An empirical study on the existence of the Environmental Kuznets Curve and its Implications

A Dissertation for

Course code and Course Title: ECO 214D & Master of Arts in Economics

Credits: 08

Submitted in partial fulfilment of Master's Degree

MA in Economics

by

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Date: 05/05/2023

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DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation / Internship report entitled, "An empirical study on the existence of the Environmental Kuznets Curve and its implications" is based on the results of investigations carried out by me in the MA Economics at the Goa Business School, Goa University under the Supervision/Mentorship of Ms. Sumita Datta and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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COMPLETION CERTIFICATE

This is to certify that the dissertation report **"An empirical study on the existence of the Environmental Kuznets Curve and its implications"** is a bonafide work carried out by **Ms Ankita Navso Chari** under my supervision/mentorship in partial fulfilment of the requirements for the award of the degree of **MA** in the Discipline Economics at the Goa Business School, Goa University.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

1.1 Introduction

The economic growth and environmental degradation go hand in hand. The economic growth generally takes place when there is an increase in the level of production. This production requires the use of resources like fossil fuels, timber, etc. at various levels of production activities. The use of these resources creates environmental degradation in the form of emissions. Not only the production process but transportation, consumption, etc. also creates environmental degradation in some or the other form. The degradation of environment is an alarming issue in today's fast-moving world. Global warming is an outcome of the emissions, which is creating an irreversible damage to the environment through climate change, melting of glaciers, and so on. The climate change is becoming more visible than before. The delayed rains, submergence of small islands, frequent forest fires, and so on are some of the prominent results that world is facing now. The study in this area is required because the governments across the globe already not only are incurring contingency and mitigation costs but also displacement costs which countries across the globe are already incurring and some will incur in the future. The costs will be huge and the most sensitive group who is going to be affected are the poor, migrants, refugees, etc. The countries all across the globe are already facing huge costs.

The Environmental Kuznets Curve (EKC) is an inverted U-shaped curve showing the relationship between the environmental degradation and economic growth. The EKC is based on the works of Simon Kuznets (relationship between inequality and per capita income) wherein he tried to explain as the economic growth takes place the inequality in the society first rises and after certain level of growth the inequality starts falling. The same concept was then extended in the field of Environmental economics by Kruger and Grossman in 1991. The

essence of this Environmental Kuznets hypothesis is that when income rises environmental degradation initially rises but after certain level the environmental degradation starts falling. The EKC explains three broad effects scale effect, composition effect and technique effect to explain why the degradation falls after certain level of income. The scale effect says that as the economy starts to grow from the agricultural to industrial economy it leads to rise in the environmental degradation. This is because the economy is new to industrial production it ought to use the traditional sources of energy like fossil fuels. The factors which are responsible for this effect are trade, GDP, FDI, etc. The composition effect comes into picture when after certain income there is shift in the structure of the economy. The shift from fossil fuel as a source of the energy to cleaner source (renewable) is one of the examples. This is happening because the standard of living has changed in the country. However, this composition effect can be negative or positive. There is something called as technique effect, according to which due to increase in the income there is a shift in the policies of the governments which like taxes on pollution which leads to negative impact on environmental degradation. The EKC hypothesis was an important piece of work as it incorporates sustainability which every country wants to achieve. Rather than economic growth held responsible for degrading the environment it focused on how this growth in the long run will improve the environment.

Greenhouse gases, by trapping heat from the sun have kept Earth's climate habitable. But now these gases are out of balance leading to climate change. Energy, is the major contributor to manmade greenhouse gas emissions. The energy is the major component of industrial process. For production the main sources of energy in developing and underdeveloped countries are fossil fuels. CO2 is created by burning fossil fuels like oil, natural gas, diesel, organic-diesel, petrol, organic-petrol, ethanol and coal. The Carbon Dioxide accounted for

91.3% of greenhouse gas emissions in 2021 (United States EPA). The carbon dioxide is the primary source of emission from human activities and also an important component in the environmental degradation. The Carbon dioxide is the major source of climate change and global warming. India ranks 3rd in global scenario after China and USA in terms of carbon emissions and India is the only low-income country in the top 10 carbon emitters list.

The economic growth with an increase in the level of income creates environmental degradation through various ways. The more and more economic growth requires infrastructure, industries, and other things which initially lead to environmental degradation through cutting of forest cover to build the buildings, emissions out of the industries, waste which is the by-product of the growth that is taking place and so on. It depends upon in which stage of development a country is and also on where is economic growth taking place, is it in developed countries which are using cleaner energies due their higher standards of living or in underdeveloped or developing countries where the major source of energies are fossil fuels. The latter will have positive impact on environmental degradation.

The Foreign Direct Investment (FDI) and trade are very significant in determining the growth of any economy. With more FDI inflows the economic activities get a boost which lead to higher levels of income accompanied by the technological transfer. Given the degree of globalisation, the FDI and trade play a significant role in determining the growth of a country. The FDI brings in investment which gives boost to the employment as well as economic activities. Also, how much a country is open to a trade determines the growth of a country. And whether FDI and trade openness are contributing to economic growth depends also on whether the country is developed or not.

Both FDI and trade openness has a relationship with environmental degradation. Since these both increases the level of economic activity in the country, which indirectly leads to

environmental degradation. The question of whether the FDI and trade openness in the host country are contributing to the environmental degradation or not is dependent on which is the host country that we are looking at. If it is a developed country where standard of living is really high with stringent environmental protection laws, the effect of FDI and trade openness on environmental degradation in these countries would be minimal whereas in developing or underdeveloped countries the rules aren't that stringent given the low level of living standards of people as well the goal of these countries is to achieve economic growth, the impact of these may be positive on environmental degradation. The former is an example of 'halo effect' and latter is of 'pollution havens' hypotheses. The investors from foreign countries take advantage of the loose environmental protection laws of poor countries and make profits at the expense of the environment. It is very important to analyse this for any country especially poor or developing countries as the question comes who will pay for the environmental degradation caused, is it the state, people or polluters.

1.2 Objectives:

1) To examine whether there exists an exception to Environmental Kuznets Curve.
2) To examine whether FDI and trade are valid for EKC hypothesis.
3) To verify if there are any exceptions to Environmental Kuznets Curve in India.

1.3 Data:

The data used for the study is secondary data. The data to fulfil the mentioned objectives of the study was collected from various sources. The data for GDP, GDP per capita and Imports and Exports was extracted from World Development Indicators, World bank at constant US 2015$, the data for FDI was collected from UNCTAD as a stock proportion of GDP. The data for carbon emissions was extracted from World Development Indicators, World bank, in per

kilo tonnes to fulfil all the three objectives. For the achievement of the first two objectives the data from 2005-2019 is used, while for the third objective the data from 1990-2019 is used.

1.4 Methodology:

The model for first two objectives looks as follows:

$$CO2 = f(GDP\ per\ capita, FDI\ and\ trade\ openness)$$

$$\begin{aligned} Ln(CO_2) = {} & \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 \\ & + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) \\ & + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it} \end{aligned}$$

Here the two ways fixed effects model will be used. For achieving the first two objectives the two-way fixed effects model is used. And for achieving the third objective the Autoregressive Distributed Lag Model (ARDL) is used.

For diagnostic tests the following tests are used:

1) The Kwiatkowski-Phillips-Schmidt-Shin test (KPSS), Phillips Perron test (PP test) and Augmented Dickey-Fuller test (ADF test) are used for testing stationarity.
2) The Breusch Pagan test for heteroskedasticity is used.
3) The Hausman test for panel data is used to see if two way fixed or random effects is valid for the models.

1.5 Scope and Limitations:

This study involves the panel of 48 countries from the year 2005-2019 from 4 different income groups (High-income countries, Upper Middle-income countries, Lower-Middle income countries and Low-income countries) based on World Bank classification of countries.

