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Factors Affecting CO₂ Emissions in the BRICS Countries: A Panel Data Analysis

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Abstract

The effects of climate change are being felt on all continents of the world and these impacts are predicted to intensify in the coming decades. Unmitigated climate change poses great risks to human health, global food security, and economic development and to the natural world on which much of our prosperity depends. Society therefore needs to take measures to adapt to these unavoidable impacts while taking action to cut the greenhouse gas emissions that are contributing to climate change. This study analyzes the interactions that may exist between the total energy consumption, FDI, economic growth, and the emission of CO₂ in the BRICS countries, using the co-integration tests and panel Granger causality in panel. The results show significantly that there is a co-integration relationship between CO₂ emissions and economic variables. The results also indicate the existence of a unidirectional causality from CO₂ to the independent variables. These results can help decision makers in these countries to understand and grasp the complexity of this phenomenon; a better understanding of this phenomenon will probably better guide future decisions to deal with this threat that weighs more heavily on the scene world politics.

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1. Introduction

Human activities are altering the global environment on an unprecedented level. The concentration of green house and ozone depleting gases in the atmosphere, the accelerated undeniably related to the human activity (Spangenberg, 2007). The question of how economic activities affect environment has become popular among

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scholars by 1960s, although historical records show that human related environmental catastrophes are not a rare event. For example, even by 800 B.C. terracing for rice farming led to a massive deforestation in China, and during the height of the Roman Empire, land and water around Rome became highly contaminated by human related activities (Kula, 1998). Yet, by those times, as Hahnel (2010) argues, the world was “empty” and environmental problems were local, which allowed humans to continue their unsustainable way of living without bothering with such questions. However, especially after the Industrial Revolution in the 18th century, the world population started to grow rapidly and ecological scarcities started to felt themselves. In 1966, the publication of a short chapter entitled “The economics of the coming Spaceship Earth” (Boulding, 1966) changed radically the economic thought. Viewing the earth as a small spaceship where all economic activities take place, Boulding argues that as population and economic activity continue to increase, the scarcity and the waste problems upon the spaceship will worsen (Kula, 1998). The term “sustainable” in modern ages was first spelled in the famous report of Club of Rome entitled *The Limits to Growth* (Meadows et al., 1972), and since then it has been gaining increasing interest from scholars. In 1980, “sustainable development” concept was introduced by the International Union for Conservation of Nature and Natural Resources report (IUCN, 1980), but it was after the publication of the *Our Common Future*, commonly known as Brundtland Report (WCED, 1987), the concept gained popularity.

In the last three decades, the effects of economic activities on CO₂ emissions have become a topic very significant both at the national and international level. However, due to the increase in the production scale it turns an environmental degradation. This phenomenon is now part of the political and economic choices of the countries. This concern manifested itself internationally though the organization of conferences in Stockholm in 1979, Rio de Janeiro in 1992, Johannesburg in 2002 and Copenhagen in 2009 and Durban in December 2011. Nowadays many countries, especially developing ones are facing a major challenge, namely, the multi-directional links between economic, social and environmental aspects of development. They one trying to fight poverty, increase economic opportunities and protect the environment.

Worldwide organizations, such as the United Nations (UN) or the World Economic Forum (WEF), have been attempting to reduce the adverse impacts of global warming and climate change on the economy. The Kyoto protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is one of the important solutions to reduce greenhouse gases (GHG).

The objective of the 1997 Kyoto protocol was to reduce greenhouse gases (GHG), which cause climate change, and it demanded a reduction of GHG emissions to 5.2% lower than the 1990 level during the period from 2008 to 2012. This came into force in 2005. Though BRICS countries (Brazil, Russian Federation, India, China and South Africa) signed the Kyoto protocol to curb emission levels, there are still environmental concerns given the region's recent economic growth.

