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Energy consumption, oil price and macroeconomic performance in energy dependent African countries

This study focuses on the relationship between energy consumption, oil price and macroeconomic performance of selected energy-dependent African countries. It was observed that energy consumption and crude oil price positively and significantly enhanced output growth but their impact on exchange rate is contradictory. Also, energy consumption and oil price were found to reduce inflation rate in the selected countries. It is therefore recommended that energy-dependent African countries should increase power generation and enhance crude oil local refining at affordable rates to boost energy consumption and reduce negative exogenous oil price shock on the macroeconomy.

Keywords: energy consumption; oil price; macroeconomic performance; African countries.
JEL classification: C22; E31; Q43; Q48.

1. Introduction

The average global oil consumption in 2011 was 88.03 million barrels per day, and with the 2011 world population figures of the United Nations (2012) which stood at 7022 billion, it then implies that an average person all over the world is expected to consume roughly two litres of oil per day (British Petroleum, 2012). The rate of energy consumption has implication (positive or negative) for a nation's economic performance. Hence, the role of energy in both energy consuming and energy producing nations cannot be over-emphasized due to the fact that it can positively or negatively affect both economies as it is being experienced with the current trend in the international crude oil market. All over the world, the quest for economic progress will be incomplete without factoring in energy use into the model for development. This is why the subject matter of energy consumption and economic growth has received attention from economic scholars (Kraft, Kraft, 1978; Asafu-Adjaye, 2000; Balat, 2008; Zaytsev, 2010; Acaravci, Ozturk, 2010; Dogan, 2016).

Despite the considerable focus on renewable energy sources like solar, water, nuclear, and wind, the role of crude oil price in determining macroeconomic direction has not diminished. For instance, oil price variation has played an important role in macroeconomic fluctuations in oil exporting countries (Bildirici, Ersin, 2015). Therefore, to study this role and identify the impacts of crude oil price on other indicators of the macroeconomy is of great importance. Also,

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happenings in the international crude oil market pose serious macroeconomic consequences to both oil exporting and oil importing countries owing to the fact that crude oil export is the main source of revenue in oil exporting countries and a major productive input in oil consuming countries. To this end, Pindyck and Rotemberg (1984), Bernanke et al. (1997), Lee and Chiu (2011), Saibu (2012), Gronwald (2012), Bildirici and Ersin (2015) have examined the effects of oil price changes on economic activity by identifying the channels through which such effects are transmitted in order to propose effective fiscal and monetary policies that can mitigate or reduce such negative impacts. These studies found oil price dynamics to be a significant contributor to macroeconomic instability in most countries.

Moreover, given that energy demand is an important factor affecting crude oil prices, it is expedient to understand oil consumption patterns and how they affect the performance of energy dependent African countries. The reason for this is not far-fetched as energy consumption among African countries still need to improve in the quest to expand industrial output and boost economic growth. African countries account for about 13% of the global population but account for only about 4% of the global energy demand (International Energy Agency, 2014). Also, about two-thirds of the entire African population does not have access to stable energy supply (Adams et al., 2016). Therefore, for the African continent to be able to achieve sustainability in economic growth process and reduce poverty, it has to be able to invest more in the supply of energy and boost energy consumption across the region (Turkson, Wohlgemuth, 2001). Furthermore, while several African countries have been observed to be very rich in energy resources, they are very poor in terms of energy supply and consequently poor in energy demand (Adams et al., 2016). Consequently, the inability of these resource rich African nations to be able to increase energy supply and boost energy demand in their various countries mean that the recent fall in international crude oil price puts them at a disadvantage position. Studies have shown that a fall in crude oil price positively impacts the economy of net oil importers but negatively impacts the economy of net oil exporters (Perry, Olivera, 2009; Suleiman, 2013; Eregha, Mesagan, 2016). Hence, the reason for African economies to expand energy consumption so that crude oil price instability will not have negative shocks on their economies.

Asafu-Adjaye (2000), Bekhet and Yusop (2009), Saibu (2011), and Suleiman (2013) among others have beamed their searchlight on the causality that flows among energy consumption, oil price and macroeconomic performance in an attempt to determine how the macroeconomy is influenced by energy consumption and oil price dynamics. While some claimed that bi-causality exist between energy consumption and oil price for some countries, some claimed unidirectional causality while others found no causality between them. This paper examines the energy-income relationship for five energy-dependent African countries: Nigeria, Algeria, Egypt, Morocco and Tunisia based on data availability. These countries were chosen because they represent African countries that are heavily reliant on energy both to earn foreign exchange and to power industrialization process. We depart from previous studies by considering the panel cointegration techniques vis-à-vis: the fully modified and dynamic OLS approaches. These approaches enable us to determine the direct impact of energy consumption and crude oil price on Africa's macroeconomic performance as against the causality analysis that previous related studies mainly focused on. The panel cointegration techniques also enable us to determine the individual country effects together with the impact of each explanatory variable on the panel. More so, the approaches enable us to correct the standard pooled OLS for serial correlation and endogeneity of regressors that are normally prevalent in a long-run relationship (Pedroni, 1996, 2000).

