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A Cointegrated Panel Approach With Economic Growth, Energy Consumption And Environmental Kuznets Curve In South Asia

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ABSTRACT

South Asia has achieved tremendous economic growth in last few decades. The condition of this region is still vulnerable for inclusive growth and sustainable. The purpose of the paper is investigating the Environmental Kuznets Curve (EKC) hypothesis with knowing the effect of renewable energy consumption (REC) and non-renewable energy consumption (NREC) on environmental degradation for South Asia. To conduct this study five South Asian countries is selected for collecting data over the period 1972-2014. Panel cointegration analysis, estimation of long run relationship and causality test among environmental sustainability and its determining factors have been performed. The results found that EKC hypothesis holds true for this region. There is a negative act for REC and NREC has positive act on environmental degradation. The bidirectional causality between pollution and economic growth (EG) indicates that South Asian region has to face challenges to obtain sustainable and inclusive growth.

Keywords: Environmental Kuznets Curve (EKC), REC, NREC, Panel Cointegration.

1. INTRODUCTION

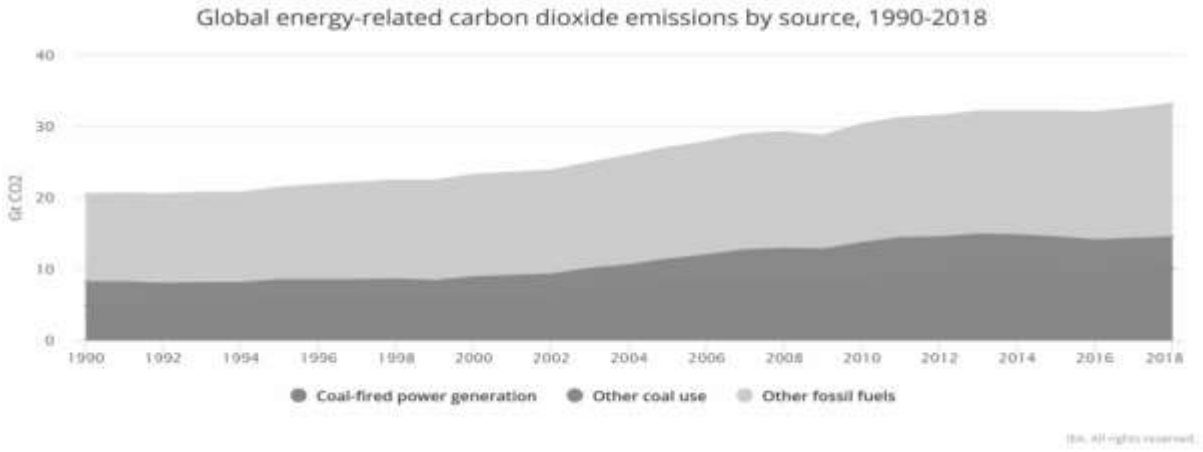
South Asian economy has experienced significant changes in last two decades and it is growing faster than the rest of the world. World Bank says, “South Asia region is the fastest region with growth rate 7% in 2019 and 7.1% in 2020 and 2021”. However attaining sustainable growth due to

increase in environmental degradation and energy consumption became a major concern for South Asia region. The New York Times (June 28, 2018) published that up to 800 million people's living standard will be diminished due to climate change (World Bank).

Temperature of South Asian countries is following an increasing trend. According to World Bank, temperature of Afghanistan, Bangladesh, India, Nepal, Pakistan and Sri Lanka increases 0.27^0 C, 0.09^0 C, 0.11^0 C, 0.14^0 C, 0.17^0 C and 0.17^0 C per decade respectively. industrial processes and fossil fuel produce 65% of the carbon emissions (IPCC, 2014). CO_2 Status and global Energy Report (April, 2019) revealed that, in 2018 global energy consumption rate of growth has become averagely doubled since 2010. For this reason high energy consumption, carbon emissions increased by 1.7% from last year and created a new record. India's primary energy consumption increased by 4% or over 35 Mtoe which is nearly 11% of global growth and it is also the third largest share (CO_2 Status and Global Energy report, 2019).

