Research article

Global oil price and food prices in food importing and oil exporting developing countries: A panel ARDL analysis

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ABSTRACT

In this study, we attempt to look into the cointegration and causal link of oil and food prices in the sample countries that are both food importing and oil exporting economies. Yearly data sets of 21 countries were used and the paper covers a time period of 2001–2015. The stationarity property of I(0) and I(I) of the variables informed the use of panel ARDL model. The short period analysis shows negative effects between food prices and oil price while positive effects exist in the long period. The causality result of the sample country shows that causality runs from food prices to oil price. The result implies that appropriate agricultural policies that promote favourable food prices and alternative energy options should be pursued in the countries to ensure sustained food and oil supply.

1. Introduction

Over the years, global interest has been over oil price fluctuations and upward food prices. The literature reveals that rapid movements in oil and food prices are affecting negatively the world economy (Heady and Fan, 2008; Galesi and Lombardi, 2009; Hakro and Omezzine, 2010; Alom, 2011; Jongwanich and Park, 2011). So, in late development, especially in recent times, the prices of food crop have been on the high side. The prices of food crops such as rice, wheat, as well as cassava have been increasingly high. Many scholars attributed the increase in food prices to increase in the oil price as an input to food production (Obadi, 2014). The increase in the prices of food has placed huge pressure on oil producing countries that are net importer of food, especially the developing oil exporting countries. For instance, a country like Egypt, which is the world’s largest wheat importer, imports average of 11 million tons of wheat per annum (Food and Agriculture Organization (FAOSTAT), 2016). This is followed by Yemen, which imports almost 2 million metric tons of wheat per annum (World Bank, 2013). Nigeria, on the other hand, as the largest world importer of Thai rice spends $700 million per year on rice importation (United States Department of Agriculture (USDA), 2015).

These sample countries are more vulnerable to higher food prices because their food importation is majorly being financed from unpredictable oil revenue that is influenced by unexpected movement in the global oil price. The neglect and decline in agricultural activities over time by many of the oil exporting developing countries despite abundance of arable land and favourable climate is another major reason of vulnerability. This study on the connection between food prices and oil prices is important for two reasons. First, the increase in production of biofuel resulting from higher oil price incentive can reduce the available food supply and make its price higher as well. Secondly, the growth in biofuel generation is because it is cleaner, it is a non-carbon emission and it acts as a signal of commitment for most oil countries to the Kyoto Protocol of combating global warming (United Nations Frame work Convention on Climate Change (UNFCC), 2016). More so, biofuel production involves the conversion of food crops such as cassava, sugarcane, sweet sorghum, corn and other related food crops into fuel for energy generation. In addition, many oil producing countries are gradually diversifying their energy mix. Nigeria, for instance, has developed 20 biofuel projects. Out of which, 10 bio refineries used cassava, 8 used sugar cane and the other 2 used sorghum (Ohimain, 2015). Mitchell (2008) has initially submitted that adequate food supply is being hindered due to the high demand and growth of biofuel production with adverse consequence of reduction in global crop supplies and higher food prices. In the same way, world bio-fuel production has largely been on the increase. It is reported that bioethanol and biodiesel contribute around 13% to global transport fuel demand (International Energy Agency, (IEA)
In addition, with increase in the prices of food and continuous fall in the price of oil, food import bills have risen for most oil exporting countries. Also, it has been observed over time that there exists line of causation between food and crude oil price (Baffes, 2007). For example, the food hike crisis in 2007 and 2008 had resulted alongside with high oil prices, such that, when oil price fell from $1US147 per barrel in 2008 to $US28, food price fell with it (Kilian, 2008). Therefore, issues such as oil price fluctuations, food hike prices and a possible correlation of energy sectors with the agricultural sector have attracted interest of researchers (Mitchell, 2008).