The BRICS countries are frequently referred to have attracted a great deal of media and academic attention in the recent years. These countries are different from one another in their culture, background, language, and the structure of their economies. However, they have a common denominator: economic growth development in the BRICs has greatly exceeded growth compared to the world's leading industrialized nations. Even after the economic crisis that started in 2007, they continued outperforming the rest of the world. While in 2009 large economies shrunk as much as 6%, (e.g., Japan and Germany), Brazil stayed steady, India grew 5.9% and China 8.1%; only Russia was the group's bad performer shrinking 7%. This and the forecast for 2015, which gives all these countries an expected economic growth above the average of developed economies, further increase the interest on these countries.

There is a large amount of literature to explain the causal relationship between energy consumption and GDP, FDI and GDP, as well as some of CO₂ emissions, energy consumption and GDP using a multivariate framework over the past two decades. These studies are often limited by the measurement method, which reduces the reliability of information on environmental policies. These limitations include focusing on a single country, a too-short period covered by the data sample, and the omission of important variables. To reduce these problems in econometric estimation, this study further extends the above-mentioned multivariate framework by including the impact of foreign direct investment into the nexus using a panel data set. However, there is no systematic time series investigation so far analyzing the relationship between pollutant emissions, energy use, output and FDI by BRIC countries. This research seeks to fill the gap in the literature. The dynamic interrelationship in the output-energy-

FDI-environment nexus is analyzed by applying a panel Co-integration technique and a panel causality link in the short-run and long-run.

2. Literature review

a. *Human activity and environment*

The question of how human activity interacts with environment can be traced back to the times of Malthus. In his famous 1798 book, titled as, “An Essay on the Principle of Population” Malthus proved that the growth of population will eventually reach the limit of resource base in the absence of technological progress. In early 1970s, a debate between Commoner, Ehrlich and Holden (1971) gave rise to the development of a formula, called as IPAT (Commoner et al., 1971), which summarizes the impact of human activity on the environment. This formula states that total environmental impact (I) is the multiplicative product of population (P), affluence (A) and technology (T) (see Marin and Mazzanti, 2009).

Conventional wisdom sees economic growth as indispensable in increasing human well-being. Yet, this view has been challenged recently especially after the global economic crisis in 2008. For example the proponents of “degrowth movement” put the paradigmatic proposition as “human progress without economic growth is possible” (Schneider et al., 2010), by also adding that sustainable degrowth does not necessarily mean degrowth in all and every sector or regions. Jackson (2009) also accepts that current development paradigm is unsustainable but he also criticizes the degrowth proposal as being “unstable” in today’s circumstances, for it may lead to “rising unemployment, falling competitiveness and a spiral of recession” (p. 46), and proposes zero growth. Proponents of green economy, on the other hand, see the triple crisis as an opportunity and argue that green investments in key sectors, like energy, construction etc., are able to create green jobs and to replace carbon-based economy with that of renewable-energy (Barbier, 2010). For them, “green Keynesian” (or popularly known as Green New Deal) policies have a capacity to heal the triple crisis in the short-run and to pave the way towards sustainability in the long-run, a promise which is attacked by many scholars as naïve on the grounds that they do not take into account the so-called rebound effect at least (Schneider et al., 2010).

The relationship between energy consumption, CO₂ emission, and the macroeconomic variables has attracted many researchers, particularly the correlation between energy consumption, CO₂ emission, and GDP growth such as (Poa et al, 2012); (Arouri et al,2012);(Saboori and Sulaiman,2013);(Park and Hong,2013);(Khan MA et al.2013); (Govindaraju and Tang, 2013); (Alam et al,2012); (Hagggar 2013). However, there have been a number of recent studies exploring the relationship between energy consumption, CO₂ emission, and trade. This is because the world had witnessed a substantial growth in international trade of goods, services, and capital over the last two decades. This growth in international trade increased its value over 77% during the period of 1990–2011 (The World Bank.)

3. Economy growth, energy consumption and CO₂ emissions literature review

A fairly large amount of literature finds 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 Soytaş, 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.

