Impact of Population and Economic Growth on CO_2 Emission (Case of Afghanistan)

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Abstract

CO2 emission, a dominant problem for many countries is the result of several economic and social factors. The objective of this study was to analyze the impact of population and economic growth on CO2 in Afghanistan. IPAT model was employed for analysis. The data were tested for normality and multicollinearity with the help of Skewness and kurtosis as well as Durbin-Watson test of multicollinearity. The tests showed that the data were normal and the variables did not have multicollinearity. The results from the model show that both population and GDP per capita are positively correlated with CO2. The model derived from regression analysis states that 1% increase in population causes a 0.32% of growth in CO2 and so is for the opposite case. Furthermore, it adds that the coefficient value for GDP per capita, says that 1% change will cause 2.354% change in the amount of CO2.

Key words: CO2; Economic growth; Population

Introduction

Human activities and environment has significant connection since the initial stages of human being. Some of these activities are more. These activities might be more or less hazardous. For instance, globalization, population growth and increase in economic activities are some key factors, which negatively affect environment (Dietz and Rosa 1997).

Among the greenhouse gases, carbon dioxide (CO2) is highly affected by human activities. The expanding CO2 density in the global environment is largely because of fossil fuel consumption. Half of carbon dioxide emission leftovers in the atmosphere, causing the rise of global temperature, and the remaining half is captivated by ocean and natural land (M Putman, Ott, Darmenov, & DaSilva, 2016). Similarly, air

CO_2 concentration is also known a key indicator of the global warming. Based on Earth System Research Laboratory Global Monitoring Division, the amount of air CO_2 concentration increased form 403 ppm in April 2014 to 407 ppm April 2015 (ESRL 2016).

Population is a key factor of CO_2 emission. It is positively correlated with CO_2 emission, means that increase in Population will lead to increase in CO_2. This is because population increase the usage of fossil fuels and natural gas that leads to direct increase in CO_2. To put things differently, increasing population creating demand for goods and service can lead to increase in GDP, increasing GDP thus increasing income can also influence the amount of CO_2 in environment. These economic activity leads to more production as a result more production lead to consume more energy (Yeh & Lio, 2017).

Numerous study has been done to see how population and factor related with population impact on CO_2 emission. Most of the studies take advantage of (IPAT) (Impact = population* Affluence* Technology) model to see the relationship between population and CO_2 emission. Dietz and Rosa (1997) used this particular model to shows that emission of CO_2 and fossil fuel burning closely related to population. Similar method also used by York et al. (2003) to see the relation of population with cross national emission of CO_2. In addition, significant numbers of study have tested the environmental Kuznets Curve (EKC) to see the inverted U shape relation with CO_2 emission with the income of population.

In order to protect the environment and introduce a sustainable strategy, many countries and international organizations around have conducted several researches in the field, to highlight the relationship among economic and environmental variables. Yet there are still some countries, which does not have enough evidence and researches to highlight these relations and introduce an effective policy for the management of these affecting factors. Afghanistan is one of these countries which lacks proper researches to highlight the impact of economic growth and population on CO_2 emission. The objective of this particular study is to highlight the impact of economic growth and population on CO_2 emission in Afghanistan.

The study is going to see the impact of population and economic growth on CO_2 emission both direct and indirect way. Our writing is organize starting with organizing literature review on the past studies on this field following by methodology. To examine the impact of population and factors linked with population we use IPAT model and derives its function for empirical analysis. After that we analysis the result mentioning by its limitation and finally we conclude our findings with making suggestion to policy makers, where we believe decision makers have the possibility to change this relationship between population and CO_2 emission.

Literature Review

Rapid population growth and high CO2 emission are two common consisting problems in many countries around the world. A number of researches are conducted to describe these dominant problems and address a specific relation between these environmental drivers in various country. Literature showed that the results are different among countries. For example, some countries like china and India are highly suffering from CO2 emission and population growth, while other are not in a high risk yet. In order to determine the gap and methodology of the study, some important researches, conducted in different countries for different variables are highlighted here.

