Effects of financial sector development on energy consumption in Africa

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Abstract

The relationship between energy consumption and financial sector development can be quite complex owing to the numerous impact channels that exist between them. Thus, examining how positive and negative variations of financial sector development can affect energy consumption is very important. While studies on finance–energy consumption nexus exists albeit insignificantly, those pertaining to Africa are almost non–existent. This study examines the effect of financial sector development on energy consumption in Africa relying on data for 45 countries covering a period of 1973–2014. Results from the generalized method of moment (GMM) reveal that whereas domestic credit appears to propel energy consumption irrespective of the model specification, private credit only spurs energy consumption when energy consumption is proxied by energy use. The study also found U–shaped relationship between private credit and energy consumption proxied by carbon dioxide (CO2) emissions. The study discusses the key implications for policy.

Keywords: Financial sector development; Energy consumption; Africa; GMM.

1. Introduction

Embarking on the study of financial development and energy consumption begins in most papers with the understanding of the demand driven means of energy. Following a plethora of extant literature in this area of research, the findings have been mixed over the period. The pioneering work to look at this area emanates from the seminal paper of Kraft and Kraft (1978). They used bivariate causality procedure and established evidence running from GNP to energy consumption for the US economy. Since then they have been a plethora of work attempting to explain economic growth - energy consumption; financial developmentenergy consumption nexus, while other works incorporate different analytical techniques, time periods and samples of different sizes and many more countries for their studies. For instance, Ciarreta and Zarraga, 2010a,b focuses on the relationship between economic growth and electricity consumption controlling for energy price fluctuations in 12 Europeans countries. The purpose was to take care of the price fluctuations that could distort the understanding of the real causal relationship between the two. Sadorsky (2010) argues that, emerging economies that continuously develop their capital markets will likely experience increases in their energy demand over and above that which comes from income. This implies that the two may not be directly proportionally related. This tells us that the nexus between them is not simple as it appears. Sadorsky (2010) again argues that, if energy demand projections in transition economics do not capture financial development as a regressor, it is more likely to under estimate the actual energy demand of such economies and when this happens, energy conservation policies will likely fall below their intended targets since policy makers may fail to include the likely impact of financial development as a prerequisite for energy demand.

With this understanding, Yousif (2002) further examined the nature and direction of the relationship between financial development and economic growth by employing both time series and panel data analysis techniques for over 30 countries from among developing nations which included African countries. The study found that both economic growth and financial development have reciprocal causality effect on each other. Further findings indicate strong evidence to show that both have bidirectional causality link. Precedent to that, the debate that was ignited by Kraft and Kraft (1978) on the economic growth and energy consumption nexus is still going on without a common agreement on the direction of causality. Muhammad *et al.*, (2017) investigated the asymmetric relationship between energy consumption and economic growth and incorporated

financial development using the Indian economy. They applied the Nonlinear Autoregressive Distributed Lag (NARDL) bounds testing approach to examine the presence of the asymmetric cointegration between the variables under study. In doing so, they also tested for asymmetric causality between the variables and found that only negative shocks in energy consumption impacts on economic growth and at the same time negative shocks in financial development equally have impact on economic growth. On one hand, some argue that financial development positively affects economic growth see (Ibrahim and Alagidede, 2018; Shaw, 1973). Their works confirmed the proponents of the "supply leading view" who contend that financial development leads to economic growth by two channels such as: (1) by raising the efficiency of capital accumulation and in turn the marginal productivity of capital and (2) by raising the savings rate and thus the investment rate" (McKinnon, 1973; Shaw, 1973).

Examining the relationship between financial development and energy consumption to know whether there is a positive or negative relationship between them is important because it allows us to study the cause and effect variables in this complex arrangement and more especially when it mirrors Africa with weak regulatory and institutional quality regimes. The empirical studies that examined the relationship between energy consumption and economic growth cited in this study include (Dogan, 2014; Dogan, 2016a,b; Dogan et al., 2016) confirmed the feedback hypothesis for Turkey stretching from 1995 to 2012 and established the same finding for Belgium from 1960 to 2012. Notwithstanding that numerous studies found the causal effect running through in many directions, they are however, a few studies that did not find any prove of causal relation between the energy consumption and economic growth debate. For instance, Jafari et al., (2012) could not establish in his study any significant relationship between the two variables neither could Menegaki and Tugcu (2016) study do so, hence the demonstration of the latter to the neutrality hypothesis between economic growth and energy consumption in 42 Sub Saharan African (SSA) countries stretching from 1985 to 2013.

