AN EMPIRICAL STUDY OF THE RELATIONSHIPS BETWEEN CO_2 EMISSIONS, TRADE OPENNESS AND ECONOMIC GROWTH IN SOUTH ASIAN COUNTRIES

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Abstract

The economic conditions and policies change over time and the changes may have different impact to their economies. In the era of globalization, demand for energy is increasing rapidly and all countries depend highly on energy. It has become one of the main problems in the world. Thus, there is requirement to identifying the impact of this dependency of energy on an economy. Impact of energy consumption is derived from environmental Kuznets curve (EKC). Based on such background, the objective of this paper is to shed light on and examine the existence of the EKC in selected SAARC countries from 1960-2016.

This study performed multiple OLS regression analysis for the cubic and squared specifications to investigate the relationships between environmental degradation, economic growth, capital stock and trade liberalization.

Depending on the inherited features of each country, the estimated EKC show different temporal patterns. Nepal shows an N-shaped curve while all other countries have an opposite to the N-shaped curve. Similar differences are also observed in the relationship between CO_2 emissions and trade openness. In the case of Sri Lanka, Nepal and Pakistan, they reveal a U-shaped curve, while Indian and Bangladesh show an inverted U-shaped curve. At the early stage of development there is insignificant influence on CO_2 emissions from economic growth because of low industrialization in these countries. In the case of trade openness in Pakistan, Nepal and Sri Lanka, the coefficients of OPEN show negative relationship with CO_2. As stated by Grossman and Krueger, (1995); Halicioglu, (2009), there is a production of pollution intensive goods as they tend to have dirty industries with heavy share of pollutants.

A suitable environmental policy to reduce total CO_2 emissions without damaging economic growth is important for these countries since all these countries still belong to the developing nations. To improve energy efficiency, policy makers can formulate strategies to avoid unnecessary use of energy. On the other hand, using less energy intensive technologies, minimizing the loss of

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power during distribution and transmission processes, and employing different tariff mechanisms to control energy use are some important policies that are possible to increase energy efficiency for these counties.

Keywords: CO_2, Environmental Kuznets curve (EKC); Economic growth; Trade openness; Capital stock; SAARC countries.

1. Introduction

Global atmospheric attentions of carbon dioxide, methane, nitrous oxide, and greenhouse gases (GHGs) have increased considerably in recent years. Historical measurements indicate that the current global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide are exceptional compared to the past 800,000 years. Carbon dioxide concentrations have increased significantly since the beginning of the industrial era. However, increasing amounts of GHG emissions due to human activities, such as burning fossil fuels, absorb heat and cause global warming, giving rise to changes in the environmental conditions. Specially, during the last few decades, the total amount of ozone in the atmosphere decreased by about 3 percent. (US EPA, 2017).

Emissions from developing economies have been growing rapidly over the last few decades. In fact, China is the largest emitter, followed by (in order) the United States, EU-28, India, Russia, Indonesia, Brazil, Japan, Canada and Mexico. The monthly emissions per capita in rich countries are mostly higher than the yearly emissions per capita than in poor countries. The largest emitter, Qatar, has per capita emissions of 50 tons per year (WRI, 2017). In 2014 China, the United States, the European Union, India, the Russian Federation, and Japan were recorded as the top carbon dioxide (CO_2) emitters. These data include CO_2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Combination of these sources represents a large proportion of total global CO_2 emissions (Boden et al, 2017)

While GHG emissions in South Asia have historically been low, the high rate of urbanization is affecting energy consumption and fossil fuel use to grow rapidly (ADB,2017). Further, the report showsa that unless clean technologies were used, energy-related GHG emissions from Bangladesh, Bhutan, the Maldives, Nepal, and Sri Lanka will increase from about 58 million tons of CO_2 equivalent in 2005 to about 245 million in 2030. ADB (2013) report on urban development in Asia revealed that cities in South Asia are suffering from the rising problem of solid waste dumping. Total annual GHG emissions from solid waste for Bangladesh, Bhutan, India, Nepal, and Sri Lanka were about 106 million tons of carbon dioxide in 2005 and were projected to reach 606 million tons by end of 2030.

The level of CO_2 emissions from developing economies has been rapidly exceeding that of developed economies, which contributed almost 50% of the world's CO_2 emissions level in 2003 (Martínez-Zarzoso and Maruotti, 2011). It is therefore a common interest for all policymakers to implement those policy measures to mitigate global CO_2 emissions level. While GHG emissions in South Asia have historically been low, the high rate of urbanization is affecting energy consumption and fossil fuel use to grow rapidly.

The Intergovernmental Panel on Climate Change IPCC (2014) revealed that globally, economic and population growth has continued to be the most prominent variables of increases in CO_2 emissions level. Although, there are differences between developed and developing economies on emission levels and even distinctions between different countries within the same group, the policy measures on emission levels will usually not be identical and should be considered for individual countries (Stern et al., 1996; De Bruyn et al., 1998; Dijkgraaf and Vollebergh, 1998; Stern and Common, 2001; Dinda, 2004).

