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Nonlinear Relationship between Income and Pollution: Evidence from the Environmental Kuznets Curve in East Asia & Pacific countries

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ABSTRACT
This study empirically investigates the nonlinear relationship between economic growth and environmental degradation in EAP countries within the framework of the Environmental Kuznets Curve (EKC) hypothesis. Using panel data for 3 EAP countries spanning 1981–2015, we examine the impact of per capita income and its square alongside forest area, foreign direct investment (FDI), population density, urbanization, and trade openness on carbon dioxide (CO_2) emissions. The Augmented Dickey-Fuller (ADF) unit root test and Autoregressive Distributed Lag (ARDL) bounds testing approach are employed to explore long-run and short-run dynamics. The results confirm the existence of an inverted U-shaped relationship between income and pollution, validating the EKC hypothesis. Forest area and urbanization significantly reduce CO_2 emissions in the long run, while FDI and trade openness exhibit mixed effects. The findings highlight the need for coordinated economic and environmental policies to ensure sustainable development in EAP economies.

Keywords: Environmental Kuznets Curve, CO_2 Emissions, Economic Growth, ARDL, Developing Countries, Nonlinear Relationship.

1. Introduction

1.1 Background and Statement of the Problem

Environmental degradation has become a major global concern due to rapid industrialization and economic expansion. One of the most debated hypotheses explaining the growth–environment nexus is the Environmental Kuznets Curve (EKC), which proposes an inverted U-shaped relationship between income and environmental pollution. According to this hypothesis, pollution initially increases with economic growth but eventually declines after a certain income threshold is reached.

Empirical evidence from EAP nations indicates a general upward trend in CO2 emissions alongside rising per capita income. Other factors, such as trade openness, urbanization, population density, and forest cover, exhibit more gradual trends, while foreign direct investment (FDI) inflows show considerable volatility, often peaking in particular years. In Sub-Saharan Africa, per capita income has shown notable growth, with population density, urbanization, and trade openness steadily increasing. Meanwhile, FDI remains inconsistent, reflecting its uneven impact on environmental outcomes.

The EKC framework suggests that environmental pressures may decline once economies reach advanced stages of growth, although the timing and magnitude vary across pollutants and regions. Population growth, however, amplifies waste generation and environmental stress, even as income rises. Econometric analyses, including unit root and co-integration tests, indicate that CO_2 emissions and per capita GDP are sometimes co-integrated, lending support to the EKC hypothesis. Achieving sustainable economic growth, however, requires robust political commitment and coordinated policy interventions to balance development with environmental protection (Beckerman, 1992).

In EAP countries, environmental degradation tends to progress more slowly due to limited resources. Key determinants of CO_2 emissions include forest area, per capita income and its squared term (PY2), FDI, population density, urbanization, and trade openness. The EKC framework predicts that emissions increase with income up to a threshold, after which environmental quality improves. Panel data analysis is particularly important, as the income–pollution relationship differs across nations. High income levels and effective policies are essential for reducing emissions in the early stages of development. Additionally, the Heckscher-Ohlin trade theory explains that developing countries, which specialize in labor- and resource-intensive production, may face higher environmental degradation compared to advanced economies.

Empirical studies consistently show that, as economies grow from low-income levels, CO_2 emissions and other pollutants initially rise, only to decline once higher income stages are achieved. Population growth exacerbates resource consumption and waste generation, increasing environmental pressures. Accurate econometric modeling is necessary to properly capture these dynamics and avoid misleading results (Perman & Stern, 2003). In high-income countries, scale effects can reverse, allowing environmental improvements to offset growth-related pressures. EKC studies also highlight that densely populated tropical regions often experience more severe deforestation and environmental degradation (Panayotou, 1993). Overall, developing nations face limited capacity to mitigate CO_2 emissions, whereas developed economies demonstrate greater resilience and significant environmental progress over time.

This study seeks to identify the main factors affecting CO_2 emissions in EAP countries, analyzing both environmental degradation and its drivers, including FDI, forest area, per capita income, PY2, population density, urbanization, and trade openness. Unlike previous research, this study specifically focuses on the context of EAP economies.

