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Article

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RESEARCH

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Investigating the relationship between changes in oil prices and unemployment rate in Nigeria: linear and nonlinear autoregressive distributed lag approaches

Isiaka Akande Raifu ^{*} , Alarudeen Aminu and Abiodun O. Folawewo

Abstract

The increasing unemployment in Nigeria has motivated several empirical studies on the causes of the problem in the country. However, attention has not been paid to the contribution of the changes in oil prices to the unemployment problem. As a net exporting oil country, a fluctuation in oil prices in the international market can have impact on economic growth and employment. In the light of this, we investigate the effect of changes in oil prices on unemployment rate in Nigeria, using real oil prices of Brent and West Texas International with linear and nonlinear autoregressive distributed lag (NARDL) estimation methods. Findings from linear ARDL show that changes in oil prices have little or no significant effects on unemployment rate. The NARDL results indicate that an increase and a decrease in oil prices have an insignificant positive effect on unemployment in the short run. However, in the long run, an increase in oil prices worsens unemployment situation, while a decrease has insignificant reducing effect. We also find evidence of a long-run asymmetric relationship between oil prices and unemployment. The need for government to invest oil revenues in generating more electricity or in providing alternative sources of energy with the objective to reduce the costs of production of firms is recommended.

Keywords: Crude oil price, Unemployment rate, ARDL, NARDL

JEL Classification: E24, L70, C20

Introduction

The connection between the crude oil price and the economy has been recognised by academic researchers and policymakers for a very long time in both the oil-producing and nonoil-producing countries. Specifically, the recognition of the importance of crude oil price in determining the course of the economy actually came to limelight in 1973 when there was a significant jump in the price of crude oil from about \$3 per barrel in 1973

to around \$12 per barrel in 1974 [58]. Since then, several issues related to the oil price–economy nexus have been investigated and documented. One of such issues is the provision of theoretical channels through which changes in oil price affect the economy. Specifically, six channels have been documented and they include supply-side channel, wealth transfer channel, real balance channel, monetary channel, sectoral adjustment channel and uncertainty about future increases in the price of crude oil channel. (See [16, 17, 21, 24] for explanation of each of these channels.) The main aspect of these theoretical channels is that most advanced countries (oil-importing countries) considered the increase in oil price inimical

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to their economies. This is because crude oil is considered as one of the factors of production being used for production of goods. An increase in the price of crude oil, therefore, would trigger an increase in the cost of production. When the cost of production increases, the firm's productivity will decline. This, in turn, will reduce the cash flow and profitability of the firm, thereby leading to a reduction in wages and employment of the firm. Another strand of the theoretical argument, however, is that an increase in oil prices is beneficial to oil-exporting countries. According to this argument, an increase in the price of crude oil directly increases the real national income through the transfer of wealth in the form of export earnings from the oil-importing countries to oil-exporting countries. However, Birol [13] opined that enjoyment of such benefit rests on several factors such as the purpose which the received wealth is used for, the share of the cost of oil in national income, the degree of dependence on imported oil, the ability of the importing countries to lower oil consumption and switching away from oil, the prices of other related competing products such as gas and coal among others. Overall, he stated that the recession triggered by high prices of crude oil in oil-importing countries could weaken the gains accrued to oil-exporting countries.

One of the macroeconomic problems facing Nigerian economy today is the problem of unemployment. Due to socio-economic, psychological and political costs of unemployment, a great deal of efforts have been devoted to empirically examining several factors that could possibly be accounting for the persistent rise in unemployment. (For recent studies, see [27, 51].) However, little or no attention has been paid to how a change in the price of crude oil affects unemployment in the country. However, there are several ways through which oil price can determine the course of employment in Nigeria. First, since the discovery of crude oil in 1956 at Oloibiri in the current Bayelsa State and its commercialisation in large quantity around the 1960s, crude oil has been the driver of the Nigerian economy, accounting for about 80% of total export [39] and 61% of the total generated revenue by the government [19]. This suggests that the country is overly dependent on the oil sector to drive its economy. However, the overreliance of the country on oil export and oil revenue has made the economy to be susceptible to the fluctuations of crude oil prices in the international market. This was what the economy went through in 2016 when it experienced a recession for the first time in 25 years, having experienced the last recession in 1991. The sudden decline in crude oil price from about \$114 per barrel to about \$50 per barrel in 2014 preceded the economic downturn in the second quarter of 2016. During the 2016 recession, available statistics show that

GDP growth rate contracted by 1.58%, and total government revenue and oil revenue fell by 17.84% and 29.66%, respectively [19]. When the total revenue fell, government's activity such as investment in critical infrastructural facilities also declined. Since government is the largest employer in the formal sector of the economy, such a decline in government's activity could worsen the economic crises and aggravate incessant unemployment problem.

The narrative above is based on the assumption that Nigeria is an exporter of crude oil. However, Nigeria is also an importer of refined petroleum products such as Prime Motor Spirit (PMS), Dual-Purpose Kerosene (DPK), Aviation Turbine Kerosene (ATK) and Automobile Gas Oil (AGO). This makes the country to be referred to as a net exporting country. Available statistics show that in the third quarter of 2018, Nigeria imported 20.15 billion litres of petroleum products [39]. Aside from this, Nigeria has been experiencing energy crisis for a very long time. Electricity generation and supply has been very erratic. Consequently, most of the firms (big and small firms) in Nigeria have had to generate their own electricity by procuring petroleum products such as PMS and diesel to power their electricity generators in order to produce their products.¹ As argued theoretically, the cost of purchasing those petroleum products will directly be added to the cost of other inputs used by the firms. Therefore, an increase in the price of crude oil would increase the cost of production of those firms. The increase in production cost will, in turn, lower their profits, future investment and output. Since the number of workers employed is directly related to the quantity of output, the ability of the firms to employ more workers will decline as firm's output falls. In fact, some of the existing workers may have to be retrenched, thereby leading to more unemployment problem in the economy.