2. Literature review

Several studies in literature have been able to trace the link between energy consumption, oil price and the macroeconomy. However, some studies focus on the subject matter in developing economies while others looked at it from developed countries' point of view. In terms of empirical literatures with developing countries' experiences, Asafu-Adjaye (2000) beamed searchlight on Asian developing countries by looking at the causal relationships between energy consumption and income for Indonesia, India, Thailand and the Philippines. The results showed a unidirectional causality running from energy to income for Indonesia and India in the short-run, while there is bidirectional causality from energy to income in Thailand and Philippines. It was also found that real GDP, energy and oil prices are mutually causal in Philippines and Thailand. Also, energy and income had effect on each other with the exception of India and Indonesia where neutrality is observed in the short-run. Balat (2008) analyzed the dynamic link between energy consumption and economic growth in Turkey by investigating the co-movement of energy demand with economic growth, domestic energy resources utilization and the case of investments and imports over two decades. It was observed that the country's macroeconomic performance was enhanced by the energy sector growth. Bekhet and Yusop (2009) extended the study to the Malaysian economy using co-integration and error correction approaches. It was observed that there is a long-run connection between energy price, growth and energy consumption with short run interactions. Fluctuations in world price of oil was found to have significant effect on energy consumption and the amount of energy consumed significantly enhanced economic growth. Zaytsev (2010) focused on Ukraine and found that increase in oil price negatively enhanced real GDP in the short run as opposed to the long run through indirect effect characterized by aggregate demand contraction in response to the adverse shock in oil supply. In a similar study conducted on the Nigerian economy by Saibu (2011), a significant negative bidirectional causality was observed between domestic investment and energy consumption while a significant positive unidirectional causality was detected running from economic growth to energy consumption but not vice versa, while Gunu and Kilishi (2010) also found that oil price volatility has repercussions for oil exporting economies and therefore calls for diversification of the economy to reduce the consequences of external shocks.

The other strand of studies relating to oil price, energy consumption and macroeconomic performance is that of developed economies. Kraft and Kraft (1978) focused on the US economy and observed a unidirectional causality running from energy consumption to real income. The unidirectional causality observed implied an energy dependent economy in which energy enhances economic performance. Pindyck and Rotemberg (1984) analyzed energy price shocks and macroeconomic adjustments and observed that energy price shock has both direct effect and adjustment effect on an industrial economy as a result of prices or wages rigidities. They also predicted a high uncertainty for future energy prices which could have important implications for the performance of industrialized economies. Bernanke et al. (1997) asserted that oil price shocks cause output to decline mainly due to the responses of monetary policy to the shocks. In a study by Wolde-Rufael and Menyah (2010) on nine developed countries, Switzerland, Netherlands and Japan reported unidirectional causality stemming from nuclear energy consumption to real GDP, while reserve causality was reported for Sweden and Canada running from the real GDP to nuclear energy consumption. Furthermore, for the United States, Spain, United Kingdom and France, bidirectional causality was found between the real GDP and nuclear energy consumption. Lee and Chiu (2011) extended the discussion to six industrialised economies using the Toda and Yamamoto (1995) test of non-Granger causality. It was observed that nuclear energy and oil are substitutes in Canada and the United States, while they are complimentary in the UK, Japan and France. Also, in Japan, unidirectional causality runs from real GDP to nuclear energy, however, bidirectional causality was found in UK, Canada and Germany, while no causality was found in the US and France. Moreover, unidirectional causality was found running from oil price to energy consumption for all countries except US meaning that oil price changes affect nuclear energy consumption. Robays (2012) focused on the European economies and found that macroeconomic uncertainty causes oil price to rise and oil price shocks inadvertently affect macroeconomic performance. Ebrahim et al. (2014) beamed searchlight on the United Kingdom and United States economies and confirmed that the global economy becomes highly susceptible to macroeconomic fluctuations due to oil dependency. It was reported that if left unchecked, oil price volatility can destabilize the macroeconomy and pose significant barrier to future growth of the economy. Therefore, supply and demand-side policies are needed to develop macroeconomic resilience to adverse oil price shocks.