However, what transcends in the recent oil price fluctuation is a concern because the price of food has been on the increase despite fall in oil price (see Figure 1). Again, for instance, the price of oil fell from close to $US100 per barrel in 2011 to $US47 per barrel by 2015 (Organization of the Petroleum Exporting Countries (OPEC) Annual Statistical Bulletin, 2017), while food price index was around $US250 in 2015 (FAOSTAT, 2016). Moreover, this study is also pertinent due to the fact that the sample countries used in this study are mostly impacted on by upward food prices because they are net food importers considering their food trade balance (FAOSTAT, 2016). They are both food importing and oil exporting developing countries. Past studies in these area are country specific or on both developed and developing countries such as Kratschell and Schmidt (2012) for the United States (US), Rosa and Vascaevco (2012) for Italy and the US, Udoh and Egywaikhide (2012) for Nigeria, Avalos (2014) for developed countries, Ibrahim (2015) for Malaysia, and Olayungbo and Hassan (2016) for developing countries but were not all food importing countries. On the other hand, the present study deviates from the past studies by selecting countries that rely on revenue from oil exportation to obtain their food importation; therefore, the recent fall in oil price in the global market below $US50 per barrel and its fluctuation would have implications for food supply in these countries. The average trends of food prices and oil price presented in Figure 1 show that both variables are moving together prior to year 2014 after which there was a divergence due to a fall in oil price and a rise in food prices in the sample countries, hence the need to test for the effects of global oil price on food prices and their dynamic relationships in the selected countries. Our findings show the existence of a long run relationship and that causality comes from food prices to oil price in the sample countries. The outcome of our analysis provides insights and policy implications which serve as a guide for energy and agricultural policies of these countries. The order of the paper is as follows. Section two deals with the review of literature. Section 3 provides the data sources and the descriptive analysis. Section 4 discusses the methodology adopted while section 5 provides the empirical results. The last section concludes and then gives the policy implications.

2. Literature review

The previous study from United States (US) by Harri et al. (2009) determined the connectedness among oil, exchange rates and commodity prices using Vector Error Correction (VEC) Model on monthly data from 2000 to 2008. The study established linkages from price of corn, soybean and cotton to oil price. In contrasting evidence, Cha and Bae (2011) studied the effects of oil price on food prices in the US and employed a VAR model on quarterly data from 1986 to 2008. The results showed that oil price had remarkable effect on prices of food in the long term but not in the short term. A similar study conducted by Trujillo-Barrera et al. (2012) studied the volatility consequence in the US with respect to price of oil and agricultural commodities. The study discovered strong spillover effects from the price of oil to the agricultural products. Avalos and Lombardi (2015) investigated the response of food prices to oil price by adopting VECM on monthly data from January 1986 to April 2012 for the US. The study found corn price to respond intensely to world demand shocks that other commodities employed. From the review of existing studies in the US, mixed results were found with different methodologies adopted by the authors, which suggest the need for more evidence -based works for the US economy.

Reviewing along methodology adopted, Arshad and Hameed (2009) examined the long-run relationship between oil and food prices with monthly data from January 1980 to March 2008, the results established evidence of long-run equilibrium relationship between oil and food prices. Also, modeling the connection between the oil price and the global food prices, Chen et al. (2010) used data on weekly basis from March 1983 to February 2010. The study employed the ARDL method, and the work revealed that the increment in the food price is significantly influenced by the increment in the crude oil price. Using data on food prices for 24 food commodities, global oil prices and US exchange rates, Nazlioglu and Soytas (2011a) employed panel co-integration and panel causality to investigate oil and food prices relationship. The period of the study was from January 1980 to February 2010. The result confirmed world price impact on the agricultural product prices. Furthermore, Peri and Baldi (2010) attempted a cointegration analysis applying Hansen and Seo (2002) for selected European countries from January 2005 to November 2007 on weekly bases. The study discovered threshold cointegration relation of rapeseed and diesel prices. Although, the study by Peri and Baldi (2010) adopted a panel threshold of Hansen and Seo

![Figure 1. Average trend of food and oil prices in selected developing economies.](image-url)
yet the precious threshold value between rapeseed and diesel price was not determined in the paper.

In a similar year, Esmæeli and Shokoohi (2010) investigated the connection among prices of food and the macroeconomic variables with monthly data from 1961 to 2005. The concluded that food production index has the highest impact on the macroeconomic index, and that there is no direct relationship between the oil price and the food price component. However, in a separate study, Nazlioglu and Soytas (2011a) employed Toda Yamamoto causality test on weekly data for world food and oil prices from January 1994 to March 2010. The result showed evidence of a response of the selected food prices to oil price variations. In addition, McPhail et al. (2012) used SVAR model with data on monthly basis from January 2000 to July 2011. The study discovered oil price is a major variable that explained changes in food prices in the sample country. In a similar vein, Roboredo (2012) used copula model parameters on weekly data between 9th January 1998 and 15th April 2011 to study the connections between world oil and food prices. The results showed no significant connection and non-significant association between the crude oil and agricultural markets. The absence of significant relationship between food and oil price in this study could be as a result of the excessive allowance of non-linearity, asymmetric cross-sectional and serial dependence in copula models (Smith 2013).

