



## Energy Consumption-poverty Reduction nexus in BRICS Nations

**Kunofiwa Tsaurai\***

Department of Finance, Risk Management and Banking, University of South Africa, South Africa.

\*Email: [kunofiwa.tsaurai@gmail.com](mailto:kunofiwa.tsaurai@gmail.com)

**Received:** 14 December 2020

**Accepted:** 18 March 2021

**DOI:** <https://doi.org/10.32479/ijeep.11075>

### ABSTRACT

This study investigated the impact of energy consumption on poverty in BRICS using panel data analysis methods (fixed effects, pooled OLS, random effects, FMOLS) with annual data ranging from 1995 to 2018. Whether economic growth is a channel through which energy consumption influences poverty in BRICS was also a subject of investigation in this study? Although there is acknowledgment that energy consumption reduces poverty through economic growth by authors such as Okwanya et al (2015), Hussein and Filho (2012) and Okwanya and Abah (2018), there is no dedicated empirical study on the subject matter which exclusively focused on BRICS. Nothing is known about the energy consumption-growth-poverty nexus in BRICS, according to the author's best knowledge. Also, majority of the energy consumption-poverty nexus empirical research wrongly assumed that the two variables (energy consumption and poverty) are linearly linked. Using both mean mortality rate and mean life expectancy as measures of poverty, the study noted that energy consumption reduced poverty in a significant way across all the four panel methods employed in BRICS. Economic growth was also generally found to have reduced poverty in BRICS countries. The complementarity between the two variables (energy consumption and economic growth) had a significant poverty reduction effect in BRICS, in support of the existing literature. BRICS nations are therefore urged to develop and implement policies that ensure more energy consumption and increased economic growth activities if they intend to reduce poverty.

**Keywords:** Energy Consumption, Growth, Poverty, BRICS, Panel Data

**JEL Classifications:** I32, Q43, O47

### 1. INTRODUCTION

Background of the study and the organization of the paper forms part of the introduction. Literature gaps are clearly discussed and pointed out under the introduction section of the paper. The contribution of the study is also clearly presented in this section.

United Nations Conference on Trade and Development (UNCTAD, 2018) report noted that energy consumption is poised to play a very huge positive role in helping reduce poverty not only in Africa, developing nations but world-wide. The report indicated that energy consumption's ability to positively influence economic growth is a channel through which it is going to be a key poverty reduction driver for many decades to come. Just like Odhiambo

(2009) whose study supported the growth hypothesis (energy consumption led growth hypothesis), UNCTAD (2018) argued that the economic growth triggered by energy consumption within the economy increase production activities, expands the industry base, attracts foreign direct investment, create employment, improves income levels, savings and raises wealth levels among individuals.

Not all the available literature supports the energy consumption led poverty reduction argument. For example, the conservation hypothesis as noted by Odhiambo (2009) argues that it is economic growth that enhances energy consumption, and not the other way round. The neutrality hypothesis says the relationship between energy consumption and economic growth does not exist, in line with Odhiambo (2009). Given the existence of such

literature between energy consumption and economic growth, it implies using UNCTAD (2018) report as a yardstick that poverty reduction is not related to energy consumption in any way. This is contradictory and should be further empirically tested.

Existing empirical literature on the impact of energy consumption on poverty reduction are quite scant. Few that available were done by Okwanya and Abah (2018), Pachauri and Spreng (2004), Thiam (2011), Ogbeide-Osaretin (2020), Nkomo (2007), Okwanya et al. (2015), Hussein and Filho (2012) and Kousar et al. (2020). There is consensus by all these empirical researchers that energy consumption leads to poverty reduction. The common denominator among these empirical researchers is that they all wrongly assumed that there is a linear influence from energy consumption to poverty reduction, contrary to UNCTAD (2018) report. This study fills in such a gap.

Despite rapid industrialization being behind improved economic growth in the last decade or so (Ogbeide-Osaretin, 2020), no empirical study has been done for BRICS on the impact of energy consumption on economic growth or on the influence of energy consumption on poverty reduction, to the best knowledge of the author. Moreover, an empirical study of the channels through which energy consumption influences poverty alleviation is non-existent not only for BRICS but world-wide to the best of the author's knowledge. This study fills in that gap. This empirical study investigates the impact of energy consumption on poverty reduction in BRICS nations. It also explores the influence of the complementarity between energy consumption and economic growth on poverty reduction efforts in BRICS. Results from such a study help BRICS countries to develop relevant policies aimed at strengthening poverty alleviation efforts.

