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Is the Environmental Kuznets Curve Hypothesis Valid in South Asian Countries? Panel Evidence (1981-2015)

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Abstract
This study examines the impact of per capita income, its square, forest area, FDI inflows, population density, urbanization, and trade openness on CO_2 emissions in South Asian countries. Using secondary data from the World Development Indicators (WDI) for 1981–2015, the analysis employs ADF tests for stationarity and the ARDL bounds testing approach for long- and short-run relationships. Results indicate that all variables significantly reduce CO_2 emissions over both periods. Unit root tests show that CO_2 emissions and per capita GDP are sometimes cointegrated, supporting the validity of the Environmental Kuznets Curve (EKC) hypothesis. The study also finds that the effect of explanatory variables on emissions depends on the type of pollutant. Overall, higher per capita income and FDI contribute to reducing emissions, confirming the EKC for South Asian economies. The findings suggest that these countries need coordinated environmental and economic policies to simultaneously promote growth and protect environmental quality.

Keywords: *Environmental Kuznets Curve Hypothesis, South Asian Countries, Panel Evidence.*

1. Introduction

1.1. Background and Problem Statement

The relationship between economic growth and environmental quality has been widely studied, with Krueger (1991) highlighting an inverted U-shaped pattern between pollution and per capita income, known as the Environmental Kuznets Curve (EKC). The EKC hypothesis posits that environmental degradation initially increases with income growth but eventually declines once a certain income threshold is reached. This reflects the decoupling of economic development from environmental damage at higher income levels. Resource depletion, if unchecked, threatens both environmental sustainability and economic activity, emphasizing the need for a steady-state approach to development. Higher-income populations typically demand cleaner environments and less resource-intensive goods, promoting environmental protection measures (Ajide & Oyinlola, 2010).

In developing countries, CO_2 emissions have shown an increasing trend over time, alongside rising per capita income and income squared. Variables such as trade liberalization, urbanization, population density, and forest area exhibit relatively stable trends, while FDI inflows fluctuate over time. Econometric analysis indicates that population growth exacerbates waste generation and environmental degradation, despite income growth, highlighting the complex interactions between development and pollution. Unit root and cointegration tests reveal that CO_2 emissions and per capita income are sometimes cointegrated, supporting the EKC hypothesis.

In early stages of economic development, environmental degradation is pronounced, whereas richer economies eventually achieve better environmental quality due to higher income, technological advancements, and stricter regulations (Beckerman, 1992). However, South Asian developing countries face slow progress in pollution reduction due to limited resources, emphasizing the importance of examining factors like forest area, per capita income, FDI inflows, population density, urbanization, and trade openness in relation to CO_2 emissions for the 1981–2015 period.

Econometric models in this study use these variables to estimate the EKC pattern, with logarithmic transformations applied to ensure linearity. Panel data methods account for cross-country heterogeneity, as the pollution-income relationship may differ across nations. Trade theory (Heckscher-Ohlin) suggests that developing countries, specializing in labor- and resource-intensive production, may experience higher environmental degradation compared to developed nations focusing on capital- and technology-intensive activities. Overall, CO_2 emissions initially rise with income but decline at higher income levels, confirming the inverted U-shaped EKC relationship.

1.2 Purpose of the Study

The primary aim of this research is to identify the key factors influencing CO_2 emissions in South Asian countries. The study evaluates environmental degradation alongside explanatory variables such as FDI, forest area, per capita income, income squared, population density, urbanization, and trade openness. It seeks to determine the relative impact of these variables on CO_2 emissions, providing insights distinct from prior studies by focusing specifically on South Asian economies.

1.3 Objectives of the Study

The main objectives are:

- To assess the relevance of the EKC hypothesis in estimating CO_2 emissions in South Asian countries.
- To analyze the role of forest area, per capita income, income squared, FDI inflows, trade openness, urbanization, and population density in influencing CO_2 emissions.

1.4 Significance of the Study

Most EKC research has focused on developed nations, leaving a gap in understanding for developing countries over 35 periods. This study provides guidance for these economies to adopt policies informed by EKC insights. Key contributions include examining whether the EKC exists in these countries and identifying potential turning points. While developed countries have generally improved environmental quality alongside economic growth, South Asian countries remain below the EKC threshold, necessitating targeted, country-specific approaches for sustainable development.