Environmental degradation can take a heavy toll in the region of South Asian. If the countries South Asian conform to use fossil fuel intensive path then this region will be facing a great loss equivalent to 1.8% of its GDP by 2050, which says that GDP will increase progressively to 8.8% through 2100 (Ahmed and Suphachalasai,2014). South Asian countries will have to face grate damages for the reason of climate change for example: low crop productivity, drought, flood, diseases and severe health problem etc. Limiting global warming to tighter target of 1.5°C compared to 2°C, a number of climate change impacts could be avoided, i.e., temperature change, number of hot days, heat related days, heat wave frequency, rainfall trend, wind pattern and sea level rise (IPCC Special Report on the Impacts of Global Warming, 2018)

On this context, the main target of this paper is investigating the EKC for the South Asian region.



Source: Global Energy and CO_2 Status Report (April, 2019)

2. RATIONALE OF THE STUDY

The impact of environmental degradation is more severe in developing countries like the South Asian countries because of lack of resources and technology. The geography, economy and population pattern make this region vulnerable to climate change (ADB, 2010). According to Asian Development Bank (2010), In the period of 1990 to 2008 minimum one disaster was attacked in South Asian region and the number of affected people is greater than 750 million in percentage it is more than 50. As its result, the number of death population 230,000 and the damages is $45 billion. Climate change will have negative impact on agriculture, deaths from different diseases will be increased in the future, future decades will be warmer and drier (Ahmed and Suphachalasai, 2010).

In the South Asian region greenhouse gas is one of the main elements of energy consumption. Energy consumption has a causal relationship with CO_2 emissions, which always shows that if energy consumption increases CO_2 emissions also increases in South Asia (Zeshan and Ahmed, 2013). South Asia's annual greenhouse gas emissions increased 3.3%since 1990 (ADB, 2010).

On this backdrop, in case of different countries and regions several studies have been done and found the existence of EKC hypothesis. But the studies did not incorporate the renewable and nonrenewable energy consumption in their models and examine the EKC hypothesis. In fact there is no study that investigated the existence of EKC hypothesis incorporating REC and NREC in the context of South Asia.

3. RESEARCH OBJECTIVES

- This study aims at investigating the existence of EKC for South Asia region. In according to the growth of economy, South Asia is one of the fastest growing regions among others, if this region can obtain economic growth with low environmental degradation then it will be really helpful for mitigating global warming.
- Another intention of this research is to find out the effect on environmental degradation of REC and fossil fuel energy consumption for South Asia.
- Lastly, using panel cointegration method this study wants to examine how environmental degradation and its determinants cause each other.

4. THEORETICAL BACKGROUND OF EKC HYPOTHESIS

There is always found a relationship with environmental degradation and economic according to EKC which is U-shaped. In 1954, Simon Kuznets recommend that income inequality increases firstly then some turning point also find out which declines the U-shaped relationship and get a bell shaped curve is found named Kuznets curve with the increasing of income per capita. Kuznets curve took an extended form which shows the same inverted U-shape relationship as per capita income and environmental degradation in 1990s (Grossman &Krueger, 1995). At the initial stage of development, pollutant generation is beyond control for the usage of resources to maintain economic growth. As economic growth sustains, technological advancement, information-intensive industries and government policies improves environmental quality (Dinda, 2004). Panayotou(1993) first introduced the term (Borghesi, 1999) EKC and showed this development-environment trade off graphically in ILO Working Paper.

Stern (2004) suggested a standard regression model for EKC as follows:

$$\ln(\mathrm{E/P})_{\mathrm{it}} = \alpha_{\mathrm{i}} + \gamma_{\mathrm{t}} + \beta_1 \ln(\mathrm{GDP/P})_{\mathrm{it}} + \beta_2 (\ln\left(\frac{\mathrm{GDP}}{\mathrm{P}}\right))^2_{\mathrm{it}} + \varepsilon_{\mathrm{it}}$$

Where, E represents emissions, P is known as population, and ln is mathematical logarithms. The RHS represents parameters of intercept which vary across i number of countries or regions in t years.

