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CO_2 Emission, Population and Industrial Growth Linkages in Selected South Asian Countries: A Co-Integration Analysis

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Abstract: This study investigates the impact of population & industrial growth on one of the important environmental problems i.e. CO_2 emissions in selected SAARC countries. This study covers the time period from 1980 to 2008. Four major SAARC countries were selected on the bases of their population size. Study applied panel co-integration methodology to find long rum relationship among the variables. Fisher Johansen to co-integration methodology found co-integrating vectors and Pedroni panel co-integration also found co-integration in the variables of study. Results of the study show that industrialization and population both were major causes of air pollution (CO_2 emission) in these SAARC countries.

Key words: Co-integration · Environmental Degradation · CO_2 Emission · Nonrenewable resources · Ecosystem · Population growth · Total fertility rate

INTRODUCTION

The possible linkage between population growth and industrial growth is generally recognized. Rising human population led to the growth of industrial sector across the world. England was the first nation to observe an industrial revolution, later on western, northern and Central Europe, Japan and Russia observed the industrial revolution. But the Asian and Latin American countries did not experience industrial growth in the same period. Both population and industrial growth caused several problems and environmental degradation is one of them. Environmental degradation means destruction of ecosystem, climate change and depletion of natural resources. Environmental problems must be addressed by policy makers to ensure the healthy survival of human life.

This paper focuses on four major SAARC countries i.e. India, Pakistan, Bangladesh and Nepal. These countries were selected on the basis of their population size in the South Asian region. SAARC was founded in 1985 with seven member countries. Afghanistan joined as a member in 2005. Among many socio-economic objectives of SAARC, one was to increase the welfare of the people of this region and quality of life as well. However environmental problem is one of the hazards in promoting welfare and improving the quality of life in this region. Many researchers linked population growth with environmental degradation as rising population indirectly affects the environment through growing consumption and production of consumer and capital goods. Rising population is a major determinant of rising demand of consumer goods, consumer durable goods and capital goods. Therefore industrialization in the SAARC countries expanded with the population growth. This has caused carbon dioxide emissions (CO_2) in the region; moreover population growth has been one of the major determinants of environmental degradation in populous SAARC countries such as Bangladesh, India, Nepal and Pakistan. According to UNEP (1999) CO_2 accounts about 82% of anthropogenic greenhouse gas in developed nations. The population growth as a determinant of CO_2 did not receive considerable attention in the past studies. This study takes a step forward to see the impact of population and industrial growth on CO_2 in populous SAARC countries using a data of most populous SAARC countries from 1980 to 2008.

Population density and high rates of consumption of nonrenewable natural resources are one of the major causes of environmental degradation [1]. Pollution has reached to the life threatening levels in several developing countries particularly air pollution [2].

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Table 1 Population size mid-2010

countries	Population in million
Bangladesh	160.44 million
India	1188.8 million
Pakistan	180.48 million
Nepal	20.8 million

Source: 2010 World Population Data Sheet, http:// www.prb.org

We have two approaches that mostly used to study the relationship between population growth and CO_2. One research study is based on statistical models and other is based on simulation models. Present study is based on statistical model that covers panel co-integration analysis to see the impact of population growth, industrialization on CO_2.

Population Growth in South Asia: South Asian is densely populated region covering 22% of the world population. Population size of some selected countries is reported in the table 1. India had highest population in the region and second highest in the world with total population of 1188.80 million in the mid-2010. Pakistan had second highest population in the region and sixth most populous in the world with the total population of 180.48 million in the mid-2010. Bangladesh had third highest population in the region and eighth highest in the world with total population of 160.44 million in the mid-2010. Nepal had fourth highest population in the region and ranked forty third in the world with total population of 20.8 million in the mid-2010. The growth rate of the population of Pakistan is 2.05 percent and total fertility rate (TFR) is 3.5 per women [3]. Population growth rate in India was 1.34 percent and total fertility rate remained stationery at 2.6 per women [4]. While population growth rate in Bangladesh has been reported 1.56 percent by July-2011and total fertility rate has been 2.6 per women.

In United Nations Conference on Environment and Development, (UNCED) held in 1992, debate about establishing the relationship among population growth, economic growth and development and natural environment. The relationship between population growth, economic development and environment cannot be deemed mutually exclusive among different school of thought on the basis of some differences in assumptions led by them [5].

However, this is globally recognized that population growth, industrialization contribute to air pollution but it has been difficult to quantify it. Many studies suggest without empirical relevance that population growth is the cause of CO2 emission [6-10]. Rapid population growth reduces the country's ability to attack on poverty and to save environment.