The primary objectives are to:

- Evaluate the applicability of the EKC hypothesis for estimating CO_2 emissions in EAP countries.
- Examine the effects of forest area, per capita income, PY2, FDI, trade openness, urbanization, and population density on CO_2 emissions.

The significance of this study stems from its emphasis on East Asia and the Pacific (EAP) countries, a region that has received limited attention in the EKC literature, especially in analyses spanning a 35-year period. By identifying income turning points and relevant policy options for pollution reduction, the research offers practical guidance for EAP nations in formulating strategies grounded in the EKC framework. It highlights the necessity of adopting country-specific sustainable development policies, recognizing that lessons drawn from high-income economies may not be directly applicable to low-income settings. Overall, the study aims to assist developing countries in balancing economic expansion with the mitigation of environmental damage.

2. Literature Review

The EKC hypothesis was first popularized by Grossman and Krueger (1991), who observed an inverted U-shaped relationship between pollution and income. Shafik and Bandyopadhyay (1992) further supported this idea, showing that certain pollutants decline after reaching income thresholds.

Beckerman (1992) argued that economic growth is necessary to achieve environmental improvement. However, Dasgupta et al. (2002) criticized EKC, stating that it does not hold for all pollutants. Stern (2004) highlighted econometric weaknesses in EKC studies such as omitted variable bias and non-stationarity.

The notion of the EKC in generally challenges by Dasgupta (2002) Perman and Stern 2003. Accordingly to the suggestions as the rise of incomes the environment will be less impacted. First, environmental quality is always considers a normal good as compare to the luxury good. Second (Grossman & Krueger, 1995) in their study focusing that as manmade capital and technology increased so there will be economic growth so it will be reduced pollution in societies.

Lopez in 1992 said as increase in economic growth the absolute pollution levels might be goes up while per unit might goes down of pollution. The effect of technical change on pollution is doubt. Fourth as the rates of growth of pollution are down due to the rising of incomes so the pressure of pollution on environment is reduced.

Accordingly to the (Ibidi UNDP, 1999) studied that high growth of population creates more wastages of dumping in economy that's why more environmental pollution or emissions are generated in economies.

As compare to the production activities the consumption pollution is generated due to the overlapping generations accordingly to the base models developed by John and Pecchenino (1994 ,1995), and McConnell (1997). Its means that John and Pecchenino theorised the based model about overlapping generation that consumption cause for pollution instead of products generation.

Endogenous technical change allows by Stokey (1998) on the bases of models where appropriate assumptions are generated of EKC as compare to the empirically tests. Although it's low level becomes started that's why the structural changes are seems in the economy due to the detrimental effect on the environment. As the share of industry goes up and goes down the share of agriculture then the pollution will be increased. Stokey theorized that agriculture sector is the most important factor for the deduction for environmental pollution because industrial sector is main factor to increase pollution than the agriculture sectors (1998).

Is there an environmental Kuznets curve for deforestation? Mather (1999) examine data from countries across the world and identify that the rate of deforestation initially increases as income rises but then decreases and gives way to reforestation. This is evidence to suggest that there is an inverted U-shaped environmental Kuznets curve for forests. Hence it might merely be illustrating that people in richer countries have more time to spend on leisure activities which generate pressure from environmental pressure groups to reforest.

Accordingly to the assumptions of Lopez (1994) and Selden and Song (1995) that the statement shows that due to the agents of exogenous technical change there is pollution occurring in the production of goods not in consumption sector. In their study focusing that as increasing the ratios of different products industries in a country. Therefore it's become a big pollution factor for environment as compared to the consumption side. It means that industries exert a lot of fossils gasses which are highly effect the health of people.

Therefore it was suggested that due to high growth in population so the consumption level will be high so it become a reason for pollution in economies. High population ratio increased the consumption and makes a lot of wastages in the surrounding areas which make the factor for environmental pollution for generations.