The relationship shows different shapes of curve:

- The EKC hypothesis requires that $\beta_1>0$ and $\beta_2<0$, which presents inverted U shape relationship between emission and GDP.
- When $\beta_1>0$ and $\beta_2=0$, is linear.
- When $\beta_1<0$ and $\beta_2=0$, then the relationship between emission and GDP is inverse.
- When $\beta_1<0$ and $\beta_2>0$, then the relationship between emission and GDP is U shaped.

Dasgupta, et al., (2002) illustrated four alternative viewpoints regarding the nature of this relation.

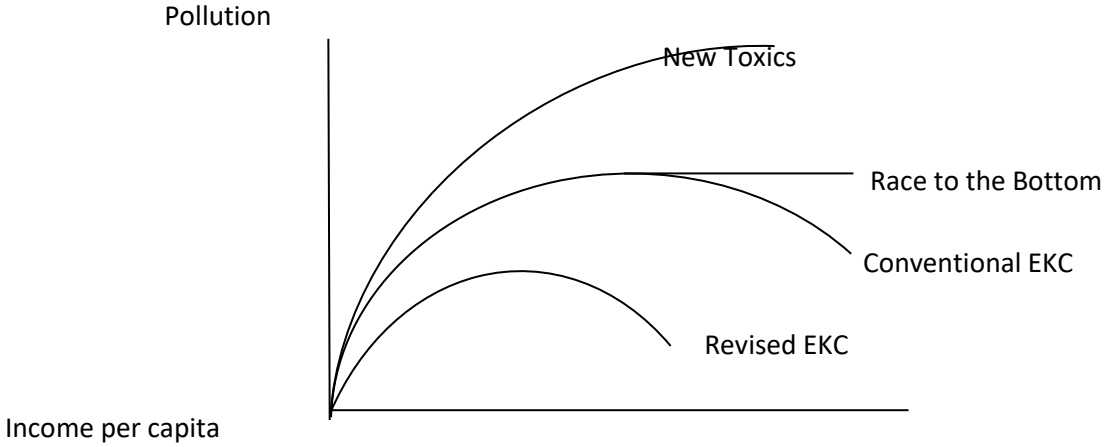


Figure 1: Alternative views of EKC(Dasgupta, et al., 2002)

"New Toxics" and "Race to the Bottom" are pessimistic scenarios which force an emerging economy to face a strong tradeoff because industrialization produces toxicants. "New Toxics" is observed for unconventional toxicants on which restriction is not imposed. The flat EKC in higher income portion suggests that pollution-intensive production cannot be applied in low income countries as well as high-income countries will find it harder to reduce pollution. The "revised EKC" suggests that, the conventional U shape EKC shifts downward in left direction over the time for technological progress.

5. LITERATURE REVIEW

In the case of European union,Boluk and Mert (2014) conducted a panel data analysis for period 1990-2008 to obverse the connection among fossil and REC, greenhouse gas (GHG) and economic growth. The results showed that

for EU countries do not maintain the EKC hypothesis. This research also declared that energy consumed in case of REC than fossil fuel based energy consumption GHG emissions is about 0.50 less per unit. Lu (2017) for 16 Asian countries found that there is a nonlinear, quadratic bonding between greenhouse gas emissions, economic growth and energy consumption.

In the United States over the period 1960-2004, Soytas, et al. (2007) invested the act of energy consumption and income on CO_2 emissions. The result of the research tells that EKC hypothesis does not exist. They also tested the Granger causality connection among income, energy consumption and CO_2 emissions. Their results showed that Granger cause CO_2 emissions in US does not maintained by income in the long run but energy consumption does.

