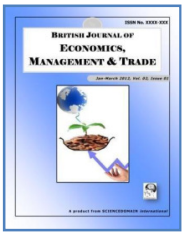

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The Impact of Volatility of Oil Price on the Economic Growth in Sub-Saharan Africa

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Authors' contributions

This study was carried out between both authors. Author TA designs the study and wrote the first draft of the manuscript. Author OTA provided the literature materials while the analyses of the study and the spectroscopy analysis were performed by both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study examines the impact of the volatility of oil price on economic growth in 20 sub-Saharan African countries from the period of 1986-2012. These countries were divided into group A and group B. Group A consists of 10 oil exporting countries, while group B consists of non oil exporting countries in sub-Saharan Africa. Panel data were used for the analysis. Panel Pooled OLS, panel Fixed Effect Model and Generalized Method of Moment model were employed in the estimation for both oil exporting and non-oil exporting countries. The estimation of panel A model consisting of the oil exporting countries shows that the volatility of oil price has a positive and significance effect on the economic growth of oil exporting countries. The result of panel B consisting of non-oil producing countries shows that the volatility of oil price also has a positive and insignificant impact on economic growth.

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1. INTRODUCTION

The volatility of oil price and its consequence on economic growth is an important issue confronting a growing number of world economies. The relationship between the oil prices and the level of economic activity has been the subject of debate for some time as this issue has been extensively discussed in empirical literature for the past decades.

The earlier studies such as [1,2] concluded that most economic recession experienced in the past was preceded by a high increase in the price of oil. However, this notion weakened over the years as later empirical studies show that the volatility of oil price has a lesser influence on economic output. Despite several interesting lines of research to examine the impact oil price on economic growth, the relationship between the volatility of oil price and economic growth is still controversial.

Even though many studies examining the relationship between the oil prices and economic growth are done, only a few studies have examined this relationship especially in sub-Saharan Africa. In this regard, we will examine the impact of the volatility of oil price in 20 sub-Saharan, African countries. These 20 countries are divided into two groups as group A and group B, the first group with 10 oil exporting countries and the latter with 10 oil importing countries.

2. OVERVIEW OF OIL IN SUB-SAHARAN AFRICA

Africa's oil history can be linked to several decades ago. Oil production in Africa started in the 1960s and has been increasing gradually since that period, except for a slowdown in the early 1980s owing to the collapse in oil prices. There are about 500 oil companies that participate in African hydrocarbon exploration presently. According to some figures, Africa's proven oil reserves have grown by nearly 120% in the past 30 years or so, from 57 billion barrels in 1980 to 124 billion barrels in 2012 [3]. In addition, it is estimated that at least *another* 100 billion barrels are offshore Africa, only waiting to be discovered. In turn, Africa's proven reserves of natural gas have grown from 210 trillion cubic feet (tcf) in 1980 to 509 tcf in 2012, representing a growth of over 140%. Furthermore, recent further discoveries of sizeable natural gas reserves in Tanzania and Mozambique point to a significant upward potential for these figures. Africa's oil production represented 12.4% of the world's total crude oil output, while Africa's crude oil exports grabbed a higher share at nearly 20% of the world's total exports of crude in 2010. – as a result of limited refining capacity and still limited oil consumption on the continent – while Africa held 8.8% of the world's proven reserves of oil in the year.

Focusing on the exploration of oil, sub-Saharan, Africa is made up of both the oil exporting and importing countries. The Atlantic Ocean coast of Western and Southern Africa has become one of the most promising oil exploration areas in the world. A convergence of interests among African governments, multinational oil companies, international financial institutions and northern governments is propelling the rush to exploit Africa's oil reserves. Nigeria, Angola, Gabon, Equatorial Guinea, São Tome, Cameroon, Ivory Coast and more recently, Ghana, Chad and Sudan are the ten major countries in sub-Saharan Africa which are stakeholders in the world's energy stake and few more countries may join them in the nearest future [4]. Africa is a significant player in world oil production. As it can be seen from Fig. 1, the contribution of Africa to world oil market has been increasing over the years. While the contribution of Africa was 3% in 2003 and 4% in 2004, it was increased to almost 35% in 2007. However, this contribution was reduced back to 4% in 2008 and 2009 due to the civil unrests in Libya and Egypt since these countries are the major oil producers of Africa.

When Africa is compared in terms of oil production to other regions of the world, it is the fourth largest oil producer. The Middle East region which contains countries like Iran, Iraq, Kuwait, Saudi Arabia, Oman and others is the world's largest producer of oil and it is followed by Europe & Eurasia region. The North America region is the third largest oil producer while the South region is the least producer.

