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Population Density, CO_2 emission and Energy Consumption in Pakistan: A Multivariate Analysis

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ABSTRACT

The objective of the research is to re-examine the influences of population density, energy consumption on CO_2 emission in Pakistan. In addition, the effect of the growth and trade is also discovered in the study using Fully Modified Least Square (FMOLS) method from 1990 to 2014. Further, robust analysis is carried by utilizing Dynamic Ordinary Least Square (DOLS) method. Initially, unit root test is tested by Augmented Dicky Fuller test and Phillips-Perron (PP) test, and long run relationship is studied by Johansen Cointegration test. The outcomes of the research show the influential contribution of population density, energy consumption on environmental decay in Pakistan. Likewise, the other elements, which plays significant role in pollution, are growth and trade. The results of the robustness check also endorse population density and energy consumption are contributing CO_2 emission in Pakistan. Therefore, the study recommends that population control should be the target of the government and limit and introduce environmentally friendly sources of energy.

Keywords: Population Density, Energy Consumption, CO_2 Emissions, Pakistan
JEL Classifications: Q4, Q42

1. INTRODUCTION

The Neoclassical theory of population growth notes that increased human activities would lead to increased environmental stress and inevitably to deterioration of the environment. This can lead to either to excessive waste being emitted into the environment, exploitation of the natural environment, cross-environmental threshold like deforestation and overgrazing. The recent climate change around the globe and its disastrous impacts has attract researchers to conduct researches on population-resources and environment. The literature on population and environment can be categorizes into three groups. The first group is "pessimistic" which argues that population is hindrance for development (Ehrlich and Ehrlich, 1991; Meadows et al., 1992; Hardin, 1993). The second group considered environment as an asset (Simon, 1986; Simon and Kahn, 1984; Kates and Haarman, 1992). The last group perceived population as a key factor of degradation in environment but not a sole element (Blakie and Brookfield 1987; Shaw, 1992). The prevailing factor in accelerating pollution and resources problem is the increasing human population in both developing and developed countries (Ehrlich and Holden, 1971). Likewise, natural destruction is exacerbating by human activities, which cause the degradation of environment (Kafka et al., 2009). Most developing countries are suffer from rapid population growth, resulting in degradation of natural resources, deforestation, increasing water and air pollution, soil erosion, damage marine and coastal ecosystems (Trainer, 1990). Moreover, the rise in population growth results in deforestation because people rely on agriculture, as a means of support would expect deforestation; the demand for wood is expected to increase due to increasing population density (Cropper and Griffths, 1994).

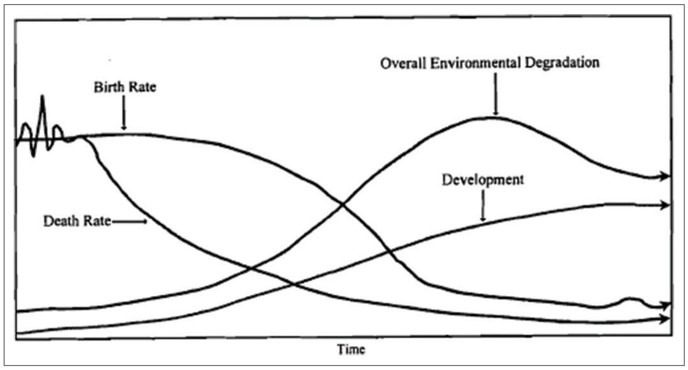
The two channels of greenhouse emission due to population are: "First, a larger population could result in increased demand for energy for power, industry, and transportation, hence increasing fossil fuel emissions. Second, rapid population growth can cause the deforestation, other changes in land use, and combustion of wood for fuel" (Birdsall, 1992. p. 30). Figure 1 shows the patters in environment, development and population. Alternatively, numerous researches have showed that the core cause of poverty and human sufferings is population growth (Repetto and Holmes, 1983; Allen and Barness, 1995; Ehlich & Holdren, 1971; and Rudel, 1989). In addition, Malthus (1798) pointed out that the growing population puts pressure on agriculture land that requires farming of poorer and poorer land. In sum, majority of studies indicated that the growing population is exerting pressure on the demand of natural resources.

