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Investigating the Pollution Heaven Hypothesis and Environmental Kuznets Curve: Evidence from Panel ARDL Approach

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Abstract: *This paper investigates the existence of pollution haven hypotheses (PHH) and the Environmental Kuznets Curve (EKC) for top five (China, Canada, Germany, Brazil, And France) carbon dioxide emitter countries during 1990-2018. The current study uses a panel autoregressive distributed lag (PARDL) technique to obtain empirical outcomes. The estimated results demonstrate the error-correction term's significant and adverse impact and the system's conversion to long-run equilibrium following a shock. The results of the short run and long term indicate that carbon dioxide emissions are positively associated with EC (energy consumption) and are statistically significant. For both the short run and long run the coefficients of GDP and the square of GDP are positive and significant respectively. This endorses the EKC relationship for the panel of these countries. The forest variable indicates that the short-run result predicts that forests are negative but insignificant relation with Carbon dioxide emission, while in the long run; it shows also a negative significant association. Domestic capital is positive and significant in the short-term analysis, while in the long run association between corban dioxide emission and domestic capital is also positive and significant. The foreign capital is negative and significantly linked to Carbon dioxide emission in the long-run analysis, which rejects the pollution heaven hypothesis in these countries. Furthermore, these nations should to switch to using cleaner, more environmentally friendly energy sources, like renewable energy sources. These nations must implement policies that do not hinder national economic expansion while achieving the goal of lower carbon dioxide emissions.*

Keywords: PHH, EKC, PARDL, Domestic capital, foreign capital, Carbon dioxide.

Introduction

Global warming and climate change is the most challenging environmental issue confronting the world. The lives of millions human being and other species are at danger, so this issue has received a lot of attention from academics and the research community (Destek & Sarkodie, 2019). Global warming is believed to be mostly caused by greenhouse gases, with carbon dioxide accounting for 79% of these gases. To tackle the issue of curtailing the emission of greenhouse gases, scientists, social workers have raised their voices at different public forums. Policy makers and politician were compelled to address the

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global issue of environmental degradation, including signing 1997 Kyoto Protocol and the 2015 Paris Climate Agreement. The Kyoto Protocol's main goal was to put the UNFCCC (United Nations Framework Convention on Climate Change) into action by demanding developed and developing countries to set individual targets to limit and diminish greenhouse gas emissions. As a result of the global industrialization process, all countries have witnessed rapid economic growth. The ongoing improvement in energy use is responsible for rapid economic expansion. The economic expansion causes an increase in carbon dioxide emanations. The deepening of the situation has resulted in global climate change. The existence and well-being of people all around the world are threatened by greenhouse gas emissions. Concerns over industrialization and economic development has become a global phenomenon. Since 1960s, environmental issues have risen over the world, forcing governments to pay more and more attention and consideration to environment while devising economic plans. In addition to signing the Kyoto Protocol, the globe has hosted numerous "Rio Conferences," "Kyoto Conferences," and "Copenhagen Conferences." The European Union (EU) target on sustainable development is part of Europe's (2020-2030) plan for sustainable growth that sets the aim for the reduction of CO_2 emissions. Furthermore, the climate activities will attempt their best to decline the GHG emissions from 20 percent and 40 percent from (2020-2030) respectively. Furthermore, these goals are included in the EU-2050 to reduced CO_2 emissions in the environment. Which further stresses the member countries that all sectors of the economy must contribute to reducing GHG emissions in order to achieve 80% decline in Green House Gas emissions compared to 1990 levels. Energy is one of the most critical components in the manufacturing process, just as significant as labor and capital (Alam, Murad, Noman, & Ozturk, 2016). Energy is important in many aspects of the economy, including agriculture, transportation, trade, and economic development. Furthermore, the use of various types of energy is regarded as a vital complement for poverty alleviation, human development, and economic growth. The findings of the study reveal that as a country's GDP rises, it emits more carbon dioxide and that increased energy and electricity use has a negative impact on carbon emissions. Furthermore, imports and exports have both negative and positive implications, but non-renewable and renewable energy efficiency methods would aid the country's growth.