The four largest producers of oil in Africa are Nigeria, Algeria, Libya and Angola in the period of 1989-2012. These four countries accounted for 77 percent of African continent production to the world oil market. Nigeria which is the biggest oil exporter with 2,5 million bpd is followed by Algeria with 1,88 million bpd and Angola with

1,84 million bpd in 2011. Libya could only manage to export 502 million bpd in the same year due to civil war that engulfed the country in 2011 but their export in 2010 was 1.37 million bpd. Smaller producers include Equatorial Guinea (303,000 bpd), Congo (Brazzaville) (298,000 bpd), Gabon (244,000 bpd), Cameroon (62,000 bpd) and Ivory Coast (40,600 bpd) with all these numbers being estimated as average daily oil output for 2011. The trend of oil production in Africa is shown in Fig. 2 below.

Nigeria is the largest producer of oil in Africa and is the second in oil reserves, with a reserve of over 35 billion barrels and a daily production of over two million barrels. When Nigerian oil and gas are combined, it accounts for about 95% of export receipts, around 15% of GDP and over 80% of fiscal revenue [5]. This situation makes Nigerian economy be more vulnerable to oil prices or to volatility of crude production. On the other hand, Algeria has one of the largest oil and gas opportunities in Africa. Algeria had an estimated 12.2 billion barrels of proven oil reserves at the end of 2012 – the third biggest in Africa [6].

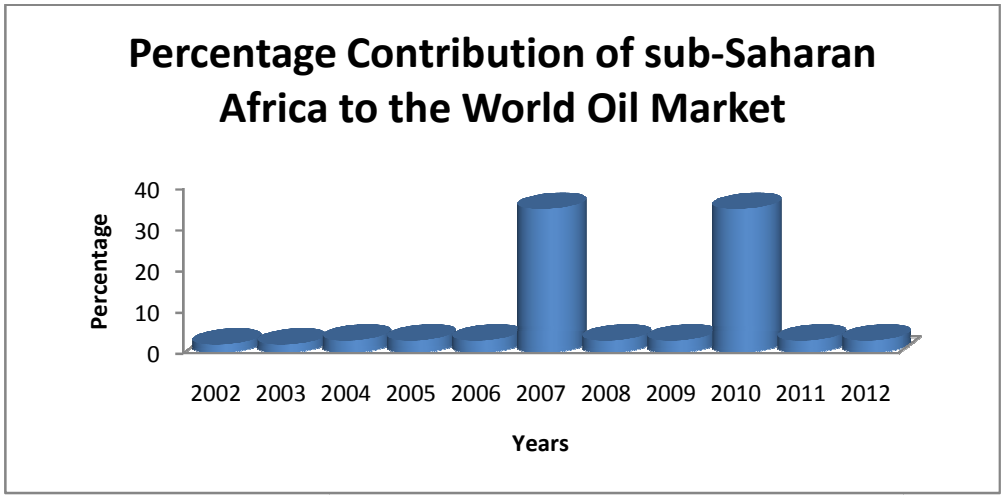

Fig. 1. The percentage contribution of Africa to oil market in the past 11 years
Source: Author's Computation based on BP statistical review of world Energy in 2013

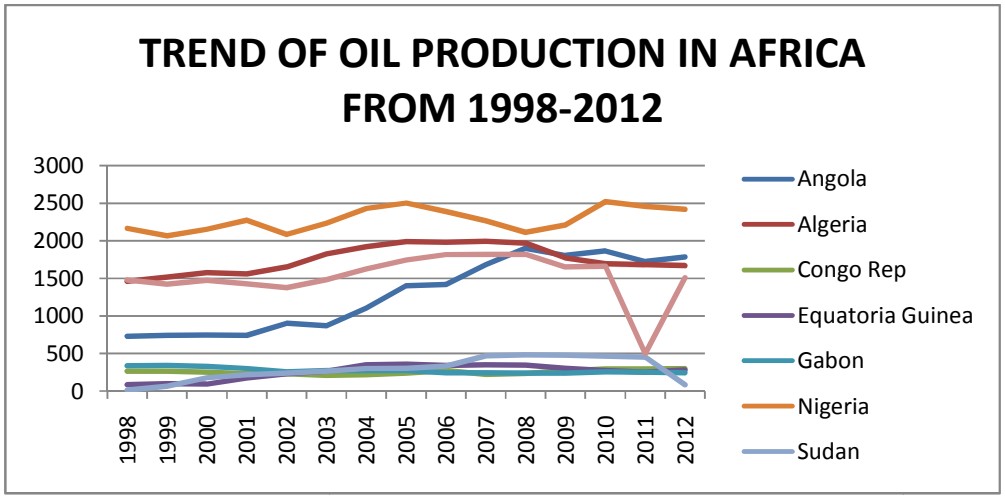

Fig. 2. Trend of oil production in Africa from the period of 1998-2012
Source: Author's Computation based on U.S. Energy Information Administration (EIA), 2012

Algeria's full hydrocarbon potential still has to be reliably established. The fact that Algeria's stock of reserves has stagnated at close to its current level over the past few years possibly reflects that tax such as windfall tax and investment laws are providing little incentive for the oil companies to invest and explore Algeria.