However, population is not only the key factor of environmental pollution; the other influential factors includes economic growth (Yang and Zhao, 2014; Omri, 2014), tourism (Paramati et al., 2017; León et al., 2014), trade openness (Chebbi et al., 2011; Naranpanawa, 2011 and Managi et al., 2008) and quality of institutions (Muhammad et al., 2019). The current study focused on the population, energy consumption on environmental decay in Pakistan. This research has unique significance because it is conducted on the fifth most population country. Likewise, it is facing several environmental challenges. In contrast to earlier studies, this study utilizes two indicators of CO_2 emission as a proxy for environmental pollution. For empirical analysis, FMOLS method is employed and for robust analysis, the study utilizes DOLS method.

2. REVIEW OF LITERATURE

In the recent literature on sustainable development, "population-energy-environment nexus" has become a key issue. A large number of studies (Ozturk and Acaravci, 2010; Apergis and Payne, 2009; Dietz and Rosa, 1997 and Lantz and Feng, 2006) have explore the effects population and energy consumption on the environment. On the other hand, empirical studies have also been carried on role of financial development (Shahzad et al., 2017) and human capital (Bano et al., 2018) on CO2 emissions in Pakistan. Similarly, a large number of studies on growth and CO_2 emissions (Hwang and Yoo, 2014; de Freitas and Kaneko, 2011; Holtz-Eakin and Selden, 1992). Begum et al. (2015) observed that the effect of population on CO_2 is insignificant and in the long run economic growth has adverse effect on CO_2. Therefore, researchers emphasized the use of renewable energy for reducing CO_2 emission. However, Alam et al. (2016) found that increase in emission as results of energy consumption and rise in income. However, the population growth- CO_2 emission nexus is varies among different countries i.e. insignificant for China and Indonesia in the short and long run. While, significant relationship is observed for Brazil and India. Similarly, Shi (2003) results also indicated the heterogeneous effect of population on co2 emission in developed and developing countries. Ohlan (2015) also observed a relationship among population, growth and energy consumption and CO_2 in both the long run and short run. Furthermore, the key factor, which have substantial effect on CO_2, is population. Antonakakis et al. (2017) also observed the long run association between growth and CO_2 emissions.

Figure 1: Patterns in population, development, and environment



Source: Mishra (1995)

Likewise, due to the rapid growing population there is pressure on agricultural lands, exploitation of soils, soil erosion, deforestation and excess use of pesticides and fertilizer causing water pollution and land degradation (Khan et al., 2009). Growth of the population increases the number of gasses that emit in many ways into the atmosphere. Each activity requires the combustion of fossil fuels or increased emissions from gasses such as carbon dioxide and Hydrofluoric Carbon (HFC) by increasing deforestation, agricultural and industrial production. According to the estimates of Houghton (1987) and Detweiler and Hall (1988), "0.4 -2.6 GtC of carbon dioxide were discharged into the environment due to alter within the pattern of land use, and 95 percent of this amount was due to deforestation within the tropical rain areas."