Forestry plays a key role in environmental protection. It offers wildlife a haven, regulates water flow, decreases erosion, and supplies clean water for fish farming. The forests through photosynthesis absorb a huge amount of carbon dioxide and emits oxygen to the environment. Biodiversity is found in forests. Moreover, through forests cyclones, extreme temperatures, landslides, and floods are all controlled naturally. The earth is also protected from erosion by the forest. In other words, forests act as a "carbon sink," absorbing a net 7.6 billion metric tons of CO_2 each year, 1.5 times the amount of CO_2 emitted by the United States. Harris et al. (2021) reveals that between 2001 and 2019, the world's forests stored roughly twice as much carbon dioxide as they emitted. As contrary to other economic sectors where carbon conducts a one-way trip to the atmosphere, forests act as a two-way highway, taking CO_2 while growing or replanting. The new map shows that protected areas are responsible for 27% of the global net forest carbon sink. When looking at specific places, it's clear how efficient these classifications are at storing Carbon dioxide in forests. Li and Wang (2017) recent study revealed that forest investment, rather than simply increasing total forest area, is the most realistic strategy for reducing carbon emissions in China. Forest management reforms would be an excellent policy for reducing pollution and creating jobs. Forests come in the top place when it comes to removing carbon dioxide from the atmosphere or reducing its emissions. Taeroe, Mustapha, Stupak, and Raulund-Rasmussen (2017) in their study looked at whether forests reduce carbon emissions by absorbing it or by offering firewood as an alternative to fossil fuels. They looked at three main kinds of European forests: managed forests, energy plantations, and specifically designated woods for carbon storage. It is important to note that forests have a higher potential to reduce carbon dioxide emissions than wood as a substitute for fossil fuels. Forests, on the other hand, can emit carbon because when a forest caught fire, carbon and many other dangerous chemicals are released into the air, according to Saranya, Reddy, and Rao (2016).

Foreign trade is important to the expansion of economies and contributes to rising CO_2 emissions. The traditional CO_2 emissions measure, which each country directly emits, receives a lot of attention in the literature now in publication. While the most alluring feature of carbon emissions, consumption-based CO_2 emissions that are adjusted for trade, receives less attention (Davis, Peters, & Caldeira, 2011).

Numerous studies have looked at the connection between CO_2 emissions and economic expansion. These studies have used Environmental Kuznets curve hypothesis and their extension version to explore CO2 emissions and economic growth relationship. According to EKC hypotheses, at the early stage of economic development environmental pollution increases positively, but later on with further economic development environmental pollution diminishes (Grossman & Krueger, 1991; Panayotou, 1993).

It is a hot debate among the researchers that difference in environmental regulations among countries leads to export their pollution intensive industries to the weaker environmental regulations countries. The Pollution Haven Hypotheses was named to describe the migrating pollution intensive industries to the less environmental standards countries (Grossman & Krueger, 1991; Copeland & Taylor, 2004).

Extensive literature is available on carbon emissions. The researcher looked at the relationship between CO_2 emissions and energy use, economic growth, and CO_2 emissions from several perspectives. However, in this instance, we are putting the Environmental Kuznets curve theory, which depicts the connection between CO_2 emissions and economic growth, to the test. By employing data from 1990 to 2020 using a panel Autoregressive Distributed Lag model, we attempt to understand how forestry, foreign capital, domestic capital, and energy consumption contribute to carbon emissions in the advanced polluting countries (Brazil, Canada, China, France, and Germany).

The second important part here will be test to the pollution haven hypotheses, where we constructed the two capital stocks series from the domestic and foreign direct investment series of the countries under investigation. Here, the impact of investment flow both domestic and foreign on the environmental degradation for the panel will be explored.

Literature Review

Due to the trade and investment barrier liberalization policies governments are competing for the inflow of FDI for accelerating their economic growth. The inflow of FDI is considered the backbone for domestic construction and stimulating economic growth. The inflow of these resources have positive as well as negative spillover effects on the environmental physiology of recipient countries. On one hand the technology is transfer, transfer of managerial skills across the borders to developing countries, which enables them to job opportunities and economic well-being. But, on other hand the pollution intensive industries directly or indirectly exploiting the natural resources and creates environmental degradation for the host countries (Lee, 2013; Omri, Nguyen, & Rault, 2014).

Since 1990's, the overflowing empirical work on the migrating pollution intensive industries to the countries of low environmental regulations. Which have examined the existence of pollution haven hypotheses (PHH) for the investment recipient countries (Jaffe, Peterson, Portney, & Stavins, 1995; Jeppesen, List, & Folmer, 2002). The literature examined the relationship of pollution indicators various variables by using different methodologies and their time period of the data. However, the evidence of supporting PHH are not remains persistent among the researchers. The first factor is the flow of foreign investment and environmental regulation and the second is the impact of FDI, trade on the pollution emission of the recipient countries. Preliminary research have studied the relationship of FDI and environmental regulations on the existence of pollution haven in the developed and developing countries (Jaffe et al., 1995; Eskeland & Harrison, 2003; Dean, Lovely, & Wang, 2009). The flow of pollution intensive industries to the from home countries to the host countries due to environmental regulations shows mixed results for the existence of PHH. The different industries show different results for the pollution emission. The flow of FDI from Germany in chemical industries show the existence of pollution haven but for primary metal and paper industries no validity of PHH were found (Kellenberg, 2009; Wagner & Timmins, 2009). Chung (2014) investigated that South Korean pollution intensive industries were migrated to the countries of looser environmental regulations. The nexus of installing dirty industries and environmental regulation of recipient countries are present but the existence of PHH still gives ambiguous results. This means that pollution export in terms of FDI and trade are not proved exclusively.

