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Does Economic Growth Have Anything To Do With Energy Consumption In The Oil-Exporting Countries Of Sub-Saharan Africa?

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Abstract:
The objective of this paper is to analyze the relationship between energy consumption and economic growth in oil exporting countries of Sub-Saharan Africa, using the work data (2022) over a period from 2002 to 2022. A panel vector autoregressive (PVAR) models have been used within generalized method of moments (GMM) framework. The estimation results show a bivariate relationship between economic growth and energy consumption and, that the simulations carried out, impulse response functions and error variance decomposition. From these results have been formulated policy implications.
Keywords*: Energy consumption, Economic growth, Panel, Sub-Saharan Africa.*

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I. Introduction

Since the 1950's, economic science research has been constantly examining the factors that can promote economic growth in a country or economic zone (Solow 1956, Romer 1989, Barro 1996). It is in this perspective that Kraft and Kraft (1978) proposed energy consumption as a determinant of economic growth. Following this seminal paper, several authors have placed the relationship between energy consumption and economic growth at the center of their concern, highlighting its interest both theoretically and empirically (Vlahinic-Dizdarevic et al. 2010; Atif et al. 2010; Isma'il et al, 2012; Masuduzzaman, 2013).

On the theoretical level, there are two opposing points of view which according to Apergis and Payne (2009), can be divided into four hypothetical relationships: (i) the growth hypothesis, (ii) the conservation hypothesis, (iii) the feedback hypothesis and (iv) the neutrality hypothesis. On the one hand, the so-called orthodox authors (Solow, 1956; Romer, 1989; Barro, 1996) maintain that energy consumption cannot be related to economic growth. This point of view is based on the idea that energy is a secondary factor that is already incorporated into the other factors of growth and is manifested by the hypothetical relationship of neutrality. Therefore, there cannot be a relationship between energy consumption and economic growth. On the other hand, heterodox authors argue, that energy consumption and economic growth are closely related (Lékana, 2018; Stern, 2012; and Georgescu-Roegen, 1979). To support their argument, they rely on, the entropy theory, which is based on the thermodynamics and the primary character of energy (Ayres and Warr, 2005; 2010). This point of view is associated with three hypothetical relationships (the growth hypothesis, the conservation hypothesis, the feedback hypothesis) showing the existence of a relationship between energy consumption and economic growth.

This theoretical controversy is also reflected on the empirical literature, regarding the orthodox approach Akarco and Long (1980) Akinlo (2008) in Togo; Ghosh (2009) in India; and Payne and Taylor (2010) in the USA, have all revealed that the relationship between energy consumption and economic growth is neutral. Regarding the works that support the heterodox approach, we can highlight, that, the seminal works of Kraft and Kraft (1978) in the USA, Tang et al. (2016) in Vietnam confirmed the existence of the univariate relationship and verified the growth hypothesis. In the same line, Shiu and Lam (2004) in China, Wolde-Rufael (2005) in nineteen (19) African countries, Bekura and Agboda (2019) in Nigeria also confirmed a univariate relationship, with the validation of the conservation hypothesis. Finally, Apergis and Payne (2012) in eighty (80) compound developed and developing countries, Nguyen and Ngoc (2020) in Vietnam and Armeanu et al. (2021) in countries classified by income level, revealed that the relationship between energy consumption and economic growth is bivariate. This validates the retroactivity or feedback hypothesis.

Generally, we note that, the theoretical and empirical literature remains controversial on the existence of these different relationships in any field. Percebois (1989), justifies this by the specific character of the different fields of study. But it is also revealed that these works merely verify the nature of the relationship between the two variables or show the effect of energy consumption on economic growth. Few attempt, reveal the impact of the energy consumption shock on economic growth and vice versa. Moreover, the groupings are done either by income, region, integration zone (monetary, economic,...) or in a grouped manner. If we rely on Percebois's developments, it would seem appropriate to verify this relationship in a grouping that is highly homogeneous. Consequently, the analysis of the relationship between energy consumption and economic growth is subject to the characteristics of the selected field of study. In two reasons, the oil-exporting countries of sub-Saharan Africa constitute an interesting field of research.

The first is that, the economics of the oil exporting countries of Sub-Saharan Africa (Nigeria, Cameroon, Congo, Gabon, Equatorial Guinea and Chad) are highly dependent on oil revenues. Indeed, oil revenues contribute on average in these economies to over 60% of fiscal revenues and over 50% of GDP. This primary type of specification hinders the development of other sectors, leading to a high dependence on oil production. In addition, with oil prices very erratic and difficult to predict, government revenues become very volatile, making these economies more fragile.

The second is related to the low level of energy consumption recorded in these countries. Indeed, the African Energy Commission report of 2019 reveals that between 2000 and 2017, the weight of oil in the production of total energy consumption was 127.68% and during 2017, the consumption of OECSSA was 2.34 Kteq (Nigeria), 0.17 Kteq (Cameroon), 2.14 Kteq (Congo), 1.29 Kteq (Gabon), 4.21 Kteq (Equatorial Guinea) and 2.42 Kteq (Chad) showing the low level of energy consumption of these countries. This contrasts with the high potential of these countries. Aware of this situation, these countries are obliged to subsidize the energy sector in order to improve the level of consumption of individuals. These subsidies can also crowd out more productive public spending, as evidenced by the negative relationship between fuel subsidies and public spending on health and education[1].