Reviewing along food types’ evidence, Campiche et al. (2007) examined the connection between oil and food prices using weekly data from 2003 to 2007 for US. The results showed co-integration for corn and soybean prices with oil price during 2006–2007 time frame but not for 2003 to 2005 periods. The study concluded that soybean prices are more correlated through the biodiesel market to oil prices than corn prices. Furthermore, Zhang and Reed (2008) used data on monthly bases on the global oil, China’s corn, soya meal, and pork prices from the period of January 2000 to October 2007. The study found oil price as the significant variable impacting food prices in China. Zhang et al. (2009) found no connection between oil and food prices in the short-run; however, causality was found to run from crops to oil and for ethanol from crops in the long-run. The paper found causality from only world three food crops such as corn, cotton, and soybeans, and not from wheat to world oil price. Corroborating this evidence, Nazlioglu and Soytas (2011b) conducted a similar investigation for Turkey, using monthly data on world crude oil prices, Turkish lira and US dollar exchange rate, and Turkish wheat, maize, cotton, soybeans and sunflower prices. The study reported a causal connection between oil and food prices. Alghalith (2010) examined the correlation between food and oil price for Trinidad and Tobago for the period of 1974–2007. The results showed that there is a strong correlation between oil price increment and food price increment. Furthermore, the spillover effects from the global oil prices to food prices for certain Asia and pacific countries was investigated by Alom et al. (2011) along with countries such as Australia, Hong Kong, India, New Zealand, South Korea, Singapore, Taiwan and Thailand. The results indicated that positive correlation is present between food and the global oil price volatility.

Concerning studies in Nigeria, Udoh and Egwaikhide (2012) employing data for the period of 1970–2008, the empirical results showed causal connection between oil price distortions and domestic food price. In a related study, Binomote and Odeny (2013) investigated the effect of crude oil price on food productivity in Nigeria. The study spanned between 1981 and 2010 and employed co-integration and error correction models in the analysis. The study suggested that, in the short run, oil price is the most determining factor to food productivity while exchange rate, capital, and labour are the significant factor of food productivity in the long-run.

Furthermore, while Baffes (2007), Harri et al. (2009), Chen et al. (2010), and most recently, with regards to short and long run effects, Baffes and Dennis (2013) all provided evidence of outstanding contribution of oil price to food prices, such studies as Zhang et al. (2010), Lambert and Miljkovic (2010), and Nazlioglu and Soytas (2011a) suggested the neutrality or, at most showed small contribution of food prices to oil price variation. This is supported by the finding by Roboredo (2012) that the food price increase is not caused by variation in oil price.

As analyzed earlier in the aspect of Granger causality, most empirical findings on direction between oil and food prices have indicated unidirectional causality with the impact coming from oil price to food prices. However, an exceptions to the findings are the empirical evidence by Natanelov et al. (2011), Serra et al. (2011) that causality is certain to flow from food commodities to crude oil. From the literature review, it is clear that the results of past empirical studies on the relationships between oil and food prices have been rather mixed. Most recent papers such as Serletis and Xu (2019) found spillover effects from crude oil to world biofuel market and the result of Pal and Mitra (2020) also showed return spillover to world ethanol. On the contrary, study by Moknik and Youseff (2019) found strong persistence by global food price crisis than oil price crisis. In the same vein, Kang et al. (2019) confirmed world vegetable oil index as the significance connection to oil price. However, these previous studies have failed to pay attention to the dynamic linkages between price of oil and food in oil-exporting developing countries, which are not only oil-dependent, but also net food-importing countries. This present study, therefore, fills this gap.

