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The Effect Of Economic Growth, Industrialization, Urbanization And Energy Used On CO2 Emission In BRIC Countries

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Abstract

This paper analyses the impact of economic growth, industrialization, urbanization and energy used on carbon dioxide emissions in BRIC countries over the period of 1992-2014. Using the Johannsen-fisher panel cointegration test, the empirical result shows a robust cointegration relationship among the variables. It also examines the long run impact of these variables on carbon dioxide emissions. By applying panel FMOLS and panel DOLS cointegrated regression model we detect the magnitude and sign of cointegration relationship. From the empirical study we found that except economic growth all other variables positively affect the carbon dioxide emissions of the BRIC countries. Among these variables' urbanization has the highest effect on carbon dioxide emissions. Moreover, we also analyze the long run and short run causal relationship among the variables. Here we apply panel VECM and Wald test to test the long run and short run causality respectively. The results reveal a bidirectional causality between urbanization and carbon dioxide emission in the both long run and short run, while there exists a unidirectional causality running from urbanization to economic growth, industrialization and energy used.

Key words: Economic growth, industrialization, urbanization, CO_2 emission, cointegration, panel FMOLS, panel DOLS, Panel VECM.

JEL CLASSIFICATION: C33, O1, O57

Introduction

Economic growth and development of a country accompany with degradation of the environment. Without environmental degradation economic development is not possible. The environmental impact of economic development includes the increased consumption of nonrenewable resources, high level of pollution, global warming and loss of habitat. On the other hand, high rates of economic development and growth are induced by Industrialization; therefore, it is crucial for economic development. But it has severe effect on environment. There are four primary impact comes from industrialization; these are air pollution, water pollution, soil pollution and loss of habitat. Industrialization accompany with an increase in energy used and urbanization. Most of the countries depend on fossil fuel for energy production. Although now a day's renewable energy sources are taking into consideration, but due to high cost of production most of them are unable adopt this. Increasing trend of industrialization in every country increase pressure on earth due to overexploitation of its resources than its reproductive capacity.

Industrialization is mostly related with emission of greenhouse gases which ultimately responsible for climate change. The prominent greenhouse gases are carbon-di-oxide (CO_2), methane (CH_4), water vapor (H_2O) and nitrous oxide (NO_2). CO_2 is considered as the main greenhouse gas among these because of its volume. In this paper we analyze the effect of industrialization on CO_2 emission in BRIC countries. BRIC (Brazil, Russia, India & China) countries are the largest of the middle-income economies and together account for over a fifth of the global economy and here industry is the second largest sector (world bank). Therefore, we analyze the effect of industrialization on carbon emission. Here we consider Industry (including construction), value added (% of GDP) as an indicator of industrialization to show the effect on CO_2 emission. Moreover, industrialization transform the living standards which in turn leads to urbanization. It could contribute to greenhouse gas emissions through deforestation. Altogether economic growth, industrialization and urbanization results an increase in energy used which in turn significantly contributing to GHG emissions. Therefore, the objective of this paper is to show the effect of economic growth, industrialization, urbanization and energy used on CO_2 emission in BRIC countries over the period of 1992-2014. Here GDP, urban population % of total population are considered as an indicator of economic growth and urbanization respectively for BRIC countries. We also examine the short-term and long-term causal relationship among these variables.

The analysis of the relationship between economic growth, urbanization, industrialization and CO_2 emission is important because of it can have useful implication regarding sustainable development. Various studies are made by various authors. Some of them [e.g. York (2007); Cole and Nuemayer (2004)] found positive relationship between urbanization and CO_2 emissions. On the other hand, others have found that urbanization and urban density improve the efficiency of public infrastructure use such as public transport and other Utilities, lowering energy consumption and emissions [e.g. Chen et al. (2008); Liddle (2004); Newman and Kenworthy 1989)].

Methodology

In this paper we investigate the cointegration relationship and assess the long run and short run impact of economic growth, industrialization, urbanization and energy used on CO_2 emission. Here we use a panel data set of BRIC countries over the period 1992-2014. Our empirical analysis relies on FMLOS and DOLS cointegration regression. In order to analyze causal relationship between our variables, we apply panel VECM model and Wald test.

