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CARBON EMISSION AND ECONOMIC GROWTH OF SAARC COUNTRIES: A VECTOR AUTOREGRESSIVE (VAR) ANALYSIS

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ABSTRACT*:* *This paper examines the causal relationship between carbon ( ) emissions and economic growth in seven SAARC countries using time series data for the period from 1972-2012. We applied Vector Error Correction Modeling (VECM) approach. We have also applied Augmented Dickey-Fuller (ADF) and Phillips-Perron (P.P) test and Johansen's cointegration approach to check time series properties and cointegration relationship of the variables. Results exhibit a cointegration relationship between environmental pollution and economic growth. Results also show that the estimated coefficients of emissions have positive and significant impacts on GDP in the long run. These results will help the environmental authorities to understand the effects of economic growth on environment for degradation and manage the environmental problems using macroeconomic methods.*

KEYWORDS: SAARC, CO_2 Emission, GDP, Causality, VECM.

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INTRODUCTION

South Asian Association for Regional Cooperation (SAARC) consists of eight countries1 which are characterized by relatively high densities of population, low per capita income and literacy rate, and unplanned use of technology in various sectors that causes environmental degradation. Conventional wisdom is that higher economic growth requires huge energy consumption which causes emission of higher level of and this in turn deteriorates environmental pollution and threatens the sustainability of environment. Now a day's climate change and global warming have attracted considerable attention worldwide.

Many scholars carried out theoretical and empirical researches on relationship between carbon dioxide emissions and economic growth from the view of EKC hypothesis and decoupling theory. This article will focus on relationship between SAARC carbon dioxide emissions and economic growth during the period of 1972-2012, meanwhile applying Vector Auto Regression (VAR) theory to analyze changes of SAARC environmental pressures in the process of economic growth.

Emissions account for the largest share of total greenhouse gas emissions which are most largely generated by human activities (World Bank, 2007). Rapid increase of emissions is mainly the results of human activities due to the development and industrialization over the last decades. It is highly dependent to the energy consumption which is inevitable for economic growth.

1These countries are Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

Chebbi and Boujelbene (2008), Hatzigeorgiou et al. (2013), Shaari et al. (2012), Ozturk and uddin (2011), Boopen and Harris (2012), Ong and sek (2013), Tiari (2011), Böhm (2011), Wahid et al. (2013), Dantama and Inuwa (2012), Amin (2012), Nain (2013), Dhungel (2008), Muhammad and smile (2012), Jinke and Zhongxue (2011), Noor and Siddiqi (2010), found causal relationship between energy consumption, emission and economic growth by applying cointegration and vecto error correction econometric model.

McKinesy Global Institute, (2008) analyzed that the successful actions on solving climate change problems should meet at least two conditions, (i) curb the increase of global carbon emissions effectively and (ii) this actions of solving global warming problem should not at the expense of declining economic development and people's living standard. Kaplan et al.(2011) found that the coefficients of the ECT terms for all models are statistically significant implying the long-run bi-directional causal relationship between energy and GDP shows that the higher the level of economic activity the higher the energy consumption and vice versa. The intergovernmental panel on climate change (IPCC, 2007) reported a 1.1 to 6.4 c increase of the global temperatures and a rise in sea level of about 16.5 to 53.8 cm by 2100. This would have tremendous negative impact on half of the world's population lives in coastal zones (Lau et al., 2009). In this respect most of the SAARC countries situated in coastal areas and for the global warming it has the vast and negative impact of climate change on SAARC countries.

