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Growth - Environment Nexus: Testing the Validity of the Environmental Kuznets Curve for the South Asian Economies

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In this study, the Environmental Kuznets curve (EKC) hypothesis validity has been tested for the five South Asian Countries (SACs). The EKC hypothesis assumes an inverted-U-shaped association between environmental pollutants and per capita income (PCI). The study uses CO_2 emissions, in addition to other measures, as proxy for environmental degradation and PCI, energy consumption, population density and afforestation as control variables. A positive significant coefficient for PCI and a negative PCI square validate the EKC hypothesis in the SACs. The estimated turning point for the South Asian Economies was found to be US$ 921.1 per capita. The study concludes that environmental policies should focus on sustainable planning and management of resources. Investment in human capital, encouraging foreign direct investment (FDI) and trade friendly policies can play an important role in keeping environment cleaner while promoting economic growth in these economies .

Keywords: EKC, economic growth, environmental pollutants, South Asia.

Continued economic growth and sustainable environment are at odd with each other. Kågesson (1997) and Meadows *et al.,* (1992) believe environmental quality is compromised when economic growth alone is perused. However, Boserup (1965), Radetzki (1990) and Beckerman (1992) believe that countries can achieve economic growth without any cost to environment.

There has been variations in climate and natural disasters are becoming more frequent and violent. Appetite for more energy use to foster developmental process is responsible for destruction (Jorgenson & Clark, 2012; UNESCO, 1992). The emission of radioactive waves, carbon dioxide, methane, nitrous oxide and other particulate matters are responsible for environmental degradation. The dumping of these gases into the atmosphere affects assimilative capacity of the universe (Kreuzwieser *et al.* 2002). Human overutilization tremendously increased the emission of CO_2 (Jorgenson & Clark, 2010; Agena, 2008).

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Persistent economic growth requires continued energy production. Low per-capita income (Arrow *et al*. 1995), energy consumption (Preur, 2009; York, 2007), population growth (Agena,2008 and Jorgenson & Clark, 2010), poverty (Agena, 2008) and illiteracy (Lee & Tilbury, 1998) affect environment. Although, environment has been the focus of many international conferences across the globe, but a huge population below the poverty line in many developing countries presents huge threat to the global environment.

Grossman and Krueger (1991) suggest that in the beginning there is direct relationship between environmental pollutants and economic growth which reverses after a certain point generally called threshold point or turning point (Figure 1). Furthermore, Panayotou (1993) argues that immature policy could be due the lack of property rights and externalities. Once these policies are remedied and market failure is resolved, the per capita GDP increases, reaches to the peak and then falls. In the last stage, people are aware of the benefits of clean environment and various aspect of the society, economy and regulations improve the environment (Bruyn & Heintz, 1999).