2: Literature review on EKC studies

Theoretical Framework and Literature Review

The Environmental Kuznets Curve (EKC) hypothesis has been central to theoretical studies examining the relationship between economic growth and environmental quality. According to the EKC, as an economy's per capita income rises, environmental degradation initially increases, reaches a peak, and then declines, forming an inverted U-shaped pattern (Kuznets, 1955; Grossman & Krueger, 1991). This framework suggests that at early stages of development, economic activities exert high pressure on the environment, but at higher income levels, greater awareness, technological advancement, and regulatory capacity allow for environmental improvement.

Early studies by Shafik and Bandyopadhyay (1992) emphasized the importance of economic growth in maintaining or improving environmental quality, particularly in developing countries. Similarly, Panayotou (1993) noted that deforestation was especially pronounced in tropical regions and areas with high population densities, linking environmental degradation to both population and income growth. Arrow (1995) and Stern (1996) highlighted the influence of trade patterns on the distribution of polluting industries, while the Heckscher-Ohlin trade theory suggested that developing countries, specializing in labor- and resource-intensive production, may experience greater environmental degradation relative to developed countries focusing on capital- and technology-intensive sectors.

The role of income in environmental protection has been widely debated. Martinez-Alier (1995) argued that wealthier populations care more about environmental quality, reflecting higher demand for a cleaner environment as income rises. Empirical studies by Shafik and Bandyopadhyay (1992) and Beckerman (1992) confirm that indicators such as CO_2 emissions and particulate matter initially increase with income but decline after reaching a threshold, supporting the EKC hypothesis. However, Dasgupta (2002) and Perman and Stern (2003) caution that EKC applicability varies across pollutants and regions, and rigorous econometric testing, including unit root and cointegration analyses, is essential to avoid spurious results.

Further empirical evidence demonstrates the influence of population growth and consumption patterns on environmental outcomes. John and Pecchenino (1994, 1995) and McConnell (1997) show that consumption, rather than production alone, contributes significantly to pollution, while Stokey (1998) emphasizes the sectoral shift from agriculture to industry as a driver of increased emissions. Mather (1999) finds an inverted U-shaped pattern for deforestation, suggesting that richer societies, with more time and resources, engage in reforestation and environmental protection. Lopez (1994) and Selden & Song (1995) highlight the role of technological change in industrial sectors as both a source of pollution and a potential tool for mitigation.

Population growth amplifies environmental pressure by increasing consumption and waste generation (Ibidi, UNDP, 1999; Neumayer, 2003). Stern (2004) identifies major econometric limitations in EKC studies, including heteroscedasticity, omitted variables, and co-integration issues, while Binder and Neumayer (2005) demonstrate that environmental NGOs and democratic governance significantly improve pollution control outcomes.

Farzin and Bond (2006) find that higher population densities can mitigate pollution under certain conditions, whereas Azomahahon (2006) identifies an inverted U-shaped relationship between population and CO_2 emissions across countries.

Overall, the EKC literature suggests that environmental degradation declines with higher income in developed countries due to stronger institutional capacity, technological advancement, and policy enforcement (Neumayer, 2003; Bernauer & Koubi, 2009). In contrast, developing economies face challenges due to limited resources, rapid population growth, and weaker institutional frameworks, making the EKC relationship less straightforward. High population density and consumption patterns exacerbate environmental pressures, while rich countries possess the capacity to mitigate emissions through efficient policies and environmental investments.

The literature consistently finds a significant inverse relationship between CO_2 emissions and variables such as per capita income, forest area, FDI, population density, urbanization, and trade openness in developed contexts. However, for developing countries, the relationship is more complex: while some studies suggest a similar inverse pattern, others indicate that limited resources and rapid demographic growth hinder pollution reduction. Consequently, sustainable environmental policy in developing nations must address both economic development and resource constraints to achieve meaningful reductions in CO_2 emissions.