The relationship between economic growth and CO_2 emission has been described in terms of the Environment Kuznets Curve (EKC) hypothesis (Grossman and Krueger 1993, 1995). They have identified an inverted-U shaped relationship between the CO_2 emission and income level with three different networks (scale effect, composition effect, and technique effect). EKC recommends that economic development primarily leads to deterioration in the environment (scale effect) because of the greater use of natural resources. Therefore, economic growth shows a scale effect and has a negative impact on the environment. Further, they have explained that economic growth has a positive impact on the environment through composition effect and technique effect. After a certain level of economic growth, a society begins to improve its relationship with the environment and levels of environmental degradation reduce due to cleaner activities or less polluting activities (composition effect). As a nation becomes well-off, they can have enough money to spend more on Research & Development, thus, technological progress occurs with economic growth. So, the wealthy nation would be able to substitute new and cleaner technology instead of the dirty and obsolete technologies. Along with the increase in the capacity of higher income countries environmental quality improves through this technological substitution (technique effect) (Dinda 2004; Piaggio and Padilla 2012).However, researchers establish the long run relationship between economic growth and environment pollution by using EKC hypothesis, the empirical findings reveals immense inconsistencies with this hypothesis.

Large number of researches have examined the relationship between CO_2 emissions and key drivers for different countries. For example, Azlina and Mustapha (2012) examined the causal relationships between energy consumption, economic growth and pollutant emissions for Malaysia over the period 1970-2010. Onafowora and Owoye (2014) investigated the long-run and the dynamic temporal relationships between economic growth, energy consumption, population density, trade openness, and CO_2 emissions in Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa based on the EKC hypothesis. Esteve and Tamarit, (2012) examined both non-linear cointegration and asymmetric adjustment in Spain. Uddin et al (2016) examined the long-run causality relationship between energy consumption, carbon emissions, economic growth, and trade openness in Sri Lanka.

According to the previous studies, no time series study has been carried out in the case of South Asian countries in recent years. In this paper, we investigate the relationship between CO_2 emissions, Economic Growth and Trade Openness in South Asian Countries over the period of 1960–2016. This study attempts to fill up that gap with application of OLS, cointegration and causality test to verify the existence of EKC hypothesis in South Asian countries with more recent data. This enables to determine the interrelationships among different variables and strength of the variables. The rest of the study is structured as follows: Section 2 covers a literature review, Section 3 presents the models used and the data, Section 4 summarizes the empirical results, and Section 5draws the conclusions.

2. Literature Review

The concept of sustainable development has become a major concern of each and every economy in the world. Brundtland (1987) defined sustainable as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. It highlighted two major issues, the problem of the environmental degradation that so commonly accompanies economic growth and yet the need for such growth to alleviate poverty. In the real world, many countries give priority to its growth and the estimating of economic growth disregards the cost of depleting the environmental resources. Therefore, the relationship between economic growth and CO_2 emission has become a long-debated issue among the researchers over the past few decades. A large number of countries is facing a major challenge, namely, to ensure stable economic growth without depleting environmental resources.

WHO (2016) report showed that air pollution levels remain seriously high in many parts of the world. According to the data, 9 out of 10 people breathe air containing high levels of pollutants. Updated information reveals an alarming death toll of 7 million people every year caused by ambient (outdoor) and household air pollution. Further, it has been revealed that ambient air pollution alone caused some 4.2 million deaths in 2016, while household air pollution from cooking with polluting fuels and technologies caused an estimated 3.8 million deaths in the same period. Meanwhile, it was reported that more than 90% of air pollution-related deaths occur in low-and middle-income countries, mainly in Asia and Africa, followed by low-and middle-income countries of the Eastern Mediterranean region, Europe and the Americas.

Grossman and Krueger (1995) examined the relationship between per capita income and various environmental indicators, such as urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins by heavy metals. The results have indicated that there was no evidence to conclude that environmental quality deteriorates steadily with economic growth**.** The results of the study confirmed that inverted U-curve of EKC hypothesis. Perman and Stern (2003) examined the form of the relationship between sulfur emissions and income per capita over a panel of 74 countries. They revealed that results of the study supported inverted U shape of KEC hypothesis.

Galeotti et al (2006) examined various functional forms of carbon dioxide and GDP relationship for the group of OECD and non-OECD countries. They indicated that there was evidence of an inverted-U pattern for the group of OECD countries and this was not held for non-OECD countries.

Moomaw and Unruh (1997) compared EKC models to structural transition models of per capita CO_2 emissions and per capita GDP for the 16 countries which have undergone a transition. Most of the countries have shown an inverted U-shaped trend, and their turning point occurred in between 1970 - 1980. Furthermore, they used the cubic model specification to the 16 countries; they found that the N-shaped curves and all the estimated coefficients were statistically significant. Martínez-Zarzoso and Bengochea-Morancho (2004) have estimated EKC for a panel of 22 OECD countries over the period 1975–1998. The results have revealed the existence of an N-shaped EKC for the majority of the countries under analysis.

Ajimi et al (2015) examined the relationships between energy consumption, CO_2 emissions and gross domestic product (GDP) in the G7 countries. They found that significant time-varying causalities running from GDP to CO_2 emissions for Italy and Japan. Further, they have revealed that the findings of the study supported inverted N-shaped curves for Italy and Japan and there was no evidence to support the traditional EKC hypothesis for these countries.