In the context of China, Zhang and Cheng (2009) found an EKC relationship between income and GHGs per capita which shape is U. They also found that unidirectional Granger causality is running from GDP to energy consumption. At the same this causality is running emissions in the long run over the period 1960-2007 from energy consumption to CO_2.

Behra and Dash (2016) worked on a paper to find the urbanization effect, they also find the effect of CO_2 emissions in foreign direct investment (FDI) on for South and Southeast Asia (SSEA) region and energy consumption over the period 1980-2012. This study divided the total sample into low income, middle income and high income group to find the CO_2 emissions intensity and it is found that fossil fuel based energy consumption and FDI increase CO_2 emissions in SSEA region.

In South Asian research work of Zeshan and Ahmed (2013), it is seen that they worked on the period 1980 to 2010 with growth, environment and energy of nexus. They found that if energy consumption is increased 1% then the output also increased by 0.81% in the long run. On the other hand if CO_2 is increased 1% the output also decreased by 0.17%. They also found short run causality between energy consumption and CO_2 emissions.

From South Asian country perspective, Islam, et al. (2013), it is observed that in the period of 1971-2012 the EKC hypothesis is valid for Bangladesh and the major

contribution of energy consumption is CO_2 emissions. Ahmed, et al. (2019) found that the positive effect of energy consumption is CO_2 emissions at the same time economic growth and CO_2 emissions has been existed feedback effect for India. Uddin, et al. (2016) and Bestola andSapkota (2015) observed long run causal relationship between CO_2 emissions and energy consumption Sri Lanka and Nepal respectively.

Table 1: Previous Studies on Environmental Kuznets Curve (EKC)

Author	Pollutant	Country	Period	Method	EKC Result
Sinha & Bhatt (2017)	CO_2, NO_x	India	1960-2012	Cubic OLS	N Shape
Balin, et al. (2018)	CO_2	Turkey	1974-2013	ARDL	Inverted U
Lu (2017)	GHG	Asian Country	1990-2012	Panel Cointegration, FMOLS, Granger causality	Inverted U (whole sample and Asian new industrial economy); invalid (Southeast Asia)
Wang, et al. (2017)	CO_2, N_2O, CH_4	USA	1960-2010	Cointegration test	U shape (CH_4) Wave (CO_2, N_2O)
Islam, et al. (2013)	CO_2	Bangladesh	1971-2010	ARDL	Inverted U
Sulaiman, et al. (2013)	CO_2	Malaysia	1980-2009	ARDL	Inverted U
Benavides, et al. (2017)	CH_4	Austria	1970-2012	ARDL	Inverted U
Sarkodie&Strezov (2019)	GHG (Carbon & non-carbon)	top 5 emitters among developing countries	1982-2016	Panel, Quantile regression	Valid N shape for all country
Yurttaguler&Kutlu (2017)	CO_2	Turkey	1960-2011	Johansen Cointegration	N Shape
Choi, et al. (2010)	CO_2	China, Japan, Korea	1971-2006	Johansen Cointegration, VAR/VECM	N (China); inverted N (Japan); U shape (Korea)
Aruga(2019)	Energy Consumption	Asia pacific	1984-2014	Pooled OLS (FE/RE), FMOLS, DOLS	Valid E-EKC (for high income group)

Armeanu, et al. (2018)	SO_2, NO_2, NH_3, non-methane volatile organic	EU-28 countries	1990-2014	Fixed Effect, Panel VECM	Valid EKC
Naminse&Jincai(2018)	CO_2	China	1952-2012	Static & Dynamic analyses, Granger Causality	Inverted U
Dogan&Turkekul(2015)	CO_2	USA	1960-2010	ARDL, VECM	U shape

6. DATA AND METHODOLOGY

To conduct the study secondary data for 5 South Asian countries is collected from the World Development Indicators (WDI) prepared by World Bank. For the relevant variables, observation from 1972-2014 can be found for South Asian countries. Data for Afghanistan, Bhutan and Maldives is not significantly available.