1.5.1 Limitations:

1) Only 48 countries are considered for the study.
2) Due to unavailability of data for a longer duration for all the countries, the data for only 15 years is used for first two objectives.

CHAPTER 2

Literature Review

2.1 Introduction

The relationship between economic growth and environmental degradation was always thought to be negative. (Krueger, 1991) found the evidence of inverted U-shaped curve for the first time in their paper. Their paper tried to find a relationship between environmental degradation with economic growth in the face of formation of NAFTA and its effect especially to Mexican counterpart. They found that Mexico in fact benefits from the agreement with greater access to US market and also through specialization from trade liberalization. They for the first time found that economic growth doesn't always leads to environmental degradation. (Panayotou, 1993) hypothesized Simon Kuznets (relationship between economic growth and inequality) inverted U-shaped curve for studying the relationship between environmental degradation and economic growth. He was the first one to come up with the term 'Environmental Kuznets Curve'. He found that the environmental degradation is temporary phenomenon for developing countries accompanied by initial economic growth. He tried to test his hypothesis by taking environmental degradation as a deforestation, Sulphur dioxide, Nitrogenous oxides and Solid particulate matter representative for environmental degradation. He found the evidence of inverted U-shaped relationship which he then named as Environmental Kuznets Curve (EKC).

2.2 Effects of Environmental Kuznets Curve

(Krueger, 1991) gave distinction between three effects caused by economic growth agents and environmental degrading agents. The first is the scale effect, when economic activities increase given that the nature of activities remain unchanged, the expansion will lead to an

increase in the environmental degradation. Second is composition effect, when economic growth increases say in the face of change in the trade policy through specialization, if that specialisation is derived from the environmental degrading policies, then the trade policy is causing positive change in the environmental degradation. Third is the technique effect, according to which the further rise in the economic growth may not contribute to environmental damage but rather lead to a reduction in them which is attributed from the technological transfer from foreign countries and the rise in the standards of living. (Bo, 2011) EKC is a curve which shows the negative scale effect in the early stages of growth, then the positive technical effect and structural changes and these effects outweighs scale effect. Thus, environment first deteriorates with increase in the growth but then this growth improves the environment. But this relationship of inverted U-shaped hypotheses may not be always true.

2.3 Exceptions to Environmental Kuznets Curve hypothesis

(Stern, 2017) found that the assumption that the over the course of developmental process the pollution or environmental degradation may not be true. The converging factors are the factors which are responsible to reduce the pollution. (Kenneth Arrow, 1995) found that the argument that was earlier literature may not hold true. There are other aspects of looking at. According to their paper the above hypotheses is acting as a justification for trying to get more economic growth while ignoring the environment. There are exceptions to Environmental Kuznets Curve which later studies have found. (Mitra, 2017) relationships between CO2 emissions, per capita GDP, energy use, and trade openness for the period of 1971-2012. The study found long run relationship between CO2 and GDP and trade openness while short run relationship with energy consumption. The paper found evidence of N-shaped EKC both in India and China but it was more popular for India. (Alexandra Allard, 2018)

conducted a study for 74 countries for the period of 1994-2012 based on CO2 emissions and GDP per capita. They found the evidence of N-shaped EKC for lower middle income, high income and whole panel. Whereas when quantile regression was used the evidence is found for few lower middle income and high income but not in upper middle income countries. The results also found that the renewable source of energy have negative impact on environmental degradation.

(Sefa Awaworyi Churchill, 2018) study's results showed evidence of inverted U-shaped EKC for Finland, France and the US. The turning point for these countries was at a higher level of incomes. The evidence of N-shaped EKC was found for Australia, Canada, and Japan. Their study confirmed that 11 countries do not hold EKC hypothesis, 9 hold the EKC hypothesis and out of these 9, 5 exhibit traditional inverted U-shaped curve, 3 show N-shaped curve and 1 show inverted N-shaped EKC curve. The 11 countries are Austria, Belgium, Germany, Greece, Italy, Netherland, Norway, New Zealand, Portugal, Sweden and Switzerland. One country (Denmark) has an inverted N-shaped EKC curve. Three countries (Australia, Canada and Japan) are characterised by an N-shaped EKC curve. (Bright Akwasi Gyamfi, 2021) tried to study the EKC for the period of 1995-2018 for 7 emerging countries. They intended to see if there exists an N-shaped EKC curve or not. The results indicated that there is no existence of N-shape environmental Kuznets curve for the 7 countries considered for the study. The results also found that the non-renewable energy has a positive impact on environmental degradation. (Ghosh, 2010) conducted a study by including energy supply, investment and employment for a period of 1971–2006 for India and tried to form a long run relationship between economic growth and carbon emissions but failed to do so. The study further found the bi-directional causality in short run between the same. (Ameer, 2018) their study focused on 11 emerging Asian Countries for the period of 1980-2014. Inverted U-

shaped EKC hypothesis holds true. Urbanisation and economic growth reduce the emissions of Sulphur Dioxide, while technology and trade openness increase it in the long run. There is a mixed responses in the literature with some researchers saying there exists no EKC and some confirming inverted-U EKC or other shapes of EKC (inverted N or N-shaped).

2.4 Environmental Kuznets Curve and FDI and trade

There are various determinants of environmental degradation. (Krueger, 1991) when the NAFTA was introduced, the environmentalists feared that it will degrade the environment due to heavy trade liberalisation but they failed to recognise the other benefits of it. The more open the trade is and more accessible the foreign investment is the more the technological accessibility is to foreign market and if the income increases due to this then there will be demand for environmental protection laws. (ABDULAI, 2013) studied relationship between economic growth, international trade and environmental degradation for the period of 1990-2003. They found that the impact of trade was positive on environmental improvement in High Income, Sub-Saharan Africa and Latin America while it had negative impact on environment of low income, North Africa and Middle East, EU and Atlantic and Asia. (Werner Antweiler, 2003) studied the relationship between the international trade and environment.

(Lin-Sea Lau, 2014) examined the Environmental Kuznets Curve hypotheses for Malaysia from 1970-2008 and found that there exists EKC in both short-run and long-run in Malaysia. The FDI and Trade showed the negative impact on environment. (Huiming Zhu, 2016) conducted a study to see the impact of FDI, economic growth and energy consumption on carbon emissions for 5 ASEAN countries and the results indicated that FDI shows positive impact on environment of ASEAN countries. The existence of pollution haven hypothesis is refuted. The inverted U-shaped EKC do not exist for the 5 ASEAN countries. The results also

indicated the negative impact of trade openness on carbon emissions. The impact is higher in high and medium emitting countries. This confirms halo effect.

(Baek, 2016) conducted a study of five ASEAN countries for the period of 1981-2010. The paper focused on FDI, income and energy consumption on environmental degradation. The results showed the existence of pollution havens hypothesis for ASEAN countries. The level of income and energy consumption showed negative impact on carbon emissions. (Ameer, 2018) found that the trade openness plays a positive role in the emissions of Sulphur Dioxide. (Daberechı Chıkezıe Ekwueme, 2021) found that the government should try to thrive trade openness and FDI in the country. (Mohd Shahidan Shaari, 2014) conducted a study for 15 developing countries from the period of 1992-2012 and tried to investigate the effects of FSI and economic growth on the CO2 emissions. The results indicated that in the long run the foreign direct investment does not contribute to carbon emissions. Thus, the evidence of halo effect was seen in this study. (Thao, 2018) found that the foreign direct investment in developed and developing countries showed a positive impact on environmental degradation but trade openness showed a negative impact in developed countries and positive impact in developing countries on environmental degradation.

(Nesrin Ozatac, 2017) investigated the EKC hypothesis for Turkey from the period of 1960-2013 and found that trade openness positively affects economic growth which increase the demand for consumption of energy which increases the level of air pollution. (Huaping Sun, 2019) the study investigated the relationship between international trade and CO2 emissions for 49 high emission Belt and Road countries from 1991-2014 and found that trade openness caused environmental degradation in the long run in the Belt and Road, developed, developing, underdeveloped, and European countries.