Above the importance of oil as the main resource of these economies and the policy of energy in these countries. The main study question is formulated as follows: what is the nature of the relationship between energy consumption and economic growth in the oil-exporting countries of Sub-Saharan Africa (OECSSA)? In other words, what is the impact of one on the other?

The objective of this study is to analyzer the nature of the relationship between energy consumption and economic growth in oil exporting countries. Given that these countries have a high endowment in an energy source which is oil, we support the hypothesis of the bivariate relationship between energy consumption and economic growth. This paper stands out from the others for its impulse response analyses, the variance decomposition of the errors and the specific character of the mobilized countries which are all oil exporters.

The rest of this work is presented as follows: section 2 is devoted to the literature review on the relationship between energy consumption and economic growth. Section 3 presents the methodological approach used in this work and section 4 presents and interprets the results. Finally, section 5 is devoted to the conclusion and economic policy implications.

II. Literature Review

On the theoretical level, the debate can be directed on the one hand towards the nature of energy as a factor of growth and on the other hand, towards the type of production function integrating energy. On the axis concerning the nature of energy in economic growth, a controversy seems to oppose to be removed the proponents of the orthodox vision to those of the heterodox vision. According to Apergis and Payne (2009), this controversy has given rise to four hypothetical relationships: (i) the growth hypothesis, (ii) the conservation hypothesis, (iii) the feedback hypothesis and (iv) the neutrality hypothesis.

For the proponents of the orthodox vision, two points of view to remove emerge: the first believes that energy is not an indispensable factor for economic growth, as defended by those who rely on traditional growth theories (Solow, 1956; 1957). For the classics, the factors mobilized by Solow are defined as primary. They are the only ones which explain the behavior of the production of a state by economic growth. The second argued that energy can be considered as an intermediate or secondary factor, supported by Solow (1974); Stiglitz (1974); Asheim (1994) and Asheim et al, (2003). For these authors, energy can explain growth only if there is perfect substitution between the capital factor and natural resources or energy, or if there is substitution between energy and technical progress (Aghion and Howitt, 1998; Scholz and Ziemes, 1999; Groth and Schou, 2002; Grimaud and Rougé, 2003; Di-Maria and Valente, 2008). Apart from that, energy cannot be considered as an indispensable factor for economic growth, and therefore there is no link between the existence of a neutrality

[1] Energy Subsidy Reform in Sub-Saharan Africa Experiences and Lessons Learned April 2013

hypothesis between energy consumption and economic growth. Thus, a policy focused on energy conservation has no effect on real GDP or economic growth (George and Nickoloas, 2011).

On the other hand, there are the proponents of the heterodox vision who maintain that energy must be considered in the same way as the capital and labor factors, or even more. To argue this, the proponents (Georgescu-Roegen's 1976; Cleveland and Stern, 2004; Shahi, 2006 and Stern, 2011) To be removed appeal to the two principles of thermodynamics (the law of conservation and the law of efficiency) and the theory of production.

With regard to the principles of thermodynamics, the principle of conservation is used to counteract the classical or neoclassical basis. For the classical proponents, the factors of production are taken in terms of stock, and energy can also be stored. Concerning the law of efficiency, energy is created each time an element is in movement. According to Georgescu-Roegen (1976), the economy is not a sphere in itself, but rather a part of biophysics. Therefore, the dynamic economy needs an energy. The proponents of this approach rely on production theory, which allows them to show that energy is a non-reproducible factor of production (Spreng, 1993; Ruth, 1995; Hall et al. 2001; 2003) and a primary factor, even superior to capital and labor (Hannon; 1973 and Stern 1998). This vision of energy is not new insofar as Kardashev, in 1964, already referred to energy as the only indicator for measuring economic growth or the evolution of a country. Thus, energy is the main variable that explains the economic growth of a country, and validates the growth hypothesis. The growth hypothesis is the one that admits the existence of a relationship going from energy consumption to economic growth. Therefore, Belke et al (2010) argue that under this assumption a decrease in energy consumption leads to a decrease in real GDP, in this case the economy is energy dependent. Therefore, energy conservation policies will have a negative effect on economic growth.

Concerning the axis on the admission of energy as a factor of production and the type of appropriate production functions, the debate is oriented on the analysis of these production functions. For some, there is a perfect complementarity between the factors of production and energy in the "Clay-Clay functions" (Berndt and Wood, 1977). For others, there is rather a substitutability between energy and the factors in the "Putty-Putty functions" (Gregory and Griffin, 1976 and Percebois, 1989), or a complementarity and a substitutability between the different factors in the "Clay-Putty functions" (Atkeson and Kehoe, 1999 and Diaz et al, 2004). For Solow (1987) and Nguyen and Streiwieser (1997), the non-conformity of the results can be explained either by the macroeconomic characteristics of the phenomenon (bearing in mind that the notions of substitution and complementarity are rather microeconomic), or by the level of production of the units or the country.

The perfect complementarity between energy consumption and economic growth and/or substitutability tend to validate two hypotheses: that of conservation and that of feedback. The conservation hypothesis is the one that supports the existence of a relationship going from economic growth to energy consumption. In this case, there is the level of economic development that leads to an increase in energy consumption. For the so-called feedback hypothesis, it indicates that energy consumption and economic growth affect each other. This hypothesis is validated when there is a bidirectional causal relationship between energy consumption and economic growth. Energy conservation policies can decrease economic growth, and changes in economic performance are reflected in energy consumption (Belke et al, 2010).