The regression model is as following

$$\ln \mathrm{CO2}_{\mathrm{i,t}} = \alpha_{\mathrm{i}} + \gamma_1 \ln \mathrm{GDP}_{\mathrm{i,t}} + \gamma_2 \ln \mathrm{GDP}_{\mathrm{i,t}}^2 + \gamma_3 \ln \mathrm{RE}_{\mathrm{i,t}} + \gamma_4 \ln \mathrm{FF}_{\mathrm{i,t}} + \gamma_5 \ln \mathrm{Trade}_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}}$$

Here all the variables are transformed in logarithmic form. The country is presented by subscript $\mathrm{i} = 1,2, \ldots, \mathrm{N}$ and time period is presented by $\mathrm{t} = 1,2, \ldots . \mathrm{T}$. $\varepsilon_{\mathrm{i,t}}$is represented the residual term which is considered to be independently, identically and normally distributed.

$\ln \mathrm{CO}_2$= Natural $\log$ of CO_2 emissions per capita

$\ln \mathrm{GDP}$ = Natural $\log$ of GDP (current US$) per capita

$\ln \mathrm{GDP}^2$= Square of Natural $\log$ of GDP (current US$) per capita

$\ln \mathrm{RE}$ = Natural $\log$ of share of renewable energy to the final energy consumption

$\ln \mathrm{FF}$ = Natural $\log$ of share of fossil fuel energy to the final energy consumption

$\ln \mathrm{Trade}$ = Natural $\log$ of trade (% of GDP)

EKC hypothesis will be satisfied if $\gamma_1 > 0$ and $\gamma_2 < 0$. The aim of this study is to observe the effect of REC and NREC on environmental degradation. The essential focus of the research is to find out the existence of EKC hypothesis for the South Asia region. We expect $\ln\mathrm{GDP}$ has an important positive effect and $\ln\mathrm{GDP}^2$ has significant negative effect on CO_2 emissions. Which implies environmental degradation increases at a decreasing rate. We expect the relationship between REC and environmental degradation is negative because when share of REC increases to the final energy consumption, CO_2 emissions will reduce automatically. On the other hand we expect the relationship between NREC and environmental degradation is positive because fossil fuel energy consumption isone of the main sources of CO_2 emissions.

7. RESULTS AND DISCUSSION

7.1. Results of Panel Unit Root Test

To check the unit root of the problem Breitung t-stat; Levin, Lin and Chu t test; Im, ADF-Fisher Chi-square and PP-Fisher Chi-square; Pesaran and Shin W-stat test have been performed. The results of the tests are shown in Table-2, when level form are maintained by all the variables and in table 3 when all the variables are in their first difference form. Table 2 shows that all the variables are non-stationary in their level form and Table-3 shows that in their first difference form all the variables are stationary. Thus we can say that the variables are used in this work all are known as I (1) variables. All of the tests assume that the null hypothesis is existence of unit root which implies non-stationary against stationary.

Table-2: Panel Unit Root Test Level Form (With Intercept and Trend)

Variables	Levin,Lin& Chu t stat	Breitung t-stat	Im,Pesaran& Shin W-stat	ADF-Fisher Chi-square	PP-Fisher Chi-square
ln_CO_2	1.076(0.859)	0.853(0.803)	1.339(0.909)	5.33(0.867)	7.677(0.660)
ln_GDP	0.044(0.517)	0.658(0.744)	1.395(0.918)	4.037(0.945)	5.919(0.822)
ln_GDP^2	0.044(0.517)	0.658(0.744)	1.395(0.918)	4.037(0.945)	5.919(0.822)
ln_Trade	-1.144(0.126)	-0.974(0.164)	-0.386(0.349)	12.035(0.282	10.964(0.360

ln_Renewabel	0.525(0.700)	0.448(0.673)	0.968(0.833)	4.959(0.893)	6.131(0.804)
ln_FossilFuel	-1.20(0.114)	0.794(0.786)	-0.300(0.381)	9.477(0.487)	6.354(0.784)