Theoretical framework of EKC in South Asian Countries

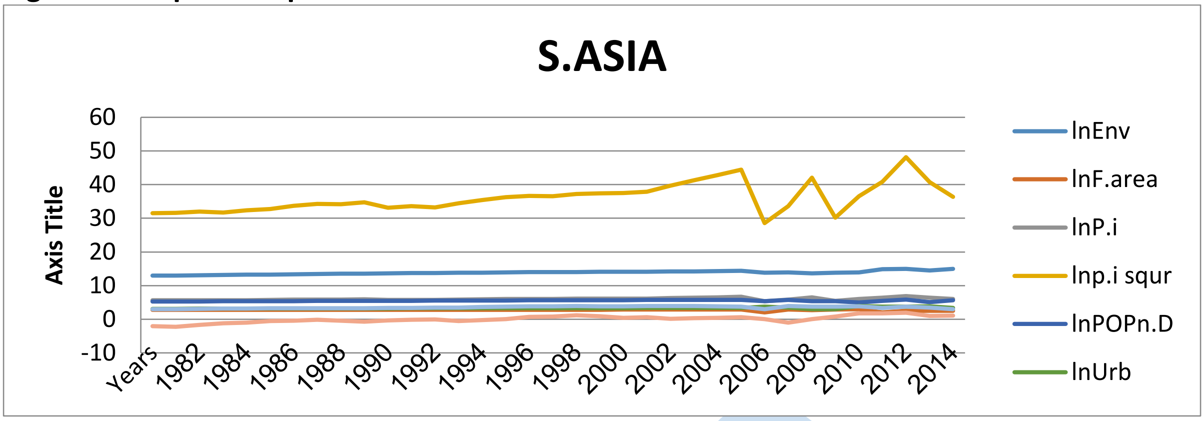
3.1. History of EKC

The Environmental Kuznets Curve (EKC) concept emerged in the early 1990s through the pioneering work of Grossman and Krueger (1991) on NAFTA's potential impacts and Shafik and Bandyopadhyay (1992) for the World Development Report. The World Commission on Environment and Development (1987) emphasized that economic growth is necessary to maintain or improve environmental quality. The EKC gained further prominence in the 1992 World Bank Development Report, which argued that while economic activity initially harms the environment, rising incomes increase demand for better environmental quality (Beckerman, 1992).

However, EKC does not universally apply to all CO_2 impacts; pure economic growth alone may proportionally increase pollution without reductions (Dasgupta, 2002). Traditional views emphasize the scale effect, but higher environmental awareness, stricter regulations, improved technology, and increased environmental spending can eventually stabilize and reduce pollution, creating the inverted U-shaped pattern (Panayotou, 1993).

Empirical and theoretical studies support the EKC's inverted U-shape, where CO_2 emissions initially rise with low per capita income but decline after a turning point as income and technology improve (Kuznets, 1995). For developing countries—among the top emitters globally—variables such as per capita income, income squared, forest area, population density, urbanization, trade openness, and FDI inflows are critical for policy-making. While extensive EKC research exists for developed countries, studies focusing on developing nations remain limited. This study addresses that gap by examining the EKC in the context of South Asian economies.

Figure 1. Graphical representation of South Aian countries



In the above graph the Environmental pollution is much higher showing a high upward trend with passage of time. Per capita income and population density show the same upward trend side by side, population density is a bit smooth while per capita show a jump at the end from 2011 to 2014. Similarly forest area, urbanization and trade openness show the same smooth trend with no jump as such in these countries whereas trade openness show an upward trend from 2003 to 2013 and then again downward trend. FDI inflow is appreciating in these countries starting from a negative point to a high level in the specific time period.

3.2. Methodology and Estimation Strategy

Selecting an appropriate research methodology is a critical step in any study, as it provides a structured framework for data collection and analysis. It guides the choice of data sources, the type of data required, and the selection of suitable models for empirical estimation.

The main objective of this thesis is to assess the impact of per capita income on environmental pollution, specifically CO_2 emissions. It examines the relationships between CO_2 emissions and key explanatory variables, including per capita income (PY), income squared (PY^2), FDI inflows, forest area, population density, urbanization, and trade openness, using data from the World Development Indicators (WDI). The study employs a panel dataset covering 35 years (1981–2015) for South Asian countries to carry out the empirical analysis.

Countries Selection criteria for developing countries as: South Asia as Pakistan, India (LMY).