Given this scenario, various governments have made tremendous efforts, in terms of programme and policy formations, to address the rising unemployment figure in the country. With regard to the government employment programme and policies, the list is endless but prominent among them include the National Directorate of Employment (NDE), Youth Employment Scheme (YES), the National Economic Empowerment and Development Strategy (NEEDS), the Subsidy Reinvestment and Empowerment Programme (SURE-P), the Youth Enterprise with Innovation in Nigeria (YOU-WIN), N-Power Programme and National Employment Policies (NPEs).

¹ It is important to know that majority of these firms in Nigeria belong to the informal sector which account for 65% of GDP growth and the biggest contributor to employment in the country [29].

Despite these efforts geared towards taming unemployment, unemployment continues to increase at an alarming rate. For instance, unemployment figure has risen from a mere 3.10% in 1970 to about 43.1 by 2018.²

In the light of the foregoing, this study seeks to conduct an empirical study on the nature of the relationship between changes in oil price and unemployment rate in Nigeria. In recent times, a number of studies has been conducted by some scholars on the relationship between the increase in oil price and unemployment in some advanced countries as well as in some oil-producing countries. However, Nigeria, which has been a member of OPEC since 1971 and ranked 13th in the comity of oil-producing countries globally, is not included in their studies. (For recent studies, see [6, 14, 32–34, 40].) Even though we follow some of these studies to examine the symmetric and asymmetric effects of changes in oil prices on unemployment in Nigeria, we, however, add some robustness to our study by accounting for structural break in our analysis which none of the studies mentioned above accounted for. Given the event that characterised the movement of oil prices in the international market and the labour market characteristics in Nigeria, it is expedient to account for structural breaks in the analysis in order to have some sort of parsimonious and meaningful analysis.

Following this introductory section, the rest of the study is divided as follows: “[Literature review](#)” section reviews existing studies in the literature. “[Theoretical framework, methodology and data sources and description](#)” section discusses the data and methodology. “[Empirical results and discussion](#)” section presents the empirical findings, while “[Conclusion](#)” section concludes with policy implications.

Literature review

Since the increase in oil prices in the 1970s, a great attention has been devoted to study the relationship between oil prices and macroeconomic variables. Several macroeconomic effects of oil price shocks have been examined including unemployment (employment). One of the aspects early examined is the connection between the recession in the USA and oil price shocks. In the studies conducted, it was found that the recession around the 1970s in the USA was caused by the increase in oil prices [28, 38].

On the nexus between oil price and unemployment, Uri and Boyd, in a series of studies, investigated the impact of oil price on unemployment in the USA, including the sectoral unemployment, especially agricultural

sector employment [59–62]. Specifically, Uri [59] investigated the link between oil price volatility and unemployment between 1890 and 1994 using error correction method (ECM). The findings from his study showed that oil price volatility and unemployment were cointegrated and that the speed of adjustment towards the long-run equilibrium would take 3 years from the short-run disequilibrium. In another version of his study, Uri [59, 60] investigated the relationship between oil price volatility and agricultural sector employment between 1947 and 1994. Still using ECM, he found that oil price and agricultural sector employment are cointegrated. Uri and Boyd [61, 62] later studied the existence of causality between oil price volatility and unemployment in the USA using the data covering the period from 1890 to 1994. They documented a unidirectional nexus between oil price volatility and unemployment in the USA with the direction of causality running from oil price volatility to unemployment. They also found that an increase in oil price had a positive effect on unemployment.

Apart from Uri and Boyd, Carruth et al. [18] investigated the relationship between unemployment equilibria and input prices in the USA in which oil price is considered as one of the input prices. They found that high rate of unemployment was associated with the increase in oil price and interest rate, albeit the effect of interest rate was statistically insignificant. Ewing and Thompson [26] also documented positive association between oil price and unemployment rate. Given the findings above, Andreopoulos [9] reconsidered the relationship between real interest rate, real oil prices and unemployment in the USA using Markov switching vector autoregressive method. The purpose is to distinguish the effect of oil price on unemployment between the periods of economic recession vis-à-vis economic expansion. It was discovered that real oil price Granger-caused unemployment in recession; however, it did not also matter for economic performance in the long run. Ordonez et al. [46] examined the nexus between oil price shocks and labour market fluctuations using smooth transition regression (STR). Their study showed that real oil price caused labour market fluctuation through job finding rate (probability) rather than job separation rate (probability).

Following the series of studies on the US economy, several other researchers have investigated the nature of the relationship between oil price and unemployment in different countries. In Greece, Papapetrou [48] examined the relationship among oil price shocks, stock market, economic activity and employment using monthly data that covered the period from 1989:M1 and 1996:M6. Using vector autoregressive (VAR) model, his results show that oil price shock increased unemployment in Greece. Similar findings were reported for Germany

² In this case, we used old classification of the unemployment rate.

by Löschel and Oberndorfer [35] who investigated the effect of oil price and unemployment. Using monthly data from 1973:M10 to 2008:M1 and subsample data of unified Germany from 1990 to 2008 estimated in the framework of VAR, they found that an increase in oil price worsened unemployment situation in Germany. In Sweden, Mellquist and Femermo [37], who investigated the connection between the price of oil and unemployment, found that oil price increase exhibited both negative and positive effects on unemployment and therefore they could not conclude the exact effect of changes in oil prices on unemployment rate. For Portugal, Robalo and Salvado [53] found that an increase in oil price worsened unemployment and inflation rate. Dogrul and Soytaş [24] considered the causality between oil prices, interest rate and unemployment in Turkey. Using Toda-Yamamoto causality estimation method, they found that oil prices and interest rate had a long-run causality effect on unemployment. Furthermore, Altay et al. [7] used VECM estimation method to examine the relationship between oil prices, output and employment in Turkey. They found the existence of cointegration among the variables, but mixed causalities were established.