Now the question comes if the source of FDI is determining any significant effect on the environmental quality. (Thao, 2018) used the panel of 51 developed and developing countries and the subpanel of 23 developing countries from 2001-2012 by taking into consideration the effect of foreign direct investment and trade openness on carbon dioxide emissions. The results showed that the globalization is creating more degradation of environment in lower income countries. The developmental stage of any country is significant in determining the impact on environmental degradation given the foreign investments. The foreign direct investment in from developing countries leads to more environmental degradation as the firms from these countries lack competence. The FDI from developed countries exhibit a halo effect, that is, it shows that FDI from developed countries show a technical transfer but at the same time the paper has mentioned that it is not that FDI from developing countries is not always undesirable.

CHAPTER 3

Exceptions to Environmental Kuznets Curve hypothesis

3.1 Introduction

The literature pointed at the possibility that the Environmental Kuznets Curve might not always be inverted-U shaped curve. To examine the same, the panel of 48 countries is used to check if there exists an exception to the EKC hypotheses. The panel was then divided into 4 sub-panels based on the World Bank classification of countries into High Income, Upper Middle Income, Lower Middle Income and Low-Income countries.

Table 3.1 List of all the countries

Low Income	Lower Middle Income	Upper Middle Income	High Income
Syrian Arab Republic	Solomon Islands	Brazil	Australia
Sudan	Iran, Islamic Rep.	Mexico	New Zealand
Congo democratic republic	Bangladesh	Argentina	Saudi Arabia
Madagascar	Egypt, Arab Rep.	Russian Federation	United Arab Emirates
Burkina Faso	Nigeria	China	Chile
Niger	Bolivia	Thailand	Uruguay
Rwanda	El Salvador	Malaysia	Germany
Sierra Leone	Ukraine	South Africa	United Kingdom
Togo	Indonesia	Botswana	Japan
Burundi	Philippines	Iraq	South Korea
Gambia	India	Jordan	United States
Mali	Pakistan	Marshall Islands	Canada

The stationarity in the data is very important otherwise the problem of spurious regression may take place. To test the stationarity the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS), Phillips Perron test (PP test) and Augmented Dickey-Fuller test (ADF test) are used.

Table 3.2 The results of stationarity tests

Variables	Augmented Dickey-Fuller test	Phillips Perron test	Kwiatkowski-Phillips-Schmidt-Shin
LN (CO2)	-6.031*	-61.719*	0.1154
LN (GDP per capita)	-5.8436*	-58.902*	0.26947
(LN (GDP per capita))^2	-5.7022*	-56.819*	0.29371
(LN (GDP per capita))^3	-5.5689*	-54.993*	0.31728
LN(FDI)	-6.2195*	-114.02*	0.28091
LN(Trade)	-6.8872*	-83.7*	0.39075

The results of the tests indicated that there is stationarity in the data at the level. The all three tests concluded the same.

Table 3.3 The descriptive summary for the whole panel

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	4.868	8.383	11.626	10.824	13.012	16.186
LN (GDP per capita)	5.599	7.067	8.258	8.334	9.439	11.014
(LN GDP per capita)^2	31.35	49.94	68.20	71.75	89.09	121.30
(LN GDP per capita)^3	175.5	353.0	563.2	636.5	840.9	1336.0
LN(FDI)	-19.265	2.635	3.284	2.963	3.687	4.828
LN (Trade openness)	-4.8476	-0.9258	-0.5910	-0.6122	-0.2701	0.5905

The above table shows the minimum, maximum, 1st quarter, 2nd quarter and mean values for all the variables that will be used for the analysis.

The basic model of the study looks as follows:

$$CO2 = f(GDP\ per\ capita, FDI\ and\ trade\ openness)$$

The above equation states that the Carbon dioxide emissions are dependent on GDP per capita, Foreign Direct Investment (FDI) and trade openness. Keeping the above model into consideration the two-way fixed effects and two-way random effects model were employed. To see which model is better suited for the models the Hausman test was used. The results of the Hausman test are as follows:

H0: The two-way random effects model is consistent.

H1: The two-way random effects model is not consistent.

Results:

chisq = 104.9, df = 3, p-value < 2.2e-16

The above results indicated that the two-way fixed effects model is more consistent for the model as the p-value is less than 0.05.

Table 3.4 Results of the two-way fixed effects model for basic model for the whole panel

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	0.6483508975	0.06579359	9.8543	< 2.2e-16 ***
LN(FDI)	-0.0003112935	0.00440143	-0.0707	0.9436378
LN (Trade openness)	0.0894353417	0.02399065	3.7279	0.0002098 ***

R-Squared: 0.16936

Adj. R-Squared: 0.088193

F-statistic: 44.5148 on 3 and 655 DF, p-value: < 2.22e-16

The above table indicates that LN (GDP per capita) is positively related to the Carbon emissions, that is, 1% increase in the LN (GDP per capita) will lead to increase in LN (CO2) by about 0.65%. It is significant as well. The coefficient of LN(FDI) is not significant but it leads to fall in the CO2 and is jointly significant. The coefficient on trade openness is significant and sates that 1% increase into it will lead to increase in the carbon emissions by 0.089%. The R-squared is 0.16936 and adjusted R-Squared is 0.088193. The model explains 8% variation in the CO2 emissions.

3.2 Exceptions to Environmental Kuznets Curve

The model to verify if there exists an exception to EKC hypothesis looks as follows:

$$Ln(CO_2) = \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it}$$

Here the CO2 is dependent on GDP per capita, GDP per capita squared, cube of GDP per capita, FDI, trade openness and the effect of FDI and trade openness together. All the variable are into natural logarithmic forms. As the results for the whole panel in the table 3.4 indicated that the two-way fixed effects model is more appropriate for the analysis, the same model will be used throughout the analysis of the panel data. The estimation is done for the whole panel, the high-income countries, upper middle-income countries, lower middle-income countries and low-income countries. The whole panel consists of 48 countries from the period of 2005-2019 and each income group has 12 countries. These countries are selected on the basis of their income level as well the availability of the data.

3.2.1 Exceptions to Environmental Kuznets Curve for the whole panel

Coming to the first objective, that is, to verify if there are any exceptions to usual EKC hypothesis, a model is estimated for the whole panel consisting of 48 countries. The two-way fixed effects model is used for the estimation. The results of the estimation are as follows:

Balanced Panel: n = 48, T = 15, N = 720

Table 3.5 Results of two-way fixed effects model for the whole panel

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	-3.470011	4.504471	-0.7703	0.4413723
(LN GDP per capita)^2	0.711736	0.538033	1.3228	0.1863499
(LN GDP per capita)^3	-0.037340	0.021325	-1.7510	0.0804089.
LN(FDI)	-0.078766	0.023120	-3.4069	0.0006974 ***
LN (Trade openness)	0.559595	0.194782	2.8729	0.0041991 **
LN(FDI)*LN (Trade Openness)	-0.151199	0.049614	-3.0475	0.0024005 **

R-squared: 0.41559

Adj. R-Squared: 0.35554

F-statistic: 77.2767 on 6 and 652 DF, p-value: < 2.22e-16

The results indicate the possibility of an inverted N-shaped curve for the whole panel of 48 countries. The 1% increase in GDP per capita leads to fall in the Carbon emissions by 3.4700114%. After some period, an increase in the GDP per capita (1%) would lead to rise in the emissions by 0.7117362% and after some period again an increase in income (1%) would lead to fall in the Carbon emissions by 0.0373403%. The coefficients on LN (GDP per capita) and LN (GDP per capita) squared are insignificant and on LN (GDP per capita cubed is significant. The coefficients are indicating towards the inverted N-shaped Environmental Kuznets curve for the whole panel but the coefficients aren't significant to conclude the same.

The model explains around 35%variation in the carbon emissions caused by the variables selected.