(Niu et al, 2011) Investigated the long-run relationship between energy consumption, GDP and CO₂ for eight Asia-Pacific countries that included four developing countries, namely China, India, Thailand, and Indonesia using panel data techniques. For the developing countries there was a long-run relationship between energy consumption,

coal, oil, and CO₂ emissions. Conversely, they could not find any long-run relationship between natural gas and electricity on CO₂ emissions. Similarly, the study concludes that the main cause of CO₂ emissions is energy consumption, especially in developing countries. The study also examines the individual countries by establishing individually-fixed varying coefficient model between per capita energy use and CO₂ emissions. For Thailand and Indonesia, the coefficient of energy consumption on CO₂ emissions is 3.44 and 3.11, respectively. Similarly, unlike the case of developed countries, the effect of per capita GDP on per capita CO₂ emissions is greater than unity, for instance, Thailand (2.08) and Indonesia (2.03). Both the coefficients of energy consumption and GDP on CO₂ emissions are relatively high for Thailand and Indonesia. Granger causality results for the developing countries show causality running from CO₂ emissions to GDP and energy consumption to CO in the long run. However, in the short run, they found evidence of unidirectional causality running from energy consumption to CO₂ emissions.

(Hossain, 2011) examined the relationship between CO₂, energy consumption, economic growth, trade openness and urbanisation for a panel of nine newly-industrialised 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 and CO₂ emissions. However, in the short run, the causality runs from income to CO₂ emissions.

(Ang, 2008) examined the long-run relationship between GDP, CO₂ and energy consumption for Malaysia. The results indicate that CO₂ emissions and energy consumption are positively related to GDP in the long run. The long-run elasticity of GDP with respect to CO₂ emissions and energy consumption are found to be 0.238 and 0.548, respectively. The results of the Granger causality show that there is evidence of unidirectional causality running from GDP to energy consumption in the long run. Likewise, there is also a weak causality running from CO₂ emissions to economic growth in the long-run. However, the study did not test the EKC hypothesis or the impact of transport energy use and FDI on CO₂ emissions.

4. FDI-Pollution nexus literature review

The existing literatures did not directly treat the FDI–pollution nexus but based their analyses on the causality from environmental regulation stringency to firm's competitiveness as entry point. They supposed under globalization circumstance, the relatively lax environmental regulation in the developing countries becomes an attractive comparative advantage to the pollution-intensive foreign capital seeking for a 'pollution-haven' to avoid paying costly pollution control compliance expenditure domestically. Though this 'pollution haven' hypothesis sounds reasonable, almost no empirical analysis has yet provided convincing supportive evidences revealing FDI's searching activity for the 'production platforms' permitting lower pollution abatement cost.

Although the majority of the studies are focused on economic development and environmental degradation, many articles have pointed out that another possible determinant of environmental performance is financial development. (Frankel and Romer, 1999) found that financial liberalization and development may attract FDI and higher degrees of R&D investments, which in turn can speed up economic growth and hence affect the dynamic of the environmental performance. (Birdsall and Wheeler, 1993) and (Frankel and Rose, 2002) indicated that financial development provides developing countries with the motive and opportunity to use new technology, help them with clean and environmentally friendly production, and consequently improve the global environment at large and enhance the sustainability of regional development. Additionally, (Jensen, 1996) and the World Bank have asserted that although financial development may enhance economic growth, it may result in more industrial pollution and environmental degradation. (Tamazian et al, 2009) found that a higher degree of economic and financial development decreases environmental degradation. In this study, we employed FDI inflows as a measure of financial development.

According to the pollution haven hypothesis, weak environmental regulation in a host country may attract inward FDI by profit-driven companies eager to circumvent costly regulatory compliance in their home countries (Jensen, 1996; Hoffmann et al., 2005; Dean et al., 2009). Second, according to the pollution-halo hypothesis, in applying a universal environmental standard, multinationals engaging in FDI will tend to spread its greener technology to their counterparts in the host country (Birdsall and Wheeler, 1993; Zarsky, 1999; Sandborke and Metha 2002). Finally, a scale effect would arise to the extent that multinational FDI operation would significantly contribute to a host

nation's industrial output and in turn the overall pollution level (Jian and Rencheng, 2002). Despite these clear theoretical arguments, empirical work designed to test these hypotheses has so far been unable to provide conclusive results (Smarzynska and Wei, 2001). Therefore, this research argues that there are strong dynamic interrelationships between output, energy consumption, environmental pollutants and FDI, which should be investigated in the same multivariate framework.

