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# The Impacts of Oil Export and Food Production on Inflation in African OPEC Members

UMAR BALA[a,b] , LEE CHIN[a*], SHIVEE RANJANEE KALIAPPAN[a] & NORMAZ WANA ISMAIL[a,c]

[a] *Department of Economics, Faculty of Economics and Management, Universiti Putra Malaysia*
[b]*Department of Economics,Faculty of Management and Social Sciences, Bauchi State University, Gadau, Nigeria*
[c]*Agricultural Production, Marketing and Trade Laboratory , Institute of Agricultural and Food Policy Studies, Universiti Putra Malaysia*

## ABSTRACT

This study examined the long run impact of oil export and food production on inflation in African OPEC member countries. The countries consist Algeria, Angola, Libya and Nigeria. This study applied Pedroni cointegration test. In addition, dynamic panel ARDL models (PMG and MG estimators) were also used. This study found that the long-run coefficient of oil exports, money supply, exchange rate and GDP are positively related to inflation while food production is negatively related to inflation. The policy makers should maintain a certain level of oil export to minimize the rate of inflation, also to encourage domestic food production to reduce the rate of inflation. Besides that, the study also concludes that increase in money supply and depreciation of exchange rate cause inflation rate. Hence, the policy makers can use the contractionary monetary policy as well as currency control to reduce the inflation rate in OPEC member countries.

**Keywords**: oil export, food production, panel ARDL, African countries.

**JEL Classification**: C22, E31, Q43

*Corresponding author: leechin@upm.edu.my

## INTRODUCTION

Inflation has been given serious attention as the prices of goods and services are increasing over time. Hence, the nature and the transmission channel on how the structure of economy affect inflation is very important. In oil exporting countries that highly depend on oil export, any changes in the amount of oil production may influence the overall economic activities and transmitted to domestic inflation. It is generally accepted that prices of goods and services are quite responsive to the fluctuation of oil prices in international market. But it seems to be different in the African oil producers, not only oil price is important in determining the inflation rate, oil export also played an important role in determining inflation. Some of these countries are unable to produce the required amount of crude oil for export due to political instability which distorts the extraction of crude oil[1]. Occasionally, even if the prices of oil are increasing when the oil export is declining, it is believed that the increase in oil price generally has little impact on the economy. Thus, the amount of oil export has to be taken into consideration whenever there are fluctuations in the oil prices.

There are numerous studies on how inflation originated in African OPEC member countries as these countries have been affected by serious increases in the price level. Among the causes that had been identified by previous studies are increasing in money supply, exchange rate pass-through, increasing oil price, growth and lack of effective policies. However, previous studies have overlooked the importance of domestic food production in reducing the inflation rate. According to Dillon and Barrett (2016), the impact of increases in oil price is higher in the countries that have a high level of subsistence food production. Therefore, in studying the inflation dynamics, especially in emerging economies that food prices consist a large share in the consumer price basket. The production of food and other agricultural commodities has to be considered (Durevall *et al*., 2013). The component of food and non-alcoholic beverage in the CPI of Algeria is 43.09 percent[2], Angola is 55.1 percent[3], Libya is 37 percent[4] and Nigeria is 51.8 percent[5], respectively. Hence, this study aims to examine the long-run impact of oil export and food production on inflation in African OPEC member countries, namely Algeria, Angola, Libya and Nigeria.

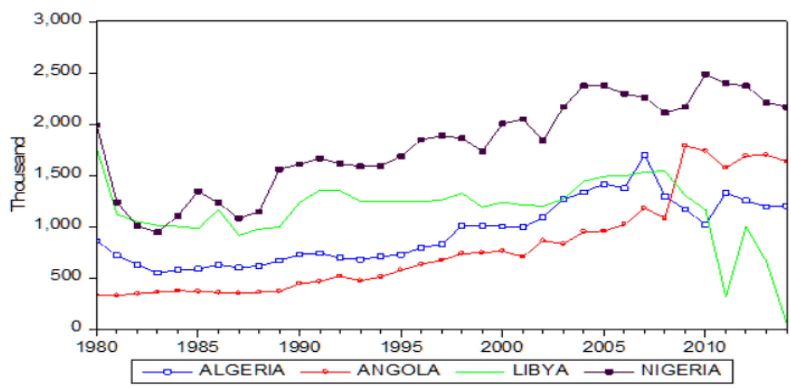
## AFRICAN OPEC MEMBERS

The sample countries in this study are Algeria, Angola, Libya and Nigeria[6] . They have been selected based on the high dependency on oil export, sharing the same continent and members of the same cartel, OPEC. According to the U.S. Energy Information Administration[7], Nigeria is the top crude oil producer in Africa. Figure 1 illustrates the oil production for African OPEC

[1] There are several issues affecting the oil exports of the African Organization of the Petroleum Exporting Countries (OPEC) members, such as political conflict, avengers, war, insecurity and the damages of the pipeline.
[2] knoema. (n.d.). Retrieved from https://knoema.com/IMFCPI2017Mar/consumer-price-index-cpi-monthly-update?tsId=1001410
[3] Trading Economics. (n.d.). Angola Inflation Rate. Retrieved from https://tradingeconomics.com/angola/inflation-cpi
[4] Cevik and Teksoz (2013)
[5] Trading Economics. (n.d.). Nigeria Inflation Rate Lowest In Over 1 Year. Retrieved from https://tradingeconomics.com/nigeria/inflation-cpi
[6] Congo is excluded since it suspended within the study period.
[7] U.S. Energy Information Administration. (n.d.). Country Analysis Brief: Nigeria. Retrieved from http://www.marcon.com/library/country_briefs/Nigeria/nigeria.pdf

