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Growth Environment Relationship: Evidence from Data on South Asia

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Economic growth is the prime focus of economic arguments and endless persuasion of growth has lead economists to forget many things that are not supposed to be ignored. One such issue is environment. We get our primary resources from environment and throw up our pollution onto that. Resource depletion and pollution collectively have degraded environment to such an extent that now it has become a concern for everybody. This study is to investigate the existence of possible long-run relationship between environmental degradation, measured through selected environmental parameters and economic growth in six South Asian countries. These countries are clustered geographically and share common environment more closely. We use panel Cointegration technique to find out existence of such relationship. To the best of our knowledge this methodology has not been applied on this issue before. We found that for these six countries carbon di oxide emission and GDP are cointegrated, and to be specific, pollution precedes GDP which goes with growth level of these countries.

Field of Research: Environmental Economics

1. Introduction

Relationship between economic growth and environmental degradation is a tricky one. For development, we need resources and in most cases, resources appear in the form of natural resource. Developing countries, whose level of technology and other economic parameters are not always optimum oftentimes disproportionately deplete resources or pollute environment in their pursuit for growth. Better technology is normally synonymous to cleaner one, but its development requires resource and expertise commitment, which is not always available to developing countries.

On another front higher level of affluence induces us to consume more and consume "complicated" goods. High value added goods are complicated in the sense that they are disproportionately resource intensive and come out of a sophisticated production process which often time produces more waste and wastes energies. A number of studies have identified consumption as the major reason for environmental degradation (see Redclift, 1996; Rothman, 1998; World watch Institute, 2004; York et al., 2003; Fuchs and Lorek, 2005; Seyfang, 2009 among others). Therefore, relationship between economic growth and environmental degradation is more interesting than it seems at first.

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Observing such non-linearity Panayotou (1993), first coined the term Environmental Kuznets Curve (EKC) which is the environmental version of Kuznets hypothesis (Kuznets, 1955), which relates income inequality and economic growth (Grossman and Kruger (1993) also used this term at its earlier stage). Following theoretical motivation, EKC argues that at the beginning high economic growth appears as the most important goal for developing countries and in that pursuit environment degrades with increases in income. Eventually they realize (by reaching a level with respect to resource and technology) the importance of environment and sustain economic growth without damaging environmental parameters.

There is a plethora of studies on these issues focusing on different aspects, countries, and using a wide varieties of methodologies to empirically identify any association between economic growth and environmental parameters keeping EKC in mind. Empirical studies did not find the existence of EKC for every pollutant, but for some pollutants such an argument explains data (List and Gallet 1999). However, results are sensitive to the choice of country, explanatory variables and method used for estimation (Stern et al., 1996).

Selden and Song (1994) found evidence of EKC on the four pollutants (SO_2, NO_x, CO and PM (Particulate Matters)) that they considered. However, Martinez-Zarzoso and Bengochea-Morancho (2004) using data of 22 OECD countries and between 1975 and 1998 did not find any support for EKC hypothesis. Azomahou, Laisney and Van (2006) in a cross country study done on 100 countries found unidirectional positive relationship between carbon dioxide emissions and per capita and GDP over a period of 1960-1996 hence rejecting the EKC.

Our study which focuses on the relationship between a few selected environmental parameters and economic growth gives insight about their interdependence which will be helpful to researchers as well as policy makers of this region. The rest of the paper is organized as follows, the next section discusses relevant literature, which is followed by the section detailing methodology and data. The subsequent section presents discussion on results obtained and the last section presents concluding remarks.

2. Literature Review

In continuation to the above discussion, there are many cross-country and country specific studies. Lashkarizadeh and Salatin (2011) found a positive relationship between GDP and the pollutants Carbon dioxide, Sulphur dioxide and Nitrogen dioxide in a cross-country study of 56 countries. However, the study found a difference in effect between OECD countries and non-OECD countries. Boopen and Vinesh (2011) on their study on Mauritius, over the period of 1975-2009 and using VAR estimation on Solow type growth model, found a similar positive relationship between GDP and carbon dioxide emissions. Apergis and Payne (2010) found support for bi-directional causality between renewable energy consumption and economic growth in both the short- and long-run in 15 OECD countries between 1985 and 2005 using panel cointegration technique. Jalil and Mahmud (2009) using Autoregressive distributed lag (ARDL) method found the existence of an inverted U relationship between carbon emissions and income as suggested by EKC for China.

