

Impact of Population, Trade and Economic Development on Environmental Degradation: A Cross Country Analysis

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Abstract

This empirical study tries to investigate the presence of the Environmental Kuznets curve (EKC) for carbon dioxide (CO₂) emissions, Mt per capita and its causal relationships with economic development, trade openness and population by using time series data from Pakistan, India and Japan for the period of 1972 to 2014. The environmental consequences of trade and economic development don't show uniform results across the multiple development stages. Depending on the national characteristics, the estimated EKC show different temporal patterns. ADF test is used for Unit root to check order of integration, VAR model is applied for long run relationship and simple Non-linear regression is applied for EKC determination. Non-linear regression results in three different models have shown some significance and some insignificance results. In case of Pakistan the Trade openness is not significantly affecting the CO₂ however population growth and per capita income is significantly contributing to environmental degradations. In Indian the population and per capita GDP are significant but same as Pakistan trade is insignificant with respect to effecting the CO₂ (environment). VAR model provided that Trade Openness is significant in the long run in Pakistan and Japan. Technically study is still open for the further researchers to trace more factors that can affect environmental degradation in different stages of development.

Keywords: Environment, Population, Trade Openness, Kuznets Curve, GDP per capita

1. Introduction

This short empirical study is about to signify the importance of population, trade openness and per capita income in environmental destruction. Recent literature has confirmed the significant relationship between environment and economic growth with taking demographics effects and trade openness. Initially Meadow et al. (1972) provided an idea of "the limit to growth" which describes that there is trade-off between economic growth and environment, to achieve a sharp increase in growth, a country would have to face polluted environment. There are two reasons behind this idea: first is the limited capacity of natural environments to use the waste generated by the economic system; and second is the finite nature of exhaustible resources (Turner et al., 1994). Recent literature has provide a decent debates with regards to some environmental problems such as the existence of the pollution heaven hypothesis, an Environmental Kuznets Curve (EKC), the "race to the bottom" hypothesis and most important the factors endowment hypothesis. In this study the authors are focussing on EKC hypothesis, which describes a reduced form or an Inverted-U-Shape relationship between income and environmental degradation, representing that the pollution level increases as a country develops, but on average with increased level of development the environment becomes cleaner, and growing income shaped the EKC to word downward from the top.

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Kuznets (1955) presented an Inverted-U-Shaped relationship between per capita income and environment which was named as Environmental Kuznets Curve (EKC). This U-shaped and inverted U-shaped relationship suggests a non-linear relationship between two variables, that is applicable to many areas. Recently a number of empirical studies have incorporated EKC to investigate the environmental significances of economic growth and trade liberalization. Furthermore, the climate change phenomenon is taking vital place in recent researches which is technically described as the outcome from the global energy system. Carbon dioxide (CO₂) Emission is mainly used measure for environmental degradation in the literature which is the largest portion of greenhouse gas emission and major source of environmental problem, so it is meaningful to examine the causal relationships between CO₂ Emission, economic development, population and trade liberalization.

CO₂ Emission per capita in Pakistan increased in last four decades in increased more than three times and Per Capita GDP in Pakistan is 1230\$ average in 2010s which is increased from 178\$ in 1970s. In India GDP per capita and CO₂ emission is increased simultaneously in recent decades. However in Japan CO₂ emission in high but growth is sustained low rise found and per capita income of Japan is more than four times than Pakistan and India.

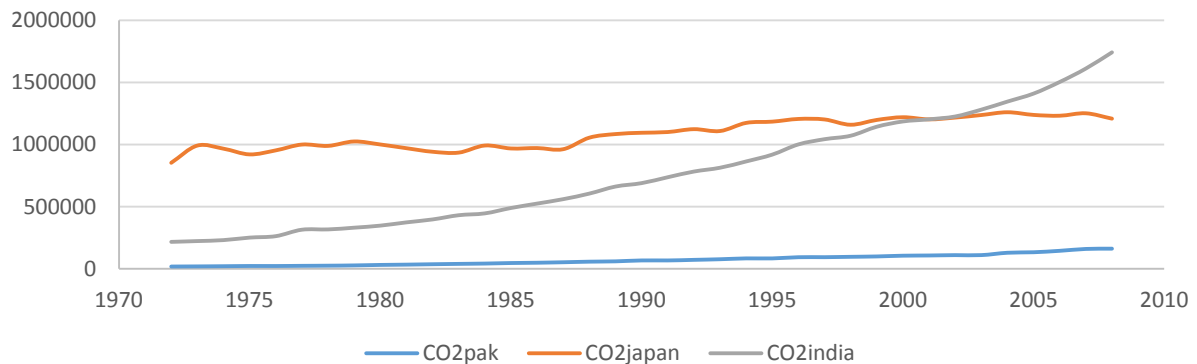
Table 1: CO₂ Emission Mt/PC and Per Capita GDP