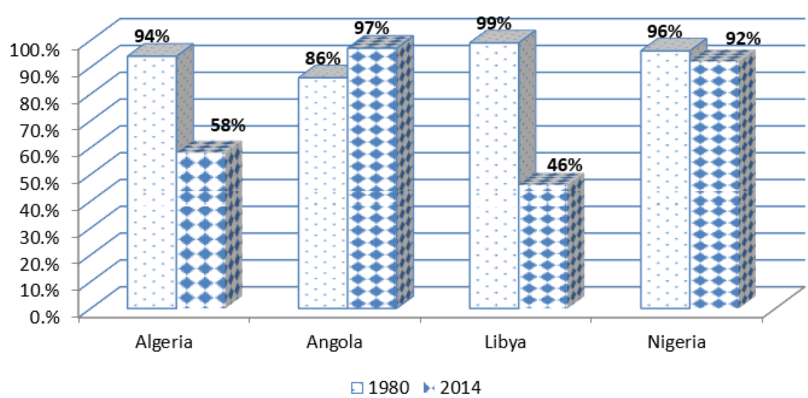
members. It can be observed that from 1980 to 2014, Nigeria had always been the top crude oil producer in Africa, averaging about 1807.047 barrels daily. This is followed by Angola with the production of 1653.688 barrels daily, on average. Algeria ranked third producing averagely about 1192.833 barrels daily. Meanwhile, Libya, holding the largest crude oil reserve in Africa, plays a significant role in contributing to the supply of light and sweet crude by producing an average of 479.899 barrels daily. Based on the oil production trend, it is observed that Libya's production is severely affected due to the ongoing political conflict and insecurity.

Figure 2 presents the percentage of petroleum exports per total exports for African OPEC Members. The figure compares the variation in terms of oil dependency among the four countries. In 1980, Algeria exported about 94 percent of petroleum products, Angola 86 percent, Libya 99 percent, and Nigeria 96 percent. Meanwhile, in 2014, Algeria exported about 58 percent of petroleum products, Angola 97 percent, Libya 46 percent and Nigeria 92 percent. The remaining percentage of the exports consists of the non-oil products. Although the comparison shows that each country has declined in terms of oil dependency, it is undeniable that these countries still heavily rely on oil exports. In the case of Libya, the huge percentage change in the year 2014 data does not mean the country is less oil export dependent. This is due to the political conflict and insecurity in the country that caused Libya unable to produce and meet the quota allocated by OPEC.




Source: OPEC Annual Statistical Bulletin (2015)

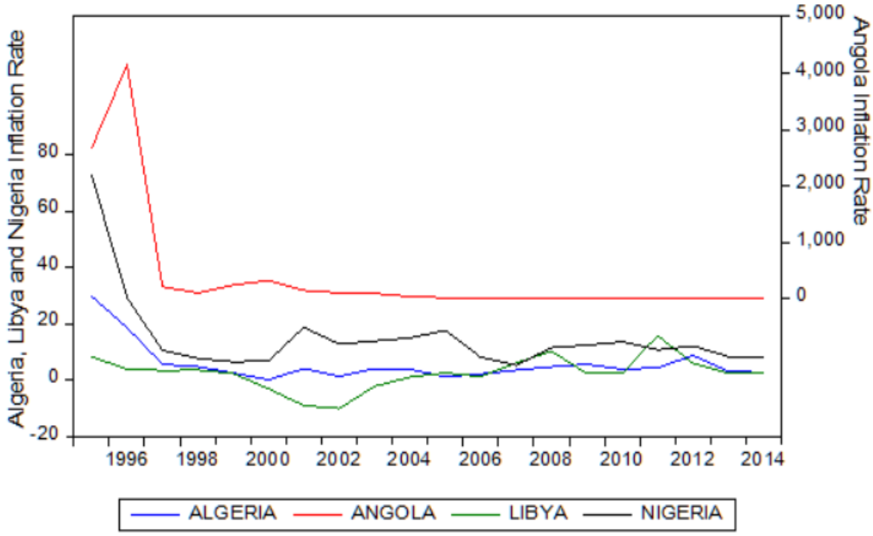
Figure 1 Exports of Petroleum Products of African OPEC Members (1,000 b/d)




Source: OPEC Annual Statistical Bulletin (2015)

Figure 2 Percentage of Petroleum Exports Per Total Exports

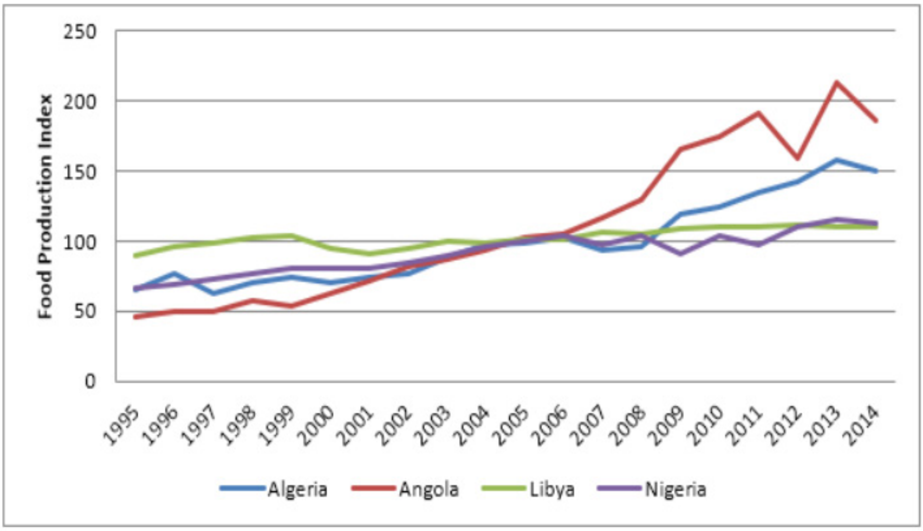
Figure 3 presents the inflation rate movement for African OPEC members from 1980 to 2014. In the past decades, Algeria, Angola, and Nigeria experienced the inflation rate at about 7 to 8 percent, except in 1990 to 1998 due to the changes in monetary policy. Angola acknowledges hyper-inflation of 4146 percent in 1996 due to the war, reformation of market policies and printing of money to finance the budget deficit. The inflation rate of Angola, Libya, and Nigeria exceeded the central bank's participation (World Bank Group, 2016). The Libyan inflation rate is considered moderate, the highest rate within the period of study was 15.90 percent in 2011 and the lowest was -9.86 percent in 2002.




