPOP is stationary at I(0).

Table 3 Unit root test results

Variables	*ADF test*				*PP test*			
	With intercept		*With trend and intercept*		*With intercept*		*With trend and intercept*	
	I(0)	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*
CO_2	4.43	–2.38	0.27	–7.04*	4.20	–5.36*	0.18	–7.06*
ln*GDP*	3.32	–6.51*	–2.38	–8.18	4.83	–6.52*	–2.68	–10.25*
ln*GDP^2*	3.73	–6.21*	–2.12	–8.18*	5.82	–6.22*	–2.50	–10.86*
ln*MVA*	1.87	–5.42*	–2.07	–5.71*	4.58	–5.28*	–1.54	–8.23*
ln*POP*	-	–0.95	0.66	–3.88**	–8.87*	2.64	6.32	–3.63**
UPOP	–0.22	–4.71*	–3.23***	–4.62*	–0.49	–4.53*	–3.47***	–4.40*
FDI	–1.54	–7.89*	–2.99	–7.80*	–1.46	–8.11*	–2.99	–8.01*

Note: *indicates significance level at 1% level, **indicates significance level at 5% and *** indicates significance level at 10%.

Source: Authors' own calculation

5.2 ARDL bounds test

The ARDL bounds test results are shown in Table 4. To perform the same, the optimal length is chosen to be four considering the VAR model. The test results in Table 4 show that the null hypothesis of no cointegration is rejected. As discussed earlier, the significance of the cointergration relationship depends on the F-statistics which has been found to be greater than the critical value of the lower and the upper bound in this study. Thus, the ARDL bounds test confirms cointegration among the variables.

Table 4 Results of ARDL bounds test

Estimated model	F_{CO_2} (*CO_2* / ln*GDP*, ln*GDP^2*, ln*MVA*, ln*POP*, *UPOP*)
Optimal lag length (AIC)	(1, 3, 3, 2, 4, 0, 3)
F-statistics (bound test)	6.77
Critical values	5% significance
Lower bound I(0)	2.27
Upper bound I(1)	3.28

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

The ARDL long-run cointegration test results have been listed in Table 5. Table 5 contains the long-run coefficients of all the regressors and their significance on the dependent variable, i.e., CO_2 emission.

Table 5 Long-run cointegration results

Regressor	*Coefficient*	*Standard error*	*t-statistics*
ln*GDP*	–40.12	9.533	–4.209***
ln*GDP*^{2}	1.442	0.321	4.485***
ln*MVA*	1.719	0.453	3.798***
ln*POP*	0.027	1.953	0.013
UPOP	–0.018	0.04	–5.14***
FDI	–0.002	0.017	–0.122
Constant	258.621	65.097	3.972***
R^2	0.999		
Adjusted R^2	0.998		

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

According to the test results in Table 5, it is clear that *GDP* and *GDP*^{2} have significant relationships with CO_2 emission. The coefficient values show the degree and direction of impact on the dependent variable by the regressors. It depicts that a % increase in the log of GDP will bring down the level of CO_2 emissions by 40.12%, i.e., a negative relationship exists between the variables. However, a % growth in log of GDP square will increase India's CO_2 emission level by 1.442%, resulting in a positive relationship. In contrast to the traditional inverted U-shaped EKC, this study confirms that the relationship between economic growth and environmental degradation portrays a U-shaped curve in India. It is confirmed by the negative and positive coefficient values of ln*GDP* and ln*GDP*^{2}, respectively. As a result, H_1 is rejected, implying that the EKC hypothesis is not valid in India. The results indicate that in the early stages of economic growth, GDP helps in reducing the CO_2 emission level in India. After a certain growth point, economic growth will encourage an increase in CO_2 emissions.

However, population density and FDIs fail to impact the CO_2 emission significantly. Due to the lack of significance on CO_2 emission levels by FDIs in India, H_2 is rejected. The rejection of the H_2 confirms that the PHH is invalid or does not hold true for the country. Additionally, the empirical results clearly represent that urbanisation can decrease 0.018% of CO_2 emissions in India. Conversely, industrialisation growth will raise the CO_2 emissions level by 1.719%. The R^2 and adjusted R^2 prove the fitness of the model specifications.