One of the crucial elements for continuous economic growth, it needed to consumption of more energy that generates huge amounts of . Several studies emerged in this regard. Bloch, et al. (2012) found that there is a unidirectional causality running from coal consumption to GDP both in short and long run under supply side analysis and bi-directional causality under demand side analysis between the variables in China. Jalil and Mahmud (2009) found a unidirectional causality running from economic growth to emissions in China. Andreoni, and Galmarini (2012) researched the decoupling relationship between economic growth and carbon dioxide ( ) emissions in Italian by the way of making a decomposition analysis of Italian energy consumption. Holtz-Eakim and Selden (1995) found that there is a diminishing marginal propensity to emit as economies develop. Bhattachryya and ghoshal (2009) analyzed that the inter relationship between the growth rates of emissions and economic development is mostly significant for countries that have a high level of emissions and pollution. Asafu-Adjaye (2010) found in a study on economic growth and energy consumption in four Asian developing economies that a combination of unidirectional and bidirectional causality between the variables. Hye and Mashkoor (2010) found bidirectional causality between economic growth and environmental sustainability. Apergis and Payne (2009) examined the relationship between emissions, energy consumption and output in Central America

and they found unidirectional causality from energy consumption and real output to emissions in the short run but there appears bi-directional causality between the variable in the long run.
This study designed to evaluate the causal relationship between Emission and GDP growth in SAARC countries applying vector error correction modeling approach covering a period of data from 1972-2012 and suggest some policies to policy makers.

DATA AND THEORETICAL ISSUES

Data

This paper uses annual time series data of real per capita GDP and CO_2 emissions covering the period from 1972 to 2012 for the seven SAARC countries- Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Real per capita GDP is taken as US dollar ($) and CO_2 emissions variable is metric tons per capita. The data have been obtained from online version of World Development Indicators, the World Bank.

Theoretical Issues

This paper analyses the relationship between the long run causal relationships of economic growth and CO_2 emission in SAARC countries. The hypothesis tests in this paper is whether CO_2 Emission is related to the economic growth. We can express the relationship applying the Following functional form between CO_2 emission and economic growth (GDP) as follows:

$$CO_2 = f(GDP) \qquad (1)$$

emission and economic growth are likely to have four types long run relationships as i) economic growth can cause emission, ii) emission can cause economic growth, iii) emission and economic growth can simultaneously cause each other and iv) finally emission may neither causes economic growth nor does economic growth cause emission.

Methodology

Assessment of Granger causality between the variables and the direction of their causality in a vector error correction framework requires three steps. The first step is to test the nonstationarity property and determine order of integration of the variables, the second step is to detect the existence of long run relationship and the third step is check the direction of causality between the variables.

Testing for Nonstationarity Property and Order of Integration

Examining the time series properties or nonstationarity properties of the variables is imperative as regression with nonstationary variables provides spurious results. Therefore, before moving further variables must be made stationary. This study applies two unit root tests-the Augmented Dickey Fuller test (Dickey & Fuller, 1979) and Phillips-Perron (Phillips-Perron, 1988) to test whether the variables are nonstationary and if nonstationary the order of integration is the same or not.

Augmented Dickey Fuller (ADF) Test:

The Augmented Dickey-Fuller (ADF) test is used to test for the existence of unit roots and determine the order of integration of the variables. The ADF test requires the equations as follows

$$\Delta y_t = \alpha_0 + \alpha_1 t + \theta y_{t-1} + \sum_{i=1}^{m} w_i \Delta y_{t-i} + \varepsilon_t \qquad (2)$$

Where, Δ is the difference operator, y is the series being tested, m is the number of lagged differences and ε is the error term.

Phillips-Perron (P.P) Test:

Phillips-Perron (1988) test deals with serial correlation and heteroscedasticity. Phillips and Perron use non-parametric statistical methods to take care of serial correlation in the terms with adding lagged difference terms. Phillips-Perron test detects the presence of a unit root in a series. Suppose, is estimating as

$$\Delta y_t = \alpha + \beta t + \rho^* y_{t-1} + u_t \qquad (3)$$

Where, the P.P test is the t value associated with the estimated co-efficient of ρ*. The series is stationary if ρ* is negative and significant. The test is performed for all the variables where both the original series and the difference of the series are tested for stationary.