Source: World Bank Online Database

Figure 3 Inflation Rates in African OPEC Members

Figure 4 illustrates the trend of food production index in African OPEC members. There is an improvement in the food production, especially in Angola from 46 percent in 1995 to 185 percent in 2014, Algeria from 76 percent to 149 percent in 2014, and Nigeria 66 percent in 1995 to 112 percent while Libya is relatively low from 89 in 1995 to 110 percent in 2014. Even though there is an improvement in the food production, African has remained a net importer of agricultural products in the last three decades (Rakotoarisoa et. al, 2011). Table 1 provides the percentage of food import for Algeria, Angola, Libya and Nigeria, it shows that the percentage of food import for Algeria is 19.31 percent, Angola is 15.68 percent, Libya is 12.13 percent and Nigeria is 17.03 percent. Cereals, meat and dairy import values represent more than half of total food import values (Rakotoarisoa et. al, 2011).




Source: World Bank Online Database

Note: Food production index (2004-2006 = 100) covers food crops that are considered edible and that contain nutrients.

Figure 4 Food Production

Table 1 Percentage of Food Import

| | Import (million $) | % of Food Import |
|---|---|---|
| Algeria | 59,440 | 19.31 |
| Angola | 27,509 | 15.68 |
| Libya | 13,620 | 12.13 |
| Nigeria | 61,980 | 17.03 |

Notes: Import is the total import of goods and services for the year 2014 and food import is the percentage of import that was food

Source: OPEC Statistical Bulletin 2016 and Trading Economics

## LITERATURE REVIEW

The price level fluctuation caused by oil has a multiplier effect on economic activity, which eventually would affect the overall economic performance. The impact of oil prices on inflation rate should not be considered insignificant even it is less (Chang and Wong, 2003). The impacts are more in emerging economies, as these economies are not financially stable and weak to the influences of external shocks (Backus and Crucini, 2000). This study is motivated by a recent study by Sek *et al*. (2015) who examined the effect of oil price change on domestic inflation among low and high oil dependent group. The study used data ranging from 1980 to 2010. The results reveal that oil price change has a direct effect on domestic inflation in the low oil dependency group, but its impact is indirect in the high oil dependency group. Although there are little studies in the literature on how oil export is affected the general inflation, there are some studies found that the impact of oil export and oil price are highly correlated. Watkins and Strelfel (1998) concluded that the quota system shared among the OPEC members could not be portrayed by the relation of normal supply function with a price. In the previous findings, Ramcharran (2002) found that the relationship between OPEC production and oil price is inverse. Cleveland and Kaufmann (2003) revealed that oil supply and oil prices interchanges, increase in oil supply lead to the reduction of oil price. Kaufmann *et al*. (2008) claimed that the real price usually has a positive impact on oil supply. In contrast, Ringlund *et al*. (2008) revealed a positive correlation between oil activities and oil price.

There are many studies on oil prices on domestic prices or inflation rates. Moosa (1993) found that oil prices and macroeconomic variables are not cointegrated and the causal relationship is unidirectional from oil price to domestic price. Sadorsky (1999) used monthly data ranging from January 1947 to April 1996 on VAR model. The author found that the impact of positive oil price is not immediate, but follows a lagged trend. Hooker (2002) using quarterly data from 1962: Q2 to 2000: Q1 estimated a Phillips curve framework with a structural break on U.S. inflation. He found that oil price pass-through has become negligible since 1980. Chang and Wong (2003) study on Singapore revealed that the impact of oil prices on inflation rate should not be considered insignificant even if it is little. Leblanc (2004) used an augmented Phillips curve framework to study G5 countries and found similar results, which oil price increases are likely to have a modest effect on inflation in the U.S., Japan, and Europe. Gregorio *et al*. (2007) found that the impacts of an oil price shock on inflation have been harmful in almost the entire 12 sample countries used in the study. A study by Ju *et al*. (2014) which applied Hilbert-Huang transform (HHT) on China's data, found that oil price shock has a negative impact on GDP and exchange rate, but has a positive and significant impact on consumer price. Oppong *et al*. (2015) used monthly data ranging from January 2000 to December 2014 found that crude oil price and inflation have a positive relationship, in which about more than 95 percent changes in crude oil price and exchange rate influence inflation in Ghana. Poh and Chin (2015) used the Autoregressive Distributed Lags (ARDL) method to study the pass-through effect of oil prices into Malaysia's consumer prices. The results indicated that oil prices and inflation have a positive relationship. In a recent study by Basnet and Upadhyaya (2016) on ASEAN-5 economies, the authors found that a fluctuation in oil price is absorbed and disappeared within the first five to six quarters after the shocks happened. The shocks do not have any significant impact in the long-run, especially when the oil price is converted to domestic currency.