3. Data sources

This paper uses 21 oil exporting developing countries (see Table 9 in Appendix). These countries are equally classified as food deficit countries (FDC) according to (FAOSTAT, 2016) i.e. these countries are net food importers over the study period of 2000 till 2015. Food import is greater than food export in these sample countries. The study is for a period of 16 years, starting from 2001 to 2015. The selection of the starting and ending dates respectively was as a result of the availability of data on food import for all the selected countries. Interestingly, this period was a time of large fluctuations in the price of oil and also captures the 2008 food crisis and the recent fall in global oil price below US$50 per barrel. Food prices are proxy by food price index, which is a measure of a change in global prices of a basket of food commodities. It consists of the average of five commodity group price indices comprises of the cereal price index, palm oil price index, meat price index, sugar price index and diary price index. Cereals price index is calculated from maize, corn, rice (paddy), wheat, oats, barley and sorghum. Oil price index is from palm oil, sunflower oil, soybean oil, cotton seed oil, olive oil, peanut oil, sesame seed oil and coconut oil. Meat price index is derived from the categories of beef, lamb, goat, calf, camel, pork and poultry. Lastly, dairy price index is derived from milk, butter and cheese. Oil price is the price at which the crude oil is sold in the global market in US dollars at Brent oil market. In addition, food import used in the analysis is measured as a percentage of merchandised imports of the sample countries valued in US dollars. Lastly, the GDP per capita employed in the analysis is defined as the nominal GDP measured in US dollar divided by the population of each sample country. Both the food imports and the GDP per capita are sourced from World Bank Development Indicators (2017). The food prices are sourced from Food and Agriculture Organization Statistics (FAOSTAT, 2017) the database of the FAO of the United Nations while the oil price is sourced from US Energy Information Administration (IEA, 2017). Lastly, the summary of the variable description is presented at Appendix in Table 10.

3.1. Descriptive analysis

The descriptive statistics, as presented in Table 1, shows the distribution and variability of the data for food import, food prices, GDP per capita and oil price employed in this analysis. It can be observed that the median and the mean variables are almost close, which suggest low variability and symmetry. The average value of food import, food prices and oil price are US$13.81, US$179.26 and US$65.85, while the average GDP per capita for the sample countries is US$16170.41. It can be observed that the average food price is higher than the average oil price.
over the study period. This implies adverse effects of unfavourable pricing for the sample countries being both oil exporting and food importing countries during the study period. Lastly, the Jarque-Bera probability value lesser than 0.01 percent implies that the null hypothesis of normal distribution is rejected.

3.2. Panel unit root tests

In this section, the time properties of the variable used in this study are tested with panel unit root tests such as the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981; Phillip Perron (PP) (Perron, 1988), Levin et al. (2002) (LLC) and Im et al. (2003) (IPS). The decision rule is that if the absolute p-value of the LLC test, IPS test, ADF test or that of the PP test is less than 5 percent critical value, then it is adjudged that the tested variable is stationary or does not have unit roots. If, on the other hand, the absolute p-value of the LLC test, IPS test, ADF test or that of the PP test is greater than 5 percent critical value, then it is adjudged that the tested variable is non-stationary or has unit roots. As shown in Table 2, food import, gdp per capita and oil price are all stationary at levels at 1 percent significance level, except for food prices which is stationary at 5 percent significance level. If cointegration is established then Eq. (2) can be written in an panel error correction model (PECM) as:

$$
\Delta f_{p_i} = \alpha + \beta_1 f_{p_{i-1}} + \beta_2 f_{i-1} + \beta_3 f_{g_{dpc_{i-1}}} + \beta_4 o_{ilp_{i-1}} + \sum_{i=1}^{S} \sigma_i \Delta f_{p_{i-1}} \\
+ \sum_{i=1}^{S} \delta_i \Delta f_{i-1} + \sum_{i=1}^{S} \gamma_i \Delta g_{dpc_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta o_{ilp_{i-1}} + \epsilon_i
$$

Where $fp$ is food prices, $fi$ is food import, $gdp$ is gdp per capita, which captures aggregate demand and lastly, $oilp$ is the global oil price for the sample countries, which is assumed to be exogenous to the sample countries. The long run coefficients are $\beta_1$, $\beta_2$, $\beta_3$ and $\beta_4$ while the short run coefficients are $\alpha$, $\beta_1$, $\beta_2$ and $\epsilon_i$. If cointegration is established then Eq. (2) can be written in an panel error correction model (PECM) as:

$$
\Delta f_{p_i} = \alpha + \sum_{i=1}^{S} \sigma_i \Delta f_{p_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta f_{i-1} + \sum_{i=1}^{S} \gamma_i \Delta g_{dpc_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta o_{ilp_{i-1}} + \epsilon_i
$$

Where $\epsilon_i$ is the error correction part and $\theta$ is the speed of adjustment from the short run dynamics to the long run equilibrium. The ecm coefficient, $\theta$, is expected to be negative and significant for long run equilibrium to exist between food price and the explanatory variables.