Cointegration

We apply Johansen and Juselius (1990) and Johansen (1988) maximum likelihood method to testfor cointegration between the series of carbon emission and economic growth. This method provides a framework for testing of cointegration in the context of Vector Autoregressive (VAR) error correction models. The method is reliable for small sample properties and suitable for several cointegration relationships. The cointegration technique uses two tests-the maximum Eigen value statistics and trace statistics in estimating the number of cointegration vectors. The trace statistic evaluates the null hypothesis that there are at most r cointegrating vectors whereas the maximal Eigen value test evaluates the null hypothesis that there are exactly r cointegrating vectors. Let us assume that y_t follows I(1) process, it is an nX1 vector of variables with a sample of t. Deriving the number of cointegrating vector involves estimation of the vector error correction representation:

$$\Delta y_t = \mu_0 + \Pi y_{t-m} + \sum_{i=1}^{m} \mu_i \Delta y_{t-i} + \varepsilon_t \qquad (4)$$

The long run equilibrium is determined by the rank of Π. The matrix Π contains the information on long run relationship between variables, that is if the rank of Π=0, the variables are not cointegrated. On the other hand if rank (usually denoted by r) is equal to one, there exists one cointegrating vector and finally if 1<r<n, there are multiple cointegrating vectors and there are nXr matrices of α and such that Π= ′, where the strength of cointegration relationship is measured by α, is the cointegrating vector and .

The tests given by Johansen and Juselius (1990) are expressed as follows. The maximum Eigenvalue statistic is expressed as:

$$\lambda_{\max} = -T \ln(1 - \hat{\lambda}_{(r+1)}) \tag{5}$$

While the trace statistic is written as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i) \tag{6}$$

Where, r is the number of cointegrating vectors under the null hypothesis and is the estimated value for the ith ordered eigenvalue from the matrix Π. To determine the rank of matrix Π, the test values obtained from the two test statistics are compared with the critical value from Mackinnon-Haug-Michelis (1999). For both tests, if the test statistic value is greater than the critical value, the null hypothesis of r cointegrating vectors is rejected in favor of the corresponding alternative hypothesis.

Error Correction Mechanism

The direction of the causality of long run cointegrating vectors in a vector error correction framework can be conducted once the long run causal relationship between the variables is established. Assuming that the variables are integrated of the same order and cointegrated, the following Granger causality test with an error correction term can be formulated:

$$\Delta Ep_t = \eta_0 + \sum_{i=1}^{n} \alpha i \Delta Ep_{t-i} + \sum_{j=1}^{m} \beta_j \Delta GDP_{t-j} + \delta ECT_{t-1} + \varepsilon_t \tag{7}$$

$$\Delta GDP_t = \mu_0 + \sum_{i=1}^{n} \gamma_i \Delta GDP_{t-i} + \sum_{j=1}^{m} \lambda_j \Delta Ep_{t-j} + \delta ECT_{t-1} + \varepsilon_t \tag{8}$$

Where, ECT is error correction term. This provides the long run and short run dynamics of cointegrated variables towards the long run equilibrium. The coefficient of error correction term shows the long term effect and the estimated coefficient of lagged variables shows the short term effect between the variables.

EMPIRICAL RESULTS

Results of Unit Root Test

The results of the Augmented Dickey Fuller (1981), ADF Stationarity test in levels show that some variables are stationary and some are non-stationary in level form. In the next step of difference form it is found that all the variables are stationary. The results of the stationarity test in levels and in difference form in shown is Table 1.