Aside from the foregoing studies on the USA and some countries of European extraction, a raft of empirical studies has equally been conducted in emerging and developing countries. Bouchaour and Al-Zeaud [15] examined the impact of oil price distortion on the Algerian macroeconomic and found that oil price distortion reduced unemployment in the country. Ahmad [3]'s study focused on impact of oil prices on unemployment in Pakistan using monthly data that spanned the period from 1991:01 to 2010:12. Adopting Toda-Yamamoto causality estimation method, Ahmad found that oil price and unemployment had a positive relationship and that oil price caused unemployment. Senzangakhona and Choga [54] used quarterly data that covered the period from 1990 to 2010 to investigate the effect of oil price on unemployment in South Africa. Using VAR estimation method, their (Senzangakhona and Choga's) results show that oil prices and interest rate worsened unemployment situation in the country.

One thing common to the studies above is that almost all of them examined oil price–unemployment nexus symmetrically except the studies by Andreopoulos [9] and Ordóñez et al. [46] for the USA. However, due to the advancement in econometric techniques, especially autoregressive distributed lag (ARDL) and nonlinear autoregressive distributed lag (NARDL), developed by Pesaran et al. [49] and Shin et al. [57], respectively, recent studies have focused on comparing the symmetric and asymmetric nexus between oil prices and unemployment both in the short run and in the long run. This

cohort of recent studies has had to use country-specific and cross-country data sets. For country-specific studies, Alkhateeb et al. [6] examined nexus between oil price and employment in Saudi Arabia using ARDL and NARDL. They found that there was an asymmetric relationship between oil price and employment and that increase in oil price had a positive effect on employment. The positive effect of oil price on employment was more than the positive effect of a decline in oil price. Bocklet and Baek [14] examined whether oil price changes had a symmetric or an asymmetric effect on unemployment in the State of Alaska in the USA. The results from their study showed that an increase in oil prices only had a short-run asymmetric effect on unemployment. Besides, they also showed that unemployment responded much more to a positive change in oil prices than to a negative change in oil prices. Karaki [32] investigated the relationship between oil price and unemployment in the USA and its States. The study used different econometric approaches such as nonlinear structural equation and structural vector autoregressive (SVAR) estimation methods and found no evidence against the null hypothesis of symmetric effect. It was also found that oil supply shocks worsened unemployment situation, while oil demand shocks reduced unemployment rate across most of the States in the USA. However, oil-specific shocks had a little effect on unemployment in the States.

Kisswani and Kisswani [33], on the other hand, studied the asymmetric effects of oil prices on total and gender employment in US market using NARDL. They concluded that asymmetric effects of oil price changes can only be observed on total and male employment in the long run. However, in the short run, asymmetric effects of oil price changes existed for all categories of employment. Kocaarslan et al. [34] investigated asymmetric impact of oil prices, interest rate and oil price uncertainty on unemployment in the USA. Their findings reveal that asymmetry existed between changes in oil prices and unemployment. More importantly, it was discovered that an increase in oil prices led to a significant increase in unemployment, while a decrease in oil prices had no significant effect on unemployment. They also found that a reduction in oil price uncertainty resulted in a decrease in unemployment, whereas an increase in oil price uncertainty had no significant impact.

For cross-country studies, Cheratian et al. [20] examined the relationship between oil price shocks and employment rate in the Middle East and North African (MENA) region using NARDL. Their results show that the positive changes in oil prices exerted a positive impact on the unemployment rate for oil-exporting countries of MENA in the short run. However, in the long run, an increase in oil prices had a significant increasing

effect on unemployment rate for both oil-exporting and oil-importing countries in the region. Furthermore, their findings show that negative changes in oil prices did not have any significant effect on the unemployment rate. Nusair [40] examined the asymmetric effects of oil price changes on employment in Canada and the USA using ARDL and NARDL estimation methods. The results based on ARDL showed that changes in oil prices had a significant effect on employment in the long run. However, there was no or minor effect in the short run. In the case of NARDL, the results reveal that positive changes in oil prices had a long-run significant and positive effect on the unemployment rate in all cases. The negative effect of oil price changes was only significant on the unemployment rate in the short run.

We now turn to a review of studies that have examined the relationship between changes in oil prices and some macroeconomic fundamentals in Nigeria. Even though there are both symmetric and asymmetric effects of changes in oil prices on some macroeconomic variables such as economic growth, stock market price, infrastructural spending, oil revenues, recurrent and capital expenditures, money supply, consumer price index, current account balance and exchange rate, to the best of our knowledge, none of these studies has included unemployment in their investigations [1, 4, 5, 12, 21, 22, 25, 30, 31, 41–43]. The current study fills this gap by examining symmetrically and asymmetrically the oil prices–unemployment nexus in Nigeria. We also extend the extant studies by accounting for the structural break in the relationship between changes in oil prices and unemployment.

Theoretical framework, methodology and data sources and description

Theoretical framework and methodology

This subsection focuses on the theoretical framework and the methodological approach employed in the study. Given the aim of this study, which is to investigate the existence of dynamic asymmetric relationship between oil price shocks and unemployment, the theoretical framework underpinning it is based on a simplified version of the model developed by Shapiro and Joseph [56], which was adopted before now by Bocklet and Baek [14]. The model is known as efficiency wage model. Following Bocklet and Baek [14], the wage equation is specified as follows:

$$w = f(\beta, ur) \quad (1)$$

where w denotes the wage, ur is the unemployment rate and β stands for the level of unemployment benefit. Equation 1 implies that wage rate is a function of the level of unemployment benefit and unemployment rate.