Previous studies have also empirically proved such a U-shaped curve for India, rejecting the traditional EKC hypothesis (Asumadu-Sarkodie and Yadav, 2019; Ansari et al., 2020). Thus, the findings of this study do not entirely deviate from the past findings on the Indian economy established on the nature of the EKC curve. It reflects that even though in the short-run, economic growth may not harm the environment but in the long-run, it can have a disadvantageous effect on the environment. It is the complete opposite of what the original EKC hypothesis instructs. The U-shaped curve suggests the government take measures and bring changes to the different industrial and environmental policies to fulfil sustainability goals. Preference should be given to upgrading and innovating more efficient energy sources which are environment friendly (Park and Lee, 2011; Hasanov et al., 2019; Mehmood and Tariq, 2020). The invalid EKC hypothesis also infers that India is still a developing economy. Studies in existing literature have also revealed that the hypothesis mostly proves to be valid for developed countries.

Moreover, it is found that an increase in industrialisation encourages CO_2 emission levels in India. The result is supported by previous studies showing a significant positive relationship between the two variables (Asumadu-Sarkodie and Owusu, 2016, 2017; Pata, 2018; Zhao et al., 2018; Aslam et al., 2021). Industrialisation is an integral part of achieving economic growth. However, it often leads to the emission of various kinds of pollutants and degrades the quality of the environment (Cherniwchan, 2012). It may indicate that the technologies used by the industries are not very environment-friendly. Advanced technologies should be implemented to tackle such issues and innovations should be encouraged so that the industrial sector does not harm the environment by increasing CO_2 and other pollutant emissions.

On the other hand, according to the test results, an increase in urbanisation casts down the environmental degradation level. It gives a new opportunity for the policymakers to control emission levels through appropriate planning of urbanisation. The result shows a capacity for urbanisation to impact environmental safeguarding. Traditionally, urbanisation is expected to result in more CO_2 emissions for a country. However, the scenario may differ in reality. After a certain level of urbanisation, it has been studied that it can potentially control emission levels of various pollutants (Martínez-Zarzoso and Maruotti, 2011; Sadorsky, 2014). Urbanisation brings economic prosperity, new technologies and more awareness to the people. People demand more environment-friendly products and functions from business organisations. Thus, environmental protection becomes a crucial factor for all (Lin et al., 2016). Sharma (2011) explains that urbanisation may initially increase pressure on natural resources. However, in the long-term, the people's environmental concerns lead to stricter environmental policy implementations in urban areas.

The rejection of PHH in India is also supported by previous studies (Dietzenbacher and Mukhopadhyay, 2007). While various polluting industries operating in India are evidently harming the environment, the country is still away from being a pollution haven for others (Sawhney and Rastogi, 2015). It means that the foreign countries are not able to transfer their pollutant industries through investments in India. However, this still raises concerns about environmental protection policies and foreign investment regulations. Even though stricter policies are implemented for the country, pressure for producing dirty products continues in the economy. India is considered to have specialised in several dirty industries. Exporting such emission-intensive products is still persistent for the country (Banerjee et al., 2021). So, it is hinted that whether PHH is valid or not, India should take measures to navigate its foreign investments to refrain from the operation of such polluting industries.

In Table 6, the ARDL short-run model results are shown. The relationship between GDP and CO_2 is significant with a time lag of two in the short-run. The same result is applicable for GDP^2 and CO_2 also. Likewise, all the other coefficients of the regressors are significant except for the contemporary difference of MVA, POP and FDI. However, the most crucial result of this model is the ECT_{t-1} and its significance. The coefficient of the same is between –1 and 0 with the significance level at 1%. It proves that the ECT_{t-1} coefficient is valid. The results in Table 5 suggest that any deviation from the long-run equilibrium will be corrected by 94% over a year. The significant coefficient value of *ECT* also proves that long-run causality is valid among the variables. The R^2 and adjusted R^2 values confirm the fitness of the model.