Table 1: Augmented Dickey-Fuller Unit Root Test Results								
Level Form					**Difference Form**			
Variabl	**With Constant and Trend**				**With Constant and Trend**			
	Statistics	**Critical Values**			**Statistics**	**Critical Values**		
		1%	**5%**	**10%**		**1%**	**5%**	**10%**
				Bangladesh				
CO_2	-	-	-3.529758	-3.196411	-9.783222	-	-	-
GDP	4.25799	-	-	-	-0.876964	-4.243644	-3.544284	-3.204699
				Bhutan				
CO_2	-	-	-3.526609	-3.194611	-5.813915	-	-	-
GDP	0.81321	-	-3.533083	-3.198312	-7.749178	-	-	-
				India				
CO_2	1.02378	-	-3.529758	-3.196411	-3.665813	-4.211868	-	-
GDP	2.95023	-	-3.526609	-3.194611	-5.102512	-	-	-
				Maldives				
CO_2	-	-	-3.540328	-3.202445	-5.095165	-	-	-
GDP	-	-	-3.536601	-3.200320	-6.657349	-	-	-
				Nepal				
CO_2	-	-	-3.540328	-3.202445	-7.441555	-	-	-
GDP	-	-	-3.533083	-3.198312	-6.560995	-	-	-
				Pakistan				
CO_2	-	-	-3.526609	-3.194611	-8.443667	-	-	-
GDP	-	-	-3.529758	-3.196411	-4.285085	-	-	-
				Sri Lanka				
CO_2	-	-	-3.526609	-3.194611	-6.999085	-	-	-
GDP	4.91994 9	- 4.205004 *	-3.526609**	- 3.194611** *	-3.712592	-4.211868	- 3.529758**	- 3.196411** *

The test is conducted using Eviews 7.1

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Note: On the base of critical value in Table 1, the * denotes that the rejection of null hypothesis of unit root at 1%, **denotes that the rejection of null hypothesis of unit root at 5% and *** denotes that the rejection of null hypothesis of unit root at 10% level of significance. Here we consider the variables with constant and trend both in level and first difference form. It is evident from Table that the calculated ADF statistics in respect of Bangladesh and GDP are greater than their critical values (denoted by asterisks) in difference form respectively. So in this case the null hypothesis can be rejected. In respect of Bhutan and GDP, we found that the calculated ADF statistic is greater than their critical value both in difference and level form respectively. So, null hypothesis can be rejected. For the Indian side we see that the Indian and GDP calculated ADF are greater than their critical value both in difference and level form. So, null hypothesis rejected here and so on for Maldives, Nepal, Pakistan and Sri Lanka, it shows that the calculated ADF statistics are greater than their critical value. So, the null hypothesis is rejected and the variables are stationary.

Table 2: Results of Phillips-Perron (P.P) Test

Level form					Difference Form			
Variables	Statistic	Critical Values			Statistic	Critical Values		
	With Constant and	1%	5%	10%	With Constant and	1%	5%	10%
Bangladesh								
CO_2	-	-	-	-3.196411	-	-	-	-
GDP	6.0263	-	-	-	-	-	-	-
Bhutan								
CO_2	-	-	-	-3.194611	-	-	-	-
GDP	0.8132	-	-	-3.198312	-	-	-	-
India								
CO_2	1.0237	-	-	-3.196411	-	-	-	-
IGDP	4.4254	-	-	-	-	-	-	-
Maldives								
CO_2	-	-	-	-3.202445	-	-	-	-
GDP	-	-	-	-3.200320	-	-	-	-
Nepal								
CO_2	-	-	-	-3.202445	-	-	-	-
GDP	-	-	-	-3.198312	-	-	-	-
Pakistan								
CO_2	-	-	-	-3.194611	-	-	-	-
GDP	-	-	-	-3.196411	-	-	-	-
Sri Lanka								
CO_2	-	-	-	-3.194611	-	-	-	-
GDP	6.6867	-	-	-	-	-	-	-

The test is conducted using Eviews 7.1

Note: On the base of critical value in Table 2, the * denotes that the rejection of null hypothesis of unit root at 1%, **denotes that the rejection of null hypothesis of unit root at 5% and *** denotes that the rejection of null hypothesis of unit root at 10% level of significance. Here we consider the variables with constant and trend both in level and first difference form.

Phillips-Perron Test used to non parametric statistical methods to take care of the serial correlation in the terms without adding lagged difference terms. Table 2 shows the Phillips-Perron (1988) tests results.