years	Pakistan		Japan		India	
	CO ₂ emission (Mt/PC)	Per Capita GDP	CO ₂ Emission (Mt/PC)	Per capita GDP	CO ₂ Emission (Mt/PC)	Per Capita GDP
1970s	0.330168	178.7633	8.603853	5503.099	0.431345	171.3017
1980s	0.479515	335.8794	8.219974	14557.83	0.633673	305.878
1990s	0.666209	433.1232	9.227335	33429.55	0.97636	371.2698
2000s	0.850926	697.2968	9.534647	35048.25	1.321415	756.8636
2010s	0.936547	1230.731	9.124962	42124.07	1.660769	1503.866

Source: World Bank

In Pakistan and India there is increasing trends in the relationship between CO₂ per capita³ and GDP per capita. In recent decades Pakistan is showing a slow upward trend but in case of India there is a sharp increase CO₂ emission trend. Japan is standing at a constant level with only minor increase. It elaborates that there is a countrole mechanisms for the prevent the environment bcoause Japan is more developed country than Pakistan and India it seams that Japan is using the resources efficient by reduced effect on environment.

³ Calculated by Green House Emission as Carbon Dioxide metric tons Per Capita Basis

Figure No. 1 Carbon Dioxide Emission (CO₂) Metric Tons

Source: World Bank

1.1 Study Objective:

The study targets to achieve following objectives:

- To highlight the issue of environmental destructions due to increase in the industrialization and opening the borders for trade. And to check the income and population effects on the environment of the countries.
- To signify empirically the implications of population explosion, trade liberalization and economic development on environmental degradation.
- To compare the results between the deviations in level of development in countries like Pakistan India and Japan which all are in Asia but have different levels in the per capita income and industrial zones.
- Study will check the existence of the Kuznets curve hypothesis which will give us a view about the relations between CO₂ per capita and GDP per capita.

Further paper is organized in to three sections, incoming sections there is discussion on previous literature to find the importance of the study with respect to previous evidence and to determine the gap. Then there is a section for determining the methodology and model specification. In the last section there are some empirical results discussion and concluding remarks.

2. Review of Literature

In the previous literature there is a big debate on the achieving a maintainable growth and trade is dose not means that these will dangerous effects on environment. A lot of studies have examined the Kuznets Curve Hypothesis in the casual relationships between environment, trade and economic growth. There is some literature exist on the topic of current study, which explain the idea of EKC.

Choi et al., (2010) estimated the relationship between CO₂ emission, economic growth and Trade Openness and used time series data from three countries Japan, China & Korea. They applied OLS, VAR & Error correction Mechanism (ECM) for the analysis & found that the Kuznets curve hypothesis exists in each country and there is negative & significant relationship between trade and environmental degradation.

Mccarney & Adamowicz (2006) conducted an empirical study on 147 countries penal to check the relationship between environment trade and income growth. They used the fixed and random effects model with the help of Hausman test. Their results were significantly affected that trade & growth coefficients are positive & significantly effecting the environment at a significant rate and then applied the Kuznets curve hypothesis to evaluate the long run developmental effects of growth on CO₂.

Grossman & Krueger (1993) examined the empirical relationship between GDP per capita and environmental quality and focused the urban air population by using the sulfur dioxide (SO₂) to check the environmental level. They estimated the multiple development levels to cope the environmental degradation. They also elaborated the turning point for environmental sustainability at \$4,000~5,000 (in 1985 U.S. dollars). This stage gave rise to an improved behavior of the people to think about their environmental issues and at the stage of \$10,000 per capita, people use more complex methods to clean the environment and want to live in non-populated society by this act the quality of their environment will recover significantly.

Seldon & Song (1994) estimated the links between air pollution and income by using a panel data set from developed economies and used random & fixed effect models. The study also elaborated the turning point in to two categories the non-industrial economies (\$5,000 or less for SPM and SO₂), and for more industrial pollutants is more than \$8,000. They found that both measures, nitrogen oxides (NO_x) and sulfur dioxide (SO₂) are significant Kuznets curve representative which develop relationship between national output and environmental value.