Recent studies (Saboori & Sulaiman, 2013; Yavuz, 2014) confirm nonlinear income–pollution relationships, while Yang et al. (2015) found varying functional forms across countries. Despite extensive research, limited evidence exists for developing economies, creating a research gap addressed in this study.

3. Theoretical Framework of EKC

3.1 History of the EKC

The concept of the Environmental Kuznets Curve (EKC) emerged in the early 1990s, notably through the pioneering work of Grossman and Krueger (1991) on the potential environmental impacts of NAFTA and the study by Shafik and Bandyopadhyay (1992) prepared for the World Development Report. Earlier, the World Commission on Environment and Development (1987) had emphasized in *Our Common Future* that economic growth is essential for maintaining environmental quality.

The EKC theory gained widespread recognition through the World Bank's Development Report of 1992 (IBRD, 1992), which suggested that economic growth initially harms the environment but that rising incomes increase the demand for environmental improvements. Beckerman (1992) further elaborated that environmental degradation is largely confined to the early stages of development, after which most countries eventually achieve higher environmental quality as they grow wealthier.

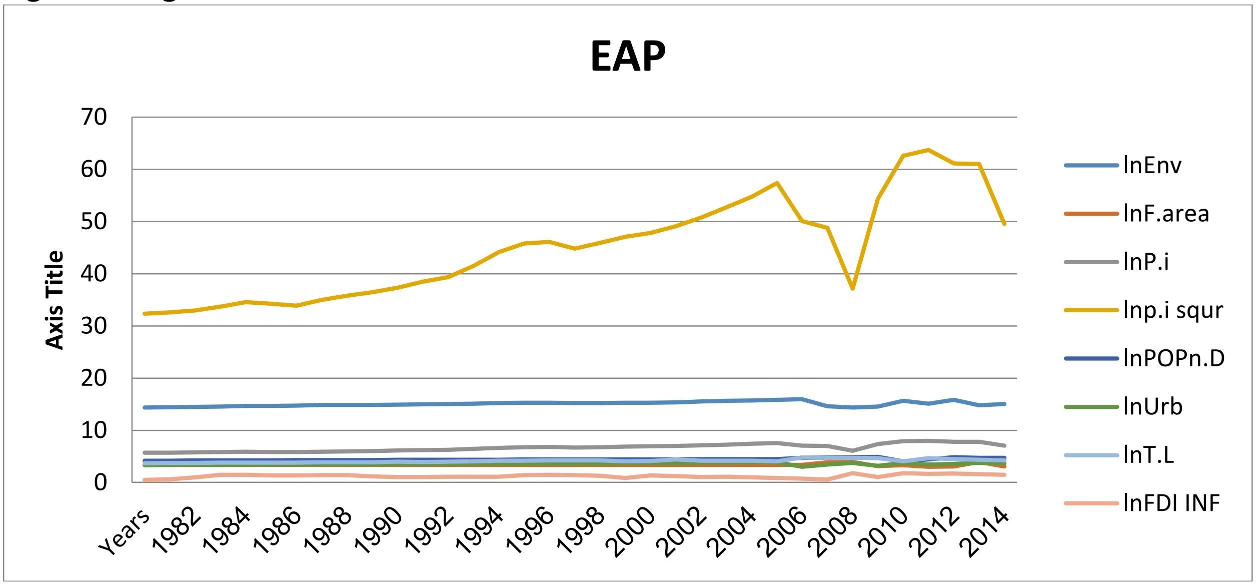
However, the EKC does not universally apply to all environmental impacts, particularly CO2 emissions (Dasgupta, 2002). Pure economic growth, without accompanying technological or policy changes, would likely produce a proportional increase in pollution, making environmental improvements unattainable. Traditional perspectives emphasizing the conflict between economic development and environmental quality primarily reflect the scale effect. Yet, as environmental awareness grows, regulations are enforced, technology improves, and environmental expenditures rise, the EKC hypothesis suggests that environmental degradation can stabilize and eventually decline (Panayotou, 1993).