Pollution rises with the rises in income too, due to increase in consumption and production activities. Air pollution has negative effects on the human health as reported that urban air pollution may account 2 percent of all local deaths [11].

Rising population in SAARC region is a serious threat to the environment and causing of atmospheric pollution, water pollution, deforestation, loss of oxygenation, depletion of non-renewable natural resources and biodiversity which is essential for life on earth. Among these dangers atmospheric pollution or air pollution is one of the factors of environmental degradation causes from industrialization, outdated vehicles and use of available fuels (e.g. coal or unleaded gasoline).

Air Pollution: Air pollution has been very serious and growing problem in SAARC countries. This problem is very intensive and wide spread in India and Pakistan. While for the rest of SAARC countries it is confined up to cities.

Air pollution has several types of pollutants that include variety of oxides such as Nitrogen Oxide, Sulphur Oxide, Carbon Dioxide, (NO_x, SO_x, CO_2,). Many Scientists believe that CO_2 emissions produced a gigantic upsurge of greenhouse gas, which has caused to rise recent temperatures [12, 13]. One of the studies in California, found a positive impact of population growth on air pollution through some sources of emissions [14, 15]. Another study analyzed the impact of population growth on CO_2 emissions in European Countries and found CO_2 emission more than proportional for recent accession countries than old EU members, where it was less than unity and insignificant. Moreover, CO_2 has strong correlation with per capita income level, intensity of energy and, industrial structure [16].

Population growth was considered as a major driving force in increasing CO_2 emissions in the world for the last two decades and according to estimation population growth would contribute one half of the emissions increased by 2025. [17, 18] also analyzed the impact of population on carbon dioxide emissions and energy. This study used IPAT model and found elasticity of CO_2 emissions and energy with respect to population growth was close to unit. [19] found a positive relationship between CO_2 emissions and population growth in the panel data study of 93 countries. This study revealed that one percent increase in population increases the emissions by 1.28 percent. Several other studies discussed and examined environmental Kuznets curve (EKC) that CO_2 emissions and income has inverted-U Curve. In few of studies additional variable of population density was taken as explanatory variable such as in the study of [20, 21]. On contrary, [22] found nonexistence of EKC. However the study of [23] did not find the existence of EKC, when it was conducted globally but studies based on local emissions witnessed the existence of EKC.

In one study based on panel data of five South Asian countries found unidirectional causality between per capita GDP and energy consumption [24]. The results of this study indicated that one percent increase in per capita energy consumption tend to decrease in 0.13 percent decrease in per capita GDP.

Industrialization: Industrialization is vital to the creation and engineering & technology is central to mitigation of the pollution problems. The impact of population growth on air pollution through industrialization is obvious. Every individual in any society makes demand of some essential goods such as food, shelter, clothing water and so forth. Most of these goods in either shape are provided by industries. Therefore increase in population also increases the demand of such basic necessities and may benefit to industrial sector for achieving increasing returns to scales. An increase in population is beneficial to the growth of industrial sector indirectly. Elasticity of demand of agriculture goods with respect to population determines the demand of industrial goods such as machineries and technology. Industrialization contributes in raising welfare if degree of welfare is measured by GDP criterion. On the other hand industrialization also generates ecological disequilibrium, which in turns decreases the quality of life also.

In the view of Malthus, increasing population puts pressure on agriculture land and forcing the cultivation of inferior quality land of poorer. This environmental degradation reduces the marginal productivity of labour which in turns reduces the income of poorer and ultimately decreases the growth rate of population. According to other school of thoughts such as Neo Classical presented their perspective a far apart from Malthusian and close to the dependency theorists regarding linkages among population, industrialization and environment [25].

Neo Classical Economists believe in free competitive market economy, where increasing population becomes the cause of market expansion, economic activity and so wealth. Their concern is about to maintain the living standard under the threat of increasing population. They are of the view that market economy is able to maintain the living standard under the condition of increasing population [26]. According to dependency theorists that people adopt new technology to protect the natural environment. This is only possible when they have industrialization and access to new technology. Different economists confirmed the rapid industrial growth as one of the stages of economic development that took place due to increase in population and this also degraded environment quality in densely- populated urban areas.

In the recent times more importance is given to environmental quality, which is measured by amount of stock of forest, absence of air, noise and water pollution. Therefore, according to this view environment is not the determinant of reducing productivity of labour as population expands. [27, 28] revealed that population growth and the development of commerce and trade led to the Industrial Revolution in Europe.