The remaining part of the paper is organized into seven sections. Section 2 discusses the role of energy consumption on economic growth from both a theoretical and empirical angle impact of energy consumption on poverty, theoretically and empirically. Section 3 presents the research methodological framework. Section 4 deals with data analysis, results discussion and interpretation. Section 5 concludes the study whilst Section 8 list all the full references used in the text.

## 2. LITERATURE REVIEW

### 2.1. Role of Energy Consumption on Economic Growth: Brief Literature Review

In line with Odhiambo (2009), the four views explaining the relationship between energy consumption and economic growth include (1) the feedback hypothesis, (2) neutrality hypothesis, (3) conservation hypothesis and (4) growth hypothesis. The feedback hypothesis is of the view that both energy consumption and economic growth influence one another whilst the two variables are not related at all according to the neutrality hypothesis. The conservation hypothesis argues that energy consumption is driven by economic growth. The growth hypothesis notes that it is energy consumption that positively drives economic growth. The weakness of these hypotheses is that they do not quite explicitly explain how energy consumption and or economic growth is

connection to poverty reduction. It is against this background that the current study is investigating the connection between energy consumption and poverty reduction in the context of BRICS nations.

Empirical studies whose findings supported the feedback hypothesis include Tsani (2010), Dagher and Yacoubian (2012), Apergis and Payne (2010), Yildirim and Aslan (2012) and Apergis and Payne (2012). The neutrality hypothesis was supported by Huang et al. (2008), Bowden and Payne (2009), Akinlo (2008), Tsani (2010), Hossein et al. (2012), Yoo and Ku (2009) and Rufael (2012). Odhiambo (2010), Bartleet and Gounder (2010), Li et al. (2011), Hossein et al. (2012), Yoo and Ku (2009), Okafor (2012), Yildirim and Aslan (2012) and Ahmad et al (2012) supported the conservation hypothesis. The empirical research whose outcome resonate with the growth hypothesis include Odhiambo (2010), Wei and Gang (2012), Tsani (2010), Okafor (2012), Yildirim and Aslan (2012).

### 2.2. Impact of Energy Consumption on Poverty: Literature Review

Access to clean and adequate energy improves (1) the people's living conditions, (2) ability to start self-help and entrepreneurial projects, (3) ability to engage in activities which are more productive and (4) health standards among the people thereby enabling them to be more productive, increase their earning capacity (Sadorsky. 2010). Dumrul (2018), Yessengali and Murat (2018) and Xu (2020) agrees with the theoretical arguments on the linkage between energy consumption and poverty reduction.

Consistent with Okwanya and Abah (2018), this study is mainly based on the energy transition theory which says that lack of access to modern energy sources reduces a country's ability lower poverty and growth. Energy deprivation stifle economic activities such as production hence exacerbating poverty levels (Sovacool. 2012).

Empirical studies on the impact of energy consumption on poverty are quite scant (Table 1).

### 2.3. Other Factors that Affect Poverty

There are some other factors that can effect poverty in which presented in Table 2.

## 3. RESEARCH METHODOLOGICAL FRAMEWORK

Equation 1 is the general model specification whose construct was informed by earlier empirical studies done by Okwanya and Abah (2018), Pachauri and Spreng (2004), Thiam (2011), Ogbeide-Osaretin (2020), Okwanya et al. (2015) and Kousar et al. (2020).

$$POVERTY=f(ENERGY, GROWTH, HCD, FIN, FDI, REMIT, INFR) \quad (1)$$

POVERTY represents poverty, ENERGY is energy consumption, GROWTH stands for economic growth, HCD is human capital

**Table 1: Effect of energy consumption on poverty - A summary of empirical literature**

Author	Country/ Countries of study	Period	Methodology	Results
Okwanya and Abah (2018)	Africa	1981-2014	Fully Modified Ordinary Least Squares (FMOLS)	Energy consumption had a poverty reduction enhancing effect in the short run.
Pachauri and Spreng (2004)	World-wide	Theoretical literature review analysis	Theoretical literature review analysis	In summary, poverty reduction was found to have been positively influenced by energy consumption.
Thiam (2011)	Senegal	1990-2005	Time series data analysis	Poverty was reduced by energy consumption in Senegal.
Ogbeide-Osaretin (2020)	Nigeria	1990-2017	Autoregressive Distributive Lag (ARDL)	Coal and firewood increased poverty whilst electricity reduced poverty levels in Nigeria.
Nkomo (2007)	Southern African Development Community (SADC)	2003 data	Descriptive statistics	Sustainable energy consumption was found to be a key factor in poverty reduction in the SADC region.
Okwanya et al. (2015)	Nigeria	1985-2010	Granger causality analysis	Energy consumption had a significant poverty reduction influence in Nigeria.
Hussein and Filho (2012)	Sub Saharan Africa	2000 data	Descriptive statistics	Energy consumption had a deleterious effect on poverty in Sub Saharan African countries.
Kousar et al. (2020)	South Asian countries	1985-2018	FMOLS and Dynamic Ordinary Least Squares (DOLS)	Cheap energy consumption reduced poverty whilst expensive and non-efficient energy sources increased poverty levels.

