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A Review of the Nexus Between Energy consumption and Economic growth in the Brics countries

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ABSTRACT

The study investigates the long run relationship and causal relationship between energy consumption and economic growth in the Brics countries during the period 1990 – 2013. The Pedroni panel co-integration method is applied to analyse the co-integration relationship among the variables. The causality relationship among the variables is analysed using Pair-wise Granger-causality technique. The study's results reveal that there is a long run relationship between economic growth, energy consumption, employment and trade openness in Brics countries. The research outcome further detected a unidirectional causality flowing from economic growth to energy consumption. This implies that the conservation policies that curb unnecessary loss in energy could be implemented in the Brics countries without adversely affecting economic growth.

Keywords: Energy consumption; Economic growth; Causality; Brics countries

1. INTRODUCTION

The world is increasingly experiencing rising levels of industrialization, rapidly climbing global population, changes in life style and rising levels of energy consumption, all of which has increased the threat of global warming over the last few decades. The key objective of international efforts

to mitigate the adverse effects of global climate change is the reduction of global CO2 emissions. The success of these efforts depends to a large degree on the commitment of the major CO2 production nations in meeting global emissions target. The problem of global warming has led to the studies on energy consumption, economic growth and carbon dioxide being of crucial importance for the energy policy makers.

The growth-led-energy hypothesis also termed the conservation hypothesis asserts that economic growth causes energy consumption. This implies that the economy is less dependent on energy in which case a reduction in energy consumption may have less or no effect on economic growth. As a result, energy crises will not affect economic growth. In this case, energy conservation policies can be implemented. The energy-led-growth hypothesis, also called the growth hypothesis, states that energy consumption causes economic growth. This means that the country is energy dependent to the extent that reducing energy consumption may lead to a fall in economic growth in a country. The existence of an energy crisis in such a country could cause significant harm to its economic growth. In this regard, the energy conservation measures are not pivotal (Jumbe 2004).

The Brics (Brazil, Russia, India, China and South Africa) countries have significantly grown in energy market of the world. The countries of this group of emerging markets share as common characteristics large populations, less developed but fast-growing economies and government willing to embrace global markets. The growth of developing countries like BRICS is constantly enhancing the global energy demand. One of the main features of Brics is that it represents close to half of the world population and the most ancient civilizations and the wealthiest cultures. This explains the high levels of energy demand in these countries. It was established though, in 2014 that approximately 38 percent of global carbon dioxide emissions was contributed by the combination of the BRICS countries (Sahu 2016). Brazil is the only country among the group that produces about 45% of its energy from the renewables. It is therefore, important to study the causal relationship between energy consumption and economic growth in Brics in order to come with policies that will enhance energy consumption at the same time curbing carbon dioxide emissions.

The causal relationship between energy consumption and economic growth has been the prime focus for the policy analyst since the early 1970s (Gosh 2002). The purpose of this study is to investigate the long run relationship between energy consumption and economic growth in Brics

countries for the period 1990 to 2013. Such a knowledge play an important role from a policy formulation point of view.

The study is structured in the following manner: section two reviews the empirical literature on economic growth and energy consumption. Section three focuses on the methodology and data collection and sources. Section four presents the empirical results followed by section 5 which concludes the study and gives policy recommendations.

3. LITERATURE

Energy is increasingly becoming the main driver of sustainable economic development (Adebola & Shahbaz 2013 and Khobai and Le Roux 2017). The neoclassical economics is neutral about the impact of energy on economic development but energy is increasingly revealing its importance on livelihoods and as a result indirectly boosting economic growth. The oil embargo that took place in the 1970s prompted the policy makers to extensively investigate the relationship between energy consumption and economic growth (Ghosh 2009). Shahiduzaman and Alam (2012) stated that to the interest in the subject has mostly been motivated by the emission of greenhouse gases into the atmosphere which causes climate change. Therefore, to formulate environmental policies, it is important to recognise the role of energy on economic growth.

The initial studies on energy consumption and economic growth were undertaken by Kraft and Kraft (1978). Their study considered the case of USA for the period 1947 to 1974. Employing the Sims Granger-causality, they found supports for a unidirectional causality flowing from gross national product (GNP) to energy consumption. This implied that energy conservation policies can be introduced without causing any harm to economic growth.

