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CO_2 Emissions, Energy Consumption and Economic Growth in BRICS:An Empirical Analysis

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Abstract:- In the last few decades, the rising levels of industrialization, urbanization, climbing: population and changes in lifestyle have increased the threat of global warming and climate changes. The Kyoto protocol of 1997 had the objective of reducing greenhouse gasses (GHG) emissions to 5.2 percent lower than the levels of 1990 during the period 2008-2012. The rise in greenhouse gasses emissions has been the major ongoing concern for both developed and developing countries. With the recent economic growth of the BRICS countries, emissions are expected to increase as BRICS countries use large quantities of fossil fuels for electricity generation, contributing to global warming. According to the UNEP emission gap report, 2015, three of the BRICS countries are the part of six largest emitters of CO_2 in the world. This paper is an attempt to find the empirical relationship among three variables, i.e., CO_2 emissions, economic growth rate (per capita GDP) and energy consumption in a panel of BRICS countries for the annual data set for the period 1991 to 2011. In this paper, we employed the Panel data both fixed and random effects and unit root test.

I. INTRODUCTION

In the last few decades, the rising levels of industrialization, urbanization, population and changes in lifestyle have increased the threat of global warming and climate change. The Kyoto protocol of 1997 had the objective of reducing greenhouse gasses (GHG) emissions to 5.2 percent lower than the levels of 1990 during the period 2008-2012. The rise in greenhouse gasses emissions has been the major ongoing concern for both developed and developing countries.The economic growth of the developing countries means the exhaustive use of energy and other resources, which contributes to rising environmental degradation. The main greenhouse gas is Carbon dioxide (CO_2), and it is regarded as the main source of the rise in global warming. The economic growth of a country is linked with the consumption of coal, oil, and gas as the main power of the source of industrialization, which is the main source of the CO_2 emissions.The term BRIC, coined in 2001 by Jim O' Neill, brings the four largest fast growing and emerging countries (Brazil, Russia, India, and China) under a common label. These four economies collectively account for more than a quarter of the world's land area, 40 percent of the world's population. On almost every scale, these economies are in line to be the largest grouping at the global level. During the BRIC summit at Sanaya (China) in April 2011, South Africa joined the group. During the last few years, BRICS economies have experienced intense structural changes that continue to influence the evolution of regional CO_2 output. In 1990, the shares of BRIC countries in global emissions were low as in Brazil it was 0.94 percent, Russian Federation at 3.80 percent, India at 3 percent and China at 11 percent. According to World Bank, the report of 2007, by the year 2007 BRIC countries' emissions increased for their economies, Brazil at 1.15 percent, Russia 6 percent, India 5 percent and China 16 percent of the global emissions. The Fifth BRICS summit, held in Durban, March 2013, acknowledged the climate change as one of the greatest challenge and threats towards achieving sustainable development. For this, the delegates from BRICS countries signed a "multilateral agreement on climate cooperation and the green economy" which will ensure the exchange of technical and financial support to combat the negative impact of climate change (South African Government News Agency, 2013).With the recent economic growth of the BRICS countries, emissions are expected to increase as BRICS countries use large quantities of fossil fuels for electricity generation, contributing to global warming. According to the UNEP Emission Gap Report, 2015, largest CO_2 emitting country in the world in 2013 was China, which shares 29 percent of total emissions; the second largest is the United States to share of 16 percent, followed by the European Union with 11 percent. In 2013, China's CO_2 emissions were 11 billion tons. The coal consumption was responsible for the three-quarters of China's CO_2 emissions from fossil-fuel combustion. Even in the two recession years, China's CO_2 emissions continued to