Source: Author compilation

**Table 2: Theory intuition and expected sign (s)/a priori expectation**

Variable	Theory intuition	Source	Expected sign
HCD	According to Afzal et al. (2010), human capital development investment programmes can widen the poverty gap in the short term because some money which was supposed to be channelled towards social security programmes is channelled towards educations, skills development and health insurance. In the long run, human capital development enhancement programmes increase education levels, skills and health standards hence enabling people to easily secure employment and earn a decent income (Chaudhry and Rehman, 2009).	Afzal et al. (2010); Chaudhry and Rehman (2009)	±
INFR	Contrary to Pradhan and Mahesh (2014) whose study observed that infrastructural development increased poverty in developing nations, Jahan and McCleery (2005) argued that infrastructural development reduced poverty as it facilitates people's access to clean energy, better education and natural disasters' natural disasters	Pradhan and Mahesh (2014); Jahan and McCleery (2005)	±
REMIT	In line with Cattaneo (2005), remittances inflows create laziness among the recipients and long-term negative influence on economic growth and development. According to Anyanwu and Erhijakpor (2010), argued that poverty reduction linked to economic growth and development is very much possible due to remittances inflows.	Anyanwu and Erhijakpor (2010); Cattaneo (2005)	±
FDI	According to Amin (1974), over-relying on foreign direct investment has a long-term negative effect on economic growth, development and income distribution because the economy will be dominated by foreign capital. In contrast, Nguyen (2003) noted that FDI creates employment, improves skills among the labour force and inject foreign capital into the economy, all of which contributes towards poverty alleviation.	Amin (1974); Nguyen (2003)	±
FIN	Financial development enables more people to be financial included and access small loans which they can use to start entrepreneurial projects and self-employ themselves (Stiglitz, 1998).	Stiglitz (1998)	-

Source: Author compilation

development, FIN is financial development, FDI is foreign direct investment, REMIT is personal remittances received whilst INFR stands for infrastructural development.

The two proxies of poverty used in this study are mean mortality rate, infant (per 1 000 births) and mean life expectancy at birth, total (years). Energy use (kg of oil equivalent per capita) is a measure of energy consumption used in this study. Domestic credit by financial sector (% of GDP), human capital development index, net foreign direct investment (% of GDP), personal remittances received (% of GDP) and number of fixed telephone subscriptions (per 100 people) are the measures used for financial development, human capital development, foreign direct investment, remittances and infrastructural development respectively.

Equation 2 is the econometric version of the general model specification.

$$POVERTY_{it} = \beta_0 + \beta_1 ENERGY_{it} + \beta_2 GROWTH_{it} + \beta_3 (ENERGY_{it} GROWTH_{it}) + \beta_4 X_{it} + \mu + \varepsilon \quad (2)$$

$\beta_0$  is the intercept, The co-efficient of energy consumption is  $\beta_1$ . The co-efficient of economic growth is represented by  $\beta_2$ .  $\beta_3$  stands for the co-efficient of the complementarity between energy consumption and economic growth.  $\beta_4$  is the co-efficient of a matrix of control variables whilst  $X_{it}$  is the vector of control variables.  $\varepsilon$  is error function whereas  $\mu$  is the time invariant and unobserved country specific effect. If the co-efficient of the complementarity variable is significant and negative, it means

that poverty is significantly reduced by the interaction between energy consumption and economic growth in BRICS nations. Panel data analysis methods used include fixed effects, random effects, pooled ordinary least squares (OLS) and fully modified ordinary least squares (FMOLS).

## 4. DATA ANALYSIS, RESULTS DISCUSSION AND INTERPRETATION

Panel data ranging from 1995 to 2018 was used for the BRICS countries. The data sources include internationally reputable public databases such as World Bank Indicators, South Africa Statistics Agency, African Development Bank, International Financial Statistics and United Nations Development Programme. The data analysis constitutes four sections, namely pre-estimation diagnostics, panel unit root tests, panel co-integration tests and final data analysis.

### 4.1. Pre-estimation Diagnostics

All the variables (energy consumption, financial development, foreign direct investment, remittances, human capital development and infrastructural development) were found to be significantly and negatively related to poverty (Table 3). What is also clear is that there is no multicollinearity problem since the maximum correlation value is 68.87% (correlation between remittances and financial development), in line with Stead (1996) and Aye and Edoja (2017).