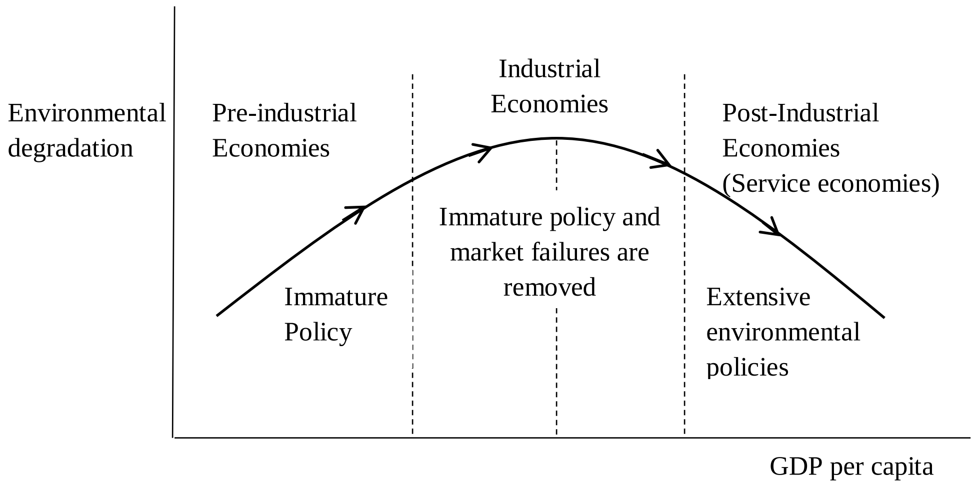

Figure 1: Phases of EKC

World Bank (1992) popularized the idea of EKC. Beckerman (1992) argued that initially economic growth causes environmental degradation to increase but eventually to increase the quality of environment, countries need to pass the threshold point and becoming rich. Stern (2004) presents the scale effect view of economic growth and environment nexus. Ikazaki & Naito (2008) explained that the inverted U shaped EKC is due to technological conversion.

Panayotou (1993) argues that with higher level of income, structural changes in an economy take place which result in transformation towards services sector, awareness and improvement in environmental standards and regulations. This study evaluates economic growth and environment association and estimates the turning point i.e. when environmental degradation turns into environmental improvement for South Asian Economies.

South Asia has been faced with ever increasing population leading to high poverty and environmental degradation. Increasing population demand more goods and services that exerts more pressure on natural resources. There are many factors besides poverty and rising human population that damage the natural environment such as diversified climatic zones, urbanization, water scarcity deforestation, highly polluted air, biodiversity loss, natural disasters, as well as extension of *Thar* Desert which is likely to destroy huge chunks of cultivable land in India and Pakistan (Hasnat *et al.* 2018). A considerable research has already been conducted on environmental Kuznets curve; such as Bairdi (2012), Beckerman (1992), Burns *et al.* (1992), Chen (2008), Christoph (1996) and Diamond (1997). There is still a gap in the body of literature, keeping in view the above mentioned environmental problems faced by South Asian region. Thus, this study attempts to analyze the economic growth-environment nexus and checks for the existence of the EKC hypothesis for the South Asian Economies.

Literature Review

Studying the relationship between economic growth and environmental degradation has been the focus of many researchers such as Besley and Burgess (2003) states that pollution is inversely related to the income level which changes with the passage of time. Dasgupta *et al*. (2002) report that unrestrained globalization may not result in the decline of pollution as countries require more resources. Robin *et al*., (1990) also showed a strong relationship between human activities and climatic changes. Rosa and Dietz (1998), Richerson and Boyd (2000), Duncan (1959) and Diamond (1997) also believed that human activities are responsible for drastic climatic changes. On the other hand Duxbury *et al.,* (1993) & Isermann (1994) explained that agriculture sector contribution to CO_2 emissions has been very high. Agriculture sector also contributes about 75 percent of the global nitrous oxide emissions. Most of the developing countries are highly dependent on agriculture sector and rely on natural environment for survival. Same is the case with South Asian economies where livelihoods of major portion of the population directly or indirectly depends on agricultural sector. Prather *et al*. (1995) found that flooded rice fields and animal waste significantly contributes to CO_2 and CH_4 emissions. Robin *et al*. (1990) argued that the global forests also contribute largely to CO_2 emissions. Many human activities affect the environment both positively and negatively (Grossman and Krueger, 1995).

According to OECD (1998), environmental improvement is positively associated with capitalism as in such system people invest in research and development. Samuelson and Nordhaus (1992) argue that in capitalist economies, entrepreneurs invest in research and development and thus increase their market share. Christoff (1996), Mol (2001), Spaargaren, Mol and Buttel (2000) and Mol and Spaargaren (2000) have argued that there is no inconsistency between the policies of modern institutions and environment. Schnaiberg and Gould (1994) and Roberts and Grime (2002) argue that economies of scale have highly exploited the environment. The theory of political economy argues that modern economic growth has no limits resulting in overexploitation of resources, more income, and reinvestment have negative impact on the environment. Wallerstein (1974) further argues that the world is divided into different zones. Wealthy nations rest in the core and are economically diversified. The poor nations rest in the periphery and are least economically diversified. Furthermore, the transition nations such as Brazil, India, Mexico rest in the semi-periphery which are in the midway between the core and periphery. Roberts and Grimes (2002), Kick *et al*. (1996), Burns *et al*. (1992), and Bunker (1984) believe that evidences of the EKC in the core is forged. Roberts and Grimes (1997) argued that EKC may be explained based on locations of countries in different trajectories and fossil fuel use, which ultimately explains local impacts.