Libya is exceedingly well endowed with hydrocarbon resources. Libya with its proven crude oil reserves of 47.1 billion barrels, accounts for nearly 38% of the continent's proven oil reserves. This country has substantial reserves not only on an African scale, but also on a global basis. The country has 12 oilfields with reserves of over one billion barrels each and two others with reserves of between 0.5 and one billion barrels. The oil and gas industry accounts for almost 70% of GDP, 90% of fiscal revenues and approximately 97% of export earnings. The oil sector made a quick recovery after the civil war caused the oil production to fall to zero in August 2011. Indeed, figures from OPEC show that Libya produced 1.51 million bpd of crude oil by October 2012 which was only slightly below the pre-crisis level of 1.55 million - 1.6 million bpd.

Libya is followed by Angola which is the fourth largest producer of oil in Sub-Saharan Africa. The hydrocarbon sector remains Angola's main engine of economic growth, accounting for more than 96% of exports, 80% of government revenue, and in excess of 60% of GDP. Although the volatilities in the production of oil and/or global oil prices tend to have a direct influence on the performance of the economy, Angola's hydrocarbon potential is indeed massive. While Angola's proven oil reserves are or are around 9.5 billion barrels, it is in fact conservatively estimated that remaining oil reserves are around 12 to 15 billion barrels, with the bulk located offshore and in the Cabinda area [7].

The Volatility of oil price can be transmitted into the economy through various channels. An increase in oil price in oil importing countries will increase the production cost and restrict the output at a micro level. Despite the fact that the producers have a way of partially passing the effect of price increase onto consumers, the households will face a higher cost of living as a result of the increase. On the other hand, if the demand for crude oil is perfectly inelastic to the changes in the price level, an increase in the international price of oil will translate to a higher import bill for the net oil importing economies at the macro level. This situation will lead to a higher trade deficit and will consequently cause a deterioration of the country's current account balance. These impacts will also have further significant, negative effects and serious repercussions throughout the economy as all the macro-indicators such as employment, trade balance, inflation and public accounts as well as stock market prices and exchange rates will be affected. The nature and extent of such an increase will depend on the structural characteristics of an economy even among the oil importing countries. For example, the countries that engage more in the oil trade, rely heavily on fossil fuels and/ or use the energy intensively in industrial production are likely to be more exposed to the volatility of oil price on global commodity markets.

A price increase in oil may be seen as a blessing since it will increase the government revenue in the oil exporting countries. However, it is a fact that the negative or positive price volatility of oil increases perceived price uncertainty for all the countries regardless of their trade balance. The price volatility of oil affects national planning, hinders investments and may require expensive reallocation of resources. Formulating robust national budgets becomes more difficult as the importing countries face uncertainty regarding import costs and fuel subsidies levels and exporters face volatile revenues. This may be a particularly profound problem in developing countries with budget constraints which rely on oil exports as the main source of public revenue. In order to protect firms and households against the price volatility on international markets, particularly in the developing countries, governments often allocate large parts of their budgets to subsidizing fuel. These subsidy systems not only expose governments to significant budgetary risks, but also result in significant environmental costs. They mainly benefit the wealthier; create disincentives for energy efficiency and crowd out resources from education, health and other investments in development.

However, past evidence reveals that the mineral-exporting countries have been witnessing disappointing economic records. Twelve of the world's 25, most mineral dependent states and six of the most oil dependent countries are classified as Highly Indebted Poor Countries by the World Bank. When taken as a group, all "petroleum rich" less developed countries have witnessed a severe decline in the living standards of their populations and many of them

currently rank in the bottom one-third of the United Nations Human Development Index. In addition to poor growth records and entrenched poverty, they are characterized by high level of corruption and a low prevalence of democratization, all of which act to create high risks of civil war.

3. LITERATURE REVIEW

Several studies have investigated the price changes in crude oil fluctuation and uncertainty besides their impact on economic activity for about four decades ago. However, most of these studies focused either on the price movements themselves or on the influence of price changes in the economies of developed, industrial countries and industries, such as the United States and Japan [8,2,9].