### 4.2. Mean Trend Analysis of Energy Consumption and Poverty Variables

Table 4 presents the mean trends of energy consumption and poverty trends in BRICS nations during the period from 1995 to 2018. Mean mortality rate, infant (1000 births) and mean life expectancy at birth, total (years) are the two proxies of poverty used in this study, following Tsauroi (2018).

Russia and South Africa are the two BRICS nations whose mean energy consumption exceeded the overall mean energy consumption level whilst Brazil, India and China's mean energy consumption were lower than the overall mean energy consumption value of 2115.27 kg per capita. Brazil, Russia and India are the outliers because their mean energy consumption values deviated from the overall mean value of 2115.27 kg per capita by a very wide margin.

BRICS nations whose mean of mean mortality rate was greater than the overall mean of mean mortality rate of 29.82 infants per 1000 births include China and South Africa. The remaining

countries (Brazil, Russia, India) had their mean of mean mortality rates below the overall mean of mean mortality rate of 29.82 infants per 1000 births. Clearly, Russia, India and South Africa are outliers because their mean of mean mortality rates deviated by a wide margin from the overall mean of mean mortality rate of 1000 infants per 1000 births.

Brazil and China are the only two BRICS countries whose mean of mean life expectancy was higher than the overall mean of mean life expectancy of 67.38 years. The remainder of the BRICS nations (Russia, India, South Africa) had their mean of mean life expectancy values below the overall mean of mean life expectancy value of 67.38 years. Brazil, China and South Africa are the outliers. This is because their mean of mean life expectancy values far much deviated from the overall mean of mean life expectancy of 67.38 years by a wide margin. In order to effectively address the outlier problem in the data set of all the values, the study transformed all the data into natural logarithms before using it for main data analysis. The strategy is in line with Aye and Edoja (2017).

### 4.3. Panel Unit Root Tests

Levin et al. (2002), Augmented Dick Fuller Fisher Chi Square, Im et al. (2003) and Phillip Peron (PP) Chi square test are the four methods used for panel unit root tests. Earlier studies done by Tsauroi (2018) and Tembo (2018) also used similar approaches. At first difference, all the variables used in this study were found to be stationary (Table 5). Odhiambo (2009) referred to similar results as integrated of order 1. The results allowed panel co-integration tests to take place (see Kao, 1999 test results in Table 6).

### 4.4. Panel Co-integration Tests

The Kao (1999) approach to panel co-integration was used (see results in Table 6).

According to the results in Table 6, the null which says that the variables are co-integrated cannot be rejected at 1% significance level. In other words, Table 6 results show that there is a long run relationship between the variables (poverty, energy consumption, financial development, foreign direct investment, remittances, human capital development, infrastructural development) under study. Such results paved way for panel data causality analysis to be undertaken, using fixed effects, random effects, pooled OLS and FMOLS.

### 4.5. Results Presentation and Interpretation

The poverty function consists of the dependent variable (poverty) and explanatory variables constituting energy

**Table 3: Correlation results**

	Poverty	Energy	FIN	FDI	REMIT	HCD	INFR
Poverty	1.00						
Energy	-0.0327***	1.00					
FIN	-0.2318***	-0.2177	1.00				
FDI	-0.2847***	0.4388**	0.0217*	1.00			
REMIT	-0.0048**	-0.2119	0.4318**	-0.6887**	1.00		
HCD	-0.2176***	0.3287*	0.2873**	0.2863**	0.1820**	1.00	
INFR	-0.3287*	0.1873*	0.2183*	0.5287***	0.1734***	0.0034**	1.00

\*\*\*, \*\*, \*Denotes statistical significance at the 1%, 5%, 10% level respectively. Source: Author compilation from E-Views

consumption, economic growth, financial development, foreign direct investment, remittances, human capital development and infrastructural development. Table 7 used mean mortality as a measure of poverty whilst Table 8 made use of mean life expectancy as a proxy of poverty.

According to Table 7, energy consumption had a significant negative effect on mean mortality rate across all the four panel methods (fixed effects, random effects, pooled OLS, FMOLS). The results mean that energy consumption reduced mean mortality rate and poverty in the BRICS nations. This is in line with Sadorsky (2010), whose study noted that clean energy consumption improves people's lives through enabling them to begin self-help entrepreneurial activities, engage in more productive activities and also increase the people's earning capacity.