5. Data

All data used in this study are annual observations covering the period from 1990 to 2012 obtained from two sources. The Data on GDP per capita and FDI Net Inflow at current prices (U.S. dollars) are obtained from the World Bank; GDP per capita is particularly useful when comparing one country to another, because it shows the relative performance of countries. An increase in GDP per capita indicates a growing economy and tends to lead to an increase in productivity. Per capita Carbon dioxide emissions (CO₂) defined in Metric Tons of Carbon Dioxide per person and Total primary Energy conception per capita, extracted from energy information administration. Our database includes 6 countries.

6. Methodology

In the analysis of the relationship in long-term panel data, the choice of the appropriate technique is an important theoretical and empirical question. Co-integration is the most appropriate technique to study the long-run relationship between the study variables. The empirical strategy used in this paper can be divided into four main stages. First, unit root tests in panel series are undertaken. Second, if they are integrated of the same order, the co-integration tests are used. Third, if the series are co-integrated, the vector of co-integration in the long term is estimated by using the methods (FMOLS) and (DOLS). Fourth, after estimating the long run relationship using FMOLS and DOLS methods, we proceed to Panel Granger Causality.

7. Panel unit root test

Many economic variables are characterized by stochastic trends that might result in spurious inference. A time series is said to be stationary if the auto covariances of the series do not depend on time. Any series that is not stationary has a unit root. The formal method of testing stationarity is the unit root test. The recent literature suggests that panel based unit root tests have a higher power than unit root tests based on individual time series.

The panel unit roots tests have many similarities, but they are not identical with unit root tests for individual time series.

They are simply multiple-series unit root tests that are applied to panel data structures where there is the presence of cross-sections generating 'multiple-series' out of a single series. There are six types of unit root tests for the panel data, namely the (Levin, Lin and Chu, 2002; Breitung, 2000; Im, Pesaran and Shin, 2003), Fisher type tests using the ADF and the PP test, and the Hadri unit root test. These tests are simply multiple-series unit root tests that have been applied to panel data structures.

LLC and IPS seem to be the most use tests; LLC is the procedure most commonly used. It is based on the ADF test, assumes a homogenous group.

Levin et al is based on the following equation:

$$Y_{it} = \rho_i Y_{i,t-1} + z_{it} \gamma + u_{it} \quad i = 1, \dots, N; \quad t = 1, \dots, T \quad (1)$$

Where z_{it} is the deterministic component and u_{it} is the stationary process. z_{it} can be a fixed effect or time trend as well as a constant like zero and 1. The LLC test assumes that residuals are independently and identically distributed with mean zero and variance σ_u^2 and $\rho_i = \rho$ for all values of i .

The coefficient of the lagged dependent variable is assumed to be homogeneous in all units of the cross section of the panel. The null hypothesis can be constructed as $H_0: \rho = 1$ which means that all series in the panel have a unit roots whereas in the alternative hypothesis $H_1: \rho < 1$ which means that all series are stationary.

Im et al; The IPS test is an extension of the LLC test that relaxes the homogeneous assumptions by allowing for heterogeneity in the autoregressive coefficients for all panel members. The basic equation for the panel unit root tests for IPS is as follows:

$$\Delta y_{i,t} = a_i + \rho_i y_{i,t-1} + \sum_{j=1}^P \varphi_{ij} \Delta y_{i,t-j} + \varepsilon_{i,t} \quad i=1,2,\dots,N; t=1,2,\dots,T \tag{2}$$

Where $y_{i,t}$ stands for each variable under consideration in our model, a_i is the individual fixed effect, $\varepsilon_{i,t}$ are assumed to be independently and normally distributed random variables for all i and t with zero means and finite heterogeneous variance σ_i^2 . P is selected to make the residuals uncorrelated over time. The null hypothesis is that $\rho_i = 0$ for all i versus the alternative hypothesis that $\rho_i < 0$ for some $i = 1, \dots, N_1$ and $\rho_i = 0$ for $i = N_1 + 1 \dots N$.