Therefore, there is need to review the existing literature on the volatility of oil price and economic growth in sub-Saharan Africa. Due to the fact that only few studies have been done on this topic in sub-Saharan African, we decided to extend our review to cover the studies done in other countries and regions. The effects of changes in the international oil price and price volatility on the macro-economy of Nigeria, the largest oil exporter of Africa, was analysed in a study [10] where five-variable Structural Vector Auto Regression (SVAR) model was applied to monthly data series from January 1970 to May 2011. Impulse response functions were calculated to see the influences among the crude oil price, Nigeria's exchange rate, money supply (M2), domestic price levels (CPI) and the policy interest rate (Discount Rate). It was found that Nigeria's exchange rate is affected not only by the changes in the international oil price but also by its price volatility. M2 increases as a response to an increase in oil price which suggests that an increase in the international price of oil leads to a huge increase in the money supply into the domestic market by both the national and international oil companies that are the largest suppliers of dollars besides the monetary authority. The long run relationship between the oil prices and real GDP in ten sub-Saharan countries was examined in another study [11] which used the Panel data for the period of 1980-2008 and applied unit root tests[1]. The author of this study came out with the result that the price movement of oil has a positive impact on the economic growth of all of the eight[2] , selected, African countries in the long run.

The fluctuations in oil prices and their effect on the GDP growth of USA and Sweden were also analysed by [12]. Bivariate correlation between the fluctuations of oil prices and GDP growth and descriptive statistics were used in this study. The result in Sweden did not show a pattern of negative correlations between the increase of real oil prices and GDP while the result in the USA showed that GDP was more sensitive to the increases in oil prices. The demand for oil, oil prices, economic growth and resource curse were examined in another study [13] by the use of Structural Time Series Modelling (STSM) technique. The co-movements and causality relationship between the oil prices and GDP of non-OECD countries which were grouped depending on whether a country is a net oil exporter or importer was also investigated by using both time-series and panel data models. As a result, a long run cointegrating relationship between the oil prices and GDP was found. The oil prices have a strong influence on the economic output of net oil exporting countries while they have a very small or no influence on the economic output of net oil importing countries.

Moreover, there are also other studies on the same issue. For instance, a study titled "Oil and Growth in Africa: A Comparative Analysis" examined the impact of oil on the economic growth of seven, major Sub-Saharan African oil exporting countries [4].

A balanced data structure was adopted in the period of 1985-2005 and it was found that the investment rate and terms of trade had a significant and positive impact on the growth process while the volatility in the price of crude oil had a negative effect on growth in the sampled countries at an initial level of GDP.

A similar study was conducted to analyze the effects of the oil price shock on Malaysia's industry by the use of EGARCH [3] model to estimate the monthly volatility of oil prices and SVAR model to the monthly data of the period 1986-2009. The researchers of this study suggested that the volatility of oil price negatively

[1] *These tests are LLC (Levin, Lin and Chu Test), IPS (Im, Pesaran and Shin Test),test of cointegration developed by Johansen, Pedroni and ARDL Test.*

[2] *These countries are Democratic Republic of Congo, Cote d'Ivoire, Gabon, South Africa, Sudan, Botswana, Swaziland and Zambia.*

[3] *EGARCH: Exponential General Auto Regression Conditional Heteroscadasticity*

affected the industrial production of Malaysia and they came up with the result that the volatility of oil price lowered the price levels in the long term. [14].

Moreover, the relationship between the volatility of oil price and US macroeconomic activity was also analyzed. [15] It was found that the volatility measure constructed by the use of daily crude oil prices had a negative and significant effect on the future growth of gross domestic product (GDP) in the period of 1984-2004 and this effect became more significant after the inclusion of the changes in oil prices in the regression. This evidence provides economic rationales for nonlinear oil shock measure "It captures *overall* effects, both symmetric and asymmetric, of oil price shocks on output [16].

4. METHODOLOGY

After a careful examination of the literature which informs the readers about the relationship between the oil prices and economic growth, we specify the model of our study. The econometric model of this study is based upon a modified study undertaken by [4].

$$Y_{it} = AK_{it}^{\alpha} L_{it}^{\beta} Z_{it} \quad (1)$$

Where Y represents the output (GDP), A denotes technology progress, K represents physical capital, L is the used labour force and Z_{it} represents some control variables.

By taking logarithm of both sides and differentiating equation (1)

$$\Delta \ln(Y_{it}) = \ln(A) + \alpha \Delta \ln(K_{it}) + \beta \Delta \ln(L_{it}) + \ln \Delta Z_{it} \quad (2)$$

Different researchers have operationalized equation 1 by several ways, depending on how they specified or measured the vector as well as the specific production they adopted [4]. The framework vector Z_{it} in [17] was taken as the total factor of productivity [4].
Therefore, in this study we model Z_{it} to be

$$Z_{it} = opv_{it} + Rexc_{it} + fdi_{it} \quad (3)$$

By taking the logarithims and differencing equation 3 and substituting it into equation 2.
Equation 2 then becomes

$$\Delta \ln(Y_{it}) = \ln(A) + \alpha \Delta \ln(K_{it}) + \beta \Delta \ln(L_{it}) + \Delta \ln opv_{it} + \Delta \ln Rexc_{it} + \Delta \ln fdi_{it} \quad (4)$$