increase by about 6 percent per year. India's CO_2 emissions in 2013 were 2.6 billion tons, making it the fourth largest CO_2 emitting country, following closely the European Union, and well ahead of the Russian Federation, which is the fifth largest emitting country. The increase in India's emission contribution in 2013 was mainly caused by a 7.3 percent increase in coal consumption, which accounted for 59 percent of India's total fossil-fuel primary energy consumption and 55 percent of its total primary energy consumption. This coal's share of 59 percent in India is smaller than in China and South Africa. Russia's CO_2 emissions were 2 billion tons in 2013. After a big drop in emissions by 5.7 percent in 2009, compared to 2008, due to the global recession, Russia recorded the highest increase of the last 20 years of 5.2 percent in 2011, compared to 2010. Brazil is the eleventh largest emitter of CO_2 in the world; in 2013, the rise in the emission of Brazil was 6.1 percent. However, South Africa stands far away in BRICS countries in CO_2 emissions. The relationship between the CO_2 emissions, economic growth, and energy consumption have gained a lot of attention over the periods. This paper is an attempt to find the empirical relationship of three variables, i.e., CO_2 emissions, economic growth rate and energy consumption in BRICS countries. For framing the policies, the direction of causality between economic growth, energy consumption, and CO_2 emissions is important.

II. REVIEW OF LITERATURE

Today's leading economic model generates extensive and serious environmental and health risk. Therefore, to deal with these problems there is a need for an economic system that can combat this problem and leads to sustainable development. Numerous studies have been conducted to analyze the empirical analysis of economic growth, carbon emissions, and energy consumption. However, most of the studies are conducted at the micro level, i.e., for a single country. As per the need of the study, a review of selected literature is done.Pao and Tsai (2010) came across a strong unidirectional causality in the short run from carbon dioxide emissions and energy consumption to real output. They also found a strong bidirectional causality between energy consumption and carbon dioxide emissions as well as between energy consumption and real output. They concluded that the growth in the BRIC countries is energy dependent.Hossain (2012) studied the dynamic causal relationship between carbon dioxide emissions, foreign trade, energy consumption, economic growth, and urbanization in Japan for 1960-2009. They found unidirectional causalities from energy consumption and trade openness to carbon dioxide emissions, from trade openness to energy consumption, from carbon dioxide emissions to economic growth, and from economic growth to trade openness in the short run. It also found that in Japan, higher energy consumption contributes more to carbon dioxide emissions. However, in the long run, the environmental quality is found to be normal in respect of economic growth, trade openness, and urbanization.

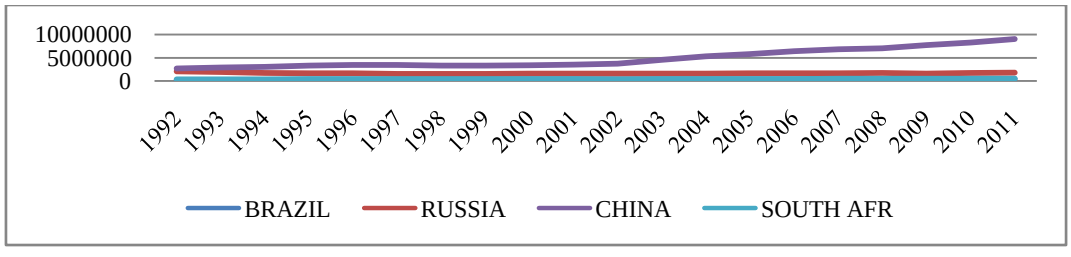
Elena (2013) analyzed the relationship between CO_2 emissions and economic growth, by using a panel data set of 93 countries for 1960-2008. The short-run relationship between CO_2 emissions and its determinants is established. Dynamic Panel Data and within models found that the growth rate of per capita CO_2 emissions depends positively on the growth rate of per capita GDP, while it has a negative relationship with the growth rate of the energy mix. Bozkurt and Yusuf Akan (2014) examine economic growth, CO_2 emissions, and energy consumption relationship in Turkey by using cointegration test for the annual data for 1960-2010. The empirical results of this study show that CO_2 emissions effect negatively on economic growth while energy consumption affects economic growth positively. Uddin and Abdul Wadud (2014) in their paper, examine the causal relationship between carbon emissions and economic growth in seven SAARC countries using time series data from 1972-2012. The Vector Error Correction Modelling (VECM) approach along with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (P.P) test and Johansen's cointegration approach is used to check time series properties and cointegration relationship of the variables. The study found a cointegration relationship between environmental pollution and economic growth and the estimated coefficients of emissions have positive and significant impacts on GDP in the long run. A large number of studies in this area found different results for different countries for different time period. From the available literature, it is clear that economic growth has positive effects on CO2 emissions. The studies for BRICS are limited, therefore there is need to analyze the relationship between CO2 emissions, economic growth, and energy consumption in these emerging economies.