In a traditional production function, labour and capital are inputs used to produce a given level of output. However, as the economy becomes modernised, energy has been considered as another significant input used for production. Given the three factors of production (capital, labour and energy), the minimum cost of producing a unit of output sold at price (p) is given as:

$$c = \frac{1}{\lambda} g(w, ir, op) \quad (2)$$

where ir is the interest rate, op is the oil price and λ is used to measure neutral technical progress. If the market is competitively perfect, then there must not be any form of profit in equilibrium. This implies that $p - c = 0$. If p is set to unity due to the assumption of homogenous of degree one, then Eq. 2 can be re-specified as:

$$\lambda = g(w, ir, op) \quad (3)$$

To eliminate wage from Eq. 3, Eq. 1 is substituted into Eq. 3 and rearranged to obtain Eq. 4 as follows:

$$ur = g(\beta(\lambda), ir, op). \quad (4)$$

Following the Bocklet and Baek [14], unemployment benefit $\beta(\lambda)$ is replaced with real GDP as a determinant of the unemployment rate. On our own, we include inflation rate and foreign direct investment as part of determinants of unemployment rate. It has been proved theoretically along the line of Phillips curve hypothesis, which postulates that unemployment rate and inflation are inversely related. However, the effect of FDI on unemployment can be positive or negative on a priori ground (see [23]). Therefore, Eq. 4 is extended to include inflation rate and FDI and thus Eq. 5 is obtained as follows:

$$ur = f(ir, inf, y, fdi, op) \quad (5)$$

where ur , ir , inf , y and op are unemployment rate, interest rate, inflation rate, real GDP, FDI and oil price, respectively. Equation 5 is transformed into a model specified as follows:

$$ur_t = \alpha_0 + \alpha_1 op_t + \alpha_2 inf_t + \alpha_3 ir_t + \alpha_4 y_t + \alpha_5 fdi_t + \varepsilon_t \quad (6)$$

Equation 6 is the long-run equation model that shows the impact of each of the independent variables on unemployment rate, while holding other independent variables constant.

In this study, however, we apply both linear and non-linear autoregressive distributed lag method proposed by Pesaran et al. [49] and Shin et al. [57], respectively. We begin with the specification of ARDL model as follows:

$$\begin{aligned} \Delta ur_t &= \alpha_0 + \alpha_1 op_{t-1} + \alpha_2 \inf_{t-1} + \alpha_3 ir_{t-1} + \alpha_4 y_{t-1} + \alpha_5 fdi_{t-1} \\ &+ \sum_{i=1}^{n1} \beta_i \Delta ur_{t-i} + \sum_{i=0}^{n1} \delta_i \Delta op_{t-i} \\ &+ \sum_{i=0}^{n3} \phi_i \Delta \inf_{t-1} + \sum_{i=0}^{n4} \varphi_i \Delta ir_{t-1} + \sum_{i=0}^{n5} \gamma_i \Delta y_{t-1} \\ &+ \sum_{i=0}^{n6} \mu_i \Delta fdi_{t-1} + \varepsilon_t \quad t = 1, 2, \dots, T \end{aligned} \tag{7}$$

where ur is the employment rate, op is the real oil price (Brent or WTI), \inf represents the inflation rate proxied by the natural logarithm of CPI, ir denotes the prime lending rate, y is the real income proxied by real GDP and fdi stands for the foreign direct investment. Δ is known as difference operator. α_0 is a constant representing a drift component. α_1 to α_5 are the long-run parameters, β_i to μ_i are the short-run parameters, and ε_t is the error term assumed to be normally distributed with constant variance. The null and alternative hypotheses of the long run are as follows:

$$\begin{aligned} \text{Null hypothesis: } &\alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0 \\ \text{Alternative hypothesis: } &\alpha_0 \neq \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0 \end{aligned}$$

The error correction terms which show the speed of adjustment from the short-run disequilibrium towards the long-run equilibrium is specified as follows:

$$\begin{aligned} \Delta ur_t &= \alpha_0 + \sum_{i=0}^{n1} \delta_i \Delta op_{t-1} + \sum_{i=0}^{n3} \phi_i \Delta \inf_{t-1} + \sum_{i=0}^{n4} \varphi_i \Delta ir_{t-1} \\ &+ \sum_{i=0}^{n5} \gamma_i \Delta y_{t-1} + \sum_{i=0}^{n6} \mu_i \Delta fdi_{t-1} + \lambda_i ect_{t-1} + \varepsilon_t \end{aligned} \tag{8}$$

The long-run NARDL model specification is given as:

$$\begin{aligned} ur_t &= \alpha_0 + \alpha_1 op_t^+ + \alpha_2 op_t^- + \alpha_3 \inf_t \\ &+ \alpha_4 ir_t + \alpha_5 y_t + \alpha_6 fdi_t + \varepsilon_t \end{aligned} \tag{9}$$

where ur_t is the logarithm of the unemployment rate, op_t^+ and op_t^- are the logarithm of the partial sum of positive and negative change of crude oil price, \inf_t is the inflation rate, ir_t is the interest rate, y_t is the logarithm of real GDP denoting real income, fdi is the foreign direct investment, and $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ and α_6 are coefficients of the long-run model. The partial decomposition of oil price into positive and negative components in Eq. 9 is accomplished as follows:

$$\begin{aligned} op_t^+ &= \sum_{j=1}^t \Delta op_j^+ = \sum_{j=1}^t \max(\Delta op_j, 0) \\ op_t^- &= \sum_{j=1}^t \Delta op_j^- = \sum_{j=1}^t \min(\Delta op_j, 0) \end{aligned} \tag{10}$$