Data and Variables: This study uses the panel data of four SAARC countries i.e. Pakistan, India, Bangladesh and Nepal, (N=1….4) based on their population size. The variables of this study are Population Density (people per square km of land area)), CO_2 emission (Kg per 2000 US $ of GDP), Industrialisation, (value added % of GDP). For this study data is taken from World Development Indicators (2008).

Theoretical Framework: A study attempted by [29] to capture the effect of population and affluence on CO_2 emission has been helpful one. This study made the transformation of IPAT model into a stochastic statistical model and used industry as a proxy of technology. Before this [30] proposed the idea of IPAT model to find the determinants of environment. [31] used IHAT model with modification that households (*H*) was compared with total population levels, as the demographic unit to capture its effect on environment.

But this study follows co-integration approach to find long run relationship among population, industrialization and CO_2 emission (Air Pollution). Therefore, model is based on neoclassical production function given below;

$$lnCO_2 = f\{(ln\ (pop, Ind)\} \quad (1)$$

Further, it is expressed in logarithm form as an additive equation instead of multiplicative and residual term makes it stochastic. Therefore equation (1) for panel version can be written as:

$$lnCO_{2i,t} = \alpha_o + \beta_{1i}\ ln\ Pop_{i,t} + \beta_{2i}\ lnInd_{i,t} + \varepsilon_{i,t} \quad (2)$$

Econometric Methodology: This study follows Fisher Johansen and Pedroni panel co-integration approach for empirical investigation to find long-run relationships between population, industrialization and CO_2 emission. For panel co-integration, this study in the first step attempts to find panel unit root test developed by [32-35] to check stationarity. MW-ADF (p- values test statistic) for unit root is non-parametric test and also has a chi-square distribution. After checking unit root and stationarity of variables, the question arises to check the co-integration of variables. If panel series are stationary at the same level of integration then panel co-integration can be applied. The test for [36] can be shown as

$$Y_{it} = \alpha_i + \rho_{it} + \beta_{1i}X_{1it} + \ldots\ldots \beta_{Ji}X_{Jit} + \varepsilon_{it}, \quad (3)$$

where t=1,.......T, (number of observation in t Time) i=1.......N (number of countries) and J=1............J, (number of variables). The equation (3) is the general form of Pedroni Panel co-integration. This test allows the heterogeneity in errors and variation in co-integration vector across the cross section units. The [37] is a extended version of Engle-Granger approach. This test has two different sets of statistic, one of them is within dimension and other is based on between dimension approaches (group mean panel co-integration statistics). Further, within dimension has four test statistics i.e. panel –v statistic, panel pp type rho- statistic and panel pp type t-statistic; while between dimensions has three statistics i.e. panel group rho-statistic, pp type t-statistic and group ADF type t-statistic. This study also uses combined and individual [38] for trace statistic and P-values of maximum eigen values are aggregated for Fisher panel test.

FMOLS Panel Estimates: Once co-integration is established in the model, then rationale of Fully Modified Least Square (FMOLS) panel estimates is valid [39]. FMOLS regression, for the very first time was originated and used by [40]. The application vector auto regression (VAR) does not remove endogeneities in regressors of non stationary series. FMOLS least squares look into the endogeneity in regressors arises from existence of cointegration. FMOLS is a non-parametric approach, which takes into account the corrections of serial correlation between regressors at first difference and error term [41].

Empirical Results: Table 2 shows the results of unit root test for the panel data. All the variables at level series with or without trend show the presence of unit root in IPS, LLC and ADF Fisher tests.

While in table 3 all the variables depict rejection of null hypotheses of unit root problem. The results of all variables at their first difference show their stationarity or integrated of order one, 1(1). Therefore we can check the co-integration in the model through [37, 38] maximum likelihood method and [42] maximum likelihood –panel test.

Fisher Johansen test to co-integration reported in Table 4 supports presence of co-integration by rejecting null hypotheses of no co-integration at 5% and 10% significance level. Results in table also show at least one co-integrating vector is present. Therefore long-run relationship also exists.

Results in table 5 showed the rejection of null hypotheses of no co-integration in panel pp type rho-statistic at 5% significant level without trend and 10% significant level with trend in within dimension.

