Renewable Energy Consumption, Education and Economic Growth in Brazil, Russia, India, China, South Africa

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ABSTRACT

The study investigated two aspects, namely, (1) the impact of renewable energy consumption on economic growth in Brazil, Russia, India, China, South Africa (BRICS) and (2) whether education is a channel through which renewable energy consumption affects economic growth in BRICS. Panel data analysis such as fully modified ordinary least squares, pooled ordinary least squares and fixed effects methods were used with data ranging from 1994 to 2015. Both models across all the three estimation techniques show that renewable energy consumption had a significant negative effect on economic growth in support of the findings by Silva et al. (2012) and Lee and Jung (2018). What is also clear across all the three panel data analysis methods used is that education reduced the size of the negative effect of renewable energy consumption on economic growth in BRICS. In other words, education is a channel through which renewable energy consumption's influence on economic growth is enhanced, in support of views by Dunn and Mutti (2004), Ozcicek and Agpak (2017) and Lawrence et al. (1991). The implication of the study is that BRICS countries are therefore urged to invest more in education as that is more likely to enhance the impact of renewable energy consumption on economic growth.

Keywords: Renewable Energy Consumption, Education, Growth, Brazil, Russia, India, China, South Africa, Panel Data
JEL Classifications: Q2, I2, F43, P2

1. INTRODUCTION

Consistent with Fotourehchi (2017), energy is a key component in the economic growth process of any country as it drives not only day to day household activities but also industrial activities that forms the basis upon which the economy is built. However, the rate at which the energy sources are depleting has led to most governments resorting to renewable energy sources, which also are clean sources, cheaper and have a sustainable impact on economic growth (Apergis and Danuletiu, 2014). It is for this reason that an increasing number of empirical researchers in the last decade has investigated what role renewable energy consumption plays in the economy.

Five views emerge in the literature with regards to the relationship between renewable energy consumption and economic growth

and these are (1) the renewable energy consumption spurred positive growth hypothesis, (2) the renewable energy consumption spurred negative growth hypothesis, (3) the feedback effect, (4) the neutrality hypothesis and (5) non-linearity hypothesis. The first four hypotheses have so far been supported by empirical literature, for example (1) the renewable energy consumption spurred positive growth hypothesis (Tugcu and Topcu. 2018; Hung-Pin, 2014; Anwar et al., 2017; Fotourehchi, 2017; Alam et al., 2016; Dogan and Ozturk, 2017; Soava et al., 2018; Sharif et al., 2019; Halkos and Tzeremes, 2013; Solarin et al., 2017; Bobinaite et al., 2011; Nia and Niavand, 2017; Inglesi-Lotz, 2016; Khobai, 2018), (2) the renewable energy consumption spurred negative growth hypothesis (Lee and Jung, 2018; Thombs, 2017; Silva et al. 2012), (3) the feedback effect (Shakouri and Yazdi, 2017; Clottey et al., 2018; Habib, 2015; Pao and Fu, 2013), (4) the neutrality hypothesis (Ozcan and OZturk, 2019; Marinas et al., 2018; Hassine

and Harrathi, 2017; Farhani, 2013; Bobinaite et al., 2011). The mixed views in the theoretical and empirical literature on the relationship between renewable energy consumption and economic growth shows that the subject matter is still quite far from being conclusive.

The non-linearity hypothesis is an emerging view which has not yet explicitly been empirically tested to the best of the authors' knowledge. Despite literature availability which says that education increases the use of renewable energy and consequently boost economic growth (Lawrence et al., 1991; Ozcicek and Agpak, 2017; Dunn and Mutti, 2004), there is no study that the authors are aware of that explored if education is a channel through which renewable energy consumption stimulates economic growth. The current study seeks to fill this gap.

The story of the influence of renewable energy consumption on economic growth has been told for several economic groupings such as Central and Eastern European countries, G7 countries, developed countries in Europe, Organization for Economic Cooperation and Development countries, Organization of Islamic Cooperation countries, developing countries, European Union, Western Europe, Asia, Latin America and African countries, Europe, European Union countries, Gulf Cooperation Council countries, Middle East and North African countries, United States of America, Denmark, Portugal and Spain. The study on the impact of renewable energy consumption on the economy also focused on individual countries such as South Korea, South Africa, Vietnam, Tunisia, Lithuania, India, Brazil and Indonesia, among others. Clearly, the story of Africa with regards to the relationship between renewable energy consumption and economic growth is still not yet told. Another notable economic grouping which the topic has not yet been explored is the Brazil, Russia, India, China, South Africa (BRICS). The current study fills in that void.