But whatever it is, a lot and more recently, studies have tried to explain the relationship between financial development and energy consumption especially during the after mouth of the 2007 world economic meltdown (see Sadorsky 2010, 2011; Islam *et al.*, 2013; Coban and Topcu, 2013; Tang and Tan 2014; Abbasi and Riaz, 2016). All these studies established that financial development and energy consumption have impact on each other. According to Tamazian and Rao (2010), financial development may attract FDI to transitional economics

which in turn can speed up economic growth and its accompanying dynamics as also alluded to by (Frankel and Romer, 1999). The second reason is that financial development could serve as a receptacle for motivation and opportunities to acquire and use new technologies that promote clean and friendly-atmosphere. As a natural consequence, such friendly technologies will improve lives (see Birdsall and Wheeler, 1993; Frankel and Rose, 2002).

Other reasons why we should be concerned in knowing the effect of finance on energy consumption is to help us push for financial development alongside economic growth and its implication on energy consumption. It may also result to more industrial pollution (Jensen, 1996; World Bank, 2000). This becomes possible because many industrial firms may embark on aggressive expansion and increase in production since they can have access to cheaper capital in the framework of developed financial system. Capital will be available from the stock markets for increase production by investing in many more positive projects on the back of such developed financial system hence the rapid rise in pollution level.

Economic literature suggests that the more financially developed a nation is, the more and better chances that country stands to attract foreign direct investment (FDI) and this makes Eskeland and Harrison (2003) to opine that foreign firms are more energy-efficient and are more likely to use friendly techniques in the production process than domestic firms. Kumbaroglu *et al.*, (2008) extended the argument and indicate that developed financial system encourages firms to adopt more energy-efficient and friendly technologies that will result in lower emissions than their counterparts with less developed financial structure. According to Capelle–Blancard and Laguna (2010), a well-organized and developed financial sector on one hand, tend to push firms towards the adoption of friendly technologies and punish firms that produce more pollutants by restricting their access to easy credit as they continue to pollute the land, water and air on the other hand. Hence this act will not only increase the market value of the firm but increase productivity as a whole.

This study makes significant contribution to literature. First, relative to earlier studies such as Yussif's (2002) work that did not focus on Africa only, this study focuses exclusively on Africa and relies on an estimation approach that controls for indigeneity eminent in this type of work regarding financial sector development – energy consumption nexus. By so doing, it provides consistent estimates of the precise effects. Second, the study relies on a wider span of data and alternative proxies of energy consumption and financial sector development.

Through this, the study unearths the differential effect of financial sector development on the different measures of energy consumption. Specifically, the results show that, while financial sector affects energy consumption, the effect is huge when energy consumption is measured by energy use. Third, beyond the direct financial sector development – energy consumption relationship, this study also examined the mediation role of financial sector development and economic growth effect on energy consumption and found a negative effect.

To the best of the author's knowledge, this study is one of the few empirical studies to examine how financial sector development affects energy consumption in Africa. In this regard, a key contribution of this study lies on its usage of different indicators of financial development to examine the robustness of the moderation effect of finance. Thus, this study therefore presents fresh evidence on the conditional moderating role of Africa's nascent financial sector development – energy consumption link. It is against this backdrop that this paper seeks to uncover and deepen the understanding of how the level of energy consumption may respond to the actions and activities emanating from the continent unwavering steps to develop the financial system. The results from the system generalized method of moment reveal that for most part, higher financial sector development is associated with higher energy consumption but the level of magnitude is indicator specific for both proxies of finance and energy consumption. With the moderation effect of financial sector developmenteconomic growth, the impact on energy consumption is negative. The rest of the paper is organized as follows: the next section outlines the methodology. Section 3 discusses the empirical results and findings while section 4 presents the conclusions and key implications for policy.