Table 6 Short-run cointegration results

Regressor	*Coefficient*	*Standard error*	*t-statistics*
$\Delta \ln GDP_t$	6.319	11.589	0.545
$\Delta \ln GDP_{t-1}$	20.861	15.058	1.385
$\Delta \ln GDP_{t-2}$	66.070	14.434	4.621*
$\Delta \ln GDP_t^2$	–0.246	0.438	–0.563
$\Delta \ln GDP_{t-1}^2$	–0.759	0.565	–1.344
$\Delta \ln GDP_{t-2}^2$	–2.543	0.543	–4.680*
$\Delta \ln MVA_t$	0.363	0.250	1.450
$\Delta \ln MVA_{t-1}$	–0.819	0.249	–3.282*
$\Delta \ln POP_t$	–384.453	198.647	–1.935***
$\Delta \ln POP_{t-1}$	819.689	530.900	1.544
$\Delta \ln POP_{t-2}$	–1,021.579	525.170	–1.945***
$\Delta \ln POP_{t-3}$	549.097	193.114	2.843*
$\Delta UPOP_t$	–0.173	0.045	–3.856*
ΔFDI_t	0.009	0.008	1.073
ΔFDI_{t-1}	0.023	0.008	2.790**
ΔFDI_{t-2}	–0.022	0.007	–3.167*
ECT_{t-1}	–0.941	0.111	–8.447*
R^2	0.838		
Adjusted R^2	0.755		

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

5.3 Diagnostic tests

The results of the various diagnostic tests are presented in Table 7.

The diagnostic test results confirm the fitness of this model by stating that the model has homoscedasticity, no serial correlation and is normally distributed in terms of its residual values. The results of the CUSUM and CUSUMSQ tests in Figure 1 and Figure 2, respectively, imply that the short-run and long-run parameters are stable at a 5% significance level.

Table 7 Diagnostic test results

Name	*F-statistics (p-value)*
Serial correlation LM test	1.042 (0.371)
Jarque-Bera (histogram of normality) test	1.989 (0.367)
Breusch-Pegan-Godfrey (heteroscedasticity) test	0.605 (0.863)

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

Figure 1 Plots of CUSUM for estimated the ECM model (see online version for colours)

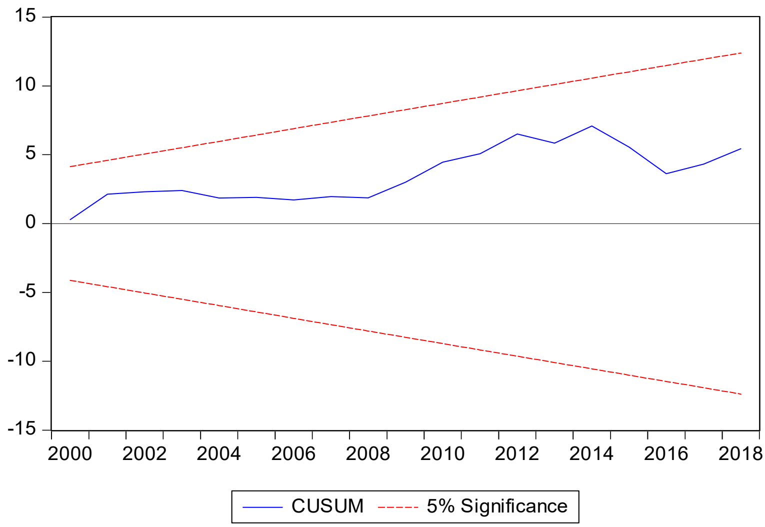
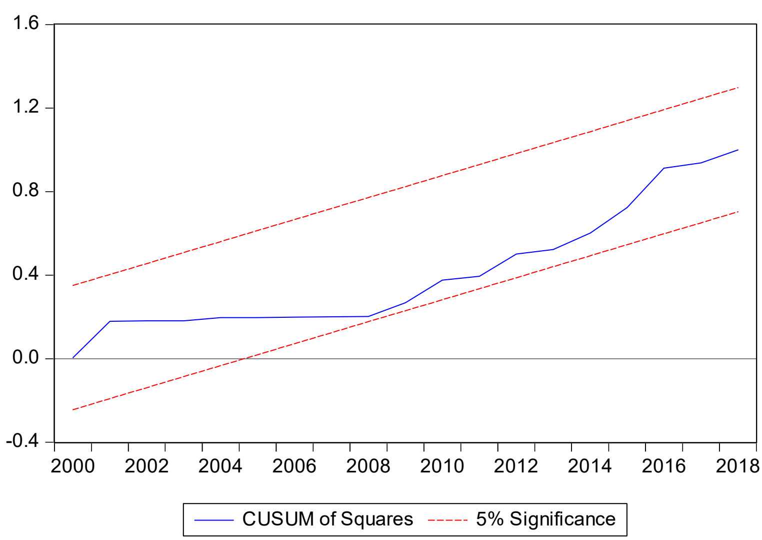