III. GREEN ECONOMY AND BRICS

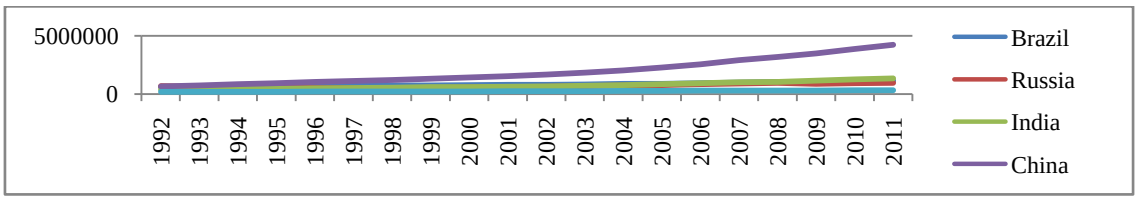
In 1970, the concept of Green Economy was introduced, but at the time of the recent global recession of 2009, it gained much significance. In October 2008, UNEP launched a Green Economy Initiative, which consisted of research, advocacy, and advisory services to the governments. The rationale behind this was to motivate policymakers to facilitate the investments in environmentally friendly sectors like clean technologies, renewable energy, waste management, etc. United Nations Environment Program (UNEP) defined Green Economy is an economy, which improves the well-being of human beings, trims down the inequality and reduces the environmental risks to maintain sustainable development.

As it is only through the balance between environment and economic growth a sustainable and equitable growth can be achieved. In Green Economy, the focus is to increase the economic growth by investing in projects, which drops the pollution, carbon emissions, and increase the efficiency of resources. With the rise in economic growth in advanced and emerging economies, environmental problems like increased pollution, global warming and the depletion of natural resources require the vital role of natural resource management to preserve the future growth. In general, the contribution of developing countries in GHG emissions is lower than that of developed countries. However, over the period in some developing countries the share of manufacturing sectors rose, there is the possibility of adoption of the same type of environmentally harmful industrial practices on which many advanced countries have grown their economies.The BRICS economies have contrary views on the green economy as the accelerator of economic growth. Brazilian policymakers are of the view that green economy concept can be suitable for developed economies as the developing economies do not have additional resources to develop environmentally friendly technologies efficiently. Russia is the leading producer of oil, gas, steel, etc., the processing of these commodities demands the high-energy intensive activities. Russian economy supports the concept of a green economy for long-term sustainable growth. In order to promote inclusive and sustainable growth, Russia has developed a network of environmental institutions and legislative frameworks in cooperation with international organizations like UNEP. The eleventh five-year plan of India had elaborated the approach towards sustainable development. In line with the green economy, India has initiated steps for poverty alleviation and to increase equality. Sustainable development has been part of the alternative development discourse in response to mainstream growth approaches in countries like India. Initiatives like National Action Plan on Climate Change, 2008 that was based on identifying the core environmental problems and ways of dealing with that got success in India. Still, the government needs to frame policies to promote environmentally friendly economic growth.China's rapid economic growth has come at the expense of the environment. In China, at the primary level, the aim has been the economic growth and the issues affecting the environment have been the secondary. China is having the highest emissions in the world, so it faces higher levels of environmental challenges. A green economy can help to address the environmental challenges in China. In its green development plan, China has now involved its strategy for green growth in the medium to long term. South Africa regards the concept of a green economy as a viable path towards sustainable development. As Africa is G-20 representative, it has to play a role in making the concept of developing green economies. South Africa has made major investments in green energy sectors and has developed policies to promote the development of a green economy. South Africa showed its commitment to transitioning to low-carbon technologies and the development of a green economy in its National Development Plan (NDP), which was released in 2011. The climate change puts the question of the sustainability of economic growth, therefore, countries are in need to develop policies and plans that focus on lower carbon emissions. BRICS countries must actively frame and implement policies to transform economic growth in the green economy for sustainable development.As in our analysis, we have used three variables stated as CO2 emissions, Gross Domestic Product (GDP) and Energy consumption. We have plotted the trends for each series of BRICS countries, before taking the logarithm values as shown in graphs 1 to 3.