Note: a indicates 1% level of significance

Table-3: Panel Unit Root Test First Difference Form (With Intercept and Trend)

Variables	Levin,Lin& Chu t stat	Breitung t-stat	Im,Pesaran& Shin W-stat	ADF-Fisher Chi-square	PP-Fisher Chi-square
ln_CO_2	-10.138[a] (0.000)	-13.049[a] (0.000)	-12.966[a] (0.000)	25.966[a] (0.000)	65.677[a] (0.000)
ln_GDP	-3.124[a] (0.000)	-3.185[a] (0.000)	-4.233[a] (0.000)	20.802[a] (0.000)	43.687[a] (0.000)
ln_GDP^2	-3.120[a] (0.000)	-3.174[a] (0.000)	-3.233[a] (0.000)	20.702[a] (0.000)	43.667[a] (0.000)
ln_Trade	-3.481[a] (0.000)	-2.953[a] (0.000)	-3.134[a] (0.000)	27.508[a] (0.000)	62.428[a] (0.000)
ln_Renewabel	-2.505[a] (0.000)	-2.907[a] (0.000)	-2.124[a] (0.000)	20.530[a] (0.000)	62.395[a] (0.000)
ln_Fossil Fuel	-2.906[a] (0.000)	-2.190[a] (0.000)	-3.017[a] (0.000)	26.989[a] (0.000)	61.190[a] (0.000)

Note: a indicates 1% level of significance

7.2. Results of Panel Cointegration Test

As it is needed to check whether they are cointegrated or not, the variables used in this work all are non-stationary and needed to transfer in stationary at first difference I(1) in nature. It can be said that the variables have a relationship among them named longrun if the used variables in the problem are cointegrated. A cointegration test named Johansen Fisher is used to find which kind of cointegration has among the variables and the result of the test is shown in Table-4. The values of the table has showed that both max-eigen value statistic and trace statistic have confirmed that the number of cointegrating vector among the used varibles is two. Therefore, based on the results of Johansen Fisher cointegration test we can easily say that all

the variables are cointegrated and they have long run relationship.

Table-4: Results of Johansen Fisher Cointegration Test

Hypothesized No. of CE (s)	Fisher Stat (from trace test)	Prob.	Fisher Stat (from max-eigen test)	Prob.
None***	115.8	0.000	51.87	0.000
At most 1***	72.62	0.000	35.18	0.000
At most 2***	45.20	0.000	27.67	0.000
At most 3	21.26	0.201	15.66	0.109
At most 4	15.73	0.107	16.70	0.108

*** indicates number of cointegrating vector (s

7.3. Results of Long Run Elasticity Analysis: FMOLS

Estimation of the cointegrating vector is performed using FMOLS. It provides three types of estimators which are pooled, weighted and grouped mean. Pooled and weighted provide panel within dimension statistics and grouped estimation provides between panel statistics. Tables-5 has showed coefficients of the FMOLS model which is long run.

The results has been presented in Table-5, we can see that the coefficient of lnGDP is statistically significant and positive and the coefficient of $\ln GDP^2$ is statistically significant and negative which implies that EKC hypothesis holds true for South Asia region. This indicates a ray of hope for this region to move toward sustainable and inclusive growth. For pooled and weighted estimation these coefficients are statistically significant except for grouped mean estimation.

The impact of REC is negative on the other hand the impact of fossil fuel energy consumption is positive impact on environmental degradation in the long run.This findings will play vital role in case of South Asia as there is high concentration on fossil fuel energy consumption rather than REC. This indicates that fossil fuel energy consumption should be substituted with renewable energy consumption. Trade (% of GDP) is positively related with environmental degradation. This does not necessarily indicate that government should take restrictive trade policies rather it

indicates how the industries who are causing pollution are reallocated towards developing countries from the developed ones.