2. Methodology

2.1. Data and preliminary findings

This study constructs a panel dataset of 45 countries over the period spanning 1973–2014.¹ The choice of these countries is exclusively based on data availability for a sufficiently longer time period particularly for the variables

¹ The countries are Algeria, Angola, Benin, Botswana, Burundi, Burkina Faso, Cabo Verde, Cameroon, Central African Republic, Chad, Congo, Dem. Rep. Congo, Rep., Cote d'Ivoire, Ethiopia, Egypt Arab Rep., Equatorial Guinea, Gabon, Ghana, The Gambia, Guinea-Bissau, Guinea, Kenya, Liberia, Libya, Lesotho, Mali, Malawi, Mauritania, Mauritius, Morocco, Niger, Nigeria, Namibia, Mozambique, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.

of interest such as energy consumption, finance and economic growth. Annual panel data was sourced from the World Development Indicators (WDI) of the World Bank. The main energy consumption variable is proxied by carbon dioxide (CO_2) emissions which is measured by those stemming from the burning of fossil fuels which include CO_2 produced during consumption of solid, liquid, and gas fuels and gas flaring. This measure has been used in the literature (see Jalil and Feridun, 2011; Ozturk and Acaravci, 2013) to measure countries' level of environmental pollution. For robustness analysis, we also measure energy consumption by the level of energy use which refers to the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. This measure of energy consumption has also been used in earlier studies (see for instance Sadorsky, 2010).

The study measures financial development by private sector credit as percentage of GDP which has been used in the finance literature (Ibrahim and Alagidede, 2018). This is a qualitative-based indicator which measures credit advanced to the private sector thus capturing the utilization and allocation of funds to more efficient and productive activities. It particularly separates credit to the private sector from those issued to governments, government agencies, and public enterprises. It also excludes credit by the Central bank. For robustness check, the study also used domestic credit provided by the financial sector to proxy financial development. Allocating credit comprise a key function of any financial sector especially in countries where the financial sector is largely bank–based like those in Africa. Indeed, financial sector development indicators focusing on the ability of the financial system to efficiently allocate credits have been developed (King and Levine, 1993). Therefore, the study measures financial sector development by using private and domestic credits to GDP ratio.

The study includes other control variables which are chosen following the literature. They are economic growth, government expenditure, inflation, school enrolment, gross fixed capital formation, and trade openness. Economic growth is proxied by annual gross domestic product growth rate. This is used to also measure the size of the domestic market for energy consumption. Inflation is measured as the annual percentage change of the consumer price index which reflects changes in the cost to the average consumer of acquiring a basket of goods and services. We used this to denote macroeconomic (in) stability. Trade openness is also included to measure whether the countries

level of international market integration and trading activities affect the nature of energy consumption and this is measured by the sum of exports and imports expressed as a ratio to GDP. School enrolment is used to proxy the stock of human capital accumulation which is taken as the total enrolment in secondary education, regardless of age and expressed as a percentage of the population of official secondary education age. Again, this study used gross fixed capital formation as a percentage of GDP to proxy investment rates. Government expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures that are part of government capital formation expressed as a percentage of GDP and used to measure government size. Table 1 presents results on the descriptive statistics of the variables.

With regard to the proxy of economic growth, there is evidence that the average growth rate of the continent economy is 4.43% with a minimum and maximum growth of -62.08% and 149.97% respectively. The wide disparity is reflected in a high standard deviation suggesting high variability across the countries. The rather low growth rate reflects the sluggish and underdeveloped nature of the continent's economy in the sample used over the years with many economic interruptions either through poor economic planning by successive governments or military interventions. Private credit and domestic credit averaged 29.54% and 17.68% of GDP respectively with a standard deviation of 62.62% and 15.58%. The values of the kurtosis and skewness show a nonnormal distribution of all the series suggesting that the variables are leptokurtic. With regard to the correlation coefficients, private credit is positively correlated with the variables except energy use, GDP growth and inflation while domestic credit is also positively correlated with all the variables except GDP growth and inflation. The correlation is however positive between trade openness and gross fixed capital formation. Furthermore, energy use is also positively associated with all the series with the exception of CO₂ emission and inflation while CO₂ emission is negatively related to government expenditure, trade openness and inflation