To start with, a study conducted in Nigeria shows that population can only increase CO2 in short run. The study analyzed the data for three different periods (1971-2000, 1971-2005, and 1971-2010) with the help of a special type of regression model. The findings reflected that in long run, population does not have significant impact on CO2. whereas, other variables in the study, such as, energy consumption and economic growth were having notable impacts on CO2 (Sulaiman & Abdul-Rahim, 2018).

Another research conducted in china, used panel co-integration and STIRPAT techniques for analyzing the data regarding CO2 and population between 1999 and 2013. The outcomes indicated that population and CO2 have an inverted U-shape relation. The study further found a weighty positive relationship among the mentioned variables in eastern part of the country, and a negative one in western and central part of china (ID, Qi, & Zhao, 2018).

Similarly, a research from Taiwan attempted to provide models for controlling CO2 emission in any developing nation. These models seek to find the impact of GDP and number of people on CO2 emission. The initial results showed that both urban and rural population have preventive impact on CO2 emission. However, economic growth can lead an amount of CO2 emission, which depends on the energy used for production. The study used regression on STIRPAT to analyze the data from Taiwan between 1990 and 2014, to find the contribution of each variable in STIRPAT model. Seven different cases of STIRPAT were projected and tried for the verification of each controlling model. Finally, the research suggested two models for predicting the effect of GDP and number of people on CO2 by 2025 in the country (Yeh & Lio, 2017).

Furthermore, a global research was conducted to evaluate the impact of affluence, technology and population on carbon emissions. The result indicated that, large countries have diseconomies of scale in terms of population, whereas, the impact of affluence on Carbone is almost $10000 per capita GDP at maximum level. The outcomes determine the overall yield of the IPAT identity as a point of beginning used for analyzing the influencing factors of global transformation. Moreover, the model states that GDP and population are expected to worsen emission for coming decade (Dietz & A. Ros, 1997).

Likewise, another research conducted in a number of countries found that lower fertility is positively related with income per capita and negatively related with CO2. The data were analyzed between 1950 and 2010 in two different stages. First, the study employed STIRPAT model to analyze panel data regarding a number of countries. The result showed that 1 percent of slower increase in population could increase population by 7 percent. In the second part the research used an economic-demographic model to analyze the impact of income per capita and population growth on emission in Nigeria. The outcome indicated that moving from medium to low fertility cause to 35 percent lower annual CO2 emission and 15 percent soaring income per person (Casey & Oded, 2016).

To continue, evidence from European Union showed the relationship between population growth and CO2emission. The study assumed population as predictor. The study is based on a sample of 24 years, starting from 1975 to 1999 for all member countries of the current European Union. The outcomes indicate that an increase in the number of people is affecting CO2 emission. The impact is higher for current European union member countries (Martínez-Zarzoso, Bengochea-Morancho, & Morales-Lage, 2006).

More interestingly in a similar empirical study has done in China through using analytical (IPAT) model in order to attempt to determine the main factors which influence carbon dioxide (CO2) emissions. After doing the regression, the results indicate that income, economic scale, and population have a positive impact on carbon dioxide (CO2) emission, yet the influence of technology on carbon dioxide (CO2) was more complicated. In the first stage of the new technology its impact on CO2 emissions was positive. While at the next phase, the effect was negative through the improvement of technology (Hang & Yuan-Sheng, 2011).

Despite all these mentioned factors there are many others which cause the carbon dioxide emissions to increase, thus, here is the study which applied in 5 BRICS countries such as Brazil, Russia, India, China, and South Africa. In this study it has been used panel data covering for the period of 1190-2012. In order to reached to the goal of this study, it is used a CO2 emissions model which consider CO2 emission as the dependent variable and the energy consumption, FDI, and GDP per capita as the explanatory variables. This research found a long term balance among these variables. Very importantly the study finds that FDI has direct effect on economic growth and has no direct effect on carbon dioxide CO2 emissions inside these countries. Meanwhile, rising energy efficiency, improve of renewal energy resources along with the introduction of latest technologies for less carbon energy may require widespread distribution (Zakarya, Mostefa, Abbes, & Seghir, 2015)