Table-5: FMOLS Estimation of Cointegrating Regression of CO_2 Emissions

Variables	Pooled Estimation	Weighted Estimation	Grouped Estimation
ln_GDP	0.359[a] (0.000)	0.268[a] (0.000)	0.918[a] (0.007)
ln_GDP^2	-0.14[a] (0.000)	-0.09[a] (0.000)	0.080 (0.570)
ln_Trade	-0.0233 (0.644)	0.322[a] (0.008)	0.135[a] (0.001)
ln_Renewabel	-0.522[a] (0.000)	-0.376[a] (0.000)	0.073 (0.916)
ln_Fossil Fuel	1.269[a] (0.000)	1.16[a] (0.000)	0.789[a] (0.000)

Note: a indicates 1% level of significance

7.4. Results of Causality Test

Determining the causal association between the variable, panel causality test has been performed by Dumitrescu and Hurlin (2012). Results of panel causality test are presented in Table-6. CO_2 emissions and economic growth has bidirectional causality between them which indicates that South Asia region has to face challenges to attain sustainable and inclusive growth. The results also found bidirectional causality between economic growth and trade (% of GDP). Unidirectional causality is run from fossil fuel energy consumption to CO_2 emissions, CO_2 emissions to trade (% of GDP) and renewable energy consumption to trade (% of GDP).

Table 6: Pairwise Dumitrescu and Hurlin Panel Causality Test

Null Hypothesis	F Statistics	Probability
GDP does homogeneously cause CO_2	3.515[a]	0.000
CO_2 does not cause homogeneouslyGDP	4.656[a]	0.000
Renewable does not cause homogeneously CO_2	0.267	0.765
CO_2 does not cause homogeneously Renewable	1.536	0.219
Fossil fuel does not cause homogeneously CO_2	3.501[a]	0.000
CO_2 does not homogeneouslycause Fossil fuel	0.519	0.596

Trade does not cause homogeneously CO_2	1.185	0.309
CO_2 does not cause homogeneously Trade	3.781[b]	0.025
Renewable does not cause homogeneously GDP	1.009	0.736
GDP does not cause homogeneously Renewable	1.936	0.149
Fossil fuel does not cause homogeneously GDP	0.394	0.675
GDP does not cause homogeneously Fossil fuel	0.004	0.995
Trade does not cause homogeneously GDP	3.776[a]	0.000
GDP does not cause homogeneously Trade	3.813[a]	0.000
Fossil fuel does not cause homogeneously Renewable	1.964	0.145
Renewable does not cause homogeneously Fossil fuel	1.222	0.298
Trade does not cause homogeneously Renewable	0.379	0.685
Renewable does not cause homogeneously Trade	2.490[b]	0.047
Fossil fuel does not cause homogeneously Trade	1.714	0.184
Trade does not cause homogeneously Fossil fuel	0.515	0.598

Note: a indicates 1% and b indicates 5% level of significance

CONCLUSION AND RECOMMENDATION

This study aimed at investigating the existence of EKC and finding the effec of REC and fossil fuel energy consumption on environmental degradation for the South Asia region using cointegration approach. Panel cointegration test confirms that the EKC hypothesis holds true for South Asia. That means the tradeoff between environmental degradation and economic growth holds true in the context of South Asia. The cointegration test also confirms the relationship among the variables is long run. In the long run, REC and CO_2 emission have negative relationship. An increase in REC decreases CO_2 emission in the long run. On the other hand fossil fuel based energy consumption has positive impact on environmental degradation. Increase in fossil fuel energy consumption increases CO_2 emission in the long run.

Effect of climate change on South Asian economy can be very vulnerable. For obtaining sustainable and inclusive growth, proper steps and efficient plans should be taken. According to this study REC has negative impact and fossil

fuel energy consumption has positive impact on environmental degradation. In order to mitigate CO2emissions fossil fuel based energy consumption should be substituted with renewable energy consumption. For this we need technological and knowledge based economic system. To reduce fossil fuel energy consumption we need to adopt new technologies. It is important to recognize the negative externalities that are arising from environmental degradation. To solve this problem government can impose tax on CO_2 emissions (Nordhaus, 2013).

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