There are huge variations in the threshold levels for various countries. Dasgupta *et al.*, (2002) reported that the threshold level of income per capita for most of the Northern countries range from \$5000 to \$8000. In the South Asia, most countries are still farther away from the threshold levels. Further, theoretical and empirical development occurred after Grossman and Kruger (1993), such as Selden and Song (1994), Stocky (1998), Bairdi (2012), Burns *et al*. (1992), Chen (2008), Christoph (1996) and Diamond (1997).

Debate between the scholars who believe in EKC hypothesis and those who do not is unending. Keeping in view the ongoing struggle for economic growth in today's world, it can be deduced that economic growth directly or indirectly results in affecting the environment. Economic growth decreases the assimilative capacity of nature. Environmental Kuznets hypothesis suggest that this relationship is a dual nature which at the beginning deteriorates the environment and improves it after reaching to a maximum threshold level.

Methods

This study considers data on five SACs including Pakistan, India, Sri Lanka, Nepal and Bangladesh, from 1990 to 2015. Economic growth measured as GDP per capita in US\$, carbon dioxide (CO_2) measuring environmental quality in kiloton (kt), methane emissions (ME) in kt of CO_2 equivalent, nitrous oxide (NO_2) emissions in thousand metric tons of CO_2 equivalent, total greenhouse gas emissions (TGGE) in kt of CO_2 equivalent, other greenhouse gas emissions (OGGE), HFC, PFC and SF6 in thousand metric tons of CO_2 equivalent, energy consumption in per capita kg of oil equivalent, afforestation as % land area under forest, and population density per square km are used for data analysis.

The EKC hypothesis assumes that

$$ED_{it} = f(PCGDP_{it}) \quad (1)$$

where ED_{it} is the CO_2 emissions per capita for country *i* in year *t* and $PCGDP_{it}$ is per capita income (US\$) of country *i* in year *t*. Following Ali *et al.,* (2014) and Stern (2004), this study uses the following nonlinear empirical equation:

$$ED_{it} = \lambda_0 + \lambda_1 PCGDP_{it} + \lambda_2 (PCGDP_{it})^2 + \lambda_3 PD_{it} + \lambda_3 EC_{it} + \lambda_4 AF_{it} + \mu_{it} \quad (2)$$

where PD_{it} represents population density, EC_{it} represents energy use, and AF_{it} stands for afforestation and μ_{it} is the normally distributed residual term which has all the standard properties of ordinary least squares (OLS) method. Ali *et al.*, (2014) and Stern (2004) calculated the turning point of inverse U-Shape EKC as follows.

$$PCGDP_{it} = \exp\left(\frac{-\lambda_1}{\lambda_2}\right) \quad (3)$$

All the data on the above given variables are acquired from the World Development Indicators (WDI).

Estimation Methods

Various panel unit root tests show that variables in our model have a mixed order of integration (Table 1). The variables, ED_{it}, AF_{it} and PD_{it} are I(0) and $PCGDP_{it}$ and EC_{it} are I(1).