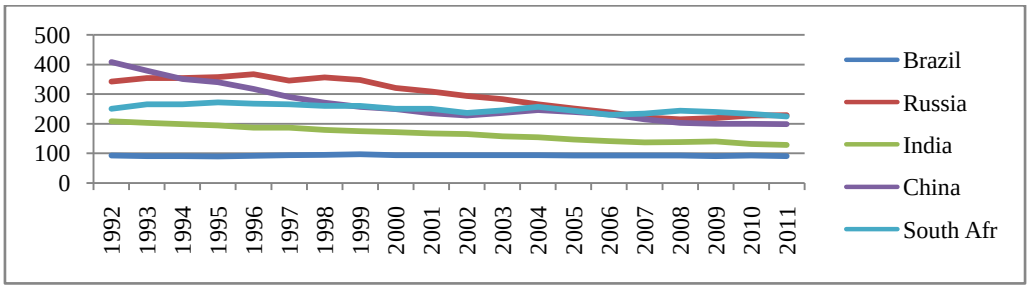
Graph 1: CO_2 Emissions of BRICS (kilotonnes) for (1991-2011)



Graph 2: GDP of BRICS (constant 2005 US$) for (1991-2011)



Graph 3: Energy use (kg of oil equivalent) in BRICS (1991-2011)



In graph 1, the levels of carbon emissions are plotted for the emerging economies of BRICS for the time 1992-2011. China is largest emitting country among the BRICS. Russia was ahead to the India emitter of CO_2, but over the period contribution of India is increasing, however, Brazil and South Africa have a lower contribution to CO_2 emission. Graph 2 depicts the GDP of BRICS countries for the period 1992-2011. China's GDP has shown a significant upward trend, it has increased at an increasing rate. The GDP of India has improved, but still, it was far behind China. The GDP of other BRICS countries, i.e., Brazil, Russia and South Africa has improved but at a slower pace. The level of energy consumption in BRICS countries was higher in the 90s, however, after the mid-2000s, there is a downward trend as depicted in graph 3.

IV. DATA AND METHODOLOGY

Based on the available literature, our study examines the relationship between economic growth, CO2 emissions (kt) and energy consumption among BRICS nations. The annual data on gross domestic product GDP (constant 2005 US$) are used as a proxy for economic growth and energy consumption in kilotons are used as a proxy for energy consumption. The data set includes the yearly observation for the period 1992-2011. The data for this study is obtained from 'World Development Indicators (WDI) 2013'. In this analysis, the dependent variable is CO2 emissions and the independent variables include Gross Domestic Product (GDP) and Energy Consumption in kilotons (En). All the defined variables are transformed into a natural log form in order to remove the problem of heteroskedasticity.For our analysis, we define the double log function:

$$LnCO2_{it} = \alpha + \beta_1 LnGDP_{it} + \beta_2 LnEn_{it} + e_{it}$$

Where,

$LnCO2_{it}$ is a log of Carbon emissions for the country i at time t.

$LnGDP_{it}$ is a log of Gross Domestic Product for the country i at the time t.

$LnEn_{it}$ is a log of Energy consumption in kilotons for the country i at the time t.

$_{it}$ it is the error term over time t.In this study, we used the Panel data model to capture the dynamic behavior of the variables and to provide a more efficient estimate. Panel data models examine group (individual-specific) effects, time effects, or both, in order to deal with heterogeneity or individual effect that may or may not be observed. These effects are either fixed or random effect. A fixed effect model examines if intercepts vary across the group or time period, whereas a random effect model explores differences in error variance components across individual or time period. Fixed effects are tested by the F test while random effects are examined by the Lagrange multiplier (LM) test. If the null hypothesis is not rejected in either test, the pooled OLS regression is favored.