Azlina and Mustapha (2012) investigated the causal relationships between energy consumption, economic growth and pollutant emissions for Malaysia over the period 1970-2010. The findings have shown that the existence of the long-run relationship between energy consumption, economic growth and emission. Furthermore, the results have revealed that there was a unidirectional causality running from economic growth to energy consumption, from pollutant emissions to energy consumption and from pollutant emissions to economic growth.

Friedl and Getzner (2003) explored the relationship between economic development and CO_2 emissions for a small open and industrialized country, Austria. They examined whether an EKC relationship exhibits for a single country rather than panel or cross-section data for a group of countries. A cubic (i.e. N-shaped) relationship between GDP and CO_2 emissions was revealed over the period of 1960- 1999 in Austria. Zakarya et al (2015) investigated the interactions between the total energy consumption, FDI, economic growth, and the emission of CO_2 in the BRICS countries, by applying the co-integration tests and panel Granger causality for panel data. The results have shown that there was a co-integration relationship between CO_2 emissions and economic variables. The results also specified the existence of a unidirectional causality from CO_2 to the economic variables. Mallickand Tandi (2015) tried to identify the existence of the EKC in selected SAARC countries from 1972 - 2010 on energy consumption, real per capita GDP, CO_2 emissions, and openness of trade. The study has revealed that there was no significant evidence of EKC in SAARC countries in long-run. Furthermore, they found that there was a positive relationship between higher level of economic growth and CO_2 emissions. There was a large amount of literature to explain the relationship between energy consumption and macroeconomic variables. The objective of this study was to employ more macroeconomic variables and recent data to identify the relationship between CO_2 and economic growth (EKC relationship) for South Asian countries.

3. The Model and Data

Data used in this paper was from annual time series covering the period 1960 - 2016 of five countries, namely Bangladesh, India, Sri Lanka, Nepal and Pakistan. Variables for the study were selected based on previous research findings and selected variables are real per capita GDP, per capita CO_2 emissions (Mt), Openness of Trade (Exports + Imports/GDP) and gross capital formation (CF) as a proxy of capital stock. The data were taken from World Bank Development Indicators (World Bank), World Economic Outlook (WEO) and Asian Development Bank. However, the country and variable selection were done on the basis of availability of data on CO_2 emissions, Real Per Capita GDP, openness of trade and gross capital formation.

The study estimated KEC based on CO_2 emissions per capita for Bangladesh, India, Sri Lanka, Nepal and Pakistan. The study expected that it provided important guidelines for the countries to establish environmental targets for CO_2 emissions. To validate the shape of the EKC, the following multiple regression equations were employed for each country:

$$InCO_{2t} = \alpha_0 + \alpha_1 InGDP_t + \alpha_2 (InGDP_t)^2 + \alpha_3 (InGDP)_t^3 + \alpha_4 OPEN_t + \alpha_5 OPEN_t^2 + \alpha_6 CF_t + \varepsilon_t$$

Equation (1)

$$InCO_{2t} = \alpha_0 + \alpha_1 InGDP_t + \alpha_2 (InGDP_t)^2 + \alpha_4 OPEN_t + \alpha_5 OPEN_t^2 + \alpha_6 CF_t + \varepsilon_t$$

Equation (*2*)

Where, CO_2 denotes CO_2 emissions per capita and is an endogenous variable which represents environmental quality. The main exogenous variables are ln GDP which is logarithm of GDP per capita, OPEN representing trade openness and CF represents capital stock of each country. To test the existence of EKC, the equation (1) and (2) which are derived from the relationships between pollution levels and independent variables; GDP, Openness and capital stock (with subscript *t* denoting a year).

In the early stages of economic growth degradation and pollution increase and after that, threshold level pollution levels are expected to decrease with higher growth levels. More specifically that as the economy grows, initially the environment suffers but gradually the relationship between the environment and the economy improves. This indicates that the environmental impact indicator (EKC) is an inverted U-shaped function of income per capita. Therefore, the combination of these two effects, $\alpha_1 > 0$ and $\alpha_2 < 0$ in equation (2), produces the inverted U-shaped relationship between per capita CO_2 emissions and per capita GDP. Under EKC hypothesis, the sign of $\alpha_1$was expected to be positive where as a negative sign was expected for α_2. Furthermore, we used equation (1) to estimate the N-shaped curve by using cubic functional form ($\alpha_3 > 0$) as estimated by Torras and Boyce (1998), List and Gallet (1999), Bradford et al. (2005). It was expected that the sign of α_3 in equation(1) depends on the phase of economic development of a country. The negative sign is an indication of developed country, because as a country develops it reduces the production of pollution intensive products and instead imports products from other countries with lower restrictive environmental protection laws. In addition, positive sign of α_3 in equation(1) shows that the economy is a developing and they tend to have more dirty industries than developed country with higher level of pollution (Grossman and Krueger, 1995; Jail and Mahmud, 2009; Halicioglu, 2009).