The another part of research studies has showed the impacts of FDI and trade on the creation of environmental pollution by using different models and indicators. Zhang, Zhu, and Hewings (2017); López, Arce, Kronenberg, and Rodrigues (2018) have applied multi-regional input-output analysis for examining trade effects on the global Carbon dioxide releases and validate the existence of pollution haven in China for other regions. Solarin, Al-Mulali, Musah, and Ozturk (2017) establishes the monotonic relationship between CO_2 emissions and FDI. Sarkodie and Strezov (2019) have verified the existence positive correlation between FDI and different pollutant indicators in developing countries. These empirical evidence advocated the existence of PHH in China, Iran, India , South Africa and Indonesia. Shao, Wang, Zhou, and Balogh (2019) studied the PHH existence and the casual association of environmental pollution and FDI, in addition with other environmental influencing factors for BRICS (Brazil, Russia, India, China and South

Africa) and MINT (Mixico, Indonesia, Nigeria, and Turkey) for the period of 1982-2014. They conducted the panel co-integration test and used panel vector error correction model was used for the empirical estimation for the two groups of countries. The empirical estimates of both BRICS and MINT groups of countries shows bidirectional and negative causation between the environmental pollution and FDI and rejects the existence of pollution haven hypotheses.

Previous studies examined the link between CO2 emanations, energy consumption, and Gross Domestic Product in the United States from 1997 to 2016 Using the ordinary least square (OLS) technique. The empirical results of their study suggest that, for both static and dynamic models, there is a long-term correlation between various forms of energy use and carbon emissions at the state level. The total consumption of industrial, household, and NREC (non-renewable energy) all significantly affect CO_2 emissions, however there is a adverse correlation between CO_2 emissions and energy consumption. The study's results also show an inverted U-shaped relationship between economic growth and carbon emissions, which is a sign of the existence of the Environmental Kuznets Curve. Gessesse and He (2020) examined the connection between China's GDP from 1971 to 2015 and energy consumption, CO_2 emissions, and autoregressive distributive lag bounds test analysis. The study's results demonstrate that increased energy use produces CO_2 emissions that are twice as high as GDP while demonstrating that there is no long-term negative correlation between GDP, carbon emissions, and energy use. In order to lessen environmental deterioration, China's central and interim governments should both use energy more effectively. Nonlinear Autoregressive Distributive Lag (NARDL) analysis was used by Saliminezhad and Bahramian (2020) to examine the causal link between the utilization of renewable energy and economic growth in China from 1965 to 2017. The study's findings indicate that while clean energy use appears to be ideal up to a point, after which it has no impact on a country's growth rate, it does not directly affect GDP. It also shows that negative GDP shocks are the sole cause of the decline in renewable energy consumption. Another study used the Autoregressive Distributive Lag (ARDL) bounds test approach to examine the relationship between energy consumption, CO_2 emissions, GDP, and population growth for Indonesia, China, Brazil, and India from 1970 to 2012. According to the findings, increased income has a bigger impact on carbon emissions in all regions studied. Brazil and India have established a significant relationship between CO_2 emissions and population growth. For China and Indonesia, the link between CO_2 emissions and population growth has been demonstrated to be inconsequential for the medium and long run. Erbaycal (2008) used the bounds test for co-integration and ARDL analysis to investigate the relationship between disaggregated energy use and GDP in Turkey from 1970 to 2003. The study's findings suggest that oil and power consumption have a positive impact on GDP in the short and long run. Also, oil consumption has a long-term beneficial impact on production growth, whereas electricity use has the opposite effect on the country's GDP. Furthermore, while oil and energy consumption have a short-term impact on GDP, they have no long-term impact. The findings show a long-term relationship between per capita energy consumption, output growth, and per capita emissions, with bidirectional causality. Additionally, there is a monotonic increasing curve between production growth and CO_2 emissions, implying that as output growth per capita increases, a linear curve in per-capita carbon emissions emerges, contradicting the environmental Kuznets curve. Liu (2018) used (DOLS), (FMOLS), and autoregressive distributive lag analysis to study the association between disaggregate and aggregate analysis on the energy consumption and output growth nexus in China from 1982 to 2015. The study suggests that increasing the usage of diverse energy sources will impact output growth in the long run. Still, in the long run, there is a one-way connection between energy use and GDP. Similarly, there is a long-term causal link between economic expansion and non-renewable energy consumption.