From the foregoing, it is clear that energy consumption and energy prices have some important roles to play in influencing real incomes and in determining the macroeconomic adjustments in several countries of the world. However, while the subject matter has been well researched in developed and developing economies, there is still dearth of related studies on the African continent, especially energy dependent African countries. Also, from the reviewed articles, it is evident that most studies in this area have dealt with the issue in terms of where causality runs from between energy consumption, energy prices and income. This present study will not only deviate a little by focusing on energy dependent African economies, but will also assess the direct impact of energy consumption and energy prices on the macroeconomic responses of these energy dependent countries using the panel cointegration techniques of analysis of Pedroni (1996, 2000), which helps to correct the standard pooled OLS for serial correlation and endogeneity of regressors that are normally prevalent in a long-run relationship. The methodology is also an improvement over previous related empirical articles that enable us to determine both the country specific and the panel impacts of energy consumption and oil price on the macroeconomy.

3. Theoretical framework

The theoretical modelling for the relationship between energy consumption, oil price and macroeconomic performance follows directly from the standard Solow theoretical model (Solow, 1956) who in his work on the central factors affecting economic growth separated an important exogenous factor that impacts significantly the growth potential among economies. Myriads of empirical studies which came after Solow's work expanded our understanding of the dynamics of economic growth as well as the key factors that are responsible for differential growth among developing and developed economies all over the world. Several economic growth theories of the classical, neo classical and endogenous were propounded to recognize and explain the variables that influence economic growth. While the classical theorists seem to dwell largely on capital as an important determinant of growth, the neoclassicals extended the Harrod–Domar classical formulation by including labour and technology to the growth model (Solow, 1956).

However, to include non-renewable energy in the standard Solow model as was the case in Asafu-Adjaye (2000), Bekhet and Yusop (2009), Mohammed et al. (2012), Saibu (2012), we assume that a fixed amount of energy resources (*E*) is available to the economy in each production period but which is exhaustible when they are used in production and that output is produced according to

$$Y = AK^{\alpha} E^{\beta} L^{1-\alpha-\beta}, \tag{1}$$

where α and β are between zero and one and $\alpha + \beta < 1$, *L* and *K* represent human and physical capital inputs and *A* represent the index of exogenous technology and multiplies the whole production function rather than the augmenting labour inputs as the Solow model suggests. The production function exhibits constant returns to scale in labour (*L*), capital (*K*) and energy (*E*) implying that if *L*, *K* and *E* are increased in the same proportions, the real GDP will also increase in the same proportion. Thus, output doubles only when all the inputs are doubled. In the same vein, with the standard Solow model, the economy is assumed further to exhibits exogenous technological progress and exogenous population growth and capital accumulates in the standard fashion. Extending the model will allow us to draft in energy consumption and oil price. For the sake of this empirical enquiry, we assume labour to be constant, so that output can be a function of capital and energy resources. This will better suit the model since our quest is determine the effect of energy consumption and oil price on real output.

3.1. Data and methodology

This empirical study probes the relationship between energy consumption, oil price and macroeconomic performance using data for energy-dependent African countries over the period 1970–2015. Based on the theoretical framework and following the works of Asafu-Adjaye (2000), Bekhet and Yusop (2009), Saibu (2011) and Suleiman (2013), we specify our empirical model as follows:

$$Y = f(ecp, op, gcf, enr). \tag{2}$$

Explicitly, equation (2) becomes

$$Y_{it} = \gamma_0 + \gamma_1 ecp_{it} + \gamma_2 op_{it} + \gamma_3 gcf_{it} + \gamma_4 enr_{it} + \mu_{it}, \tag{3}$$

where *Y* is a vector of macroeconomic variables like real GDP per capita (RGDP), inflation rate (INFLR) and exchange rate (EXR). Energy consumption per capita is represented with «ECP», crude oil price is represented with «OP», gross capital formation (GCF) is used to proxy capital in the model, while the proxy for labour is enrolment rate (ENR) and μ is the stochastic residual term. Present below are the FMOLS and DOLS approaches models.

Consider the regression

$$Y_{it} = \alpha_i + \beta_i x_{it} + \mu_{it}, \tag{4}$$

where Y_{it} is as defined, x_{it} is the vector of explanatory variables as previously defined. $rgdp_{it}$ and x_{it} are cointegrated with slopes β_i, which may or may not be homogeneous across *i*.

Let $\xi_{it} = (\widehat{\mu}_{it}, \Delta x_{it})$ be a stationary vector consisting of the estimated residuals from the cointegrating regression and the differences in x and let $\Omega_i = \lim_{T\to\infty} \mathrm{E}\left[T^{-1}\left(\sum_{t=1}^{T}\xi_{it}\right)\left(\sum_{t=1}^{T}\xi'_{it}\right)\right]$ be the long-run covariance matrix for this vector process. We can decompose this into $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma'_i$, where Ω_i^0 is the contemporaneous covariance and Γ_i is the weighted sum of auto covariance.