Table 1

Panel Unit Root Tests

Variables	Tests	Coefficients with Probabilities, I(0)	Coefficients with Probabilities, I(I)	Stationary at Level
ED_{it}	Levin, Lin and Chu Test	-1.89 (0.02)	-	I(0)
	Im, Pesaran and Shin W-stat	0.38 (0.64)	-3.80(0.00)	I(I)
	ADF - Fisher Chi-square	0.39 (0.65)	-3.80(0.00)	I(I)
	PP-Fisher Chi-square	1.12 (0.86)	-7.14 (0.00)	I(I)
$PCGDP_{it}$	Levin, Lin and Chu Test	6.91 (1.00)	-1.97 (0.02)	I(I)
	Im, Pesaran and Shin W-stat	2.09 (0.98)	-3.76 (0.00)	I(I)
	ADF - Fisher Chi-square	7.03 (1.000)	-1.43 (0.07)	I(I)
	PP-Fisher Chi-square	8.72 (1.000)	-3.12 (0.00)	I(I)
EC_{it}	Levin, Lin and Chu Test	-0.07 (0.47)	-3.05 (0.00)	I(I)
	Im, Pesaran and Shin W-stat	2.09 (0.98)	-3.76 (0.00)	I(I)
	ADF - Fisher Chi-square	2.15 (0.98)	-3.62 (0.00)	I(I)
	PP-Fisher Chi-square	2.99 (0.99)	-6.08 (0.00)	I(I)
AF_{it}	Levin, Lin and Chu Test	-3.01 (0.00)	-	I(0)
	Im, Pesaran and Shin W-stat	-0.57 (0.28)	-2.08 (0.01)	I(I)
	ADF - Fisher Chi-square	-0.60 (0.27)	-1.59 (0.05)	I(I)
	PP-Fisher Chi-square	-1.56 (0.06)	-	I(0)
PD_{it}	Levin, Lin and Chu Test	-3.00 (0.00)	-	I(0)
	Im, Pesaran and Shin W-stat	-3.80 (0.00)	-	I(0)
	ADF - Fisher Chi-square	-3.40 (0.00)	-	I(0)
	PP-Fisher Chi-square	-4.38 (0.00)	-	I(0)

Panel Autoregressive Distributed Lag Model (PARDL) developed by Pesaran and Shin (1998), Pesaran and Shin (1999) and Pesaran, *et al*. (2001) is suitable when explanatory variables are endogenous and have mixed order. Shwartz Bayesian Criterion, Aikaike Information Criterion and Hannan-Quin Criterion (HQ) indicated the optimum lag order of two. Panel ARDL approach comprises of two steps (Pesaran and Pesaran, 1997). The first step comprises estimation of F-test to test for the long run relationship among variables. The second step consists of estimation of the short and long-run associations. The speed of adjustment to equilibrium in the long-run can be determined from error correction term (ECT) in the PARDL. The bound F-test is used for the joint significance of the coefficients. The two asymptotic critical values of bounds provide a test for cointegration when regressors are I (d) and $0 \leq d \leq 1$. The lower bound values shows that the independent variables are I(0), while the upper bound values shows I(1). When the F-statistics falls below the lower value, then H_0 of no cointegration cannot be rejected. The test statistic is inconclusiveness when its value falls between the two bound values.

The following modified version of Panel ARDL model is used to carry out the bound test procedure for cointegration.

$$ED_{it} = \nu_0 + \sum_{i=1}^{p} \beta_1 \Delta(ED_{i,t-i}) + \sum_{i=1}^{p} \beta_2 \Delta(PCGDP_{i,t-i}) + \sum_{i=1}^{p} \beta_3 \Delta(PCGDP_{i,t-i})^2 + \sum_{i=1}^{p} \beta_4 \Delta(EC_{i,t-i}) + \sum_{i=1}^{p} \beta_5 \Delta(PD_{i,t-i}) + \sum_{i=1}^{p} \beta_6 \Delta(AF_{i,t-i}) + \delta_1 ED_{it-1} \quad (4)$$
$$+\delta_2(PCGDP_{it-1}) + \delta_3(PCGDP_{it-1})^2 + \delta_4(EC_{it-1}) + \delta_5(PD_{it-1}) + \delta_6(AF_{it-1}) + \omega_{it}$$