However, there are some limitation of this variable impacting on CO2 emission. Although population growth lead to urbanization, energy consumption but those are more interrelated with middle and high income countries than low income countries (Behera & Das (2017). Most of the studies conducted in various countries show different results, some of them reached a result which represents positive relationship between Population, economics growth and CO2, while others reflect negative relation. To highlight such a relation in Afghanistan, yet there is no research available. Moreover, most of the researches conducted in other countries tested the relationship for a short run. Considering these two gaps, this research aims to address the impact of population and economic growth on CO2.

Data Description and Methodology

Data:

The study considered a time series data starts from 1971 to 2016 for empirical analysis. In order to find the relationship, the study employed CO2, as dependent and population & Affluence as independent variables. The date are collected from World Bank indicators `s database of Afghanistan.

Model Specification:

To develop our analysis, we used IPAT model, where I represent Impact, P represents Population, A represents Affluence and T stands for Technology. The model was introduced by Erlich and Holdren in 1971. The model was supported by a huge number of researches, some of which are stated in the literature review. The model can be written as:

I = P*A*T

As specified by MacKellar et al. (1995), the IPAT equation is a suggestive method which states that environmental degradation is affected by number of factors, rather than a single variable. Since it was the first model for analyzing the relationship, several scholars have attempted to improve the identity, they have suggested some new changes in IAPT model. Though they have attempted to evaluate the soundness of the model, they have just depended on qualitative assessments, ground researches demonstrations, or forecasts instead of assessing the model's over all fit to a suitable data base. They have redesigned the model slightly and applied their formulation to the sources of CO2 emission. The final reformulated and improved version of the IAPT model is stated in the equation below:

$$I = ap_i^b A_i^c e_i$$

At this point, I, A and P still represent environmental impact, affluence and population. However, the addition of i in the model is only for describing the quantities which are differ across the observation.

Moreover, the new developed model reflects a multiplier represented with (a) which is a constant for scaling the equation. It also developed exponents for population and affluence, which are represented by (b) and (c). These letters are fixed values used to determine the sole impact of each variable. Lastly, the letter (e) is used instead of technology and all those affecting variables which are not included in the model. It is worth mentioning that all of these constants require different statistical measures.

To analyze the relationship of CO2, population and GDP per capita throughout the time, a developed version is considered, where a natural logarithm of both sides is taken, the new model is employed for analyzing data.

$$I = ap_i^b A_i^c e_i$$

$$lnI = lna + blnP_i + clnA_{i+} e_i$$

Many environmental researches developed linear, quadratic and cubic equations to address the relationship among mentioned variables. (Shafik 1994, Moomaw and Unruh 1997, Wu 1998, Friedl and Getzer 2003). The analysis begins with the descriptive statistics, Durbin Watson test of multicollinearity, a test of fit and significance to evaluate normality and validity of data and model.

Empirical Analysis:

Before testing the relationship and employing an empirical model, we will take advantage of a number of descriptive statistic tools to analyze all the variables (CO2 emission, population and GDP per capita) in the model. The descriptive statistics are reflected in the table 1 and table 2.

Table 1 shows minimum, maximum, mean, standard deviation, skewness and kurtosis of each variable. A number of 40 observations are analyzed and calculated. The statistics show that the country has an average of 3379707.9495 tons CO2, 3516353.350 population and $311 of average GDP per capita in each year of the period.

Table 1

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
CO2	40	768195.25	1223000	3379707.95	3115950.661
Population	40	1695709. 0	9900004.	3516353.35	2290788.951
GDP_PerCapita	40	179.00	642.00	311.2500	141.12147
Valid N (listwise)	40				

Moreover, Table 2 reflects skewness and kurtosis of the data, which are employed to test the normality of the data. The skewness value for all variables is very close to zero, which means that the data for all variables are assumed to be normal because of the small value of skewness. on the other hand, Kurtosis have small value between 0 and 2 for all three indicators, which means that the data do not have outliers or extreme values.