Economic growth had a significant negative influence on mean mortality rate under fixed effects, non-significant negative effect under random effects and pooled OLS. This means that economic growth had a poverty reduction effect under fixed effects, random effects and pooled OLS approaches in BRICS. The results are supported by Kuznets (1995) whose study noted that economic growth leads to more people getting employment, saving more money, getting more diversified income and getting out of poverty zone. In line with Todaro (1997) whose trickle up theory argues that economic growth exacerbates the plight of the poor by throwing them further into the poverty zone, economic growth in Table 7 was found to have had a non-significant positive impact on mean mortality rate (poverty) under the FMOLS approach.

Across all the four panel methods used, the complementarity between energy consumption between energy consumption and

economic growth was found to have had a significant negative impact on mean mortality rate. The results indicate that economic growth is a channel through which energy consumption reduces poverty in BRICS nations. Such a finding resonates with Okwanya et al. (2015), Okwanya and Abah (2018) and Hussein and Filho (2012) whose empirical research noted that the poverty reduction impact of energy consumption happens through the economic growth channel.

Financial development also had a significant negative impact on mean mortality rate (poverty), in line with Stiglitz (1998) whose study argued that the development of the financial sector enables the poor people to access small loans for entrepreneurial projects.

FDI had a significant negative influence on mean mortality rate (poverty) under fixed effects and pooled effects, results which resonate with Nguyen (2003) whose study noted that FDI creates jobs and helps spread income among the people. On the other hand, random effects and FMOLS produced results which show a non-significant positive relationship running from FDI towards mean mortality rate (poverty), in line with Amin (1974).

Fixed effects and pooled OLS shows that remittances had a significant negative effect on mean mortality rate (poverty), results which agree with Anyanwu and Erhijakpor (2010), whose study observed that remittances reduce poverty through its positive influence on economic growth. Random effects and FMOLS shows that remittances had a non-significant positive impact on mean mortality rate (poverty), in line with Cattaneo (2005), whose study argued that remittances create laziness among the people and results in poverty increase in the long run.

Across all the four panel methods used, human capital development was found to have a negative effect on mean mortality rate (poverty), in support of Chaudhry and Rehman (2009) whose research human capital development reduce poverty in the long run through its ability to increase the chances of securing decent employment.

FMOLS and fixed effects produced results which show a significant negative impact of infrastructural development on mean mortality rate (poverty) in line with Jahan and McCleery (2005), whose research revealed that poverty was reduced by infrastructural development in developing countries through availing clean water and delivering decent educational facilities. On the other

**Table 4: Energy consumption and poverty trends in BRICS countries (1995-2018)**

	Energy use (kg of oil equivalent per capita)	Mean mortality rate, infant (per 1000 births)	Mean life expectancy at birth, total (years)
Brazil	1266.05	23.53	72.28
Russia	4621.60	11.69	65.14
India	506.03	52.99	65.14
China	1552.76	20.13	73.90
South Africa	2629.95	40.78	57.62
Overall Mean	2115.27	29.82	67.38

**Table 5: Panel root tests – Individual intercept**

	Level				First difference			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
LPOVERTY	-2.14**	0.73	33.19***	67.19**	-4.87***	-3.45**	-5.13***	46.15***
LENERGY	-3.16***	-3.18*	34.87*	21.45	-7.98***	-6.34***	101.63***	103.61***
LGROWTH	-5.76***	-2.03**	35.87*	11.98	-3.18***	-2.43***	71.09***	77.07***
LFIN	-1.98	3.86	3.87	6.54	-5.98**	-10.65***	109.45***	206.87***
LFDI	-4.77**	-3.87**	33.75*	63.12**	-12.65***	-9.29***	104.12***	271.23***
LREMIT	-2.13*	-5.18**	37.17**	74.10**	-6.17***	-9.21***	103.18***	187.17***
LHCD	-3.13*	-1.12*	-2.18*	-3.88*	-5.17***	-3.32***	-4.18***	-6.87***
LINFR	-8.17***	-5.17***	49.18**	76.13**	-8.93***	-4.17***	71.85**	84.88**

LLC, IPS, ADF and PP stands for Levin et al.; Im et al.; 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 - E-Views figures

hand, random effects and pooled OLS shows that mean mortality rate (poverty) was positively but insignificantly affected by infrastructural development, a finding which is supported by Pradhan and Mahesh (2014) whose research noted poverty was increased by infrastructural development in developing nations.

Energy consumption was found to have had a significant positive influence on mean life expectancy across all the four panel data analysis methods (fixed effects, pooled OLS, random effects, FMOLS) used. The results mean that energy consumption reduced poverty in BRICS nations, in support of the theoretical views by Dumrul (2018), Xu (2020) and Yessengali and Murat (2018).

Economic growth had a significant positive effect on mean life expectancy under the fixed and random effects and a non-significant positive impact under the pooled OLS and FMOLS. These results imply that economic growth reduced poverty in BRICS during the period under review, consistent with the trickle-down theory proposed by Kuznets (1995) and supported by Thorbecke (2013).

