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Prospects of Environmental Kuznets Curve and Green Growth in Developed and Developing Economies

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ABSTRACT

The study empirically investigated the determinants of Environmental Quality using energy utilization intensity, and globalization. The investigation determines linear, inverted U shaped or N shaped relationship between CO2 emission and GDP using panel ARDL approach. 64 countries are selected for making two panel data models of developed economies and developing economies for the time period 1970-2015. The outcomes showed that in long run increase in the energy use intensity and the global integration lead to an increase in the CO2 emissions. In the case of GDP, the study has confirmed an inverted U shape relationship proposing prospects of green growth. Hence, results of the study found that there is significant evidence of global environmental Kuznets curve for both economies. In comparison, developing economies pollute more with an increase in GDP, but they are also expected to revert faster towards green growth as compared to developed economies.

Keywords: CO2 emissions, Environmental Kuznets Curve, Panel ARDL, Green Growth.

JEL Classification Q55, Q56

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1. Introduction

When human beings were not highly developed, the universe was too peaceful and relaxed. Fresh air, forest cover and natural foods are commonly available and lives were safe from hazardous diseases. Though today we are advancing in technology, but we are facing different kinds of problems like pollution, causing the standard of living, environment and ecology degradation (Dockery & Pope, 1996). This is evident from observable fall in the life expectancy of humans in the history from Adam and Eve to present. In many cases, in pursuit of growth countries, corporations and people ignored the environmental implications (Murphy, 2003).

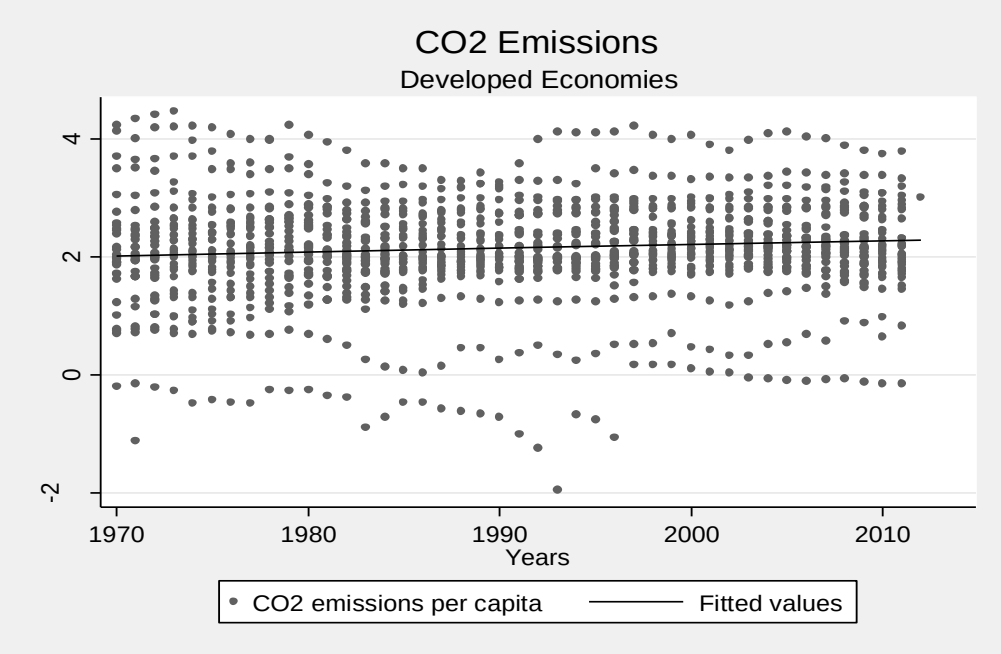
Taking account of the significant changes in the environment, the objective of this empirical study is to investigate the presence of EKC (Environment Kuznets Curve). It will also control for the spillover effect and interconnectivity through trade effect in a dynamic panel data model. This study will also intend to find an appropriate specification of EKC, from linear, inverted U shaped and N shaped and compared the results among the developed and developing economies.

People gave attention to environmental issues in the 19th century, because of human activities highly damaged natural environment. There are few major events which grabbed the attention of the worlds to think about the safety of the environment. These are Japan's mercury poisoning, smoke pollution from London and a great oil leakage by Terry Canyon accident in UK (Bassey, Effiok, & Eton, 2013). Most researchers argued that environmental performance is associated with elements other than the growth and use of polluting resources.

In the initial phase of the development process, countries start the industrialization to feed the demand of the population. Industrialization increases the population density in selective locations which cause higher usage of vehicles for transporting people and goods. The increase in industrialization and population density contributes to pollution. Later on, people realized the consequences of the free development system and started to propose the environmental protection regulations and promotion of environmental protection processes. In the later stage of the development process, environmental safety occupies a momentous place in the economic policy and creates a main concern for the worldwide community. To expedite this process, many research and seminars started to discuss the role of sustainable growth and saving environment for future generations. Further, worldwide concern regarding environmental protection can be seen when United Nations put forward sustainable growth as 8th millennium development goals. (Drabo, 2010).