In addition, there are some studies that examined the nonlinear between oil prices and inflation. Guney and Hasanov (2013) used monthly data ranging from 1990:1 to 2012:3 and found that the asymmetric behavior of oil price changes and oil price increases have positive and significant impacts on inflation. However, the decrease in oil price is insignificant in the case of the Turkish economy. Du, *et al*. (2010) applied multivariate VAR models specification on monthly data from January 1995 to December 2008 in China. The authors found that China's GDP growth is positively correlated with the world oil price and oil price shocks have a significant impact on domestic inflation in nonlinearity form. Applying quarterly data ranging from 1975:1 to 2002:2, Cunado and Gracia (2005) found evidence of nonlinearity between oil prices and macroeconomic nexus in six Asian economies. The outcomes indicate that the impacts of inflation were significantly influenced by the oil price shock. Gómez-loscos *et al*. (2016) employed the data from G7 countries over the period of 1970 to 2008 identified three nonlinear breaks. The study concludes that the response of inflation to oil price shocks is greatest in the 1970s and progressively disappears until the late 1990s, then in the 2000s both impacts happen again. Ahmed and Wadud (2011) used structural VAR methodology and EGARCH model on monthly data from 1986 to 2009. The study found an asymmetric impact of oil price that is during the positive shock of oil price, uncertainty level of Consumer Price Index (CPI) will decline. On the other hand, using the nonlinear ARDL model, Wong and Shamsudin (2017) found that crude oil price has no asymmetric effect on Malaysian food price fluctuation.

The inflation dilemmas around the globe, as well as nature of causes and implications have given rise to a lot of researchers on the link between agricultural production and inflation. Among the earlier studies recognized the importance of food production on food prices is Kaldor (1976). The study indicated that sharp rise in food prices following upon the shortage in supply. Sala-i-Martin and Subramanian (2013), Chand (2010) and Arndt *et al*. (2016) argued that a sharp decline in the production of agricultural commodities will raise the food prices. In addition, due to the excess of demand, a country may experience an increase in domestic food prices even though the rate of production of the agricultural items is improving.

Much of the previous research concludes that increase of oil prices is the main causes of inflation. If necessary action not in place, inflation can be widespread and harmful to the economic activities. There is limited research considered the impact of oil exports on inflation and the domestic food production has a way to tackle inflation. This study included food production in the model because generally, the oil exporting countries like Algeria, Angola, Libya, and Nigeria are food scarce countries.

## RESEARCH METHODOLOGY

In order to model the impact of oil export on inflation, this study followed the study of Bowdler and Malik (2017) who specified inflation depends on trade openness. This study disaggregates the trade openness into oil export as the main aim of the study is to explore the impact of oil export on inflation the model is as equation (1):

$$cpi=f\,(ox) \tag{1}$$

Where: cpi, is the consumer price index which is the proxy for inflation, ox is the oil export, decrease in export prices may reduce the nominal value of trade so that inflation rises (Bowdler and Malik, 2017).

This study includes food production index (FPI) in the model of oil export and inflation because the four African OPEC members (Algeria, Angola, Libya and Nigeria) are food scarce countries. As noted by Dillon and Barrett (2016), domestic food prices are affected by the global crude oil price shock, especially in the countries that are high levels of subsistence food production. Therefore equation (1) can be extended as follows:

$$cpi=f\,(ox,fpi) \tag{2}$$

Apart from these main variables, this study also included some common variables that found by previous studies which influenced the inflation rate such as money supply, exchange rate and GDP as a control. The theoretical relationship between money supply and inflation has been well recognized as the more the supply of money increases, the more the inflation increases, unless if the money supply is equaled to the increases in the level of production. The relationship between exchange rate and inflation is positive. Exchange rate depreciated will lead to higher inflation. The relationship between GDP and inflation is positive. Empirical studies show that rapidly rising gross domestic product (GDP) is more inflation (See Bernanke *et al*., 1997; Jiang and Kim, 2013; Ibrahim and Chancharoenchai, 2014; Kofi *et al*., 2015). Next, the model specification of the impacts of oil exports and food production on inflation in African OPEC members can be written as below:

$$lcpi_{it} = \alpha_0 + \beta_1\, lox_{it} + \beta_2\, lfpi_{it} + \beta_3\, lm2_{it} + \beta_4\, lE_{it} + \beta_5\, lGDP_{it} + \mu_{it} \tag{3}$$

Where, $lcpi_{it}$ is the log of consumer price index, $lox_t$ is a log of oil exports, $lfpi_{it}$ is the log of food production index and $lm2_{it}$ is a log of money supply as monetary policy instruments, $lE_{it}$ is a log of exchange rate and $lGDP_{it}$ log of gross domestic product are the control variables. $\alpha = (\alpha_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5)$ is the vector of long-run parameters to be estimated. It is expected that $\beta_1$, $\beta_3$ and $\beta_4$ to be positive while $\beta_2$ and $\beta_5$ to have negative impact on inflation. A decrease in export prices may reduce the nominal value of trade so that inflation rises (Bowdler and Malik, 2017). An increase in food production may reduce inflation pressure in food scarce countries (Kofi *et al*., 2015). Expansionary monetary policy may induce inflation (Valcarcel and Wohar (2013). Depreciation of exchange rate increases inflation (Bala *et al*., 2017). Increase in gross domestic product may reduce inflation (Ibrahim and Chancharoenchai, 2014). The short-run and the long-run dynamics could be, captured through the unrestricted error correction term as ARDL equation:

$$\begin{aligned}\Delta lcpi_{it} = \alpha_0 &+ \sum_{i=0}^{p} b_i\, \Delta lcpi_{it-i} + \sum_{i=0}^{p} c_i\, \Delta lox_{it-i} + \sum_{i=0}^{p} e_i\, \Delta lfpi_{it-i} + \sum_{i=0}^{p} d_i\, \Delta m2_{it-i} \\ &+ \sum_{i=0}^{p} e_i\, \Delta lE_{it-i} + \sum_{i=0}^{p} f_i\, \Delta lGDP_{it-i} + \delta_1 lcpi_{it-1} \\ &+ \delta_2 lox_{it-1} + \delta_3 lfpi_{it-1} + \delta_4 lm2_{it-1} + \delta_5 lE_{it-1} + \delta_6 lGDP_{it-1} \\ &+ \mu_{it}\end{aligned} \tag{4}$$