The exploited model is indicated as follows

$$LCO_2 = \propto_{1i} LGDP_{it} + \propto_{2i} LINDUS_{it} + \propto_{3i} LURBANP_{it} + \propto_{4i} LENER_{it}$$

$$(i = 1,2, 3\ldots\ldots, N) \qquad (t = 1, 2, 3, \ldots, T) \qquad (1)$$

The variables in the equation are natural logarithms of carbon di-oxides emissions (LCO_2), GDP (LGDP), [Industry (including construction), value added (% of GDP) {LINDUS}], urban population % of total population ($LURBANP$), and energy used ($LENER$).

Literature Review

There are large amount of literature which founds a causal relationship between energy consumption and economic growth, especially in OECD countries (Lee et al., 2008), in the G7 countries (Narayan and Smyth, 2008), in OPEC member countries (Squalli, 2007), in African countries (Akinlo, 2008; Wolde-Rufael, 2009), in Central America (Apergis and Payne, 2009), in South America (Yoo and Kwak, 2010) , in the Middle East(Al-Iriani, 2006); (Narayan and Smyth, 2009), in Asian countries (Chen et al., 2007; Lee and Chang, 2008), in the Commonwealth of Independent States (Apergis and Payne, 2010), in European countries (Ciarreta and Zarraga, 2010), in developing countries (Lee, 2005; Sari and Soytas, 2007), and in developed and developing countries (Chontanawat et al., 2008; Mahadevan and Asafu-Adjaye, 2007); (Sharma, 2010). They find that economic growth exerts a Granger causal influence on energy consumption in the long-run, and energy consumption points to output growth in the short run.

The study by Ugur Korkut Pata (2018) explored the effect of urbanization and industrialization on carbon emissions in Turkey and he found that an increase in per capita GDP, per capita energy consumption, financial development, urbanization and industrialization have positive effect on per capita CO_2emissions in the long term, and also the variables other than urbanization increase per capita CO_2emissions in the short term.

On the other hand, Xu and Lin (2015) found a nonlinear effect of urbanization on CO_2 emissions in China using nonparametric additive regression models and provincial panel data from 1990 to 2011. He also found that industrialization follows an inverted U-shaped link with CO_2emissions. Al-mulali et al. (2012) analyzed the long run relationship between urbanization and CO_2 emissions in seven regions over the period 1980-2008 by applying Fully modified Ordinary Least Square model, and they found a positive long run relationship between urbanization and CO_2emissions in 84% of countries, while in 16% countries they found mixed results.

Farhani and Rejeb (2012) investigate the short run and long run relationship between Energy consumption, GDP and CO_2emissions in MENA countries by using panel data from 1973-2008. They found that there is no causal link between GDP and energy consumption; and between CO_2emissions and energy consumption in the short run. However, in the long run, there is a unidirectional causality running from GDP and CO_2emissions to energy consumption.

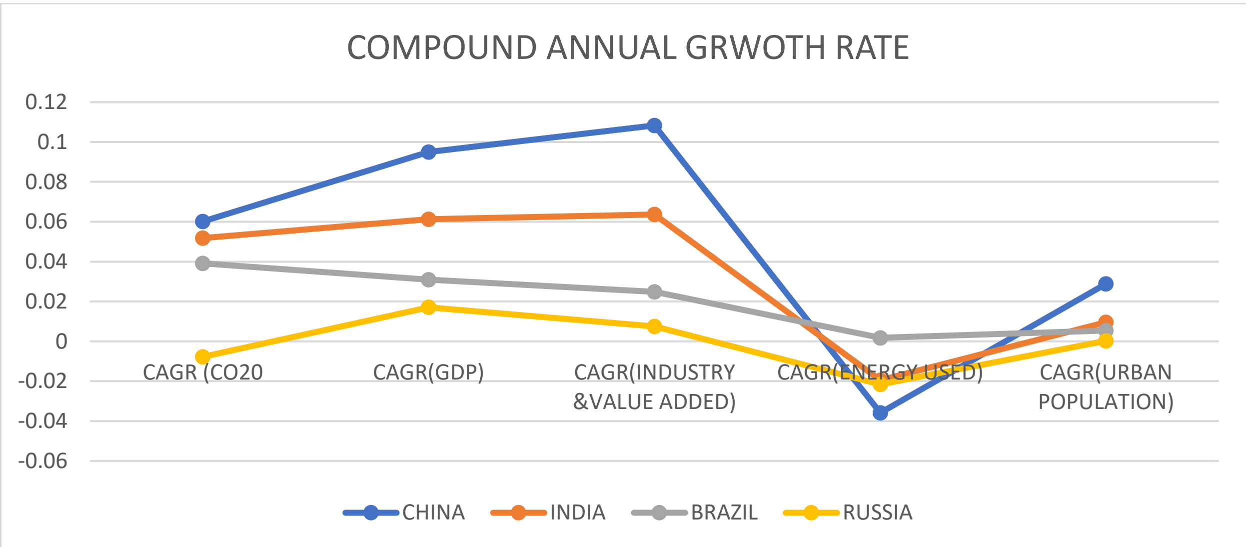
Hossain (2011) examined the relationship between CO2, energy consumption, economic growth, trade openness and urbanization for a panel of nine newly-industrialized countries that included Malaysia, the Philippines and Thailand. The study indicates that income and energy consumption have a long-run significant impact on CO2 emissions in the Philippines and Thailand but not for Malaysia. The panel Granger causality test indicates that there is no long-run causality between income, energy consumption andCO2 emissions. However, in the short run, the causality runs from income to CO2 emissions.