In line with Pedroni (2004, 2000), we specify the expression for the between-dimension, group mean panel FMOLS estimator is given as

$$\widehat{\beta}^*_{GFM} = N^{-1}\sum_{i=1}^{N}\left(\sum_{i=1}^{N}(x_{it}-\overline{x}_i)^2\right)^{-1}\cdot\left(\sum_{i=1}^{N}(x_{it}-\overline{x}_i)Y^*_{it} - T\widehat{y}_i\right), \tag{5}$$

where $Y^*_{it} = \left(Y_{it} - \overline{Y}_i\right) - \frac{\widehat{\Omega}_{21i}}{\widehat{\Omega}_{22i}}\Delta x_{it}$, $\widehat{y} = \widehat{\Gamma}_{21i} + \widehat{\Omega}^0_{21i} - \frac{\widehat{\Omega}_{21i}}{\widehat{\Omega}_{22i}}\left(\widehat{\Gamma}_{22i} + \widehat{\Omega}^0_{22i}\right)$.

The between-dimension estimator can be constructed as $\widehat{\beta}^*_{GFM} = N^{-1}\sum_{i=1}^{N}\widehat{\beta}^*_{FM,i}$, where $\widehat{\beta}^*_{FM,i}$ is the conventional FMOLS estimator applied to the *i*-th member of the panel. The associated *t*-statistics for the between dimension can be obtained as $t_{\widehat{\beta}^*_{GFM}} = N^{-1/2}\sum_{i=1}^{N} t_{\widehat{\beta}^*_{FM,i}}$, where $t_{\widehat{\beta}^*_{FM,i}} = \left(\widehat{\beta}^*_{FM,i} - \beta_0\right)\left(\widehat{\Omega}^{-1}_{11i}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)^2\right)^{1/2}$.

Similarly, a between-dimension, group mean panel DOLS estimator is as follows. However, we begin by augmenting the cointegrating regression with lead and lagged differences of the regressor to control for the endogenous feedback effect which plays similar role in the FMOLS procedure

$$Y_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-k_i}^{k_i}\gamma_{it}\Delta x_{i,t-k} + \mu_{it}. \tag{6}$$

From the above, the group-mean panel DOLS estimator is

$$\widehat{\beta}^*_{GD} = \left[N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{it}z'_{it}\right)^{-1}\left(\sum_{t=1}^{T} z_{it}Y_{it}\right)\right]_1,$$

where z_{it} is the $2(k+1)\times 1$-vector of regressors $z_{it} = (x_{it}-\overline{x}_i), \Delta x_{i,t-k}, ..., \Delta x_{i,t+k}$; $Y_{it} = Y_{it} - \bar{Y}_i$, and subscript 1 outside the brackets indicates that we are taking only first element of the vector to obtain the pooled slope coefficient. The between-dimension estimator can be constructed as $\beta^*_{GD} = N^{-1}\sum_{i=1}^{N}\beta^*_{D,i}$, where $\beta^*_{D,i}$ is the conventional DOLS estimator applied to the *i*-th member of the panel. Similarly, if we denote $\delta_i^2 = \lim_{T\to\infty}\mathrm{E}\left[T^{-1}\left(\sum_{t=1}^{T}\widehat{\mu}^*_{it}\right)^2\right]$ be the long-run variance of the residuals from the DOLS, the associated *t*-statistics for the between-dimension estimator can be obtained as $t_{\widehat{\beta}^*_{GD}} = N^{-1/2}\sum_{i=1}^{N} t_{\widehat{\beta}^*_{D,i}}$, where $t_{\widehat{\beta}^*_{D,i}} = \left(\widehat{\beta}^*_{D,i} - \beta_0\right)\left(\widehat{\delta}_i^{-2}\sum_{t=1}^{T}\left(x_{it}-\overline{x}_i\right)^2\right)^{1/2}$.

Data for the study were extracted from the World Development Indicator and International Financial Statistics (IFS), and analyzed with two recent panel cointegration techniques vis-a-vis: the fully modified and the dynamic OLS approaches. These techniques help to correct the standard pooled OLS for serial correlation and endogeneity that are normally contemporaneous in a long-run relationship Pedroni (2004, 1999, 2000). Whenever cointegration tests are to be applied to long-run hypotheses in aggregate panel data, a principal concern is to construct the estimators in a manner that does not hinder the transitional dynamics to be similar among the different countries of the panel. Rather, we will be interested in pooling only the information that concerns the long-run hypothesis of interest, and also allow the short-run dynamics to be potentially heterogeneous. This is the fundamental theme for the panel fully modified and dynamic OLS approaches (Bangake, Eggoh, 2011).