Figure 2 Plots of CUSUMSQ for the estimated ECM model (see online version for colours)



5.4 Partial least square structural equation model

The results of PLS-SEM indicate a causal relationship between economic growth and environmental degradation. Table 8 reports the statistical results of the empirical test. The results state that a significant causal relationship flows from economic growth to environmental degradation at 1% significance level. Also, the path coefficient verifies that economic growth positively affects environmental degradation, which means that increased economic development results in an increase in environmental degradation. The R^2 and adjusted R^2 values imply that the economic growth indicators can explain 97% of the variations in environmental degradation.

Table 8 PLS-SEM test results

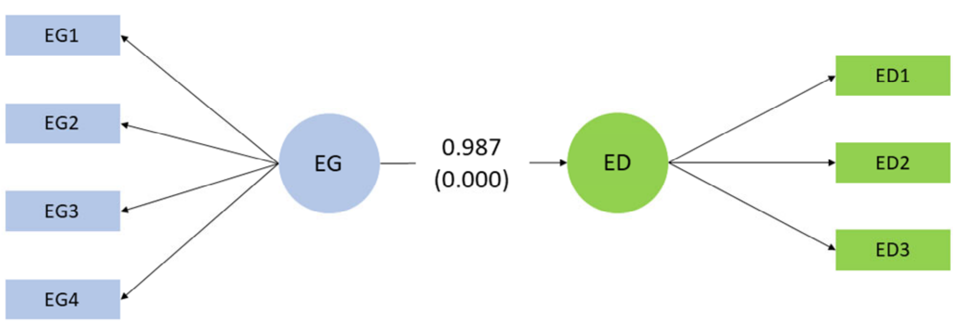
Path	EG → ED
Path coefficient	0.987*
p-value	0.000
R^2	0.973
Adjusted R^2	0.972

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

Figure 3 provides a graphical representation of the PLS-SEM test results with the flow of causal direction between EG and ED. The path coefficient (p-value) represents the positive effect and its significance.

Figure 3 PLS-SEM results (graphical) (see online version for colours)



Source: Authors' own calculation

Table 9 PLS-SEM fitness results

Test results	*EG*	*ED*
Cronbach's alpha	0.98	0.95
Composite reliability	0.99	0.96
AVE	0.97	0.86
SRMR	0.06	

Source: Authors' own calculation

To verify whether the results are reliable or not, additional tests validating the model fitness are shown in Table 9.

The results in Table 9 satisfy all the criteria of the model fitness tests to ensure that its results are reliable and consistent. Thus, the causal relationship established by the model is significant and valid.

6 Robustness test

The study further tests the EKC hypothesis in India as per the new approach developed by Narayan and Narayan (2010). The approach suggests that if the long-run GDP elasticity on CO_2 emission is of lower value than that of the short-run, it depicts that the CO_2 emission level decreases over time. As a result, this reduction in its emissions indicates the validity of the inverted U-shaped EKC hypothesis. To conduct it as a robustness test for the findings in the present study, equation (5) has been formulated.

$$\ln CO_{2_t} = \alpha + \beta_1 \ln GDP_t + \varepsilon_t \tag{5}$$

In equation (5), $\ln CO_2$ and $\ln GDP$ refer to the natural log of CO_2 emission (kiloton) and the natural log of GDP (constant LCU) in India. The ADF and PP unit root tests define that both the variables are stationary at I(1). Thus, the long-run and the short-run elasticity can be calculated from the long-run cointegration test and short-run ECM through the ARDL approach. The results are shown in Table 10.