The summary of the different forms of economic growth environment relationships from the Equation (1) indicates as follows:

$\alpha_1 > 0, \alpha_2 < 0, \alpha_3 = 0$ *an inverted-U shaped relationship*
$\alpha_1 < 0, \alpha_2 > 0, \alpha_3 = 0$ *a U-shaped relationship*
$\alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0$ *an N-shaped relationship*
$\alpha_1 < 0, \alpha_2 > 0, \alpha_3 < 0$ *an opposite to the N-shaped relationship*
$\alpha_1 > 0, \alpha_2 > 0, \alpha_3 < 0$ *a cubic polynomial inverted-U shaped relationship*
$\alpha_1 < 0, \alpha_2 < 0, \alpha_3 > 0$ *a cubic polynomial U-shaped relationship*

In addition to CO_2 and economic growth, in an effort to extend the concept of EKC, the study examined the relationship between environment quality and trade openness. Hui Zuo et al. (2017) showed that with rapid economic growth, South China had to face the most serious water pollution problem. However, still it is not clear whether such kind of water pollution is mainly caused by foreign trade. Therefore, they examined the relationship between environment quality and foreign trade. The findings of the study indicated that less opening economy may be beneficial to environment and opening modes also impact the environmental performance in South China. As of their opinion the South China Suffered more from international trade than North China. Furthermore, they revealed that balanced trade growth was not a result of EKC change. They suggested that China needs to promote environmentally friendly export or pollution intensive import. Based on the above findings, a country tends to follow increasing pollution levels as trade openness proceeds ($\alpha_4 > 0$), and then it is expected to decline pollution levels at more advanced stage of free trade ($\alpha_5 < 0$).

4. Empirical Results

As illustrated above, estimating the relationship between growth and emission level is important and it differs according to circumstances such as individual countries' development stage, the degree of openness, amount of capital stock and policies of each country. The time series data span for each country is differ from one another from 1960-2016. In the case of Sri Lanka and India, data span is from 1960-2016, meanwhile sample period for Bangladesh is from 1972-2016. In the case of Nepal and Pakistan, data are from 1965-2016 and 1967-2016, respectively. In this study, the exogenous variables such as GDP, OPEN and CF were used. By employing OLS regression for individual countries, we expected to get an estimation of the effects on each country's environment. Individual country regressions permit for heterogeneous properties in response to differences in level of development of the sample countries. Thus, in order to investigate the relationships between environmental degradation, economic growth, trade liberalization and capital stock, simple OLS regression analysis was applied.

Table 1 shows unit root test results for five countries. It indicates that all variables are I (0) in their level form in the Philip Peron (PP) unit root test. Therefore, we cannot reject the null hypothesis of a unit root in the level of the series at various lag lengths. Therefore, again we tested for stationary by allowing first difference and found that there was significant evidence of stationary in first difference of all series. Henceforth, the study confirmed that all variables take first difference to be stationary and in level all are nonstationary. In other words, they followed integrated of order one, I (1), processes.

Table 1: **Result of Unit Root Tests**

Test Statistics	**Log CO_2**	**Log GDP**	**Log OPEN**	**Log CF**
		Sri Lanka		
Level	0.659132	0.934416	-1.462971	0.644016
First Difference	-7.691352**	-4.875474**	-6.557782**	-7.376096**
		India		
Level	0.987830	1.382539	-0.297807	-0.303182
First Difference	-7.961942**	-5.275502**	-5.944316**	-7.542694**
		Nepal		
Level	0.308903	0.305472	-0.959710	-0.745955
First Difference	-11.30290**	-7.042402**	-8.400967**	-7.107451**
		Pakistan		
Level	-0.320925	-0.660469	-2.253152	-0.626071
First Difference	-6.182709**	-5.438469**	-7.893890**	-5.548534**
		Bangladesh		
Level	-1.592841	-2.817932	-1.049474	-2.287190
First Difference	-18.27131**	-5.783352**	-8.991420**	-8.293496**

**, * Significant at 1 % and 5%, respectively
Source: Author's calculation

In additions to unit root property, we had to meet the assumptions of regression also to estimate coefficient by using OLS. Therefore, serial correlation test, Heteroskedasticity test and normality test were applied for our time series data. The estimated Breusch-Godfrey Serial Correlation LM test statistics for the all models are approximately greater than 5 percent significant level. Hence, Therefore, it could be assumed that the residuals are uncorrelated. Heteroskedasticity Test: Breusch-Pagan-Godfrey test results confirm that heteroscedasticity of residuals were not present. Furthermore, a test for the normality of residuals was conducted as well; the Jarque-Bera statistics for all countries did not reject the hypothesis of normal distribution. The p-values were greater than 5 percent level of significant so it indicates that there was no reason to reject the nullhypothesis and it allowed us to accept the normality of residuals distribution (see Table 2).

After testing all the properties of the variables, a simple OLS regression analysis for the cubic and squared specifications was performed to investigate the relationships between environmental degradation, economic growth, capital stock and trade liberalization. Table 2 reports the estimation results of the OLS based on the two model specifications. Difference of the two models was only by one parameter, so we were able to use the t-test to determine the level of generality of the model. Key concern was the estimated coefficients, their signs and level of significance. We were interested to present not only cubic Model 1, but also quadratic Model 2 to establish the relationship of EKC which is inverted-U or N-shaped nature of the Kuznets curve.