	Private credit [1]	Domestic credit [2]	Energy use [3]	CO ₂ emission [4]	GDP growth [5]	Gov. Exp [6]	Trade openness [7]	Inf [8]	Gfcf [9]	Senrol [10]
Mean	29.536	17.683	626.936	35429.7	4.426	15.257	69.976	64.583	21.390	606567.2
St. dev.	62.618	15.581	532.618	190481	9.098	7.679	42.858	943.588	15.436	1063298
CV	2.120	0.881	0.850	5.376	2.056	0.503	0.612	14.616	0.722	1.753
Min	-114.694	0.156	9.585	29.336	-62.076	0.000	11.087	-35.837	-2.424	514
Max	2066.184	106.307	3369.03	2516435	149.97	88.983	531.737	24411.03	219.069	1.25e+07
Skewness	24.487	1.958	2.945	8.738	4.902	3.847	3.937	24.437	6.210	3.937
Kurtosis	790.037	7.604	12.396	87.428	83.827	30.283	31.228	619.537	63.663	26.718
Correlation										
[1]	1.000									
[2]	0.268	1.000								
[3]	-0.060	0.078	1.000							
[4]	0.074	0.185	-0.026	1.000						
[5]	-0.006	-0.038	0.042	0.029	1.000					
[6]	0.021	0.191	0.149	-0.093	-0.039	1.000				
[7]	0.076	0.139	0.228	-0.112	0.291	0.195	1.000			
[8]	-0.027	-0.050	-0.021	-0.010	-0.054	-0.056	-0.013	1.000		
[9]	0.026	0.113	0.126	0.053	0.437	0.075	0.719	-0.051	1.000	
[10]	-0.016	-0.329	-0.235	-0.110	0.250	-0.0343	0.035	0.013	0.097	1.000

TABLE 1: DESCRIPTIVE STATISTICS

Notes: Gov't Exp = Government expenditure; Inf = Inflation; Gfcf = Gross fixed capital formation; Senrol = Secondary school enrolment.

2.2. Empirical strategy

This study seeks to investigate the overall effect of financial development on energy consumption in Africa. In this endeavor, the study exclusively relies on a panel dataset in examining financial development–energy consumption nexus because the focus here is on how financial sector development influences energy consumption in the entire continent as a single unit of analysis. To empirically investigate the effect of financial development on energy consumption, equation (1) is employed, where energy consumption depends on finance and other covariates:

$$EC_{it} = f(FD_{it}, Z_{it}, \varepsilon_{it})$$
(1)
 $i = 1, 2, \dots, N; \quad t = 1, 2, \dots, T,$

where EC_{it} stands for indicators energy consumption such as carbon dioxide CO_2 and energy use; FD_{it} stands for indicators of financial development such as private and domestic credits; Z_{it} are the control variables, subscripts *i* and *t* are country and time indices respectively while ε_{it} is the error term. To examine whether financial development promotes or inhibits energy consumption in Africa, the study delineates a baseline model where energy consumption is modeled as a function of its lag, finance and other control variables in equation (2) below:

$$EC_{it} = \alpha_o EC_{it-1} + \alpha_1 FD_{it} + \alpha_2 Z_{it} + \epsilon_{it}$$

$$\epsilon_{it} = \gamma_i + \mu_t + \varepsilon_{it}$$
(2)

 α_o is used to examine whether the continent's level of energy consumption diverges or converges to a common steady state; γ_i is the country–specific fixed effects; μ_i is the time effects while the error term assumed to be independently and identically distributed, *iid* $N(0, \sigma^2)$. To determine the threshold effect of FD on EC the study include a quadratic term of FD into equation (2) in order to examine possible nonlinearities in FD–EC nexus in equation 3:

$$EC_{it} = \beta_o EC_{it-1} + \beta_1 FD_{it} + \rho FD_{it}^2 + \beta_2 Z_{it} + \epsilon_{it}$$
(3)

The threshold is determined by relying on the sign of β_1 and that of ρ . To examine how financial development influences energy consumption given countries' level of economic growth, there is an inclusion of a multiplicative interactive term of finance and economic growth, thus estimating equation (4) as follows:

$$EC_{it} = \varpi_o EC_{it-1} + \varpi_1 FD_{it} + \eta FD_{it}^2 + \varpi_2 Z_{it} + \theta (FD_{it} \times EG_{it}) + \epsilon_{it} \quad (4)$$

where EG_{it} is economic growth for country *i* at time *t* while the other variables are as previously defined. From equation (4), θ measures the impact of FD on EC given the countries' economic growth. Indeed, the introduction of lagged dependent raises issues on endogeneity as the lagged dependent may be correlated with the error term. In this study, we therefore estimate equation (4) relying on the system generalized method of moments (GMM) dynamic pooled estimator developed by Arellano and Bond (1991). The study uses 5–year data averaging to avoid biased estimates as well as abstracting from business cycle components eminent in the data. This exercise entails the construction of 5-year periods of data for each country (1973–1977; 1978–1982; 1983–1987;; 2005–2009; 2010–2014) yielding eight non-overlapping periods. Provided $T \ge 3$ and N > T substantially as in the case where T = 8 and N = 45, the GMM approach is especially suitable as it provides key advantages in terms of accounting for potential endogeneity of the regressors, simultaneity bias and possible autocorrelation stemming from the data (see Arellano and Bond, 1991).