Table 2

	Skewness	Skewness	Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
CO2	0.422	.374	1.121	.733
Population	1.717	.374	1.651	.733
GDP_PerCapita	0.229	.374	.601	.733
Valid N (listwise)				

In order to run our model, we should check the goodness of fit and multicollinearity of the data. To do so, first we are employing a test for goodness for fit along with a Durbin-Watson test of multicollinearity.

Table 3 shows the results of test for fitness and multicollinearity. The results show that the model is fit because of the satisfying value for R square which is equal to 0.889, meaning that 88.9% change in dependent variable or CO2 is because of a change in population and GDP per capita. Moreover, Durbin-Watson test declares that there is almost no collinearity among the calculated variables. The value obtained from Durbin-Watson is 1.998, which pretty close to 2 means that the variables are not correlated.

Table 3

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.948[a]	.899	.894	.25980	1.998

Table 4 provides the information about the relationship of the variables. The table shows the results and significance of the f test, a test for analysis of variances. The test shows that the outcomes reflected by the model are highly significant because of the p-value which is less than 0.05, which means that population and GDP per capita are reliable contributors of a change in CO2.

Table 4

ANVOA						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	22.246	2	11.123	164.7	.000[b]
	Residual	2.497	37	.067		
	Total	24.743	39			

Finally, Table 5 reflects the values for the coefficients of the model to describe the impacts of the independent variables population and GDP per capita on CO2 emission.

Table 5

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.150	1.703		3.61	.001
	lnPopulation	.320	.195	.203	1.64	.009
	lnGDP_PerCapita	2.354	.257	1.128	9.14	.000

From the result we can write our estimated model as:

$$lnI = 6.15 + 0.32lnP_i + 2.354lnA_{i+}e_i$$

The estimated model has a constant of 6.15, which is the natural logarithm of the of the scale in original IPAT identity. By taking the antilogarithm of the constant with a base of Euler number (e = 2.718281), one can predict the value of the scale in original IPAT identity.

The results further show a positive coefficient of (.320) for population, which represents a positive relationship between population and CO2. The numerical value states that 1% increase in population causes a 0.32% of growth in CO2 and so is for the opposite case. It is important to add that the correlation is statistically significant, because p value for this particular coefficient is smaller than 0.05.

Likewise, the coefficient for GDP per capita is also a positive number and is representing a positive significant relation between GDP per capita and CO2. The coefficient value for GDP per capita (2.354), says that 1% change will cause 2.354% change in the amount of CO2. In Short, from the results, we can easily infer that in case of Afghanistan, economic growth has relatively high impact on CO_2 than population.

Conclusion

The study aimed to highlight the impact of population and GDP per capita on CO_2. The study considered a developed version IPAT to analyze a time series data starts from 1971 to 2016. IPAT is a famous model used among ecologist and economists. The letter I represent Impact, P represents Population, A represents Affluence and T stands for Technology. The model was introduced by Erlich and Holdren in 1971. The model was supported by a huge number of researches. Skewness and Kurtosis were employed along with Durbin-Watson for the purpose of testing normality and multicollinearity respectively. The evidence showed that the data were normally distributed and the variables in the model did not have multicollinearity. Because The value obtained from Durbin-Watson is 1.998, which pretty close to 2, the skewness value for all variables is very close to zero and Kurtosis have small value between 0 and 2 for all three indicators. Similarly, f test showed that the outcomes reflected by the model are highly significant. The regression analysis showed that both population and GDP per capita are positively correlated with CO_2. The model derived from regression analysis states that 1% increase in population causes a 0.32% of growth in CO_2 and so is for the opposite case. Furthermore, it adds that the coefficient value for GDP per capita, says that 1% change will cause 2.354% change in the amount of CO_2. In Short, from the results, we can easily infer that in case of Afghanistan, economic growth has relatively high impact on CO_2 than population. Based on the research it is recommended that future scholars, who want to research in the same field should include some variables such as technological progress, waste management and deforestation to obtain more reliable results.

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