On the empirical level, we find the same structuring. Thus, in the orthodox approach, the identified results are those of the neutrality hypothesis. For example, we can cite the work of Akarca and Long (1980). They show that the period chosen was unstable, since it included the first oil shock. By reducing the study period by two periods, they repeated the analysis with the same technique, from 1950 to 1968. The test revealed no causality between GDP and energy consumption. Akinlo (2008), in his study on the relationship between energy consumption and economic growth for eleven (11) Sub-Saharan African countries, used the ARDL approach. His study revealed the existence of a neutrality hypothesis in Cameroon, Côte d'Ivoire, Nigeria, Kenya and Togo. This neutrality hypothesis was also confirmed in the work of Ghosh (2009) in India and Payne and Taylor (2010) in the USA.

For the heterodox approach, these results are opposed to the orthodox approach. Instead, we speak of the conservation hypothesis, the growth hypothesis and the feedback hypothesis. Regarding the growth hypothesis, it was highlighted in the seminal work of Kraft and Kraft (1978) who found a unidirectional causality between GDP and energy consumption in the USA over the period 1947-1974 and also several authors, notably those of Ambapour and Massamba (2005) in the context of Congo over the period 1960-1999 and Cheng and Lai (1997) in Taiwan covering the period 1955-1993. More recently, Tang et al (2016) in Vietnam and Faisal et al (2017), in their study of the relationship between energy consumption and economic growth in Belgium, used the ARDL method and Toda Yamamoto's causality and found that both in the short and long term, energy consumption affects economic growth. But there is a univariate relationship from GDP to energy consumption.

Regarding the work that validates the conservation hypothesis, we can cite the work Shiu and Lam (2004) apply the error correction model to examine the causality relationship between electricity consumption and real GDP for China during 1971-2000. Their estimation results indicate that real GDP and electricity consumption for China are co-integrated and that there is unidirectional causality in the Granger sense from electricity consumption to real GDP. The work Wolde-Rufael (2005) who examined the long-run relationship between energy consumption per capita and real gross domestic product (GDP) per capita for nineteen (19) African countries for the period 1971-2001 using Co-integration and vector autoregression regression. The results show that there was a long-run relationship between the two sets for eight (8) countries and causality for only ten (10) countries. Regarding Cameroon, Ongono (2009), analyzed the impact of energy consumption on growth. The results show that, overall, there is no direct causal relationship, but at the sectoral level, the results are different. In the primary sector, the Granger test also rejects the existence of causality between net output (value added in the agricultural sector) and energy consumption. Causality only appears in the secondary and tertiary sectors. However, while in the secondary sector, it is production (value added in the industrial sector) that causes energy consumption, in the tertiary sector, the causality goes in the opposite direction since it is energy consumption that causes production (value added in the services sector). Orhewere and Machame (2011) examined the relationship between energy consumption and economic growth in Nigeria (1970 to 2005). They used an error correction model based on the Granger causality test. Their result shows that there is a unidirectional causality from electricity consumption to GDP in the short run and in the long run. While for the relationship between gas consumption and real GDP, there are two causal relationships: one unidirectional in the short run and one bidirectional in the long run. They found a unidirectional causal relationship between oil consumption and real GDP in the long run. Similarly, Akomolafe et al (2014) study the relationship between electricity consumption and economic growth in Nigeria from the period 1990 to 2011. The result shows that there is a univariate relationship in the direction of electricity consumption and economic growth. Also in the field Bekun and Agboola (2019) also confirmed the existence of a conservation hypothesis.

Finally the work that tested the feedback hypothesis, Apergis and Payne (2012) who examined the relationship in 80 countries and confirm the existence of bidirectionality between energy consumption and economic growth. Kazar and Kazar (2013) also confirmed it in the case of 154 countries. More recently, Nguyen and Ngoc (2020) in their work revisiting the relationship between energy consumption and economic growth in Vietnam showed that energy consumption and economic growth are mutually causal. Armeanu et al (2021) also found that there is a bidirectional relationship between energy consumption and economic growth in high and low income countries.

From this literature review, it appears that the question on the relationship between energy consumption and economic growth does not seem to present a consensus both theoretically and empirically. This suggests that the topic is still interesting for future work. It is also worth noting that few studies have attempted to group the oil-exporting countries of the Sub-Saharan African sub-region in an analysis. With respect to the feasibility plan, the question on the relationship between energy consumption and economic growth tends to hide a sub-question on the effect of energy consumption on economic growth.

III. Methodological Approach

In this section we present on the one hand, the theoretical and specific framework that allows us to analyze the relationship between energy consumption and economic growth and on the hand, the source of data and variables used.

Theoretical and specific framework of the model

Regarding the theoretical framework of this paper, we retain the panel VAR model to understand the relationship between energy consumption and economic growth in oil exporting countries of Sub-Saharan Africa.

This model is appropriate because it does not make any priori restriction on the exogeneity and endogeneity of variables (Ramde, 2015). Moreover, it allows us to identify the existence or not of a bidirectional or unidirectional relationship. Furthermore, it allows capturing both static and dynamic interdependencies.

Introduced by Sims (1980), VAR models are a critique of Keynesian-inspired macroeconomic models, particularly with regard to identification techniques. For the author, Keynesian models suffer from a number of shortcomings. The endogenous or exogenous character of a variable is too often defined as priori without statistical justification. Too much restrictions are placed on the parameters. According to Sims, given the numerous interdependencies between economic variables, it is appropriate to impose the minimum a priori restriction, apart from the number of variables and lags to be included in the model. All the variables are thus a priori endogenous, and the possible exogeneity of one of them can be tested statistically by means of causality tests.