The results of the estimation of the OLS equation allow to state that the estimated coefficient of GDP (α_1) is negative and the GDP^2 (α_2) has a positive sign in the Sri Lanka, India, Nepal and Bangladesh in Model 2. This indicates that economic growth does not have the expected Kuznets effect on environmental effect in these countries. These signs do not expect EKC hypothesis and thereby an inverted U-shaped curve in these countries couldn't be found. In the case of Pakistan, GDP (α_1) had a positive coefficient and the GDP^2 (α_2) had a negative sign in Model 2. These coefficients are not statistically significant. Meanwhile $\alpha_{1,}$ α_2 and α_3 in Model 1 showed statistically significant relationship in all countries. The negative, positive and negative coefficient of GDP, GDP squared and GDP cubed respectively indicated an opposite to the N-shaped relationship between per capita carbon dioxide emissions and GDP in Sri Lanka, India, Pakistan and Bangladesh.

In the case of Nepal, the results showed that the positive, negative and positive coefficient of GDP, GDP squared and GDP cubed respectively and all coefficients were statistically significant. These together revealed an N-shaped curve explaining the relationship between pollution level and GDP. It is an indication of the initial deterioration of environmental conditions cause to enhancement of the economy and then economic growth causing an improvement of the environment, due to the environment-friendly development. Thereafter, again environmental pollution increased and GDP of the economy is also improving. These results show that we cannot expect better environmental conditions continuously with economic prosperity.

Table 2: **Results of the OLS Models**

	Sri Lanka		**India**		**Nepal**	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
C	127.4662**	36.28363**	38.06374	0.762847	-374.1795*	14.90878
LGDP	-11.90713*	-0.470998	-4.037514*	-0.180774	44.92411*	-1.449103
$LGDP^2$	0.452855*	0.011131	0.135455*	0.004496	-1.801576*	0.032060
$LGDP^3$	-0.005716*	-	-0.001478	-	0.024335*	-
LOPEN	-13.06700**	-15.24307**	0.012866	0.043088	-1.233136	-1.153816
$LOPEN^2$	1.590480**	1.866897**	-0.011679	-0.011034	0.291888	0.247447
LCF	0.065880	-0.108875	0.042010	0.021024	-0.314929*	3.09E-11
$LCO_2(-1)$	1.922486**	1.734455**	0.646396**	0.670220**	-0.255851*	0.274304*
Breusch-Godfrey Serial Correlation LM Test						
F – Value	0.123585	1.912753	0.009202	0.485002	1.882838	3.233204
P- Value	0.8840	0.1592	0.9908	0.6188	0.0701	0.0499
Heteroskedasticity Test: Breusch-Pagan-Godfrey						
Prob. Chi-Square	0.6822		0.8453		0.8330	
Normality Test						
Jarque-Bera	1.263994		3.376761		1.660308	
Probability	0.531529		0.184819		0.435982	
	Pakistan		Bangladesh			

Table 2 Continued

	Model 1	Model 2	Model 1	Model 2
C	117.2608*	-1.902935	103.3742*	4.547495
LGDP	-12.54802*	0.472303	-11.74391**	-0.909791**
$LGDP^2$	0.470202*	-0.007980	0.415818**	0.023578**
$LGDP^3$	-0.005826*	-	-0.004750*	-
LOPEN	-3.999128	-2.982784	0.307252	0.635055
$LOPEN^2$	0.580739	0.432735	-0.029332	-0.075722
LCF	6.67E-12	1.63E-12	0.055225	-0.026314
$LCO_2(-1)$	0.566527**	0.809515**	-	-
Breusch-Godfrey Serial Correlation LM Test				
F - Value	0.008866	0.709025	1.689514	0.649624
P- Value	0.9912	0.4984	0.1985	0.5283
Heteroskedasticity Test: Breusch-Pagan-Godfrey				
Prob. Chi-Square	0.7191		0.6779	
Normality Test				
Jarque-Bera	2.234940		2.781887	
Probability	0.127120		0.248840	

**, * Significant at 1 % and 5%, respectively
Source: Author's calculation

Table 2 shows that the OPEN and its square term in Model 1 and 2 are statistically significant in Sri Lanka. This is an evidence of the dependency on foreign trade and its impact on CO_2 emissions in Sri Lanka. These variables represent a U-curve type quadratic relationship with the CO_2 emissions in Sri Lanka. It reveals that there is a threshold level of openness, but in reversed form. Capital stock (CF) indicates negative significant impact on CO_2 in Nepal. CF shows insignificant impact for all the other countries. The value of CO_2 (−1) implies that per capita CO_2 emissions correction level for each country in each year.

After estimating the relationship between CO_2 emissions, GDP, trade openness and CF, this paper employs a vector auto regression (VAR) to examine the short-run relationship among the variables. The VAR has few advantages. The VAR structure is one that declares each variable is a linear function of past lags of itself and past lags of the other variables. We can use it without any theoretical structure on the estimators. Furthermore, the VAR can adopt dynamic analysis which is useful to overcome the static disadvantage of OLS. The VAR can estimate the dynamic structure of time series better than the OLS estimation. In this paper, AIC is selected to estimate the optimal lag for the models. To decide whether the variables were cointegrated, he Johansen cointegration test was applied. The result of the Johansen co-integration test is presented in Table 3.