4.1 Measurement of Variables and Data Source

Unbalanced panel data will be adopted for our empirical analysis in this study. Annual data from 20 sub-Saharan Africa countries which will cover the period from 1986 to 2012 will be used for our analysis. These 20 countries will be divided into two groups as A and B and each group is made up of 10 countries. Group A consists of 10 oil exporting countries in sub-Saharan Africa which are Nigeria, Angola, Chad, Sudan, Ivory Coast, Gabon, Libya, Cameroon, Democratic Republic of Congo and Equatorial Guinea. The second group of group B consists of 10 non-oil exporting countries in sub-Saharan Africa, namely Gambia, Mali, Senegal, Sierra Leone, Botswana, Central Africa Republic, Kenya, Malawi, Rwanda and Lesotho. Panel A will represent the oil exporting countries in sub-Saharan Africa while Panel B will represent the oil importing countries in sub-Saharan Africa. These countries are divided into groups in order to investigate whether the volatility of oil price will have the same effect or a different impact on these country groups.

We used three methods of estimations, namely panel OLS regression, fixed effect and Generalized Method of Moment (GMM) in this study. The pooled OLS models were estimated with cross-section effects and they were corrected for cross-section correlation, period arbitrary serial correlation, time varying variances in the disturbances and observation specific heteroskedasticity. A serious empirical challenge in the estimation of cross-country regressions is to choose which model to use, whether to use the random or the fixed effect model. We make use of fixed effect model since we want to control the omitted variables in addition to our unbalanced data. We use GMM due to its advantage of taking care of omitted variables and solving the endogeneity problem through the choice of appropriate instruments of lagging independent variables [4].

Moreover, variables [4] which are GDP (gross domestic product), labour, capital, REXC (real

[4] *GDP is measured in current US dollars, labour is measured by total labour force, capital is mearured by gross capital formation, fdi is the foreign direct investment or foreign owned capital, EXCH is the real exchange rate and OPV is generated using the Garch Methodology.*

exchange rate), OPV (volatility of oil price) and foreign direct investment (FDI) were used for the regression. Data on the variables were obtained from United Nations Conference on Trade and Development (UNCTAD) Statistics, a database maintained by the United Nations Conference on Trade and Development, Selected Statistics on African Countries and African Statistical Year book.

5. Data Analysis and Empirical Results

In order to investigate the impact of the volatility of oil price on economic growth in sub-Saharan Africa we begin our analysis with descriptive analysis. We first examine the descriptive statistics and the correlation matrix of the oil exporting countries and non-oil exporting countries. The descriptive statistics of data series provide information about sample statistics such as mean, median, minimum value, maximum value and distribution of the sample measured by the skewness, kurtosis and the Jarque-Bera statistic. The descriptive statistics of Panel A consisting of oil exporting countries from 1986-2012 is provided in Table 1 below.

There is high level of consistency displayed by the series in Table 1 as their mean and median fall within the minimum and maximum values of the series. For example, the growth rate of GDP is very low over the period of this study as the mean value stands at 7.87%. The mean value of oil price volatility is -0.934341 which reveals that fluctuation in oil price is minimal for the study period. The standard deviation which measures the level of variation or the degree of dispersion of the variables from their mean is relatively very low for all the series; indicating that the deviations of actual data from their mean values are very small. The standard deviation of GDP is 4.722800 which shows that the growth rate of GDP is unstable when compared to other variables. Oil price volatility with the standard deviation of 1.497345 is the least stable after capital and this shows that fluctuation in oil price is relatively stable.

In order to examine the degree of a possible association among the variables**,** we obtained the correlation matrix of both the dependent and independent variables. The correlation matrix usually provides information about the direction of the relationship among the variables. The correlation matrix result is presented in Table 2 below.

The result of Table 2 of panel A above shows that both the, real exchange rate, labour and oil price has a negative relationship with GDP. The correlation matrix has shown interesting results on the relationship between dependent and independent variables. Due to the fact that one of the major consideration in econometric analysis concerning time series data is the non-stationarity of underlining data. If non-stationarity is not accounted for in the estimation process, it may lead to spurious regression with serious negative consequences for public policy. Due to this, we preformed unit root test based on [18] and [19] and the results of the unit root tests of Panel A are presented in 3 below.

The results of Levin et al and Im et al. of Panel A in Table 3 show that all the variables are not fixed at levels despite being fixed at first difference. Therefore, they are integrated of order I (1). Therefore we reject the null hypothesis of unit root.

After examining the descriptive statistics, the correlation matrix and unit root of the Panel A we now proceed to examine the descriptive and correlation matrix and unit root of Panel B. The descriptive statistics of panel B are presented in Table 4 below.