Using Autoregressive distributed lag (ARDL) for Turkey Acaravci and Ozturk (2010) did not find the existence of EKC. Lean and Smyth (2010) using vector error correction model found existence of a non-linear relationship between Carbon dioxide emissions and economic growth over the period 1980-2006 in five ASEAN countries. They further found that in the long run, environmental degradation granger causes the economic growth. Sanglimsuwan (2011) found an inverted U-shaped relationship in a cross-country analysis including 63 countries. Such support is also found by Kaika and Zervas (2011) for CO_2 emissions.

Ahmed, Herve and Zhao (2012) using OLS estimation of time series data for 34 years (1975-2008) of Maldives, found that a strong positive correlation exists between environmental pollution and economic growth. Regarding causality, they found GDP per capita Granger causes the carbon emissions. However, reverse causality has been found by Menyah and Wolde-Rufael (2010) using data of South Africa for 41 years (1965-2006) and bound test approach to cointegration. Zhang and Cheng (2009) analyzed the relationship among economic growth, energy consumption and carbon emissions in China using Vector autoregression (VAR) and error correction model (ECM). They found a unidirectional Granger causality runs from GDP to energy consumption and from energy consumption to carbon emissions in the long run. However, Chang (2010) using vector error correction model found bi-directional causality between carbon dioxide and GDP for China. Ang (2008) using data of Malaysia for the period 1971–1999 found causality between economic growth to energy consumption both at short and long run. Also Ang (2007) using cointegration and vector error-correction models found existence of a unidirectional causality from output growth to carbon dioxide emissions in the long run for France for the period of 1960-2000. However, Ghosh (2010) using ARDL bounds testing approach could not find any long term relationship between growth and carbon dioxide for emissions in India, though the study found a short run bi-directional causality among these two variables. Soytas et al. (2007) found no causality between income and carbon emissions in US data. Halicioglu (2009) using multivariate model and cointegration technique found bidirectional causality between carbon emissions and income, both in the short and long run in case of Turkey.

Sari and Soytas (2009) analyzed five OPEC countries (Algeria, Indonesia, Nigeria, Saudi Arabia and Venezuela) to understand the relationship among carbon emissions, income, energy and total employment. They used the ARDL model and found variables are cointegrated only in Saudi Arabia.

Olusegun (2009) using cointegration technique could not find existence of causal relationship considering the annual data of carbon dioxide per capita and GDP per capita over a period of 1970-2005 of Nigeria. Omojolaibi (2010) using panel data also could not find the existence of the EKC relationship in case of West Africa.

In an interesting study, done on 50 countries Kauppi et al. (2006) found that, no country with Gross Domestic Product (GDP) per capita exceeding US$ 4600 experienced decrease in their forest area during the period 1990–2005 except Brazil, where deforestation continued. Some low income countries (China, India, and Vietnam) also experienced an increase in forest cover (World Bank, 2010; FAO, 2006). Aide and Grau (2004) found that many Latin American countries (e.g., Dominican Republic, Honduras, and Ecuador) experienced

simultaneous increases in forest cover and GDP. In their study they used the definition of forest given by FAO (2006) “land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agriculture or urban use.”

Shafik and Bandyopadhyay (1992) have not been successful in depicting the EKC relationship between income and deforestation but Panayotou (1993) successfully found an inverse U-shaped relationship between GDP per capita and forest area. Waluyo and Terawaki (2012) found an inverted U-shaped relationship between economic development and deforestation in Indonesia. Miah et al. (2011) found existence of EKC also in the case of Bangladesh between deforestation and development.

Ewers (2006) analyzing data of 103 countries, found that high-income countries with low forest cover tend to establish new plantations but, low-income countries with little forest are more likely to deplete their remaining portion of forest. Nations with large amounts of forest have approximately equal deforestation rates, regardless of national wealth.

Lopez and Galinato (2005), found a negative effect of economic growth on the forest cover in Brazil, Indonesia, Malaysia and Philippines. Bhattarai and Hammig (2001) examined 66 countries of Latin America, Africa and Asia over a span of 1972-1991, and found that the EKC relationship exists between deforestation and income for all three continents.

On Particulate Matters (PM), Akbostanci et al. (2009) found an “N” shaped relationship between income and environmental quality (Sulphur dioxide emissions and PM10 emissions) over a period of 1992-2001.

This review, although incomplete, is sufficient to make the case that relationships between environmental degradation parameters and economic growth are far from conclusive and most probably are influenced by many factors (as mentioned in Stern et al., 1996). In that case, the most reliable approach will be to empirically analyze a specific country or a group of countries bonded by a certain factor. In this study, we have analyzed data of six SAARC countries. They share the same environment due to their geographic proximity and are economically integrated which gives us a theoretical basis to bring them on a platform. To the best of our knowledge there is no cross country study on this issue done on this region.