The test for heteroskedasticity (Breusch Pagan test) was conducted and found the existence of heteroskedasticity in the model. The results of the test are as follows:

BP = 99.145, df = 6, p-value < 2.2e-16

Since the p-value is less than 0.05 we conclude that there is heteroskedasticity in the model. The white robust standard errors were then calculated for the model.

3.2.2 Exceptions to Environmental Kuznets Curve in high income countries.

The world bank defines the High-Income countries as those countries whose GNI per capita is more than $12535. In this study 12 such high-income countries are selected from the high-income category or classification. The list of the high-income countries is given in the table 3.1. The descriptive statistics of the high-income countries is as follows:

Table 3.6 Descriptive statistics of the High-Income Countries panel

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	8.598	11.605	13.050	12.565	13.365	15.565
LN (GDP per capita)	9.228	9.947	10.518	10.364	10.685	11.014
$(\text{LN GDP per capita})^2$	85.16	98.94	110.62	107.66	114.16	121.30
$(\text{LN GDP per capita})^3$	785.9	984.1	1163.4	1120.7	1219.8	1336.0
LN(FDI)	0.7364	3.0760	3.4905	3.3062	3.8770	4.3173
LN (Trade openness)	-1.4517	-0.8286	-0.5270	-0.5516	-0.3153	0.5905

The above table shows the minimum, maximum, 1st quarter, 2nd quarter and mean values for all the variables that will be used for the analysis.

The model for the High-income countries panel

$$Ln(CO_2) = \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it}$$

The two-way fixed effects model is estimated for the panel of 12 high income countries. The following are the results

Table 3.7 Results of two-way fixed effects model for the high-income countries panel.

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	-137.862002	87.273232	-1.5797	0.116320
(LN GDP per capita)^2	14.156884	8.668478	1.6331	0.104564
(LN GDP per capita)^3	-0.482245	0.286174	-1.6851	0.094068.
LN(FDI)	0.166280	0.128169	1.2974	0.196528
LN (Trade openness)	-0.967411	0.406885	-2.3776	0.018703 *
LN(FDI)*LN (Trade Openness)	0.217473	0.081967	2.6532	0.008844 **

R-Squared: 0.37051

Adj. R-Squared: 0.23865

F-statistic: 14.5182 on 6 and 148 DF, p-value: 5.4641e-13

The results indicate the possibility an inverted N-shaped curve for the panel of 12 high income countries. The 1% increase in GDP per capita leads to fall in the Carbon emissions by 137.862002%. After some period, an increase in the GDP per capita (1%) would lead to rise in the emissions by14.156884% and after some period again an increase in income (1%) would lead to fall in the Carbon emissions by 0.482245%. The coefficients on the LN GDP per capita, LN GDP per capita squared are insignificant and cubed is significant. The coefficients are indicating the towards an inverted N-shaped Environmental Kuznets curve for the panel but we fail to conclude the same due to insignificant coefficients. The model explains around 24% variation in the carbon emissions caused by the variables selected.

The test for heteroskedasticity (Breusch Pagan test) was conducted and found the existence of heteroskedasticity in the model. The results of the test are as follows:

BP = 31.389, df = 6, p-value = 2.137e-05

Since the p-value is less than 0.05 we conclude that there is heteroskedasticity in the model. The white robust standard errors were then calculated for the model.

3.2.3 Exceptions to Environmental Kuznets Curve in low-income countries.

The world bank defines the High-Income countries as those countries whose GNI per capita is less than $1036. In this study 12 such low-income countries are selected from the high-income category or classification. The list of the low-income countries is given in the table 3.1. The descriptive statistics of the low-income countries is as follows:

Table 3.8 Descriptive statistics of the Low-Income Countries panel

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	5.011	6.620	7.581	7.672	8.119	11.086
LN (GDP per capita)	5.599	6.134	6.357	6.430	6.558	7.775
(LN GDP per capita)^2	31.35	37.63	40.41	41.61	43.00	60.46
(LN GDP per capita)^3	175.5	230.8	256.9	271.0	282.0	470.1
LN(FDI)	-0.5128	2.4463	3.0837	2.8729	3.5946	4.4025
LN (Trade openness)	-4.8476	-1.0843	-0.6920	-0.8752	-0.4763	0.4844

The above table shows the minimum, maximum, 1st quarter, 2nd quarter and mean values for all the variables that will be used for the analysis.

The model for the Low-income countries panel

$$Ln(CO_2) = \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it}$$

The two-way fixed effects model is estimated for the panel of 12 low-income countries. The following are the results

Table 3.9 Results of two-way fixed effects model for the low-income countries panel.

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	-63.312247	46.239760	-1.3692	0.173006
(LN GDP per capita)^2	8.287596	7.083916	1.1699	0.243915
(LN GDP per capita)^3	-0.345886	0.359745	-0.9615	0.337881
LN(FDI)	-0.088576	0.077796	-1.1386	0.256719
LN (Trade openness)	0.556681	0.180923	3.0769	0.002493 **
LN(FDI)*LN (Trade Openness)	-0.142147	0.048977	-2.9023	0.004271 **

R-Squared: 0.67737

Adj. R-Squared: 0.60979

F-statistic: 51.7884 on 6 and 148 DF, p-value: < 2.22e-16

The results indicate the possibility of an inverted N-shaped curve for the panel of 12 low-income countries. The 1% increase in GDP per capita leads to fall in the Carbon emissions by 63.312247%. After some period, an increase in the GDP per capita (1%) would lead to rise in the emissions by 8.287596% and after some period again an increase in income (1%) would lead to fall in the Carbon emissions by 0.345886 %. The coefficients on the LN GDP per capita, LN GDP per capita squared and cubed are not significant. The coefficients are indicating towards an inverted N-shaped Environmental Kuznets curve for the panel but we fail to conclude the same due to insignificant results. The model explains around 61% variation in the carbon emissions caused by the variables selected.

The test for heteroskedasticity (Breusch Pagan test) was conducted and found the existence of heteroskedasticity in the model. The results of the test are as follows:

BP = 53.311, df = 6, p-value = 1.016e-09

Since the p-value is less than 0.05 we conclude that there is heteroskedasticity in the model. The white robust standard errors were then calculated for the model.

3.2.4 Exceptions to Environmental Kuznets Curve in lower middle-income countries.

The world bank defines the Lower Middle-Income countries as those countries whose GNI per capita is between $1036-$4045. In this study 12 such lower middle-income countries are selected from the high-income category or classification. The list of the lower middle-income countries is given in the table 3.1. The descriptive statistics of the lower middle-income countries is as follows:

Table 3.10 Descriptive statistics of the Lower middle Income Countries panel

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	5.737	10.310	11.820	11.296	12.674	14.714
LN (GDP per capita)	6.632	7.501	7.799	7.753	8.098	8.604
$(\text{LN GDP per capita})^2$	43.98	56.26	60.82	60.33	65.57	74.02
$(\text{LN GDP per capita})^3$	291.7	422.0	474.3	471.0	531.0	636.8
LN(FDI)	1.608	2.484	3.057	2.953	3.582	4.227
LN (Trade openness)	-1.5449	-0.9245	-0.6968	-0.6052	-0.3092	0.4747

The above table shows the minimum, maximum, 1st quarter, 2nd quarter and mean values for all the variables that will be used for the analysis.

The model for the Lower middle income countries panel

$$Ln(CO_2) = \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it}$$

The two-way fixed effects model is estimated for the panel of 12 lower middle-income countries. The following are the results

Table 3.11 Results of two-way fixed effects model for the lower middle income countries panel.