Six more sections constitute the rest of the paper. Section 2 is the literature review on the impact of renewable energy consumption on economic growth, section 3 discusses the education-led growth hypothesis whilst section 4 focuses on the relationship between education and renewable energy consumption. Methodological framework, data analysis and interpretation is discussed in section 5 whereas section 6 concludes the study and highlight policy implications of the study. Section 7 is the bibliography.

2. EFFECT OF RENEWABLE ENERGY CONSUMPTION ON ECONOMIC GROWTH: LITERATURE REVIEW

Consistent with Odhiambo (2009), four dominant views on the relationship between energy consumption and economic growth include (1) the growth hypothesis, (2) feedback hypothesis, (3) conservation hypothesis and (4) neutrality hypothesis. The growth hypothesis is of the view that economic growth is enhanced by energy consumption whilst feedback hypothesis argues that both energy consumption and economic growth have got a positive influence on each other. According to the conservation hypothesis, economic growth is the one that drives energy consumption whilst

the neutrality hypothesis argues that the relationship between energy consumption and economic growth is non-existent.

On the empirical front, Table 1 shows a summary of the empirical literature which focused on the influence of renewable energy consumption on economic growth.

From the literature, it is clear that the relationship between renewable energy consumption and economic growth has got mixed results. Firstly, renewable energy consumption has a positive impact on economic growth. Secondly, renewable energy consumption negatively affects economic growth. Thirdly, both renewable energy consumption and economic growth influence each other. Fourthly, economic growth has a deleterious effect on renewable energy consumption. Fifth, there is no relationship between renewable energy consumption and economic growth. Sixth, a non-linear function describes the relationship between renewable nervy consumption and economic growth. These contradictions are evidence that the relationship between these two variables is still inconclusive and needs further research.

In line with Dunning (1988), one of the locational advantages of Foreign direct investment (FDI) and consequently drivers of economic growth in the host country is human capital development. According to Keynes (1936), human capital development as measured by education is one of the key drivers of economic growth, a view which was empirically supported by a study done by Li and Huang (2009).

According to Ozcicek and Agpak (2017), socioeconomic factors that influence renewable energy consumption include education, demographic qualifications, energy prices and carbon intensity. Moreover, Lawrence et al. (1991) argued that education enhances people's ability to adapt to new technology, coordination, learning and self-dependency on economic matters and it also increases the people's chances of getting employed, skills, higher incomes and a differentiated consumption pattern. Dunn and Mutti (2004) also argued that higher income make the people want to live in a clean environment thereby preferring the use of clean energy (renewable energy). In the study of Erdogan et al. (2020), it was observed that there was a negative relationship between oil revenues and educational level for the relevant group of countries in the long term. According to this result, it was concluded that there was no strong awareness of the importance of education in the countries those are included in the analysis, and that the resources were not sufficiently transferred to the increase of human capital power.

3. METHODOLOGICAL FRAMEWORK, DATA ANALYSIS AND INTERPRETATION

3.1. Data, its Description and Sources
This paper used annual panel data (1994-2016) to investigate the relationship between renewable energy consumption, education and economic growth in BRICS group of countries. The sources of the secondary data used include African Development Indicators, World Development Indicators, International Financial Statistics and International Monetary Fund database. The study used these sources of data because they are reliable, reputable and consistent.

Table 1: A summary of the impact of renewable energy consumption on growth-empirical literature