Across all the four panel methods employed, a significant positive relationship was observed running from the complementarity between energy consumption and economic growth towards mean life expectancy. This means that the combination between energy consumption and economic growth reduced poverty in BRICS countries, consistent with Okwanya et al. (2015), Hussein and Filho (2012) and Okwanya and Abah (2018) whose empirical research noted that energy consumption reduced poverty through its positive economic growth influence.

Financial development, foreign direct investment and remittances all had a positive effect on mean life expectancy across all the four panel data analysis methods used. The results mean that foreign direct investment, financial development and remittances were found to have had reduced poverty in BRICS nations, in support of the existing literature (Table 2).

Human capital development was found to have had (1) a significant positive impact on mean life expectancy under fixed effects and (2) a non-significant effect on mean life expectancy under random effects and FMOLS. These results show that human capital development reduced poverty in BRICS nations, in line with Chaudhry and Rehman (2009)'s argument which states that human capital development enable the securing of employment, improvement of salaries and standard of living in the long run. Pooled OLS shows that human capital development had a

**Table 6: Results of Kao (1999) co-integration tests**

Series	ADF t-statistic
Poverty energy FIN FDI remit HCD INFR	-3.4103***

Source: Author compilation

**Table 7: Panel regression results**

Variable	Dependent: Poverty (Mean mortality rate)			
	Fixed effects	Random effects	Pooled OLS	FMOLS
Energy	-0.0216**	-0.1112*	-0.0555**	0.1178**
Growth	-0.3482*	-0.0378	-0.0032	0.2387
Energy growth	-0.1763***	-0.0008**	-0.0128*	-0.0277*
FIN	-0.5471*	-0.2374*	-0.1287**	-0.4443**
FDI	-0.6216*	0.0328	-0.1184*	0.0538
REMIT	-0.0217**	0.2178	-0.2876**	0.3287
HCD	-0.0004	-0.3284	-0.0388	-0.0278*
INFR	-0.3222*	0.2121	0.0388	-0.2167*
R-squared	0.73.18	0.6892	0.6318	0.7188
Adjusted R-squared	0.6902	0.6502	0.5892	0.6821
F-statistic	41.83	38.21	39.92	51.93
Prob (F-statistic)	0.00	0.00	0.00	0.00

\*\*\*, \*\* and \*Denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from E-Views

**Table 8: Panel regression results**

Variable	Dependent: Poverty (mean life expectancy)			
	Fixed effects	Random effects	Pooled OLS	FMOLS
ENERGY	0.0021*	0.2222**	0.0989**	0.1272*
GROWTH	0.0009*	0.3377*	0.2121	0.4343
ENERGY.GROWTH	0.0488***	0.3189**	0.0323*	0.1111*
FIN	0.3289	0.3218	0.0268	0.1893
FDI	0.2378	0.3286	0.2345	-0.1188
REMIT	0.1294**	0.0898**	0.0217	0.0389
HCD	0.2180*	0.1276	-0.2345	0.1293
INFR	0.1993	0.1999	0.2398	0.0004
R-squared	0.7218	0.6134	0.5782	0.6399
Adjusted R-squared	0.6781	0.5811	0.5519	0.5902
F-statistic	42.19	39.82	42.93	53.98
Prob (F-statistic)	0.00	0.00	0.00	0.00

\*\*\*, \*\* and \*Denote 1%, 5% and 10% levels of significance, respectively. Source: Author's compilation from E-Views

non-significant negative impact on mean life expectancy. This means that human capital development increased poverty levels, consistent with Afzal et al. (2010) whose study noted that human capital development can widen the poverty gap in the short run due to the need to reallocate resources away from social security priorities.

Across all the four panel methods employed, infrastructural development was found to have had an insignificant positive influence on mean life expectancy. In other words, infrastructural development reduced poverty levels under fixed effects, random effects, pooled OLS and FMOLS, consistent with Jahan and McCleery (2005) whose research work noted that infrastructural development reduces poverty through facilitating the availability of good roads, clean water, clean energy and disaster management infrastructure.

## 5. CONCLUSION

This study investigated the impact of energy consumption on poverty in BRICS using panel data analysis methods (fixed effects, pooled OLS, random effects, FMOLS) with annual data ranging from 1995 to 2018. Whether economic growth is a channel through which energy consumption influences poverty in BRICS was also a subject of investigation in this study? Although there is acknowledgment that energy consumption reduces poverty through economic growth by authors such as Okwanya et al (2015), Hussein and Filho (2012) and Okwanya and Abah (2018), there is no dedicated empirical study on the subject matter which exclusively focused on BRICS. Nothing is known about the energy consumption-growth-poverty nexus in BRICS, according to the author's best knowledge. Also, majority of the energy consumption-poverty nexus empirical research wrongly assumed that the two variables (energy consumption and poverty) are linearly linked.