From Eq. 9, we specify NARDL model which incorporates both short-run and long-run asymmetric effects of oil price shocks and other variables on unemployment rate as follows:

$$\begin{aligned} \Delta ur_t &= \phi_0 + \phi_1 ur_{t-1} + \phi_2^+ op_{t-1}^+ + \phi_3^- op_{t-1}^- + \phi_4 \inf_{t-1} + \phi_5 ir_{t-1} \\ &+ \phi_6 y_{t-1} + \phi_7 fdi_{t-1} + \sum_{i=1}^{p1} \delta_t \Delta ur_{t-1} + \sum_{i=0}^{p2} \lambda_t^+ \Delta op_{t-1}^+ \\ &+ \sum_{i=0}^{p3} \varphi_t^- \Delta op_{t-1}^- + \sum_{i=0}^{p4} \eta_t \Delta \inf_{t-1} + \sum_{i=0}^{p5} \gamma_t \Delta ir_{t-1} \\ &+ \sum_{i=0}^{p6} \mu_t \Delta y_{t-1} + \sum_{i=0}^{p7} \lambda_t \Delta fdi_{t-1} + \varepsilon_t \end{aligned} \tag{11}$$

where p 's are the lag orders, $\phi_0, \phi_1, \phi_2^+, \phi_3^-, \phi_4, \phi_5, \phi_6$ and ϕ_7 are the long-run coefficients which are estimated, $\sum_{i=0}^{p2} \lambda_t^+$ and $\sum_{i=0}^{p3} \varphi_t^-$ are the coefficients of the short-run asymmetric distributed lags. The long-run positive and negative impacts of oil price on unemployment are represented as: $\theta_2^+ = -\frac{\phi_2^+}{\phi_1}$ and $\theta_3^- = -\frac{\phi_3^-}{\phi_1}$, respectively. The null hypothesis of the long-run asymmetric is that there is no long-run asymmetric effect of positive and negative oil price changes on the unemployment rate ($\frac{\phi_2^+}{\phi_1} = \frac{\phi_3^-}{\phi_1}$). This null hypothesis is tested against the alternative hypothesis denoted as $\frac{\phi_2^+}{\phi_1} \neq \frac{\phi_3^-}{\phi_1}$. Similarly, the null hypothesis of no short-run asymmetric effect of oil price on the unemployment rate is specified as $\sum_{i=0}^{p2} \lambda_t^+ \sum_{i=0}^{p3} \varphi_t^-$ against the alternative of the short-run asymmetric effect of oil price on the unemployment rate $\sum_{i=0}^{p2} \lambda_t^+ \neq \sum_{i=0}^{p3} \varphi_t^-$.

The error correction of nonlinear ARDL model is also specified as follows:

$$\begin{aligned} \Delta ur_t &= \phi_0 + \sum_{i=1}^{p1} \delta_t \Delta ur_{t-1} + \sum_{i=0}^{p2} \lambda_t^+ \Delta op_{t-1}^+ \\ &+ \sum_{i=0}^{p3} \varphi_t^- \Delta op_{t-1}^- + \sum_{i=0}^{p4} \eta_t \Delta \inf_{t-1} + \sum_{i=0}^{p5} \gamma_t \Delta ir_{t-1} \\ &+ \sum_{i=0}^{p6} \mu_t \Delta y_{t-1} + \sum_{i=0}^{p7} \lambda_t \Delta fdi_{t-1} + \theta ect_{t-1} + \varepsilon_t \end{aligned} \tag{12}$$

where ect_{t-1} is the error correction term and θ is the coefficient of error term which must be negative, less than 1 and statistically significant before it can be adjudged that there is an adjustment towards the long-run equilibrium from the short-run disequilibrium.

Table 1 Descriptive statistics. *Source: Computed by the authors*

Variables	Obs	Mean	SD	Min	Max	p1	p99	Skew.	Kurt.
<i>Unemployment–real oil price model (Brent)</i>									
unempl	160	12.185	10.711	1.531	45.144	1.578	43.801	1.143	3.483
ropbtr	160	0.608	0.322	0.165	1.372	0.167	1.350	0.661	2.196
rgdp	160	3.473e + 13	1.840e + 13	1.604e + 13	7.122e + 13	1.610e + 13	7.074e + 13	0.845	2.185
cpi	160	53.234	64.445	0.365	248.882	0.365	243.242	1.316	3.836
lrate	160	17.284	5.141	8.089	32.482	8.121	31.947	0.145	3.317
fdi	160	1.481	1.309	– 1.274	6.37	– 1.233	6.233	1.360	5.813
<i>Unemployment–real oil price model (WTI)</i>									
unempl	148	12.956	10.771	1.531	45.144	1.619	43.801	1.059	3.298
rwti	148	0.561	0.261	0.192	1.366	0.194	1.279	0.751	2.600
rgdp	148	3.580e + 13	1.868e + 13	1.604e + 13	7.122e + 13	1.610e + 13	7.074e + 13	0.725	1.997
cpi	148	57.516	65.162	0.500	248.882	0.514	243.242	1.223	3.587
lrate	148	17.996	4.665	9.219	32.482	9.333	31.947	0.296	3.927
fdi	148	1.605	1.252	0.024	6.37	0.221	6.233	1.696	6.159

unempl, ropbtr, rwti, rgdp, cpi, lrate and fdi stand for unemployment rate, real brent oil price, real WTI oil price, real GDP, consumer price index, prime lending rate and foreign direct investment, respectively