Authors	Countries of study	Methodology	Findings
Marinas et al. (2018)	CEE countries	ARDL - 1990-2014	Renewable energy consumption and economic growth were found to have had no relationship in the short run in Bulgaria and Romania. In Lithuania, Slovenia and Hungary, renewable energy consumption improved economic growth in the short run. A feedback effect in the long run was detected in the CEE group of countries
Tugcu and Topcu (2018)	G7 countries	NARDL - 1980-2014	In the long run, renewable energy consumption had a positive effect on the economy in G7 group of nations
Lee and Jung (2018)	South Korea	VECM and ARDL - 1990-2012.	ARDL results show that renewable energy consumption had a deleterious impact on economic growth whilst VECM approach shows a positive relationship running from economic growth towards renewable energy consumption in South Korea
Ucan et al. (2014)	Developed countries in Europe	FMOLS - 1990-2011	A uni-directional causality relationship from non-renewable energy consumption to economic growth was detected
Hung-Pin (2014)	OECD countries	ARDL and VECM approaches (1982-2011)	In the long run, renewable energy consumption had a positive impact on economic growth in the case of Germany, United Kingdom and Italy. In United Kingdom and Italy, short run results show that economic growth granger caused renewable energy consumption
Anwar et al. (2017)	OIC countries	FMOLS and DOLS - 1990-2014	A significant positive impact of renewable energy consumption on economic growth was detected both in the short and long run
Shakouri and Yazdi (2017)	South Africa	ARDL (1971-2015)	The relationship between renewable energy consumption and economic growth supported the feedback hypothesis both in the long and short run
Fotourehchi (2017)	Developing countries	Panel granger causality tests (1990-2012)	GDP was granger caused by renewable energy consumption in developing countries in the long run
Saad and Taleb (2018)	Europe	Panel VECM (1990-2014)	In the short run, economic growth Granger caused renewable energy consumption whilst the long run is characterized by a bi-directional relationship between renewable energy consumption and economic growth
Soava et al. (2018)	European union countries	Panel data analysis (1995-2015)	Economic growth was found to have been enhanced by renewable energy consumption in European Union countries studied
Apergis and Danuletiu, (2014)	European union, Western Europe, Asia, Latin America and African countries	Group mean panel test statistics (1990-2012)	Across all the regions studied, renewable energy consumption was found to be a source of economic growth
Halkos and Tzeremes (2013)	European countries	Data envelopment analysis and non-parametric regressions	For lower renewable energy consumption levels, economic efficiency was found to have been enhanced by renewable energy consumption. The study also revealed that regional characteristics determined the impact of renewable energy consumption on economic efficiency in European countries
Clottey et al. (2018)	Vietnam	ARDL and VAR models (1985-2017)	In Vietnam, the study revealed that renewable energy consumption and economic growth positively affected each other in the long run
Hassine and Harrathi (2017)	GCC countries	FMOLS and DOLS (1980-2012)	No causality between renewable energy consumption and output was detected in the short run. However, a strong and statistically significant influence of renewable energy consumption on output was found in the long run
Habib (2015)	Tunisia	ARDL (1980-2011)	Renewable energy consumption and economic growth in Tunisia positively influenced each other in the short run. On the contrary, long run results show that economic growth increased renewable energy consumption in Tunisia
Farhani, (2013)	MENA countries	FMOLS and DOLS (1975-2008)	In the short run, no causality between renewable energy consumption and economic growth was found. Economic growth was found to have a positive influence on renewable energy consumption in the long run in the MENA region
Thombs (2017)	Developing countries	Panel data analysis	Renewable energy consumption had a negative influence on total carbon emissions per unit of GDP
Bobinaite et al. (2011)	Lithuania	Granger causality test (1990-2009)	Renewable energy consumption positively influenced economic growth in the short run in Lithuania. In the long run, the study could not find any relationship between renewable energy consumption and economic growth in Lithuania

(Contd...)

Table 1: (*Continued*)

Authors	Countries of study	Methodology	Findings
Nia and Niavand, (2017)	India	Descriptive statistics	Renewable energy consumption enhanced economic growth through countering the effects of climate change and improving energy security
Silva et al. (2012)	USA, Denmark, Portugal and Spain	Structural vector autoregressive (1960-2004).	For all the countries with the exception of USA, renewable energy consumption had a deleterious impact on economic growth
Pao and Fu, (2013)	Brazil	ECM - 1980-2010	The results on the relationship between renewable energy consumption and economic growth are threefold: (1) Non-hydroelectric renewable energy consumption had a positive influence on economic growth, (2) total renewable energy consumption and economic growth positively affected each other and (3) economic growth positively influenced non-renewable energy consumption in Brazil
Inglesi-Lotz, (2016)	OECD countries	Panel data analysis (1990-2010)	Renewable energy consumption had a significant positive effect on economic growth in OECD group of nations
Khobai, (2018)	Indonesia	ARDL (1990-2014)	In both the short and long run, renewable energy consumption was found to have had a significant positive impact on the economy in Indonesia

Source: Author compilation. OECD: Organization for Economic Cooperation and Development, CEE: Central and Eastern European, ARDL: Autoregressive distributive lag, NARDL: Non-linear autoregressive distributive lag, VECM: Vector error correction method, FMOLS: Fully modified ordinary least squares, OIC: Organization of Islamic Cooperation, GDP: Gross domestic product, GCC: Gulf Cooperation Council, MENA: Middle East and North African, USA: United States of America, ECM: Error correction model, DOLS: Dynamic ordinary least squares

3.2. Variables, a Priori Expectation and Justification

Table 2 is a summary of the variables, proxies, expected sign(s) and the author(s).