3. Findings and discussions

The study presents its findings in two forms in this section. First, it examines the impact of finance on energy consumption in Africa proxied by CO_2 whilst it measures financial development by private credit and domestic credit. In the second section, the study re-examined the impact of finance on energy consumption proxied by energy use. In the first section, several regressions of CO_2 are estimated on its regressors including it lagged term as an explanatory variable as well as extending the regressors to include the quadratic term of both proxies of finance to check for non-linearities.

From Table 2, the study finds a negative relationship between private credit and CO₂ emissions although insignificant. It means that private credit as a measure of financial development effect on carbon dioxide emissions is inversely related. In addition to that, trade openness in all the energy consumption equations are insignificant and positive hence trade openness enhances energy consumption through CO₂ emissions. From Table 2 again, the evidence is that government expenditure dampens carbon emissions at conventional level when it is controlled for with private credit while it becomes insignificant when controlled for with domestic credit. In model 1, whereas private credit dampens energy consumption albeit insignificantly, Government expenditure, inflation and capital formation have dampening effects on energy consumption (carbon dioxide emissions) and highly significant at 1% level. This is possible especially where governments become environmentally conscious and a lot of budgetary allocations and foreign direct investments (FDI) leading to fixed capital are pushed towards green revolution and technologically efficient production. Because of the environmental awareness campaigns over the period especially the famous Rio de Janeiro 1995 conference, some governments of the African countries and multinational firms investing in foreign countries become more conscious on spending with the environment protection in mind. In inflationary economies, fuels turn to be expensive and therefore will limit the amount of purchasing power of consumers which ultimately dampens energy consumption.

	1	2	3	4	5	6
Constant	-0.499 (0.000)	-0.166 (0.390)	-0.090 (0.702)	-0.113 (0.532)	-0.775 (0.004)	-0.389 (0.120)
Lagged CO ₂ emission	0.637*** (0.000)	0.625*** (0.000)	0.538*** (0.000)	0.613*** (0.000)	0.618*** (0.000)	0.617*** (0.000)
Private credit	-0.001 (0.867)	-	-0.181*** 0.048***	-	-0.181*** (0.000)	-
Domestic credit	-	0.042*** (0.042)	-	0.003 (0.978)	_	0.056** (0.019)
Economic growth	0.025*** (0.000)	0.025*** (0.000)	0.025*** (0.000)	0.027*** (0.000)	0.0971*** (0.000)	0.058*** (0.000)
Government expenditure	-0.063** (0.046)	-0.077 (0.113)	-0.105*** (0.009)	-0.069** (0.019)	-0.065 (0.172)	-0.045 (0.388)
Trade openness	0.171*** (0.000)	0.196*** (0.000)	0.168*** (0.000)	0.155*** (0.000)	0.146*** (0.000)	0.198*** (0.000)
Inflation	-0.011*** (0.000)	-0.012*** (0.000)	-0.013*** (0.000)	-0.008** (0.000)	-0.010^{***} (0.000)	-0.009** (0.000)
Capital formation	-0.034 (0.182)	-0.009 (0.820)	-0.043 (0.165)	-0.022 (0.602)	-0.023 (0.520)	-0.018 (0.660)
Enrolment	0.235*** (0.000)	0.196*** (0.000)	0.282*** (0.000)	0.214*** (0.000)	0.267*** (0.000)	0.214*** (0.000)
Private credit squared	-	-	0.048*** (0.000)	-	-	-
Domestic credit squared	_	_	_	0.014 (0.519)	-	-
Channels:						
Private credit x economic growth	-	_	_	_	-0.024*** (0.007)	-
Domestic credit x economic growth	-	-	-	-	-	-0.012*** (0.029)
Diagnostics						
No. of countries	45	45	45	45	45	45
Wild x^2	26387.32	37296.81	7689.41	20234.85	9562.91	77536.18
<i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000
Sargan test	28.829	34.060	28.750	33.234	30.775	34.449
<i>p</i> -value	1.000	1.000	1.000	1.000	1.000	1.000
AR(1)	-1.737	-1.964	-1.604	-1.993	-1.781	-1.967
<i>p</i> -value	0.082	0.050	0.109	0.046	0.075	0.049
AR(2)	1.078	0.830	0.940	0.904	1.032	0.869
<i>p</i> -value	0.281	0.406	0.347	0.366	0.302	0.385