Many scholars argue that the interplay between societal preferences and technology can shape different trajectories for environmental quality over time. While numerous studies have produced an inverted U-shaped pattern for pollution intensity, this outcome is not inevitable. According to Kuznets (1995), CO2 emissions initially increase with economic growth at low-income levels, but after reaching a turning point—where income distribution and development stabilize—emissions begin to decline. A substantial body of empirical and theoretical research supports the EKC, demonstrating an inverted U-shaped relationship between per capita income and CO2 emissions.

The EKC framework posits that as national income rises, environmental pressure initially grows but eventually diminishes in the later stages of development, illustrating a de-linking between economic growth and environmental degradation. This inverted U-shaped pattern is now widely recognized as the Environmental Kuznets Curve.

EAP countries are among the highest emitters when measured relative to GDP, and key variables such as per capita income (PY), its squared term (PY2), forest cover, population density, urbanization, trade openness, and FDI inflows are critical to understanding their environmental impact. These insights carry important policy implications. While numerous studies indicate that environmental pollution negatively affects per capita income and other economic indicators in developed countries, research on developing nations remains limited. The current study aims to address this gap by focusing on the environmental and economic dynamics in EAP countries.

Figure.1 Diagram of the East Asia and Pacific countries.



In the above figure 1, East and Pacific countries graph illustrates that environmental pollution increases as CO_2 emission increases with the passage of time in these countries. While per capita is much good and show an increasing trend from 2008 to 2014. Trade liberalization, Urbanization, population density and forest area graph show as such no change and have a smooth normal trend like the above variables FDI is looking fluctuated but having no changes except in the year 1992 with the highest value.

4. Resaerch Methodology

The selection and identification of an appropriate research methodology is an important and crucial feature of the research. It is like a guide line for collecting data from different sources. The most important aspect is that it defines the type of data to be selected and identifying the model for further empirical analysis for a suitable research methodology.

Main objective of thesis to measure the impact of per capita income for the Environmental pollution (CO2) emissions. To check the basic relationship among PY,PY^2,FDI, forest area, population density, urbanization and trade openness position on CO2 emissions of developing regions (Source: WDI).The numerical measurement of the thesis on a data sampling for EAP countries for 35 years (1981-2015).

4.1 Data

Annual data for EAP countries covering 1981–2015 were obtained from the World Development Indicators (WDI). East Asia and Pacific countries are follow as Sri Lanka, Indonesia, China (Lower Middle income).

4.2 Model Specifications

The empirical model is:

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 developing countries. Our sample consists of three 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

4.2.1 Econometric Model

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

Where: 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= ($\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7$) 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.

Fixed effects have traditionally been applied for EKC studies in developed countries, but their use in EAP countries is limited (Stern & Perman, 2003). Both authors emphasize that per capita GDP should be tested for unit roots, as spurious regression results may arise if variables are not co-integrated. Diagnostic statistics for integration and cointegration are often missing in EKC studies, which is a limitation in the literature.

4.3 Theoretical Framework of the Model

CO2 emission levels differ across countries at specific income levels, consistent with the study's hypothesis. At a given income level, all countries are assumed to exhibit the same income elasticity. Variations over time, including stochastic shocks and residual effects, are captured through period-specific intercepts. The model is estimated using panel data, incorporating both fixed and random effects, as widely applied in the literature.

In the model, αi and γt represent fixed-effect parameters, whereas the random-effects model treats them as stochastic disturbances. Random-effects estimation is unreliable if αi and γt correlate with explanatory variables, whereas fixed-effects estimation provides consistent results (Mundlak, 1978). Random-effects estimates may be inconsistent due to correlation between error components and independent variables. At the country level, however, estimates reflect conditional effects over time, mitigating statistical issues (Hsia, 1986).

Fixed effects have traditionally been applied for EKC studies in developed countries, but their use in developing countries is limited (Stern & Perman, 2003). Both authors emphasize that per capita GDP should be tested for unit roots, as spurious regression results may arise if variables are not co-integrated. Diagnostic statistics for integration and cointegration are often missing in EKC studies, which is a limitation in the literature. Overall, the EKC hypothesis is considered valid primarily at local and global emission levels. EAP countries are among the highest CO2 emitters compared to developed regions. Across countries, per capita environmental pollution varies, although income elasticity is assumed uniform. Time-specific intercepts account for economic fluctuations and stochastic shocks over the study period.