The descriptive statistics of panel B shows that the series display a high level of consistency like that of panel A since the mean and the median are within the maximum and minimum values. The growth rate of the GDP is 6.36% which is 1% below the oil producing countries. The standard deviation is relatively low in which volatility of oil price is the next least stable after capital follow by GDP with standard deviation of 1.049856.

The results of correlation matrix of Panel B are presented in Table 5 below. The results of correlation matrix of Panel B consisting of non oil producing countries are not a little different from the result of Panel A consisting of oil producing countries as all the variables apart from capital and labour are negatively correlated with GDP. This means that the volatility of oil price has a negative relationship with economic growth in non oil producing countries in sub-Saharan Africa.

The results about the variables from Table 6 are the same with those from Table 3. Therefore, the null hypothesis of unit root can also be rejected here.

Due to the fact the correlation matrix cannot be a reliable indicator of association we use the panel data. The results of both panel A and panel B are presented below in Table 7 and 8 respectively.

In order to determine the impact of the volatility of oil price on the economic growth in sub-Saharan Africa, we used three, functional forms of estimation techniques, namely the pooled ordinary least squares (OLS), the fixed effect model (FEM) and the generalized moment method (GMM).

The result of pooled OLS of panel A shows that the volatility of oil price is positive but statistically insignificant. The pooled OLS results also show that FDI is negatively signed and statistically significant at 10% which means that FDI has negative relationship with economic growth of oil exporting countries in sub-Saharan Africa.

Table 1. Descriptive statics of group A

	dln(gdp)	dln(rexc)	dln(opv)	dln(cap)	dln(lab)	dln(fdi)
Mean	7.873694	3.977946	-0.934341	2.833373	15.29256	0.995106
Median	6.651195	4.601622	-0.502762	2.811804	15.58052	1.061146
Maximum	25.25767	6.932705	0.795224	4.732489	17.76037	4.978126
Minimum	4.518534	-7.600902	-5.434137	0.360291	12.20895	-6.660992
STD.dev	4.722800	2.115380	1.497345	0.705100	1.531009	1.682984
Skewness	2.997328	-1.938493	-1.148579	-0.236108	-0.482562	-0.890423
Kurtosis	10.73609	8.044650	3.609865	4.361342	2.413329	6.085447
Jarque-bera	674.4719	285.0432	39.77743	14.62020	8.982685	89.36857
Probability	0.000000	0.000000	0.000000	0.000669	0.011206	0.000000
Sum	1330.654	672.2729	-157.9036	478.8401	2584.443	168.1729
Sum SQ dev	3747.213	751.7717	376.6630	83.52399	393.7900	475.8490
Observation	169	169	169	169	169	169

Table 2. Correlation matrix of panel A

	dln(gdp)	dln(rexc)	dln(opv)	dln(cap)	dln(lab)	dln(fdi)
dln(gdp)	1.0000					
dln(rexc)	-0.5576	1.0000				
dln(opv)	-0.1954	0.3334	1.0000			
dln(cap)	0.0880	-0.1314	0.2994	1.0000		
dln(lab)	-0.2994	0.0505	-0.5034	-0.6334	1.0000	
dln(fdi)	-0.1435	0.0151	0.0363	0.4937	-0.1693	1.0000

Table 3. Unit root tests of panel A

Variables	Levine et al.		Im et al.	
	Without trend	With trend	Without trend	With trend
lnGDP	-5.11(0.0000)	-4.35(0.0000)	-5.10(0.0000)	-4.62(0.0000)
lnREXC	-6.21(0.0000)	-5.87(0.0000)	-6.36(0.0000)	-5.79(0.0000)
lnOPV	-3.86(0.0000)	-4.64(0.0000)	-5.18(0.0000)	-17.34(0.0000)
lnCAP	-10.27(0.0000)	-9.0633(0.0000)	-9.82(0.0000)	-8.70 (0.0000)
lnLAB	-2.33(0.0000)	-4.21(0.0000)	1.22(0.025)	-1.89(0.029)
lnFDI	-5.24(0.0000)	-8.91(0.0000)	-4.9090(0.0000)	-2.29(0.0000)

Table 4. Descriptive statistics of panel B

	dln(gdp)	dln(rexc)	dln(opv)	dln(cap)	dln(lab)	dln(fdi)
Mean	6.369791	4.419022	-0.528117	2.878638	14.77272	0.756355
Median	6.038336	4.623149	-0.510311	2.889533	14.58121	0.993259
Maximum	8.980025	5.364732	1.184265	4.315112	16.74400	3.562038
Minimum	4.787148	0.626633	-2.020177	-1.228027	12.89764	-5.962707
STD.dev	1.049856	0.919567	0.707066	0.618580	1.064155	1.387359
Skewness	1.063942	-2.645199	0.265977	-1.766164	0.207667	-1.494274
Kurtosis	2.981464	8.978373	2.526600	13.96593	1.910121	7.182727
Jarque-bera	36.79193	517.8002	4.120043	1078.423	11.05275	214.7163
Probability	0.000000	0.000000	0.127451	0.000000	0.003980	0.000000
Sum	1242.109	861.7092	-102.9829	561.3344	2880.680	147.4893
Sum SQ dev	213.8264	164.0471	96.98877	74.23242	219.6907	373.4046
Observation	195	195	195	195	195	195