TABLE 2: CARBON DIOXIDE (CO_2) Emissions – Financial Development Nexus

Note: Values in () are p-values. Robust standard errors are used. ***, ** and * represent the level of significance at 1%, 5% and 10% respectively.

The finding therefore is not surprising given that Africa is largely an inflationary continent. On the other hand, economic growth, trade openness and school enrolment heighten energy consumption proxied by carbon dioxide emissions. According to the Environmental Kuznets Curve (EKC) hypothesis, in the initial stages of every country's economic development, economic activities turn to cause damage to the environment in many forms including pollution due to exploitation of natural resources and only get conscious after they have attained a certain level of development. In line with that argument, it is understandable why economic growth in Africa occasions higher CO₂ emissions given that the continent's economy is still predominantly driven by the exploitation of natural resources. African countries until recently, when the Millennium Development Goals (MDGs) came into force, did not put stricter regulations on the type of products they open their markets to. As a result, outdated and environmentally non-compliant products easily get into their markets. That could account for why trade openness heightens CO₂ emissions. School enrolment also increases energy consumption, once many people get educated and the income levels rise, they turn to purchase big ticket gadgets leading to high demand for energy hence high energy consumption in the process.

In model 2, the study proxies financial development by domestic credit and the finding sharply contradicts the first instance when financial development is proxied by private credit. Domestic credit here is positively related to CO₂ emissions and significant at 5% level implying that it heightens CO₂ emissions. This shows that when the financial sector develops, firms and individuals have more access to cheaper capital and will likely turn to invest more on big tickets gadgets and machinery in the production process leading to higher energy consumption in the form of CO₂ emissions. But this study finds that the direction of financial development on energy consumption is largely determined by the proxy used given the differential effect. These findings show that a unit-percentage increase in domestic credit leads to 0.042% increase in CO2, emissions. It is imperative to note that countries will have to watch out for the level of emissions when taking steps to develop their financial sectors especially when they are embarking on domestic credit policies. These policies should not be taken in isolation without incorporating CO, emission reduction and environmental protection policies. After controlling for economic growth, trade openness and school enrollment still remain positive and highly significant as well as heighten energy consumption as explained above in model 1.

Further analysis in model 3 and 4 by examining the possibility of the existence of non-linearities in finance-energy consumption (CO₂ emissions) nexus is done. Quadratic terms are taken with both indicators of finance (private and domestic credits) in the energy equations to ascertain the existence of thresholds. It is only the private credit that turns to be negative and highly significant at 1% level. The study finds that the coefficients of the level of private credit and its square term are -0.181 and 0.048 respectively. This suggests a non-monotonic relationship between private credit and energy consumption measured by CO₂ emissions. With the significantly negative coefficient of the level of private credit and its corresponding positive coefficient of the square term, the study conclude that the nexus between private credit and CO₂ emission is U-shaped. This implies that finance measured by private credit dampens CO₂ emission but only to some level and turns to rise when it exceeds the threshold level. This study determines the threshold by taking the first derivative of energy consumption in the energy consumption equation with respect to financial development and setting the results to zero. With this determination, the study arrived at the threshold value of 189%. The understanding here is that if a country is to avoid too much energy consumption effects, that country's financial development (private credit) to GDP ratio should not be above the threshold of 189%. But given that generally African economies are still underdeveloped, most countries are still below the threshold, which is a positive indication that they have not reached the "red line" which may be a threat to their energy consumption curve. However, that does not mean governments should not take precautionary measures to avoid reaching the threshold. Evidence from this study is not consistent with earlier studies (Selden and Song, 1994; Copeland and Taylor, 2004; Dasgupta et al., 2002; Dinda, 2004) who found an inverted U-shaped and concluded that countries with strong institutional and regulatory framework are wealthier and better able to regulate CO₂ emissions than their counterparts with the opposite characteristics. Their work show that pollutions increase with growth among poor nations with weak institutions and decreases with growth in wealthy countries with strong institutions. However, this study departs from those work by finding the Ushaped between financial development and energy consumption. Economic growth, trade openness and school enrollment continue to maintain their high level significance and heightening effects of CO₂ emission whilst government expenditure and inflation also continue to maintain the reverse and dampening effects on energy consumption.