Commencing with studies that considered single countries study, Albiman, Suleiman and Baka (2015) conducted a study to determine the relationship between energy consumption, environmental pollution and per capita economic growth in Tanzania for the period between 1975 and 2013. The study investigated the causality relationship by employing the more robust causality technique of Toda and Yamamoto's non-causality test. The findings revealed a unidirectional causality flowing from economic growth and energy consumption to environmental pollution through carbon dioxide emissions.

In India Mahalik & Mallick (2014) investigated the relationship between energy consumption, economic growth, including financial development and population as the intermittent variables to form a multivariate system. The study applied the ARDL approach for co-integration and found that a proportion of urban population in total population positively affected economic growth but was negatively affected by financial development, economic growth, proportion of industrial output in total output. The ARDL approach results further found that energy consumption positively affected economic growth and a proportion of the urban population has a negative impact on economic growth.

In Tunisia, a study was undertaken by Abid and Sebri (2012) to determine the causal relationship between energy consumption and economic performance for aggregate levels and disaggregated levels (industry, transport and residential sectors). The data used covered a period from 1980 to 2007. The ARDL model found that at aggregated levels, energy consumption plays an important role in the development of the economy. The results failed to find an impact on a sectoral level.

Vidyarthi (2013) carried out a study to investigate the long term and causal relationship between energy consumption, economic growth and carbon emissions in India. The data used in this study covered a period from 1971 to 2009. To determine the co-integration between the selected variables, the Johansen co-integration technique was employed while the Vector Error Correction Model (VECM) Granger-causality test was used to find the direction of causality between the variables. The Johansen co-integration technique results established a long term relationship between energy consumption, carbon emissions and economic growth. The long term causality results validated a unidirectional causality flowing from energy consumption and carbon dioxide emissions to economic growth while the short term causality revealed mixed results: A unidirectional causality flowing from energy consumption to carbon emission; carbon emission to economic growth and; economic growth to energy consumption.

A multivariate study that incorporated capital and labour as the additional variables was undertaken by Shadiduzzaman and Alam (2012). This Australian study aimed to determine the relationship between energy consumption and economic growth applying a single-sector aggregate production function. The following results were established: Firstly, a long term relationship was found to exist between energy consumption and economic growth; Secondly, feedback hypothesis was established between energy consumption and economic growth; Thirdly, a weak

unidirectional causality flowing from energy consumption to economic growth was detected when considering thermal aggregate of energy consumption and lastly, a strong Granger-causality was found flowing from energy consumption to economic growth when energy consumption was adjusted for energy quality.

Linh and Lin (2014) contribute to the most recent studies that assessed the dynamic relationship between energy consumption and economic growth using multivariate framework by adding the variables foreign direct investments and carbon dioxide emissions. This Vietnam study used data for the period between 1980 and 2010. The co-integration findings show that there is a long term relationship between economic growth, energy consumption, foreign direct investments and carbon dioxide emissions. The Granger-causality results established bidirectional causality between foreign direct investment and income in Vietnam. This implies that an increase in Vietnam's income has a potential of attracting more capital from overseas.

Khobai and Le Roux (2017) carried a study that served to examine the causal relationship between energy consumption, carbon dioxide emissions and economic growth in South Africa for the period between 1971 to 2013. Their study included trade openness and urbanisation as intermittent variables. The results from Johansen test of co-integration confirmed that there is a long run relationship between the variables. Moreover, it was established that there is a unidirectional causality flowing from energy consumption, carbon dioxide emissions, trade openness and urbanisation to economic growth in the long run. Furthermore, a unidirectional causality running from economic growth, carbon dioxide emissions, trade openness and urbanisation to energy consumption was also established.

Another multivariate study was undertaken by Apergis and Payne (2009) to investigate the relationship between energy consumption and economic growth incorporating labour force and real gross fixed capital formation. The study focused on six Central American countries for the series from 1980 to 2004. The results from heterogeneous panel co-integration using Pedroni's (1999; 2004) tests indicated the existence of a long term relationship between the energy consumption, real GDP, labour force and real gross fixed capital formation. The results further supported a unidirectional causality flowing from energy consumption to economic growth.