3.3. Econometric Model Specification

The following empirical models were tested.

$$GROWTH_{i,t} = \beta_0 + \beta_1 RENEW_{i,t} + \beta_2 EDUC_{i,t} + X_{i,t} + \mu_i + \varepsilon_{it} \quad (1)$$

$$GROWTH_{i,t} = \beta_0 + \beta_1 RENEW_{i,t} + \beta_2 EDUC_{i,t} + \beta_3 (RENEW_{it}.EDUC_{i,t}) + \beta_4 X_{i,t} + \mu_i + \varepsilon_{it} \quad (2)$$

GROWTH, RENEW, EDUC and X represents economic growth, renewable energy consumption, education and explanatory factors (FDI, infrastructural development, trade openness, financial development). Following Goff and Singh (2014), the combination between renewable energy consumption and education is denoted by $(RENEW_{i,t}, EDUC_{i,t})$. ε_{it} is error term. Subscripts t and i stands for time and country respectively. β_0 is the unobserved country specific time invariant effect.

3.4. Main Data Analysis

Pre-estimation diagnostics (correlation analysis, descriptive statistics, trend analysis), diagnostic tests (panel unit root tests, panel co-integration tests) and main data analysis (fixed effects, fully modified ordinary least squares [FMOLS], pooled ordinary least squares [POLS]) are the three categories dealt with under this sub-section.

The correlation analysis results in Table 3 shows that there is significant negative relationship between (1) renewable energy consumption and economic growth and (2) savings and economic growth. The results also show that the relationship between (1) education and economic growth and (2) infrastructure development and economic growth is significant positive. Moreover, a non-significant positive relationship between (1) FDI and economic growth, (2) trade openness and economic growth and (3) financial development and economic growth was detected. The fact that the maximum correlation in Table 3 is 79% (between trade openness and renewable energy consumption) is an indication that there is no multi-collinearity between and among the variables studied, in line with Abel and Le Roux (2016).

According to Table 4, Brazil, Russia and South Africa had their mean GDP per capita above the overall mean GDP per capita of United States Dollars (US$ 4382.89). It is also clear that Brazil, Russia, India and China are extremes because their mean GDP per capita are far away from the overall mean GDP per capita. The mean renewable energy consumption for Russia, China and South Africa are below the overall mean of 26.71% whilst the mean education of Brazil, Russia and China exceeded the overall mean education (human capital development index) of 0.70.

Moreover, Brazil and China are the only two countries whose mean FDI are above the overall mean FDI during the period under study (1994-2015). China is the only outlier because its mean FDI far much exceeded the overall mean FDI of all the BRICS nations. With regards to savings, South Africa, Brazil, and China are outliers because their mean savings deviated too much from the overall mean savings of 28.39% of GDP. Moreover, Russia and India are outliers with regards to infrastructural development as their mean values deviated a lot from the overall mean infrastructural development of 14.48 fixed telephone subscriptions per 100 people.

Russia and South Africa are the only two BRICS nations whose mean trade openness exceeded the overall mean trade openness of 43.20% of GDP. However, Brazil, Russia and South Africa are outliers in this case for the same reasons mentioned earlier on. Brazil, Russia and India's mean financial development are below the overall mean financial development of 94.17% of GDP. Russia and India are outliers because their mean financial development are much less than the overall mean financial development value.