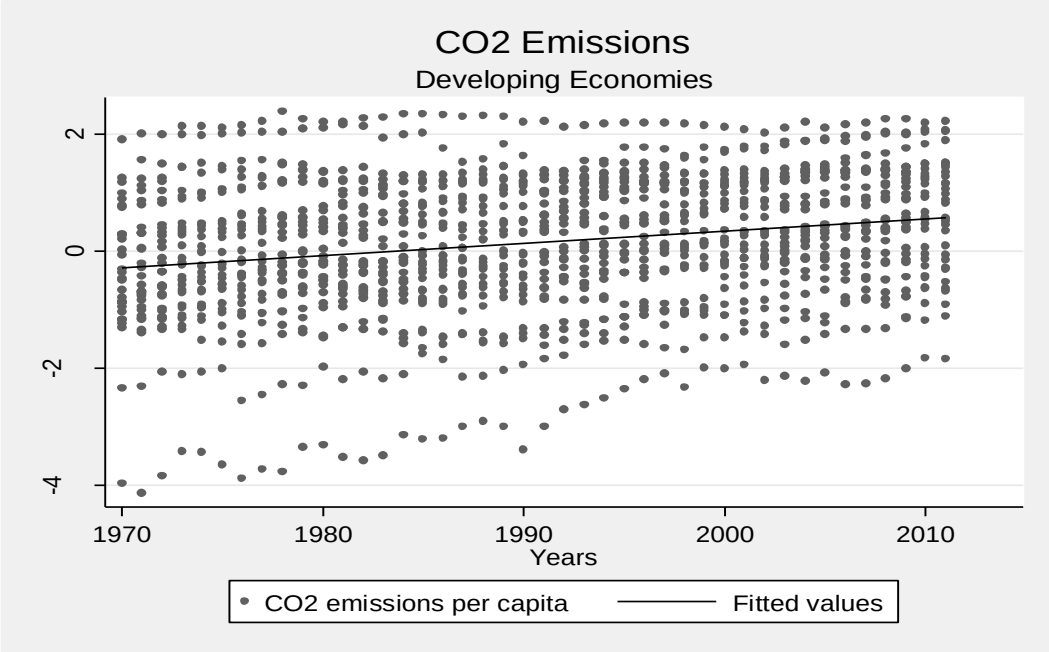
From the last two and half decades, the Environmental Kuznets curve hypothesis got popularity in 1991 Grossman and Krueger studied EKC by considering the relationship between economic growth and pollution. The findings of that study suggested an inverse U-shaped relationship between environmental quality and economic growth. According to EKC study, initially, economic growth brings about a negative change in environment or damaged environment. However, as much as economic grows or matures, environmental quality tends to improve (Ahluwalia, 1976; Fields & Jakubson, 1994; Kuznets, 1955, 1979). There are many studies which tested environmental Kuznets curve in different forms because of its implications (Akbostancı, Türüt-Aşık, & Tunç, 2009; Grossman & Krueger, 1991; Johansson & Kriström, 2007; Nasir & Rehman, 2011; Selden & Song, 1994; Shafik, 1994; Shahbaz, Ozturk, Afza, & Ali, 2013; Stern, 2004; Stern, Common, & Barbier, 1996; Tao, Zheng, & Lianjun, 2008; Wagner, 2008; Awan et al., 2018).

Figure 1: CO_2 emissions trend for developed economies



Source : Self generated using WDI data

Figure 2: CO2 emissions trend for developing economies



Source: Self generated using WDI data

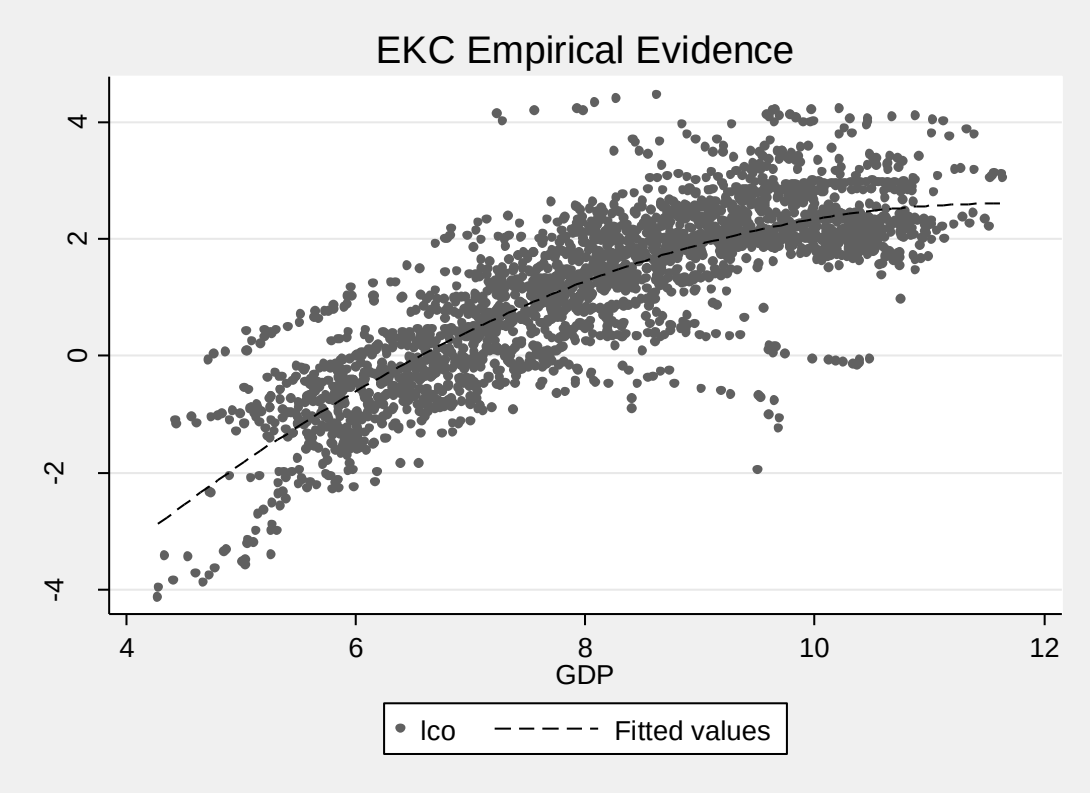
The need for revisiting the EKC is asserted from observing the increasing trend of average CO_2 emissions for developed and developing economies in figure 1 and figure 2. The CO_2 emissions growth in developing economies are higher than in developed economies. The idea of EKC was developed from the Kuznets study (Kuznets, 1955), which hypothesized that initial growth will promote inequality and after a certain level, it will reduce inequality. Huang, Hwang, and Yang, (2008) conducted a study to evaluate the effect of income on the environment, concluded that higher income initiates energy efficient processes which reduce CO_2 emissions. Figure 3 shows a plot of a quadratic approximation on the scatter plot of CO_2 emissions and GDP of developed and developing economies. Here it is evident that an initial increase in GDP shown in x-axis increases CO_2

but later the rate of increase slows down, represented by downward bending (inverted U shaped) curve.

The earlier mentioned studies tested Kuznets curve in different regions and periods. It is important to know that most of the researchers only focused on economic growth or Income level as an only explanatory variable for Green House Gases (GHGs). However, few studies include energy consumption to include the effect of an increase in demand of energy. Similarly, only a few studies used globalization to incorporate the effect of global connectivity like Destek and Ozsoy, (2015) used economic globalization only for Turkey, Leitao (2013) used KOF index of globalization for Portugal, Spain, Greece and Ireland. And Leitao and Shahbaz, (2013) used KOF index for 18 developed countries only.