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	33.837411	41.387999	0.8176	0.4149
(LN GDP per capita)^2	-4.264870	5.538928	-0.7700	0.4425
(LN GDP per capita)^3	0.186727	0.246006	0.7590	0.4490
LN(FDI)	-0.050401	0.111948	-0.4502	0.6532
LN (Trade openness)	-0.229215	0.412428	-0.5558	0.5792
LN(FDI)*LN (Trade Openness)	0.063146	0.115822	0.5452	0.5864

R-Squared: 0.61565

Adj. R-Squared: 0.53514

F-statistic: 39.5103 on 6 and 148 DF, p-value: < 2.22e-16

The results indicate there is a possibility of an N-shaped curve for the panel of 12 lower middle-income countries. The 1% increase in GDP per capita leads to rise in the Carbon

emissions by 33.837411%. After some period, an increase in the GDP per capita (1%) would lead to fall in the emissions by 4.264870% and after some period again an increase in income (1%) would lead to fall in the Carbon emissions by 0.186727 %. The coefficients on the LN GDP per capita, LN GDP per capita squared and cubed are not significant. The coefficients are indicating towards N-shaped Environmental Kuznets curve for the panel but we fail to conclude the same. The model explains around 53% variation in the carbon emissions caused by the variables selected.

The test for heteroskedasticity (Breusch Pagan test) was conducted and found the existence of heteroskedasticity in the model. The results of the test are as follows:

BP = 83.009, df = 6, p-value = 8.529e-16

Since the p-value is less than 0.05 we conclude that there is heteroskedasticity in the model. The white robust standard errors were then calculated for the model.

3.2.5 Exceptions to Environmental Kuznets Curve in upper middle-income countries.

The world bank defines the Upper Middle-Income countries as those countries whose GNI per capita is between $4046-$12535. In this study 12 such upper middle-income countries are selected from the high-income category or classification. The list of the upper middle-income countries is given in the table 3.1. The descriptive statistics of the upper middle-income countries is as follows:

Table 3.12 Descriptive statistics of the Upper middle Income Countries panel

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	4.868	10.978	12.348	11.764	13.024	16.186
LN (GDP per capita)	8.013	8.471	8.742	8.790	9.120	9.561
(LN GDP per capita)^2	64.21	71.76	76.42	77.42	83.18	91.41
(LN GDP per capita)^3	514.5	607.9	668.0	683.3	758.6	874.0
LN(FDI)	-19.265	2.974	3.407	2.718	3.761	4.828
LN (Trade openness)	-1.5139	-0.7753	-0.4008	-0.4167	0.1080	0.5194

The above table shows the minimum, maximum, 1st quarter, 2nd quarter and mean values for all the variables that will be used for the analysis.

The model for the Upper middle income countries panel

$$Ln(CO_2) = \beta_i + \beta_1 Ln(GDP\ per\ capita_{it}) + \beta_2 (LnGDP\ per\ capita_{it})^2 + \beta_3 (LnGDP\ per\ capita_{it})^3 + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Trade\ Openness_{it}) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \alpha_i + \theta_t + \varepsilon_{it}$$

The two-way fixed effects model is estimated for the panel of 12 Upper middle-income countries. The following are the results

Table 3.13 Results of two-way fixed effects model for the upper middle income countries panel.

Coefficients	Estimates	Standard errors	t-value	p-value
LN (GDP per capita)	24.8740276	75.4940879	0.3295	0.742256
(LN GDP per capita)^2	-2.5428523	8.6450385	-0.2941	0.769063
(LN GDP per capita)^3	0.0867300	0.3296639	0.2631	0.792850
LN(FDI)	-0.0253789	0.0078051	-3.2516	0.001421 **
LN (Trade openness)	-0.0780620	0.1423839	-0.5483	0.584346
LN(FDI)*LN (Trade Openness)	-0.0365335	0.0131682	-2.7744	0.006244 **

R-Squared: 0.28524

Adj. R-Squared: 0.13553

F-statistic: 9.84398 on 6 and 148 DF, p-value: 3.9986e-09

The results indicate that there exists a possibility of N-shaped curve for the panel of 12 upper middle-income countries. The 1% increase in GDP per capita leads to rise in the Carbon emissions by 24.8740276%. After some period, an increase in the GDP per capita (1%) would lead to fall in the emissions by 2.5428523% and after some period again an increase in income (1%) would lead to fall in the Carbon emissions by 0.0867300%. The coefficients on the LN GDP per capita, LN GDP per capita squared and cubed are not significant but are jointly significant. The coefficients are indicating towards the N-shaped Environmental Kuznets curve for the panel but we fail to conclude it due to insignificant coefficients. The

model explains around 13% variation in the carbon emissions caused by the variables selected.

The test for heteroskedasticity (Breusch Pagan test) was conducted and found the existence of heteroskedasticity in the model. The results of the test are as follows:

BP = 30.981, df = 6, p-value = 2.557e-05

Since the p-value is less than 0.05 we conclude that there is heteroskedasticity in the model. The white robust standard errors were then calculated for the model.

3.3 Country wise comparison

The intensity of GDP per capita's consequence on the carbon emissions differs based on the level of income of the countries. The following table shows the country wise comparison of coefficients on GDP per capita corresponding to the level of income of the countries.

Table 3.14 Comparison of countries based on the level of income

Coefficients	Whole panel	High Income	Low Income	Lower Middle Income	Upper Middle Income
LN (GDP per capita)	-3.470011	-137.862002	-63.312247	33.837411	24.8740276
(LN GDP per capita)^2	0.711736	14.156884	8.287596	-4.264870	-2.5428523
(LN GDP per capita)^3	-0.037340	-0.482245.	-0.345886	0.186727	0.0867300

The intensity differs based on the level of income of the countries. The study found the evidence of the inverted N-shaped Environmental Kuznets Curve for the whole panel, High income and Low-income countries. But in the whole panel the initial increase in the GDP per capita leads to fall in the carbon emissions by very low percentage, in low-income countries it is higher but the in high income countries the initial increase in GDP per capita has the largest impact on carbon emissions. The further rise in GDP per capita leads to rise in the carbon emissions in these three categories but the impact is largest in high income countries. After this stage the further rise in the GDP per capita leads to fall in the GDP per capita. Here as well the high-income countries have the highest intensity in lowering the carbon emissions.

In lower middle income and upper middle-income countries, the evidence of N-shaped curve is found. The initial increase in GDP per capita leads to rise in the carbon emissions in these countries. In lower middle-income countries, the impact of initial growth is larger in increasing the carbon emissions. The further rise in GDP per capita leads to fall in the emissions, here in the lower middle-income countries the fall is more. The further increase in economic growth after this stage, leads to rise in the carbon emissions. The lower middle-income countries have more share in the increasing the emissions than the upper middle-income countries.

The scale effect comes first in the first stage of the economic growth for the N-shaped Environmental Kuznets curve whereas the technique effect comes first in the first stage of the economic growth for the inverted N-shaped Environmental Kuznets curve. The conclusion of whether an inverted-N or N-shaped curve exists cannot be drawn due to insignificant results.

CHAPTER 4

FDI and Trade

4.1 Introduction

The Foreign Direct Investment (FDI) and trade has a significant impact on the economic growth as well as environmental degradation. The literature found conflicting impacts of the FDI and trade on the environmental degradation. The FDI and trade can have two effects- the 'Halo effect' and 'Pollution havens' hypotheses. The Halo effect states that FDI leads to improvement in the environmental conditions. This is attributed to the factors like more inflow of foreign technology or access to better foreign technology. Also, the production practices of the foreign firms may be sustainable. The Pollution havens hypotheses states that the FDI and trade leads to environmental degradation than the environmental improvement. This is because the foreign investors or traders wants to take the advantage of the loose environment protection laws of especially poor countries and make profits.

In this study the impact of FDI and trade on the carbon emissions has been analysed on the basis of the 4 income groups classification given by the World Bank. For FDI the annual stock of FDI inflow as a proportion of GDP was taken and for trade the index of trade openness was calculated. The trade openness refers to the value of exports and imports as the proportion of GDP was taken. The two-way fixed effects model was used and the panel of 48 countries has been taken.