Table 2: Variables, proxies, data sources and expected signs

Variable	Proxy	Expected sign (influence on economic growth)	Authors
Economic growth	GDP per capita	N/A	-
Renewable energy consumption (RENEW)	Renewable energy consumption (% of total final energy consumption)	±	Tugcu and Topcu (2018), Thombs (2017)
Human capital development (EDUC)	Human capital development index	+	Keynes (1936), Li and Huang (2009)
FDI	Net FDI inflow (% of GDP)	+	Romer (1986)
Savings (SAV)	Gross domestic savings (% of GDP)	+	McKinnon (1973)
Infrastructural development (INFR)	Fixed telephone subscriptions (per 100 people)	±	Tsaurai (2018)
Trade openness (OPEN)	Total of exports and imports (% of GDP)	±	Tsaurai (2018), Baltagi et al. (2009)
Financial development (FIN)	Domestic credit provided by financial sector (% of GDP)	±	King and Levine (1993), Goldsmith (1969), Townsend (1983), Kiprop et al. (2015)

Source: Author's compilation. GDP: Gross domestic product

Table 3: Correlation analysis

	GROWTH	RENEW	HCD	FDI	SAV	INFR	OPEN	FIN
GROWTH	1.00							
RENEW	−0.30***	1.00						
EDUC	0.48***	−0.48***	1.00					
FDI	0.14	−0.05	0.24**	1.00				
SAV	−0.18*	−0.34***	0.06	0.41***	1.00			
INFR	0.60***	−0.55***	0.77***	0.34***	0.24**	1.00		
OPEN	0.03	−0.79***	0.09	−0.01	0.32***	0.23**	1.00	
FIN	0.10	−0.14	−0.12	0.11	0.03	−0.17*	0.28***	1.00

***/**/*Denotes statistical significance at the 1%/5%/10% level respectively. Source: Author compilation from e-views

Table 4: Mean trend analysis for BRICS (1994-2015)

Countries	GROWTH	RENEW	EDUC	FDI	SAV	INFR	OPEN	FIN
Brazil	6 702.08	45.00	0.75	2.75	18.71	18.18	23.51	80.97
Russia	6 516.29	3.55	0.78	1.98	30.82	25.28	54.72	33.04
India	851.21	46.77	0.57	1.33	27.71	2.74	36.98	60.15
China	2 858.61	21.06	0.71	3.77	45.27	16.50	45.61	131.01
South Africa	4 986.25	17.16	0.67	1.49	19.46	9.70	55.20	165.66
Overall mean	4 382.89	26.71	0.70	2.26	28.39	14.48	43.20	94.17

Source: Author compilation

China and South Africa are also outliers because their mean financial development values far much exceeded the overall mean financial development value of 94.17% of GDP.

Table 5 shows a standard deviation of economic growth at 3655 (above 1000), an indication that there are extreme values in the economic growth data. There are also probabilities of the Jarque-Bera criteria which are equivalent to zero in economic growth and savings data, a sign that data for the variables does not follow a normal distribution, a problem which needs to be addressed before using the data for main analysis in order to avoid spurious findings. This was done using Hair et al.'s (2014) recommendations.

3.5. Panel Unit Root Tests
Table 6 produced results which show that the data for all the variables is integrated of order 1 (stationary at first difference).

Employing Johansen fisher panel Co-integration test, at most six co-integrating vectors were established (results in Table 7). It means

that the no co-integration null hypothesis is rejected, a finding which allows main data analysis to take place, in line with Tsaurai (2018).

4. FINDINGS AND ANALYSIS

Tables 8-10 show results of the fixed effects, FMOLS and the POLS respectively.

In model 1 and 2 under the fixed effects, FMOLS and POLS, renewable energy consumption was found to have a significant negative effect on economic growth, consistent with Lee and Jung (2018) in the case of South Korea and Silva et al. (2012) in the case of Portugal, Denmark and Spain. Education was however observed to have a non-significant negative impact on economic growth in model 1 and 2 under the fixed effects and FMOLS approaches, in contradiction to majority theoretical predictions on the subject matter.