Data sources and description

The study uses quarterly data of two oil prices (Brent oil and West Texas Intermediate oil prices in real terms) with different time scopes. For instance, the Brent oil price covers the period from 1979:Q1 to 2018:Q4, while the WTI oil price covers the period from 1982:Q1 to 2018:Q4.³ The real Brent oil price and West Texas Intermediate oil price are used for robust analysis. The oil prices are sourced from the World Bank Commodity Price Data Sheet and St Louis FED. Also utilised are data on unemployment rate, inflation rate, interest rate, real GDP and foreign direct investment. While unemployment rate is obtained from National Bureau of Statistics database, inflation rate, interest rate, real GDP and foreign direct investment are sourced from World Development Indicators. These variables, apart from the oil prices, serve as control variables which determine the unemployment rate. Both oil prices are measured in dollar per barrel, unemployment rate, interest rate and inflation rates are measured in percentage terms, real GDP is measured in billion naira, and FDI is measured as a percentage of GDP. The descriptive statistics of the variables are presented in Table 1.⁴ From the table, Brent and WTI real oil prices average 0.608\$/barrel and 0.561\$/barrel. During the period, the minimum real oil prices for Brent

and WTI are 0.165\$/barrel and 0.192\$/barrel, while the maximum real oil prices for Brent and WTI are 1.372\$/barrel and 1.366\$/barrel, respectively. Unemployment rate averages 10.711%. During the period of investigation, the minimum unemployment rate in Nigeria is 1.531%, while the maximum unemployment rate is 45.144%. This suggests that unemployment has been rising steadily in the country.

The graph that shows the relationship between unemployment and real oil prices is contained in the Appendix. From the graph named Fig. 1, it can be seen that some periods of increase in unemployment rate are associated with the period of plunge in oil prices. Two important periods are observed from the figure. The first period is around 1980s, it can be seen that a decline in oil prices was associated with a steady rise in unemployment. The second period is around 2014; when the oil prices suddenly crashed in the international market, one can see a significant spike in unemployment rate, that is, the unemployment figure was trending upwards. However, there are periods when both real oil prices and unemployment figure were rising simultaneously. For instance, during period from 1999 to around 2013, as the oil prices increased, unemployment rate also increased.

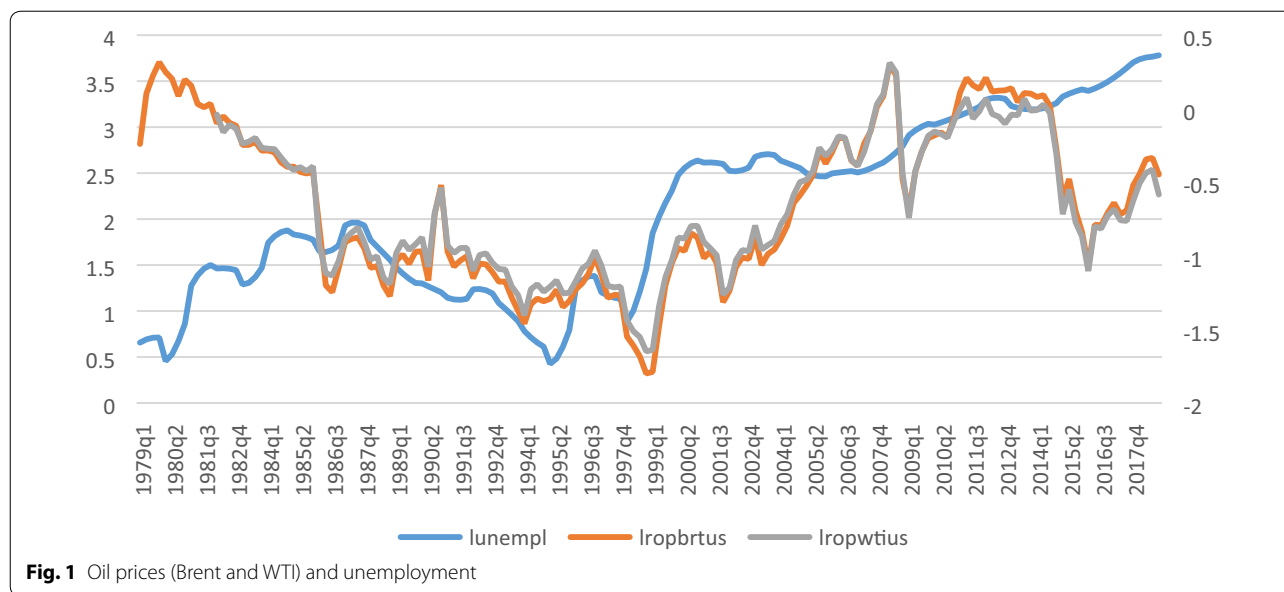
Empirical results and discussion

Unit root test results

This section begins by presenting the stationarity test results of the variables used in this study. The objective is to determine whether the variables are stationary at level or stationary at first difference. Two series of stationarity tests are carried out. First to be performed is unit root

³ Some variables such as real GDP, foreign direct investment, inflation rate, unemployment rate and interest rate are converted from annual data to quarterly data using quadratic match average, while oil prices are converted from monthly data to quarterly data using an average of 3 months. The quadratic match average performs a proprietary local quadratic interpolation of the low-frequency data to fill in the high observations.