The economic literature on panel VAR models was first mobilized in the work of Holtz-Eakin et al (1988). Panel VARs are particularly well suited to analyzing the transmission of idiosyncratic shocks across units and over time (Canova and Ciccarelli , 2013). Apart from that, panel VAR models also have more power than standard VARs and thanks to the inclusion of the cross-sectional dimension in the explanation of economic phenomena (Alinsato et al, 2019). It is worth noting that this model is often used in the analysis of the relationship between energy consumption and economic growth (Adams et al, 2016)

Regarding the specific framework, we draw on the developments of Abrigo and Love (2016). Thus, the specific econometric model is as follows:

$i \in \{1,2,\ldots,N\}$, $t \in \{1,2,\ldots,Ti\}$

Where ***Y*** is a vector of dependent variables; the matrices ; ; … and are parameters to be estimated; is a vector of country-specific effects that is introduced in order to capture country heterogeneity; and is a vector of idiosyncratic, homoscedastic, and non-autocorrelated errors. That is: [***e***] = ; ***E***[***e'it*** , ***eit***] = Σ et ***E***[***e'it***, ***eis***] = ***s*** for all t>s.

i : corresponds to the number of individuals, t : the period of the study and P is the number of optimal lags associated with the model.

IV. Source And Presentation Of Data

The data used in this paper to analyze the relationship between energy consumption and economic growth cover twenty Sub-Saharan African countries and extend over a period from 2002 to 2020. They are extracted from the World Bank, specifically in two databases: the first corresponds to the World Development Indicators (WDI) database (2022) for economic variables and the World Governance Indicators (WGI) database (2022) for governance data. This range is dictated by the availability of governance data.

The variables used in this model are the following:

- Gross domestic product in purchasing power parity, which explains economic performance in Sub-Saharan African countries. It is measured in U.S. dollars.
- energy consumption is captured by the energy use variable in kilograms of oil equivalent (Kep), which is calculated by the World Bank by aggregating all energy use from all sources
- real gross fixed capital formation is the variable that captures the investments made in a country.
- the capacity of these countries to trade with the outside world is captured by trade openness.
- To assess the quality of governance in this model, the indicators proposed by the World Bank have been used (Kaufmann et al., 1999). However, without being exhaustive on its composition, we can cite: control of corruption, government efficiency, political stability, control of regulation, the role of law and freedom of expression. The indicators are evaluated on an interval that ranges from approximately -2.5 to 2.5. The closer a country is to 2.5, the better its situation and vice versa. We proceeded by creating a composite variable obtained by the principal component analysis approach.

V. Presentation And Interpretation Of Results

It is presented here, on the one hand, the execution of the model and the presentation of the results and, on the other hand, the interpretation of these.

The table below presents the descriptive statistics of the variable energy consumption and economic growth.

Table 1: Descriptive statistics

Variable		Mean	Std. dev.	Min	Max	Observations
LGDPPPP	overall	24.799	1.303	22.930	27.663	N = 133
	between		1.376	23.683	27.358	n = 7
	within		0.251	24.046	25.130	T = 19
GFCF	overall	26.523	11.676	4.722	81.021	N = 133
	between		6.899	18.822	40.008	n = 7
	within		9.758	4.501	67.537	T = 19
LEC	overall	35.46468	1.463	32.767	38.728	N = 133
	between		1.535	34.214	38.506	n = 7
	within		0.324	34.018	36.052	T = 19
OPP	overall	80.238	33.584	20.723	156.862	N = 133
	between		32.676	33.967	123.852	n = 7
	within		14.340	37.501	120.252	T = 19
INST	overall	-0.717	0.771	-2.206	0.465	N = 133
	between		0.768	-1.954	0.223	n = 7

	within		0.292	-1.735	-0.177	T = 19

Source: *Author, based on data from WB (2022)*

The reading of table n°1, shows that the average on the whole of the sample the logarithm of the GDP by parity of the purchasing power is 24.799 and that of the logarithm of the energy consumption of 35.465. As far as the standard deviation is concerned, we notice that it presents a total variance of 1.303 on the level of the logarithm of the GDP by purchasing power parity and of 1.462 on the side of the logarithm of the energy consumption. The inter-individual (Between) variance of the logarithm of GDP per purchasing power parity is equal to 1.376, while its intra-individual (temporal) variance is equal to 4.45e+10. In other words, the variance of GDP across countries is very homogeneous (Overall>Between) and it is, also, almost stable within countries (Overall≈ Between). This finding is similar to the case of energy consumption, in fact, the level of inter-individual (Between) variance of energy consumption is 51.86292 while its intra-individual (Temporal) variance is equal to 32.219.

Execution of the model and presentation of the results

Prior to estimating the VAR panel, a number of precautions regarding the panel data and the VAR models are taken. Therefore, the starting point of the analysis is the study of the characteristics of the data used in this work. The aim is to verify the existence or not of the unit root in the data. To do this, several econometric tests can be used (Mignon, 2004). There are the tests of Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and the LM test of Hadri (2000). In this paper we will prefer the Im, Pesaran and Shin (2003) test. This test is preferred to the others because Hurlin and Mignon (2007) show that it is convergent when T is low (T less than 30). Moreover, it allows under the alternative hypothesis not only heterogeneity in the autoregressive root, but also relative heterogeneity in the presence of a unit root in the panel (Mignon, 2004).