3.2.1. Econometric Model

As our research objective is to enumerate and analyze the importance of other precipitating factors like forest area, per capita GDP, PY^2, FDI inflows, trade openness, and urbanization and population density for CO2 emissions in South Asian countries. Our sample consists of South Asian countries during the period from 1981 to 2015. Model is used to investigate the basic interaction of CO2 emissions with independent variables based on the following equation: source are given below as

$$E_{it} = \varphi_t + \beta_1 FA_{it} + \beta_2 PY_{it} + \beta_3 PY^2_{it} + \beta_4 FDI_{it} + \beta_5 Uit + \beta_6 PD_{it} + \beta_7 TO_{it} + \mu_{it}$$

So for i=1,..., N t=1,.....,T

Hence E_{it}= Ln(E_{it}) show Environmental pollution in term of (CO2) emissions in log form. LnFA (Forest Areas) PY_{it}=Ln(PY_{it}) log of p/c income in country ith in year (periods(t)),PY_{it}^2=Ln(PY^2_{it}) log of per capita income square and TL_{it}= Ln(TL_{it}) show the log of trade liberalization. LnPD (Population density), Urbanization and FDI Inflows are the explanatory variables which may affect the pollution. The parameter vectors as β= (β_1=β_2=β_3=β_4=β_5=β_6=β_7) and an error term is μ_{it}. If the relationship between environmental pollution and income is not monotonic but it show U-shape inversely, so coefficient FA of β_1, is positive and coefficient on per capita income β_2 is negative. At country level term μ_i it shows a country specific effect due to the controls for unobserved factors that affect pollution.

3.3. Theoretical Framework of the Model

The level of CO_2 emissions varies across countries at different income levels, consistent with the EKC hypothesis. It is generally assumed that all countries share the same income elasticity at a given income level, though variations over time occur due to stochastic shocks and period-specific effects. This study employs panel data for empirical estimation, as both fixed and random effects models are commonly used in the literature. In the model, α_i and γ_t represent regression parameters capturing fixed effects, whereas in random effects models these are treated as random disturbances. However, the random effects model produces inconsistent estimates if α_i and γ_t correlate with explanatory variables, making the fixed effects model preferable (Mundlak, 1978). Fixed effects estimation is often used in EKC studies for developed countries, though it is rarely applied to South Asian countries (Stern & Perman, 2003).

Unit root tests are required to ensure that per capita GDP and other variables are integrated, as spurious results may arise if EKC regressions are not cointegrated. Diagnostic statistics for variable integration and regression cointegration are limited in previous EKC studies, making empirical validation challenging. Overall, the EKC hypothesis is applicable at both local and global levels, with developing countries identified as top CO_2 emitters. Across countries, per capita pollution levels differ, and time-specific economic shocks contribute to variations in emissions.

3.3.1 Dependent Variable

The primary dependent variable in this study is CO_2 emissions, representing environmental degradation at both local and global scales. CO_2 is widely used as a proxy for air quality by WDI and other organizations. Log-transformed per capita CO_2 data ($\log CO_2$) are employed to capture relative changes across countries. CO_2 emissions primarily result from fossil fuel consumption, including solid and gas fuels, gas flaring, and cement production, and are measured in metric tons per capita using World Bank data.

3.3.2 Independent Variables

Key explanatory variables include per capita income (PY), its square (PY^2), FDI inflows, population density, urbanization, trade openness, and forest area. These variables are essential for assessing both environmental quality and economic development. Higher economic growth generally increases energy consumption, which may raise environmental pollution, though developed countries often have mechanisms to mitigate this effect (WDI, 2011).

Explanation of Variables

- Forest Area: Countries with larger forest areas can better mitigate environmental degradation. Empirical evidence suggests an inverted U-shaped relationship, where deforestation initially rises with income but declines at higher income levels due to reforestation initiatives and increased environmental awareness.

- Per Capita Income (PY): Represents the inverse relationship between income and CO_2 emissions, particularly in South Asian countries.
- Per Capita Income Squared (PY^2): Captures the inverted U-shaped EKC relationship, indicating that environmental degradation increases at low income levels, peaks, and then declines as income grows.
- FDI: Foreign direct investment is a crucial determinant of environmental pollution in developing countries, influencing industrial emissions.
- Population Density: High population density increases environmental pressure, making sustainable resource use more challenging.
- Trade Liberalization: Expanding trade can reduce pollution by facilitating access to cleaner technologies, though it may also lead to "pollution haven" effects if dirty industries relocate from developed to South Asian countries.
- Urbanization: Higher urban population shares increase fossil fuel consumption through transportation and energy use, contributing to CO_2 emissions.