On the other hand, model 2 under the fixed effects, FMOLS and POLS shows that education positively but insignificantly influenced

Table 5: Descriptive statistics

Statistic	GROWTH	RENEW	HCD	FDI	SAV	INFR	OPEN	FIN
Mean	4383	26.71	0.70	2.26	28.39	14.48	43.20	94.17
Median	3451	19.69	0.72	2.16	25.20	11.97	46.76	83.32
Maximum	14487	55.56	0.82	6.01	51.46	31.83	72.87	192.66
Minimum	353.29	3.23	0.45	0.17	15.09	1.04	15.64	20.81
Standard. deviation	3655	17.41	0.08	1.44	10.26	9.15	14.70	51.41
Skewness	1.01	0.09	−0.66	0.45	0.77	0.18	−0.23	0.39
Kurtosis	3.20	1.53	2.66	2.34	2.50	1.79	1.90	1.92
Jarque-Bera	18.79	10.12	8.63	5.71	11.94	7.32	6.48	8.15
Probability	0.00	0.01	0.01	0.06	0.00	0.03	0.04	0.12
Observations	110	110	110	110	110	110	110	110

Source: Author compilation from e-views

Table 6: Panel unit root tests –individual intercept

Variables	Level				First difference			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
LGROWTH	0.43	1.94	2.67	2.12	−1.35*	−1.74**	17.12*	27.33***
LRENEW	0.22	0.28	10.67	12.48	−1.23*	−2.65***	25.12***	284.63***
LHCD	−4.37***	−3.91***	33.67***	46.48***	−8.36***	−7.83***	68.32***	561.80***
LFDI	−1.58*	−2.08**	21.92**	32.45***	−1.30*	−3.60***	32.84***	282.16***
LSAV	−2.15**	−2.41***	26.67***	12.58	−2.20**	−4.35***	38.19***	62.60***
LINFR	−1.76**	−1.08	14.63	23.47	−6.16***	−7.17**	37.83***	49.258***
LOPEN	−1.33*	−0.51	9.58	9.19	−2.68***	−3.05***	28.16***	62.51***
LFIN	−0.18	1.33	3.56	2.41	−1.48**	−4.79***	41.038***	213.61***

LLC, IPS, ADF and PP stands for Levin et al. (2002); Im et al. (2003); ADF Fisher Chi-square and PP Fisher Chi-square tests respectively. * , ** and *** denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from e-views

Table 7: Johansen Fisher panel co-integration test

Hypothesised No. of CE (s)	Fisher statistic (from trace test)	Probability	Fisher statistic (from max-eigen test)	Probability
None	13.86	0.8374	13.86	0.8374
At most 1	9.70	0.9732	64.97	0.0000
At most 2	2.77	1.0000	150.1	0.0000
At most 3	184.2	0.0000	184.2	0.0000
At most 4	238.8	0.0000	188.3	0.0000
At most 5	91.47	0.0000	74.46	0.0000
At most 6	52.17	0.0001	52.17	0.0001

Source: Author's compilation from e-views

economic growth and the same finding was observed in model 1 under POLS approach. These results resonate with literature (Keynes, 1936; Li and Huang. 2009) whose view is that economic growth is enhanced by human capital development (education, skills, health).

The interaction between renewable energy consumption and education had a negative but insignificant impact on economic growth in model 2 under the fixed effects, FMOLS and POLS, a finding which contradicts available literature (Ozcicek and Agpak, 2017; Lawrence et al., 1991; Dunn and Mutti, 2004) which says that educated people are more likely to use renewable energy because they prefer clean energy. Consistent with Inglesi-Lotz (2016) and Khobai (2018), increased use of renewable energy leads to higher economic growth. In other words, the interaction between renewable energy consumption and education is expected by literature to have a significant positive impact on the growth of the economy.

In both models 1 and 2 under the fixed effects, FMOLS and POLS, economic growth was found to have been positively and significant affected by FDI, results which follows an argument by

Romer (1986). Financial development was also observed to have had a significant positive influence on economic growth in both models 1 and 2 across all the three estimation approaches used in the study (King and Levine, 1993).

Across all the three estimation approaches, trade openness had a significant negative impact on economic growth in both models 1 and 2, results which support a view by Baltagi et al. (2009). A non-significant positive relationship running from infrastructural development towards economic growth was detected in both models under the fixed effects and FMOLS whilst infrastructural development had a significant positive effect on the economy in BRICS. The findings resonate with Tsaurai (2018).

Savings were found to have had a significant positive impact on the economy of BRICS in both models under the fixed effects and FMOLS, in support of the view by McKinnon (1973). Moreover, a significant negative relationship running to economic growth from savings was observed in both models under the POLS approach, in contradiction with the available literature.