From the above ARDL cointegration equation (4), the estimation of long-run and short-run-run parameters are treated in separate evaluation as follows: Estimation of the long -run equation:

$$\begin{aligned}lcpi_{it} = \alpha_0 &+ \sum_{i=1}^{p} b_i\, lcpi_{it-i} + \sum_{i=0}^{p} c_i\, lox_{it-i} + \sum_{i=0}^{p} e_i\, lfpi_{it-i} + \sum_{i=0}^{p} d_i\, lm2_{it-i} \\ &+ \sum_{i=0}^{p} e_i\, lE_{it-i} + \sum_{i=0}^{p} f_i\, lGDP_{it-i} + \mu_{it}\end{aligned} \tag{5}$$

Estimation of the short-run equation:

$$\Delta lcpi_{it} = \alpha_0 + \sum_{i=0}^{p} b_i \, \Delta lcpi_{it-i} + \sum_{i=0}^{p} c_i \, \Delta lox_{it-i} + \sum_{i=0}^{p} e_i \, \Delta lfpi_{it-i} + \sum_{i=0}^{p} d_i \, \Delta lm2_{it-i} + \sum_{i=0}^{p} e_i \, \Delta lE_{it-i} + \sum_{i=0}^{p} f_i \, \Delta lGDP_{it-i} + \gamma ECT_{it-1} + \mu_{it} \tag{6}$$

Estimation of the error correction term:

$$ECT_t = lcpi_{it} - \alpha_0 - \sum_{i=1}^{p} b_i \, lcpi_{it-i} - \sum_{i=0}^{p} c_i \, lox_{it-i} - \sum_{i=0}^{p} e_i \, lfpi_{it-i} - \sum_{i=0}^{p} d_i \, lm2_{it-i} - \sum_{i=0}^{p} e_i \, lE_{it-i} - \sum_{i=0}^{p} e_i \, lGDP_{it-i} \tag{7}$$

Equation (7) measures the error correction term which indicated the adjustment speed toward long-run equilibrium. The negative sign of ECT also confirms the existence of cointegration among the variables in the models. The study adopted the methodology developed by Pesaran and Smith (1995) and Pesaran *et al*. (1999) which based on the panel autoregressive distributed lag (ARDL) procedure. The methods have two estimators namely, mean group (MG) and pooled mean group (PMG) which are based on the maximum likelihood procedure. The method carefully measured the dynamic heterogeneity of the adjustment process to the long-run equilibrium (Demetriades and Law, 2006). Specifically, the PMG imposes a restriction on the long-run parameters to be similar across panel members. However, it also allows the short-run parameter (together with the speed of adjustment), intercepts, and error variances to be different across the panel (Kim *et al*., 2010). The Hausman test would conduct to verify the null hypothesis of the homogeneity in the long-run coefficients.

## Data

This study applied balanced panel data which comprises of oil exports for the four countries (OX), consumer price index (CPI), food production index (FPI), money supply (M2), exchange rate (E) and gross domestic product (GDP). The oil exports data used is the specific individual countries' crude oil exports measured in 1,000 barrels/day. The inflation is the annual average consumer price index (CPI 2010 = 100). Money supply is M2 (in USD). Food production is proxy by food production index (2004 - 2006 = 100)[8]. The exchange rate is the average official exchange rate against USD and economic growth is GDP (in constant USD). The data are extracted from World Bank Development Indicators. The countries included in this study are Algeria, Angola, Libya and Nigeria. The sample period in this study is from 1995 to 2014. All the data are converted to natural logarithm[9].

[8] According to WDI, food production index covers food crops that are considered edible and that contain nutrients. Food production index measures the changes in the production of food commodity in a given year relative to base year.
[9] Coefficients on the natural-log scale are directly interpretable as approximate proportional differences.

## Panel Descriptive Statistics and Correlation Matrix

The descriptive statistics for all the variables used in this study are presented in Table 1. The results show the mean, standard deviation, maximum and the minimum value of each variable both overall, between and within. The overall mean of annual CPI of African OPEC members is 74.98 while oil export 31167.76, food production 100.51, money supply 40.79, exchange rate 59.29, gross domestic products 95851. The correlation matrix displays the sign and magnitude of each variable related to the other variable. Table 2 shows that there is a positive relationship between the dependent variable (CPI) and all the independent variables. Among the independent variables, oil export is positively related to food production, money supply, exchange rate and GDP, but negatively related to exchange rate. Food production is positively related to money supply, exchange rate, and GDP. Exchange rate is negatively associated with money supply and GDP. Money supply is positively related to GDP.