Copeland & Taylor (2004) investigated the association among free trade and environment quality they recommended on countries there are three types of effects. The first effect is technological effect, that when the income increases due to the technology effect there is also increase in the consumption of ecological commodities. Free trade brings people's interest with sympathetic of environmental issues due to this people want effective pollution control with better administration policies. Thus, environment improves with the upshot of free trade in other words when the free trade happen it improves the environment because foreign goods and products are better than the local goods. The second is the scale effect. World trade capacity can be increases with the increase of free trade, due to this each country can increase its output, but on the other hand this can degrade the environment. The third is the composition effect, pollution-intensive industries are being attracted by Developing countries while developed countries are probable avoid such industries to appeal foreign direct investment (FDI). A reduction in contamination depends on the comparative size of the technology and structure effects.

Cole et al. (1997) used the cross-country panel data & inspected the association among GDP per capita & an extensive range of indicators. The study found that for only local pollutants significant EKC. More worldwide or indirect environmental possessions tend to rise monotonically with income, which infers that it is calmer to improve urban air pollution than to decrease national air pollution. The study also advocated that attentions of local pollutants tend to grasp a turning point at a lower level of GDP per capita and that global air pollutants are likely to reach a turning point at advanced level of GDP per capita.

Zaman (2013) examined the relationship among CO₂ emission, trade openness and growth in the Bangladeshi perspective. Study used time series analysis with Johansson's Cointegration analysis showed that economic growth is positively significant with CO₂ and trade openness also significant. Bangladesh has golden times in the 1990's have a great increase in industrialization.

Schmalensee et al. (1998) investigated the effect of income on CO₂ emissions by using the more flexible model and used the sample of 141 countries over the period 1950-1990, also found evidence of an EKC. The specification consisted in a piecewise linear function with fixed year-and country-specific effects.

Koop & Tole (1999) examined theoretically the existence of EKC and elaborated some literature on the subject matter. The study developed a model for panel data set analysis and found random coefficients are differ across but not within countries over time and confirmed the empirical evidence for the existence of an EKC. The study also commented on

previous literature that has a lot of arguments and evidences on the application and existence of Kuznets curve on the relationship of CO₂ emission and GDP per capita.

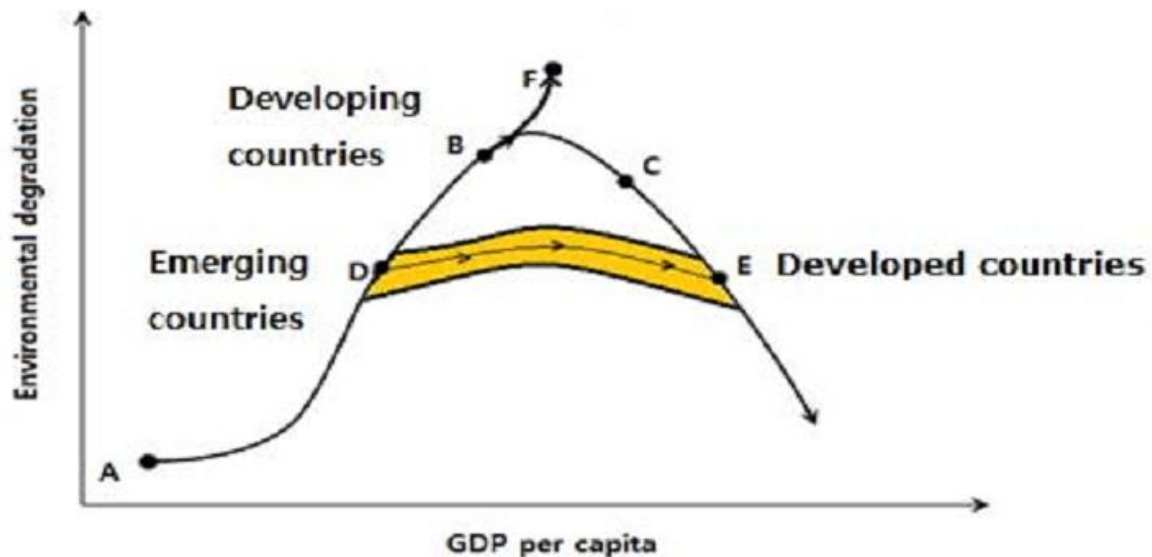
Previous literature suggested that population size is significant measure for environmental degradation and trade openness enhance the manufacturing activities and also put upward pressure on CO₂ Emission. However, in case of economic development there are multiple stages to have impact on environment. This study can be a handful contribution in the literature to signify the all three factors in three different development stages.