The IPS statistic is based on averaging individual Augmented Dickey-Fuller (ADF, hereinafter) statistics and can be written as follows:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^N t_{iT} \tag{3}$$

Where t_{iT} is the ADF t-statistic for patient i based on the patient specific ADF regression, as in Eq. (2) IPS show that under the null hypothesis of non-stationary in panel data framework, the \bar{t} statistic follows the standard normal distribution asymptotically. The standardised statistic t_{IPS} is expressed as:

$$t_{IPS} = \frac{\sqrt{n} \left(\bar{t} - \frac{1}{N} \sum_{i=1}^N E[t_{iT} | \rho_i = 0] \right)}{\sqrt{\frac{1}{N} \sum_{i=1}^N \text{Var} [t_{iT} | \rho_i = 0]}} \tag{4}$$

8. Panel Co-Integration test

(Engle and Granger, 1987) reported that a linear combination of two or more non-stationary time series may be stationary. According to (Granger, 1988), Co-integration means that the two or more non-stationary variables are integrated in the same order with the stationary of residuals. If the variables are cointegrated, there exists a force that converges into a long-run equilibrium.

The cointegrating equation may be interpreted as a long-run equilibrium relationship among variables.

Similar to the panel unit root tests, the panel Co-integration tests are much more powerful than the normal time series Co-integration. The Pedroni test will be employed in this study to examine whether the long run relationship exists between the variables. Pedroni made several tests to test the null hypothesis of no Co-integration in the panel data model. This test allows for a considerable heterogeneity. The Pedroni Co-integration test can be organized in two groups. The first group involves average test statistics for no Co-integration in the time series across cross section while in the second group set the average is done in piecemeal so that the limiting distributions can be based on limits of piecewise numerator and denominator terms.

Pedroni considers the following type of regression:

$$y_{it} = a_i + \delta_i t + \beta_i X_{it} + \varepsilon_{it} \tag{5}$$

For a panel of time series observable y_{it} and X_{it} for the numbers $i = 1, \dots, N$ for periods of time $t = 1, \dots, T$. The variables y_{it} and X_{it} are supposed to be integrated of order one, denoted $I(1)$, the parameters a_i and δ_i they allow the opportunity to observe the individual effects and individual linear trends, respectively. The β_i slope coefficients are allowed to vary from one person to another, so in general, the co-integration vectors may be

heterogeneous among the panel members. Pedroni proposes seven statistics to test the null hypothesis of no co-integration in heterogeneous panels. These tests include two types of tests. The first is the Co-integration tests panel (within-dimension). Within tests dimensions consist of four statistics, namely panel v -statistic, panel ρ -statistic, panel PP-statistic, and panel ADF-statistic. These statistics pool the autoregressive coefficients across different members for the unit root tests on the estimated residuals, and the last three test statistics are based on the "between" dimension (the "Group"). These tests are group ρ , group PP, and group ADF statistics.

All seven tests are conducted on the estimated residuals from a model based on the regression in (5). Following, Pedroni, heterogeneous panel and heterogeneous group mean panel Co-integration statistics are calculated as follows:

$$\text{Panel } v - \text{Statistics} \quad z_v \equiv T^2 N_i^{-1} \left(\sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1} \tag{6}$$

$$\text{Panel } \rho - \text{Statistics} \quad z_\rho = \left(\sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right) \tag{7}$$

$$\text{Panel PP} - \text{Statistic} \quad z_i = \left(\bar{\sigma}_{N,T}^2 \sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 (\hat{\epsilon}_{i,t-1} \Delta \hat{\epsilon}_{it} - \hat{\lambda}_i) \tag{8}$$

$$\text{Panel ADF} - \text{Statistic} \quad z_i^* \equiv \left(\bar{\sigma}_{N,T}^2 \sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^N \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1} \Delta \tag{9}$$