Researchers around the world in developed countries also notice the similar devastation. The study of Dasgupta et al. (2000) have stated that the nature and scale of activities is changing the chemistry of the country's land, water and the atmosphere to such an enormous degree that some of those changes have an adverse effect on its natural capital. Mitra (1984) argues that the biggest environmental challenges include pollution and overcrowding which is linked to the concentration of industries. The outcomes of the congestion are; degradation of the forests, soil erosion and the drying up of huge tracts of land. In addition, the higher population, lack of land reforms and lower level of education in rural areas results in the exhaustion of agrarian soils. Developing countries are facing serious problem of accelerating environmental degradation, with a rapidly increasing population. Ahmad et al. (2005) found a co-integrating vector, which indicates a strong long relationship between demographic and environmental indicators. The results suggest that both population growth and population density raise CO_2 emissions over the long term and reflect a potentially harmful environmental effect for the population. Zaman et al. (2011) examine the intersection of population environmental degradation and figuring out the interrelationship in developing countries, in particular Pakistan, India and Sri Lanka. The outcomes have shown the detrimental impression on the environment of the rapid population growth rate. Hassan et al. (2015) explore the major forces that have influenced the short-term and term trend of carbon emissions because of development, inequality and poverty triangles in Pakistan. The results showed that in the short-term, the affiliation among economic and carbon growth and economic growth and poverty is significantly negative. The findings of the environmental hypothesis of Kuznets curve (EKC) suggest an inverted U-formed trajectory for Pakistan's economic growth. In addition to population growth, energy consumption have also adverse effects on the emissions. Mirza and Kanwal (2017) observed a bidirectional causality for Pakistan among the growth, CO_2 and energy consumption. Likewise, Hussain et al. (2012) explored the energy, environment and growth relation using time series analysis and the researchers observed a long run relation among the variables of the study. However, Nasir and Rehman (2011) found varying results in short and long run for the association among trade, CO_2 and income. Their results showed that income and trade have substantial effect on emissions. Lastly, Shahzad et al. (2017) also found existence of inverted relation between co2 and energy consumption.

3. MATERIAL AND METHOD

To achieve the main objective of the study the researchers obtained the time series of Pakistan from 1990 to 2014. The previous studies utilize CO_2 metric tons per capita for CO_2 emissions as a proxy for environmental decay (CO_{2a}). However, we have introduced CO_2 emissions kg per 2010 US$ of GDP in this study as a second indicator of environmental decay (CO_{2b}). The main explanatory variables are population density (*popdens*) measured as people per sq. km of land area and energy consumption (enguse) measured by energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP). Lastly, the proxy for economic growth (*gdp*) is gross domestic product and trade openness (*top*) is measured by trade as % of gdp.

The details description of the variables and source of the data are given in Table 1.

$$environment_{i,t}=\beta_0+\beta_1[population]_t+\beta_2[energy]_t+\beta_3[conditioningset]_{i,t}+u_{it} \quad (1)$$

This study utilizes two indicators of environmental decay. Therefore, for first indictor the model is written as

$$CO_{2a}=\beta_0+\beta_1 poden+\beta_2 encon+\beta_3 gdp+\beta_4 top+\mu_t \quad (2)$$

Similarly, the regression model for the second indicator of environmental decay is

$$CO_{2b}=\beta_0+\beta_1 poden+\beta_2 encon+\beta_3 gdp+\beta_4 top+\mu_t \quad (3)$$

For econometric analysis, this study proposed FMOLS Method and for robust analysis this study employed Dynamic Ordinary Least Square (DOLS) as the estimators are free from serial correlation, endogeneity problem, small sample bias and the estimators are asymptotically efficient (Phillips and Hansen, 1990; Kao and Chiang,2000). In addition, long run association among the variables is measured by Johansen Cointegration test. However, before using the proposed techniques, Augmented Dicky Fuller (ADF) and Phillips-Perron (PP) test is employed to know the unit root problem.

4. RESULTS AND DISCUSSION

4.1. Pre-testing

Initially, unit root problem in the data is testes by employing ADF and PP test as the data used in the present research is time series. From Table 2 the findings of the ADF test and PP test has shown that initially all variables i.e. *gdg, enguse,* CO_2a, CO_{2b}, *popden* and *top* are non-stationary and later became stationary at first difference.