⁴ Tables 1 and Table 7 are prepared using STATA code (ASDOC) provided by Shah [55].



test without structural break. In this regard, three unit root tests are performed. These are Augmented Dickey–Fuller (ADF), Phillips–Perron (P–P) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS). A unit root test with structural break is equally performed on the variables using Zivot–Andrews unit root test. The unit root tests are performed at level and at first difference along the lines of unit root tests with constant (C), constant and trend (CT) and without constant and trend (WCT). The overall purpose of performing the stationarity tests is to avoid any form of spurious regression. The results are presented in Tables 2 and 3, respectively. In Table 2, the results show that the variables are a mixture of 0 and 1 orders of integration. However, this varies across the unit root test methods. For instance, ADF unit root test results show that all variables are integrated of order 1, particularly in the Brent real oil price–unemployment model. In the Phillips–Perron unit test, only FDI is integrated of order 0. Also, ADF and P–P unit test results show that WTI real oil is integrated of order 0 in the WTI real oil price–unemployment relation. This suggests that most of the variables are not stationary at level. They only become stationary after they are first-differenced. Interestingly, the mixture of orders of integration is suitable for the method we adopted in this study. According to Pesaran et al. [49] and Shin et al. [57], ARDL and NARDL are suitable when the order of integration of variables is either $I(1)$ or $I(0)$. It is not, however, appropriate to use either of the two estimation techniques when the variables are integrated of higher order than order 1.

Table 3 reports the results of a Zivot–Andrews unit root test with structural break. The test is conducted at

level and at first difference along the lines of breaking point occurring at constant, at trend and at both constant and trend. Unlike Chow test in which the structural break is determined exogenously, structural break in Zivot–Andrews unit root test is determined endogenously [63]. This implies that the researcher does not need to have an a priori period of breaking point; the period of breaking point is determined within the system of Zivot–Andrews unit root test mechanism. Focusing on the main series (real oil prices and unemployment), it can be observed that the unemployment rate is only stationary at first difference with structural break occurring at different dates depending on the assumptions made. For constant and both constant and trend, the break occurs in the second quarter of 1995 (1995q2). However, for trend, the break occurs in the second quarter of 1986 (1986q2). Despite the fact that the period of 1990s was characterised by slow economic growth and some macroeconomic problem, unemployment declined during the period of 1995. For instance, from 3.141% in the first quarter of 1991, unemployment rate declined to 1.531% before it continued to rise. With regard to real oil prices, they are stationary at first difference. Specifically, real Brent oil price is stationary at first difference with structural breaks occurring at break, trend and both break and trend in 2003q3, 2005q2 and 2014q3, respectively. The structural breaks for the real WTI oil price are akin to those of real Brent oil price except the break that occurs in 2004q4. The most important crash of the oil prices that really affects the Nigerian economy in recent is the one that occurred in 2014q2. The sudden plunge in oil

Table 2 Unit root test results

	ADF unit root test						Phillips-Perron unit root test						KPSS unit root test					
	Level		First difference		Level		First difference		Level		First difference		Level		First difference			
	C	CT	WCT	C	CT	WCT	C	CT	WCT	C	CT	WCT	C	CT	WCT	C	CT	WCT
<i>Unemployment-real oil price model (Brent)</i>																		
lunempl	-0.329	-2.107	0.941	-3.439**	-3.492**	-3.232***	-0.775	-1.914	1.197	-6.136***	-6.108***	-6.199***	1.272***	0.189**	0.074	0.063	...	...
lropbtr	-2.011	-2.174	-0.998	-9.902***	-9.946***	-9.927***	-1.785	-2.022	-1.169	-10.254***	-10.257***	-10.286***	0.329	0.283***	0.099	0.060	...	...
lrgdp	0.336	-4.636	1.427	-2.937**	-3.404*	-2.564**	0.961	-2.472	2.862	-5.899***	-6.273***	-5.471***	1.429***	0.314***	0.468**	0.148**	...	...
lcpi	-1.674	-1.525	0.709	-3.262**	-3.527**	-1.982**	-1.569	-0.691	2.365	-9.100***	-9.136***	-7.175***	1.510***	0.337***	0.339	0.109	...	...
lrate	-2.403	-2.166	-0.232	-3.192**	-3.369*	-3.182***	-2.087	-1.817	-0.106	-6.386***	-6.293***	-6.427***	0.417*	0.282***	0.188	0.041	...	...
fdi	-2.909	-2.755	-1.362	-5.781***	-5.865***	-5.809***	-3.366**	-3.406*	-2.291**	-7.701***	-8.583***	-7.767***	0.259	0.186**	0.036	0.032	...	...
<i>Unemployment-real oil price model (WTI)</i>																		
lunempl	-0.245	-2.381	0.848	-3.156**	-3.349*	-2.986***	-0.281	-1.889	1.157	-5.850***	-5.851***	-5.915***	1.161***	0.196**	0.148	0.060	...	...
lrvwti	-2.189	-2.783	-0.947	-10.288***	-10.269***	-10.320***	-2.302	-2.678	-0.974	-10.149***	-10.127***	-10.187***	0.483**	0.232***	0.148	0.089	...	...
lrgdp	-0.469	-1.605	3.227	-3.951***	-3.705**	-2.265**	0.986	-3.045	4.044	-5.234***	-5.287***	-5.271***	1.390***	0.291***	0.440	0.175	...	...
lcpi	-1.774	-1.594	0.782	-3.881***	-4.174***	-1.960**	-1.866	-0.810	2.485	-3.815***	-4.198***	-2.508**	1.388***	0.323***	0.387	0.089	...	...
lrate	-2.656*	-2.596	-0.257	-3.054**	-3.240*	-3.052***	-2.024	-2.072	-0.138	-6.161***	-6.062***	-6.200***	0.256	0.245***	0.189	0.046	...	...
fdi	-3.032***	-2.992	-1.293	-5.804***	-5.962***	-5.829***	-3.113**	-3.066	-1.794*	-6.956***	-7.587***	-7.019***	0.148	0.147**	0.071	0.028	...	...