3. Methodology

For the purpose of this paper, we will use panel cointegration test. Non-stationary time series give rise to spurious results for which it is important for us to make our data stationary. Furthermore, cointegration test requires variables to be at most first degree integrated. Panel unit root test is different from that of unit root test. A panel unit root test consists of two processes: common unit root process and individual root process. In the common unit root process, the persistent parameters are assumed to be common across cross section, whereas in the individual root process, the persistent parameters are assumed to move freely across cross-section. Normally these tests are done simultaneously and a decision is taken based on the overall test results. We used Im, Pesaran and Shin

(2003) and Levin, Lin, and Chu (2002) tests. In both cases, our null hypothesis of no unit root is defined on ϕ of the following equation:

$$\Delta y_{it} = \phi \Delta y_{it-1} + \sum_k \gamma_{ki} \Delta y_{it-k} + \varepsilon_{it}$$

For testing cointegration we followed the methodology proposed by Pedroni (2004), which includes seven test statistics for the null of no cointegration. As explained earlier these statistics are based on residuals of the basic regression:

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$$

Three of these statistics are group-mean tests (also called "between") and four are pooled (also called "within") tests. The mean group versions of the Pedroni t-test are not based on pooling the normalized residuals; but on averaging the test statistics estimated unit by unit. Test hypothesis are formed and are tested based on the following regression done on residuals:

$$\Delta \hat{e}_{it} = \rho \Delta \hat{e}_{it-1} + \sum_k \gamma_{ki} \Delta \hat{e}_{it-k} + \nu_{it}$$

Null and alternative hypothesis for pooled tests are:

$$H_0 : \rho_i = 0; H_1 : \rho_i = \rho, -2 < \rho < 0, \forall i$$

The between-dimension (or "group") tests allow for heterogeneous coefficients under the alternative hypothesis:

$$H_0 : \rho_i = 0; H_1 : -2 < \rho_i < 0, \forall i$$

Upon finding the existence of a cointegrated relationship, we ran the Granger Causality test on panel data as well. Granger causality test proposed by Granger (1969) test between two variables indicates which one occurs first and which one occurs next. This should suffice causality except cases of reverse causality. Regressions that we will estimate are:

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots\cdots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \cdots\cdots + \beta_l y_{t-l} + u_t$$
$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots\cdots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \cdots\cdots + \beta_l x_{t-l} + v_t$$

The reported F-statistics are the Wald statistics for the joint hypothesis:

$$\beta_1 = \beta_2 = \beta_3 = \cdots\cdots = \beta_l = 0.$$

To the best of our knowledge this question has not been approached by any study with panel cointegration techniques (though country specific study involving cointegration technique is quite common) and in that sense it adds to the literature with newer estimation technology.

4. Data

The six countries considered in our analysis are Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. The other two countries of SAARC, Maldives and Afghanistan are dropped because of data unavailability. We used GDP per capita (current US$) as a representation of economic growth. The indicators used to represent environment degradation are CO_2 emissions (metric tons per capita), Net forest depletion (current US$) and Particulate Matters (micrograms per cubic meter) respectively. All data used are drawn from World Development Indicators (WDI) 2012, published by the World Bank. Data spans over the period 1970-2008.

5. Results

Table 1 gives unit root test results.

Table 1: Results of unit root test

Variable	Level of integration	
	Levin, Lin, and Chu test	Im, Pesaran and Shin test
Difference of Per capita GDP	I(1)	I(1)
Carbon dioxide emissions	I(1)	I(1)
Net forest depletion	I(1)	I(1)
Particulate matters	I(1)	I(1)

The table shows that first difference of per capita GDP is integrated at first level and other variables are first degree integrated at their level. Therefore, for running cointegration we need to use variables in these forms. Running pair wise Pedroni Residual cointegration tests between Carbon dioxide emissions and Difference of Per capita GDP we get the results shown in Table 2.

Table 2: Pedroni Residual Cointegration Test between Carbon dioxide emissions and Difference of Per capita GDP

Statistics	Carbon dioxide emissions and Difference of Per capita GDP	
	Statistics	Probability
Panel v-Statistic	3.381636	0.0004
Panel rho-Statistic	-9.622644	0.0000
Panel PP-Statistic	-6.813951	0.0000
Panel ADF-Statistic	-0.594652	0.2760
Group rho-Statistic	-7.726305	0.0000
Group PP-Statistic	-9.358007	0.0000
Group ADF-Statistic	-2.086085	0.0185

Six out of seven statistics are significant, therefore, we can conclude the existence of a long-term relationship between these two variables. Upon further investigation into Granger causality test, we found one-way causality running from Carbon dioxide to GDP. Their mutual association is a positive one, which jointly, with causality test results, indicates that in the process of development first production of Carbon dioxide increases, most probably

to meet increasing demand for power and mechanization (given low level of technology) and then GDP increases strongly (even at per capita level).