V. EMPIRICAL RESULTS

We have used the data on above-defined variables from the period 1992 to 2011. We have compared the estimation results of pooled OLS with fixed effects model and random effects model as shown Table 1(a).

Table 1(a).Results of pooled OLS, Fixed effects and Random Effects Models.

Variables	Pooled OLS	Fixed Effects Model	Random Effects Model
LnGDP	1.19***	1.09***	1.09***
LnEn	1.55***	1.13***	1.14***
Constant	-16.38***	-12.94***	-13.02***

R square	0.9364	0.975	0.975
Adjusted R square	0.9351	0.973	-
F-Test/Wald (Model)	713.65	1814.56	3690.56
			-
Root MSE	0.1117	0.016	-
SSE	1.21	0.026	0.016
DF	97	93	-
F-test (FE)	-	1024.51	-
N	100	100	100

Firstly, the output of the pooled OLS regression with fixed effects estimations are compared. In both regressions, all the variables are statistically significant at 0.05 levels of significance and CO2 emissions are positively related to GDP and Energy consumption among BRICS nations. But, there is some significant difference between the pooled OLS and fixed effects results. Fixed effects model improved all goodness-of-fit measures like F-test, SSE, root MSE, and (adjusted) R- square significantly but lost 4 degrees of freedom. Thus, we concluded that the fixed effects model is better than the pooled OLS.Secondly, the comparison of the pooled OLS estimation results with the random effects model is carried out by applying Breusch and Pagan Lagrange Multiplier (LM) test as the table 1(b) is depicting. The LM test examines if any random effect exists. The null hypothesis of this test is that individual-specific or time-specific error variance components are zero: H_0: $\sigma^2_u = 0$

Table 1(b). Breusch and Pagan Lagrangian Multiplier Test for Random Effects

	Variance	**S.D.**
Lnco2	.1921101	.4383036
E	.002888	.0169935
U	.0288816	.169946
Test: Var (u) =0 Chibar2 (01) = 868.24 Prob> chibar2= 0.0000		

With the large chi-squared of 868.24 in Table 1(b), we reject the null hypothesis and concluded that individual-specific or time-specific error variance components are not zero i.e. the random effects model is better than pooled OLS.Thirdly, we have applied the Hausman Specification test to know which effect is more significant because both the models are significant.

Table 1(c). Hausman Specification Test Results

	Fixed Effects (b)	**Random Effects (B)**	**Difference (b-B)**	**S.E.**
Lngdp	1.094736	1.097953	-.0032165	.0040045
Lnen	1.135262	1.143357	-.008095	.0094629

b= consistent under H0 and Ha; obtained from xtreg
B= inconsistent under Ha, efficient under H0; obtained from xtreg
Test: H0: difference in coefficients not systematic
Chi2 (2) = 0.73

Prob>ch2= 0.6929

Based on the Hausman specification test as shown in Table 1c, the chi-squares score is 0.73 which is small enough not to reject the null hypothesis. Therefore, we have concluded that the random effects model is better than the fixed effects model. The results show the positive relationship between with the rise in GDP and energy consumption the levels of CO_2 emissions are elevated. For long-term sustainability, there is need to have more environment friendly projects for economic growth in BRICS.

VI. CONCLUSION AND SUGGESTIONS

Over the periods, with economic growth, the climate is also changing. The rate of economic growth of the BRICS economies will have a significant climate change. From the above empirical analysis, it is clear that CO_2 emissions are positively related to GDP and Energy consumption among BRICS nations. Today, BRICS countries are among the largest GHG emitters at the global levels. With the rapid economic growth in the emerging economies, it is assumed that the CO2 emissions will rise, a threat to climate will increase. Therefore, to mitigate the climate change effect, there is a need for close cooperation among BRICS countries. There is a need to promote the economic development by investing in environmental friendly projects, which can lead to sustainable development. This study can be further improved by undertaking extensive variables to find the impacts of economic growth on environment in BRICS.

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