4. Empirical Result

4.1. Panel unit cross sectional dependence tests result

Before testing for panel unit root, one has to ascertain whether it is first generation or second generation panel unit tests that are applicable. This is because the first generation panel unit root tests assume cross sectional independence which are classified as either homogenous or heterogeneous panel unit root tests while the second generation panel unit root tests take cognizance of the possibility of cross sectional dependence and they are classified into factor structure approach and that of the approach that consists in imposing few or none restrictions on the residuals covariance matrix. Hence, in this study we test for cross sectional dependence in the panel data before proceeding with which panel unit root tests are applicable and two cross sectional dependence tests are employed: the Breusch–Pegan and Peseran cross sectional dependence tests as shown in Table 1.

Table 1. Cross sectional dependence test

Test	Statistics	Probability
Breusch–Pagan	25.92	0.12
Peseran CD	1.16	0.25
Average absolute value of the off diagonal elements	0.22	

From the Table 1, it is established that none of these two tests are significant. This implies that we fail to reject the null hypothesis of cross sectional independence alluding to the use of first generation panel unit root tests. This also supported by the low average absolute value of the off diagonal elements of the Peseran CD test. Therefore, we proceed with the first generation panel unit root tests.

4.2. Panel unit root test result

This study presents in Table 2 the outcome for both homogenous panel unit root process tests (Breitung, 2000; Levin et al., 2002) as well as the heterogeneous panel unit root process tests of Im et al. (2003). From the table, it is clear that at level, we cannot reject the null hypothesis of unit roots for the panel data for the variables in the study. It thus implies that all the variables employed in the model are non-stationary at levels.

Table 2. Panel unit root

Variables	Homogeneous unit root process				Heterogeneous unit root process			
	Level		1st difference		Level		1st difference	
	Levin et al. (2002)	Breitung (2000)	Levin et al. (2002)	Breitung (2000)	Im et al. (2003)	ADF–Fisher	Im et al. (2003)	ADF–Fisher
RGDP	4.28	4.06	–2.30***	–2.84***	7.19	0.07	–3.46***	30.82***
INFLR	–2.42***	–3.89***	–6.99***	–5.20***	–2.68***	24.17***	–9.94***	86.80***
ECP	0.99	1.37	–4.24***	–2.83***	2.00	3.41	–5.90***	49.99***
OP	–3.29***	3.43	–2.34***	–2.85***	–2.35***	2.57	–4.76***	31.14***
GCF	3.55	5.05	–4.54***	–5.15***	5.28	0.60	–5.53***	45.04***
ENR	2.68	0.11	–2.76***	–2.28***	2.30	3.50	–2.83***	26.38***
EXR	–1.03	–0.71	–4.93***	–4.10***	–1.20	15.06	–3.44***	28.88***

Note. *** indicates significant at 1%.

Taking a cursory look at the first difference section of Table 2, it is clear that all the variables in the panel are stationary for the individual linear trends model. It can therefore be concluded that while the variables are not stationary at levels, they are all stationary at first difference.

4.3. Panel cointegration result

Having confirmed that the panel variables are stationary at first difference, rather than at levels, we proceed further to conduct the panel cointegration test. This is to ascertain the long run relationship of the series between the variables of macroeconomic performance and the explanatory variables in each of the models. In doing this, we employ four tests that are within group and three tests that are between group to find out whether there is a long run relationship among the panel data employed in the study. This is shown in Table 3. The columns in Table 3 labeled as within-dimensions contain the statistics' computed value on the basis of the estimators that pool the autoregressive coefficient across the different countries in the panel for the unit root tests on the estimated residuals.

Table 3. Pedroni residual cointegration test

	Within-dimension		Between-dimension	
	Statistics	Weighted Statistics		Statistics
Panel v	1.94**	–1.41*	Group rho	0.93
Panel rho	–0.75	0.26	Group PP	–1.88**
Panel PP	–4.00***	–1.87**	Group ADF	–2.59***
Panel ADF	–1.76**	–1.73**		

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

In Table 3, the columns labeled within-dimension report that the estimators are statistically significant with the exception of the panel rho that is statistically insignificant. Also, the between-dimension reports the computed value of the statistic on the basis of average individually calculated coefficients for every country in the panel and it shows that except for the group rho, the between-group test shows that the null hypothesis of no cointegration is rejected. Table 4 which is Kao residual cointegration test also complements this result that the variables are cointegrated.