Data Sources and Empirical Estimation

4.1 Data

The study uses a panel dataset covering 35 years (1981–2015) for 17 developing countries. Data for CO_2 emissions, per capita income (PY), and income squared (PY^2), forest area, population density, trade openness, urbanization, and FDI inflows were obtained from the World Development Indicators (WDI). Most regions have complete data for the entire sample period.

4.2 Estimation Procedures

4.2.1 Augmented Dickey-Fuller (ADF) Test

The ADF test is applied to all variables to check for stationarity. Before applying the ARDL bounds testing approach, the order of integration for each variable must be determined, as the ARDL model requires all variables to be integrated at I(0) or I(1). Non-stationary variables beyond these orders may lead to spurious results.

4.3 Descriptive Statistics

Descriptive statistics were calculated using EViews software to summarize the characteristics of each variable. These results allow comparison across the different regions of South Asian countries.

4.4 Correlation Analysis

Correlation analysis was conducted to examine the relationships between dependent and independent variables, identifying whether the associations are positive or negative.

4.5 Unit Root Test

A preliminary requirement for panel co-integration is that all variables must be integrated of order one. Both univariate and panel unit root tests were applied using the ADF method. Unit root tests were performed for each panel to ensure consistency across variables before further analysis using ARDL and bounds testing.

4.6 ARDL and Bounds Testing Approach

The ARDL bounds testing approach is employed to determine the long-run relationships between CO_2 emissions and explanatory variables including PY, PY^2, forest area, population density, urbanization, and trade openness. The advantages of ARDL over traditional models include:

- Accurate and refined estimation results
- Systematic handling of variables integrated at different levels
- Reduced complexity compared to other co-integration models

4.7 Long-Run Estimation

The ARDL framework is also used to estimate long-run co-integrating relationships, examining the covariance and correlation among variables to provide robust empirical results across all panels.

5 Emperical Estimation of the South Asian Panel

5.1. Descriptive Statistics

Table 1. DESCRIPTIVE STATISTICS FOR SOUTH ASIA COUNTRIES

	ENV	FA	FDI	PY	PY^2	POPD	T.OPENSS	URB
Mean	988654.1	16.87	1.122	405.79	164665.5	256.18	35.37	25.87
Median	947859.0	16.74	0.8906	358.86	128780.5	255.59	31.71	25.83
Maximum	1716152	17.44	3.375	785.01	616240.7	321.68	53.00	29.45
Minimum	423699.8	16.51	0.107	274.63	75421.64	192.7	19.39	22.69
Std. Dev	391190.2	0.36	0.802	130.97	171.14	39.92	11.51	1.97
Skewness	0.1832	0.45	0.98	1.4	1.96	0.036	0.21	0.11
Kurtosis	1.812	1.55	3.58	4.5	20.25	1.76	1.51	1.95
Jarque-Bera	1.672	3.15	4.58	11.36	129.0496	1.65	2.59	1.22
Probability	0.433	0.207	0.10	0.003	0.000009	0.43	0.27	0.54

The results of descriptive statistics is listed in the given table 22 as that mean values of (EnvCO2) and (FA) are 988654 and 16.87 respectively, while standard deviation values 391190 and 0.36 while the maximum values are 1716152 and 17.44 respectively. Similarly their minimum values are 423699 and 16.61. (FDI) have mean value 1.12 correspondingly, while stand-deviation are 0.802 respectively as well as minimum and maximum values of 0.107, and 3.3 correspondingly. (Per capita income) and PY^2 have a mean value 405.79,164665 and maximum values are 785, 616240.2 and their minimums values are 274, 75421.6 and standards deviation values are 130.7, 171.7 respectively. (POPD) has a mean value of 256.18 while (TO) & (URB) have 35.37 and 25.87 respectively and these three variables have standard deviation values of 39.92, 11.51, 1.97 respectively. Their maximums are 321.68,53 and 29.45 respectively and minimums are 192.7, 19.39and 22.69 respectively.