It is also important to mention that different studies have produced different results. Some of them like [Nasir and Rehman (2011); Acaravci and Ozturk (2010)] were confirmed the existence of EKC while few researchers such as Wagner (2008) revealed non-existence of EKC. In addition, there are some studies which highlighted the N-shaped specification of EKC. This means that high incomes do no sustain environment quality. Therefore, the review of literature describes the ambiguous evidence for EKC existence. Because of the global focus on sustainable growth, this study intends to revisit the EKC using a larger and comparative country sets in a panel data configuration.

Figure 3: Environmental Kuznets curve empirical evidence



Source: Self generated using WDI data

The present study is conducted with the prime objective of revisiting Environmental Kuznets curve by panel data of selected 64 developed and developing countries. There are several single country empirical analyses, the issue with them is that, they might be influenced by contemporaneous correlation from trading partners, regional efforts and technology transfer. Furthermore, present study employed globalization index as an additional variable in the current model to know the impact of global economic, social and political integration on EKC, which was rarely used in previous studies, especially in a comparative case of developed and developing economies. The remaining of the study is structured in 4 sections; the second section is of review of

empirical studies in the literature review of empirical studies. Section 3 of the methodology will introduce the data set, and descriptive, followed by the presentation of the estimation of outcomes. The last section of the paper is concerned with the conclusion and policy recommendations.

2. Literature review

From the last two and half decades environmental Kuznets curve hypothesis got popularity, in 1991 Grossman and Krueger studied the Environmental Kuznets curve. In this study, economic growth and environmental pollution had Inverse U-shaped relationship (Grossman, & Krueger, 1991). According to EKC during the early stage of economic growth leads to ecological deprivation, but when per capita GDP arrive at the threshold, it leads to decrease in environmental degradation (Selden & Song, 1994; Stern et al., 1996). Later on, many studied conducted on that topic, but researchers argued that there are many econometric problems which are ignored in literature (Johansson & Kriström, 2007; Stern, 2004; Wagner, 2008).

While exploring EKC in developing economies, Tao et al. (2008), explored the association between ecological pollution and economic growth based on EKC hypothesis. This study employed a panel cointegration approach using Chinese provincial data for the time period of 1985-2005. The findings of panel data showed long-run association between emissions of water, gas, solid and GDP. It is also observed that all three pollutants have an inverse U-shape relationship. Wagner (2008) using balanced panel of 95 counties for the time period of 1950 – 2000, argued that in past many econometric problems were ignored while working on environmental Kuznets curve, Wagner considered all that problems and found no evidence of inverse U-shaped affiliation among GDP and CO_2 emissions. Wagner argued three problems in earlier studies which used non-stationary panel data, like the use of nonlinear transformations of an integrated process, in the presence of small sample size panel unit root tests and panel cointegration tests perform poorly.

There are several recent studies which explored the evidence of Environmental Kuznets Curve. A study for the case of Kenya between 1970-2012 (Al-Mulali, Solarin & Ozturk, 2016; Sakodie & Ozturk, 2020), for the case of India and China (Solarin, Al-Mulali & Ozturk, 2017), for the case of Indonesia (Darwanto et al., 2019; Sasana & Aminata, 2019) and for Egypt, Kenya and Turkey (Base & Kalayci, 2019) confirmed the presence of EKC. Further there are several studies which confirmed the EKC within the panel data framework, like for African Countries (Shahbaz, Solarin & Ozturk, 2016), for OBOR economies (Rauf et al., 2018), for ASEAN- 5 (Phong, 2019).

Christmann and Taylor (2001) investigated associations between environment and globalization in China, findings suggest that having international clients, multinational proprietorship and export to industrialized countries develops self - regulation of ecological performance. Christmann and Taylor (2002) argued that the multinational firms are facing pressure from non-governmental actors for ecological accountability which is making production processes greener.

Ang (2008) found a positive and significant association between energy consumption and emissions. In addition, unidirectional causality also confirmed from economic growth to energy consumption. Results are sensible as for the case of Malaysian economic growth which is fueled by industrialization growth based on the intensive use of energy.

Nasir and Rehman (2011) explored link among FDI, energy consumption, and income with CO_2 emissions for the period of 1972-2008. Finding of the study showed the long run association among income and CO_2 emissions, thus verified Kuznets curve in Pakistan. In addition, energy consumption and foreign direct investment also affect emissions while in short run EKC did not exist.

Acaravci and Ozturk (2010) investigated affiliation energy consumption, economic growth and Carbon dioxide emissions in European economies. The findings of the study confirmed the environmental Kuznets curve in developed economies. In addition, the findings also confirmed long run association among energy consumption, economic growth and Carbon dioxide emissions. While, Soytas, Sari and Ewing, (2007) and Soytas and Sari (2009) found causality between Carbon dioxide emissions and energy consumption.

Halicioglu (2009) carried a study in turkey for the time period of 1950-2005 using ARDL approach. The findings of the study confirmed that FDI, energy consumption and income are the major determents of Carbon dioxide emissions. Friedl and Getzner (2003) investigated affiliation among economic development and CO_2 emissions from Austria. This study advocated the presence of N shaped relationship where a decrease in CO_2 is not sustainable.

Akbostancı et al. (2009) inspected the association between income and environmental quality at two levels in Turkey. At first level, the present study employed time series data using a cointegration approach, while at second level panel data used of Turkish provinces to investigate the relationship between income and air pollution. Time series analysis showed a linear relationship between CO_2 and income, while panel data analysis suggested N-shaped relationship means in both levels present study did not find perfect Kuznets curve. Tucker (1995) analyzed the link between CO_2 emissions and global GDP for 137 countries and a positive relationship observed between CO_2, GHG and GDP. While it also observed that if as per capita income increases across countries, emissions also increase which rejects the Kuznets hypothesis.

Wheeler (2000) analyzed air quality trends from United States and other three developing countries which are largest FDI recipients like China, Brazil and México. The findings of the study showed that during globalization, air pollution reduced from the largest cities of these four countries, hinting presence of EKC.