3. Empirical Model and Specification of Environmental Kuznets curve

Previous studies like Shafik & Bandyopadhyay (1992), Panayotou (1993), Shafik (1994) and Grossman & Krueger (1995) are mainly focused to environmental degradation and determine an inverted U-shape relationship between income and environmental degradation. The concluding hypothesis of the literature was popularly known as the Environmental Kuznets curve. Some studies elaborated the link between development stages and level of environmental degradation, genuinely the main implication from the EKC studies is that environmental quality worsens in the early stage of economic development and improves eventually after a level of income per-capita. This implies that as income increases, the people become more sophisticated in selection of goods and services, so does demand for a cleaner environment, people shift away from CO₂ intensive goods and services they select more energy saving products to live in unpolluted environment.

Munasinghe (2008) argued on the importance and value of the “tunnel effect”⁴, which may allow developing countries to accomplish their goal economic growth while maintaining a lower level of pollution. As in figures the emerging economies go from point D to point E by utilizing clean technologies. Same as for Developing countries can go from point B to point C or to pint E by using clean technologies.

Figure No. 2 Tunnelling Through the EKC



Source: Choi & Cho (2010) and Munasinghe (2008)

⁴ For detailed discussion on tunnel effect see Choi et al. (2010).

3.1 The Model

The study develops model by following Choi et al. (2010). In the model we specify and estimate the Environmental Kuznets curve (EKC) based on CO₂ emissions Mt per capita for Pakistan India and Japan to resolve whether these countries have an EKC or not. The results are expected to have important implications for the countries as they establish environmental targets for CO₂ emissions. To make sure the shape of the EKC, the study develops the following non-linear regression equations for each country.

$$CO_{2t} = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 POP_t + \beta_4 OPEN_t + \beta_5 OPEN_t^2 + \varepsilon_t \dots \dots \dots (1)$$

Table 2: Variables Description

Variable	Description
CO ₂	Carbon dioxide CO ₂ Mt per capita
GDP	GDP per capita (current US \$)
POP	Population Growth (Annual)
OPEN	Trade (% of GDP). Included as a proxy for openness.

The study incorporates CO₂ Carbon dioxide emissions Metric ton per capita to measure environmental level and for population size the study implies population growth rate, economic development is measured by Per Capita income and trade openness is measured by the total trade volume to GDP ratio. To test the presence of EKC the model is developed as non-linear equation, which is derived for the objective relationship specification of EKC in different levels of economic development.

Environment quality levels CO₂ Emission are anticipated to rise with mounting income GDP per capita up to a threshold level beyond which pollution levels are expected to decrease with higher income levels is the combination of these two effects, $\beta_1 < 1$ and, $\beta_2 < 0$ in Model (Choi et al., 2010). In an attempt to broaden the core concept of EKC, the study also investigate the relationship between environmental pollution and trade openness with using an extra curriculum of demographics (Mccarney & Adamowicz, 2006).

As in above Based on the pattern, a country tends to follow an increasing pollution levels as trade openness proceeds ($\beta_4 > 1$) and the this can be decreasing as on the more advanced stages come ($\beta_5 < 0$)

The empirical results for this study are based on the time series data from Pakistan as Developing country as newly industrialized country, India emerging economy, or we can say fast efficient growing country and Japan a developed nation. Date is taken from World Bank on time series (1972-2014). The data is sourced from World Bank. Data will cover the effects of openness, Income, Demographic (population) and trend on the CO₂ (environment degradation).

Table No. 3 Summary Descriptive analysis Country Individual

Countries	Pakistan		India		Japan	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev
CO ₂	.58555	.19799	.8409048	.3365267	8.9203	.6291
GDP	408.203	195.222	393.6024	233.1206	22569.15	13017.75
OPEN	33.798	3.1156	21.047	11.0446	22.6845	4.9127
POP	2.729	.5509	1.965	.3224948	.5112	.442

A summary of statistics in the annual time series data is presented in Table 3 Japan's emission per capita is the highest at star and slowly decreased, followed by India which have now at peak level with an increasing trend and Pakistan is having slow increase over time in

43 years. A similar pattern is found concerning GDP per capita where Japan is standing high on top. Pakistan and India are on the same line slow low increase.