Model and Methodology

The existing study intends to explore the contribution of carbon dioxide emissions to environmental distortions and testing the pollution heaven hypothesis and EKC in five leading polluted nations of the world at aggregate level. In the current study, we examine the macroeconomic conditions of the most polluted countries, which are of particular interest to be studied in EKC and pollution heaven hypothesis framework . We examine the consumption patterns of these countries, as well as their emissions, as an important determinant, as well as other macroeconomic variables. We're going over each country's economic situation one by one, based on carbon dioxide emissions from beginning to end. Following the analyses of Liddle (2018), the model specification for this study is given as

$$CO_{2i,t} = fEC_{it}, For_{it}, GDP_{it}, Kf_{it}, GDP^2_{it}, IP_{it}, Tr_{it}, Kd \tag{1}$$

$$CO_{2it} = \alpha_0 + \alpha_1 EC_{it} + \alpha_2 GDP_{it} + \alpha_3 GDP^2_{it} + \alpha_4 IP_{it} + \alpha_5 Tr_{it} + \alpha_6 For_{it} + \alpha_7 Kf_{it} + \alpha_8 Kd_{it} + \epsilon_{it} \tag{2}$$

Where in the equation (1) CO_2 represents carbon dioxide emissions, energy consumption is represented by EC, GDP represents economic growth, GDP_2 denotes that when GDP increases what is the effect of economic growth on carbon dioxide emissions, IP indicates industrial production, for shows the forestry, Kf represent the foreign capital stock, Kd shows the domestic capital stock and Tr represents a set of control variable that involve international trade. ϵ stand for error term which is normally distributed having constant variance and zero mean. While i indicates a nation, and t describes the time duration (1990-2019) for this investigation. Here in equation (1) α_0 indicates intercept of the model, and α_1, ... α_7 are the coefficients of variables under investigation respectively.

Data

Data of carbon dioxide emission (million tons) extracted from British Petroleum Statistics. The remaining variables Gross Domestic Product (constant 2010 US$), energy consumption (kg of oil equivalent per capita), GDP_2 (GDP square after taking natural logarithms), IP (industrial production, Constant 2010 US$) and control variable international trade (% of GDP) are obtained from world development indicators. The data of percentage of area under forest, has been taken from WDI. Here, we have constructed the domestic capital stock and foreign capital stock from the domestic investment and foreign direct investment by using each country economic growth rate and 5 percent depreciation of capital stocks. The intuition behind using the capital stock at disaggregate level was to the test the PHH for the panel of these countries. In the present study including five top polluted carbon dioxide emitter's economies of the world for time 1990-2019.

Variable's Construction

In the existing study, the CO_2 emission is the dependent variable at aggregate level while the independent variables in the aggregate model are energy consumption, economic growth, GDP_2, domestic capital stock, foreign capital stock l, industrial production and international trade. We investigated the relationship between carbon dioxide emissions, energy consumption, economic growth, domestic capital, foreign capital, industrial production, and international trade. In addition, we incorporated the control variable are international trade for the leading five carbon oxide emitting countries. The variables, description, units, and sources are described in given table 1.

Table 1
Variables, Units, and Sources

Variable	Description	Unit	Source
CO2	Carbon dioxide	Million tons	www.bp.com
EC	Energy consumption	Kg of oil equivalent per capita	https://data.worldbank.org
GDP	GDP	(Constant 2010 US$)	https://data.worldbank.org
GDP2	GDP square	GDP square after taking natural logarithms	Constructed from GDP by the author
IP	Industrial production	(Constant 2010 US$)	https://data.worldbank.org
TR	International trade	(% of GDP)	https://knoema.com/WBGEM2020Mar/ world-bank-global-economic-monitor
Kd	Domestic capital	Constant PPP 2011 US dollars	Constructed
Kf	Foreign capital	Constant PPP 2011 US dollars	Constructed

Econometric Techniques

Cross-sectional Dependence

To begin, we assess the prevalence of CSD across the selected nations in order to use fitting panel econometric approaches. Using panel data, econometric methods that cannot account for cross-sectional dependency may produce erroneous results. We used the CSD test recommended by Pesaran 2004 to determine whether cross-sectional dependence existed for carbon emissions, energy consumption, economic growth, industrial production, international trade, and population. The alternative hypothesis is that there is cross-sectional dependence among the variables, contrary to the null hypothesis that there is no cross-sectional dependence. These test statistics are provided.

$$CD = \frac{\sqrt{2T}}{N(N-1)}(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\beta_{ij}), N(0,1) \quad (3)$$

Panel Unit Root Tests

We continue to employ the panel unit root test, which elaborates the issue of cross-sectional dependency among the entities, due to the larger likelihood of CSD in the current data. As a result, Pesaran's CIPS unit root test is used in the current study to address the cross-sectional dependency issue. Apply the second-generation CIPS unit root test devised by Pesaran as a result (2007).

The CIPS's equation is given as follows:

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \beta_i \hat{y}_{t-1} + \sum_{j=0}^{k} \Upsilon_{ij} \Delta \hat{y}_{it-1} + \sum_{j=0}^{k} \delta_{ij} y_{it-1} + \epsilon_{it} \quad (4)$$

Where, α_i, k, and t represented the deterministic term, lag of order and cross-sectional averages respectively. The researcher claims that even though the sample size is small, this approach enables CSD across the reporting countries and also produced consistent findings. Following is a comparison between the cross-sectional Augmented Dickey Fuller (CADF) statistics and the CIPS data:

$$C\hat{I}PS = N^{-1}\sum_{i=1}^{N} CDF_i \quad (5)$$

While CADF shows the cross-sectional augmented Dickey Fuller test.

