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Does CO_2 emission Cause Average Life Expectancy in BRIC nations to Decline? Evidence from Granger Causality Test

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Abstract

Air pollution not only creates environmental degradation or climate change, rather it also causes serious health issues ranging from respiratory problems to allergies. This makes it a concern for human capital, leading to serious economic consequences. This paper tries to analyse the causality between environmental degradation and health standards. The Granger Causality test has been applied to check the association between CO_2 emission and life expectancy in the BRIC nations. The results found that CO2 emissions and average life expectancy have bidirectional causality. The study recommends that policymakers must focus on reducing CO2 emissions in order to achieve longer life expectancy.

Keywords: Average life expectancy, CO_2, Granger Causality, BRICS.

I. Introduction

In the era of globalization, air pollution has become a crucial issue for the world (Molina, et. al., 2004). It not only creates environmental degradation or climate change but also causes serious health issues (Bord, et. al., 2000). Therefore, investigation of air pollution as a health indicator becomes vital. Air pollution creates serious health issues ranging from respiratory problems to allergy, threatening the quality of human capital with serious economic consequences (Manisalidis, et. al., 2020; Swart, et. al., 2003). In this respect, it is crucial to take into consideration (CO_2 emission) and health (Average Life expectancy).

The world has witnessed an increasing demand of consumer goods and services (Brennan, & Ritch, 2010; Grytten, & Minde, 1998) which has led to an increase in environmental degradation through the emission of various toxic gases into the atmosphere (Chopra, 2016; Sonwani, & Maurya, 2018). These gases degrade the environment through climate change and global warming, steering the health of the people (McMichael, & McMichael, 1993; Patz, et. al., 2007; Measey, 2010; Yoro, & Daramola, 2020). Intergovernmental Panel on climate change (IPCC) published a report and stated that over the last 50 years, the planet temperature rose due to the activity done by human. Emission of gases is considered as one of the results of human activity that has degraded the environment and made the health condition worse off. Human activities comprise of various types of production and consumption that include traffic, burning of fuels, deforestation and intensive agriculture (Dincer, 1998; Scanes, 2018; Nagdeve, 2002) causing gas emissions. Therefore, it is important to arrest the emission of gases into the atmosphere.

Production process, deforestation and burning of fuel is higher in selected economies in order to achieve sustainable growth in GDP and to cater to the needs of their people efficiently (Oyedepo, 2012; Shaaban, & Petinrin, 2014). Countries like India where the air quality has been recorded very poor

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throughout the year (Haque, & Singh, 2017; Agarwal, et. al., 2020) suffer in terms of health (Pariyar, et. al., 2013). Industries like energy, agriculture, food processing, industrial process and waste management are mainly responsible for the environmental deterioration and hence making health issues a matter of concern (Hamer, 2003; Ngoc, & Schnitzer, 2009; Bhuvaneshwari, et. al., 2019). Reducing emission of toxic gases like CO_2 and others has become a major challenge for the policy-makers in the current century (Barnosky, et. al., 2014). International agencies continuously make efforts to reduce the use of fossil fuel, deforestation, use of plastic, etc., in order to preserve the environment (Popp, et. al., 2014).

Dust particles and chemicals can easily be transferred from one place to other with air. Hence, air pollution and the emission of toxic gases are complementary to each other (Faber, et. al., 2015; Bauer, et. al., 2019). Emission of gases into the atmosphere causes air pollution and global warming which ultimately do climate change and hence degradation of ecosystem and humanity (Manisalidis, et. al., 2020; Mannucci, et. al., 2015). Emission of gasses is all around and can be from different sources, for instance, CO_2 and SO_2 from energy sector, and CH_4 and N_2O from agriculture and allied sector (Pénard-Morand, & Annesi-Maesano, 2004). Emerging economies in order to catch up with the rate of economic growth of advanced economies emphasize more on economic activities which has enhanced the emission of toxic gases into the atmosphere (Khan, et. al., 2019; Khan, 2019; Zhang, 2000). These gases have polluted the environment resulting in climate change, global warming, etc., which ultimately has affected the health standard (Jacobson, 2009). This correlation between emission of gases due to increase in economic activities and its consequent impact on health is the prime motive behind the idea of this research for the selected economies.

Many studies on the emission of gases and its impact on health have been done so far. They have proved that climate change and global warming due to emission of gases and air pollution is are critical for the health of population. The fact that emission of gases is the biggest threat for the existence of humanity over the planet has been validated by many researchers. Studies, for instance, by Ali, & Ahmad, 2014; Fakhri, et. al., 2015; Delavari, et. al., 2016; Nadimi, et. al., 2017; Amuka, et. al., 2018; Nkalu, & Edeme, 2019; Erdoğan, et. al., 2019; Mohmmed, et. al., 2019; Adedoyin, et. al., 2020; Wang, & Li, 2021; Murthy, et. al., 2021; Osabohien, R. 2021; Rjoub, et. al., 2021; Mahalik, et. al., 2022; Nwani, & Imhanzenobe, 2022, have investigated the relationship between toxic gases emission and health status (life expectancy). They explored the nature of relationship between toxic gases emission and health standard or economic growth. However, literature on the direction of relationship between these variables remains scanty.