Hossein, Yazdan and Ehsan (2012) conducted research to assess the relationship between energy consumption and economic growth for OPEC countries. The study utilised co-integration and error correction model techniques. The causality results established a unidirectional causality flowing from income to energy consumption for Iran, Iraq, Qatar, United Arab Emirates and Saudi Arabia in the short term. The short term causality results also showed a one-way causality flowing from energy consumption to economic growth for the rest of the OPEC countries.

Tagcu, Ozturk and Aslan (2012) undertook a multi-country study to examine the causal relationship between renewable and non-renewable energy consumption and economic growth. A sample of the group of seven (G7) countries was taken for the period 1980 to 2009. The autoregressive distributed lag model for co-integration showed no evidence of a long term relationship between either renewable or non-renewable energy consumption and economic growth. Granger-causality between these variables was tested by using a causality test developed by Hatemi-J (2012) and the results supported a bidirectional relationship between the variables for all the countries. Different results were established when the study examined countries individually. For example, neutral hypothesis was found for France, Italy, Canada and the United States of America, whilst feedback hypothesis was supported for England and Japan and in Germany a conservation hypothesis was found.

Another study that used a trivariate framework is by Dehnavi and Haghnejad (2012) which aimed to determine the relationship between energy consumption, pollution and economic growth for a selected panel of 8 Organisation of the Petroleum Exporting Countries (OPEC). The study used a panel data technique for the period 1971-2008. The Granger-causality identified a two-way causality between carbon dioxide emissions and energy consumption and a one-way causality flowing from economic growth to energy consumption and pollution in the long term. The short run results observed that economic growth Granger-causes carbon dioxide emission while energy consumption Granger-cause carbon dioxide emission and economic growth.

Matei (2015) undertook a study that aimed to explore the relationship between energy consumption, economic growth and financial development using dynamic panel estimation techniques for the period between 1990 and 2012. This study considered three groups of countries; 25 European Union (EU) countries, 10 Emerging European (EE) countries and 15 Eurozone (EZ) countries. The results revealed bidirectional causality between energy consumption and economic

growth for 25 EU countries and Eurozone countries. The results further validated a unidirectional causality flowing from economic growth to energy consumption for EE countries. both in the long term and short term. A unidirectional causality was further established from energy consumption to financial development for EU countries, EZ countries and EE countries in the long term while in the short term a unidirectional causality from energy consumption to financial development was only observed for EZ countries and EE countries.

A multi-country study was conducted by Vidyarthi (2014) to investigate the relationship between energy consumption, carbon emissions and economic growth for 5 South Asian countries: Bangladesh, India, Pakistan, Nepal and Sri Lanka. The study used Pedroni's co-integration test to determine the long term relationship among the variables and panel VECM Granger-causality to find the direction of causality between the variables. In using data for the period between 1972 and 2009, the study found that there exists a long term relationship between energy consumption, carbon emissions and economic growth in all these countries. The VECM Granger-causality suggested bidirectional causality between energy consumption and economic growth, a unidirectional causality flowing from carbon emissions to economic growth and energy consumption in the long term. The short term results identified a unidirectional causality flowing from energy consumption to carbon emissions.

Apergis and Payne (2010) investigated the relationship between energy consumption and economic growth. This study considered nine Southern African countries, using data covering a period from 1980 to 2005. Similar to their 2009 study, they used Pedroni's heterogeneous panel co-integration and error correction model to determine the long term relationship between energy consumption and economic growth and the direction of causality. The long term relationship between real GDP, energy consumption, real gross fixed capital and labour force was established. The long and short term causality, flowing from energy consumption to economic growth, was also established.

A study conducted by Wolde-Rufael (2010) to investigate the relationship between real GDP and coal consumption for six main coal consuming countries. The study incorporated labour and capital for the period between 1965 and 2005. The Granger-causality tests of Toda and Yamamoto (1995) were used and findings revealed a one-way causality flowing from coal consumption to economic growth in Japan and India. The results for South Korea and China showed a

unidirectional causality flowing from economic growth to coal consumption. Bidirectional causality flowing between economic growth and coal consumption was established in the US and South Africa. These results imply that energy conservation can only be applied in South Korea and China as coal consumption will not have a negative impact on economic growth.