On one hand, out of five, in four countries the null-hypothesis of zero and $r \leq 1$ is rejected at the 5% level of significance. On the other hand, the null-hypothesis of $r \leq 2$ is rejected at 1% level of significance in India. The null-hypothesis of zero is rejected at the 5% level of significance in Bangladesh. Based on these findings, it revealed that these variables have at least one cointegrating vector representing a long-run relationship for all countries. Since the data is stationary and the variables are cointegrated the VECM model is applied to estimate long-run relationships.

Table 3: **Results of Cointegration Test**

Hypothesized No. of CE(s)	**Eigen value**		**Trace Statistic**	**0.05 Critical Value**	**Max-Eigen Statistic**	**0.05 Critical Value**
Sri Lanka						
None **	r = 0	r =1	100.6774	47.85613	68.44633	27.58434
At most 1 *	r ≤ 1	r =2	32.23107	29.79707	23.05569	21.13162
At most 2	r ≤ 2	r =3	9.175378	15.49471	7.100514	27.58434
India						
None **	r = 0	r =1	88.90969	47.85613	42.27096	27.58434
At most 1 **	r ≤ 1	r =2	46.63873	29.79707	27.57141	21.13162

Table 3 Continued

At most 2 **	r ≤ 2	r =3	19.06731	15.49471	17.40030	14.26460
Nepal						
None **	r = 0	r =1	86.03478	47.85613	42.41831	27.58434
At most 1 **	r ≤ 1	r =2	43.61647	29.79707	33.89594	21.13162
At most 2	r ≤ 2	r =3	9.720531	15.49471	8.438965	14.26460
Pakistan						
None **	r = 0	r =1	92.41964	47.85613	55.03861	27.58434
At most 1 **	r ≤ 1	r =2	37.38103	29.79707	25.59243	21.13162
At most 2	r ≤ 2	r =3	11.78860	15.49471	9.008043	14.26460
Bangladesh						
None *	r = 0	r =1	52.00442	47.85613	30.71367	27.58434
At most 1	r ≤ 1	r =2	21.29075	29.79707	12.29721	21.13162
At most 2	r ≤ 2	r =3	8.993533	15.49471	5.448600	14.26460

** and* denote rejection of the hypothesis at the 0.01 and 0.05 level, respectively
**MacKinnon-Haug-Michelis (1999) p-values
Source: Author's calculation

The results of the VECM are reported in Table 4. The coefficient of the ECT (α) shows the speed of adjustment coefficient in the long-run. The βcoefficient represents individual variables' coefficient in the error correction term. The results indicate that, in the case of India, since all of the βcoefficients of the ECT's less than 5%, it is interpreted that GDP, OPEN and CF are significant in this equation and have a long-run relationship with CO_2. In Sri Lanka and Bangladesh cases, the β coefficients of the ECT of CF are significant while GDP and OPEN is not statistically significant. In the case of Pakistan, the β coefficient of the ECT of OPEN is significant.

The coefficient on the ECT (α), adjustment speed in the long-run for CF in the case of Sri Lanka is -5.87E+09. If the coefficient value is under-valued, then it will be adjusted upward and vice versa. The ECT implies that when once a shock begins, convergence to equilibrium is quick so that the size of coefficient of the ECT(α) can be taken as an adjustment speed. Similarly, we examine the coefficient of the ECT (α) for GDP and OPEN in India. Both coefficients of GDP and OPEN are significant. In Pakistan, the coefficients of CO_2 and GDP are significant at the 5% level meanwhile in Bangladesh, the coefficients of GDP and CF are significant at the 5% level.

Table 4: **Long – run Relationship of the VECM**

Sri Lanka	**CO_2**	**GDP**	**OPEN**	**CF**
β coefficients of the ECT (standard error)	1.000000	1.98E-13 (6.8E-14)	-0.001317 (0.00100)	4.69E-11* (2.1E-11)
Coefficient on the ECT(α) (standard errors)	-0.140372 (0.10162)	-5.74E+10 (3.5E+11)	-7.415808 (16.3279)	-5.87E+09* (2.3E+09)
India				
β coefficients of the ECT (standard error)	1.000000	5.73E-14** (1.5E-14)	-0.026044** (0.00628)	-3.66E-12* (1.5E-12)
Coefficient on the ECT(α) (standard errors)	-0.030001 (0.03851)	-6.82E+11** (1.1E+12)	8.146846** (2.90856)	5.49E+10 (4.1E+10)
Nepal				
β coefficients of the ECT (standard error)	1.000000	-2.13E-13 (2.5E-14)	-0.001281 (9.7E-05)	5.06E-11 (6.4E-12)
Coefficient on the ECT(α) (standard errors)	-0.361808 (0.26140)	-7.96E+11 (4.7E+11)	-35.23900 (88.5101)	-2.25E+10 (3.7E+09)
Pakistan				
β coefficients of the ECT (standard error)	1.000000	6.67E-14 (6.7E-15)	0.017646** (0.00329)	-8.04E-11 (4.2E-12)
Coefficient on the ECT(α) (standard errors)	0.216175* (0.09129)	-2.81E+12* (1.0E+12)	-13.25871 (9.34417)	1.60E+10 (4.5E+09)
Bangladesh				
β coefficients of the ECT (standard error)	1.000000	-2.95E-13 (8.1E-14)	-0.006849 (0.00406)	4.02E-11* (1.9E-11)
Coefficient on the ECT(α) (standard errors)	-0.048672 (0.03051)	-9.66E+11** (2.0E+11)	7.686080 (10.6901)	-6.43E+09** (1.9E+09)