Using both mean mortality rate and mean life expectancy as measures of poverty, the study noted that energy consumption reduced poverty in a significant way across all the four panel methods employed in BRICS. Economic growth was also generally found to have reduced poverty in BRICS countries. The complementarity between the two variables (energy consumption and economic growth) had a significant poverty reduction effect in BRICS, in support of the existing literature. BRICS nations are therefore urged to develop and implement policies that ensure more energy consumption and increased economic growth activities if they intend to reduce poverty.

## REFERENCES

- Afzal, M., Malik, M.E., Begum, I., Sarwar, K., Fatima, H. (2010), Relationship among education, poverty and economic growth in Pakistan: An econometric analysis. *Journal of Elementary Education*, 22(1), 23-45.
- Ahmad, N., Hayat, M.F., Hamad, N., Iuqman, M. (2012), Energy consumption and economic growth: Evidence from Pakistan. *Australian Journal of Business and Management Research*, 2(6), 9-14.
- Akinlo, A.E. (2008), Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries. *Energy Economics*, 30(5), 2391-2400.
- Amin, S. (1974), *Accumulation on a World Scale: A Critique of the Theory of Underdevelopment*. New York: Monthly Review Press.
- Anyanwu, J.C., Erhijakpor, A.E.O. (2010), Do international remittances affect poverty in Africa? *African Development Review*, 22(1), 51-91.
- Apergis, N., Payne, J.E. (2010), A panel study of nuclear energy consumption and economic growth. *Energy Economics*, 32(3), 545-549.
- Apergis, N., Payne, J.E. (2012), A global perspective on the renewable energy consumption-growth nexus. *Energy Sources, Part B: Economics, Planning and Policy*, 7(3), 314-322.
- Aye, G.C., Edoja, P.E. (2017), Effect of economic growth on CO<sub>2</sub> emission in developing countries: Evidence from a dynamic panel threshold regression model. *General and Applied Economics*, 5(1), 1379239.
- Bartleet, M., Gounder, R. (2010), Energy consumption and economic growth in New Zealand: Results of trivariate and multivariate models. *Energy Policy*, 38(7), 3508-3517.
- Cattaneo, C. (2005), *International Migration and Poverty: A Cross Country Analysis*. Torino: Centro Studi Luca d'Agliano. Available from: [https://www.dagliano.unimi.it/media/cattaneo\\_cristina](https://www.dagliano.unimi.it/media/cattaneo_cristina).
- Chaudhry, I.S., Rahman, S. (2009), The impact of gender inequality in education on rural poverty in Pakistan: An empirical analysis. *European Journal of Economics Finance and Administrative Sciences*, 15, 174-188.
- Dagher, L., Yacoubian, T. (2012), The causal relationship between energy consumption and economic growth in Lebanon. *Energy Policy*, 50(3), 795-801.
- Dumrul, Y. (2018), Estimating the impact of financial development on energy consumption: A co-integration analysis. *International Journal of Energy Economics and Policy*, 8(5), 294-299.
- Hossein, S.M., Yazdan, G.F., Hasan, S. (2012), Consideration the relationship between energy consumption and economic growth in oil exporting country. *Procedia-Social and Behavioural Sciences*, 62(1), 52-58.
- Hussein, M.A., Filho, W.L. (2012), Analysis of energy as a precondition for improvement of living conditions and poverty reduction in Sub Saharan Africa. *Scientific Research and Essays*, 7(30), 2656-2666.
- Im, K.S., Pesaran, M.H., Shin, Y. (2003), Testing unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53-74.
- Jahan, S., McCleery, R. (2005), *Making Infrastructure Work for the Poor: Synthesis Report of four Country Studies-Bangladesh, Senegal, Thailand and Zambia*. New York: UNDP.
- Kao, C. (1999), Spurious regression and residual-based tests for co-integration in panel data. *Journal of Econometrics*, 90, 247-259.
- Kousar, S., Ahmed, F., Pervaiz, A., Zafar, A., Abbas, S. (2020), A panel co-integration analysis energy consumption and poverty: New evidence from South Asian countries. *Estudios de Economia Aplicada*, 38(3), 1-13.
- Kuznets, S. (1995), Economic growth and income inequality. *American Economic Review*, 45(1), 1-28.
- Levin, A., Lin, C.F., Chu, C.S.J. (2002), Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108(1), 1-24.
- Li, F., Dong, S., Li, X., Liang, Q., Yang, W. (2011), Energy consumption-economic growth relationship and carbon dioxide emissions in China. *Energy Policy*, 39(2), 568-574.
- Nguyen, T.P.H. (2003), Contribution of foreign direct investment to poverty reduction: The case of Vietnam in the 1990S. In: Frenkel, M., Stadtmann, G., editors. *Foreign Direct Investment: Theory, Empirical Evidence and Policy Implications*. German: Verlag Fuer Wissenschaft Un.
- Nkomo, J.C. (2007), Energy use, poverty and development in the SADC.