Copeland and Taylor (1995) studied the theoretical connection between trade and environment. On the basis of results, it was observed that due to globalization, most population intensive industries shift toward developing countries where environmental laws are not strict. Similar studies like [Fischer-Kowalski and Amann, (2001) and Gallagher, (2009)] provided the foundation regarding the channel of globalization's effect on environment. They indicated the role of environmental regulations in improving the environment and make country export competitive. Shahbaz et al. (2013) investigated the relationship between CO_2 emissions, energy consumption, economic growth and globalization using time series data of 1970-2010. It is observed that energy consumption is a major contributor to CO_2 emissions, while globalization seems to reduce CO_2 emissions. Furthermore present study found evidence for EKC, a similar outcome was observed in the study on Turkey by (Destek & Ozsoy, 2015). Kahuthu (2006) also, inspected about economic growth and environmental performance in a global sense. The study confirms the existence of an inverted U-shaped relationship between income growth and CO_2 emissions, in addition, the present study also include globalization in the model and finding confirmed that increase in the rate of global integration leads to environmental degradation. Author argued that no doubt with globalization economies become developed but environmental principals should also consider for their sustainable growth, similar results are observed in the studies by (Leitao, 2013; Laitao & Shahbaz, 2013; Al-Mulali et al., 2016). Zarzoso and Morancho (2004) used the pooled mean group model on 22 OECD economies indicated the presence of N shaped EKC curve for the majority of the countries in the sample. But theoretically quadratic specification seems appropriate. This study did not check for the presence of cointegration and possibility of inverted U shape relationship.

This study will use the energy intensity and the globalization as used by previous studies to control the effect of demand for energy and global integration on the CO_2 emission. While analyzing the previous studies, reveal that there are studies in favor and against environmental Kuznets curve. Most of the empirical studies used the time series data to investigate the EKC, such method ignores the possibility of technology spillover effect and policy integration between the economies and regions which may lead them in joint pursuit in making policies to decrease CO_2 emission. Studies like (Arshed & Zahid, 2016; Eberhardt & Teal, 2010; Masood, Farooq & Saeed,2015) indicated the dynamic panel data models like Pooled Mean Group. The asserted that the qualitative aspects like technology spillover effects and interconnectivity of countries via trade which were ignored in time series or simple panel data models. And this PMG model is also consistent as compared to their counterparts MG and DFE models (Blackburne & Frank, 2007). The only study by Zarzoso and Morancho (2004) used PMG model only on developed economies. Similarly, this study will base the

discussion regarding the possible relationship between CO_2 and GDP. It opened the possibility for a linear effect, inverted U shape or N shaped relationship and compare this EKC relationship between developed and developing economies. Based on the empirical studies, it is expected that the nature of inverted U shape EKC will perform differently for both type of economies.

Research Hypotheses

In order to achieve the objective of the present study, following are the hypothesis in the alternative form stated below.

H_a: Out of Liner, U shaped and N shaped relationship, which EKC exists in developed and developing economies?

H_b: Is there a difference in EKC relationship between developed and developing economies?

H_c: Does energy demand intensity lead to increase in CO_2 emission in developed and developing economies?

H_d: Does globalization lead to increase in CO_2 emission in developed and developing economies?

3. Data and Methodology

This study has employed data of CO_2 emissions (Metric tons per capita), energy consumption (Kg of oil equivalent per capita), real GDP per capita, real GDP per capita square, real GDP per capita cube (constant US$) and globalization index (2016 KOF Globalization Index report) to investigate the presence of EKC. This data collected from 64 countries shown in appendix table 1, in which 32 representative developing countries and 32 representative developed countries. The purpose of constitute two data sets it to compare the effects of difference is human development levels on production processes (Acaravci & Akalin, 2017). The WDI is a main source of data collection which is consist on 1970-2015. The selection of representative developed and developing economies is based on World Bank reports[1]. While, globalization index data collected from KOF Index of Globalization report of 2016.

3.1. Model specification

To verify the findings of the previous studies and answer the research questions, these equations are developed

$$CO_2 = \beta_i + \beta_{1i} Ener_{it} + \beta_{2i} GI_{it} + \beta_{3i} GDP_{it} + \varepsilon_{it} \quad (1)$$

$$CO_2 = \beta_i + \beta_{1i} Ener_{it} + \beta_{2i} GI_{it} + \beta_{3i} GDP_{it} + \beta_{4i} GDP_{it}^2 + \varepsilon_{it} \quad (2)$$

$$CO_2 = \beta_i + \beta_{1i} Ener_{it} + \beta_{2i} GI_{it} + \beta_{3i} GDP_{it} + \beta_{4i} GDP_{it}^2 + \beta_{5i} GDP_{it}^3 + \varepsilon_{it} \quad (3)$$

Whereas:

CO_2 = Carbon dioxide emissions
GDP = Gross domestic product
Ener = Energy consumption
GDP^2 = Gross domestic product square
GDP^3 = Gross domestic product cube
GI = Globalization Index

3.2. Panel unit root test

Pedroni (2008) and Eberhardt (2011) specify that when time period is increased beyond 20 years per cross section, the panel data tend to show time series properties. Time series panel data show non-stationary behavior which requires the presence of cointegration among the proposed variables for a valid long-run relation, otherwise, it might lead to spurious results (Gujarati & Porter, 1999).

[1] Country and lending Groups. World Bank. Accessed on July1,2015

This study has used IPS panel unit root (2003), which assumes an individual unit root process. And LLC panel unit root test (2002) which assumes common unit root process in the variable while determining stationarity behavior. IPS and LLC unit root test works with null hypothesis, which series has unit root.

3.3. Panel Cointegration test

Since some of the variables are non-stationary at level, but after differencing all variables become stationary. Hence there is need of confirming the presence of panel cointegration to ensure the long-run estimates to be valid. For this Kao (1999) and Canning and Pedroni (2008) panel cointegration tests are used. Both of these tests adopt Engle Granger procedure (Engle and Granger, 1987) with the difference that Kao used pooled ADF test of cointegration and Padroni used group heterogeneous tests having a similar null hypothesis of no cointegration among the proposed variables.