Table 2 Descriptive analysis

| Variables | | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| CPI | Overall | 74.9837 | 38.0718 | 0.0006 | 146.0394 |
| | Between | | 19.4111 | 53.4242 | 96.8450 |
| | Within | | 34.1070 | 21.5602 | 167.5989 |
| OX | Overall | 31167.76 | 23933.85 | 3080 | 94642 |
| | Between | | 8234.44 | 25538.95 | 43380.5 |
| | Within | | 22832.67 | -2659.737 | 82429.26 |
| FPI | Overall | 100.5181 | 32.0088 | 46.0700 | 213.3900 |
| | Between | | 7.4388 | 91.6992 | 109.5935 |
| | Within | | 31.3454 | 36.9945 | 204.3146 |
| E | Overall | 59.2915 | 50.3602 | 0.0027 | 158.5526 |
| | Between | | 45.2360 | 0.9945 | 110.3545 |
| | Within | | 31.3369 | -29.1785 | 107.4897 |
| M2 | Overall | 40.7900 | 23.9209 | 13.2307 | 131.7197 |
| | Between | | 19.2011 | 22.1446 | 57.8042 |
| | Within | | 17.0938 | 8.9813 | 114.7056 |
| GDP | Overall | 95851.01 | 110624 | 4670 | 561600 |
| | Between | | 62940.88 | 46625.75 | 178607 |
| | Within | | 96067.12 | -50229.99 | 478844 |

Note: CPI = consumer price index, OX = oil export, FPI = food production index, E = exchange rate, M2 = money supply, GDP = GDP constant. n = 4, T = 20 and N = 80

Table 3 Correlation Matrix

| | CPI | OX | FPI | E | M2 | GDP |
|---|---|---|---|---|---|---|
| CPI | 1.0000 | | | | | |
| OX | 0.6460 | 1.0000 | | | | |
| FPI | 0.7385 | 0.6373 | 1.0000 | | | |
| E | 0.5308 | -0.0658 | 0.2412 | 1.0000 | | |
| M2 | 0.2259 | 0.5859 | 0.3012 | -0.2966 | 1.0000 | |
| GDP | 0.5616 | 0.7935 | 0.3439 | -0.0398 | 0.6625 | 1.0000 |

Note: CPI = consumer price index OX = oil export, FPI = food production index, E = exchange rate, M2 = money supply, GDP = GDP constant. n = 4, T = 20 and N = 80

## RESULTS AND DISCUSSION

In this section, the study discusses the results obtained from the model's specification in the previous section. The procedure in the analysis followed the methodological discussion with the objective of examining the impact of oil export and food production on inflation in African OPEC members. Firstly, preliminary tests were used to study the nature of the data and its structure. Five different panel unit root tests were used to analyze the data, namely; Levin *et al*. (2002), Im *et al*. (2003), Breitung (1999) and Fisher-ADF and Fisher PP. Secondly, this study employed Pedroni residual test which is based on panel cointegration procedure. Then, the PMG and MG estimators were used to estimate the short-run and the long-run coefficients including the error-correction term.

### Panel Unit Root Test

It is recommended that before conducting the panel cointegration test, there is a need to identify the level of stationarity of the variables. This study applied five different methods of unit root test to confirm the level of stationarity of the each variable, namely; Levin *et al*. (2002), Im *et al*. (2003), Breitung (1999) and Fisher-ADF and Fisher PP. The Fisher ADP and Fisher PP are straightforward and nonparametric unit-root test (Maddala and Wu, 1999). The test was conducted in two different modes, initially was carried out with an intercept and then with an intercept and linear trend in all methods except for Breitung test. Table 3 presents the result of panel unit root tests revealed that the null hypothesis of the unit root cannot be rejected at the level form for all variables, Except for exchange rate (E) without trend in LLC and money supply (M2) with trend in LLC. Moreover, all the variables are stationary after first-difference. In a nutshell, the stationarity results from the five different techniques confirm the fact that all the variables are free from the unit root in first difference. The next step is to conduct the panel cointegration test.

Table 4 Panel Unit Root Results

| | CPI | | OX | | FPI | | E | | M2 | | GDP | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levels | No trend | Trend | No trend | Trend | No trend | Trend | No trend | Trend | No trend | Trend | No trend | Trend |
| LLC | 7.11 | -0.29 | -0.87 | -1.44 | 2.84 | 0.25 | -1.74** | -0.89 | -0.38 | -1.90** | 3.16 | -1.41 |
| | (1.00) | (0.38) | (0.19) | (0.07) | (0.99) | (0.60) | (0.04) | (0.19) | (0.35) | (0.02) | (0.99) | (0.07) |
| IPS | 7.17 | 1.84 | 0.62 | -1.11 | 3.23 | -0.61 | -0.29 | -0.31 | -0.52 | -0.08 | 4.32 | 0.51 |
| | (1.00) | (0.96) | (0.73) | (0.13) | (0.99) | (0.27) | (0.38) | (0.37) | (0.29) | (0.46) | (1.00) | (0.69) |
| Breitung | | 0.84 | | -0.62 | | 2.24 | | -1.10 | | 0.89 | | 1.15 |
| | - | (0.96) | - | (0.26) | - | (0.98) | - | (0.13) | - | (0.81) | - | (0.87) |
| Fisher ADF | 0.50 | 4.99 | 4.58 | 11.03 | 2.30 | 10.76 | 6.80 | 9.15 | 9.21 | 8.62 | 3.45 | 5.78 |
| | (0.99) | (0.75) | (0.80) | (0.19) | (0.97) | (0.21) | (0.55) | (0.32) | (0.32) | (0.37) | (0.90) | (0.67) |
| Fisher PP | 0.16 | 3.17 | 3.88 | 10.16 | 2.49 | 13.64 | 7.81 | 2.98 | 6.40 | 8.79 | 3.33 | 5.93 |
| | (1.00) | (0.92) | (0.86) | (0.25) | (0.96) | (0.09) | (0.45) | (0.93) | (0.60) | (0.36) | (0.91) | (0.65) |
| First Difference | | | | | | | | | | | | |
| LLC | -2.41*** | -2.03** | -7.88*** | -4.73*** | 0.20 | 1.05 | -5.28*** | -4.81*** | -5.90*** | -6.11*** | -6.94*** | -7.67*** |
| | (0.00) | (0.02) | (0.00) | (0.00) | (0.58) | (0.85) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| IPS | -1.82** | -1.87** | -7.15*** | -4.52*** | -4.25*** | -5.88*** | -4.17*** | -3.21*** | -4.20*** | -5.29*** | -6.07*** | -6.46*** |
| | (0.03) | (0.03) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Breitung | | -1.37 | | -2.47*** | | -2.63*** | | -4.84*** | | -2.85*** | | -5.89*** |
| | - | (0.08) | - | (0.00) | - | (0.00) | - | (0.00) | - | (0.00) | - | (0.00) |
| Fisher ADF | 16.70** | 15.74** | 54.14*** | 32.94*** | 33.71*** | 41.43*** | 31.11*** | 23.05*** | 32.76*** | 36.79*** | 45.56*** | 45.52*** |
| | (0.03) | (0.04) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Fisher PP | 14.61 | 32.48*** | 63.59*** | 50.06*** | 75.84*** | 63.05*** | 28.61*** | 21.74** | 56.21*** | 48.22*** | 49.80*** | 63.41*** |
| | (0.06) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.02) | (0.00) | (0.00) | (0.00) | (0.00) |