Table 4. Kao Residual Cointegration Test

ADF	–4.25***

Note. *** indicates 1% level of significance.

Table 4 shows that the Kao cointegration test suggests that we reject the null hypothesis of no cointegration in the panel. It means we can therefore conclude that the indicators of macroeconomic performance and the included variables are cointegrated for the panel of energy-dependent African countries. Therefore, there is a long-run relationship between macroeconomic performance, energy consumption and oil price in the panel of energy-dependent African countries is economically meaningful in that it advocates that the performance of these energy-dependent countries significantly rests on the price of crude oil as well as energy consumption. Since we have been able to establish the existence of long run relationship, the coefficients of the model can now be estimated using the panel cointegration techniques.

4.4. Panel cointegration estimates

The cointegrating vector is estimated using the Fully Modified OLS and the Dynamic OLS approaches. Tables 5a and 5b show the coefficients of real GDP of both methodologies for the country-specific and the panel together. Tables 5a and 5b show the coefficients of exchange rate, while tables 6a and 6b show the coefficients of inflation rate for both fully modified and dynamic OLS.

Table 5a. Fully Modified OLS result of real GDP

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	0.335	0.907***	0.596***	0.421*	0.581	0.568***
OP	0.155***	0.089**	–0.046**	0.135***	0.089***	0.084***
GCF	0.028	–0.170**	0.349	0.002	–0.006	0.041***
ENR	0.440***	–0.115	0.437***	–0.054	0.228*	0.187*
C	7.895***	1.355***	1.261***	8.580***	1.245*	4.067**
R^2	0.97	0.95	0.96	0.79	0.35	
Durbin–Watson	1.60	1.82	1.46	1.21	1.89	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

In Table 5a, the FMOLS result shows that energy consumption enhanced growth in all selected energy-dependent countries of Africa. The panel result also shows that energy consumption positively and significantly impacts on growth in selected energy-dependent African countries. One striking feature of this result is that energy consumption in Nigeria did not significantly impact on growth. This is said to conform to expectation as energy consumption per-capita in Nigeria is very low owing to electricity supply instability and low energy generation capacity. In terms of oil price, the result shows that it significantly and positive enhanced growth in each country with the exception of Morocco. The panel result also shows that crude oil price enhanced growth in selected energy-dependent African countries. This is not unconnected to the fact that most of these countries are oil producing countries and it is therefore in consonance with previous studies which assert that oil price is an important driver of growth in oil producing countries.

Table 5b. Dynamic OLS estimation result of real GDP

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	0.080	0.974***	–0.053	0.987*	1.262	0.65*
OP	0.155***	0.105	–0.057*	0.035	0.047*	0.057**
GCF	0.058*	–0.313**	0.199	–0.024	0.067	–0.003
ENR	0.554***	–0.572	0.308**	–0.251	0.063	0.020**
C	5.644**	1.577***	5.609	6.531***	1.57	4.186
R^2	0.99	0.99	0.99	0.95	0.89	
Durbin–Watson	1.90	1.23	1.87	2.04	1.52	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

The dynamic OLS result in Table 5b is similar to the FMOLS result as energy consumption enhanced the real GDP in each country except Morocco. The panel result also confirmed that energy consumption is growth enhancing in energy-dependent African countries and that it is significant too. In the same vein, the result of the DOLS also shows that energy consumption is not significant in Nigeria. This implies that both methodologies are in agreement as to the state of energy consumption in Nigeria. A cursory look at the DOLS result also suggests that crude oil price enhanced growth in each country with the exception of Morocco and that in the panel, oil price in energy-dependent African countries positively and significantly enhanced the real GDP. Moreover, the negative impact being witnessed in Morocco might not be unconnected to the fact that the country is a net importer of crude oil.

Table 6a. Fully Modified OLS result of exchange rate

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	0.570	2.016**	0.666	1.343**	2.542	1.427**
OP	–0.065	0.440*	–0.315***	–0.084	–0.200	–0.045**
GCF	–0.389***	–1.269**	–0.405**	0.779	–0.912	–0.439***
ENR	0.509**	0.348	0.671***	2.875	3.349***	1.550***
C	1.770	4.137	5.703	3.984**	1.307	3.380**
R^2	0.92	0.88	0.51	0.71	0.42	
Durbin–Watson	1.41	1.90	1.13	1.62	1.11	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

In Table 6a, the FMOLS result clearly shows that energy consumption positively impacts on exchange rate in each country. The panel result is also in agreement as energy consumption significantly enhanced exchange rate in the selected energy-dependent African countries. The intuition behind this is that a rise in energy consumption will translate to improvement in economic activities, higher national output, and greater income, higher consumption of both foreign and domestic goods. This will consequently mean more demand for foreign goods and foreign currencies relative to local currency and exchange rate will rise. This means that improvement in energy consumption in energy dependent African countries will translate to a rise in domestic currency relative to foreign currencies and currency depreciation results. In terms of oil price, the FMOLS result also conforms to expectation as crude oil price in each country with the exception of Egypt leads to a fall in the exchange rate. The panel result is also in synch with this result. This implies that a positive oil price shock will mean greater demand for these countries' local currencies vis-à-vis foreign currencies in the international market as they are able to earn more during this period. This will translate to a fall in exchange rate or appreciation of local currency and vice-versa.