3.4. Panel ARDL

Since the variables are in mixed order of integration this study will use the panel ARDL cointegration approach (Meo, Chowdhury, Shaikh, Ali & Sheikh, 2018). This estimation approach introduces homogeneous long run estimates and cross-sectional heterogeneous short-run estimates (Meo, Ali, Poswal & Ali, 2018). This model is named as Pooled Mean Group which is suggested by (Pesaran, Shin & Smith, 1999). According to this model, the differences in the countries will contribute to the short-run deviations from the long run model of EKC. And the speed at which convergence will occur will be different for each cross section. Martínez-Zarzoso and Bengochea-Morancho (2004) and Sharif et al. (2019) earlier used this methodology for the EKC.

4. Empirical Results

While analyzing the developed economies in table 2, it is found that all the series are non-normal indicated from the probability values less than 0.05 of Jarque Bera Test (Jarque & Bera, 1980). This indicates that either data does not have a true central tendency (skewness ≠ 0). Or the number of outliers in data is non-standard (kurtosis ≠ 3). Because of this characteristic of data, there is a need of constructing a panel data model which incorporates the cross section unobserved heteroskedasticity. Also, the cross-section dependence (CD) test indicate that there is a correlation between the cross sections for each variable (Pesaran, 2004). While observing the developing economies in table 3, these variables being non-normal also indicate the use of panel data models and they are also cross-sectionally correlated. The presence of cross-sectional correlation in both data sets prompts to use the second-generation panel data models.

Table 2: Descriptive Statistics for developed economies

Developed countries						
	CO_2	ENER	GDP	GDP^2	GDP^3	GI
Mean	2.13	8.18	9.48	90.94	881.3	4.18
Std. Dev.	0.82	0.71	1.01	18.71	263.9	0.22
Skewness	-0.70	-0.41	-0.46	-0.22	0.01	-0.37
Kurtosis	5.48	3.94	2.77	2.48	2.41	2.12
Jarque-Bera	454.60	92.52	55.47	27.34	36.52	74.86
Probability	0.00	0.00	0.00	0.00	0.00	0.00
CD Test	12.55	71.08	121.65	121.64	135.3	123.80
Probability	0.00	0.00	0.00	0.00	0.00	0.00

Table 3: Descriptive Statistics for developing economies

Developing countries						
	CO_2	**ENER**	**GDP**	**GDP^2**	**GDP^3**	**GI**
Mean	0.14	6.49	7.02	50.50	371.2	3.72
Std. Dev.	1.13	0.62	1.08	15.25	164.9	0.32
Skewness	-0.53	0.45	-0.03	0.24	0.51	-0.49
Kurtosis	3.45	2.39	2.23	2.26	2.50	3.30
Jarque-Bera	75.31	68.35	35.14	46.55	66.88	62.82
Probability	0.00	0.00	0.00	0.00	0.00	0.00
CD Test	48.69	42.08	117.15	117.83	131.23	121.85
Probability	0.00	0.00	0.00	0.00	0.00	0.00

Table 4: Unit root for developed economies

Variables	**Levin, Lin & Chu test**		**Im, Pesaran and Shin test**		**Decision**
	1(0)	**1(1)**	**1(0)**	**1(1)**	
CO_2	2.38 (0.99)	-14.60 (0.00)*	1.26 (0.89)	-19.36 (0.00)*	**I(*1*)**
ENER	1.21 (0.88)	-12.94 (0.00)*	-17.94 (0.00)*	2.46 (0.99)	**I(*1*)**
GDP	-5.36 (0.00)*	-4.74 (0.00)*	-18.75 (0.00)*	-13.96 (0.00)*	**I(*0*)**
GI	3.36 (0.99)	-14.71 (0.00)*	5.11 (1.00)	-14.68 (0.00)*	**I(*1*)**
GDP^2	-5.36 (0.00)*	-18.75 (0.00)*	-4.74 (0.00)*	-13.96 (0.00)*	**I(0)**
GDP^3	-8.72 (0.00)*	-25.64 (0.00)*	-0.84 (0.20)	-21.57 (0.00)*	**I(0)**

Note: I(0)& I(1) refers to statiorny at levels and first difference respectively
*&** refers to 1% and 10% level of significance

Table 5: Unit root of developing economies

Variables	**Levin, Lin & Chu test**		**Im, Pesaran and Shin test**		**Decision**
	1(0)	**1(1)**	**1(0)**	**1(1)**	**1(0)**
CO_2	0.06 (0.52)	-14.28 (0.00)*	-0.42 (0.33)	-16.74 (0.00)*	**I(*1*)**
ENER	0.54 (0.71)	-11.25 (0.00)*	1.96 (0.97)	-15.35 (0.00)*	**I(*1*)**
GDP	-1.90 (0.03)**	-11.80 (0.00)*	-1.94 (0.02**)	-13.17 (0.00)*	**I(*0*)**
GI	1.88 (0.97)	-12.71 (0.00)*	5.10 (0.90)	-15.20 (0.00)*	**I(*1*)**
GDP^2	-1.90 (0.03)**	-11.80 (0.00)*	-1.94 (0.02)**	-13.17 (0.00)*	**I(*0*)**
GDP^3	3.34 (0.99)	-12.40 (0.00)*	7.44 (.80)	-15.54 (0.00)*	**I(1)**

Note: I(0)& I(1) refers to statiorny at levels and first difference respectively
*&** refers to 1% and 10% level of significance

Table 4 and 5 shows that for both developed and developing economies, there is a mixed order of integration such that few variables like GDP and GDP^2 are stationary while all others are non-stationary.