Kao test of co-integration

Developed a constrained version of Padroni's method where the intercepts are permitted to change but the slope parameters are fixed across groups. The calculated residuals from the first-stage regression are then subjected to the ADF test regression in order to determine the viability of the null hypothesis of no co integration. A test that is a generalization of Johansen's maximum likelihood-based co integration test in the setting of heterogeneous panels was created by Larsson, Lyhagen, and Löthgren (2001), in contrast to the tests mentioned above.

Panel Autoregressive Distributed Lag (PARDL) Model

We build the Panel Autoregressive Distributed Lag (PARDL) model as described within the context of the current investigation (2016). The rationale for choosing this strategy in the current investigation is that it may be used for both large time periods and small cross-sectional panels. It aids in the discovery of linear inconsistencies, which is the second and most significant reason. And finally, when the integration order is lower than 1(I), it is more appropriate. The mean group (MG) estimator and the pooled mean group (PMG) estimator are the two basic methods for estimating the dynamic heterogenous panel data model. We estimate utilizing the PMG technique since it gives homogeneous coefficients over the long run though heterogeneous coefficients of all nations for the panel in the short run (Alkhathlan & Javid, 2013). The economic theory behind using the PMG technique is used because the relationship between CO2 emissions, GDP, energy consumption, industrial production, international trade, and population density may change in the short term for each cross-section. Nevertheless, the same pattern for the relationship of these variables seems possible in the long term. It is also worth mentioning that alternative methods, such as FMOLS and DOLS, can be applied. This argument further emphasizes the fact that PMG is relevant for the current study.

The panel ARDL is defined as:

$$CO_{2it} = \beta_{0i}+\beta_{1i}EC_{i,t-1}+\beta_{2i}GDP_{i,t-1}+\beta_{3i}GDP^2_{t-1}+\beta_{4i}IP_{t-1}+\beta_{5i}IT_{t-1}+\beta_{6i}Kf_{t-1}+ \beta_{7i}Kd_{t-1}+\sum_{j=1}^{N1}\lambda_{ij}\Delta EC_{i,t-j}+\sum_{j=0}^{N2}\gamma_{ij}\Delta GDP_{t-j}+\sum_{j=0}^{N3}\eta_{ij}\Delta GDP^2_{t-j}+\sum_{j=0}^{N4}\alpha_{ij}\Delta IP_{t-j}+ \sum_{j=0}^{N5}\varphi_{ij}\Delta IT_{t-j}+\sum_{j=0}^{N6}\gamma_{ij}\Delta Kf_{t-j}\sum_{j=0}^{N7}\Phi_{ij}\Delta Kd_{t-j}+\epsilon_{it} \quad (6)$$

Where i=1, 2, 3, ... N; t=1, 2, 3, ... T

Where CO_2 it is the log of CO_2 emissions over a period t for each cross-sectional unit i; E_ct represents energy consumption and GDP_t indicates economic growth respectively at period t; GDP_2 square represents that when GDP increase over time then what is its effect on the emissions level; IP_t, represents industrial production, and IT_t represent international trade respectively at time t; sample units are indicated by i whereas, the number of time periods is represented by t. It is probable to re-specify equation (7) to include the ECM (error correction term) as follows:

$$\Delta CO_{2it} = \delta_i v_{i,t-1}+\sum_{j=1}^{N1}\lambda_{ij}\Delta EC_{i,t-j}+\sum_{j=0}^{N2}\gamma_{ij}\Delta GDP_{t-j}+\sum_{j=0}^{N3}\eta_{ij}\Delta GDP^2_{t-j}+\sum_{j=0}^{N4}\alpha_{ij}\Delta IP_{t-j} +\sum_{j=0}^{N5}\varphi_{ij}\Delta IT_{t-j}+\sum_{j=0}^{N6}\gamma_{ij}\Delta Kf_{t-j}\sum_{j=0}^{N7}\Phi_{ij}\Delta Kd_{t-j}+\epsilon_{it} \quad (7)$$

where $v_{i,t-1} = EC_{i,t-1} - \Phi_{1i}GDP_{t-1} - \Phi_{2i}GDP^2_{t-1} - \Phi_{3i}IP_{t-1} - \Phi_{4i}IT_{t-1}$

Is the linear ECM for each unit; the parameter δ_i is the error-correcting speed of adjustment term for each unit which is also equivalent to β_{1i}. The parameters $\phi_{0i}, \phi_{1i}, \phi_{2i}, \phi_{3i}$, and ϕ_{4i} are computed as - $\frac{\beta_{0i}}{\beta_{1i}}, -\frac{\beta_{2i}}{\beta_{1i}}, -\frac{\beta_{3i}}{\beta_{2i}}, -\frac{\beta_{4i}}{\beta_{3i}}$, and - $\frac{\beta_{5i}}{\beta_{4i}}$ respectively.

