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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 (2 CO) 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 DickeyFuller (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 2 CO 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.

Index terms— SAARC, emission, GDP, causality, VECM.

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. 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 longrun 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 2 CO . Several studies emerged in this regard. **??**loch, 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 2 CO emissions in China. Andreoni, and Galmarini (2012) researched the decoupling relationship between economic growth and carbon dioxide (2 CO) 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 2 CO emissions and economic development is mostly significant for countries that have a high level of 2 CO 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 2 CO 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 2 CO 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.

1 a) Data

This paper uses annual time series data of real per capita GDP and 2 CO 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 2 CO emissions variable is metric tons per capita. The data have been obtained from online version of World Development Indicators, the World Bank.

2 b) Theoretical Issues

This paper analyses the relationship between the long run causal relationships of economic growth and 2 CO emission in SAARC countries. The hypothesis tests in this paper is whether 2 CO Emission is related to the economic growth. We can express the relationship applying the following functional form between 2 CO emission and economic growth (GDP) as follows: 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.) (2 GDP f CO ? (1)

3 a) 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.

4 b) 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 followst i t m i i t t y w y t y ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 1 1 1 0 (2)

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

5 c) 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 ast t t u y t y ? ? ? ? ? ?1 * ? ? ? (3)

Where, the P.P test is the t value associated with the estimated co-efficient of ?*. The series is stationary if ?* 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.

6 d) Cointegration

We apply Johansen and Juselius (1990) and Johansen (1988) maximum likelihood method to test for 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 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:t i t m i i m t t y y y ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 1 0 (4)

The long run equilibrium is determined by the rank of ?. The matrix ? contains the information on long run relationship between variables, that is if the rank of ?=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 ? and such that ?=?? ?, where the strength of cointegration relationship is measured by ?, ? is the cointegrating vector and t y '? .

The tests given by Johansen and Juselius (1990) are expressed as follows. The maximum Eigenvalue statistic is expressed as:) 1 ln( ) 1 (max ? ? ? ? ? r T ? ? (5)

While the trace statistic is written as follows:) 1 ln( ) (1 ? ? ? ? ? ? ? k r i i trace T r ? ? (6)

Where, r is the number of cointegrating vectors under the null hypothesis and ? i ? is the estimated value for the ith ordered eigenvalue from the matrix ?. To determine the rank of matrix ?, 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.

7 e) 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:t t j t m j j i t n i t ECT GDP Ep i Ep ? 1 1 1 0 (7) t t j t m j j i t n i i t ECT Ep GDP GDP ? 1 1 1 0 (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.

8 a) 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.

9 CO

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 2 CO 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. 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 2 CO 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 2 CO and GDP are greater than their critical value. So, the null hypothesis can be rejected and the data series are stationary. 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. 2 CO 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 **??**

10 c) 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.

10 C) RESULTS OF ERROR CORRECTION MODELING

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. [1]

Figure 1:

1

Level Form

Figure 2: Table 1 :

[1]Carbon Emission and Economic Growth of SAARC Countries: A Vector Autoregressive (VAR) Analysis

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Difference Form		Variables	Level form Statistics	Critical Values			Difference Form Critical Values	
		With Constant and trend	1%	5%	10%	With Constant and trend	1%	5%
					Bangladesh			
CO	2	1.723054	-4.211868	-3.529758	-3.196411	-13.90476	4.211868*	-3.529758**
GDP		6.026398	-4.205004*	-3.526609**	3.194611***	-5.186016	-4.211868*	-3.529758**
					Bhutan			
CO	2	1.475181	-4.205004	-3.526609	-3.194611	-5.799355	4.211868*	-3.529758**
GDP		0.813214	-4.219126	-3.533083	-3.198312	-7.848361	-4.211868*	-3.529758**
					India			
2 IGDP CO		1.023785	-4.211868	4.425492	-3.196411	-3.705744	-4.211868*	-3.529758**
				-3.529758	-	-	-	
				-				
				3.526609**		5.145096		
			4.205004*		3.194611***		4.211868*	
					Maldives			
CO	2	0.571652	-4.234972	-3.540328	-3.202445	-25.76413	4.211868*	-3.529758**
GDP		-	-	-	-3.200320	-	-	-3.529758**
			4.226815	3.536601		14.22380		
		1.687696			Nepal		4.211868*	
Nepal 2 CO		2.849825	-	-	-3.202445	-	4.211868*	-3.529758**
		-	4.234972	3.540328		7.410771		
GDP		-	-	-	-3.198312	-	-	-3.529758**
			4.219126	3.533083		8.621159		
		1.680807					4.211868*	
					Pakistan			
CO	2	2.701688	-	-	-3.194611	-	4.211868*	-3.529758**
		-	4.205004	3.526609		8.470362		
GDP		-	-	-	-3.196411	-	-	-3.529758**
			4.211868	3.529758		4.285085		
		2.243989					4.211868*	
					Sri Lanka			
CO	2	2.116680	-	-	-3.194611	-	4.211868*	-3.529758**
		-	4.205004	3.526609		6.955575		
GDP		6.686738	-	-	-	-	-4.211868	-3.529758**
				3.526609**		3.653982		
			4.205004*		3.194611***			

The test is conducted using Eviews 7.1
Note:

Figure 3: Table 2 :

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b) Cointegration Results

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

[Note: Cointegration]

Figure 4: Table 3 :

Figure 5:

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			Coefficient	t	F				Coefficient
					Bangladesh				
GDP ?	f	? ? 2 CO	0.012022	[0.42823]	1.867654	CO ? 2	f	? GDP ?	51.52446** [7.74284]
					Bhutan				
GDP ?	f	? ? 2 CO	0.002749	[0.23656]	0.364334	CO ? 2	f	? GDP ?	-22.31243** [-4.80641]
					India				
[0.23656] GDP ?	f	? ? 2 CO	-0.002613 [-0.43108]		9.506284	CO ? 2	f	? GDP ?	-10.77139** [-4.42385]
[- 4.80641]					Maldives				
GDP ?	f	? ? 2 CO	-0.361661** [-3.72978]		7.365691	CO ? 2	f	? GDP ?	-79.42380 [-0.92433] 5
					Nepal				
GDP ?	f	? ? 2 CO	-0.197094 [-1.91152]	[-1.91152]	1.160219	CO ? 2	f	? GDP ?	-106.6725** [-3.68314]
					Pakistan				
GDP ?	f	? ? 2 CO	-0.112020 [-0.57248]		4.644593	CO ? 2	f	? GDP ?	131.6173 [1.47971] 2.
					Sri Lanka				
GDP ?	f	? ? 2 CO	0.000134	[0.06242]	0.656019	CO ? 2	f	? GDP ?	-3.472699** [-3.81311]

Figure 6: Table 4 :

4

shows the significance of Error
Correction Term (ECT) for carbon dioxide (emission and economic growth (GDP) of SAARC CO) 2

countries. It is evident from the Table that the error correction term (ECT) is significant for the country Ba

of GDP, i.e. in these country GDP causes 2 CO for the long term perspective. But in Maldives the ECT is significant in respect of 2

Figure 7: Table 4

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