Table 2: Unit root tests

	IPS- constant *Level*		*IPS-trend Level*		*IPS*- constant first differences		*IPS-trend* first differences	
	Stat	*P-val*	*Stat*	*P-val*	*Stat*	*P-val*	*Stat*	*P-val*
LGDPPPP	-2.850	0.004	-0.810	0.993	-2.517	0.004	-3.346	0.000
LEC	-3.314	0.001	-0.704	0.241	-5.164	0.000	-5.578	0.000
LGFCF	-2.025	0.021	-1.173	0.120	-5.442	0.000	-5.605	0.000
LOPP	-1.907	0.028	-2.438	0.007	-5.895	0.000	-5.469	0.000
Inst	-2.248	0.036	-2.616	0.006	-5.385	0.000	-5.940	0.000

Source: *Author based on results from Stata*.

The results of the SPI test summarized in the table above reveal the existence of stationarity at the 1% and 5% thresholds. The variables log energy consumption (LEC) and log GDP at purchasing power are stationary at the 1% threshold and the other variables such as gross fixed capital formation as a percentage of GDP, trade openness as a percentage of GDP and the quality of institutions (LGDPPPP, GFCF, OPP and INST) are at the 5% threshold. In the context of an equation with a trend, we note that the variables LGDPPPP, LEC and GFCF admit the existence of a unit root. OPP and INST are stationary at the 1% threshold. When we convert the variables into first differences, they all become stationary at the 1% threshold. Thus, we can conclude that the variables are stationary in level with constant. Therefore, we can proceed to determine the optimal lag.

Determining the optimal number of lags

In order to perform the estimations, we need to determine the optimal number of lags (P) to take into account in the vector autoregressive model in panel data. To do so, we compute a number of autoregressive processes and we retain the number of lags that minimizes both the Schwartz information criteria (MBIC, MAIC and MQIC). According to these criteria, the optimal number of lags is one (1). It is therefore for all models a PVAR (1) as described in the table below:

Table 3: optimal lag

optimal lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	0.999	81.375	0.235	-253.328	-64.625	-140.952
2	0.999	22.181	0.999	-193.312	-71.819	-120.960
3	0.999	21.049	0.518	-79.820	-22.951	-45.953

Source: *Author based on results from Stata*.

Granger causality test

The Granger Causality Test is used to detect the direction of causality in the long run. Apart from the role of detecting causality, the Wald test (Granger Causality - VAR in Panel data) allows us to determine the degree of exogeneity of the variables retained for each model. For this purpose, the least exogenous variables are introduced to the most exogenous. The table below shows the results of this test.

Table 4: Granger causality test

	LGDPPPP	LEC	INST	LOPP	LGFCF
LGDPPPP		4.099 (0,043)**	3.883 (0.049)**	0.000 (0.991)	6.778 (0.009)***
LEC	4.508 (0.034)**		0.094 (0.759)	0.431 (0.510)	0.262 (0.609)
INST	0.039 (0.844)	0.000 (1.000)		0.019 (0.891)	0.001 (0.817)
LOPP	3.054 (0.081)*	1.115 (0.291)	0.809 (0.370)		0.054 (0.003)***
LGFCF	3.109 (0.078)*	0.225 (0.635)	9.202 (0.002)**	3.708 (0.054)*	

Source: *Author from Stata extracts. Probability values are in parenthesis. *, ** and *** represent the 10%, 5% and 1% thresholds, respectively*

Reading the above table shows that the log variable of GDP causes the log variable of energy consumption, institutional quality, trade openness and gross fixed capital formation. The Log variable of energy consumption also causes the Log variable of GDP. Thus, it can be concluded that there is a bivariate relationship between energy consumption and economic growth in SSA oil exporting countries. With respect to the variables of trade openness and gross fixed capital formation cause each other. The trade openness variable also causes logGDPPPP. As for the variable gross fixed capital formation, it causes variables such as log GDPPPP, the quality of institutions and also gross fixed capital formation. We also notice that except for GDP per purchasing power, the variable energy consumption does not cause any other variables. As for the quality of institutions variable, it does not cause any other variables.

Presentation of PVAR Results

The table below presents the results of the PVAR model.

Table 5: Results of the PVAR model

	LGDPPPP	LEC	FBCF	LOPP	INST
LGDPPPP	0.976	0.297	11.619	-17.878	0.036
	(19.13)***	(2.12)**	(1.76)*	(1.75)*	(0.20)
L,EC	0.003	0.001	0.158	-0.053	$-1.267.10^{-4}$
	(2.60)***	(0.51)	(0.94)	(-0.23)	(-0.02)
L,fbcf	-0.152	0.337	4.938	17.876	$1.741.10^{-4}$
	(2.02)**	(1.20)	(0.47)	(1.06)	(0.00)
LOPP	$-1.62.10^{-5}$	-0.004	0.371	0.926	-0.001
	(-0.01)	(-0.66)	(1.93)*	(2.75)***	(-0.14)
INST	-0.067	0.035	12.875	6.332	0.998
	(-1.97)**	(0.31)	(3.03)***	(0.90)	(6.94)**
			N	119	