Notes: Figures in parentheses are probability values. ** and *** denote rejection of the null of non-stationary at the 5 and 1 percent levels of significance. The maximum numbers of lags length are selected based on Akaike information criterion (AIC). The null hypothesis is the series contains a unit root.

## Panel Cointegration Results

This study used panel cointegration tests proposed by Pedroni (1999). The panel cointegration test has a heterogeneous feature which allows for interdependence in cross-section with different individual effects. The Pedroni test provides seven different sets of residual based tests and these tests are divided into two groups. Four out of seven are within dimension test namely: panel v-statistic, panel rho-statistic, panel PP-statistic and panel ADP-statistic while the remaining three are between-dimension tests namely: group rho-statistic, group PP-statistic, and group ADF-statistic. The within dimension regression are based on the pooling estimators in the autoregressive coefficient across individual countries on the residuals while the between dimension are based on averaging the coefficients estimators of each country. The panel cointegration results are estimated in four different model specifications. Table 4 presents the results for all the models. Model 1 is the basic model, then, the variables were added into the basic model one by one at a time. Model 4 is our main model. The remaining estimated models are for robustness check. For each model, the first columns are estimated without trend while in the second columns are including the trend accordantly. The cointegration results reveal that three to four out of seven null hypotheses of no cointegration have been rejected at the 1 percent and 5 percent level of significance. Therefore, the models are cointegrated in both within dimension and between dimension.

Table 5 Panel Cointegration Results

| Models | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | *CPI = f(OX,M2)* | | *CPI = f(OX,M2,E)* | | *CPI = f(OX,M2,E,FPI)* | | *CPI = f(OX,M2,E,FPI,GDP)* | |
| | w/o trend | with trend | w/o trend | with trend | w/o trend | with trend | w/o trend | with trend |
| Panel v-statistic | 0.703 | 8.291*** | 1.640* | 1.640* | 0.997 | 3.025*** | 0.660 | 2.286** |
| | (0.24) | (0.00) | (0.05) | (0.05) | (0.15) | (0.00) | (0.25) | (0.01) |
| Panel rho-statistic | -0.304 | 0.563 | 0.729 | 0.729 | 0.740 | 1.614 | 1.399 | 2.367 |
| | (0.38) | (0.71) | (0.76) | (0.76) | (0.77) | (0.94) | (0.91) | (0.99) |
| Panel PP-statistic | -1.706** | -0.495 | -1.550* | -1.550* | -1.150 | -0.970 | -2.877*** | -0.957 |
| | (0.04) | (0.31) | (0.06) | (0.06) | (0.12) | (0.16) | (0.00) | (0.16) |
| Panel ADF-statistic | -1.690** | -2.805*** | -3.350*** | -3.350*** | -1.436* | -3.889*** | -3.986*** | -3.618*** |
| | (0.04) | (0.00) | (0.00) | (0.00) | (0.07) | (0.00) | (0.00) | (0.00) |
| Group rho-statistic | 0.635 | 0.252 | 1.740 | 1.740 | 1.866 | 1.357 | 2.056 | 2.202 |
| | (0.73) | (0. 9) | (0.95) | (0.95) | (0.96) | (0.91) | (0.98) | (0.98) |
| Group PP-statistic | -1.082 | -3.626*** | -1.657** | -1.657** | -0.065 | -2.648*** | -2.629*** | -2.385*** |
| | (0.13) | (0.00) | (0.04) | (0.04) | (0.47) | (0.00) | (0.00) | (0.00) |
| Group ADF-statistic | -1.313* | -4.895*** | -3.489*** | -3.489*** | -0.249 | -2.791*** | -3.808*** | -3.050*** |
| | (0.09) | (0.00) | (0.00) | (0.00) | (0.40) | (0.00) | (0.00) | (0.00) |

Notes: Figures in parentheses are the probabilities values. *, ** and *** denote the level of significance at 10, 5 and 1 percent, respectively. Number of countries (N) = 4 and periods (T) = 20. The maximum lags are automatically selected by Akaike information criterion (AIC)