Table 6b. Dynamic OLS result of exchange rate

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	2.461**	–0.261	0.314	3.719	1.418	1.530
OP	–0.211**	–1.257**	–0.264***	0.426	–0.303	–0.322***
GCF	–0.399*	2.548**	–0.245	1.113	–1.439	0.316*
ENR	–0.469	2.408	0.443	7.230*	2.748	2.472
C	10.026**	–2.103	4.639	4.692	1.675	3.786**
R^2	0.98	0.35	0.91	0.84	0.94	
Durbin–Watson	1.41	1.64	1.71	1.13	1.31	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

In Table 6b, similar results were obtained in DOLS for the effect of energy consumption and oil price on exchange rate with the exception of Egypt. The energy consumption per capita in each country enhanced the exchange rate situation except in Egypt where improvement in energy consumption tends to decrease exchange rate. The main reason for this is the fact that, unlike what obtains in each of the other energy-dependent African countries, improvement in energy consumption in Egypt propelled the level of output locally to rise thereby enabling Egyptians to substitute for imported goods, lowering pressure on demand for foreign currencies and resulting into exchange rate appreciation over the period. The panel result for the five selected countries also indicates that energy consumption across the region enhanced exchange rate. In the same vein, oil price in the DOLS result is also in consonance with that of the FMOLS result where it negatively impacts on exchange rate, that is, leads to exchange rate appreciation for each country and the panel. Only Algeria suggests otherwise. This conforms to apriori expectation as increase or decrease in crude oil price for energy-dependent countries is expected to cause appreciation or depreciation in exchange rate respectively.

As observed in Table 7a, the result of the FMOLS shows that energy consumption negatively impact on inflation for the panel, while crude oil price intensified inflation rate further. For the country-specific result, energy consumption result in Table 6a suggests that energy consumption

Table 7a. Fully Modified result of inflation rate

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	–7.843***	–0.261	–9.239	–6.472	6.642	–3.435*
OP	0.631***	–1.257**	2.947***	0.200	–3.802	–1.281***
GCF	1.673***	0.548**	1.507	1.838*	–3.548	0.404**
ENR	2.418***	1.407	–7.585**	0.164	2.297	–0.290***
C	–5.184***	–2.107	–2.537	1.654	7.136	–0.208
R^2	0.66	0.63	0.49	0.55	0.92	
Durbin–Watson	2.19	1.43	1.86	0.97	1.16	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

in each country, with the exception of Nigeria, negatively impacts on inflation rate. The intuition behind this is that an improvement in energy consumption in energy-dependent African countries is expected to boost the productive sector of the economies of Tunisia, Egypt, Morocco and Algeria which consequently put pressure on output to rise to meet the expectation of the aggregate demand sector thereby forcing down inflation rate. However, in Nigeria, improvement in energy consumption did not enhance the productive sector due to several challenges being witnessed in the country ranging from electricity instability, high operation cost and financial rigidities. Oil price in Tunisia, Morocco and Algeria indicates that it intensifies inflation with the exception of Nigeria and Egypt as well as the panel where oil price negatively impacts on inflation rate. It thus means that in energy-dependent African countries selected, jointly, oil price increase did not worsen the general price level which is a good omen for the performance of the region.

Table 7b. Dynamic OLS result of inflation rate

Regressors	Tunisia	Egypt	Morocco	Algeria	Nigeria	Panel
ECP	–1.260***	–1.152	0.724***	1.825	–0.752	–0.615***
OP	0.940***	–0.453	3.641**	–4.337	–2.452	–0.532*
GCF	1.969***	3.420*	–2.578***	1.375	1.088	1.055**
ENR	4.593***	2.175*	–1.375***	–4.602	4.086	0.975**
C	10.93***	12.510	2.539***	7.619	6.307	7.981
R^2	0.72	0.73	0.92	0.58	0.65	
Durbin–Watson	2.40	1.44	2.77	1.44	1.59	

Note. ***, ** and * indicate 1, 5 and 10% level of significance.