Insert a concluding paragraph that discusses the main findings from the literature review. Then discuss what you think will be our entry point and contribution to theory.

3. METHODOLOGY

3.1 Data and model specification

The study employs data for Brics countries for the period 1990 – 2013. The data for the four variables (energy consumption, economic growth, employment and trade openness) were collected from different sources. The data for electricity consumption was sourced from World Bank, World Bank Indicator (WDI, 2016). Real gross domestic product (using constant prices of 2010) was collected from the South African Reserve Bank. Trade openness data was collected from United Nations and Trade Development (UNCTAD). Lastly, data for employment was sourced from The Conference Board (2016).

To analyse the nexus between energy consumption, economic growth, trade openness and employment, the standard linear functional specification can be used following from the studies by (Khobai and Le Roux 2017, Vidyarthi, 2014 and Apergis and Payne, 2009). The standard linear functional specification can be estimated as in equation (1). All the series are expressed in log-linear form as follows:

$$LEC_{i,t} = \alpha_1 + \alpha_{GDP} LGDP_{i,t} + \alpha_{CO2} LTR_{i,t} + \alpha_{UBN} LL_{i,t} + \varepsilon_t \quad (1)$$

The variables used in the study are measured as follows: Gross domestic production (GDP) per capita at 2010 constant prices is used as a proxy for economic growth (GDP), Trade openness (TR) is the taken as sum of imports and exports in nominal terms as a function of GDP, Employment (L) is measured by labor productivity per person employed in 2015 US$ and energy consumption (kg of oil equivalent) per $1000 GDP (constant 2011 PPP) is used as a proxy for energy consumption (EC).

3.2 Methods analysis

3.2.1 Unit root tests

Panel unit root tests are used to determine the stationarity of the variable to avoid running spurious regressions. This is accomplished using the panel unit root tests are employed using three different methods for robustness purposes. These include IPS unit root test formulated by Im, Pesaran and Shin (2003), Fisher-type test using ADF and PP tests of Maddala and Wu (1999). These three panel unit root tests assume that there are individual unit root processes across the cross-sections. The IPS, Fisher-ADF and Fisher-PP tests contain null hypothesis of unit root against the alternative hypothesis of some cross sections do not contain a unit root.

3.2.2 Co-integration tests

To examine whether energy consumption, economic growth, trade openness and employment move together in the long, the Pedroni panel co-integration test is applied. Pedroni (1999) proposed two types of co-integration tests, namely; the panel tests and the group tests. The panel test is referred to as within dimension and contains four statistics: the panel-v, panel rho(r), panel nonparametric (PP) and panel parametric (ADF) statistics. The group tests also known as between dimension method contains three statistics: group rho-statistic, group PP-statistic, and group ADF-statistic. The difference between the dimensions is that the within-dimension has a homogeneous alternative, $\rho_i = \rho < 1$ for all i whilst the between dimension has a homogeneous alternative $\rho_i < 1$

The seven of Pedroni's tests are based on the estimated residuals from the following long run model:

$$y_{it} = \alpha_i + \sum_{j=1}^{n} \beta_{ji} x_{jit} + \varepsilon_{it}$$

Where i=1;… n for each country in the panel and t is the time period. The parameter α_i allows for the possibility of country-specific fixed effects. The estimated residuals, denoted by ε_{it} represents deviations from the long run relationship. The null hypothesis of no co-integration, $\rho_i = 1$, is tested by conducting a unit root test on the residuals as follows:

$$\varepsilon_{it} = \rho_i \varepsilon_{i(t-1)} + \omega_{it}$$

3.2.3 Granger-causality

The Granger-causality based on the vector error correction model can only be used if the variables are co-integrated. In this study, the pair-wise granger-causality technique will be applied to examine the causal relationship between energy consumption, economic growth, trade openness and employment.