Kais and Ben Mbarek (2017) analyze the relationship between Energy consumption, CO_2emissions and economic growth in the three North African countries on the basis of panel data from 1980-2012 by applying panel co-integration test and panel VECM and they found unidirectional causality running from economic growth to CO_2emissions and also from energy consumption to CO_2emissions.

Results and Discussion

The economic transformation of BRIC countries is very significant in 21st century. The GDP of BRIC countries is responsible for 43% of world's GDP, while Europe and the United states together represent 36% . The emerging countries were also responsible for 70% of the growth of world's GDP (Arbix and salerno, 2008). Most of the researcher found that china has progressed disproportionately better than the other member of BRIC countries. Besides it is clear from the Fig.1 that the CAGR of all other elements of china is higher than the rest of the members of BRIC countries except energy used during the period of 1992-2014. In contrast to this in case of energy used the only brazil has experienced positive CAGR among the BRIC countries. On the other hand, although the CAGR of energy used in china is negative, china has experienced highest CAGR of carbon-di-oxide emission in between the period of 1992-2014. Only Russia has experienced negative CAGR of carbon-di-oxide emission. Consequently, the CAGR of urban population (% of total population) is very negligible in the member countries of BRIC except china. So, it is clear that china is the strongest economic power with highest GDP growth in BRIC countries.

Fig.1



Note: Calculated by the author on basis of data collected from World Bank.

Panel Unit root test

The first step in panel cointegration test is to check the stationarity of the data set. In order to test the stationarity of the data set we run Im pesaran and shin unit root test by taking lag 1. The results are given in the following table 1. Here we found that except Ln Industry (including construction), value added % of GDP) all other variables are non-stationary at level. Therefore, we take first difference of all variables and we found that all variables except urban population % of total population are stationary. In order to get the stationarity of the variable urban population % of total population we take second order difference. Here we found that all the variables are stationary at 1% significance level except urban population. The results are given in the table 1

Table 1 Panel Unit Root Test

	level	First difference	2nd order difference
Im pesaran and shin	**W-t-bar Statistic**	**W-t-bar Statistic**	**W-t-bar Statistic**
Ln Industry (including construction), value added (% of GDP)	-2.3368 ***	-4.1866 ***	-10.1979 ***
Ln energy used	1.5849 (0.9435)	-3.7029 ***	-7.2729 ***
Ln CO_2 emission kt	1.342 (0.9102)	-2.8551 ***	-7.4304 ***
Ln GDP	2.9854 (0.9986)	-3.3005 ***	-7.0200 ***
Ln urban population	2.1708 (0.9850)	1.3437 (0.9105)	-2.6038 **

Note:

p values are in bracket *** indicates significance at 1%. ** indicates significance at 5%.

Panel cointegration test

We have seen that all the variables are stationary. On the basis of the result of panel unit root test we have proceed to run panel cointegration test to make sure that there is a stable equilibrium relationship. Here we rely on Johansen Fisher's panel cointegration test. From the table 2 it is clear that Johansen Fisher's Panel Cointegration results clearly reject the null hypothesis of no cointegration. According to panel cointegration result, we can assume that there exists a long run equilibrium relationship between CO_2 emission, GDP, urbanization, energy used and industrialization. The results are given in following table 2.