Table: 2: IPS LLC and ADF Fisher Unit Root Tests Results

	Level Series				
Test	Variables	Intercept	P-values	Trend & Intercept	P-values
IPS	$LnCO_2$	-0.72386	0.2346	0.55199	0.7095
	LnIn	1.43170	0.9239	1.73002	0.9582
	Lnpop	-0.70601	0.2401	5.88627	1.0000
LLC	$LnCO_2$	-4.05244	0.0000	-0.03019	0.4880
	LnIn	0.76104	0.7767	1.90293	0.9715
	Lnpop	-3.34178	0.4514	0.81526	0.79250
ADF-Fisher	$LnCO_2$	11.9949	0.1514	6.01127	0.6460
	LnIn	3.38058	0.9083	2.19466	0.9745
	Lnpop	9.46967	0.3042	0.04728	1.0000

Table 3: IPS LLC and ADF Fisher Unit Root Tests Results

	At Ist Difference				
Test	Variables	Intercept	P-values	Trend & Intercept	P-values
IPS	$LnCO_2$	-5.48794	0.0000	-5.69539	0.0000
	LnIn	-3.83787	0.0001	-3.09076	0.0010
	Lnpop	3.14856	0.0350	-2.01397	0.0220
LLC	$LnCO_2$	-5.23008	0.0000	-5.21778	0.0000
	LnIn	-3.05833	0.0011	-2.43363	0.0075
	Lnpop	-1.81172	0.0350	-5.71717	0.0000
ADF-Fisher	$LnCO_2$	43.5723	0.0000	42.0559	0.0000
	LnIn	29.3968	0.0003	23.0529	0.0033
	Lnpop	27.0102	0.0951	28.2560	0.0004

Table 4: Fisher-Johansen Cointegration results

Country	Null Hypotheses	Alternative Hypotheses	Trace Statistic	P-values
Bangladesh	Ho: $r\leq0$	H1: $r>0$	43.9911*	0.0006
	Ho: $r\leq1$	H1: $r>1$	14.2220*	0.0770
	Ho: $r\leq2$	Ho: $r>2$	5.4126*	0.0200
India	Ho: $r\leq0$	H1: $r>0$	25.2680*	0.0152
	Ho: $r\leq1$	H1: $r>1$	13.3069	0.1040
	Ho: $r\leq2$	Ho: $r>2$	5.3192*	0.0211
Nepal	Ho: $r\leq0$	H1: $r>0$	38.9812*	0.0033
	Ho: $r\leq1$	H1: $r>1$	19.3816*	0.0123
	Ho: $r\leq2$	Ho: $r>2$	5.4501*	0.0196
Pakistan	Ho: $r\leq0$	H1: $r>0$	41.3994*	0.0015
	Ho: $r\leq1$	H1: $r>1$	16.3726*	0.0368
	Ho: $r\leq2$	Ho: $r>2$	2.6816	0.1015
Country	Null Hypotheses	Alternative Hypotheses	Maximum Eigen Values	P-values
Bangladesh	Ho: r=0	Ho: r=1	29.7691*	0.0024
	Ho: r=1	Ho: r=2	8.8094	0.3024
	Ho: r=2	Ho: r=3	5.4126*	0.0200
India	Ho: r=0	Ho: r=1	11.9611	0.5515
	Ho: r=1	Ho: r=2	7.9877	0.3800
	Ho: r=2	Ho: r=3	5.3192*	0.0211
Nepal	Ho: r=0	Ho: r=1	19.5996*	0.0808
	Ho: r=1	Ho: r=2	13.9315*	0.0564
	Ho: r=2	Ho: r=3	5.4501*	0.0196
Pakistan	Ho: r=0	Ho: r=1	25.0268*	0.0134
	Ho: r=1	Ho: r=2	13.6911*	0.0164
	Ho: r=2	Ho: r=3	2.6816	0.1015

Note:* denotes rejection of null hypothesis at 5% and 10% significance level.

Table 5: Padroni panel Cointegration Results

Test Statistic	Without Trend		With Intercept and Trend	
(Statistic within Dimension)				
Weighted		weighted		
Panel v-statistics	-1.050880 (0.8533)	-0.329406 (0.6291)	-2.200993 (0.9861)	-1.095723 (0.8634)
Panel pp type roh- statistics	-2.928672 (0.0017)	-1.770082 (0.0384)	-1.560965 (0.0593)	-1.530435 (0.0630)
Panel pp type t-statistics	4.183788 (0.0000)	-3.126424 (0.0009)	-4.312299 (0.0000)	-4.337770 (0.000)
Panel ADF type t-statistics	-2.955176 (0.0016)	-1.965985 (0.0247)	-3.873277 (0.0001)	-3.766794 (0.0000)
Group Mean Panel Cointegration Statistic (Between Dimension)				
Group pp type roh- statistics	1.057548 (0.1451)		-1.280601 (0.1002)	
Group pp type t-statistics	-3.097907 (0.0010)		-4.944411 (0.000)	
Group ADF type t-statistics	-1.891605 (0.0293)		-2.819036 (0.0024)	

Table 6: Long run elasticity coefficients from panel FMOLS

	Dependent variable LCO2		
Countries	Intercept	Lpop	Lind
BNG	-3.6915 (0.000) ***	1.4294 (0.000) ***	0.32780 (0.0183) *
IND	-1.9225 (0.000) ***	0.99800 (0.0000) ***	0.13943 (0.0485) **
NEP	-5.6041 (0.000) ***	1.6762 (0.000) ***	1.0594 (0.000) ***
PAK	-1.0920 (0.000) ***	0.44995 (0.000) ***	0.22208 (0.020) **
Panel Group	-6.2174 (0.000) ***	0.083184 (0.0245) **	4.4353 (0.000) ***

Note: The number of lag is 1.