Table 10 Long-run and short-run elasticity and ECT

Regressors	*Coefficient*
(Long-run test)	
$\ln GDP$	0.958*
(Short-run test)	
$\Delta \ln GDP$	0.052
ECT	–0.055*

Note: *indicates significance level at 1% level, **indicates significance level at 5% and ***indicates significance level at 10%.

Source: Authors' own calculation

Table 10 reports that the long-run elasticity of $\ln GDP$ on $\ln CO_2$ is 0.958 and it is significant at 1% level. The ECT coefficient of the short-run equation also verifies a long-run cointegration, which is significant at 1% level. However, the short-run coefficient is not significant. It only implies that the results are inconsistent with the EKC hypothesis in India. It supports the previous findings of Narayan and Narayan (2010). They have reported an invalid EKC in India in the same manner.

7 Policy implications

The study results of an invalid EKC indicate crucial policy measures regarding India's industrial and environmental regulations. As a developing economy, India has to formulate its plans and policies carefully, considering future generations' safety and health. The U-shaped curve in the Indian economy can foresee the abuse of the industries on its environment in the coming years. India's regulations should be stricter and more compelling regarding the usage of technologies and energy resources.

The positive coefficient of industrialisation implies that the industrial sector requires attention. The advancement of the industries is an inevitable part of any country's economic prosperity. It helps a country in two primary ways. The first is helping the economy become self-reliant and fulfil its domestic demand for products. The second primary benefit of industrialisation is to earn foreign currencies by exporting its products to foreign lands. However, this industrialisation advancement should include two aspects: generating more economic benefits and becoming harmless to the environment simultaneously. It is the responsibility of the government and other concerned authorities to keep in check from time to time whether the industries are following the environmental regulations correctly or not. Likewise, the industries should also bear it as their duty and responsibility to steer their activities with the vision of sustainability. They should try to adhere to the government's guidelines without taking advantage of the loopholes.

The empirical test results show that the Indian economy can reduce harmful environmental activities through proper policy handling of urbanisation. The negative and significant coefficient of urbanisation indicates that it may help improve the quality of India's environment over the years. The people living in urban areas have become more aware and concerned about protecting the environment nowadays. They try to promote organic and environment-friendly products and brands. The concept of 'green products' has recently been marketed aggressively, especially in urban areas. However, urbanisation can lead to GHG emissions in the transportation sector significantly. So, the policies are to be handled and implemented with utmost attention so that urbanisation does not portray any adverse effects on the environment in the forthcoming years.

The population and FDIs reveal insignificant effects in encouraging CO_2 emissions. However, these results are attained assuming that the economy's policies and other related conditions remain unchanged over time. We can only expect the same insignificant effects of the variables if the situation continues to be in effect the same way. There is a possibility that population density and FDIs may also contribute to pollution if the policies are not maintained properly. The literature has shown us how the developing countries have become pollution havens for developed countries. So, the environmental and industrial policies should be effective enough to protect the country's environment from outsiders.

8 Conclusions

Based on the analysis presented in this paper, we find evidence of a U-shaped EKC for the Indian economy while using carbon emission as the indicator for environmental degradation. Future studies may consider different variables and methodologies to test the EKC hypothesis for the economy. The production system in a developing country like India fails to take into account the environmental impact of the production process and overuse of natural resources in the initial stages, which later may have serious consequences on the environment. According to the empirical results, formulating and implementing India's environmental policies is crucial in the short-run. Correspondingly, the long-run coefficients demonstrate how economic development can potentially harm the environment. To preserve the environment and its natural resources, the concerned authorities can take certain steps such as:

a spreading awareness about the matter

b emphasising on using renewable energy sources

c encouraging to use cleaner and environment-friendly technologies

d implementing stricter policies to control and direct investments regarding the emission-intensive industries.

As Ganda (2018) has rightly pointed out, developing countries like India have to emphasise more on improving technologies and using alternative environment-friendly energy sources in order to reduce carbon emission levels. Such crucial steps can help achieve a developed Indian economy by preserving the environment for future generations in the coming days.

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