4. Methods

Given that the variables of interest are combination of I(0) and I(1) process, then we resort to panel autoregressive distributed lag (ARDL) model proposed by Pesaran et al. (1999). The benefit and the superiority of the panel ARDL model is that, it can be applied regardless of whether the selected variables in the model are purely I(0) or purely I(1) or partly integrated. The import function can be simply stated as:

$$
fp = \alpha + \beta f_i + \chi g_{dpc} + \phi o_{ilp} + \epsilon_i
$$

Eq. (1) describes food price ($fp$) to depend on food import ($fi$), gross domestic product per capita($gdp$), and the global oil price ($oilp$) at time

Table 1. Descriptive statistics.

| Variable | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | Jarque Bera | Kurtosis | Skewness | Maximum | Prob. | Prob. | Prob. | Prob. |
|----------|------|--------|---------|---------|-----------|----------|----------|-------------|----------|----------|---------|-------|-------|-------|-------|
| food import | 13.82 | 14.08 | 46.93 | 2.49E-05 | 6.74 | 0.73 | 5.14 | 84.82 | 5.14 | 2.98 | 14.83 | 0.00 | 0.00 | 0.00 | 4172.23 |
| food prices | 179.25 | 138.75 | 948.3 | 96.2 | 112.61 | 2.98 | 14.83 | 2209.37 | 1074.62 | 2.74 | 10.44 | 0.00 | 0.00 | 0.00 | 5414 |
| GDP per capita | 16170.41 | 5487.84 | 142714.3 | 350.26 | 26267.41 | 2.74 | 10.44 | 1074.62 | 24.66 | -0.18 | 1.65 | 0.00 | 0.00 | 0.00 | 4883 |
| oil price | 65.85 | 66.05 | 99.67 | 25.98 | 25.95 | -0.18 | 1.65 | 24.66 | 2027 |

Note: ***, **, * represent 1%, 5% and 10% level of significance respectively; p-v indicates probability value.

Table 2. Result of the panel unit root.

| Variable | Level | LLC | IPS | ADF | PP |
|----------|-------|-----|-----|-----|-----|
| food imports | 0 | -6.01*** | 3.83*** | 76.51*** | 90.56*** |
| food prices | 0 | -1.65 | 0.02 | 34.85 | 39.1 |
| GDP per capita | 1 | -1.99*** | -1.90** | 25.04** | 18.3** |
| oil price | 0 | -6.24*** | 3.14*** | 65.79*** | 47.57*** |

Note: ***, **, * represent 1%, 5% and 10% level of significance respectively; p-v indicates probability value.

Before the panel error cointegration model (PECM) is estimated, it is necessary to first establish the presence of cointegration among the variable of interest. As a result, the panel Engle and Granger based cointegration test proposed by Pedroni (2004) and Johansen (1995) Fisher panel cointegration test were conducted. The assumption of a possible long run relationship between oil price and food prices emanates from the direct relationships between food prices and oil price. It is a known fact that oil can be produced from food crops through biofuel process. In the same vein, oil price can also act as an input cost to food production processes. In the cointegration analysis, both the Pedroni

4.1. Panel cointegration tests

In this section, the time properties of the variable used in this study are tested with panel unit root tests such as the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981; Phillip Perron (PP) (Perron, 1988), Levin et al. (2002) (LLC) and Im et al. (2003) (IPS). The decision rule is that if the absolute p-value of the LLC test, IPS test, ADF test or that of the PP test is less than 5 percent critical value, then it is adjudged that the tested variable is stationary or does not have unit roots. If, on the other hand, the absolute p-value of the LLC test, IPS test, ADF test or that of the PP test is greater than 5 percent critical value, then it is adjudged that the tested variable is non-stationary or has unit roots. As shown in Table 2, food import, gdp per capita and oil price are all stationary at levels at 1 percent significance level, except for food prices which is stationary at 5 percent significance level. If cointegration is established then Eq. (2) can be written in an panel error correction model (PECM) as:

$$
\Delta f_{p_i} = \alpha + \sum_{i=1}^{S} \sigma_i \Delta f_{p_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta f_{i-1} + \sum_{i=1}^{S} \gamma_i \Delta g_{dpc_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta o_{ilp_{i-1}} + \epsilon_i
$$