In models 5 and 6, the study wanted to know whether financial development proxied by private and domestic credits can have impact on energy consumption

(CO₂ emissions) when passed through economic growth. The results indicate that the level of financial development is positive and significant at 1% whilst the pass-through effect of economic growth is negative with coefficients of -0.024 and -0.012 for private and domestic credits respectively. This shows that when financial development is interacted with economic growth energy consumption is dampened. The explanation is that governments design deliberate policies through their economic schemes towards environmentally-friendly spending and that is why the pass-through effect of financial development on economic growth is negative. As earlier indicated, excessive energy consumption is most often associated with the initial stages of a country's economic development because of exploitation of natural resources. But as the economy grows over time, energy consumption turns to fall and all the economic actors also begin to be sensitive to the consequences of higher energy consumption. The findings in this case conforms to the Environmental Kuznets Curve hypothesis hence higher economic growth is associated with lower energy consumption in Africa. The control variables such as economic growth, trade openness and school enrollment continue in the same pattern as in the case of models 1, 2, 3, and 4.

In the next section, the study performs further regressions but proxied energy consumption by energy use. The findings are presented in table 3. In model 1, there is sharp contrast to the findings in Table 2 where private credit is negatively related to energy consumption proxied by CO₂ and therefore dampens energy consumption albeit insignificantly. Private credit here rather heightens energy consumption when energy consumption is proxied by energy use. It is positive and strongly related to energy use and significant at 1% level. This confirms the earlier accession that the magnitude and direction of financial development on energy consumption depends on the type of proxy used for both variables. At least the finding in this study reveals that, a unit percentage increase in private credit will lead to about 9.946% in energy use. This is a reasonable outcome given that private credits are funds that are mainly provided to the productive private sectors of the economy and will make funds accessible and cheaper. When the financial sector is developed by way of provide credit, firms and consumers can access funds at cheaper rates which will lead to the purchase of big ticket machinery and gadgets that will ultimately cause higher energy use. Though higher energy consumption (energy use) is not good for the environment, governments in balancing their economic objectives will definitely strive to achieve economic growth and prosperity on the back of progressive financial sector development. If this turns out to cause higher energy consumption as in the findings of this

study, with its consequential hazards to the environment, then government may have to put deliberate stricter measures in place to regulate spending with the environment in mind but not to slow down financial development in attempt to reduce energy consumption.

In this section, the covariates used in the regressions in Table 2 are maintained. Economic growth in model 1 is the only significant variable as in the case of model 1 in Table 2. It is positive and significantly related to energy use at 1% level. As the economy grows, consumers' purchasing power increase and production also increases leading to consumers' ability to use more and more energy at both the domestic and industrial levels. Therefore, it is not surprising that high economic growth leads to high energy use with at least a unit percentage increase in economic growth amounting to about 4.279% energy use because industrial breakthrough and advancement is only possible in the presence of abundant and cheap energy. In model 2, where financial development is proxied by domestic credit, all the variables are insignificant except trade openness and school enrollment. Whereas trade openness is positive and significantly related to energy use at 1% level. This indicates that trade openness is energy use enhancing while school enrollment is also negative and significant at 1% level showing it dampens energy use. The latter is not surprising given that a more educated population will be expected to have knowledge and understand the need for efficient and environmentally-friendly approaches to energy use and application.

In model 3 and 4, the study again examined the possibility of the existence of non–linearities in finance–energy consumption (energy use) nexus. As seen in the case of Table 2. This is done by including the quadratic terms of both private and domestic credits in the energy consumption equation. After the analysis, both of them are not significant even at conventional levels. Some of the covariates however, are significant which include economic growth in both models 3 and 4, trade openness and inflation in model 2. Whilst economic growth and trade openness heighten energy consumption (energy use) but inflation dampens energy use.