Δ is the 1st difference, ν_0 is the drift component and μ_{it} is the white noise. Moreover, the terms with summation signs are the error correction dynamics. The short-run dynamic can be found through error correction (EC) model as follows:

$$\Delta(ED_{it}) = \nu_0 + \sum_{i=1}^{p} \chi_i \Delta(ED_{i,t-i}) + \sum_{i=1}^{p} \delta_i \Delta(PCGDP_{i,t-i}) + \sum_{i=1}^{p} \nu_i \Delta(PCGDP_{i,t-i})^2 + \sum_{i=1}^{p} \phi_i \Delta(EC_{i,t-i}) + \sum_{i=1}^{p} \theta_i \Delta(PD_{i,t-i}) + \sum_{i=1}^{p} \eta_i \Delta(AF_{i,t-i}) + \mu_{it} \quad (5)$$

In Table 2, F-statistics is statistically significant at lag length of 1 and 2 indicating a long-run relationships.

Table 2

Lag Length Selection

Lag	Akaike information criterion	Schwarz information criterion	Hannan-Quinn information criterion	F-Statistics
1	-12.92*	-12.22*	-12.64*	16.84*
2	-12.70	-11.41	-12.18	10.35*

* Indicate 1% significance level

Results and discussion

Table 3 provides the descriptive statistics for the entire time period (1990-2015). It indicates that the level of CO_2 emissions was 296,546.4 (kt), per capita GDP was US$ 697.12 and population density was 370.7 persons per square kilometer. About 19.4 percent is under forests while per capita energy consumption was 367 kg of fuel equivalent. The values of the Jarque-Bera shows that data are normally distributed except CO_2 emissions, per capita GDP and population density. However, Fischer (2011) argued that Central Limit Theorem (CLT) states that variables follows a normal (Gaussian) distribution when sample size tends to infinity (in practice n>30), therefore normality can be assumed. Table 3 also shows that per capita GDP, population density and forest area are negatively while forest area and energy consumption are positively related to CO_2 emissions.

Table 3

Descriptive statistics and correlation matrix

	CO_2	PCGDP	PD	AF	EC
Mean	296,546.4	697.1	370.6	19.4	367.5
Maximum	2,008,823.0	3279.9	1203.0	37.5	613.7
Minimum	634.0	178.5	126.7	2.1	114.2

Std.Dev	551498.1	560.7	339.8	11.2	124.8
Jarque Bera	108.2	311.5	45.3	9.4	6.7
Correlation					
CO_2	1	-0.15	-0.04	0.22	-0.05
PCGDP	-0.15	1	0.34	0.09	0.12
PD	-0.04	0.34	1	0.03	0.22
AF	-0.22	0.09	0.03	1	-0.15
EC	-0.05	0.12	0.22	-0.15	1

Source: Author's calculation

Table 4 presents the estimates where besides CO_2, ME, NO_2, OGGE and TGGE are used as dependent variables. The results in table 4 validates EKC hypothesis in case of selected SACs, which is apparent from the statistically significantly positive coefficient of GDP and statistically significant negative coefficient of square term of GDP. When λ_1 is greater than 0 and λ_2 is less than 0 and significant, it indicates that the EKC curve is an inverted U shaped curve. The estimated threshold/turning point for SACs is found to be US$ 921.1 per capita. There is a reduction in environmental degradation once the GDP per capita goes beyond this point. Ali *et al.* (2014), Galeotti *et al.* (2006), Dijkgraaf & Vollebergh (2005), Focacci (2005), Cole and Neumayer (2004) and Stern (2004) found a similar association between GDP per capita and CO_2 emissions. We also found positive and statistically significant relationship between energy consumption (EC) and CO_2 emissions. Ali *et al.* (2014) and Dijkgraaf & Vollebergh (2005) found similar results. Afforestation (AF) was found to have negative and statistically significant relationship with CO_2 emissions. Nepstad *et al.* (2009) and Asner *et al.* (2009) found a similar relationship. Excessive deforestation has been occurring mainly due to increase in population and increasing demand for housing. Therefore, we found a positive and statistically significant association between the population density and CO_2 emissions. Ehrhardt-Martinez *et al.* (2002), Selden & Song (1994) and Suri & Chapman (1998) also found similar results. Carbon Dioxide emission is the only variable which confirmed the EKC hypothesis in our study. Kelly (2003) stated that *"one possible explanation is that some pollutants are quickly assimilated into nature, while others remain in the air, water, or ground in hazardous form for a greater period of time, making their effects longer-lasting"*. As South Asian countries are striving for economic development, thus producing more CO_2 emissions, hence providing support to the validity of EKC hypothesis. Aubourg *et al*., (2008) and Criado (2008) stated that "*each model herein includes only a few of the many variables that are likely involved in the development of empirical results predicted by EKC theory, which indicates that future research will likely investigate further those variables that are necessary for a thorough analysis*". Stern (2004) also considers the research conducted on the EKC as "*flimsy*" support for the EKC hypothesis.