## PMG and MG Estimators Results

Table 5 presents the long run PMG and MG estimated results on oil export, food production, and inflation. The probability value for Hausman Test is more than 5 percent which indicates that we fail to reject the null hypothesis of homogeneity in the long-run coefficients. Therefore, Hausman test recommends that the PMG estimator is a better estimator over the MG estimator[10]. From the four estimated models, this study observed that oil exports positively impact inflation while food production negatively influences inflation. Our main model (PMG Model 4) shows that 1 percent increase in oil export is related to 0.19 percent increase in inflation. While 1 percent increase in food production is related to 0.88 percent reduction in inflation. The results are in line with the theoretical expectation. As for the control variables, money supply, exchange rate, and GDP have a positive impact on inflation. Increase in money supply and GDP increase inflation while exchange rate depreciation increases inflation. This relation is in line with the situation witnessed in African OPEC members. The findings are remarkably similar compared to the previous studies conducted on this issue (see Valcarcel and Wohar 2013; Ibrahim and Chancharoenchai 2014; Kofi *et al*. 2015; Bowdler and Malik, 2017; Bala *et al*. 2017). Moreover, in all the four models, the error-correction terms are negative and significant, suggesting the speeds of adjustment towards the long-run equilibrium.

Table 6 PMG and MG Results

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Long-run | PMG | MG | PMG | MG | PMG | MG | PMG | MG |
| LOX | 0.31*** | -0.33 | 0.13*** | 0.38*** | 0.83*** | 0.29 | 0.19*** | -0.64 |
| | (2.69) | (-0.27) | (3.94) | (2.78) | (5.10) | (1.35) | (2.97) | (-1.41) |
| LM2 | 0.41*** | 0.50 | 0.42*** | 0.29 | 0.71*** | 0.44*** | 0.15*** | 0.06 |
| | (4.02) | (0.39) | (8.27) | (1.34) | (3.46) | (3.08) | (2.83) | (0.88) |
| LE | - | - | -0.06 | -0.21 | 0.31*** | 0.23 | 0.20*** | 0.89** |
| | | | (-1.21) | (-0.38) | (2.88) | (0.83) | (7.32) | (2.05) |
| LFPI | - | - | - | - | -2.38*** | -0.27 | -0.88*** | -0.29 |
| | | | | | (-2.71) | (-0.28) | (-3.79) | (-1.15) |
| LGDP | - | - | - | - | - | - | 0.42*** | 1.26*** |
| | | | | | | | (12.04) | (2.15) |
| Error | -0.12** | -0.05* | -0.17** | -0.34*** | -0.10** | 0.26 | -0.20* | -0.05 |
| Correction | (-2.04) | (-1.71) | (-2.23) | (-2.61) | (-2.18) | (1.03) | (1.93) | (-0.17) |
| Short-run | | | | | | | | |
| LOX | 0.01 | -0.001 | -0.003 | 0.01 | 0.05 | -0.003 | 0.20 | -0.04 |
| | (0.80) | (-0.04) | (-0.11) | (0.67) | (0.84) | (-0.21) | (0.87) | (-0.82) |
| LM2 | -0.03 | -0.08 | -0.07 | -0.07 | -0.07 | 0.02 | -0.05 | -0.05* |
| | (-0.53) | (-0.70) | (-0.73) | (-0.60) | (-1.49) | (0.64) | (-1.87) | (-1.68) |
| LE | - | - | 0.16 | 0.16 | -0.04 | 0.02 | -0.08 | 0.03 |
| | | | (0.96) | (0.84) | (-1.10) | (0.45) | (-0.79) | (0.26) |

[10] The PMG imposes a restriction on the long-run parameters to be similar across panel members.

Table 6 (Cont.)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LFPI | - | - | - | - | -0.07 | -0.02 | -0.09* | -0.03** |
| | | | | | (-1.57) | (-0.71) | (-1.81) | (-2.33) |
| LGDP | - | - | - | - | - | - | -0.21 | 0.08 |
| | | | | | | | (-0.72) | (1.18) |
| Cons | 0.06 | 0.34 | 0.35*** | -0.71 | 4.11** | 1.79 | 0.10 | 0.96 |
| | (1.52) | (1.06) | (3.98) | (-0.69) | (2.31) | (1.35) | (1.12) | (0.70) |
| Hausman | - | (0.25) | - | (0.96) | - | (0.55) | - | (1.0) |
| (N x T) | 320 | 320 | 320 | 320 | 320 | 320 | 320 | 320 |

Notes: Figures in parentheses are t-statistics values while for the Hausman are p-values *, ** and *** denote the level of significance at 10, 5 and 1 percent, respectively

## CONCLUSIONS

The aim of this study is to examine the impacts of oil exports and food production on inflation in African OPEC members. The study used annual panel data ranging from 1995 to 2014 on four African OPEC members namely, Algeria, Angola, Libya and Nigeria. Moreover, the study applied Pedroni cointegration test to investigate if there is a long-run relationship between the variables in the models. The dynamic panel ARDL (PMG and MG) estimators were used to examine of the short-run and the long-run impact of oil exports on inflation. This study found that the long-run coefficient of oil exports, money supply, exchange rate and GDP are positively affecting the inflation while food production is negatively affecting inflation. This study concludes that increases in oil exports would lead to increase in inflation rate. Therefore, the policy makers need to aware that the strategy to boost the economy by increasing oil exports will lead to inflation. If the policymakers would like to maintain the targeted inflation, the increment in oil exports should keep at a minimum. Besides that, this study concluded that an increase in domestic food production reduces the rate of inflation in African OPEC member countries. The government should encourage domestic food production both in quantity and quality to reduce inflation. The study also concludes that increase in money supply and depreciation of exchange rate cause inflation rate. Hence, the policy makers can use the contractionary monetary policy as well as currency control to reduce the inflation rate. The economy can grow with low and stable inflation if the supply-side factors stimulate output independent of aggregate demand through increases in labor productivity or through capital goods and technological advances.

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