Table 6: Panel Cointegration Tests

Panel Cointegration Test						
	Developed Economies			**Developing Economies**		
	Linear Effect	**Inv. U Shape**	**N Shaped**	**Linear effect**	**Inv U Shaped**	**N Shaped**
Alternative Hypothesis: Joint AR coefficient						
Kao T Statistic	-1.53 (0.10)	-2.85 (0.00)*	-1.19 (0.11)	-1.50 (0.10)	-3.79 (0.00)*	-0.42 (0.33)
Alternative Hypothesis: Common AR coefficients (within dimension)						
Panel v Statistic	2.73 (0.22)	2.41 (0.52)	0.55 (0.59)	0.34 (0.37)	-0.04 (0.33)	-1.56 (0.92)
Panel rho Statistic	-3.59 (0.01)*	-2.45 (0.05)*	-2.17 (0.43)	-1.64 (0.00)*	0.33 (0.01)*	1.68 (0.16)
Panel PP Statistic	-6.77 (0.00)*	-6.59 (0.00)*	-6.73 (0.00)*	-3.90 (0.00)*	-3.24 (0.00)*	-2.69 (0.00)*
Panel ADF Statistic	-1.35 (0.03)*	-6.82 (0.00)*	-1.03 (0.10)	-2.37 (0.17)	-4.72 (0.00)*	-0.45 (0.30)
Alternative Hypothesis: Individual AR Coefficients (between dimension)						
Group rho Statistic	-1.09 (0.14)	0.21 (0.58)	1.76 (0.96)	-3.08 (0.00)*	-1.59 (0.05)*	-0.30 (0.38)
Group PP Statistic	-4.86 (0.00)*	-4.64 (0.00)*	-6.93 (0.00)*	-8.14 (0.00)*	-8.40 (0.00)*	-9.22 (0.00)*
Group ADF Statistic	-0.63 (0.26)	-3.98 (0.00)*	-0.49 (0.31)	-1.04 (0.15)	-8.02 (0.00)*	0.03 (0.51)
* Significant at 10%						

Table 6 shows that the both Kao and Padroni panel cointegration tests on the variables in equation 1, to test the linear cointegration, for equation 2 to test the inverted U shaped and for equation 3 to test N shaped cointegration. While analyzing Kao panel cointegration test, it can be seen that only inverted U shaped cointegration exist in both developed and developing economies. For the case of Pedroni test on developed country showed 4 indicators out 7 in linear, 5 indicators out 7 in inverted U shaped and 2 indicators out of 7 in N shaped showed the presence of cointegration. Similarly, for developing 4 indicators out of 7 in linear, 6 indicators out of 7 in inverted U shape and 2 indicators out of 7 in N shaped showed cointegration. The majority of indicators suggested that there is a stronger cointegration for the case of inverted U shape hypothesis for both economies. Hence, it can be concluded that there is significant evidence of inverted U shaped EKC cointegration.

Following is the ARDL equation of inverted U shape version (eq. 2) since they have the highest degree of cointegration.

$$\Delta CO_{2\,it} = \alpha_i + \alpha_{1i}\Delta Ener_{it} + \alpha_{2i}\Delta GI_{it} + \alpha_{3i}\Delta GDP_{it} + \alpha_{4i}\Delta GDP_{it}^2 + \gamma_i(CO_{2\,t-1} + \beta_1 Ener_{t-1} + \beta_2 GI_{t-1} + \beta_3 GDP_{t-1} + \beta_4 GDP_{t-1}^2) + \mu_t \quad (4)$$

Using the error correction based PMG model (in equation 4), table 7 provides the cross-sectional homogeneous estimates of the long run portion. The results show that 1% increase in the energy usage intensity in the country leads to higher CO_2 emission in developed economies by 1.03% as compared to the developing economies by 0.92%. The difference between developed and developing economies is quite significant as even at 99% confidence interval both slopes do not coincide with each other. This higher elasticity of CO_2 emission to energy intensity in developed economies is due

to the fact that they are already using higher levels of energy utilization in their capital intensive industrial processes.

While comparing the coefficient of globalization, 1% increase in the globalization in the country will lead to 0.17% increase in the CO_2 emission in developed economies and 0.13% increase in CO_2 emission in developing economies. The results are similar to the panel data studies of (Kahuthu, 2006; Leitao, & Shahbaz, 2013; Leitao, 2013) but opposing the study for Turkey by (Destek & Ozsoy, 2015; Shahbaz et al., 2013). Since both of these coefficients coincide even at 90% confidence intervals, hence it can be said that the effect of globalization is homogeneous across both economy groups. This means that globalization induces energy demand equally in both types of economies through the expansion of trade.

While comparing the coefficients of GDP and GDP^2, in both cases the coefficient of GDP is positive and the coefficient of GDP^2 is negative, indicating that the effect of GDP on CO_2 emission is increasing at a decreasing rate (inverted U shape). This statistically significant pattern of GDP confirms the presence of Environmental Kuznets Curve (EKC). The results are surprising, here we can see that initially increase in GDP has higher effect on CO_2 emission in developing as compared to developed economies because of the fact that developed economies have already involved in higher tech production and higher R&D investments in effort to ensure environmental sustainability, opposite to that, the decreasing rate of effect of GDP (indicated by GDP^2) is higher in developing economies as compared to developed economies, is because of the advantage of backwardness (Todaro and Smith, 2003). The developing economies are enjoying already developed production methods and standards which are environment friendly.

The long run results also confirm the empirical results by (Acaravci & Ozturk, 2010; Ang, 2008; Shahbaz et al., 2013; Tao et al., 2008) with this study having a larger country group and a comparison between developed and developing economies.

Table 7: Long-Run Coefficients of ARDL (1, 1, 1, 1, 1) Model Dependent Variable (CO_2)

	Developed Economies	**Developing Economies**
Variables	**Coefficient (Prob.)**	**Coefficient (Prob.)**
ENER	1.03 (0.00)*	0.92 (0.00)*
GI	0.17 (0.00)*	0.13 (0.00)*
GDP	0.14 (0.05)*	1.22 (0.00)*
GDP^2	-0.01 (0.00)*	-0.09 (0.00)*
Sample	1232	1251
*significant at 10%		

Table 8 shows the average of country specific short run coefficients of the model. The smaller value of intercept shows that, assuming other factors remain constant, developing economies have 0.78% lower CO_2 emissions on average as their economies are smaller in terms of production size and sophistication as compared to developed economies.

In the short run, a 1% increase in energy intensity has 0.32% higher impact on CO_2 emission in developing economies as compared to developed economies. Compared to long run, the impact of globalization is insignificant in the short run for both economies.

In the case of short run, the Environmental Kuznets curve only exists in developed economies as compared to developing economies, this is because developed economies already have a strict rule in place to ensure their industrial processes to comply with environmental protection standards.