Table 2

Johansen and Fisher Panel cointegration test				
	Fisher Stat.*			
Hypothesis	**(from trace test)**	**Prob.**	**(from maxeigen test)**	**Prob.**
None	119.2	0.0000	63.56	0.0000
At most 1	69.24	0.0000	36.12	0.0000
At most 2	40.05	0.0000	25.64	0.0012
At most 3	23.02	0.0033	16.32	0.0380
At most 4	20.27	0.0094	20.27	0.0094

Note:

Trend assumption: Linear deterministic trend

Lags interval (in first differences): 1 1

Panel DOLS and Panel FMOLS

Having established a unique cointegration relationship among the variables, we can apply Panel Dynamic Least Squares (DOLS) and panel FMOLS methods. Panel DOLS and FMOLS methods are more efficient than OLS because it takes care endogeneity by adding leads and lags (DOLS). Panel DOLS method is a parametric method that is used to obtain long run coefficients. On the other hand, panel FMOLS is a method which eliminate serial correlation effect. These methods are applicable under the condition that there exist a cointegrating relation among the variables. By this means, we can detect the magnitude and direction of the relationship between the dependent variable CO_2 emission and independent or explanatory variables GDP, energy used, industrialization and urbanization. By applying both of these method sit is possible to analyze without loss of any information about dependent and explanatory variables.

The group mean Panel FMOLS method is based on the following panel regression model:

$$yit = \propto_i + \beta Xit + eit \quad (2)$$

$$Xit = Xit-1 + it \quad (3)$$

Group mean Panel DOLS method is based on the following panel regression model:

$$Yit = \propto_i + \beta Xit + \gamma ik\Delta Xit-k + it \quad (4)$$

Here p_i and $-p_i$ are lagged and lead values. It is assumed that there is no dependence relationship between cross sections according to this model.

Table 3 represents the results of panel FMOLS and DOLS regressions. The results of panel FMOLS and DOLS shows that all variables are statistically significant and have positive coefficients except LGDP. According to the panel FMOLS results, LGDP is significant at 10% level in BRIC countries and the coefficient of LGDP have negative sign which is 0.270015, it implies that increase in GDP of BRIC countries leads to decline in CO_2 emission by 0.27% and 0.46% as per the both FMOLS and DOLS model respectively. When we examine the variable urban population, we found that it is significant at 1% level in FMOLS model and at 10% level in DOLS model. The empirical results of both FMOLS and DOLS model shows that increase in urban population as percentage of total population leads to increase in CO_2 emission in the long run by 1.42% and 1.41% respectively. The outcome of LENER series indicates that coefficient of LENER is significant at 1% level in both FMOLS and DOLS model. It is seen from the table 3 that increment in energy used also positively affect the CO_2 emission in BRIC countries by 1.29% in FMOLS model and 1.33% in DOLS model. Similarly, industrialization have also significantly positive impact on CO_2 emissions. According to FMOLS model 10% increase in industrialization leads to 0.23% increase in CO_2 emissions. On the other hand, according to DOLS model 5% increase in industrialization leads to increase in CO_2 emission in BRIC countries in the long run. The panel DOLS estimator is more efficient than panel FMOLS estimator. From the analysis it is clear that as per the panel DOLS model the urbanization, energy used and industrialization have significantly positive impact except GDP on CO_2 emissions in BRIC countries in the long run.

Table 3

FMOLS			**DOLS**		
Variables	**Coefficients**	**t- stat.**	**Variables**	**Coefficients**	**t- stat.**
LGDP	-0.270015	-1.676655 *	LGDP	-0.462099	-1.984564 **
LURBANP	1.422425	3.78395 ***	LURBANP	1.414813	1.728929 *
LENER	1.288248	15.8314 5 ***	LENER	1.332323	9.003312 ***

LINDUSTRY	0.234737	1.669002 *	LINDUSTRY	0.415249	1.993543 **

Note: here *, ** and *** represent the significant level of 10%, 5% and 1%.