5.2. Correlation Matrix

Table 2. CORRELATION MATRIX

Variables	LnENV	LnF.A	lnFDI	Ln PY	$LnPY^2$	lnPOPD	LnTL	LnUrbon
LnENV	1							
ln F.AR	0.922	1						
LnFDI	0.894	0.768	1					
LnPY	0.903	0.927	0.735	1				
$LnPY^2$	0.091	0.917	0.643	0.900	1			
lnPOP.D	0.997	0.941	0.878	0.917	0.975	1		
LnTL	0.955	0.930	0.891	0.832	0.932	0.957	1	
LnURBN	0.992	0.945	0.858	0.940	0.912	0.997	0.939	1

The correlation matrix results is given in Table 23 are showing that forest area (FA), per capita income (PY),($PY^{2)}$,(FDI),population density(POPD), urbanization and trade liberalization with CO2 are positively correlated, while FDI, p/c income, population density, trade liberalization, and urbanization with forest Area are positively correlated. Hence p/c income, population density, trade liberalization and urbanization are positively correlated with FDI, whereas population density, trade liberalization and urbanization have positively correlated with per capita income. Hence trade liberalization and urbanization are positively correlated with population density. Whereas urbanization also positively correlated with trade liberalization.

5.3 Unit Root Findings

Table 3. AUGMENTED DICKEY FULLER TEST FOR SOUTH ASIA

Variables	Intercept		Intercept and Trend		Outcome
	Level	1st Difference	Level	1st Difference	
LnENV	-2.718**	-1.134	-3.893**	-4.884	1(0)
LN F.AREA	-0.741	-2.513*	-1.636	-1.344*	1(1)
LNFDI	-1.997**	-1.967	-4.649***	-5.034	1(0)
LNP/C	2.110	0.036**	-3.650	-3.367**	1(1)
$LnPY^2$	-0.673	-4.30	-2.93	0.0001	1(0)
LNPOP.D	-2.291***	5.319	1.431**	-2.549	1(0)
LNTL	-1.684**	0.166	-3.917***	-4.322	1(0)
LNURBN	1.056	-3.616**	-1.446	-1.464**	1(1)
***, (**) and * indicates the rejection of Null hypothesis at 1%, 5% and 10% level of significance respectively. Critical values are MacKinnon (1996) one sided p-values.					

In table 24 before applying ARDL to get long run and short run results stationary of the data must be checked either all the variables are stationary at level are not otherwise the results will be spurious and for such purpose Augmented Dickey Fuller test has been used in this research. Results ADF showing that natural lag of variables (CO2), (FDI), (POPD) and (TL) at level are stationary but at first difference. Similarly natural log of (FA), (PY), (PY^2) are positive correlated but insignificant negative impact on CO2 emissions in long rung as well as in short run in MENA. Similarly per capita income have positive correlated, insignificant positive impact on CO2 emissions in long run but have significant positive impact on CO2 emissions in short run in EAP. While per capita income positive correlated, insignificant positive in long run but insignificant negative impact on CO2 in short run LAC. P/c income have positive correlation, significant positive in long run but significant positive impact on CO2 emissions in short run in South Asia. Per capita income has positive correlated, insignificant negative but insignificant negative impact on CO2 emissions in Sub-Sahara.

And (URBN) are stationary at first difference while stationary at level. So, overall it is concluded that ADF test gives mixed results that is why we use ARDL approach directly.

5.4 Var Lag Order Selection Criteria

Table 4. VAR LAG ORDER SELECTION CRITERIA

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	342.650	NA	4.75e-21	-26.96	-26.59	-26.832
1	670.861	444.96*	1.21e-3*	-49.19*	-46.46*	-48.474*
*** indicates lag order selected by the criterion**						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error,			**SC: Schwarz information criterion**			
AIC: Akaike information criterion,			**HQ: Hannan-Quinn information criterion**			

ARDL approach should be run firstly decided that our in model how many lags includes. In this study the criteria of log length must be based on AIC if the observation less than 60. We can select lag in our model accordingly to the criteria of log length.

5.4. CRITICAL VALUES BOUNDS

Table 5. ARDL BOUND TEST RESULTS

ARDL Bound Test		
Sample: 1981-2015	**Included observations: 35**	
Null Hypothesis: No long-run relationships exist.		
Test Statistic	**Value**	**K**
F-Statistic	45.02	6
Critical Value Bounds		
Significance	**Lower Bound (L0)**	**Upper Bound (L1)**
10%	1.99	2.94
5%	2.27	3.28
2.5%	2.55	3.61
1%	2.88	3.99

The listed table 25 show about lower bound (L0) or upper bound (L1) greater show the long relationship if the F-test value falls in it. If it lies between lower and upper bound then the results are inconclusive. In the following listed table the F-value as 45.02>1.99.