The following VAR model is used to test for the existence of Granger-causality:

$$Y_t = a_0 + a_1 Y_{t-1} + \ldots + a_p Y_{t-p} + b_1 X_{t-1} + \ldots + b_p X_{t-p} + U_t$$

$$X_t = c_0 + c_1 X_{t-1} + \ldots + c_p X_{t-p} + d_1 Y_{t-1} + \ldots + d_p Y_{t-p} + V_t$$

The null hypothesis that X does not Granger-cause Y is presented as follows

$$H_0 : b_1 = b_2 = \ldots = b_p = 0$$

is tested against

$$H_1 : not H_0$$

Similarly, the null hypothesis that Y does not Granger-cause X can be presented as follows:

$$H_0 : d_1 = d_2 = \ldots = d_p = 0$$

Against

$$H_1 : not H_0$$

In each, the Granger-causality relationship between the variables exists if the null hypothesis is rejected.

4. FINDINGS

4.1 Unit root tests

Table 5.1 summarises the results of the Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chi-square. The results show that the variables energy consumption, economic growth, trade openness and employment are not stationary at level form. At the first difference, all the variables are stationary rejecting the null hypothesis at 1% level of significance. This means that the variables contain a panel unit root and are integrated of order one *I*(1).

Table 5.1: Panel Unit root test results

Variable	Level			
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
Im, Pesaran and Shin W-stat				
ENG	1.63171	0.78446	-6.15524*	-5.62144*
GDP	4.32261	-2.51773	-4.31654*	-3.15511*
TO	3.57480	-0.67792	-6.90562*	-5.39134*
EM	4.00426	-1.52289	-4.17061*	-3.18871*
ADF-Fisher Chi-square				
ENG	9.21055	6.36944	52.5227*	44.5054*
GDP	1.88441	22.5177	37.6388*	27.4325*
TO	0.82415	11.6460	58.8077*	42.1336*
EM	1.31074	19.4536	35.6765*	27.1401*
PP-Fisher Chi-square				
ENG	9.31686	6.34227	52.6474*	44.8896*
GDP	1.20251	13.5531	38.0162*	28.1101*
TO	0.82942	5.17806	58.5969*	41.7712*
EM	1.25176	15.2562	36.4842*	28.2069*
Note: The optimal lag length was selected automatically using the Schwarz information criteria The unit root tests were done with done with individual trends and intercept for each variable *, ** represent significance at 1% and 5% levels				

4.2 Co-integration test

Since the variables are found to be integrated of a similar order as indicated in Table 5.1, the long relationship among the variables can be tested. The results for the long run relationship are summarized in Table 5.2. Commencing with the energy consumption model, it can be realised that three out of eleven statistics is significant failing to reject the null hypothesis of no co-integration. This implies that energy consumption, economic growth, trade openness and employment are not co-integrated

Table 5.2 Pedroni Co-integration

	ENG model	GDP model	TO model	EM model
Alternative hypothesis: common AR coefs. (within-dimension)				
Panel v-statistics	0.824862*	0.192080*	0.848531	1.149689
Panel rho-statistics	-0.847674*	0.171008*	-0.195296	-0.496228
Panel pp-statistics	-2.269803	-1.256125*	-1.395071	-2.386328*
Panel ADF-statistics	-1.276071	0.010962*	-1.176860	-0.813010
Panel v-statistics (weighted statistics)	0.724976	0.534009	0.819346	0.540326
Panel rho-statistics (weighted statistics)	-0.891504	-0.006324	-0.490189	-0.099453
Panel pp-statistics (weighted statistics)	-2.243066*	-1.359770*	-1.790426*	-1.752668*
Panel ADF-statistics (weighted statistics)	-1.060842	-0.263107	-0.849185	-1.271201
Alternative hypothesis: common AR coefs. (between-dimension)				
Group rho-statistics	-0.135910	0.775414	0.365376	0.498075
Group PP-statistics	-2.407038	-1.246886*	-1.628029	-2.112339*
Group ADF-statistics	-0.761835	0.298833	-0.591234	-0.786776

The results obtained from economic growth model showed that six statistics out of eleven are significant rejecting the null hypothesis of no co-integration. This implies that when economic growth is used as the dependent variable, there is existence of a long run relationship between the variables.

The trade openness model also suggests that one statistics out of eleven is significant rejecting the null hypothesis of no co-integration. This indicates that energy consumption, economic growth, trade openness and employment are not co-integrated. Lastly, the results found from the employment model posit that three statistics out of eleven is significant failing to reject the null hypothesis of no co-integration.