Panel Granger Causality Test

We found that there exists co-integration among the variables. The existence of cointegration implies the existence of causality at least in one direction (Mostefa Belmokaddem, et al). Having established co-integration relationship among the variables we apply panel VECM and Wald test to test long run and short run causality between CO_2 emissions, GDP, industrialization, Energy used and urbanization respectively. The model of panel VECM model is mentioned below.

$$\Delta LCO2_t = \varphi_1 + \sum_{i=1}^{n} \propto_{1i} \Delta LCO2_{t-i} + \sum_{j=1}^{n} \beta_1 \Delta LGDP_{t-j} + \sum_{k=1}^{n} \gamma_{1k} \Delta ENER_{t-k} + \sum_{l}^{n} \delta_{1l} \Delta LINDUS_{t-l} + \sum_{q}^{n} \theta_{1q} \Delta URBANP_{t-q} + {}_1ECT_{t-1} + \mu_{1t} \quad (5)$$

A panel VECM can be applied to test both short run and long run causality. Before the estimation of panel VECM, the number of optimal lags was considered as 1 Akaike AIC criteria under unrestricted panel VAR model. As illustrated in the above table 4, the short run causality tests are performed by applying Wald chi statistics and the long run causality is deduced from the coefficients of ECT and corresponding t-statistics. In case of short run causality, we found that there is no causal relationship between CO_2 emissions and other explanatory variables except urban population. In case of urban population, we found that there is bidirectional causal relationship running from urban population to CO_2 emissions in short run. Moreover, we also found unidirectional causality running from urban population to energy used, economic growth and industrialization.

For long run causality the coefficients of ECT is taking into consideration. From the table 4 it is clear that the coefficients of ECT is negative only then, when the dependent variable is CO_2 emission and urbanization. It means that there exist long run causality running from the explanatory variables to CO_2 emissions. In the long run we found a bidirectional causal relationship between CO_2 emissions and urbanization.

Table 4

Panel Granger Causality based on VECM estimation

	direction of causality /explanatory variables

Dependent variable	chi-square statistics and p-value					Long run coefficient, t-statistics
	Ln co2	Ln energy	Ln GDP	Ln industry	Ln urban pop	ECT
Ln co2		0.680512	0.304565	0.06155	4.982337 **	-0.027521 *
		-0.4094	-0.581	-0.8041	-0.0256	-0.0827
Ln energy	0.262103		0.042448	0.001126	8.195857 **	-0.000819
	-0.6087		-0.8368	-0.9732	-0.0042	0.9452
Ln GDP	1.628712	2.376851		0.624242	9.652005 ***	-0.01609
	-0.2019	-0.1231		-0.4295	-0.0019	-0.1505
Ln industry	0.880456	0.788847	0.11832		10.04429 ***	-0.020301
	-0.3481	-0.3744	-0.7309		-0.0015	0.2111
Ln urban pop	2.807839 *	0.99077	0.02371	0.203983		-0.000976 ***
	-0.0938	-0.3196	-0.8776	-0.6515		0.0025

Note: here *, ** and *** represent the significant level of 10%, 5% and 1%.

Conclusion and policy implication

This study investigates the effect of economic growth, industrialization, energy used and urbanization on CO_2 emissions in BRIC countries. From the investigation we found that all these variables except economic growth positively affect the CO_2 emissions in BRIC countries over the period of 1992-2014. Moreover, we also found a bidirectional causal relationship between CO_2 emissions and urbanization in the both short run and long run respectively. While in the short run we did not find any causal relationship between CO_2 emissions, economic growth, industrialization and energy used. In contrast to this in the short run there exist a unidirectional causality running from urbanization to economic growth, industrialization and energy used. From the discussion we can say that urbanization increase the economic activities in BRIC countries which in turn increase the CO_2 emissions. Although urbanization increase the CO_2 emissions it also helps to facilitate economies of scale for public infrastructure and this result in reduced environmental damage.

Industry sector of BRIC countries plays an important role in the economy of these countries. Increasing trend of industrialization demand more energy and increase in energy consumption leads to increase in CO_2 emissions in these countries because for energy BRIC countries mainly depends on non- renewable resources. So, it is necessary to increase the use of renewable resources. For doing this technological innovation is very crucial to reduce the emission of CO_2.

The implication of results found in the study on BRIC countries suggest that achievement of urbanization sustainability is necessary to ensure decrease in CO_2 emissions. For doing this, effective environmental policies are required. Furthermore, there is a need for the BRIC countries to reduce the consumption of fossil fuels. In contrast to this they should transform their industries to a green economy as per as possible.

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