Note: * Significant at the 5% level, (standard errors are in parentheses). ECT is an error correction term.
Source: Author's calculation

For the time series analysis, it is important to identify whether changes in one variable directly caused changes in the other variable. Focusing on this, the pairwise Granger causality test was applied to our variables to determine the direction of causality and the short-run effect of the relationship.

Looking at Table 5 which relates to the Granger causality test, we have presented results for only the direction of causality between CO_2, GDP, OPEN and CF. The results basically confirm that bidirectional causality between CO_2, GDP, OPEN and CF in India. In addition, the results reveal that the existence of a unidirectional causality from economic growth and capital stock to carbon emissions in Sri Lanka and Nepal. This result provides evidence that GDP and capital stock have a predictive ability for CO_2 emission in these countries. In other words, apart from the previous value of CO_2 emission, the past value of GDP and capital stock can also help to predict the path of CO_2 emission. Further, in Bangladesh, there is an evidence of unidirectional causality from carbon emission to capital stock. Overall, the results confirm the causal role of economic growth, trade openness and capital stock for CO_2 emission in these developing countries.

Table 5: **Results of Granger Causality *F*-tests**

Null Hypothesis	F-Statistic	Prob.
Sri Lanka		
LGDP does not Granger Cause LCO_2	3.66001	0.0079
LCF does not Granger Cause LCO_2	2.97838	0.0220
India		
LGDP does not Granger Cause LCO_2	5.64064	0.0005
LCO_2 does not Granger Cause LGDP	4.80865	0.0015
LOPEN does not Granger Cause LCO_2	5.00753	0.0011
LCO_2 does not Granger Cause LOPEN	2.75125	0.0312
LCF does not Granger Cause LCO_2	8.16473	2.E-05
LCO_2 does not Granger Cause LCF	3.81278	0.0063
Nepal		
LGDP does not Granger Cause LCO_2	2.58282	0.0520
LCF does not Granger Cause LCO_2	4.79411	0.0030
Bangladesh		
LCO_2 does not Granger Cause LCF	3.79844	0.0313

Source: Author’s calculation

Finally, the estimated Equation 1 is selected for stability testing. Figures 1 - 5 present the plots of cumulative sum (CUSUM) for selected countries in this study. The results indicate the absence of any instability of the coefficients because the plots of the CUSUM statistics fall inside the critical bounds of the 5% level of significance. Thus, it concludes that all coefficients in the error correction model are stable over the sample period.