Table 5. Correlation matrix of panel B

	dln(gdp)	dln(rexc)	dln(opv)	dln(cap)	dln(lab)	dln(fdi)
dln(gdp)	1.0000					
dln(rexc)	-0.5717	1.0000				
dln(opv)	-0.1174	0.2788	1.0000			
dln(cap)	0.2855	-0.2945	-0.0630	1.0000		
dln(lab)	0.0688	0.2530	0.2346	-0.0700	1.0000	
dln(fdi)	-0.0037	-0.1389	0.1449	0.3871	-0.1848	1.0000

Table 6. Unit root tests of panel B

Variables	Levine et al.		Im et al.	
	without trend	with trend	without trend	with trend
lnGDP	-6.68	-5.98	-7.13	-6.05
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
lnRECX	-7.98	-6.69	-8.57	-7.16
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
lnOPV	-3.35	-3.20	-3.60	-3.53
	(0.0004)	(0.0007)	(0.0000)	(0.0000
lnCAP	-7.76	-5.75	-9.83	-7.94
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
lnLAB	-3.2482	-6.2117	-0.5883	-4.0288
	(0.0006)	(0.0000)	(0.2782)	(0.0000)
lnFDI	-12.27	-9.07	11.31	-8.53
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

The real exchange rate is also negative and statistically significant at 1% under pooled OLS. This also means that real exchange rate has a negative relationship with economic growth in oil exporting countries in sub-Saharan Africa. Labour and capital are positivly correlated with on economic growth as they are positively signed and statistically significant at 5% and 1% respectively. The results of fixed effect show that only volatility of oil price has positive relationship with economic growth and statistically significant at 1%. On the other hand, the results of the volatility of oil price under GMM model is the same with those of the fixed result. In other words, the volatility of oil price is positive related with economic growth in sub-Saharan Africa. All other variables except the lagged dependent variable and labour have negative relationship with economic growth. The positive relationship of volatility of oil price with economic growth of oil exporting countries found in this study may be due to investment in labour couple with trade openness. Investment in labour will lead to increase in output and when domestic supply is more than domestic demand more goods will be available for export. Therefore, this will lead to increase in export and when export increases revenue will also increases. It could also be due to the fact that the increases in oil prices will lead to currency appreciation which make interest payments on international debt less expensive if those debts are denominated in a foreign currency and the accumulation of this interest rate can be used for the expansion of the economy.

The results of pooled OLS in Panel B show that the volatility of oil price and the capital have positive signs but the volatility of oil price is statistically significant at 5% under fixed model only. This effect of the volatility of oil price on oil importing countries may have probably occurred because such countries identify and explore alternative sources of energy so that they are protected from the impact of price volatility or they may adopt measures to reduce the level of dependency on oil international markets.

Table 7. Estimates of panel A

Variables	Pool OLS effect	Fixed effect	GMM
C	5.6775***	4.6059***	
	(5.9387)	(14.3710)	
dlnGDP_{-1}			0.1224
			(0.4974)
dlnCAP	0.2922**	-0.04530	-0.4757*
	(2.7087)	(-1.2586)	(-2.2673)
dlnLAB	0.2001***	-0.0565***	3.4712***
	(3.3550)	(-3.8123)	(3.4739)
dlnREXC	-0.6819***	-0.0025	-0.2846*
	(-9.5685)	(-0.0747)	(-1.9273)
dlnOPV	0.0442	2.2749***	0.2951***
	(0.4855)	(3.7157)	(2.4182)
dlnFDI	-0.0909*	-0.1549***	-0.1106
	(-1.8856)	(-4.2724)	(-1.0246)
R^2	0.40	0.99	
Adjusted R^2	0.38	0.99	
F-Statistics	25.37	492.10	
D-Watson stat	0.081	0.30	
J-Statistics			2.39
Instrument rank			6
No of Observation	195	195	131
Cross section Included	10	10	10

*Note: t values are in parentheses, Due to endogeneity problem between FDI and GDP, also between volatility of oil price and exchange rate volatility.The list of instrument employed for GMM include: c gdp (-1) rexcv (-1) opv(-1) lab (-1) cap(-1) fdi(-1) , ***denote significant at 1%, ** significant at 5 % and * at 10%*