It is evident from Table 2 that the calculated Phillip-Perron (P.P.) statistics in respect of Bangladesh and GDP are greater than their critical values (denoted by asterisks) both in difference and level form. In respect of Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, we see that the calculated P.P statistics in respect of and GDP are greater than their critical value. So, the null hypothesis can be rejected and the data series are stationary.

COINTEGRATION RESULTS

Cointegration test clarifies that the existence of long run equilibrium relationship among the variables. The cointegration technique is meant to calculate two statistics: Trace ( ) statistics and the Maximum Eigen value (λ) statistics. The estimated results, particularly Maximum Eigen value and Trace statistics are presented in the Table 3 which indicates that the statistics value is greater than the critical value. This means that the hypothesis of no cointegration is rejected and hence they are cointegrated. The Trace statistics and Maximum Eigen value tests indicate that there is one cointegration eqn(s) at 5% level. This means that the variables among environmental pollution (i.e. emission) and economic growth (i.e. GDP) have the long run relationships. So, it is clear that there is one linear cointegration eqn(s) for each of the variables that there is one long run relationship and liner deterministic trend among the variables.

More specifically, Table 3 shows that at 5 percent level of significance the likelihood ratios (trace statistics) for the null hypothesis having one (r=1) cointegration (Bangladesh 52.09660, Bhutan 20.14684, India 31.24033, Maldives 30.52002, Nepal 26.51150, Pakistan 35.34613 and Sri Lanka 27.80299) are higher than their respective critical values (Bangladesh 15.49471, Bhutan 15.49471, India 25.87211, Maldives 25.87211, Nepal 25.87211, Pakistan 25.87211 and Sri Lanka 15.49471). At 5% level of significance, the maximum eigenvalue statisticsfor the null hypothesis having one cointegration (Bangladesh 50.89387, Bhutan 19.79190, India 26.51020, Maldives 21.64308, Nepal 21.65528, Pakistan 31.54539 and Sri Lanka 25.86416) are higher than their respective critical values (Bangladesh 14.26460, Bhutan 14.26460, India 19.38704, Maldives 19.38704, Nepal 19.38704, Pakistan 19.38704 and Sri Lanka 14.26460). Hence, according to the likelihood ratio and maximum Eigen value statistics tests, carbon emission and economic growth are cointegrated. Thus, the long run equilibrium relationship among these series is cointegrated.

Table 3: Co-integration Results

Variable	H0	H1	Trace	5% Critical	Max. Eigen	5% critical	Hypothesis
Bangladesh							
CO_2 GDP	r=0	r=1	52.09660	15.49471	50.89387	14.26460	Ho: Rejected
	r=1	r=2	1.202731	3.841466	1.202731	3.841466	H1: Accepted
Bhutan							
CO_2	r=0	r=1	20.14684	15.49471	19.79190	14.26460	Ho: Rejected
	r=1	r=2	0.354942	3.841466	0.354942	3.841466	H1: Accepted
India							
CO_2	r=0	r=1	31.24033	25.87211	26.51020	19.38704	Ho: Rejected
	r=1	r=2	4.730134	12.51798	4.730134	12.51798	H1: Accepted
Maldives							
CO_2	r=0	r=1	30.52002	25.87211	21.64308	19.38704	Ho: Rejected
	r=1	r=2	8.876940	12.51798	8.876940	12.51798	H1: Accepted
Nepal							
CO_2	r=0	r=1	26.51150	25.87211	21.65528	19.38704	Ho: Rejected
	r=1	r=2	4.856219	12.51798	4.856219	12.51798	H1: Accepted
Pakistan							
CO_2	r=0	r=1	35.34613	25.87211	31.54539	19.38704	Ho: Rejected
	r=1	r=2	3.800743	12.51798	3.800743	12.51798	H1: Accepted
Sri Lanka							
CO_2	r=0	r=1	27.80299	15.49471	25.86416	14.26460	Ho: Rejected
	r=1	r=2	1.938833	3.841466	1.938833	3.841466	H1: Accepted

Note: The Trace and Max. Eigen value test indicates that there is at least one (1) cointegrating eqn(s) at 5% level of significance. Here ** denotes the rejection of the hypothesis at 0.05 level.