The data of CO₂ emission Mt is taken on per capita basis and mean value of CO₂ emission is 0.59 for Pakistan & in India CO₂ emission is higher than Pakistan 0.84, while in Japan it is 8.9203, it seems that CO₂ emission is increasing with level of development in three different economies. As same case in GDP per capita, where it is in Pakistan 408.2 (US\$ constant 2005), In India 233.12, while in Japan it is highest among these three economies, which is 1301.8, If we talk about trade openness it is higher in less develop country (Pakistan) 33.79 on average during last four decades. In case of population growth it varies from less developed to develop on decreasing trend. In Pakistan average population growth is 2.73 & in India 1.97 while in Japan 0.511.

4. Results and Discussions

To determine the impact of population growth, trade openness and economic development on environmental degradation. The study incorporate two different approaches to signify the results, first of all the study implies a unit root check by using Augmented Dickey-Fuller Test for deciding the appropriate econometric technique and then a simple OLS method is used on the model in non-linear equation model where variables are collinear because of the use of GDP² & trade openness². At second step according to the order of integration of each variable I(1) the study used Vector Autoregressive Model (VAR) to check the causal long run relationship between the variables. Regression diagnostics for Multicollinearity, Heteroskedasticity and Autocorrelation are also applied model efficiencies but included in the discussion of results because they are out of context of Non-linear regression analysis.

Table 4: Unit Root Test (ADF) and Optimum lag selection criterion (AIC)

Variables	Pakistan		India		Japan	
	ADF results	AIC	ADF	AIC	ADF	AIC
CO ₂ Emission	I(1)	1	I(1)	1	I(1)	1
Population	I(1)	4	I(1)	4	I(1)	3
Trade Open	I(1)	1	I(1)	1	I(1)	1
Per Capita GDP	I(1)	1	I(1)	1	I(1)	3

Note: In Table I(1) stands for the order of integration of the variable which is found from the ADF critical value and probability value and AIC is the lag selection criterion.

Table 4 shows the unit root test results by using Augmented Dickey-Fuller Test of Stationarity and optimum lag length selection criteria of AIC. Only final values of test decision results are included in the table. All the variables used in the model are stationary at first lag I(1) by taking a look on the critical values and p-values of each variable. We can apply ECM if there is cointegration present between the variables or we can apply Vector autoregressive Model (VAR) when there is no cointegration found in between the variables. First we have simple non-linear regression results to quantify the EKC in all three countries of different development stage.

Table 5: Non Linear Regression results by individual Country

Countries	Pakistan		India		Japan	
	Co. eff(S.E)	t (p-value)	Co. eff(S.E)	t (p-value)	Co. eff(S.E)	t (p-value)
Constant	-.962(.145)	6.66(.000)	-.419(.125)	-3.35(.002)	.934(.219)	4.28(.000)
GDP	-.153(.044)	-3.50(.001)	-.059(.036)	-1.62(.114)	.009(.039)	.24(.810)
GDP ²	-.076(.022)	-3.50(.001)	-.30(.018)	-1.62(.114)	.005(.019)	.24(.810)
POP	.277(.0718)	3.85(.000)	.421(.153)	2.74(.009)	.016(.020)	.78(.443)
OPEN	.414(.088)	4.70(.000)	-.066(.056)	-1.18(.246)	-.055(.058)	-.93(.359)
OPEN ²	.207(.044)	4.70(.000)	-.033(.028)	-1.18(.246)	-.027(.029)	-.93(.359)
Trend	.018(.001)	14.12(.000)	.022(.001)	20.50(.000)	.002(.001)	1.77(.085)
R ²	0.9876		0.9930		0.476	
F-Value	755.59		1340.88		8.36	

Note: p-value at 0.00 shows significance at 1%, 0.05 and less shows 5% and 0.10 shows 10% confidence interval.

Results of non-linear regression of three Country individual models are estimated in STATA 11. The entire models are well good fit the R² are very high and F-statistics are also showing significant results. But about the β 's (coefficients) are significant in some case and insignificant some cases results because of the different country characteristics. Table 5 provides results of regression where we can see GDP per capita is significant in case of Pakistan & it negatively effecting environmental degradation. It means increase in per capita income leads to decrease in CO₂ emission. However in case of Japan & India is showing insignificant results. Where GDP & GDP² both are not effecting environment and population is significant in Pakistan and India which means increase in population leads to decrease the environment, while in case of Japan population have slow growth rate annually, even negative in recent years. It showed insignificant in CO₂ emission, trade openness is found insignificant in all the three economies. Results of the present study found the evidence of EKC per capita GDP in Pakistan is significant both in single and square form and in emerging economy India only per capita GDP square is significant; however, in Japan both per capita GDP and per capita GDP square are insignificant that shows the tunnel effect in developed countries.