- Journal of Energy in Southern Africa, 18(3), 10-17.
- Odhiambo, N.M. (2009), Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach. *Energy Policy*, 37(2), 617-622.
- Odhiambo, N.M. (2010), Energy consumption, prices and economic growth in three SSA countries: A comparative study. *Energy Policy*, 38(5), 2463-2469.
- Ogbeide-Osaretin, E.N. (2020), Analyzing energy consumption and poverty reduction nexus in Nigeria. *International Journal of Sustainable Energy*, 2, 1-17.
- Okafor, H.O. (2012), Testing the relationship between energy consumption and economic growth: Evidence from Nigeria and South Africa. *Journal of Economics and Sustainable Development*, 3(11), 111-124.
- Okwanya, I., Abah, P.O. (2018), Impact of energy consumption on poverty reduction in Africa. *CBN Journal of Applied Statistics*, 9(1), 105-139.
- Okwanya, I., Moses, O., Alhassan, A. (2015), Economic linkages between energy consumption and poverty reduction: Implication on sustainable development in Nigeria. *International Journal of Innovative Social Sciences and Humanities Research*, 3(2), 113-120.
- Pachauri, S., Spreng, D. (2004), Energy use and energy access in relation to poverty. *Economic and Political Weekly*, 39(3), 271-278.
- Pradhan, B.K., Mahesh, M. (2014), Impact of trade openness on poverty: A panel data analysis of a set of developing countries. *Economic Bulletin*, 34(4), 2208-2219.
- Rufael, Y.W. (2012), Nuclear energy consumption and economic growth in Taiwan. *Energy Sources, Part B: Economics, Planning and Policy*, 7(1), 21-27.
- Sadorsky, P. (2010), The impact of financial development on energy consumption in emerging economies. *Energy Policy*, 38(5), 2528-2535.
- Sovacool, B.J. (2012), The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development*, 16(3), 272-282.
- Stead, R. (1996), *Foundation Quantitative Methods for Business*. England: Prentice Hall.
- Stiglitz, J. (1998), The role of the state in financial markets. In: *World Bank Annual Conference on Development Economics*. p19-52.
- Tembo, J. (2018), *Regional Financial Integration and Its Impact on Financial Sector Development: The Case of Southern Africa*, Unpublished Doctoral Thesis, University of South Africa.
- Thiam, D.R. (2011), Renewable energy, poverty alleviation and developing nations: Evidence from Senegal. *Journal of Energy in Southern Africa*, 22(3), 23-34.
- Thorbecke, E. (2013), The interrelationship linking growth, inequality and poverty in Sub-Saharan Africa. *Journal of African Economies*, 22(S1), i15-i48.
- Todaro, M.P. (1997), *Economic Development*. Reading, Mass: Addison-Wesley.
- Tsani, S.Z. (2010), Energy consumption and economic growth: A causality analysis for Greece. *Energy Economics*, 32(3), 582-590.
- Tsauroi, K. (2018), Complementarity between foreign aid and financial development as a driver of economic growth in selected emerging markets. *Comparative Economic Research*, 21(4), 45-61.
- UNCTAD. (2018), *World Investment Report*. New York: United Nations.
- Wei, L.Z., Gang, Z.X. (2012), Study on the relationship of energy consumption and economic growth in China. *Physics Procedia*, 24(4), 313-319.
- Xu, S.J. (2020), The impact of financial development on energy consumption in China: Based on SYS GMM estimation. *Advanced Materials Research*, 524-527, 2977-2981.
- Yessengali, O., Murat, I. (2018), The impact of financial development on energy demand in transitional economies. *Global Economy Journal*, 18(3), 20180014.
- Yildirim, E., Aslan, A. (2012), Energy consumption and economic growth nexus for 17 highly developed OECD countries: Further evidence based on bootstrap-corrected causality tests. *Energy Policy*, 51(3), 985-993.
- Yoo, S., Ku, S. (2009), Causal relationship between nuclear energy consumption and economic growth: A multi-country analysis. *Energy Policy*, 37(5), 1905-1913.