Results and Discussions

This section provides the study's findings. We begin by estimating the variables' descriptive statistics. The outcomes of the cross-sectional dependency, slope heterogeneity, unit root, and lag selection criteria were then provided in the next section. Finally, we calculated the Kao Test for panel co-integration test and PMG analysis by panel ARDL.

The results of the descriptive statistics for all variables for the top 5 emitter countries worldwide are exhibited in table 2. The findings demonstrate that the specified variables have minimum values of 1.076 and 1.18, respectively, and maximum values of 16.67 and 11.91. The table's minimum mean values are 1.09 and 1.66, respectively, while its standard deviations are.008 and.194, respectively.

Table 2
Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
logco2	150	8.906	0.450	8.316	10.008
Logec	150	3.460	0.330	2.867	3.927
Loggdp	150	12.36	0.229	11.91	13.061
loggdp2	150	1.092	0.008	1.076	1.116
Logip	150	11.77	0.342	11.31	12.732
Logtr	150	1.665	0.194	1.181	1.947
Kf	145	8.245	1.211	4.616	9.779
Kd	145	10.99	1.013	7.851	11.927
Forest	145	36.86	15.23	16.67	70.458

We used the Pesaran CD (2004) test in Table 3 to determine the cross-sectional dependencies between the variables. A second-generation test is Pesaran CD (2004). CSD is a crucial issue, so it's crucial to pinpoint it among the chosen variables. According to the results of the CSD test, every variable seems to be cross-sectionally dependent.

Table 3
Pesaran CD (2004) test

Variable	CD-test	p-value	Corr	abs(corr)
logco2	-1.900	0.058	-0.110	0.768
logec	17.30	0.000	0.992	0.992
loggdp	16.94	0.000	0.978	0.978
loggdp2	16.94	0.000	0.978	0.978
logip	1.800	0.072	0.104	0.732
logtr	9.000	0.000	0.520	0.520
kf	16.25	0.000	0.938	0.938
kd	16.63	0.000	0.960	0.960
forest	15.84	0.000	0.914	0.914

Table 4
Slope Heterogeneity Test

Models	Delta	Adjusted Delta Tilde
Model-1 LCO2=f (LEC, LGDP, Kf, Kd, Forest, LGDP2, LIP, TR)	6.404***	7.843***

The slope homogeneity test was developed by Pesaran and Yamagata in 2008 to deal with the homogeneity problem in panel data, test outcomes are portrayed in table 4 to ascertain whether or not the slope is homogenous. Slope heterogeneity in the model is problematic, which suggests that results from unit root tests and cointegration processes would be skewed (Hamakhan & Taha, 2020). The large delta tilde $\hat{\Delta}$ and adjusted delta tilde $\hat{\Delta}$ values in the upper half of Table 4.3 demonstrate that slope heterogeneity issue exist in the model. The test statistics support the model statistically.

Table 5
Unit Root Test and Lag Selection Criteria

Cross-Sectionally Augmented IPS (CIPS, 2007)		
Variables	**Level**	**Order of Integration**
LCO2	-4.071***	I (0)
LEC	-2.673***	I (0)
LGDP	-2.614***	I (0)
LGDP2	-2.734***	I (0)
LOGIP	-4.335	I (1)
LOGTR	-3.261	I (1)
KF	-3.076	I (1)
KD	-3.475	I (1)
FOREST	-3.789	I (1)

The sequence of integration of the various variables listed in Table 5 is examined by the study using the Cross-Sectionally Augmented IPS (CIPS, 2007) test. The (CIPS, 2007) is a second-generation unit root test. The results of the IPS (CIPS, 2007) demonstrate that energy consumption, GDP2, GDP and corban emission are integrated in order 0, whereas Industrial production, trade, forest, domestic and foreign capital are integrated in order (0). For this reason, the panel autoregressive distributive lag (PARDL) technique is used.

This test is used to determine whether the variables' long-term cointegration. As a consequence of the Kao cointegration, the alternative hypothesis for this study is accepted and the null hypothesis for all tests is rejected. All of the P-values in the table are noteworthy. The test's results show that all of the study's variables have a long-term link. The Kao test validates the long-term link between the study's variables. The Kao cointegration test result is shown in table 6.