$$\text{Group } \rho - \text{Statistics} \quad \tilde{z}_\rho \equiv TN^{-1/2} \sum_{i=1}^N \left(\sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1} \tag{10}$$

$$\text{Group PP} - \text{Statistic} \quad \tilde{z}_t \equiv N^{-1/2} \sum_{i=1}^N \left(\bar{\sigma}_i^2 \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1/2} \sum_{t=1}^T (\hat{\epsilon}_{i,t-1} \Delta \hat{\epsilon}_{it} - \hat{\lambda}_i) \tag{11}$$

$$\text{Group ADF} - \text{Statistic} \quad \tilde{z}_t^* \equiv N^{-1/2} \sum_{i=1}^N \left(\sum_{t=1}^T \hat{S}_i^2 \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1}^2 \right)^{-1/2} \sum_{t=1}^T \hat{\epsilon}_{it}^2 \hat{\epsilon}_{i,t-1} \Delta \hat{\epsilon}_{it}^* \tag{12}$$

9. Empirical results

The general specification of the model we estimate can be written as follows:

$$CO2_{it} = a_{0i} + b1iGDP_{it} + b2iFDI_{it} + b3iEC_{it} + \epsilon_{it}$$

With: CO2 is the per capita carbon dioxide emissions, GDP is the gross domestic product, FDI is the foreign direct investment, and EC is the total primary energy consumption ϵ_{it} is an error term. This equation is considered a balanced long-term relationship if she has Co-integration relations. The data must then be integrated in the same order.

We will test the stationarity and the relationship of long-term series of these variables, the technical unit root and co-integration panel data require a minimum of homogeneity in order to draw more general conclusions. It is for this reason that we broke our sample into six economically close countries.

10. Unit root tests

To investigate the stationarity of the series used, we used the unit root tests on panel data (LLC, IPS, BRT, and MW). The results of these tests are presented in the following tables:

Table 1: Unit root tests for the variables in six countries

Null: Unit Root		Null: NO Unit Root						
Methods	Variables	Levin, Lin and Chu (LLC)	Breitung t-stat	Im, Pesaran And Shin (IPS) W-stat	MW-ADF Fisher Chi-square	MW-PP Fisher Chi-square	Hadri Z-stat	Heteroscedastic consistent Z-stat
Level	CO2	-1.24077 (0.1073)	-1.41899 (0.0780)	-1.75467 (0.0397)	19.6148 (0.0331)	14.5133 (0.1508)	3.00204 (0.0013)*	2.02516 (0.0214)
	EC	-0.99791 (0.1592)	-2.55343 (0.0053)*	-1.19868 (0.1153)	16.1654 (0.0950)	16.4948 (0.0863)	2.68161 (0.0037)*	2.29885 (0.0108)
	FDI	-2.67727 (0.0037)*	-1.08284 (0.1394)	-3.40404 (0.0003)*	30.0389 (0.0008)*	19.4475 (0.0349)	1.69570 (0.0450)	1.69455 (0.0451)
	GDP	-1.22666 (0.1100)	1.10374 (0.8651)	-1.58213 (0.0568)	15.0433 (0.1305)	8.43628 (0.5863)	3.56005 (0.0002*)	2.48824 (0.0064)*
First difference	ΔCO2	-6.70475 (0.0000)*	-4.77474 (0.0000)*	-7.02706 (0.0000)*	55.6559 (0.0000)*	180.345 (0.0000)*	1.68828 (0.0457)	5.33730 (0.0000)*
	ΔEC	-8.04939 (0.0000)*	-7.98605 (0.0000)*	-6.98314 (0.0000)*	54.8273 (0.0000)*	306.317 (0.0000)*	-0.10007 (0.5399)	3.87356 (0.0001)*
	ΔFDI	-4.96927 (0.0000)*	-2.91911 (0.0018)*	-6.40446 (0.0000)*	50.3448 (0.0000)*	59.6577 (0.0000)*	1.44102 (0.0748)	0.68456 (0.2468)
	ΔGDP	-3.38372 (0.0004)*	-2.69087 (0.0036)*	-3.14411 (0.0008)*	25.6583 (0.0042)*	22.4400 (0.0130)	2.91169 (0.0018)*	2.55392 (0.0053)*

* Significance at 1%. Δ is the first difference operator.