4.2 The impact of FDI and trade openness for the entire panel.

The two-way fixed effects model for the whole panel of 48 countries was estimated for the whole panel of 48 countries. These countries include all 4 classification of income groups. The following are the estimates.

Table 4.1 Results for the whole panel by incorporating FDI and trade openness

Coefficients	Estimates	Standard errors	t-value	p-value
LN(FDI)	-0.078766	0.023120	-3.4069	0.0006974 ***
LN (Trade openness)	0.559595	0.194782	2.8729	0.0041991 **
LN(FDI)*LN (Trade Openness)	-0.151199	0.049614	-3.0475	0.0024005 **

The above table shows the impact of FDI and trade openness on the level of carbon emissions. The 1% increase in FDI will lead to fall in the carbon emissions by 0.0787663%. The coefficient on the LN(FDI) is significant. This shows the halo effect of FDI inflow. The trade openness however has a positive relationship with the carbon emissions. The 1% increase in the trade openness will lead to rise in the carbon emissions by 0.5595953%. This is the pollution havens effect. Trade openness is significant in this model. To see if both of these variables (FDI and trade openness) have any significant combined effect on the carbon emissions the interaction effect of the FDI and trade openness was added to the model. The interaction effect shows that 1% increase in the interaction effect leads to fall in the carbon emissions by 0.1511994%. The combined effect is significant and shows the halo effect.

The above evidence was for the whole panel of 48 countries. To see if income of the country has any significant effect on the carbon emissions by incorporating the FDI and trade openness, the separate study for each income group is conducted.

4.3 The impact of FDI and trade openness for the high-income countries.

The two-way fixed effects model for 12 high income countries was estimated. The countries selected are listed in table 3.1. The following are the estimates for the high-income countries panel.

Table 4.2 Results for the high-income countries panel by incorporating FDI and trade openness

Coefficients	Estimates	Standard errors	t-value	p-value
LN(FDI)	0.166280	0.128169	1.2974	0.196528
LN (Trade openness)	-0.967411	0.406885	-2.3776	0.018703 *
LN(FDI)*LN (Trade Openness)	0.217473	0.081967	2.6532	0.008844 **

The above table shows the impact of FDI and trade openness on the level of carbon emissions. The 1% increase in FDI will lead to rise in the carbon emissions by 0.166280%. The coefficient on the LN(FDI) is not significant, but is jointly significant. This shows the pollution havens effect of FDI inflow. The trade openness however has a negative relationship with the carbon emissions. The 1% increase in the trade openness will lead to fall in the carbon emissions by 0.967411%. This is the halo effect of trade openness. The trade openness is significant. To see if both of these variables (FDI and trade openness) have any significant combined effect on the carbon emissions the interaction effect of the FDI and trade openness was added to the model. The interaction effect shows that the 1% increase in the interaction effect leads to increase in the carbon emissions by 0.217473%. The combined effect is significant and shows the pollution havens effect.

4.4 The impact of FDI and trade openness for the low-income countries.

The two-way fixed effects model for 12 low-income countries was estimated. The countries selected are listed in table 3.1. The following are the estimates for the low-income countries panel.

Table 4.3 Results for the low-income countries panel by incorporating FDI and trade openness

Coefficients	Estimates	Standard errors	t-value	p-value
LN(FDI)	-0.088576	0.077796	-1.1386	0.256719
LN (Trade openness)	0.556681	0.180923	3.0769	0.002493 **
LN(FDI)*LN (Trade Openness)	-0.142147	0.048977	-2.9023	0.004271 **

The above table shows the impact of FDI and trade openness on the level of carbon emissions. The 1% increase in FDI will lead to fall in the carbon emissions by 0.088576%. The coefficient on the LN(FDI) is insignificant but it is jointly significant. This shows the halo effect of FDI inflow. The trade openness however has a positive relationship with the carbon emissions. The 1% increase in the trade openness will lead to rise in the carbon emissions by 0.556681%. This is the pollution havens effect. It is significant in the model. To see if both of these variables (FDI and trade openness) have any significant combined effect on the carbon emissions the interaction effect of the FDI and trade openness was added to the model. The interaction effect shows that 1% increase in the interaction effect leads to fall in the carbon emissions by 0.142147%. The combined effect is significant and shows the halo effect.

4.5 The impact of FDI and trade openness for the lower middle-income countries.

The two-way fixed effects model for 12 lower middle-income countries was estimated. The countries selected are listed in table 3.1. The following are the estimates for the lower middle income countries panel.

Table 4.4 Results for the lower middle income countries panel by incorporating FDI and trade openness

Coefficients	Estimates	Standard errors	t-value	p-value
LN(FDI)	-0.050401	0.111948	-0.4502	0.6532
LN (Trade openness)	-0.229215	0.412428	-0.5558	0.5792
LN(FDI)*LN (Trade Openness)	0.063146	0.115822	0.5452	0.5864

The above table shows the impact of FDI and trade openness on the level of carbon emissions. The 1% increase in FDI will lead to fall in the carbon emissions by 0.050401%. The coefficient on the LN(FDI) is insignificant. This shows the halo effect of FDI inflow. The trade openness also has a negative relationship with the carbon emissions. The 1% increase in the trade openness will lead to fall in the carbon emissions by 0.229215%. This is the halo effect. It is insignificant. To see if both of these variables (FDI and trade openness) have any significant combined effect on the carbon emissions the interaction effect of the FDI and trade openness was added to the model. The interaction effect shows that 1% increase in the interaction effect leads to rise in the carbon emissions by 0.063146%. The combined effect is insignificant and shows the pollution havens effect.

4.6 The impact of FDI and trade openness for the upper middle-income countries.

The two-way fixed effects model for 12 upper middle-income countries was estimated. The countries selected are listed in table 3.1. The following are the estimates for the upper middle income countries panel.

Table 4.5 Results for the upper middle income countries panel by incorporating FDI and trade openness

Coefficients	Estimates	Standard errors	t-value	p-value
LN(FDI)	-0.0253789	0.0078051	-3.2516	0.001421 **
LN (Trade openness)	-0.0780620	0.1423839	-0.5483	0.584346
LN(FDI)*LN (Trade Openness)	-0.0365335	0.0131682	-2.7744	0.006244 **

The above table shows the impact of FDI and trade openness on the level of carbon emissions. The 1% increase in FDI will lead to fall in the carbon emissions by 0.0253789%. The coefficient on the LN(FDI) is significant. This shows the halo effect of FDI inflow. The trade openness also has a negative relationship with the carbon emissions. The 1% increase in the trade openness will lead to fall in the carbon emissions by 0.0780620%. This is the halo effect. It is insignificant but is jointly significant. To see if both of these variables (FDI and trade openness) have any significant combined effect on the carbon emissions the interaction effect of the FDI and trade openness was added to the model. The interaction effect shows that 1% increase in the interaction effect leads to fall in the carbon emissions by 0.0365335%. The combined effect is significant and shows the halo effect.

4.7 Comparison of countries based on the FDI and trade openness

The impact of FDI and trade openness on carbon emissions differ based on the level of income of the countries. The impact of FDI, trade openness and the interaction effect of both of them is tabulated in the table below

Table 4.6 Comparison of the countries by incorporating the impact of FDI and trade openness.

Coefficients	Whole panel	High Income	Low Income	Lower Middle Income	Upper Middle Income
LN(FDI)	-0.078766***	0.166280	-0.088576	-0.050401	-0.0253789**
LN (Trade openness)	0.559595**	-0.967411*	0.556681**	-0.229215	-0.0780620
LN(FDI)*LN (Trade Openness)	-0.151199**	0.217473**	-0.142147**	0.063146	-0.0365335**

The above table shows the impact of FDI, trade openness and their interaction effect on the different countries based on their level of income. In the whole panel of all these 4 income groups the FDI shows halo effect. In the high-income countries FDI exhibits pollution havens hypotheses. In low-income countries FDI exhibits halo effect. In lower middle and upper middle-income countries as well FDI shows the halo effect. In the whole panel of all these 4

income groups the trade openness exhibits pollution havens hypothesis. In the high-income countries trade openness halo effect. In low-income countries trade openness exhibits pollution havens hypothesis. In lower middle and upper middle income countries trade openness exhibits the halo effect.