Table 1: Variables description

Variables	Description	Source
gdp	Gross domestic product is proxy for economic growth	World Development Indicators
popdens	Population density (people per sq. km of land area)	World development indicators
CO_{2a}	CO_2 emissions (metric tons per capita)	World development indicators
enguse	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	World development indicators
CO_{2b}	CO_2 emissions (kg per 2010 US$ of GDP)	World development indicators
top	trade as % of gdp	World development indicators

Table 2: Unit root results

Variables	Intercept		Intercept and trend	
	Level	1st difference	Level	1st difference
		Phillips-Perron test statistic		
gdp	–3.073819 (0.0423)	6.158819 (0.0000)	3.004104 (0.1515)	–6.003639 (0.0003)
enguse	1.722536 (0.9993)	–4.034370 (0.0053)	0.328275 (0.9976)	–11.67545 (0.0000)
CO_{2a}	–1.314835 (0.6056)	–4.611104 (0.0014)	–0.978744 (0.9285)	–4.979894 (0.0030)
CO_{2b}	–1.196148 (0.6588)	–5.521407 (0.0002)	–0.004748 (0.9936)	13.72158 (0.0000)
popden	–5.850484 (0.001)	—3.209101 (0.0325)	–4.324104 (0.0116)	–0.936355 (0.0010)
top	–2.500013 (0.1279)	–6.639900 (0.0000)	–2.766509 (0.2217)	–6.428090 (0.0001)
		Augmented Dicky Fuller test statistic		
gdp	–3.073819 (0.0423)	–5.740874 (0.0000)	–3.395452 (0.0803)	–5.612592 (0.0008)
enguse	–1.548079 (0.9989)	–4.037303 (0.0053)	–0.521657 (0.9748)	–5.837364 (0.0005)
CO_{2a}	–1.423515 (0.6011)	–4.575639 (0.0015)	–3.666785 (0.0492)	–5.002868 (0.0029)
CO_{2b}	–0.117549 (0.9347)	–5.497921 (0.0002)	0.148552 (0.9958)	–6.739101 (0.0001)
popden	–1.185855 (0.6588)	–2.542215 (0.0211)	–2.536185 (0.3092)	–2.323863 (0.0437)
trade	–2.500013 (0.1279)	–6.630437 (0.0000)	–2.788054 (0.2147)	–6.419547 (0.0001)

In second stage of the analysis, the researchers have utilizes Johansen Cointegration test to studied the long run association among the variables. From Table 3, the results of trace statistics and maximum Eigenvalue reveals the rejection of null hypothesis and shows long run relationship among the variables. Similarly, Antonakakis et al. (2017) also observe a long run relation between energy consumption and CO_2 emission.

4.2. FMOLS Estimation Results

After pretesting, we have employed FMOLS and the regression results of both models (eq. 1 and 2) are presented in Table 4. The first column of the Table 4 shows the findings of first indicator of CO_2 i.e. CO2a. The results indicates that the population density have positive and noteworthy contribution in increasing CO_2 emission in line with studies of (Ohlan, 2015; Shahbaz et al., 2015). According to results a 1 %, increase in population causes an increase of 0.99 % in CO_{2a} emission. Shi (2003) obtains the similar results where "a 1% increase in population is associated with a 1.42% increase in CO_2 emissions on average." However, growth and trade have positively but insignificant influence on environmental decay. While, the other main factor of pollution in Pakistan in energy consumption consistent with studies of (Mirza and Kanwal, 2017; Alam et al., 2016; Ozturk and Acaravci, 2010). The results of the FMOLS for CO2a reveals that population is not only factor of environmental pollution (Blakie and Brookfield, 1987; Shaw, 1992). Further, the rise is environmental pollution has questioned the effectiveness and role of renewable energy source for environmentally friendly and sustainable growth (Antonakakis et al., 2017).

The second column of the Table 4 describes the results of second indicator of CO_2 emissions, which is CO_{2b}. From results, the effect of growth is positive and insignificant on CO_2 emissions. The study of Chebbi et al. (2011) also detect a positive relation in both and short and long run. In line with the outcomes of the model-1, population density, trade and energy consumption are increasing pollution in Pakistan given factors have positive and significant effect on CO_{2b}.