Table 8: Error Correction Representation of the Selected ARDL (1, 1, 1, 1, 1) Model Dependent Variable (CO_2)

	Developed Economies	**Developing Economies**
Regressor	**Coefficient (Prob)**	**Coefficient (Prob)**
Constant	-1.74 (0.00)*	-2.52 (0.00)*
D(ENER)	0.66 (0.00)*	0.98 (0.00)*
D(GDP)	0.47 (0.03)*	0.22 (0.24)
D(GDP^2)	-0.02 (0.06)*	-0.01 (0.37)
D(GI)	-0.14 (0.47)	0.03 (0.74)
ECM(–1)	-0.24 (0.00)*	-0.23 (0.00)*
*Significant at 10%		

The ECM(-1) value shows the coefficient of adjustment to the equilibrium. In both cases of developed and developing economies, any policy intervention or random shock to equilibrium will have a significant adjustment. This shows that in both cases the Environmental Kuznets Curve theory is a sustainable, but it is slow such that any policy intervention like 1% decrease in dependency on energy or increase in environment friendly growth will show its results in a decrease of CO_2 emission within 4 years.

Below table 9 shows the post regression diagnostics for the U shaped environmental Kuznets curve for developing and developed economies. These diagnostics include the Pesaran cross-sectional dependence (Pesaran, 2004), autocorrelation Q statistic, ANOVA F test for cross-sectional heteroskedasticity and time series heteroskedasticity. Probability values of these tests indicate that there is no hint of issues related to the regression estimates.

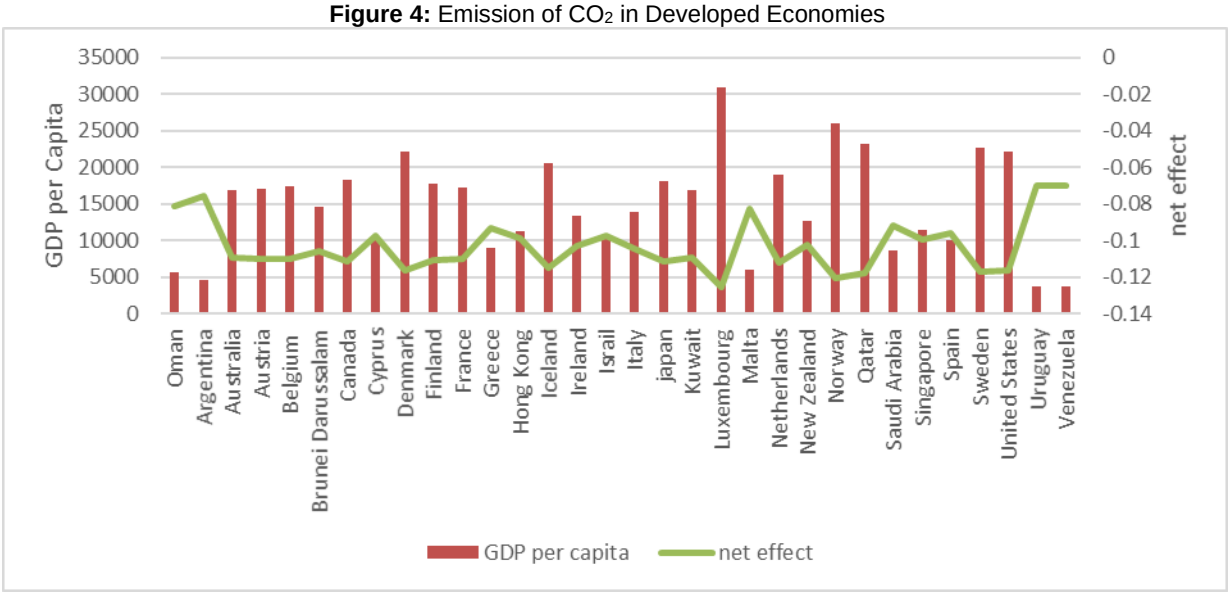
Table 9: Post Regression Diagnostics

	Developed Economies	**Developing Economies**
	Statistic (P value)	**Statistic (P value)**
Pesaran LM Cross-sectional Dependence	1.29 (0.19)	1.63 (0.10)
Q Statistic Time series autocorrelation	0.12 (0.73)	0.13 (0.70)
ANOVA F Test Cross sectional Heteroskedasticity	0.00 (1.00)	0.00 (1.00)
ANOVA F Test Time series Heteroskedasticity	1.27 (0.12)	1.29 (0.11)

4.1. Emission of CO_2, GDP and EKC

The estimation results confirmed the presence of inverted U shaped Kuznets curve. Since it is inverted U shaped, there is a need to investigate which side (increasing or decreasing) of the inverted U shape each country is. Below plots the average real GDP per capita (bars) and the net effect of it (line). Here it can be seen that the GDP per capita for the developed (in figure 4) is high enough to induce a negative effect on the CO_2 emissions. Hence developed economies have grown enough to reap benefits from the EKC.