Where $fp$ is food prices, $fi$ is food import, $gdp$ is gdp per capita, which captures aggregate demand and lastly, $oilp$ is the global oil price for the sample countries, which is assumed to be exogenous to the sample countries. The long run coefficients are $\beta_1$, $\beta_2$, $\beta_3$ and $\beta_4$ while the short run coefficients are $\alpha$, $\beta_1$, $\beta_2$ and $\epsilon_i$. If cointegration is established then Eq. (2) can be written in an panel error correction model (PECM) as:

$$
\Delta f_{p_i} = \alpha + \sum_{i=1}^{S} \sigma_i \Delta f_{p_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta f_{i-1} + \sum_{i=1}^{S} \gamma_i \Delta g_{dpc_{i-1}} + \sum_{i=1}^{S} \delta_i \Delta o_{ilp_{i-1}} + \epsilon_i
$$

Where $\epsilon_i$ is the error correction part and $\theta$ is the speed of adjustment from the short run dynamics to the long run equilibrium. The ecm coefficient, $\theta$, is expected to be negative and significant for long run equilibrium to exist between food price and the explanatory variables.
At 1 percent statistical significance level. On the other hand, significant effects on the dependent variable than more recent lags. Also, from econometric point of view, lower lags are more parsimonious because higher lags usually result to loss of degree of freedom, information and over parameterization of the ARDL models. The ARDL long run result in Table 5 shows that both food import and oil price are found to have significant relationship with food prices while GDP per capita has insignificant relationship with food prices. The result suggests that 1 percent increment in food import leads to 0.47 percent decrease in food prices at 1 percent significance level. On the other hand, 1 percent increase in gdpcit leads to 0.12 percent increase in food prices insignificantly. Lastly, 1 percent increment in oil price leads to 0.79 percent increase in food prices at 1 percent significance level. The positive outcome between oil and food price confirmed the positive correlation the two variables experienced in the food crises periods of 2007–2008 and 2010 to 2011 (Ibrahim, 2015). This outcome can be traced to the input cost of oil price on food production. The positive relationship also corroborates the establishment of the presence of long run equilibrium relationship between oil and food prices. Recent previous studies that support this assertion of high impact of oil price on food prices are Harri et al. (2009) for US, Cha and Bae (2011) for US, Baffes and Dennis (2013) for global estimates and Ibrahim (2015) for Malaysia among others. All the past studies found oil price to have direct impact on palm oil, wheat, rice, soya beans and maize.

Concerning the short run result in Table 6, we found gdpcit and food import not having significant relationships with food price. We

### Table 3. Pedroni Residual cointegration test results.

|                          | t-statistics | Prob. |
|--------------------------|--------------|-------|
| within group             |              |       |
| panel v-statistics       | -1.57        | 0.94  |
| panel rho-statistics     | -2.02        | 0.97  |
| panel pp-statistics      | -3.93***     | 0.00  |
| panel ADP- statistics    | -4.37***     | 0.00  |
| between group            |              |       |
| panel rho-statistics     | -3.72        | 0.99  |
| panel pp-statistics      | -4.62***     | 0.00  |
| panel ADP- statistics    | -4.67***     | 0.00  |

*** indicates that the estimated parameters reject the null hypothesis of no cointegration at 1%.

4.3. Results and discussions

The Pedroni (2004) panel cointegration test that is capable of revealing cointegration analysis of the 21 sampled countries in within and between groups. The groups are in two parts. The first four test statistics are calculated by the within group of the panel statistics while the second part is calculated between group. The result in Table 3 with one lag optimal length as presented in Table 8 shows that null hypothesis of no cointegration is rejected as indicated by the panel pp-statistics and panel ADF-statistics at 1 percent statistical significance level for both the within and between group respectively. This suggests the presence of cointegration between the dependent variable (food prices) and the explanatory variables such as food imports, GDP per capita and oil price of the 21 sample countries.