In summary, the results posit that there is no long run relationship between energy consumption, economic growth, trade openness and employment when energy consumption, trade openness and employment are used as dependent variables but when economic growth is used as the dependent variable, there is co-integration among the variables. These results are in line with the studies by Abid and Sebri (2012), (Mahalik & Mallick 2014) and Vidyarthi (2014) for India, Tunisia, 5 South Asian countries, respectively.

4.3 Granger-causality

The existence of a long run relationship between energy consumption, economic growth, trade openness and employment leads to this study examining the direction of causality among the variables using Panel Granger causality. The results are indicated by the significance of the p-values of the Wald statistics as reported in Table 5.5.

The panel Granger causality results reports that we reject the null hypothesis that GDP does not Granger cause energy consumption at 1 percent level of significance. This implies that there is a long run causality running from economic growth to energy consumption for Brics countries. These results confirm the findings of Kraft and Kraft (1978), and Albiman, Suleiman and Baka (2015).

The results further suggest a long run Granger causality flowing from trade openness to energy consumption. The null hypothesis that employment does not Granger cause energy consumption is rejected at 1 percent level of significance. This indicates that there is a one-way Granger causality flowing from employment to energy consumption in the long run.

Table 5.5: Panel Granger causality results

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG_GDP does not Granger Cause LOG_ENG	110	8.31192	0.0004
LOG_ENG does not Granger Cause LOG_GDP		0.20064	0.8185
LOG_TO does not Granger Cause LOG_ENG	110	4.65273	0.0116
LOG_ENG does not Granger Cause LOG_TO		1.23242	0.2958
LOG_EM does not Granger Cause LOG_ENG	110	9.71515	0.0001
LOG_ENG does not Granger Cause LOG_EM		1.24656	0.2917
LOG_TO does not Granger Cause LOG_GDP	110	5.63019	0.0048
LOG_GDP does not Granger Cause LOG_TO		4.81553	0.0100
LOG_EM does not Granger Cause LOG_GDP	110	6.02898	0.0033
LOG_GDP does not Granger Cause LOG_EM		7.55838	0.0009
LOG_EM does not Granger Cause LOG_TO	110	2.73080	0.0698
LOG_TO does not Granger Cause LOG_EM		3.96530	0.0219

The results validated a one-way Granger causality running from trade openness to economic growth in the long run. It was also established that economic growth Granger-causes trade openness. This implies that there is bidirectional causality flowing between economic growth and trade openness. The results further confirmed bidirectional causality flowing between employment and economic growth. Lastly, there is bidirectional causality running between trade openness and employment.

5. CONCLUSION

The impact of energy consumption on economic growth is a subject of debate in the existing literature. There have been divergences in results with studies either in support or against the nexus between the two. These mixed results may be because of the differences in country specific characteristics and the analytical framework. This study investigates the relationship between energy consumption and economic growth for Brics countries for the period 1990 - 2013. The

study incorporated employment and trade openness in the analysis to form a multivariate framework. The Pedroni panel co-integration technique is used to estimate co-integration among the variables, while pairwise Granger-causality test is employed to determine the direction of causality between the variables.

The findings from Pedroni panel co-integration technique indicated that there is a long run relationship between economic growth, energy consumption, employment and trade openness. Moreover, the study found that trade openness and employment Granger-cause energy consumption. A unidirectional causality flowing from economic growth to energy consumption was also established. Furthermore, the results suggested a unidirectional causality flowing from trade openness and employment to economic growth.

These results have important policy implications. Commencing with the trade-led growth hypothesis, the findings of this study shows that a substantial portion of the economic expansion of the Brics countries is external. Therefore, it is important that the Brics countries reduce the trade barriers and promote international trade by reducing and simplifying procedures and controls. The unidirectional causality flowing from economic growth to energy consumption also portray a very crucial policy implication. This is because, it implies that a reduction in energy consumption will not have a substantial impact on economic growth. Therefore, energy conservation policies that will reduce unnecessary loss of energy can be implemented in the Brics countries without adversely affecting economic growth.

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