4.4.1 Dependent Variab**le**

The study uses CO2 emissions as the dependent variable, representing both local and global environmental degradation. Carbon dioxide emissions are widely used by the WDI and other organizations as an air quality indicator. Controlling CO2 is feasible through effective regulation and alternative production technologies. Both per capita and logarithmic forms of CO2 are used in the analysis. CO2 emissions, a major contributor to global greenhouse gas (GHG) emissions, result from fossil fuel consumption, cement production, and gas flaring. Data on CO2 emissions (metric tons per capita, log-transformed) is sourced from the WDI.

4.4.2 Independent Variables

The key independent variables include per capita income (PY), its square (PY2), FDI inflows, population density, urbanization, trade openness, and forest area. These variables are central for assessing environmental quality and economic development. Higher economic development tends to increase energy consumption and, consequently, environmental pollution. Developed countries, however, have greater capacity to mitigate emissions (WDI, 2011).

(a) Forest Areas: Extensive forest coverage mitigates environmental degradation. Globally, deforestation initially rises with income but eventually declines as reforestation occurs, supporting the inverted U-shaped EKC pattern. Wealthier countries experience greater environmental awareness and pressures to preserve forests.

(b) Per Capita Income (PY): Reflects the inverse relationship between income and CO2 emissions in developing countries.

(c) Per Capita Income Squared (PY2): Captures the EKC's inverted U-shaped relationship, where environmental degradation increases at low income levels, peaks, and declines at higher income levels.

(d) FDI: A crucial determinant in developing countries, as foreign investment can significantly influence environmental degradation.

(e) Population Density: Higher population density can lead to excessive environmental exploitation, highlighting the need for population management.

(f) Trade Liberalization: May reduce pollution by improving access to cleaner technologies, though it can also increase emissions if developed countries export polluting industries to developing nations.

(g) Urbanization: The proportion of urban population drives higher energy consumption, particularly through transportation, contributing to CO2 emissions.

5. Data Sources and Empirical Estimation

5.1 Data

The study uses panel data covering 1981–2015. Variables include CO2 emissions, PY, PY2, forest area, population density, trade liberalization, and FDI inflows, sourced from the WDI.

5.2 Estimation Procedures

5.2.1 Augmented Dickey-Fuller (ADF) Test

The ADF test is applied to all variables to assess stationarity. The ARDL bounds testing approach is employed for cointegration analysis. Variables must be integrated at I(0) or I(1) to avoid spurious results.

5.3 Descriptive Statistics

Descriptive statistics are computed using EViews to summarize and compare indicators across EAP regions.

5.4 Correlation Analysis

Correlation analysis is conducted to evaluate the strength and direction of relationships between dependent and independent variables.

5.5 Unit Root Test

Before panel cointegration testing, all variables must be integrated of order one. ADF tests confirm stationarity across the EAP countries. For panel analysis, each variable should exhibit the same integration properties. ARDL and bounds testing are then used to examine long-run relationships, covariance, and correlation.

5.6 ARDL and Bounds Testing for Cointegration

The ARDL bounds testing approach is employed to examine long-run relationships among CO2 emissions, forest area, PY, PY2, population density, urbanization, and trade openness. ARDL is preferred over traditional models because:

- It provides accurate and robust results.
- It accommodates variables integrated at different levels.
- It is less affected by common econometric complications.

5.7 Long-Run ARDL and Cointegration

The ARDL framework is used to estimate long-run equilibrium relationships and correlations among all model variables, ensuring consistent estimation of the determinants of CO2 emissions in EAP countries.