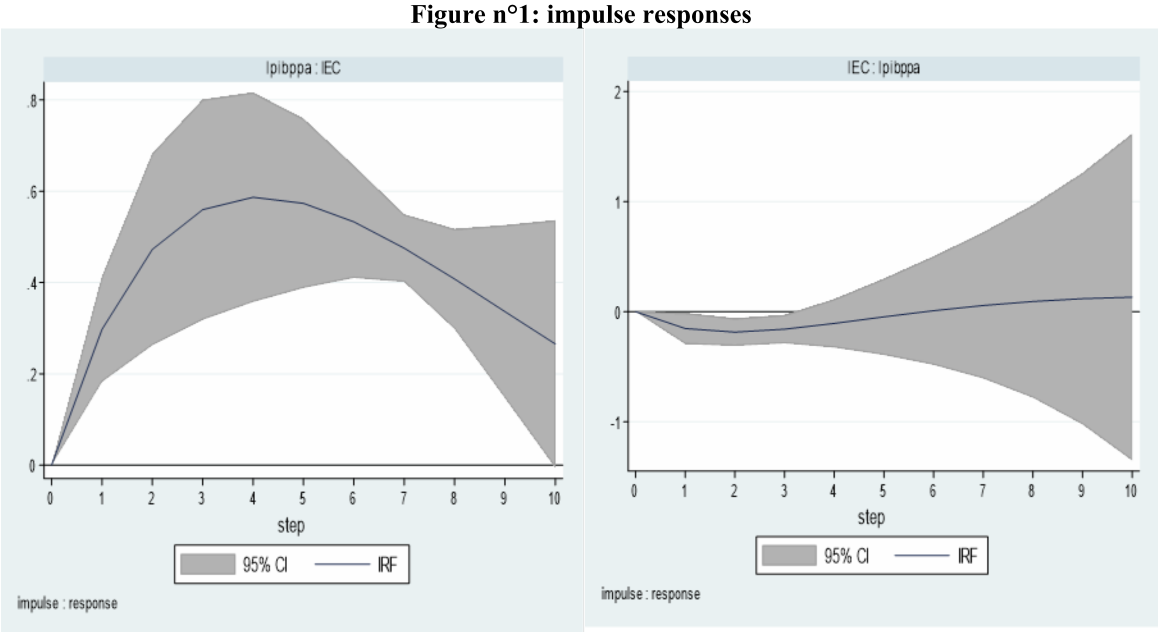
Source: *Author from Stata extracts. Values in parentheses are Student's t-test statistics. *, ** and *** represent the 10%, 5% and 1% thresholds, respectively.*

The results of the P-VAR model reveal that the economic growth variable is explained by itself as well as by energy consumption, gross fixed capital formation and institutional quality. Thus, if we increase the lagged GDP and the lagged energy consumption by 1%, the GDP will vary from 0.97% to 0.003% respectively. Thus an increase of 1% of the logarithm of the GDPPPA leads to an increase of about 0.297% of the energy consumption. It should also be noted that too much importance cannot be attached to the coefficients of a PVAR model. Indeed, their economic interpretation is delicate insofar as all the variables are considered and treated as endogenous. Thus, a coefficient cannot be directly interpreted as a marginal effect. Because of the dynamic definition of the model, the assumption that all other things are equal does not hold in the medium or long term. Therefore, the variation of one variable will affect the other variables of the model in a dynamic way (Lütkepohl, 1993). That is why these models are best understood through the shock response functions and the variance decomposition.

Once the PVAR model is estimated, we implicitly compute and graph the impulse response functions (IRFs) to analyze the impulse responses of energy consumption on economic growth of oil exporting countries in Sub-Saharan Africa and vice versa as well as the variance decomposition of the errors. In view of the objective of this article, which is to determine the nature of the relationship between energy consumption and economic growth, we will focus on the variable energy consumption and economic growth.

For impulse response functions, they describe the response of one variable to innovations in another variable in the system, while holding all other shocks equal to zero. However, since the true variance-covariance matrix of the errors is unlikely to be diagonal, in order to isolate shocks to one of the variables in the system, it is necessary to decompose the residuals so that they become orthogonal. It will therefore be necessary to orthogonalize the shocks using the Cholesky decomposition. This method of identifying shocks is advocated by Sims (1980) in his early work. The usual convention is to adopt a particular order and allocate any correlation between the residuals of any two items to the variable that comes first in the order. The identifying assumption is that variables that come earlier in the orders affect the following variables simultaneously, as well as with a lag, while variables that come later affect the preceding variables only with a lag. In other words, variables appearing earlier in the systems are more exogenous and those appearing later are more endogenous. The figure below represents the impulse responses of energy consumption and economic growth of OECSSA.

Figure n°1: impulse responses



Source: *Author based on results from Stata*.

A reading of the impulse response figure for energy consumption and economic growth suggests that the response of economic growth following an energy consumption shock is instantaneous. A positive energy consumption shock results in an increase in the level of economic growth. Beyond the first four (04) horizons, there is a downward trend but, overall, the shock remains positive. Furthermore, we observe that following a positive shock to economic growth, the reaction of energy consumption is also instantaneous. A positive shock to economic growth causes energy consumption to react negatively over a longer period than economic growth, with a subsequent upward trend. After a period of time the effect of the shock becomes positive; overall the effect is increasing.

Thus the graph shows an instantaneous and positive reaction of economic growth to a shock in energy consumption. In other words, energy consumption has a positive impact on economic growth. Moreover, if we analyze the two shocks simultaneously, we can see on the graph that after the fifth year, the reaction of economic growth decreases, but remains positive, and that of energy consumption increases and becomes positive. So we can say that in the short and medium term, energy consumption and economic growth are out of phase and in the long term the two variables converge.