In order to probe further into the cointegration analysis among food prices, food import, gdpcit and oil price, we employ the Johansen (1995) Fisher panel cointegration. The Johansen (1995) panel cointegration test uses the trace test and the maximum eigen test to show the possible rejection or acceptance of the null hypothesis of no cointegration. The result of the presence of cointegration in Table 4, using Fisher cointegration test corroborates that of the Pedroni (2004) cointegration result. As presented in Table 4, the values of the trace test statistics are higher than the maximum eigen values. This also suggests the rejection of the null hypothesis of no cointegration at 1 percent significance level. We therefore conclude that there is cointegration among food prices, food imports, GDP per capita and oil price in the 21 sample countries.

Given the presence of cointegration, we present both the long and the short run results of the panel ARDL (1,1,1,1) in Tables 3 and 4 respectively with optimal lag length of one using the Akaike information criterion (See Table 9 and Figure 4 at Appendix). The ARDL (1,1,1,1) is the accepted and optimal distributed lags at the estimation level. Estimation could not be done with any other chosen lags. This parsimonious model confirms the conclusion of Koyk (1958), a scholar in ARDL, that more recent lags exert significant effects on the dependent variable than more remote lags. Also, from econometric point of view, lower lags are more parsimonious because higher lags usually result to loss of degree of freedom, information and over parameterization of the ARDL models. The ARDL long run result in Table 5 shows that both food import and oil price are found to have significant relationship with food prices while GDP per capita has insignificant relationship with food prices. The result suggests that 1 percent increment in food import leads to 0.47 percent decrease in food prices at 1 percent significance level. On the other hand, 1 percent increase in gdpcit leads to 0.12 percent increase in food prices insignificantly. Lastly, 1 percent increment in oil price leads to 0.79 percent increase in food prices at 1 percent significance level. The positive outcome between oil and food price confirmed the positive correlation the two variables experienced in the food crises periods of 2007–2008 and 2010 to 2011 (Ibrahim, 2015). This outcome can be traced to the input cost of oil price on food production. The positive relationship also corroborates the establishment of the presence of long run equilibrium relationship between oil and food prices. Recent previous studies that support this assertion of high impact of oil price on food prices are Harri et al. (2009) for US, Cha and Bae (2011) for US, Baffes and Dennis (2013) for global estimates and Ibrahim (2015) for Malaysia among others. All the past studies found oil price to have direct impact on palm oil, wheat, rice, soya beans and maize.

Concerning the short run result in Table 6, we found gdpcit and food import not having significant relationships with food price. We

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1 It should be noted that conducting the cross sectional dependence (CD) of Pesaran (2004) is not necessary in this study. The essence of the CD in panel data analysis is to account for a common structure among observation in the sample. This is not relevant in this study and does not affect the results in any way given that the global oil price data used is common to all the 21 sampled countries.
found that 1 percent increment in gdp per capita leads to 0.28 percent insignificant increase in food prices. The same is found for food imports. 1 percent increment in food import lead to 0.03 percent insignificant increase in food prices. However, oil price is found to have negative effects on food prices in the short run at 10 percent significance. 1 percent increase in oil price leads to 0.26 percent decrease in food prices at 10 percent significant level. Lastly, the error correction term (ecm), which represents the speed of adjustment from the short run to the long run, is significant at 1 percent and negatively signed. The long run result implies a direct connection between oil and food prices in the sample countries while the short run result suggests that there could be indirect connection between oil and food prices in the short run, but they will always adjust back to equilibrium from the long run result. The PECM result indicates that after a deviation from the equilibrium due to shock, it will take about 0.26 percent for the explanatory variables to adjust back to equilibrium. The speed of adjustment is perceived to be slow at 0.26 percent for the explanatory variables to adjust back to equilibrium. The PECM result indicates that both oil and food price have long run cointegration result implies that there is a unidirectional causality emanating from food prices to oil price in the long run. This equally implies that movement in oil price can be explained by the past values of food prices. This result suggests a link of biofuel production from food crops to fuel production. The causality result corroborates the direct relationship between oil price and food prices as suggested by the ARDL long run result. This finding supports the hypothesis that the increased global diversification into renewable energy for which biofuel (which is derived from food crops) is a major source has increased food crops demand for the production of biofuel. Consequently, a possibility of food prices causing oil price is therefore established. Therefore, it can be inferred that economic happenings in the agriculture industry has a direct effects on the energy industry. In conclusion, the assertion that biofuel markets have been able to shape fossil fuel prices has been previously established by Serra et al. (2011), Natanelov et al. (2011).