6 Results and Discussions of EAP Countries

Table 6.1 Descriptive Statistics

	ENVCO2	FA	FDI	PY	PY^2	POPD	T.OPENSS	URB
Mean	3716258	29.04	3.28	734.56	20721.3	77.43	54.92	36.75
Median	3572882	28.87	3.16	578.85	10342.43	78.08	54.69	36.15
Maximum	7483192	29.78	4.45	1952.05	39342.2	87.99	69.04	47.64
Minimum	7483192	28.51	1.58	294.3	1231.2	64.82	40.60	28.15
Std. Dev	3716258	0.48	0.79	450.34	5432.1	7.27	9.62	5.85
Skewness	0.8748	0.33	-0.344	1.088	-0.5432	-0.20	-0.012	0.285
Kurtosis	3.198	1.44	2.25	3.46	1.6542	1.77	1.53	1.93
Jarque-Bera	3.36	3.12	1.07	5.38	8.381	1.803	2.32	1.58
Probability	0.191	0.22	0.58	0.067	0.003	0.405	0.31	0.45

In the given table 8 as that mean values of (EnvCO2) and (FA) are 3716258 and 29.04 respectively, while standard deviation values 3716258 and 0.48 while the maximum values are 7483192 and 29.78 respectively. (Per capita income) and PY^2 have a mean value 734, 20721.2, and maximum values are 1952.05, 39342.2 and their minimums values are 1231.8, 64.80 and standards deviation values are 5432, 7.4 respectively. Similarly their minimum values are 7483192 and 28.51. (FDI), (population density) mean are 3.28 and 77.43 correspondingly, although S-Deviation is 0.79, 7.27 respectively while minimum and maximum values of87.99, 64.82 and 4.45, 1.58, respectively. Trade openness & (urbanization) have mean values are 54.92 and 36.75 respectively and these two variables have standard deviation values of 9.62, 5.85 respectively. Their maximums are 69.04 and 47.64 respectively and minimums are 40.60, and 28.15 respectively.

Table 6.2 Correlation Matrix

Variables	LnENV	LnF.Area	LnFDI	Ln PY	LnPY^2	LnPOPD	lnTL	lnUrbon
LnENV	1							
ln F.AR	0.873	1						
LnFDI	0.065	-0.069	1					
LnPY	0.976	0.952	-0.010	1				
LnPY^2	0.950	0.891	0.013	0.930	1			
lnPOP.D	0.973	0.880	0.114	0.960	0.920	1		
LnTL	0.663	0.819	0.257	0.871	0.830	0.919	1	
LnURBN	0.984	0.922	0.044	0.985	0.941	0.988	0.881	1

In the above table the correlation matrix results are clear showing that forest area (FA), per Capita income (PY),PY^2, (FDI),population density(POPD), urbanization and trade openness with CO2 emission are correlated positively, while FDI are negatively correlated with forest area, Similarly per capita income, population density, trade openness, and urbanization are positively correlated with forest area. Similarly per capita income is negatively correlated with FDI, while population density, trade liberalization and urbanization are correlated with FDI positively, whereas population density, trade liberalization and urbanization have positively correlated with per capita income. Similarly, trade liberalization and urbanization with population density are correlated positively. Where urbanization also have positively correlated with trade liberalization.

Table 6.3 Augmented Dickey Fuller Test Results

Variables	Intercept		Intercept and Trend		Outcome
	Level	1stDifference	Level	1stDifference	
LnENV	-1.092	-2.194**	-4.163	-4.149**	1(1)
Ln F.A	-1.175	-3.151**	-1.468	-1.215**	1(1)
LnFDI	-3.223**	-3.066	-4.171**	-4.508	1(0)
LnPY	0.988**	-2.007	-2.648**	-3.027	1(0)
LnPY^2	-2.3209**	-1.4820**	-1.609***	-2.991	1(1)
LnPOP	-2.721**	-0.618	0.421**	-5.363	1(0)
LnTL	-1.594**	-1.103	-5.040**	-5.314	1(0)
LnURB	1.346*	0.546	-1.809*	-2.257	1(0)

****, (**) 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*

****, (**) and * indicates the rejection of Null hypothesis at 1%, 5% and 10% level of significance*

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. Natural log of all indicators as (CO2), (FA) and (FDI), (PY), (PY^2), (POPD), (URB), and (TL), is given below in time series Table 10. ADF results show that the natural log of the given variables (CO2), (FA) and (FDI) is not stationary at level while at first difference is stationary, whereas (PY), (PY^2), (POPD), (TL), (URBN) at level are stationary while1st difference is stationary at. So, ADF test gives mixed results for the empirical estimation that's why we use ARDL.