Table 4

Long run estimates

Variable	CO_2	ME	NO_2	OGGE	TGGE
$PCGDP_{it}$	5.87***	-0.50	0.81***	-30.84	96.73
	(3.03)	(-0.09)	(2.42)	(-0.99)	(1.43)
$PCGDP_{it}^2$	-0.86***	0.01	-5.83	0.01*	-0.01
	(-2.46)	(0.32)	(-1.15)	(1.70)	(-0.45)

AF_{it-1}	-2.17***	597.14	-13.2	17906.46*	5667.49
	(21.9)	(0.26)	(-0.09)	(1.80)	(-0.21)
PD_{it-1}	2.62***	-124.29	-24.57***	2002.95**	-1151.32
	(13.0)	(-0.84)	(-2.64)	(2.32)	(-0.61)
EC_{it-1}	3.18***	81.37***	-0.01	288.45**	840.37***
	(9.22)	(2.88)	(0.01)	(3.56)	(2.47)
R-Square	0.99	0.99	0.99	0.81	0.99
F-Statistics	16.84***	6.34***	5.42***	1.59***	8.17
Chi-Square	48.62***	38.07***	32.56***	9.56***	9.56
Turning Point	921.11	----	----	----	----

***, **, * Indicate 1% , 5% and10% significance levels

Furthermore, generally time series data produce high R^2 which is not surprising. The value of high R^2 indicates a good fit. Also, our different models have different R^2 values which is logical as it depends on relevancy of variables and the number of variables included in each model.

Table 5 shows the ECM estimates for the short-run relationship among our variables. A negative and statistically significant value of Λ (-0.92) shows that 92% adjustment take place every year towards equilibrium.

Table 5

Short Run Results

Variables	**Coefficients**	**t-Statistics**
D(PCGDP)	1.12	8.38(0.00)
D(EC)	3.13	11.5(0.00)
D(PD)	2.74	16.8(0.00)
D(FA)	2.25	26.5(0.00)
Λ	-0.92	-7.82(0.00)
R-Square 0.93		
F-Statistics 170.9		

Conclusions and recommendations

We found EKC to hold for all the South Asian Countries (SACs) and that the threshold level was US$ 921.11. We found that the relationship between environmental pollutants and gross domestic product of a country is positive up to a specific level and when economic growth is maintained for a longer time period, this relationship then becomes negative. Energy consumption and population density showed a strong relationship with CO_2 emission. From this study we conclude that sustained economic growth and development can help in promoting the environment. Since our results verify the EKC hypothesis and the long-term economic growth will eventually decreases the environmental degradation i-e the CO_2 emissions in South Asian economies. We found that population density and energy consumption increase the carbon emissions and afforestation decreases it, therefore steps need to be taken to grow more forests, controlling the population density and a switch to greener and environment friendly use of energy resources. Production of goods and services should be regulated on the basis of damage it causes to the environment. State procurement policies, in this regard could be important in identifying and promoting those products which cause no or less harm to the environment. Sustainable environmental policies require sustainable management of the resources and well defined property rights.

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