*, ** and *** show level of significant at 10%, 5% and 1% respectively.

This means long run relationship exist in panel pp type roh-statistic, while in between dimension Group type roh statistic did not find long run relationship. On the other hand in between dimension, Group panel pp type t-statistic and Group panel ADF type t-statistic showed the rejection of null hypotheses of no co-integration at 1% and 5% significant level against alternative hypotheses which found long run relationship. Panel pp type t-statistic and panel ADF type t-statistic also rejected null hypotheses of no co-integration at 1%, 5% and 10% significant level showed in with and without trend. This means long run relationship exist through both statistic. GMP statistic of between dimensions also showed no co-integration in Group pp type roh-statistic and did not reject the null hypotheses of no co-integration at at 1% 5% and 10% significant level. However three statistics within dimensions and two statistics between dimensions showed the existence of long run relationships. Therefore, this approach found co-integration and long run relationship among the concerned variables.

Results reported in table 6 shows the long-run elasticity coefficients from FMOL of four cross sections and panel group. In Bangladesh 1% increase in population causes the environmental degradation (CO_2 emission) about 1.4%. The population and industrialization all together effect natural environment or air pollution (CO_2 emission). Industrialization coefficient is 0.32 in Bangladesh show 1% increase in industrialization cause air pollution to increase by 0.32%. In India 1% increase in population causes the air pollution through other factors by 0.99%, while industrialization increases air pollution by 0.13%. Nepal has rather severe situation as 1% increase in population and industrialization increase air pollution by 1.6% and 1.05% respectively. The situation in Pakistan is not much different as compared to other countries. In Pakistan 1% increase in population and industrialization increase air pollution (CO_2 emission) by 0.44% and 0.22% respectively. Panel group shows the situation of this region partially as selected countries of SAARC were taken in study. However, in this region altogether population and industrialization cause air pollution significantly. Industrialization coefficient is 0.4 shows 1% increase in industrialization in these countries altogether increase air pollution (CO_2 emission) by 0.4%.

CONCLUSION

As this study followed panel co-integration approach to check the long run relationship between air pollution and population & industrial growth. Four major SAARC countries were selected on the basis of their population size in the region. For panel co-integration study used Fisher Johansen and Pedroni co-integration approaches. Results found in both studies depicted strong long run relationships and existence of co-integration. To estimate the elasticity coefficients, study applied Fully Modified Phillips Hansen approach. Results obtained through this approach showed that in Bangladesh population and industrialization were the cause of air pollution (CO_2 emission) at 1%, 5% and 10% significant level. The case of India was not much different where population caused air pollution (CO_2 emission) at 1%, 5% and 10% significant level while industrialization caused the air pollution at 5% and 10% significant level respectively. Environment in Nepal is immensely affected by rising population and industrialization in the region as its coefficient considerably affected at 1%, 5% and 10% significant level. Pakistan also could not desist herself from environmental degradation problem that was aggravated due to growing population and industrialization in the region. The long run coefficients obtained through FMOLS showed that in Pakistan, population and industrialization significantly caused air pollution (CO2 emission) at 10%, 5% and almost at 1% significant level too.

Overall in the region it was found industrialization and population were major causes of CO2 and environmental degradation.

To combat this environmental problem of CO_2 emission, individual countries are required to undertake some measures to reduce CO_2 emission. In this respect, there could be different causes of this CO_2 emission in different countries such as increase in energy production; household's activities, industrial growth, transportation, agriculture and food system, forestry etc. Behind all these problems the major cause is huge size of population and their increasing demands for the consumption of variety of goods These SAARC countries should make and implement on command and control policies like other developed nations. New technology and emission standards should be made and revised for example corporate average-fuel economy (CAFE) standards in United States. Further incentive based policies may be advocated such as carbon taxes to give incentive to reduced fuel consumption. Moreover there should be shift in such forms of energy that may reduce carbon. To the industrial end such means and technology should be followed that increase energy efficiency of production processes.

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