In the whole panel of all these 4 income groups the interaction effect of FDI and trade openness exhibits halo effect. In the high-income countries, the interaction effect of FDI and trade openness exhibits pollution havens hypothesis. In low-income countries the interaction effect of FDI and trade openness exhibits halo effect. In lower middle-income countries, the interaction effect of FDI and trade openness exhibits pollution havens hypothesis. And in upper middle countries the interaction effect of FDI and trade openness exhibits halo effect.

CHAPTER 5

India level study

5.1 Introduction

India falls into the category of lower middle-income countries as per the World Bank classification of countries. In the previous chapters it was found that for lower middle-income countries there exists an N-shaped Environmental Kuznets Curve. It is important to study this individually for India. Given India's large population and India being one of the fastest growing economies in the world with around 5.9% of growth projected by World Economic Outlook, 2023. Being one of the growing countries, the economic activities are growing in the country. Now this will have an impact on the environment. Whether it will be a good or bad impact depends upon the kind of activities that are being taking place in the economy.

5.2 Data description

The period of study for India is from 1990-2019. The following is the description of the data collected for the study.

Table 5.1 Description statistics of the data for India level study

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
LN (CO2)	13.24	13.62	13.92	13.99	14.44	14.71
LN (GDP per capita)	6.271	6.511	6.824	6.862	7.189	7.571
$(\text{LN GDP per capita})^2$	39.32	42.39	46.57	47.25	51.68	57.33
$(\text{LN GDP per capita})^3$	246.6	276.0	317.8	326.5	371.5	434.0
LN(FDI)	-0.6864	0.8978	1.6903	1.5513	2.5061	2.6929
LN (Trade openness)	-2.0677	-1.5491	-1.0457	-1.1946	-0.8298	-0.5997

The above table shows the minimum, maximum, mean, median, 1st quarter and 2nd quarter values for the variables selected across the period 1990-2019.

5.3 Stationarity

The data collected was first tested for the stationarity so that spurious regression can be avoided. The Phillips Perron test (PP) and Kwiatkowski-Phillips-Schmidt-Shin test (KPSS) was conducted. Following are results:

Table 5.2 Results of the stationarity tests

Variables	Phillips Perron test		Kwiatkowski-Phillips-Schmidt-Shin	
	Level	First Difference	Level	First Difference
LN (CO2)	-5.6367	-30.204*	1.0914*	0.12695
LN (GDP per capita)	-8.1779	-23.732*	1.0894*	0.44702
(LN (GDP per capita))^2	-5.4794	-23.788*	1.0863*	0.58007
(LN (GDP per capita))^3	-3.7847	-23.853*	1.0821*	0.6853
LN(FDI)	-1.4299	-26.411*	1.0254*	0.63917
LN(Trade)	-0.69786	-26.887*	0.97806*	0.44126

The results from the Phillips Perron test indicated that all the variables were non-stationary at the level but became stationary after taking the first difference. The null hypothesis in PP test is that the variables are non-stationary and alternate hypothesis that they are stationary. The results from Kwiatkowski-Phillips-Schmidt-Shin test indicated that all the variables were

non-stationary at the level but became stationary after taking the first difference. The null hypothesis in KPSS test is that the variables are stationary and alternate hypothesis is that the variables are non-stationary.

5.4 ARDL model

5.4.1 Simple ARDL model

The automatic ARDL model selection was used for the computation of the following model.

$$Ln(CO_2) = \beta_t + \beta_1 Ln(GDP\ per\ capita_t) + \beta_2 (LnGDP\ per\ capita_t)^2 + \beta_3 (LnGDP\ per\ capita_t)^3 + \beta_4 Ln(FDI_t) + \beta_5 Ln(Trade\ Openness_t) + \beta_6 (Ln(FDI) * Ln(Trade\ Openness)) + \mu_t$$

The optimal lag selection was (1,0,0,0,0,1,1). The results of the simple ARDL model are as follows:

Table 5.3 Results of simple ARDL model

Coefficients	Estimates	Standard errors	t-value	p-value
Intercept	225.85762	121.70543	1.856	0.079066.
L (LN (CO2),1)	0.53245	0.12156	4.380	0.000322 ***
LN (GDP per capita)	-91.67229	50.89212	-1.801	0.087548.
(LN GDP per capita)^2	12.73582	7.14342	1.783	0.090592.
(LN GDP per capita)^3	-0.58711	0.33379	-1.759	0.094685.
LN(FDI)	-0.01500	0.06314	-0.238	0.814706
LN (Trade openness)	0.08230	0.09105	0.904	0.377317
L (LN (Trade openness),1)	0.24547	0.11359	2.161	0.043674 *
LN(FDI)*LN (Trade Openness)	-0.01528	0.03934	-0.388	0.702015
L(LN(FDI)*LN (Trade Openness),1)	-0.06441	0.03822	-1.685	0.108268

Multiple R-squared: 0.9989, Adjusted R-squared: 0.9983

F-statistic: 1846 on 9 and 19 DF, p-value: < 2.2e-16

The above table indicates that the lag on LN (CO2) is very significant. The coefficients of GDP per capita, GDP per capita squared and GDP per capita cubed indicates that there exists an inverted N-shaped curve for India. The initial 1% increase in GDP per capita leads to fall in the Carbon emissions by 91.67229%. In the second stage the 1% increase in GDP per capita will lead to rise in the carbon emissions by 12.73582%. However, after some time more increase in GDP per capita say by 1%, the carbon emissions decline by 0.58711%.

The coefficients on FDI and trade openness are not significant. The coefficient on FDI and openness indicates halo effect and pollution havens effect respectively. The first lag of trade openness is significant and exhibits pollution havens hypothesis. The interaction effect of FDI and trade openness isn't significant and it shows halo effect. The first lag of the interaction term is also not significant but shows the halo effect. Overall, this model explains about 99% variation in carbon emissions caused above mentioned variables.

After calculating the simple ARDL model, the bounds t-test for no cointegration was conducted. The results of the bounds t-test are as follows:

Bounds t-test for no cointegration

t = -3.8463, Lower-bound I (0) = -3.4332, Upper-bound I (1) = -4.9847, p-value = 0.1456

alternative hypothesis: Possible cointegration

null values:

k T

6 1000

The t-bound test concluded that there is no possibility for cointegration. Then the Bounds Wald-test for no cointegration was conducted for the same model. The results of this test are as follows:

Bounds F-test (Wald) for no cointegration

F = 4.5013, Lower-bound I (0) = 3.1421, Upper-bound I (1) = 4.4375, p-value = 0.008787

alternative hypothesis: Possible cointegration

null values:

k T

6 1000

Since the p-value is less than 0.05, we conclude that there is possibility for cointegration.