As for the variance decomposition, it allows us to see what percentage of the variation of a variable is explained by the shock to another variable over time. Variance decompositions show the size of the total effect. The table below presents the results of the variance decompositions of the selected variables.

Table 5: Variance decomposition

Response variable and Forecast		**variables Impulse**				
	horizon	LGDPPPP	GFCF	**LEC**	**OPP**	**inst**
	0	0	0	0	0	0
	1	1	0	0	0	0
	2	0.839	0.097	0.044	0.001	0.019
	3	0.678	0.170	0.102	0.013	0.038
	4	0.539	0.217	0.138	0.056	0.050
LGDPPPP	5	0.428	0.245	0.153	0.119	0.055
	6	0.344	0.261	0.154	0.189	0.053
	7	0.282	0.268	0.147	0.254	0.048
	8	0.238	0.271	0.139	0.311	0.041
	9	0.208	0.270	0.129	0.357	0.036
	10	0.187	0.267	0.121	0.391	0.034
	0	0	0	0	0	0
	1	0.101	0.028	0.872	0	0
	2	0.138	0.025	0.799	0.036	0.001
	3	0.172	0.023	0.728	0.075	0.002
	4	0.200	0.022	0.680	0.097	0.002
LEC	5	0.220	0.025	0.650	0.101	0.004
	6	0.233	0.032	0.630	0.097	0.009
	7	0.237	0.041	0.611	0.093	0.017
	8	0.235	0.052	0.591	0.097	0.025
	9	0.227	0.064	0.568	0.109	0.032
	10	0.218	0.074	0.545	0.127	0.037

Source: *Author based on results from Stata*.

A reading of the error variance decomposition table presented above suggests that the error variance decomposition of GDP by purchasing power parity is in its first year explained by 100% by the innovation of its own variable. From the fifth year onwards, it represents only 42.8% and more than 50% is explained by GFCF (24.5%), energy consumption (15.3%), trade openness (11.19%) and the quality of institutions (5.5%). In the tenth year, it is self-explanatory to the tune of 18.7%, and trade openness is the most representative variable, followed by gross fixed capital formation and energy consumption with respective values of 39.1%, 26.7% and 12.1%. These results corroborate those obtained from the impulse responses. Indeed, the reading of the latter reveals that a shock to energy consumption on economic growth has a positive impulse and that the latter tries to return to its initial position.

On the other hand, the decomposition of the variance of energy consumption shows that from the first period, energy consumption is influenced by GDP and GFCF to the tune of 10.1% and 2.8%. It is itself explained by 87.2%. In the middle period, it represents more than 60% of the decomposition of its variance and the other variables only 35%, of which 22.2% for GDP per capita, 2.25% for GFCF, 10.1% for OPP and 0.04% for inst. In the last period, the variance is greater than 50% and GDP per capita is the main explanatory variable with 21.8%. We can conclude that the results are consistent with those obtained with impulse responses. Since a shock to GDP in purchasing power parity has a negative influence on energy consumption and its influence increases over time.

Therefore, the innovation of energy consumption has a positive effect on economic growth and has a bell shape, since in the first periods it grows and arrives at the horizon six it decreases. On the other hand, the innovation of the economic growth also has a positive effect on the energy consumption and that is presented in an increasing linear form. Indeed, the decomposition of energy consumption shows that the share of economic growth increases from the second period to the tenth period.

From the results obtained, three lessons can be drawn:

Existence of a bivariate relationship between energy consumption and economic growth in OECSSA

This result of the causality test reveals that economic growth and energy consumption cause each other in OECSSA. This result corroborates with the work of Ongono (2009), Bozoklu and Yilanci (2013) and Acheampong et al. (2021), which focus on exporting countries in Sub-Saharan Africa. To this end, this result verifies the feedback or bidirectionality hypothesis and supports the orthodox view that energy consumption and economic growth are two inseparable phenomena. The bidirectional causality between economic growth and energy consumption could statistically be explained by the impact or effect relationship of one on the other jointly. In plain language, this means that a change in energy consumption will have an automatic effect on the change in economic growth and vice versa. From this perspective, growth or energy consumption strategies can be carried out by acting on one of the variables. In addition, this situation could give a clearer (accurate) picture of the energy intensity of the country. Therefore, one cannot assume an increase in growth without an increase in energy consumption.

This result can also be explained in the context of OECSSA by the principle of abundance of natural resources. The main idea that emerges is that the exploitation of a natural resource in a given sector following a discovery provides revenues that increase the purchasing power of the recipient country. This increase in government revenue leads the leaders of these countries to invest in programs. These programs all include substantial public investments in large infrastructure projects and in the social sector (health, education, etc.). Given the financial structure of these countries and the strong budgetary dependence on oil revenues, it is above all thanks to oil that these plans are financed. These investments lead to an improvement in the standard of living of households as well as their demand for energy. This situation can be seen in the evolution of the value added of the service and agricultural sectors in the OECSSA.