In model 5, the study examined to know whether financial development proxied by private credit has any effect on energy consumption (energy use) when pass through economic growth whilst maintaining the control variables as done in the other models. The results show that private credit is insignificant but economic growth and trade openness are found to be significant and positively related to energy use while inflation is significant and negatively related to

	1	2	3	4	5	6
Constant	12.296	440.439	21.764	330.620	21.764	421.588
Lagged energy use	(0.946) 0.973*** (0.000)	(0.115) -	(0.889) 39.985 (0.198)	(0.243)	(0.889) 39.985 (0.198)	(0.078)
Private credit	9.946*** (0.023)	_	39.985 (0.198)	-	39.985 (0.198)	_
Domestic credit	_	39.279 (0.111)	_	53.016 (0.172)	_	32.381** (0.045)
Economic growth	4.279*** (0.007)	-5.080 (0.162)	3.489* (0.059)	7.101** (0.033)	3.489* (0.059)	-5.047 (0.496)
Government expenditure	10.357 (0.503)	-18.127 (0.368)	-11.378 (0.457)	-20.304 (0.204)	-11.378 (0.457)	-36.790 (0.108)
Trade openness	16.241 (0.452)	30.970** (0.031)	22.237** (0.027)	5.392 (0.676)	22.237** (0.027)	33.135** (0.028)
Inflation	0.214 (0.928)	-3.036 (0.120)	-6.700** (0.044)	-2.721 (0.367)	-6.700** (0.044)	-2.879 (0.180)
Capital formation	-11.665 (0.594)	4.107 (0.740)	48.579 (0.204)	-15.713 (0.238)	48.579 (0.204)	3.360 (0.799)
Enrolment	-7.842 (0.691)	-37.381* (0.092)	-1.942 (0.905)	-20.371 (0.317)	-1.942 (0.905)	-32.073 (0.100)
Private credit squared	-	-	-11.373 (0.175)	-	_	_
Domestic credit squared	-	_	-	-5.447 (0.460)	_	_
Channels:						
Private credit x economic growth	_	_	_	_	-11.373 (0.175)	-
Domestic credit x economic growth	-	-	-	-	_	2.283 (0.365)
Diagnostics						
No. of countries	45	45	45	45	45	45
Wild x^2	1748.18	2168.19	1841.62	5768.26	1841.62	5153.19
<i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000
Sargan test	20.112	16.730	19.031	18.967	19.031	16.761
<i>p</i> -value	1.000	1.000	1.000	1.000	1.000	1.000
AR(1)	-1.339	-1.662	-1.407	-1.646	-1.408	-1.539
<i>p</i> -value	0.181	0.097	0.159	0.100	0.159	0.124
AR(2)	0.194	0.319	0.485	0.181	0.485	0.258
<i>p</i> -value	0.846	0.750	0.628	0.856	0.628	0.798

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TABLE 3: ENERGY USE (KT) – FINANCIAL DEVELOPMENT NEXUS

Note: Values in () are *p*-values. Robust standard errors are used. ***, ** and * represent the level of significance at 1%, 5% and 10% respectively.

energy use in the energy consumption equation. In the case of model 6, while the pass through effect is almost non existing, domestic credit however, has positive effect directly on energy use at conventional level of significance. Interestingly, only trade openness is significant at all levels of models 3, 4, 5 and 6 while it is energy use enhancing. This is possible due to the fact that many countries have opened their borders including African countries in a bit to improve on international trade flows and market integration as recently espoused by *Sare et al.*, (2019) and Sare *et al.*, (2018). When that happens, the use of high energy use. Apart from that there is dampening phenomenon, where used electronic gadgets, non–friendly environmental machines are disposed of through international trade creating a lot of energy issues in these developing countries where regulatory regimes are weak and in some instances almost non–enforceable.

4. Conclusion

Evidence from this study suggests that when financial development is proxied by private credit against energy consumption proxied by carbon dioxide (CO_2) emissions, the effect is negative while domestic credit appears to spur carbon dioxide emissions. This evidence switches sign depending on the indicator of energy consumption and the model specification. For instance, while private credit turns to inhibits energy consumption (CO₂) emissions, the same proxy spurs energy consumption proxied by energy use, indicating that the direction and magnitude of financial development depends on the proxy used for both financial development and energy consumption. Whereas domestic credit spurs energy consumption irrespective of the model specification, private credit is model dependent. The results from the system generalized method of moment (GMM) reveal that only private credit-energy consumption nexus is threshold specific and U-shaped in particular, with 189% of GDP as the inflection point. This study recommends that governments in Africa should pursue policies towards keeping energy consumption under control while taking steps to improve their financial systems.

Biographical Notes

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