As mentioned in the existing literature on the emission of gases and health risk, environmental degradation is a crucial factor for human life and emission of harmful gases is not an exception. But the literature suggesting the impact of life expectancy on CO_2 emission and/or impact of CO_2 emission on life expectancy is scarce. This study is an attempt to fill this gap by considering the issue of causality between CO_2 emission and average life expectancy, a proxy for health parameter. We have used Granger Causality Test (1969) to estimate the direction of causality between annual CO_2 emissions (CO_2) and average life expectancy (ALE) for BRICS countries. The latter are the fastest growing economies in the world (Asongu, et. al., 2018) having the ability to catch up with the economic growth of most developed economies (Radulescu, et. al., 2014; Siva, et. al., 2018). In order to achieve the set target of reducing emission of gases into the atmosphere, it is essential to find out the direction of causality between health and emission. An insight on causality is important in order to know whether emission of gases (CO_2) is the result of poor health standard (lower average life expectancy) or vice versa is correct. In the study we have measured health indicator by average numbers of years a human life and emission of gases by annual emission of CO_2.

II. Data and Methodology

Data set includes two variables, namely, CO_2 emission and average life expectancy for four countries from 1990 to 2019. The stationary test was done by applying Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test. The conventional ADF unit root test is defined as:

$$\Delta y_t = \alpha + \emptyset t + y_{t-1} + \sum_{i=1}^{m} \emptyset \, \Delta y_t + \mu$$

Where, y denotes the time series under consideration, Δ is the first difference operator, μ is the white noise disturbance term, i= 1, 2, 3….m denotes countries and t indicates time.
Phillips and Perron (PP) unit root test has also been used to check the unit root property of the selected variables. PP unit root test is done in the following manner:

$$\Delta y_{t-1} = \alpha_0 + \Upsilon y_{t-1} + \mu_t$$

Next, to explore the causality between emissions of gases and average life expectancy in the BRIC nations, we employed Granger Causality Test. Granger Causality (GC) test first proposed by Clive Granger in 1969. GC test is used to analyse the two-way relationship between the two variables (CO2 emission and average life expectancy). It is a statistical method adopted to test a hypothesis for examining whether a time series is affected by others. Policy makers are often unsure about the impact of emission of gases into the atmosphere and its impact on average years of life of a person, i.e., whether average life expectancy affects emission of gases (CO2) or CO2 affects average life expectancy. We use Granger Causality Test in this paper over other alternative methods because of its significant response to large as well as small data set.

The causality test involves testing of the null hypothesis that CO2 does not impact average life expectancy and vice versa. We have the following two equations:

$$X_t = \beta_{10} \, Y_t + \Upsilon_{11} X_{t-1} + \Upsilon_{12} X_{t-1} + \mu_{yt} \qquad (1)$$
$$Y_t = \beta_{20} \, Y_t + \Upsilon_{21} Y_{t-1} + \Upsilon_{21} X_{t-1} + \mu_{yt} \qquad (2)$$

Here X, Y are dependent variables, β is the coefficient of the respective variable, t-1 is the lag period and μt is the random disturbance term.

III. Results and Discussions

In the first step, selected variables were transformed into natural log form. Then we applied Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test to check the unit root property of the selected variables. ADF and PP results are mentioned in Table 1. ADF result shows that the selected data series are stationary at level and PP result reveals that while India and China data series are stationary at first difference, the Brazil and Russia data are stationary at level.

In the next step we have analysed the causality relationship between CO2 and ALE, and the lag lengths are chosen for each country by using AIC and SIC criteria. Table 2 presents the lag values for each country. The AIC and SIC criteria led us to choose 5 lags for Brazil, 1 lag for Russia, 5 lags for India and 3 lags for China.

Table 1: Unit root test

Countries	*CO2*		*ALE*	
	ADF	PP	ADF	PP
BRAZIL	-0.807	-1.851	-1.812	0.802*
RUSSIA	-2.147	---	-0.045	-2.777
INDIA	1.269	-0.354	-1.465	0.294*
CHINA	-1.373	-0.827	-2.023	0.746

Note: *(First Difference); ADF- Augmented Dickey Fuller; PP- Phillips-Perron.

Table 2: Number of Lags taken for CO2 and ALE

Country	*Lag1*	*Lag2*	*Lag3*	*Lag4*	*Lag5*
Brazil	-16.425	-19.135	-20.986	-20.994	-21.7756**
Russia	-11.5795**	-11.444	-11.261	-11.088	-11.213
India	-16.541	-19.785	-22.075	-22.41	-22.8695**
China	-15.37	-20.372	-22.0858**	-22.032	-22.019

Note; **- Lags value. (Leg length for the model was determined by using information criteria AIC (Akaike Information Criteria).