RESULTS OF ERROR CORRECTION MODELING

Engle and Granger (1987) showed that, if two variables (say X and Y) are individually integrated of order one [i.e. I (I)] and cointegrated then there is possibility of a causal relationship in at least one direction. That means cointegration with I (1) variables indicate the presence of Granger causality but it does not indicate the direction of causality. The vector error correction model is used to detect the direction of causality of long-run cointegrating vectors. Moreover, Granger Representation Theorem indicates how to model a cointegrated series in a Vector Auto Regressive (VAR) format. VAR can be constructed either in terms of level data or in terms of their first differences [I (0)] with the addition of an error correction to capture the short run dynamics.

If the two variables are cointegrated, there must exist an error correction mechanism. This implies that error correction model is associated with the cointegration test. The long term effects of the variables can be represented by the estimated cointegration vector. The adjusted coefficient of error correction term shows the long term effect and the estimated coefficient of lagged variables shows the short term effect. Causality test among the variables are based on Error Correction Model with first difference. Table 4 shows the results of error correction model of the variables.

Table 4: Results of Error Correction Model

	Coefficient	t	F		Coefficient	t	F
Bangladesh							
$GDP = f(CO_2)$	0.012022	[0.42823]	1.867654	$CO_2 = f(GDP)$		[	50.44211
Bhutan							
$GDP = f(CO_2)$	0.002749	[0.23656]	0.364334	$CO_2 = f(GDP)$	-	[-	8.089451
India							
$GDP = f(CO_2)$	-0.002613	[-0.43108]	9.506284	$CO_2 = f(GDP)$	-	[-	17.17979
Maldives							
$GDP = f(CO_2)$	-	[-3.72978]	7.365691	$CO_2 = f(GDP)$	-79.42380	[-	5.569285
Nepal							
$GDP = f(CO_2)$	-	[-	1.160219	$CO_2 = f(GDP)$	-	[-	3.250268
Pakistan							
$GDP = f(CO_2)$	-0.112020	[-	4.644593	$CO_2 = f(GDP)$	131.6173	[	2.041946
Sri Lanka							
$GDP = f(CO_2)$	0.000134	[0.06242]	498.7884	$CO_2 = f(GDP)$	-	[-	11164.72

Note: ** denotes the rejection of the hypothesis at 5% level of significance. The ** values are statistically significant and shows the estimated coefficient of lagged variables. Values in the third brackets are t-statistics.

Table 4 shows the significance of Error Correction Term (ECT) for carbon dioxide ( ) emission and economic growth (GDP) of SAARC countries. It is evident from the Table that the error correction term (ECT) is significant for the country Bangladesh, India, Nepal, Bhutan and Sri Lanka in term of GDP, i.e. in these country GDP causes for the long term perspective. But in Maldives the ECT is significant in respect of emission and for Pakistan we did not find the significance of ECT.

CONCLUSION

This paper examines the long-run causal relationships between CO_2 emissions and economic growth in SAARC countries during the period of 1972-2012. We apply cointegration and VECM to evaluate the relationship. Empirical results suggest that a long run relationship exist between CO_2 emissions and economic growth in SAARC countries. The application of the cointegration based Granger Causality test found that there is a long run (short run also) relationship between economic growth and CO_2 emissions that is energy consumption granger causes CO_2 emissions and economic growth (GDP). Hence, the long run income elasticity of carbon emissions are greater than the short run income elasticity of carbon emissions, which implies that income (GDP) leads to greater carbon dioxide emissions in the SAARC countries. That is why the significant and positive impact of energy consumption is crucial for economic growth, but the rapid pace of CO_2 emissions requires the adoption of environment friendly developed technology or alternative sources of energy for the protection of environment in seven SAARC countries.

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