Further analyses are carried out on time series analysis for each individual country and ADF test provide results of order of integration that all the variables are integrated of order I(1) so we moved to VAR model for long run analysis. Results of VAR model shows that per capita GDP and Population growth is found insignificant in the higher level of development stages. However, trade openness has impact on environmental degradation in the long run. VAR model also gave evidence about the persistence of environmental quality with changes in the development level in the long run. Current study follows the previous evidence confirmed in the literature.

Table 6: VAR Results by Individual Country

Countries	Pakistan		India		Japan	
	Co.eff(S.E)	t (p-value)	Co.eff(S.E)	t (p-value)	Co.eff(S.E)	t (p-value)
Constant	.055(.172)	.32(.750)	-.067(.107)	-.62(.532)	.175(.154)	1.14(.256)
CO ₂						
L ₁	.714(.144)	4.93(.000)*	.690(.148)	4.66(.000)*	.717(.183)	3.91(.000)*
L ₂	.276(.142)	1.94(.053)	.212(.141)	1.50(.134)	.079(.168)	.47(.636)
GDP						
L ₁	.045(.044)	1.02(.307)	.014(.057)	.24(.809)	-.027(.054)	-.50(.614)
L ₂	-.043(.046)	-.92(.359)	.007(.054)	.12(.901)	.048(.050)	.95(.340)
POP						
L ₁	-.069(.214)	-.33(.744)	-1.967(.82)	-2.39(.017)	-.009(.013)	-.70(.483)
L ₂	.115(.188)	.61(.542)	1.965(.738)	2.66(.008)*	.015(.010)	1.45(.148)
OPEN						
L ₁	.175(.075)	2.33(.020)**	.0405(.733)	.55(.581)	-.113(.053)	-2.12(.03)***
L ₂	-.220(.079)	-2.75(.006)	-.030(.063)	-.48(.634)	.059(.063)	.96(.338)

Note: *, **, *** are showing the significance at 1, 5 and 10 percent confidence interval

The results of VAR model show that CO₂ emission is persistent in all three models. In long GDP growth per capita is insignificant in case of Pakistan and Japan. It means the extreme ends of development level are not affecting environment. However trade openness is significant on the extreme ends of level of development in Pakistan & Japan however, it is still insignificant in India. Current study has signifies the existence of EKC in Pakistan and India, where income and environment have significant relationship in simple and squared form but in Japan there is sustained level of high per capita income and peoples of Japan have controlled their environmental population level. Further researchers can add more indicators in the analysis to determine the relationship between demography and environment, soft power and environmental degradation and other macroeconomic measures to signify the implications on environmental degradation.

5. Conclusion

The study is concerned with the development stages effect on the countries environment where the CO₂ was tested with a relationship with Openness, GDP Per Capita, population and Time Trend. This relationship is been tested with help of Kuznets curve and for econometric analysis ADF test for Unit Root, VAR Model and OLS are used. Results shown different diversifications in different stages of development over the countries individual perspectives, countries included are Pakistan, India and Japan were in the sample as Japan is a developed country, developing country Pakistan and for emerging economy India's data is used. There is a big economic developmental gap between these three countries. After getting results the study argued that the relationship between the CO₂ emission per capita and GDP per capita is at different levels of development, GDP per capita is significant in Pakistan and negatively affecting environment, it seems that increase in per Capita income is technically reducing CO₂ emission. Technically if we see in for Trade openness is insignificant an all the three stages, however in long run there is impact on environment in less developed nation and in developed nation. Population growth is significant measure for environmental degradation in less developed and emerging economies. The study finally concluded that economic development and population are found significant in environmental regression. And the results are similar to the previous studies but

there is contradiction in case of trade openness is found insignificant in Short Run and significant in long run different for Pakistan and Japan. This study has made an open question for the further reaches on Kuznets curve hypothesis to incorporate more factors of demography, soft power and macron economy to test the factors for environmental degradation. Further it can be said that sharp industrialization is a factor for environment distraction or the poor governance and poor efficiencies are also the factor for the environmental inefficiencies.

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