Table 8. Estimates of panel B

Variables	Pool OLS effect	Fixed effect	GMM
C	5.6775***	21.6154***	
	(5.9387)	(5.1272)	
dlnGDP_{-1}			0.0244
			(0.1765)
dlnCAP	0.2922**	0.0575	0.2139*
	(2.7087)	(1.6893)	(1.7177)
dlnLAB	-0.2001***	-1.1652***	3.3008*
	(-3.0349)	(-4.0447)	(1.7976)
dlnREXC	-0.6819	0.4232***	2.0758**
	(-9.5685)	(6.6332)	(2.6235)
dlnOPV	0.0441	0.1260*	0.1231
	(0.4855)	(2.5918)	(0.2266)
dlnFDI	-0.0909	-0.0015	-0.1335
	(-1.8856)	(-0.1159)	(-1.1813)
R^2	0.40	0.98	
Adjusted R^2	0.38	0.97	
F-Statistics	24.372		
D-Watson stat	0.0731		
J-Statistics			0.98
Instrumental rank			6
No of observation	195	195	131
Cross section Included	10	10	10

*Note: t values are in parentheses, Due to endogeneity problem between FDI and GDP, also between volatility of oil price and exchange rate volatility.The list of instrument employed for GMM include: c gdp (-1) rexcv (-1) opv(-1) lab (-1) cap(-1) fdi(-1) , ***denote significant at 1%, ** significant at 5 % and * at 10%*

Measures such as decreasing the share of fosil fuels in the national energy portfolio, increasing the efficiency of energy and developing structural and technological alternatives to make the production processes less fosil fuel intensive can all reduce the dependency on oil. Since these structural policy measures have long-term time horizons, they can be complemented with short-term risk management instruments such as physical reserves, strategic purchasing contracts and financial instruments which are all a common practice among many large private companies for hedging their supply risks [20]. In addition, the positive effect of the volatility of oil price on oil importing countries may be due to the fact that the problem of high oil price is offset through foreign aid or government subsidies. Especially the subsidiaries given by government help to reduce the burden of poor people so that the nation can still buy products at cheaper price. Besides, the production cost remains low through the subsidiaries and this creates the chance to attract more foreigners to invest in the local [21].

The results of fixed effect of panel B are a little different from the results of pooled OLS since the result of the volatility of oil price is the same with that of pooled OLS. Both labour and FDI are negative but labour is statistically significant at 1%. This result is consistence with [13].

We choose (GMM) as the robustness check due to its advantage of accounting for heteroscedasticity and eliminating any trace of serial correlation [4]. This method shows little difference from the fixed effect results as the volatility of oil price is positive but statistically insignificant. Capital, labour and real exchange rate show positive signs and they are all statistically significant. The adjusted coefficient of determination of pooled OLS is 0.38 and 0.97 under fixed estimation. The negative and significant of labour in oil importing countries might due to the high illiteracy rate and as well as lack of skilled workers leading to their low productivity. Also, it could be that the personnel management system in firms and enterprises does not allow well-educated employee to contribute meaningfully to the enterprises. The

positive and significant of capital in oil importing countries might have occurred through technological innovation. This might be as result of reallocating their revenue among different capital producing technologies or invention of new production processes and goods in an attempt to widen their sources of income. While it is otherwise in oil exporting countries as they majorly rely on oil revenue as main source of income and neglected other sectors.

With respect to the results of Panel A and Panel B, the relationship of the volatility of oil price on economic growth of oil exporting countries is the same with that of the oil importing countries in sub-Saharan Africa. This result is consistent with the study [22] where no statistically significant difference was found between the economic performance of commodity and non-commodity exporters.

6. CONCLUSİON

Although there are many studies which especially focus on the volatility of oil prices in a single country and other regions, such as OECD countries and OPEC members, such studies do not usually examine the countries in sub-Saharan Africa. Therefore, we examined the impact of the volatility of oil price on the economic growth of selected, sub-Saharan African countries. Our study is different from the other studies as we divide the selected, sub-Saharan countries into two groups as Panel A and Panel B. Panel A consists of oil exporting countries while panel B consists of non oil exporting countries. We used three different estimations namely, the pooled OLS, fixed effect and Generalised Method of Moment to determine the effect of the volatility of oil price on the economic growth in sub-Saharan Africa. The results of this study show that the volatility of oil price has a positive relationship with economic growth of both the oil exporting and importing countries. The significant effect of the volatility of oil price in panel A means that the oil price witnessed more increases than the decreases during the study period and the revenue of the oil exporting countries boosted due to the increases. Moreover, the positive relationship of the volatility of oil price with economic growth of the oil importing countries shows that having alternative sources of energy and taking necessary measures of reducing the level of dependency on international oil markets are some of the ways an economy can to be protected against the volatility of oil prices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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