Table 6
Kao test of cointegration

Cointegrating vector:	Same		
Panel means:	Included	**Kernel:**	Bartlett
Time trend:	Not included	**Lags:**	2.20 (Newey-West)
AR parameter:	Same	**Augmented lags:**	1
		Statistics	**P-value**
Modified Dickey-Fuller t		-4.7686	0.000
Dickey-Fuller t		-3.0678	0.001
Augmented Dickey-Fuller t		-2.7344	0.003
Unadjusted modified Dickey-Fuller t		-4.5397	0.000
Unadjusted Dickey-Fuller t		-3.0206	0.001

The above table 7 shows the PMG estimation about the impact of corban dioxide on other macroeconomic variables, hare basically we are testing the environmental Kuznets curve and pollution heaven hypothesis. The results observed that environmental Kuznets curve exist but due to the negative sign of Kf we reject the pollution heaven hypothesis for these group of countries and for the period of investigation. We also reported that there is no endogeneity in the model.

Table 7
PMG estimation

D.logCO2	**Coef.**	**Std. Error**	**z**	**P>$\lvert z\rvert$**	**95%**	**conf. Interval**
-ec						
Logec	1.36	0.91	14.94	0.000	1.19	1.54
Loggdp	6.66	0.38	17.26	0.00	5.90	7.41
Loggdp2	-200.53	-	-	-	-	-
Logip	0.078	0.02	2.63	0.009	0.019	0.13
Logtr	0.02	0.03	1.32	0.18	-0.02	0.12
Kf	-0.25	0.04	5.85	0.000	0.16	0.33
Kd	0.91	0.13	6.78	0.000	-1.17	-0.64
Forestry	-0.35	0.08	4.01	0.000	0.17	0.52
SR						
-ec	-0.19	0.17	-0.09	0.27	-0.54	0.15
logec D1.	0.67	0.18	3.65	0.000	0.31	1.03
loggdp	26.53	48.51	0.55	0.58	-121.61	68.55
longdp2	-769.49	1380.78	0.56	0.57	-0.1936.79	3475.78
logip D1	-0.01	0.03	-0.41	0.68	-0.08	0.057
logtr D1	-0.02	0.032	-0.66	0.51	-0.08	0.04
kf D1	-0.006	0.02	-0.31	0.75	-0.04	0.033
kd D1	0.30	0.101	-0.30	0.76	-0.23	0.16
Forest D1	-1.61	1.65	0.98	0.32	-1.62	4.84
	Hausman test(PMG)			**88.64**	**(prob 0.000)**	

Table 8
Aggregate Model Results of (PARDL)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
Dependent variable; CO_2 Long Run Equation				
LEC	0.949593	0.079269	11.97942	0.000
LGDP	0.123012	0.051654	2.381476	0.018
LIP	0.012787	0.055625	0.229878	0.818
LGDP2	-0.42341	0.129214	-1.38461	0.023
PD	0.004258	0.000412	10.33698	0.000
TR	-0.002628	0.000558	-4.707642	0.000
KD	1.434953	0.158964	-9.026912	0.000
KF	-0.046438	0.007949	5.841707	0.000
FOREST	-0.050189	0.007125	6.496846	0.000
Dependent variable; CO_2 Short Run Equation				
COINTEQ01	-0.491926	0.17509	-2.809555	0.006
D(LEC)	0.446371	0.222972	2.001913	0.046
D(LGDP)	0.453656	0.15621	2.904138	0.004
D(LIP)	-0.05731	0.045241	-1.266792	0.206
D(GDP2)	4.032219	0.15741	1.517326	0.138
D(PD)	-0.044685	0.060031	-0.74437	0.457
D(TR)	0.000416	0.000475	0.874857	0.382
D(KD)	1.094754	0.315507	3.469826	0.000
D(KF)	-0.024965	0.018804	1.32766	0.187
D(FOREST)	-3.435137	6.466081	0.995214	0.021
C	1.645752	0.717668	2.293195	0.022
Mean dependent var	0.016463	S.D. dependent var	0.053726	
S.E. of regression	0.042846	Akaike info criterion	-4.717007	
Sum squared resid	0.354311	Schwarz criterion	-3.638552	
Log likelihood	730.5885	Hannan-Quinn criteria.	-4.284192	

The table 8 indicates the result of the PARDL model. It shows that the outcomes of the error-correction term which has a significant negative effect, showing that the system converts to long-run equilibrium after a shock. The results of the short and long term indicate that CO_2 emissions are positively associated with energy consumption and are statistically significant. More specifically one percent increase in consumption of energy will tend to increase CO_2 emissions by 0.44 million tons each year in the short run while 1% growth in the use of energy leads to arise carbon emissions by 0.94 million tons in the long run. The outcomes of the study are consistent with that of Adebayo, Awosusi, Kirikkaleli, Akinsola, and Mwamba (2021). For both the short and long-run CO_2 emissions are positively related to GDP and statistically significant. Specifically, in the short run, an increase of 1% in economic growth will lead to arise carbon emissions by 0.45 million tons per year in the short run, whereas, in the long run, a one percent increase in GDP would tend to increase CO_2 emissions by 6.12 million tones. The results indicate that CO_2 emissions are negatively associated with industrial production in the short term and insignificant while positively associated in the long term but also insignificant. The variable domestic capital shows a positive and significant relation with carbon dioxide emission in the short run as well as in the long run. In the short run an increase of 1% domestic capital leads to increase carbon emission by 1.094 million tons each year, similarly in the long run if a one percent incline in domestic capital leads to increase carbon emission by 1.43 million tons.