Table 6.4 Var Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	312.9978	NA	5.51e-20	-24.47	-24.13	-24.38
1	621.34	419.34*	6.3e-29*	-45.22*	-42.49*	-44.47*

**** 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*
HQ: Hannan-Quinn information criterion, *AIC: Akaike 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..

Table 6.5 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	3.26	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 above table 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 12 the F value as 3.26 >1.99. The above table conclude that there no existence of long relationship among indicators.

Table 6.6 Estimated Long Run Cofficents Using ARDL Approach

Dependent Variable: lnEnv(CO2)

REGRESSOR	**COEFFICENTS**	**STANDARD ERROR**	**T-Statistics**
LnFA	-11.97	1.9	-6.33***
LnPY	0.045	0.04	1.31
$LnPY^2$	0.00165	0.02	1.002*
LnPOPD	0.43	0.12	3.82***
LnURB	-5.33	1.50	-3.55**
LnTO	0.23	0.153	1.45*
LnFDI	5.66	1.21	4.7***
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.

The above table shows that in long runs relationship forest Areas have a significant negative impact on Environmental CO2 emission. Similarly, per capita income (PY) and (PY^2) shows an insignificant positive impact on CO2 emission. Population density (pop D) shows a significant negative impact on CO2 emission. Urbanization (URB) and trade liberalization shows a significant positive impact on CO2 emission. FDI both in long run and in short run affects CO2 emission insignificantly positive impact On CO2 emission.

Table 6.6 Error Correction for the Selected EAP ARDL Model

*Dependant Variable: **ΔEnv(CO2)***

REGRESSORS	**COEFICINTS**	**STANDARRD ERROR**	**T-Statistics**
ΔFA	7.98	4.53	1.76**
ΔPY	0.031	0.026	1.14
ΔPY^2	0.0096	0.0004	1.021
ΔPOPD	0.41	0.08	4.8***
ΔURB	31.94	7.40	4.31***
ΔFDI	0.17	0.11	1.67*
ΔTL	4.7	1.06	4.38***

*ECM= LNENV – 1.001*LNFA 0.005* LNFDI 0.042*LNPY -5.33* LNPY² -9.342* LNPOPD 0.22* LNTL 5.66* LNURBN 53.91*

R^2= 0.956	Adjtd R^2=0.285	F-stat =2.052
S.E. of Regression = 0.03	Rsidual Sum of Sqr=0.020	SD-depdant var = 0.043
AIC = -3.45	SBC =2.96	

***Note:** *** (**) and * represents significance at 1%, (5%) and 10% levels respectively.*

In the above table error correction term followed long run relationship among variables. The ECM the Forest Area value must be negative and insignificant showing with CO2 emission. For long and short run equilibrium the ECM change are convergence. The ECM estimated values are highly significant at 57% approximately. So, the long relationship in the current years is disequilibria than the previous shocks.

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

7 Findings, Conclusion, Policy Recommendation and Limitations

7.1 Findings of the Study for EAP Countries

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

In the long run forest area have positive correlated, but in long run have insignificant positive impact on CO2 emissions but have significant positive impact on CO2 emissions in short run in East Asia Pacific.

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

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.

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

Per capita income square 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.

(d) Impact of FDI on CO2 Emissions in EAP

FDI have positive correlated but in long run as well as in short run in EAP have insignificant positive impact on CO2 emissions.

(e) Impact of Population density (POPD) on CO2 Emissions in EAP

Population density has positive correlated, significant negative impact on CO2 emissions in long run but significant positive in short run in EAP.