The results of the unit roots in panel, shows that all the variables for the six countries in Level are not stationary, but in first differences all variables are stationary. Stationarity for all countries in the first difference leads us to study the existence of a long-term relationship. Therefore, we find that all variables are integrated of order 1.

11. Co-Integration

We have seen that all variables are integrated order.1, Based on these test results panel unit root, we proceed to test co-integration panel, and that by relying on tests Pedroni. The results are as follows:

Table 2: Co-integration tests for the SIX COUNTRIES

Methods	Within dimension (panel statistics)			Between dimension (individuals statistics)		
	Test	Statistics	Prob	Test	Statistics	Prob
Pedroni (1999)	Panel v-statistic	1.020319	0.1538	Group ρ-statistic	0.247190	0.5976
	Panel rho-statistic	-0.590889	0.2773	Group pp-statistic	-9.908542	0.0000
	Panel PP-statistic	-5.111237	0.0000	Group ADF-statistic	-5.449957	0.0000
	Panel ADF-statistic	-4.673604	0.0000			
Pedroni (2004) (Weighted statistic)	Panel v-statistic	0.787656	0.2154			
	Panel rho-statistic	-0.452936	0.3253			
	Panel PP-statistic	-4.624218	0.0000			
	Panel ADF-statistic	-3.948873	0.0000			

* Significance at 1%. Δ is the first difference operator.

The table summarizes the results of seven (07) Statistical Co-integration Pedroni, four probability values are less than 5%. It is mainly (Panel PP-Statistic) and (Panel ADF-Statistic) regarding intra-individual tests, and we have (Panel PP-Statistic) and (Group ADF-Statistic) for testing inter-individual, all this proves that there is a relationship of co-integration between the variables in the model.

The results we obtained show the relevance and power of co- integration tests in panel compared to the tests of time series. In this step, we estimate the long-term relationships pooled and grouped using FMOLS methods and DOLS estimators Proposed by Pedroni and Mark and Sul FMOLS and DOLS estimators give different results. It is important to note that the DOLS method has the disadvantage of reducing the number of degrees of freedom including untermillage in the variables studied, which leads to less reliable estimates. As the size of our sample important especially in the temporal dimension, the estimated DOLS can give acceptable results.

12. Estimating the long run Co-Integration relationship in a panel context

After confirmation of the existence of a Co-integration relationship between the series, must be followed by the estimation of the long-term relationship. There are different estimators available to estimate a vector Co-integration panel data, including with and between groups such as OLS estimates, fully modified OLS (FMOLS) estimators and estimators dynamic OLS (DOLS).

The results of FMOLS and DOLS tests are presented in table 3.

Table 3: Estimated long relationship for THE SIX COUNTRIES

Dependent Variable	FMOLS			DOLS		
“CO2”	Independent Variables			Independent Variables		
Variables	EC	FDI	GDP	EC	FDI	GDP
WithinResults	[0.547490 11.11854 (0.0000)*	[0.320226 6.003564 (0.0000)*	[0.248712 6.077520 (0.0000)*	[-0.02903 -0.58922 (0.5572)	[0.062989 7.478946 (0.0000)*	[0.296869 4.430288 (0.0000)*
BetweenResults	[0.447576 7.448661 (0.0000)*	[0.045292 5.702576 (0.0000)*	[0.162312 4.930973 (0.0000)*	[0.468483 4.528072 (0.0000)*	[0.021570 1.559736 (0.1224)	[0.135718 2.964775 (0.0039)*

* Significance at 1%. Δ is the first difference operator.