Foreign capital shows a negative and insignificant relation with carbon dioxide emission in the short run while in the long run it indicates also positive but significant correlation with carbon dioxide emission. In the short run an increase of 1% foreign capital leads to decrease carbon emission by -0.024 million tons each year, similarly in the long run if a one percent incline in foreign capital leads to decrease carbon emission by -0.04 million tons. Due to the negative sign of Kf we reject the pollution heaven hypothesis for these group of countries and for the period of investigation. It means that that these countries have high level of domestic capital and Kd have a positive relationship with carbon dioxide emission, while foreign capital in these countries is not the major contributor for CO_2 emissions. Here actually we disaggregated the capital stock accumulation of these countries in two series one is Kd and the other is Kf. It is believed that foreign investment is responsible for creating pollution in the recipient countries. The multinational companies locate their global foreign investment to the less developed countries and create pollution (Yang & Li, 2017; Li & Wang, 2017). In our case we converted the FDI to the foreign capital stock to investigate their impact explicitly from domestic capital stock. After our empirical investigation we found negative relationship between Kf and carbon emission, which reject the pollution heaven hypothesis in thesis countries for the given time period. It is also evident from the results that the GDP and there have positive and negative sign of their coefficients respectively, which validate the EKC hypotheses in the long run.

And the forest variable demonstrates the negative relation with carbon emission in both the short run and long run. If 1% forest increase leads to decrease carbon emission by -3.43% in the long run, while in short run it decreases carbon emission by -0.0501%. The results of GDP_2 for both the short and long run indicates that an increase of 1% in

GDP_2 tend to increase carbon emissions by 4.032% which is positive and insignificant in the short run while, for the long run an incline of 1% in GDP_2 tends to decline carbon emissions by -0.138%. The study is based on the ordinary EKC which assumes that in the first half with the energy consumption carbon emissions increases but as the country goes towards development the consumption of energy does not harm the environment and the result of our study is consistent with the findings of Sato and Kuwano (2015); Rani and Kumar (2018). Furthermore, the outcome of the GDP2 indicates the existence of the EKC curve for the top five selected polluted countries.

Conclusion and Policy Implications

In this existing study, we try to test the pollution heaven hypothesis and environmental Kuznets curve in the advanced polluted countries (Brazil, Canada, China, France, and Germany) taking data from 1990 to 2018 using panel Autoregressive Distributed Lag model. The PARDL results of the short and long term indicate that CO_2 emissions are positively associated with energy consumption and are statistically significant. CO2 emissions are negatively associated with industrial production in the short term and insignificant while positively associated in the long term but also insignificant.

GDP_2 for both the short and long run indicates that an increase of 1% in GDP_2 tend to increase carbon emissions by 4.032% which is positive and insignificant in the short run while, for the long run increase of 1% in GDP_2 tends to decline carbon emissions by -0.138%. The study is based on the EKC frame work. Furthermore, the outcome of the GDP_2 indicates the existence of the EKC curve for the top five selected polluted countries. The variable domestic capital shows a positive and significant relation with carbon dioxide emission in the short run as well as in the long run. In the short run an increase of 1% domestic capital leads to increase carbon emission by 1.094 million tons each year, similarly in the long run if a one percent incline in domestic capital leads to increase carbon emission by 1.43 million tons.

Foreign capital shows a negative and insignificant relation with carbon dioxide emission in the short run while in the long run it indicates also positive but significant correlation with carbon emission. In the short run an increase of 1% foreign capital leads to decrease carbon emission by -0.024 million tons each year, similarly in the long run if a one percent incline in foreign capital leads to decrease carbon emission by -0.04 million tons. Due to the negative sign of Kf we reject the pollution heaven hypothesis in these group of countries.

And the forest variable demonstrates the positive relation with carbon emission in the short run as well as in the long run. In particular, the top five carbon-emitting nations and other nations need to cut their energy consumption of coal and oil, which might assist to reduce carbon dioxide emissions for the purpose of sustaining the environment, according to fresh findings presented in this study for policymakers and experts. Furthermore, these nations ought to switch to using cleaner, more environmentally friendly energy sources, including gas. These nations must implement policies that do not hinder national economic expansion while achieving the goal of lower carbon emissions if they want to reduce their consumption of carbon emissions and promote economic growth. By implementing environmentally friendly technologies, and the exploit the renewable energy resources (wind, water fall, solar, and geothermal) for mitigating the volume of poison emission from environment.

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