5.4.2 Cointegration equation

5.4.2.1 Unrestricted model

The unrestricted model looks as follows

Table 5.4 Results of unrestricted cointegration model

Coefficients	Estimates	Standard errors	t-value	p-value
Intercept	225.85762	121.70543	1.856	0.07907.
L (LN (CO2),1)	-0.46755	0.12156	-3.846	0.00109 **
LN (GDP per capita)	-91.67229	50.89212	-1.801	0.08755.
(LN GDP per capita)^2	12.73582	7.14342	1.783	0.09059.
(LN GDP per capita)^3	-0.58711	0.33379	-1.759	0.09468.
LN(FDI)	-0.01500	0.06314	-0.238	0.81471
L (LN (Trade openness),1)	0.32778	0.14717	2.227	0.03822 *
L(LN(FDI)*LN (Trade Openness),1)	-0.07969	0.05748	-1.387	0.18164
Δ (LN (Trade openness))	0.08230	0.09105	0.904	0.37732
Δ (LN(FDI)*LN (Trade Openness))	-0.01528	0.03934	-0.388	0.70201

Multiple R-squared: 0.6347, Adjusted R-squared: 0.4617

F-statistic: 3.668 on 9 and 19 DF, p-value: 0.008199

The above table shows the results of unrestricted ARDL cointegration model. The variables L (LN (CO2),1), LN (GDP per capita), (LN GDP per capita)2, (LN GDP per capita)3, LN(FDI), L (LN (Trade openness),1) and L(LN(FDI)*LN (Trade Openness),1) are long run variables affecting CO2 while the variables Δ (LN (Trade Openness)) and Δ (LN(FDI)*LN (Trade Openness)) are short run variables affecting CO2 emissions. All the variables except FDI and interaction of FDI and trade openness are significant in the long run. The results indicate the evidence on inverted-N shaped Environmental Kuznets Curve for India in the long run. So, in the long run economic growth will become sustainable in India. The technique effect can be seen for India in the long run.

In the short run however, the trade openness and interaction of trade and FDI are insignificant. The model explains about 46% variation in carbon emissions. The overall model is significant.

5.4.2.2 Restricted model

The restricted model looks as follows

Table 5.5 Results of restricted cointegration model

Coefficients	Estimates	Standard errors	t-value	p-value
Intercept	225.85762	35.06926	6.440	9.61e-07 ***
Δ (LN (Trade openness))	0.08230	0.04005	2.055	0.0504.
Δ(LN(FDI)*LN (Trade Openness))	-0.01528	0.01335	-1.145	0.2632
ect	-0.46755	0.07261	-6.439	9.64e-07 ***

Multiple R-squared: 0.6347, Adjusted R-squared: 0.5909

F-statistic: 14.48 on 3 and 25 DF, p-value: 1.139e-05

In the above table the results of the restricted cointegration model are shown. The intercept is significant. The short run variable LN (Trade Openness) is significant and exhibits the pollution havens hypothesis. The coefficient on the interaction term is insignificant in the short run. The 'error correcting term' (ect) is significant and shows the negative relationship with the carbon emissions. The ect term is the long run term. In the long run there exists a halo effect for India which is shown by the ect term. The model explains about 59% variation in the carbon emissions.

CHAPTER 6

Summary, Findings and Conclusion

6.1 Summary

The decision of whether there is an exception to Environmental Kuznets Curve was tested but the decision remains unsolved. The different income groups exhibit different Environmental Kuznets Curve but the models were insignificant, so we cannot conclude whether there exists an exception in the form of N-shaped or inverted N-shaped Environmental Kuznets curve. The FDI and trade were very significant in determining the level of carbon emissions. The effect of these both (halo effect or pollution havens hypothesis) differed based on the level of income of the countries. In some countries FDI was exhibiting halo and trade pollution havens while in some both were exhibiting the halo effect/ pollution havens hypothesis. The effect of FDI and trade together also showed a significant effect on the carbon emission. This effect again differed based on the level of the income of the countries. India exhibited inverted-N shaped Environmental Kuznets Curve. This inverted-N shaped environmental Kuznets curve is valid in the long run. In the long run all the variables depict technique effect. In the short run only trade openness is significantly related to the carbon emissions.

6.2 Findings

1) LN (GDP per capita) is significant and is positively related to the carbon emissions for the whole panel of 48 countries.

2) Trade openness shows a strong pollution havens hypothesis for the whole panel of 48 countries.

3) The results of two-way fixed model indicate the possibility of an inverted N-shaped curve for the whole panel of 48 countries but we fail to conclude the same due to insignificant results.

4) The results of two-way fixed model indicate the possibility an inverted N-shaped curve for the panel of 12 high income countries but we fail to conclude the same due to insignificant results.

5) The results of two-way fixed model indicate the possibility an inverted N-shaped curve for the panel of 12 low-income countries but we fail to conclude the same due to insignificant results.

6) The results of two-way fixed model indicate that there is a possibility of an N-shaped curve for the panel of 12 lower middle-income countries but we fail to conclude the same due to insignificant results.

7) The results of two-way fixed model indicate that there is a possibility of an N-shaped curve for the panel of 12 upper middle-income countries but we fail to conclude the same due to insignificant results.

8) The intensity differs based on the level of income of the countries. The high-income countries have the highest intensity in lowering the carbon emissions between itself, the whole panel and low-income countries.

9) The lower middle-income countries have more share in the increasing the emissions than the upper middle-income countries.

10) The conclusion of whether an inverted-N or N-shaped curve exists cannot be drawn due to insignificant results.

11) The FDI shows halo effect for the whole panel of 48 countries. Trade openness shows pollution havens hypothesis for the whole panel and interaction of FDI and trade openness exhibits a halo effect.

12) FDI in high income countries shows exhibits a pollution havens hypothesis but is not significant and trade openness exhibits halo effect. The interaction between the FDI and trade openness exhibits a halo effect.

13) FDI in low-income countries shows exhibits a halo effect but is not significant and trade openness exhibits pollution havens hypothesis. The interaction between the FDI and trade openness exhibits a halo effect.

14) FDI in lower middle-income countries shows exhibits a halo effect but is not significant and trade openness exhibits halo effect but is not significant. The interaction between the FDI and trade openness exhibits a pollution havens hypothesis but is not significant.

15) FDI in lower middle-income countries shows exhibits a halo effect and is significant and trade openness exhibits halo effect but is not significant. The interaction between the FDI and trade openness exhibits a halo effect and is not significant.

16) The results indicate the evidence on inverted-N shaped Environmental Kuznets Curve for India in the long run.

17) In the short run however, the trade openness and interaction of trade and FDI are insignificant.

18) The technique effect can be seen for India in the long run.

19) All the variables except FDI and interaction of FDI and trade openness are significant in the long run.

20) The short run variable LN (Trade Openness) is significant and exhibits the pollution havens hypothesis. The coefficient on the interaction term is insignificant in the short run.

21) In the long run there exists a halo effect for India which is shown by the ect term. The error correcting model or term is depicting negative relationship with the carbon emissions.

6.3 Conclusion

The exceptions to the environmental Kuznets curve for the whole panel, high income, low income, lower middle income and upper middle-income countries cannot be concluded as the results aren't significant. The intensity however differs based on the level of the income of the countries. Some countries depict higher intensity in reducing carbon emissions while some very low. The FDI and trade openness also has a differing effect based on the level of the country. In the whole panel of all these 4 income groups the FDI shows halo effect. In the high-income countries FDI exhibits pollution havens hypotheses. In low-income countries FDI exhibits halo effect. In lower middle and upper middle-income countries as well FDI shows the halo effect. In the whole panel of all these 4 income groups the trade openness exhibits pollution havens hypothesis. In the high-income countries trade openness halo effect. In low-income countries trade openness exhibits pollution havens hypothesis. In lower middle and upper middle income countries trade openness exhibits the halo effect. In the whole panel of all these 4 income groups the interaction effect of FDI and trade openness exhibits halo effect. In the high-income countries, the interaction effect of FDI and trade openness exhibits pollution havens hypothesis. In low-income countries the interaction effect of FDI and trade openness exhibits halo effect. In lower middle-income countries, the interaction effect of FDI and trade openness exhibits pollution havens hypothesis. And in upper middle countries the interaction effect of FDI and trade openness exhibits halo effect.

For India level study, the evidence of inverted-N shaped Environmental Kuznets curve was found in the long run. In the long run all the variables are exhibiting the strong halo or technique effect. In the short run only trade openness is significant and exhibits pollution havens hypothesis. In the long run the economic growth in India is becoming sustainable. India being one of the top 10 carbon emitting country has a prospect of reducing it in the future. The initial growth may result in environment degradation but in the long run the environment will improve. The policy makers should make the policies keeping in consideration the concept of sustainable development where inter as well as intra generational needs can fulfilled.

CHAPTER 7

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