5. Conclusion and policy implications

This study investigates the causality between oil and food prices in 21 developing oil-exporting and food-importing countries from 2001 to 2016. We found negative relationship to exist between oil price and food prices in the short run but direct relationship exists in the long run. Furthermore, in view of the controversies that abound in the literature over the causal connection between oil price and food prices, this study established that the movement of causality between oil price and food prices is a unidirectional one with causality emanating from food prices to oil price. In which case, the agricultural markets is a significant driver of the energy markets in the sample countries. This study therefore contributes to the literature on the understanding of oil and food prices nexus for oil-exporting and food-importing developing countries. The policy implication of the causal result is that biofuel production, as an alternative source of energy, is one of the channels that explains oil price variation apart from the international macroeconomic conditions. Although, biofuel production has only been initiated in few of
the sample countries, yet there is still huge global demand of feedstock to meet the industrial growth in China and the US which explains the food price link to the global oil price. For instance, Nigeria exported 3.2 million tonnes of cassava to China in 2013 for industrial use (Premium times, 2013). It should be noted that such large export demand can create artificial food scarcity and increase in its prices if preventive measures are not taken. It is therefore important that appropriate agricultural policies that would promote favourable food prices and food supply should be pursued by the developing oil exporting countries. In essence, oil exporting countries within their capacities can create incentive in their domestic economies to boost food production. This can be done by providing credit facilities, seedling, fertilizers and farming equipment to farmers. The oil producing countries may not be able to subsidize food importation even in the short term due to dwindling global oil price and consequently their revenue from oil export. These countries can therefore improve the agricultural value chain for export. This can be done through research and development and adding value to their food produce to increase revenue by correcting exchange rate misalignment and unfavourable term of trade. These countries can also diversify their economies into non-oil sectors as reliance on oil export alone is no longer economically sustainable given the high rate of volatility of global oil price. Lastly, resource endowed and oil exporting countries can shift to other renewable energy sources that are not associated with food crops such as solar, hydro, coal, wind, wave and tidal energy. By so doing, both global food and oil supply would not be hampered but sustained.

Declarations

Author contribution statement

David Olayungbo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendix

Table 8. VAR lag order selection criteria.

| Lag | Logl  | LR     | FPE     | AIC    | SC     | HQ     |
|-----|-------|--------|---------|--------|--------|--------|
| 0   | -6992.013 | NA     | 8.55E-16 | 50.33823 | 50.39042 | 50.35917 |
| 1   | -6673.376 | 627.7778* | 9.62e-15* | 48.15378* | 48.41476* | 48.25848* |
| 2   | -6662.879 | 20.31415 | 1.00e+16 | 48.19337 | 48.66314 | 48.38184 |
| 3   | -6552.429 | 19.92198 | 1.04E+16 | 48.23330 | 48.91185 | 48.50553 |
| 4   | -6441.875 | 19.81637 | 1.08e+16 | 48.27249 | 49.15982 | 48.62848 |

Note: * indicates optimal lag order selected by the criteria, where Logl is loglikelihood, LR is likelihood ratio, FPE is Final Prediction Error, AIC is Akaike Information criterion, SC is Schwarz Criterion and HQ is Hannan Quinn.

Table 9. Selected Oil exporting countries.

| Albania | Algeria | Azerbaijan | Bahrain | Egypt | Gabon | Iran |
|---------|---------|------------|---------|-------|-------|------|
| Iraq    | Kazakhstan | Kuwait | Mexico | Nigeria | Oman | Qatar |
| Saudi Arabia | Sudan | Syria | Trinidad and Tobago | Tunisia | Venezuela | Yemen |

Table 10. Variable Descriptions.

| s/n | Variable | Acronyms | Units |
|-----|----------|----------|-------|
| 1   | food price comprises of cereal, palm oil, meat, sugar and diary price index | fp | US dollars per metric ton |
| 2   | food import | fi | US dollars per metric ton |
| 3   | gross domestic product per capita | gdpc | measured in US dollar |
| 4   | Brent oil price | oilp | measured in US dollar |
Table 10. Model selection criteria table.

| Model | LogL  | AIC   | BIC   | HQ    | specification |
|-------|-------|-------|-------|-------|---------------|
| 1     | 274.98* | -1.1885* | 0.2099* | -0.6276* | ARDL (1,1,1,1) |

Note: * indicates optimal lag order selected by the criteria.
Figure 4. The optimal lag length of the estimated ARDL (1,1,1,1) model.

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