4.3. Robustness Check

Lastly, the study utilizes DOLS method for robust analysis and the findings are given in Table 5. The factors that have significant and positive influence in increasing pollution are trade and population density in Pakistan. While, the effect of trade is positive and substantial only in model. In line with earlier studies, growth has insignificant and positive on environmental decay in Pakistan. In sum, the outcomes of DOLS are similar to earlier results of multiple regression analysis (Table 5). The study findings also endorse the (Blakie and Brookfield, 1987; Shaw 1992) who considered population as a factor of environmental pollution but

Table 3: Johansen cointegration test

Unrestricted cointegration rank test (trace)				
Hypothesized no. of CE (s)	**Eigenvalue**	**Trace statistics**	**0.5 critical value**	**Probability**
None*	0.931955	144.7840	69.81889	0.0000
At most 1*	0.861393	82.96959	47.85613	0.0000
At most 2*	0.713487	37.51893	29.79707	0.0053
At most 3	0.301050	8.769588	15.49471	0.3871
At most 4	0.022846	0.531542	3.841466	0.4660
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized no. of CE (s)	**Eigenvalue**	**Max eigen statistics**	**0.5 critical value**	**Probability**
None*	0.931955	61.81446	33.87687	0.0000
At most 1*	0.861393	45.45065	27.58434	0.0001
At most 2*	0.713487	28.74935	21.13162	0.0035
At most 3	0.301050	8.238046	14.26460	0.3550
At most 4	0.022846	0.531542	3.841466	0.4660

*Denotes rejection of the hypothesis at the 0.05 level

Table 4: FMOLS results

CO_{2a}				CO_{2b}		
Variables	**Coefficient**	**t-value**	**Probability**	**Coefficient**	**t-value**	**Probability**
gdp	0.005555	1.152171	0.2635	0.001155	0.394795	0.6974
enercon	0.005708	2.601813	0.0175	0.008535	6.410208	0.0000
popden	0.997077	7.484830	0.0000	0.467151	5.778623	0.0000
trade	0.013448	3.009073	0.0072	0.006415	2.365159	0.0288

Table 5: Robust analysis results

CO_{2a}				CO_{2b}		
Variables	**Coefficient**	**t-value**	**Probability**	**Coefficient**	**t-value**	**Probability**
gdp	0.007283	1.176789	0.2922	0.003239	0.630559	0.5560
enercon	0.010150	0.1604	0.1604	0.013747	2.688597	0.0434
popden	1.560189	2.245162	0.0747	1.187084	2.058238	0.0946
trade	0.016486	3.270341	0.0222	0.009495	0.269434	0.0725

not a single only factor of pollution. In contrast to pessimistic view (Ehrlich and Ehrlich, 1991; Meadows et al., 1992; Hardin, 1993), optimistic argues that population is not a hindrance for development (Simon, 1986; Simon and Kahn, 1984; Kates and Haarman, 1992).

5. CONCLUSION AND RECOMMENDATIONS

This study re-examined the influence of population density and energy consumption on CO_2 emissions in Pakistan from 1990 to 2014 using FMOLS method. In contrast to previous studies, the present research uses two indicators of CO_2 emissions i.e. CO_{2a} and CO_{2b}. The estimation results of model 1 and 2 have shown that the major factors contributing in CO_2 emissions in Pakistan are population density and energy consumption. Similarly, growth and trade are also positively contributing in deterioration of environment but their effect is insignificant. The robustness check is performed by using DOLS method (Table 5) also endorses that influential elements of the CO_2 emission are population density and energy consumption. Therefore, to curtail CO_2 emission alternate sources of energy is explored to mitigate the adverse effects of the energy. However, Antonakakis et al. (2017) reveals that renewable energy consumption has no any role in sustainable and environmental friendly growth. Furthermore, the other policy agenda should be control on population to overcome its adverse effects on environment in Pakistan.

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