Granger causality test results are given in the Table 3.

Table 3: Granger Causality Test between Carbon dioxide emissions and Difference of Per capita GDP

Null hypothesis	Carbon dioxide emissions and Difference of Per capita GDP	
	F – Statistics	Probability
Carbon dioxide does not Granger Cause DGDPPC	13.4532	3.E-06
DGDPPC does not Granger Cause Carbon dioxide	2.25790	0.1072

The next variable for our attention was net forest depletion. Given poor economic condition, forest can be considered as a generous gift from nature to consume. Therefore, it is depleted in this region sharply. Cointegration results are given in Table 4:

Table 4: Pedroni Residual Cointegration Test between Net forest depletion and Difference of Per capita GDP

Statistics	Net forest depletion and Difference of Per capita GDP	
	Statistics	Probability
Panel v-Statistic	9.039016	0.0000
Panel rho-Statistic	-8.089398	0.0000
Panel PP-Statistic	-6.717637	0.0000
Panel ADF-Statistic	-0.788368	0.2152
Group rho-Statistic	-6.865257	0.0000
Group PP-Statistic	-10.48638	0.0000
Group ADF-Statistic	-3.141356	0.0008

Results show that six out of seven statistics are significant; therefore, we can expect to have one cointegrating relationship between them. This induces us to run causality test, which is shown in Table 5.

Table 5: Granger Causality Test between Net forest depletion and Difference of Per capita GDP

Null hypothesis	Net forest depletion and Difference of Per capita GDP	
	F – Statistics	Probability
Net forest depletion does not Granger Cause DGDPPC	2.64158	0.0737
DGDPPC does not Granger Cause Net forest depletion	1.28289	0.2795

Net forest depletion seems to have one-way causality running from net forest depletion to GDP growth. This result confirms our previous understanding that people extract natural resources first and then convert them to growth. Some other studies have also reached such a conclusion for other developing countries (see Ewers, 2006).

The third variable under attention was Particulate Matter. These small particles are produced from different commercial processes and taking advantage of their size remain suspended in the atmosphere and create complications in respiratory systems. They are of serious concern to the environment. Production of these particles does not directly help GDP growth but they are produced out of a process that enhances GDP. They are produced and remain in the air mostly due to low level of technology and naïve air purification system. Therefore, we may expect to see a relationship between them. In fact, cointegration test shows five statistics are significant, with one more significant at 6% out of seven statistics (Table 6).

Table 6: Pedroni Residual Cointegration Test between Particulate matters and Difference of Per capita GDP

Statistics	Particulate matters and Difference of Per capita GDP	
	Statistics	Probability
Panel v-Statistic	1.506868	0.0659
Panel rho-Statistic	-4.829515	0.0000
Panel PP-Statistic	-6.254031	0.0000
Panel ADF-Statistic	-1.777492	0.0377
Group rho-Statistic	-3.653428	0.0001
Group PP-Statistic	-6.840745	0.0000
Group ADF-Statistic	-2.762959	0.0029

Granger causality test results (given in Table 7) indicate that Particulate Matter granger causes growth.

Table 7: Granger Causality Test between Particulate matters and Difference of Per capita GDP

Null hypothesis	Particulate matters and Difference of Per capita GDP	
	F – Statistics	Probability
Particulate matters does not Granger Cause DGDPPC	3.08829	0.0818
DGDPPC does not Granger Cause Particulate matters	0.91221	0.3417

However, the relationship between these two variables are negative and significant. We can explain these results as follows; Particulate Matters are by-products of production processes and we can restrict their production only by following better, cleaner technology. So first we import (or invent) better technology, use that and then go for GDP growth. This forces us to revise our previous comment that we made in case of Carbon dioxide emission. In fact better technology will produce less Carbon dioxide, therefore the production of

Carbon dioxide mentioned before is most probably to meet growing demand of energy in anticipation of economic growth not due to use of primitive technology. This is a significant finding as this indicates that the extra carbon generated in the South Asia region is somewhat "necessary" for growth.

6. Conclusion

Environmental analysis should be anthropocentric and its decision criteria should be set keeping that in mind. It is true that our activities have exceeded the carrying capacity of our environment. In fact, research has suggests that the global level of human activity began to overshoot the planet's carrying capacity during the 1980s (Wackernagel et al. 2002; and Loh and Wackernagel 2004). Still we need economic growth as the population is continuing to grow and we need more consumption goods for the extra population. Such human factors should enter into our discussion as well (see Dietz et al., 2009).

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