So, it indicates that there is no long run relationship between variables in our selected model.

Table 1. ESTIMATED LONG RUN COEFFICENTS USING ARDL APPROACH

Dependent Variable: lnEnv(CO2)			
REGRESSOR	**COEFFICENTS**	**STANDARD ERROR**	**T-Statistics**
LnFA	-3.34	0.47	-7.01***
LnPY	0.001	0.055	0.031
$LnPY^2$	-1.821	-2.24**	-1.510**
LnPOPD	0.25	0.04	6.08***
LnURB	4.75	0.50	9.30***
LnTO	-0.005	0.03	-0.147
LnFDI	-4.20	0.98	-4.25***

DIAGNOSTIC TEST		
TEST	**STATISTICS**	**P-Values**
χ^2	0.98	
χ^2**Serial**	8.39	0.000
χ^2**ARCH**	1.23	0.26
χ^2**WHITE**	0.83	0.53
χ^2**Normal**	0.16	0.92

Note:

- **χ^2 Normal (Jarque–Bera statistic of the test for normal residuals)**
- **χ^2 WHITE (White's test statistic to test for homoscedastic errors)**
- **χ^2 (Serial is the Breusch–Godfrey LM test statistic for no first-order serial correlation)**
- **χ^2ARCH (Engle's test statistic is for no autoregressive conditional heteroscedisticity)**

***** Test statistics are significant at 1% level of significance.**
**** Test statistics are significant at 5 % level of significance.**
*** Test statistics are significant at 10% level of significance.**

Results of the listed table 27 showing that in long run relationship forest areas and urbanization have a significant impact on Environmental CO2 emission negatively. Similarly, per capita income (PY), (PY^2), and population density shows a significant impact on CO2 emission positively. While (FDI) shows a insignificant positive impact on CO2 emission. Trade liberalization in long run affects insignificantly impact on CO2 emission negatively.

Table 7. ERROR CORRECTION REPRESENTATION FOR THE SELECTED ARDL MODEL

Dependent Variable: ΔEnv(CO2)			
REGRESSOR	**COEFFICENTS**	**STANDARD ERROR**	**T-Statistics**
ΔFA	2.94	1.31	2.24**
ΔPY	0.002	0.006	0.35
ΔPY	0.001	0.003	0.0002
ΔPOPD	0.120	0.38	3.13***
ΔURB	5.94	0.62	9.5***
ΔFDI	-0.006	0.03	-0.21
ΔTL	-5.28	1.60	-4.5***
ECM= LNENV –(-1.31*LNFA 0.002* LNFDI 0.25*LNPY 4.7* LNPY^2 -2.342* LNPOPD -0.009* LNTL -4.20* LNURBN 9.04			
R-Squared= 0.996	Adjusted R-Squared=0.423	F-statistics =34.93	
S.E. of Regression = 0.024	Residual Sum of Squares=0.009	SD-dependant var = 0.317	
Akaike Info. Criterion = -4.26	Schwarz Bayesian Criterion =-3.77		
Note: * (**) and * represents significance at 1%, (5%) and 10% levels respectively.**			

By the ECM the listed table 28 have relationship in short run among the indicators, hence to CO2 the values of (FA) should be insignificant and negative that's why the long run relationship show convergence change because the value of the ECM 9% is significant its showing that disequilibria from the previous year shocks to the current year equilibrium.

In short run the results show that per capita income (PY),PY^2,population density and forest Area have a significant positive impact on CO2 emission, while urbanization have a significant negative impact in short run. Similarly FDI have positive and trade openness have a negative insignificant impact on CO2 emission.

6 Findings, Conclusion, Policy Recommendations and Limittations of the the Study

6.1. Findings

(a) Impact of Forest Area on (CO2) Emissions

Forest area has positive correlation, significant negative in long run but significant positive impact on CO2 emissions in short run in South Asia.

(b) Impact of Per Capita Income (PY) on CO2 Emission

The Per capita income have positive correlation, significant positive in long run but significant positive impact on CO2 emissions in short run in South Asia.