Table 6: Average value added of agriculture and services (%GDP)

	Average value added of agriculture	Average value added of services
Angola	6.915	42.306
Cameroon	13.855	51.761
Congo	4.808	26.230
Gabon	4.273	34.003
Equatorial Guinea	1.424	27.084
Nigeria	22.719	52.405
Chad	51.331	32.935

Source: *Author, based on data from WB (2022).*

This table shows that the average value added of agriculture and services in the OECSSA countries from 2006 to 2017 is low, except for Chad, which has exceeded the 50% mark in the agriculture sector. Nigeria and Cameroon exceeded the 50% mark in the services sector. This situation shows that these economies are making efforts to move from the primary sector to the tertiary sector.

Energy consumption: driving economic growth in the *OECSSA*

The results obtained by the impulse response analysis coupled with the variance decomposition show that a shock to energy consumption has a direct impact on economic growth in OECSSA and that this impact has the shape of a bell. These results corroborate with the work of Adams et al, (2016) in the context of Sub-Saharan African countries. Thus, to understand this case, two explanations can be formulated.

The first explanation can be associated with the level of supply production and the inefficiency of the level of energy consumption. Indeed, the low level of energy production pushes the countries to invest more either in the purchase of energy, which reduces the level of GDP. Apart from this aspect, we can also mention the excessive consumption of energy in the unproductive sectors of the economy. It can be seen that the OECSSA countries have a low level of competitiveness in terms of production and that the majority of energy consumption is devoted to the population. These countries have a very low level of access to business financing, which prevents them from developing.

The second explanation for the negative effect of energy consumption on economic growth in OECSSA is the high rate of energy subsidy. According to the 2013 IMF Report, energy subsidies have an adverse impact on economic efficiency, particularly on allocation, competition and growth. In Sub-Saharan countries and in particular oil exporters in the region, companies or energy production units are quasi-budgeted in order to ensure the energy supply of economic agents. According to the IMF (2012) the level of subsidy represents nearly 1.4% of the region's GDP.

Economic growth: driving energy consumption in OECSSA

These results corroborate with the work of Adams et al, (2016) in the context of Sub-Saharan African countries. These results can be explained in this work by the structure of their economy. Indeed, the level of household incomes as well as that of their development being low, the governments of these states must reinvest in the energy sector to alleviate the well-being of the populations. Thus, an investment policy in the energy sector has two effects. First, it will lead to a reduction in total energy consumption, which explains the negative effect observed in this work. This decrease in energy consumption can be explained by the theory of energy transition. This theory is based on the work of Hosier and Dowd (1987) and Leach (1992) who postulate that as income increases, energy consumers tend to transition from traditional or inferior energy to modern energy due to ease of use and comfort. Thus, Chioroleu-Assouline (2001) argues that the energy transition has a double dividend. First, it reduces the consumption of fossil fuels, which improves the health of populations. Secondly, it increases the purchasing power of the populations, due to the decrease in the energy bill. This double dividend is beneficial for human development in terms of improvements in income, health and education. This situation is justified by the level of energy consumption in the world. Indeed, we notice that the developed countries have a total consumption of final energy that seems to stabilize and that the variations are weaker, whereas, that of the emerging or developing countries presents stronger variations; the table below illustrates these facts:

Table 7: Evolution of primary energy consumption between 2000, 2010 and 2019 in Ktep.

Regions	2000	2010	2019
North America	113.87	113.50	116.90
Pacific Asia	112.51	196.60	256.54
OECD	230.28	234.19	234.48
Middle- East	17.98	29.33	37.51
Africa	11.50	15.99	19.87

Source: *Author, based on data from IEA (2021).*

The second phase can be explained by the fact that households will take this policy into account and have a rebound effect. Jevons' paradox (1865) states that as technological improvements increase the efficiency with which a resource is employed, the total consumption of that resource may increase rather than decrease. In particular, this paradox implies that the introduction of more energy-efficient technologies can, in the aggregate, increase total energy consumption. Clearly, the recognition of the importance of clean energy in the lives of households will lead to a high dependence on energy, thereby increasing energy consumption.

VI. Conclusion And Policy Implications

The objective of the present work is to verify the nature of the relationship between energy consumption and economic growth in oil exporting countries of Sub-Saharan Africa. For this purpose, the PVAR model was mobilized within the framework of a generalized method of moments (GMM) on a sample of seven (07) countries over the period 2002-2020. After estimation, two lessons were drawn: that of the existence of a bidirectional relationship between energy consumption and economic growth in the OECSSA and that this relationship is confirmed after the analysis of the variance decomposition of errors and impulse responses. Thus, energy consumption causes GDP by purchasing power parity and that both have a positive effect in OECSSA. Thus, the hypothesis supported in this paper is verified.

In terms of economic policy, we suggest that the leaders of these countries improve the energy sector by investing in clean energy projects. Indeed, an improvement of this sector has two advantages. First, it will help reduce the level of subsidy funding allocated to the energy sectors, while directing these resources into more efficient production and better energy. Secondly, it will allow households to consume better energy which will reduce the level of polluting energy and through the positive externalities approach maintain the level of economic growth. Apart from this point, these countries need to diversify their economies by continuing to spread the revenues from the oil sector to other sectors of the economy. Given that these economies are vulnerable to oil price fluctuations and are highly dependent on oil revenues for large-scale investments, diversification seems to be the main solution. In addition to diversification, OECSSA countries must also observe rigorous institutional management in order to improve their level of governance and better direct oil revenues. Knowing that the GDP currently has a major limitation in that it does not take into account the social aspects. Thus, it seems interesting to analyze the effects of energy consumption on human capital in African and Middle Eastern countries. Middle East because, the countries of the North of Africa are similar programs with these last ones.