Figure 1: **Plot of CUSUM India**

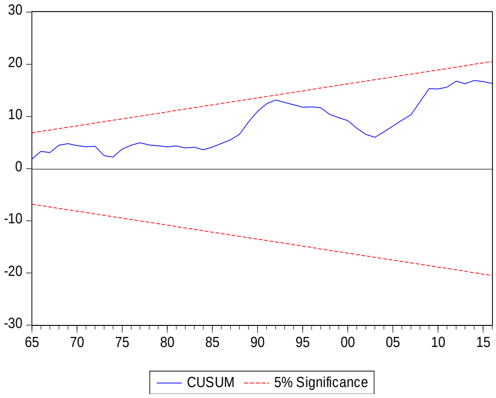


Figure 2: **Plot of CUSUM Nepal**

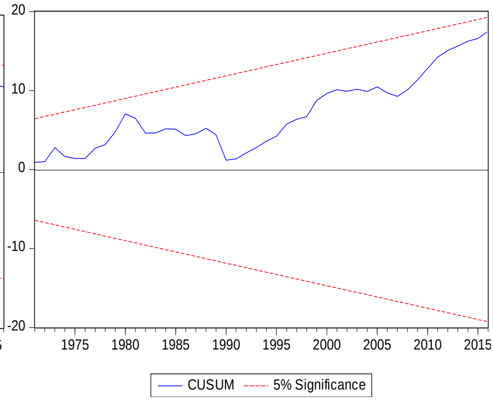


Figure 3: **Plot of CUSUM Sri Lank**

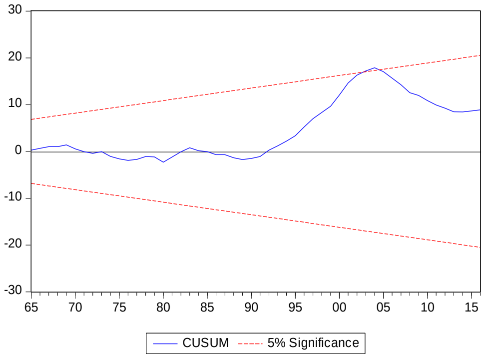


Figure 4: **Plot of CUSUM Bangladesh**

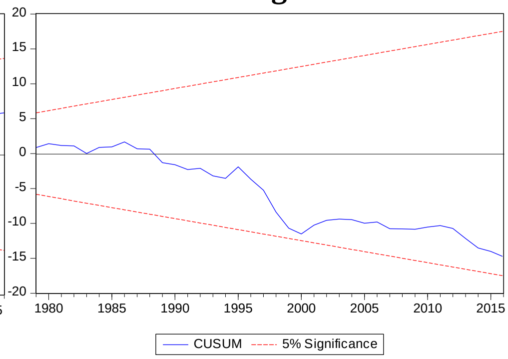
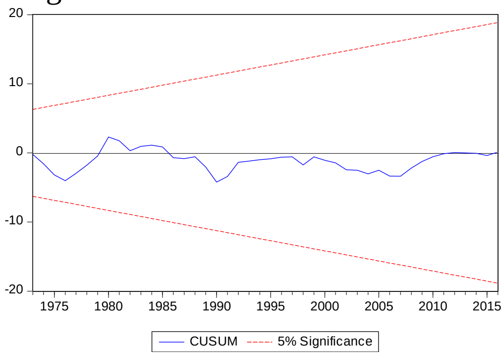


Figure 5: **Plot of CUSUM Pakistan**



Source: Author compiled

5. Conclusion

This study examined the long run and short run dynamic relationship between CO_2 emissions and GDP, trade openness and capital stock for SARCC countries using the VECM testing approach and the Johansen and Juselius cointegration system within a multivariate setting.

The paper took into consideration the debate over the existence of the EKC hypothesis for selected SARCC countries (India, Sri Lanka, Bangladesh, Pakistan and Nepal) over the period of 1960 - 2017. The five countries exhibited significant differences in the temporal patterns of environmental quality and the EKC. Results of the study revealed that economic growth does not have the expected Kuznets outcome on environmental effect in SARCC countries. The signs of the coefficients do not exhibit the expected signs for EKC hypothesis and thereby it could not find an inverted U-shaped KE curve in these countries. In the case of Nepal, the results showed that an N-shaped EK curve in the cubic model which explains the relationship between environmental emission level and GDP. The shape of this curve was initially an inverted U-shaped thereafter, it reached to turning point and again,and it increased. Understanding signs of the estimated coefficient, it revealed that beyond a certain income level, CO_2 emissions and income have a negative relationship. This was not the expected results from the study. It indicated that initial level of the development created more damage to the environmental and then economic growth causing an improvement of the environment, due to the environment-friendly development. Thereafter, again environmental damages increased and GDP of the economy is also improving. These results showed that we cannot expect better environmental conditions continuously with economic prosperity.

We assumed that there should be an inverted U-shaped relationship between CO_2 emissions and trade openness. If a particular country does not have high enough income level to protect the environment, then trade openness is expected to be a significant influencing factor towards the weakening of the quality of the environment. Hence, development level of a country had substantial impact on CO_2 emissions and trade openness.

CUSUM test was applied to test whether or not parameter stability existed in the short term. CUSUM test graph in Figure 1-5 indicated that variables were in confidence interval for %5 level of significance and had negative signs in some countries; Sri Lanka, Bangladesh and Pakistan for some periods. Meantime, all coefficients lied in between confidence interval for % 5 level significance and short term coefficients were stable.

For Sri Lanka, OPEN and its square were statistically significant. It exhibited a U-shaped between CO_2 and Trade openness. After the turning point, the quality of the environment starts to decrease, and there is a positive relationship between openness and environmental quality. This is because of the environmental and trade policies which are followed by the developing economies. Developing economies are implementing policies of openness which are tending to accept pollution-intensive industries to achieve a higher economic growth rate. D countries generally use strict environmental policies and standards to attract eco-friendly industries. When developing economies use trade liberalization policies, it creates more pollution, which reflects in this result for the case of Sri Lanka. Further, results reveal that similar relationship between trade openness and CO_2 emission levels in Nepal and Pakistan also, but these coefficients were not significant. For India and Bangladesh, the relationship between CO_2 and OPEN were positive and insignificant.

For India, CO_2 emissions and GDP, OPEN, CF had a significant long-run relationship by contrast; CO_2 emissions and OPEN had a significant relationship for Pakistan. There was significant relationship between CO_2 emissions and CF in Sri Lanka and Bangladesh.

The results of Granger causality test confirmed that bidirectional causality between carbon emissions and economic growth, trade openness as well as capital stock in India while unidirectional causality from economic growth and CF to CO_2 in Sri Lanka and Nepal. It suggests that emission reduction policies and new investment in pollution reduction project will not discourage economic growth. Carbon capture and storage and also carbon emissions tax can be performed by policy makers to mitigate environmental damage and to achieve sustainable development. Meantime, these mechanisms should be accompanied by other possible schemes, such as increasing plant efficiency, employing fuel balancing or switch to less carbon-intensive fuels and encouraging the use of renewable energy.

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