(c) Impact of Per Capita Income Square (PY^2) on CO2 Emission

P/c income square have positive correlation, significant positive in long run but significant positive impact on CO2 emissions in short run in South Asia

(a) Impact of FDI on CO2 Emissions

FDI have positive correlation but in long run as well as significant positive in short run in South Asia have insignificant positive impact on CO2 emissions

(b) Impact of Population density (POPD) on CO2 Emissions

Population density has positive correlation but in long run as well as in short run have significant positive impact on CO2 emissions in South Asia.

(c) Impact of Urbanization (URBN) on CO2 Emissions

Urbanization have positive correlation, in long run have significant negative impact on CO2 emissions but significant positive in short run in South Asia.

(d) Impact of Trade Liberalization (TL) on CO2 Emissions

Trade openness has positive correlation but in long run as well as in short run have insignificant negative impact on CO2 emission in South Asia.

6.2. Conclusion

The empirical analysis of this thesis examines the relationship between CO_2 emissions and explanatory variables such as forest area, per capita income, per capita income squared, FDI inflows, population density, urbanization, and trade openness across South Asian countries. Utilizing a panel dataset spanning 1981 to 2015, the study emphasizes the significant role of these independent variables in determining carbon dioxide emissions. What distinguishes this research from previous studies is its focus on low- and middle-income economies in the South Asian region, as classified by the World Bank.

The findings suggest that generalizing the impact of these explanatory variables on CO_2 emissions in accordance with the Environmental Kuznets Curve (EKC) hypothesis is reasonable. Specifically, variables such as forest area, per capita income, per capita income squared, FDI, population density, urbanization, and trade openness demonstrate potential in mitigating environmental degradation in line with EKC positions. The study further highlights that responses to the EKC hypothesis are largely contingent on the nature of both dependent and independent variables. Results indicate that while the EKC hypothesis holds for certain CO_2 emission measures in the selected developing countries, it does not apply universally. Consequently, the study underscores the need for developing countries to adopt coordinated environmental and economic policies that simultaneously enhance economic output and protect environmental quality.

In exploring the EKC relationship, this thesis reviews studies employing recent unit root and cointegration tests. Empirical results reveal mixed integration outcomes, with cointegration among variables assessed using the ARDL approach. Long-run cointegration results indicate that forest area, per capita income, per capita income squared, FDI, population density, urbanization, and trade openness significantly contribute to reducing CO_2 emissions in South Asian countries.

6.3 Policy Recommendations

The upward trend in CO_2 emissions has prompted several policy interventions. Previous studies have proposed multiple strategies to mitigate carbon dioxide emissions from various sources. The primary objective of this thesis is to evaluate the relevance of the EKC hypothesis

in estimating CO_2 emissions, while also analyzing the influence of factors such as forest area, per capita income, per capita income squared, FDI inflows, trade openness, urbanization, and population density on environmental degradation in South Asia.
Key implications of the findings suggest that although these countries demonstrate a long-run reduction in CO_2 emissions through per capita income, per capita income squared, FDI, forest area, and trade openness, the overall impact remains positive in the long run and only slightly lower in the short term.
Policy recommendations include as follow:

- Introducing a carbon tax or polluter-based tax to curb CO_2 emissions.
- Implementing a carbon emissions trading scheme, though the study does not evaluate the comparative effectiveness of taxation versus trading schemes. Growth-oriented and environmentally sustainable policy reforms are essential for the South Asian region.
- Restricting the importation of carbon-intensive products and regulating highly polluting transnational corporations within the sub-region.
- Enhancing government efforts to reduce CO_2 emissions across all developing countries in the region.
- Strengthening environmental institutions to ensure compliance, enforce sanctions, and facilitate the adoption of cleaner technologies.
- Recognizing and differentiating the EKC relationship for CO_2 emissions to guide policy decisions aimed at improving environmental quality.
- Encouraging leadership in South Asian countries to prioritize significant reductions in carbon emissions.

6.4 Limitations of the Study

This research is limited to a select set of variables, including forest area, per capita income, per capita income squared, FDI inflows, population density, urbanization, and trade openness, which may have significant or insignificant impacts on CO_2 emissions across five regions in South Asia. The study is constrained by the following factors:

- Environmental policies in South Asian countries are largely unimplemented or ineffective.
- These countries may not follow the same development trajectory as developed nations.
- Concepts such as a pollution tax for polluters are virtually nonexistent in the South Asian context.

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