As mentioned above, we used two techniques for obtaining estimates of parameters of the long-term relationship between GDP per inhabitant and tourism spending; Table 3 presents the results FMOLS and DOLS. The coefficients of the heterogeneous panel in pooled estimation and grouped estimation are positive and statistically significant at the 1% significance whatsoever for FMOLS method or the DOLS, and given the variables are expressed in natural logarithms. The coefficients can be interpreted as elasticity. Overall, the results of this study show that there is a strong long-term relationship between independent variables and CO2.

The results obtained for the all heterogeneous panel in pooled and grouped estimation suggest that a 1% increase in EC,FDI and GDP increases the CO2, respectively, 7.448661%, 6.003564%and 6.077520%, these results highlight the involvement of tourism spending to gross domestic production.

13. Panel granger causality results

Having established that the CO2 is Co-integrated in the long-term with other variables, this step is done to objectively examine the causal relationship between these variables, the following table summarize all the results of causality, the optimal structure of delays was established using the Akaike and Schwarz information criteria.

Table 4: panel causality test results

Lags	CO2	EC	FDI	GDP
1				
CO2		3.87552* (0.0004) 	5.08899* (3.E-07) 	3.65216* (0.0011) 
EC	0.14536 (0.2092)		5.70221* (3.E-09) 	1.68292 (0.4654)
FDI	0.83872 (0.7187)	1.84473 (0.3477)		2.68852 (0.0425)* 
GDP	1.68292 (0.4654)	3.82757 (0.0005)* 	2.55036 (0.0643)	

14. Conclusion and policy implication

Climate change is a major challenge for developing countries as the BRICS, which are exposed to a higher risk of this phenomenon. Climate change regarding the BRICS countries have led to the formulation of the International Plan of Action on Climate Change, which lists several missions that are adaptation and mitigation in nature.

As part of the international mitigation efforts, the BRICS countries registered with the UNFCCC then make voluntary efforts to reduce their emissions intensity of its GDP by 2020 compared to 2005 levels even they pursue the path of inclusive growth. Therefore, it is important to better understand the causes of emissions greenhouse gas emissions in these countries in order to address these emissions and ensure the sustainability of economic development.

This study examined some of the possible factors that increased CO2 emissions in 6 BRICS countries, namely Brazil, Russia, India, China, and South Africa. A panel model was used taking the period 1990-2012. To achieve the goal of this study, a CO2 emission model was designed considering CO2 emission as the dependent variable and the total primary energy consumption, FDI net inflows, and GDP per capita, as the primary variables.

This research discovers and improves understanding of a long-term balance between the variables in the study. More importantly, as a tory exploration study, the findings indicate that FDI directly affects economic growth and has no direct effect on CO2 emissions within these countries. The applicability of the findings imply that FDI plays an important role in the continued economic growth of the region and in reducing emissions through changes in policy and practice. Increasing energy efficiency, development of renewable energy resources, and the introduction of new technologies for low-carbon energy will require widespread deployment. There is evidence that when policy makers are making significant efforts to attract FDI through political campaigns, the economy and the environment benefit.

The Pedroni and the Fully Modified OLS were used to examine whether the long run relationship exists between the variables. The Granger causality was used to examine the long run and the short run causal relationship. The results showed that the total primary energy consumption, FDI net inflows, and GDP, are important factors that increase CO2 emission in the long run. In addition, it was also found that the variables have a long run and a short run positive unidirectional causal relationship between the variables. Since FDI net inflows increases CO2 emission, it is important for the investigated countries to examine the requirements for foreign investment to promote environmental protection and increase the technological transfer through foreign companies to reduce the environmental damage. This recommendation has also been indicated by Pao and Tsai* for Brazil, Russia, India, and China. Moreover, it is important that these countries should adopt trade related measures and policies to

increase environmental protection since total trade have been shown to be a contributing factor for increase in carbon emissions. Finally, since fossil fuels contribute more than 98% to the total energy consumption, it is essential for these countries to increase energy productivity by increasing energy efficiency, implementing energy-saving projects, and energy infrastructure outsourcing to achieve their GDP growth.

We hope that other researchers will use our results and methodology for better guidance on funding and economic environment link in other developing countries.

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