(f) Impact of Urbanization (URBN) on CO2 Emissions in EAP

Urbanization positive correlated but in Long Rung as well as in short run have significant positive impact on CO2 emissions in EAP.

(g) Impact of Trade Liberalization (TL) on CO2 Emissions in EAP

Trade openness has positive correlated but in Long Rung as well as in short run have significant positive impact on CO2 emission in EAP.

7.2 Conclusion

The empirical results of the thesis attempts to investigate the relationship between CO2 emissions along with explanatory variables like forest areas, per capita income, per capita income square, FDI, population density, urbanization and trade openness in EAP countries. The study considers that independent variables play important role in the deduction of carbon dioxide emissions. While makes the study exclusive from previous studies in terms of low and middle level economies as classified by World Bank for developing countries. This study reveals that it may be correct to generalize the reaction of these explanatory variables on the CO2 emissions as an environmental variable to EKC hypothesis. Also it is found that these variables like: forest area, per capita income, per capita income square, FDI, population density, urbanization and trade openness may degrade environmental pollution in the EKC positions. We are able to observe that the responses to EKC hypothesis depend largely on the nature of dependant and independent variables. The results reveal that Environmental Kuznets Curve is valid for the selected developing countries for some CO2 emissions but invalid for others. The findings show that developing countries need to bring into line a well-coordinated environmental and economic policy mix that would ensure greater output. Therefore at the same time look after their environment from deprivation and pollution.

With regard to the EKC relationship, we reviewed studies adopting the recently developed unit root and co –integration tests for dataset. The results which we found up from empirical analysis are showing mixed results of integration, the co-integration amongst variables finds through application of ARDL test. In long run co integration results show that forest area, per capita income, per capita income square, FDI, population density, urbanization and trade openness show significant positive impact to reduce CO2 emissions in the EAP regions.

7.3 Policy Recommendations

The increase in trend of CO2 emissions has promoted a number of policy responses. Several studies have suggested ways of reducing carbon dioxide emissions through different sources. The main objective of the thesis to be acquainted the importance of the Environmental Kuznets curve hypothesis in order to estimate of CO2 emissions. It also to enumerate and analyze the importance of other precipitating factors like forest area, per capita GDP, per capita income square, FDI inflows, trade openness, urbanization and population density for degradation of CO2 emissions in developing countries.

The main implication of our finding is that even though 17% of these countries considered in this study reveal that in the long run per capita income, per capita income square, FDI, forest area, and trade openness have contributed less to carbon dioxide emissions. Its impact is still positive in the long run and only slightly lower in the short run.

(i) One feature of carbon dioxide emissions policies suggests a possible tax on polluters.

(ii) A second feature of policy related to restriction carbon dioxide emissions is through a carbon emissions trading scheme. Whether a pollution tax or emissions trading scheme is more relevant is not an issue considered in this study. Policy reforms that are growth oriented and environmental preserving are necessary in the developing regions.

(iii) Policies that restrict importation of carbon-intensive products and highly polluting Trans-National Corporations must be embarked upon in the sub-region of EAP countries.

(iv) Governments in the various EAP countries should make greater efforts to reducing the discharge of carbon dioxide CO2 emission.

(v) Environmental-related institutions are to be strengthened to ensure suitable sanctions on significant companies and approval of cleaner technologies. It was found that the EKC hypothesis may be clear in EAP countries.

(vi) The EKC relationship for CO2 emissions necessary to be recognized and differentiated because environmental policies are adopted to ensure better environmental quality in theEAP countries.

(vii) Leaders in developing countries should make greater efforts to reducing the discharge of carbon dioxide emissions in the EAP regions.

7.4 Limitations of the Study

This research thesis is limited to a few variables as forest area, per capita income, per capita income square, FDI inflow, population density, urbanization and trade openness having a significant and insignificant impact on environmental CO2 in all the EAP countries due to following limitations as:

I. The implementations of the environmental policies of the EAP countries are equal to zero almost.

II. The EAP may not be able to follow the same path of development as sit by the developed countries.

There is no concept of pollution tax on the polluters in the EAP countries

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