Figure 4: Emission of CO_2 in Developed Economies

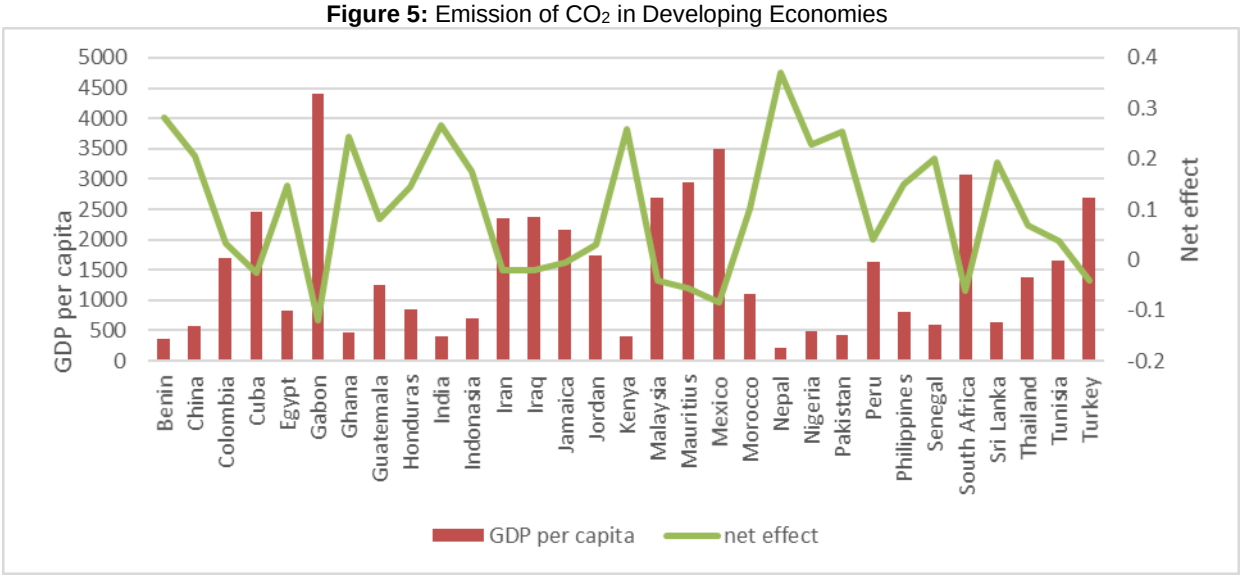


Source: Self generated using regression estimates

While analyzing the figure 5, it can be seen that though developing countries can reverse the production of CO_2 emissions faster than developed economies, which is a great prospect. But out of all selected developing economies, only a few economies have been able to breach the barrier of the real GDP capita where benefits of EKC starts. These economies include Cuba, Gabon, Iran, Iraq, Jamaica, Malaysia, Mauritius, Mexico, South Africa, and Turkey. Still, they are posing minimal negative effect on CO_2 emissions. Even the lowest of the developed economies (i.e. Argentina) is twice as effective in reversing the CO_2 emissions.

Hence, within the selected sample of developing economies, only 1/3rd are able to achieve the level of GDP per capita, which is required to sustain the green economy in the long run, whereas in short run developing economies are not potent to reduce pollution. So it is advisable for developing economies to target the real $2084 per capita of threshold income found by this study which initiates the CO_2 emission reversal.

Figure 5: Emission of CO_2 in Developing Economies



Source: Self generated using regression estimates

5. Conclusion and Discussions

Excessive emission of CO_2 offers a threat to our environment; if these emissions are not curtailed, then it will depreciate the environmental quality for the coming generations. In this case it will be more difficult for them to reverse the effects of environmental damage.

This study was intended to inquire the presence of Environmental Kuznets Curve which state that with the increase in the growth of the country, it tends to use sophisticated and environment friendly production mechanisms. Hence GDP which increased CO_2 emissions initially, it is slowing down the rate of CO_2 emissions, and eventually, it will reverse the environment degradation process.

This study used a representative set of 32 developed economies and 32 developing economies to test the presence of the Environmental Kuznets Curve and later on compare the difference between both types of economies. This study used 45 years of empirical data, i.e. 1970 to 2015 for all the countries. According to Canning and Pedroni (2008) if panel data with more than 20 years per cross section, it induces time series properties in the data, which requires the need to test the presence of non-stationary nature of variables. The cointegration test using [Kao (1999) and Pedroni (1999)] identified appropriate model out of the linear model, inverted U shaped and N shaped model. Based on the number of significant indicators out of 8 (1 of Kao and 7 of Pedroni). The results showed that U shaped model is superior to other specifications. The estimation of the coefficient of inverted U shaped hypothesis was done using Pesaran et al. (1997) Pooled Mean Group Model, which is similar to its time series version ARDL cointegrating bounds approach. This test is used in the case when there is mixed order of integration among the variables which is confirmed using LLC and IPS panel unit root test. This study also checked PMG estimates of the linear and N shaped hypothesis, but the estimates came out to be insignificant.

The results of the U-shaped model revealed that in long run Environmental Kuznets Curve exist in both developed and developing economies, with an interesting result that the increase in GDP leads to higher increases in CO_2 emissions in developing economies as compared to developed economies but the decreasing rate of CO_2 emission is higher in developing economies as compared to developed economies. Hence, both economies can have green growth by pursuing higher GDP and energy efficient methodologies which lead to inverted U shape EKC. Reason behind is expected to be the fact that developing economies have initially lower level of GDP, which is combined with weak environmental protection policies, but these developing economies enjoy the advantage of backwardness as they can adopt already invented production procedures from the developed economies which lead them to decrease the rate of CO_2 emission to a greater extent (catch-up effect). By using the actual data of real GDP per capita, it was evident that the majority of the developing economies do not have high enough income which can trigger the benefits from inverted U shape EKC. These economies are not able to reap fruits of the eco-friendly technology, for this they need to generate higher incomes such that businesses start to invest in new expensive production methodologies.

This study indicates the fact that developing countries can be more environmentally friendly as compared to developed economy, they only have to focus on eco-friendly growth. Since the environmental degradation is not a single country issue as depicted by the cross-sectional correlation of CO_2 emission variable, countries need to put their heads together to improve the procedures which are causing pollutions. The combined effort will be necessary to counter the spillover effect of CO_2 emissions in one economy to its neighboring economies.

Even though this theory provides green future prospects, but still, it will take time to reverse the harm which has already been done to the environment. Countries should impose strict laws for domestic and multinational organizations to control pollutant emissions. Further, we should reduce our dependency on the energy especially the non-renewable / fossil fuel energy which leads to pollution. The demand for energy consumption has increased significantly in economic and technological growth (Arain et al., 2019).Therefore, Meo at el. (2020) results clearly endorse the

strategy of rising renewable energy use. We should think about the posterity, and help inherit a better environment for our offspring.

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Appendix

Appendix Table 1 – List of sample countries

Developed economies		Developing economies	
Argentina	Japan	Benin	Kenya
Australia	Kuwait	China	Malaysia
Belgium	Luxembourg	Colombia	Mauritius
Brunei Darussalam	Malta	Cote d'Ivore	Mexico
Canada	Netherlands	Cuba	Morocco
Cyprus	New Zealand	Egypt	Nepal
Denmark	Norway	Gabon	Nigeria
Finland	Oman	Ghana	Pakistan
France	Qatar	Guatemala	Peru
Germany	Saudi Arabia	Honduras	Philippines
Greece	Singapore	India	Senegal
Hong Kong	Spain	Indonesia	South Africa
Iceland	Sweden	Iran	Sri Lanka
Ireland	United States	Iraq	Thailand
Israel	Uruguay	Jamaica	Tunisia
Italy	Venezuela	Jordan	Turkey