Table 8: Panel fully modified ordinary least squares (fixed effects) results

Variables	Without interaction variable (model 1)			With interaction variable (model 2)		
	Co-efficient	Std. Error	t-statistic	Co-efficient	Std. Error	t-statistic
RENEW	−1.7009***	0.2223	−7.6499	−1.8517***	0.3399	−5.4472
EDUC	−0.2450	0.5719	−0.4284	1.1729	2.4797	0.4730
RENEW.EDUC	-	-	-	−0.4277	0.7277	−0.5878
FDI	0.2256***	0.0527	4.2810	0.2284***	0.0531	4.3019
SAV	1.6246***	0.3712	4.3769	1.6312***	0.3726	4.3779
INFR	0.1110	0.0983	1.1294	0.1037	0.0994	1.0431
OPEN	−1.2335***	0.2227	−5.5376	−1.1996***	0.2308	−5.1976
FIN	1.5139***	0.1875	8.0730	1.5138***	0.1882	8.0457
R-squared - 0.90				R-squared - 0.91		
Adjusted R-squared - 0.89				Adjusted R-squared - 0.89		

GDP per capita is the dependent variable. ***, ** and * denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from e-views

Table 9: Panel fully modified ordinary least squares (FMOLS effects) results

Variables	Without interaction variable (model 1)			With interaction variable (model 2)		
	Co-efficient	Std. Error	t-statistic	Co-efficient	Std. Error	t-statistic
RENEW	−1.4108***	0.2829	-4.9878	−1.6454***	0.4561	-3.6078
EDUC	−0.3411	0.7898	−0.4319	1.8205	3.2862	0.5540
RENEW.EDUC	-	-	-	−0.6585	1.0021	−0.6571
FDI	0.3213***	0.0748	4.2965	0.3241***	0.0749	4.3250
SAV	2.0006***	0.5092	3.9293	2.0079***	0.5098	3.9384
INFR	0.1414	0.1419	0.9969	0.1225	0.1445	0.8477
OPEN	−1.4202***	0.2932	−4.8436	−1.3639***	0.3027	−4.5051
FIN	1.6458***	0.2420	6.8006	1.6518***	0.2422	6.8206
R-squared - 0.90				R-squared - 0.90		
Adjusted R-squared - 0.88				Adjusted R-squared - 0.88		

GDP per capita is the dependent variable. ***, ** and * denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from e-views

Table 10: Panel fully modified ordinary least squares (POLS effects) results

Variables	Without interaction variable (model 1)			With interaction variable (model 2)		
	Co-efficient	Std. Error	t-statistic	Co-efficient	Std. Error	t-statistic
RENEW	−0.5734***	0.1437	−3.9898	−0.6257*	0.3354	−1.8655
EDUC	0.0541	0.8069	0.0670	0.6721	3.6664	0.1833
RENEW.EDUC	-	-	-	−0.1769	1.0232	−0.1729
FDI	0.1839**	0.0822	2.2374	0.1863**	0.0838	2.2233
SAV	−1.1896***	0.1886	−6.3063	−1.1995***	0.1979	−6.0605
INFR	0.5294***	0.1290	4.1026	0.5323***	0.1308	4.0708
OPEN	−0.5033*	0.2638	−1.9077	−0.4989*	0.2663	−1.8731
FIN	0.6023***	0.1249	4.8229	0.6199***	0.1618	3.8325
R-squared - 0.72				R-squared - 0.72		
Adjusted R-squared - 0.70				Adjusted R-squared - 0.70		

GDP per capita is the dependent variable. ***, ** and * denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from e-views

5. CONCLUSION AND POLICY RECOMMENDATIONS

The study investigated two aspects, namely, (1) the impact of renewable energy consumption on economic growth in BRICS and (2) whether education is a channel through which renewable energy consumption affects economic growth in BRICS. Panel data analysis (FMOLS, POLS, fixed effects) methods were used with data ranging from 1994 to 2015. Both models across all the three estimation techniques show that renewable energy consumption had a significant negative effect on economic growth in support of the findings by Silva et al. (2012) and Lee and Jung (2018). What is also clear across all the three panel data analysis methods used is that education reduced the size of the negative effect of renewable energy consumption on economic growth in BRICS. In other words, education is a channel through which renewable

energy consumption's influence on economic growth is enhanced, in support of views by Dunn and Mutti (2004), Ozcicek and Agpak (2017) and Lawrence et al. (1991). The implication of the study is that BRICS countries are therefore urged to invest more in education as that is more likely to enhance the impact of renewable energy consumption on economic growth.

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