After choosing the lag lengths, equations (1) and (2) are estimated for each country to test the direction of causality between CO2 emission and Average Life Expectancy (ALE) in selected countries. Granger causality is one type of relationship between time series. The basic idea of Granger causality (GC) can be stated as if the prediction of one-time series is improved by incorporating the knowledge of a second time series, then the latter is said to have a causal influence on the first. Towards this end, we estimate the Granger causality.

The null hypothesis is tested separately for each country and the corresponding F-statistics are reported in Table 3. The null hypothesis (H_0) states that lagged CO_2 emissions do not cause ALE, i.e., $CO_2(L) \neq ALE(L)$. The alternative hypothesis (H_1) posits that lagged CO_2 emissions do cause ALE, i.e., $CO_2(L) = ALE(L)$.

Table 3: Granger Causality Test

Country	Variables	F-Statistics	P-Value	Ho	Causality Direction
Brazil	CO2 → ALE	3666	0.000	R	Bidirectional
	ALE → CO2	3.8275	0.000	R	
Russia	CO2 → ALE	4.3647	0.0466	R	Bidirectional
	ALE → CO2	8.3994	0.0075	R	
India	CO2 → ALE	3095.8	0.000	R	Bidirectional
	ALE → CO2	11.259	0.0002	R	
China	CO2 → ALE	39231	0.000	R	Bidirectional
	ALE → CO2	21.215	0.000	R	

Source: Authors' calculations.

Table 3 shows that bi-directional causality is observed in all the four selected nations which means that CO2 emission affects ALE which affects the CO2 emission as well. The reason could be that the selected economies are developing focusing more on research & development and productive activities that increase the emission of greenhouse gasses (Hossain, 2011). Industrialization is in the first and second phases of development in these countries which leads to a remarkable increase in the CO2 emission (Dong, et. al., 2019). On the other hand, improvement in health care sector advancement and increase in healthcare utilization due to increased GDP share to health sector and per capita income has enhanced ALE (Anderson, & Frogner, 2008).

Bidirectional causality proves that the importance of increased ALE has contributed to the CO2 emission and/or increased CO2 emission has reduced ALE (Matthew, 2020). Lesser emission of harmful gases (CO2) helps in improving the health standard and hence average number of years of life by a person (Menz, & Welsch, 2012). Existing literature validates that carbon emission is a vital factor of ALE (Chen, et. al., 2021; Majeed, & Ozturk, 2020). CO2 emission has a negative impact on life span meaning that larger CO2 emission causes lower life expectancy (Amuka, et. al., 2018). Increase in CO2 emission causes severe diseases that increase morbidity and mortality rate reducing ALE.

The selected economies under study are developing facing heavy population burden. This forces these economies to go for higher production to fulfil the demands of growing population (Awan, A. G. 2012; O'neill, 2011; Misra, 2015; Zhao, et. al., 2021). Production process leash generation of harmful gases inducing negative relationship between CO2 emission and ALE (Chen, & Lin, 2008; Erdogan, 2021). Release of CO2 into the air can cause environmental problems affecting ALE (Rjoub, et. al., 2021; Koroneos, et. al., 2004). On the other hand, longer ALE induces higher emission of CO2 into the air through the consumption process (Peters, et. al., 2007). This is because developing nations experience the highest level of air pollution (Bell, et. al., 2011). Burning of coal and oil by the industrial sector and the burning of coal/woods and kerosene for cooking purposes increase the CO2 emission in the emerging countries (Quadrelli, & Peterson, 2007; Sumabat,et. al., 2016).

IV. Conclusion

Over the past few decades, the BRIC nations- Brazil, Russia, India and China have experienced rapid economic growth, industrialisation, urbanisation and technological advancement, resulting in substantial improvements in ALE. However, these developments have also been accompanied by increasing environmental degradation, particularly in the form of rising carbon dioxide (CO_2) emissions. The latter constitute a major component of greenhouse gases and are widely regarded as a primary contributor to climate change and environmental pollution. The main objective of this paper was to unveil the causality between CO2 emission and ALE in BRICS nations. It is an addition to the existing literature to show the direction of relationship between CO2 emission and ALE, i.e., whether there is unidirectional or bidirectional causality between selected variables. This study employed the Granger Causality test to investigate the causality between the selected variables. Results show that CO2 emission and ALE have the bidirectional causality meaning that CO2 emission causes ALE and/or ALE causes CO2 emission. The findings of the study imply that with the advancement of the economies, people should be made aware about the harmful impacts of CO2 emission in general and on ALE in particular so that measures could be taken by public and private stakeholders to counter the effects of CO2 on life expectancy. The study recommends that policies should be designed on reducing the CO2 emission in order to achieve longer life expectancy.

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