In agreement with the FMOLS result, the DOLS result presented in Table 7b clearly supports the fact that energy consumption in the selected energy-dependent African countries negatively and significantly impacts on the general price level. The panel coefficient of –0.615 attests to the fact that energy consumption did not worsen inflation rate position in the selected countries. In the same vein, crude oil price in Egypt, Algeria, Nigeria and the panel means that inflation rates fall across the region with every increase in oil price. This is not unconnected with the fact that the proceeds and revenue earned from oil export does not get circulated easily and might not even get to the masses. This is so because most times, these oil proceeds either find their ways into private accounts or leave the country in the form of capital flight. Also, international crude oil price does not directly affect the general price level locally. In Nigeria for instance, it is only increases in the domestic price of petrol, and kerosene that are normally transmitted straight away to increases in the general price level and consequently inflation (Eregha et al., 2015). Most times when the price of crude oil goes up in the international market, it does not affect the domestic price of premium motor spirit (PMS) or petrol and kerosene. This explains why crude oil price increase for the three countries and across the panel did not worsened the level of inflation.

Table 8. Panel causality analysis for the selected energy dependent African countries

No causality	Unidirectional causality	Bidirectional causality
EXR — ECP	OP → EXR	GDPPC ⇔ INFLR
OP — ECP	OP → GDPPC	
INFLR — ECP	OP → INFLR	
	EXR → INFLR	
	EXR → GDPPC	
	GDPPC → INFLR	

Note. — denotes no causality, → denotes the direction of causality, ⇔ denotes bidirectional causality.

In Table 8, the panel causality for the selected energy dependent African countries suggests that there is no causality between exchange rate and energy consumption per capita, between inflation rate and energy consumption per capita and between crude oil price and energy consumption per capita. Bidirectional causality was observed between energy consumption and real GDP per capita. However, unidirectional causality was observed in the study running from crude oil price to exchange rate, from crude oil price to real GDP per capita and from crude oil price to inflation. This means that since these countries are energy dependent and several of them are crude oil net exporters, international crude oil price affects domestic inflation across the region. Also, the unidirectional causality observed running from crude oil price to exchange rate is justified because a fall in crude oil price has adversely affected the energy-dependent African countries selected through currency depreciation, especially Nigeria, which is currently in recession. In the same vein, Table 8 shows the existence of a unidirectional causality running from exchange rate to RGDP per capita. The implication of this is that while economic growth does not cause the appreciation or depreciation of currencies among the selected countries, currency situation in the panel influences the growth of the various economies. Also, a unidirectional causality was found running from exchange rate to inflation rate in the panel. It means that an appreciation of currency in the panel could reduce the level of inflation while a depreciation could bring about a rise in inflation rate depending on the cause of inflation. Finally, there is unidirectional causality running from RGDP per capita to inflation rate. This conforms to theory as inflation is not expected to affect real output, whereas economic growth increases the level of aggregate demand and consequently brings about demand pull inflation in the region.

5. Conclusion

The study examines the impact of energy consumption and oil price on the macroeconomic performance of selected energy-dependent African countries over the period of 1980 to 2013. Five energy-dependent countries in Africa were selected based on the availability of data.

The study employed a panel data cointegration approach specifically examining the time series properties of panel data using both the homogeneous and heterogeneous panel unit root tests. The study confirmed that the data were not stationary at levels but became stationary after first difference. The Pedroni and Kao residual based panel cointegration tests were also conducted in the study and it was established that a long run relationship exists among the series. The estimation technique employed for analysis is the Fully Modified and Dynamic OLS cointegration approaches. It was observed in the study that the three macroeconomic variables of real GDP, inflation rate and exchange rate responded well to energy consumption and crude oil price in most of the countries and in the panel, with the exception of slight different results in a few of the selected countries. Specifically, the panel result indicates that energy consumption and oil price significantly enhanced the real GDP in selected energy-dependent African countries which implies that crude oil price and energy consumption provides impetus for economic growth in these African countries. Moreover, energy consumption and oil price enhanced the exchange rate situation thereby enabling these economies, albeit, with a contrasting effect. Improvement in energy consumption will bring about currency depreciation while a positive oil price shock is expected to stimulate a currency appreciation. Energy consumption and crude oil price were also observed to similarly have negative effects on inflation rate in energy-dependent African countries as they have significant effect in enhancing the productive capacity of the region in order to accommodate the needs of the aggregate demand sector thereby forcing down inflation and consequently propelling economic boom. Therefore, energy-dependent African countries should put in more effort in generating stable electricity and encouraging local refining of crude oil at affordable rates in order to boost energy consumption and reduce negative exogenous oil price shock on the macroeconomy.

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