C, CT and WCT denote unit root with constant, with constant and trend and without constant and trend, respectively

lunempl, lropbtr, lrvwti, lrgdp and lcpi are natural logarithms of unemployment rate, real Brent oil price, real WTI oil price, real GDP and consumer price index, while lrate and fdi are prime lending rate and foreign direct investment, respectively

*, ** and *** represent 10%, 5% and 1% level of significance

Table 3 Zivot–Andrews unit root test results. *Source: Authors' computations*

	Break intercept		Break (trend)		Break (both)	
	Level	First difference	Level	First difference	Level	First difference
<i>Unemployment–real oil price model (Brent)</i>						
lunempl	–3.921 (1988q1)	–8.767*** (1995q2)	–3.522 (1993q2)	–8.328*** (1986q2)	–5.187** (1998q2)	–9.701*** (1995q2)
lropbtr	–3.543 (2003q3)	–10.351*** (2008q3)	–3.040 (1986q2)	–10.115*** (2005q2)	–3.218 (1999q2)	–10.531*** (2014q3)
lrgdp	–5.213** (2001q2)	–6.619*** (2001q2)	–2.216 (2012q4)	–7.041*** (2004q1)	–3.916 (2001q2)	–8.581 (2001q2)
<i>lcpu</i>						
lrate	–4.689* (1987q1)	–10.375*** (1993q2)	–4.706** (1992q2)	–9.191*** (2005q1)	–5.332** (1994q1)	–10.671*** (1993q2)
fdi	–5.600*** (1988q2)	–11.493*** (1994q2)	–5.376*** (1993q2)	–10.800*** (1988q4)	–6.362*** (1995q1)	–11.676*** (1994q2)
<i>Unemployment–real oil price model (WTI)</i>						
lunempl	–3.675 (1988q1)	–8.040*** (1995q2)	–3.517 (1992q4)	–7.039*** (1988q3)	–6.291*** (1998q2)	–8.493*** (1995q2)
lrwt	–4.177 (2003q3)	–10.607*** (2008q3)	–3.170 (1988q1)	–10.391*** (2004q4)	–3.929 (2004q1)	–10.589*** (2014q3)
lrgdp	–4.133 (1992q2)	–8.690*** (2001q2)	–2.669 (1995q1)	–8.349 (2009q3)	–3.640 (1992q2)	–9.685*** (2001q2)
<i>lcpu</i>						
lrate	–4.636* (1988q2)	–9.995*** (1993q2)	–4.837** (1990q2)	–8.887 (1995q4)	–5.870*** (1994q1)	–10.287*** (1993q2)
fdi	–5.308** (1988q2)	–11.281*** (1994q2)	–4.974*** (1993q1)	–10.542*** (1996q2)	–6.058*** (1995q1)	–11.519*** (1994q2)

The values in brackets are the years when the structural break occurs for individual variable

*, ** and *** represent 10%, 5% and 1% level of significance

price eventually resulted in the collapse of the economy in the second quarter of 2016 owing to the dwindling revenue that accrued to the government and the associated exchange rate crisis. As the oil price plunged, total government revenue and the economy contracted by 1.58%.

Symmetric and asymmetric responses of unemployment to changes in oil prices (without structural break)

In this section, we present the results of ARDL and NARDL models for the response of unemployment to changes in the real Brent and WTI oil prices. The ARDL assumes that unemployment responses to change in oil prices are linear, while the NARDL assumes that the response of unemployment to change in oil prices is non-linear and it distinguishes between the response of unemployment to an increase in oil prices and the response to a decrease in oil prices. For short run, it is observed that the real Brent and WTI oil prices have positive effects on unemployment, albeit only the effect real Brent oil price is statistically significant at 10% level. In the long run, even though both oil prices exhibit negative impacts on unemployment, the impacts, however, are not significant

at any level. This suggests that a change in oil prices may have little or no effect on the unemployment rate in Nigeria, either in the short run or in the long run. This finding is slightly similar to the one documented for Canada and the USA by Nusair [40]. However, some differences are noticeable. For instance, while a negative insignificant impact is found in the long run in this study, Nusair [40] found positive significant effects in the long run.

With regard to NARDL results, the results show that an increase or a decrease in oil prices has positive effects on unemployment in the short run. However, the results differ slightly based on the real oil price that is used in the model. For instance, under the real Brent oil price–unemployment model, it is only the positive effects of oil prices that are statistically significant at 10%. The opposite occurs in the case of real WTI oil price–unemployment model in which the impact of a decrease in oil price on unemployment rate is statistically significant at 10%. In the long run, an increase in oil prices still exhibits significant positive effects on unemployment, while a decrease in oil prices has negative effects on unemployment, albeit not statistically significant. The findings are consistent with those of Cheratian et al. [20] for oil-exporting

countries of MENA region. In specific term, an increase in oil prices exerts a positive effect on unemployment rate, that is, oil prices increases worsen unemployment in the economic region. The author argued that although an increase in oil price is expected to bring more revenues to the governments of oil-exporting countries, the problem of Dutch disease characterises the economies of many oil-exporting countries, especially developing oil-exporting countries (see [20]).

Some plausible explanations can still be provided to rationalise findings obtained in this study on Nigeria. In some oil-exporting countries, especially Nigeria, where most of the oil revenues realised from the increase in the price of crude oil either go to recurrent expenditure or unproductive or later abandoned capital expenditure projects. In this kind of scenario, an increase in oil price that is supposed to trigger economic growth and employment may end up creating jobless economic growth as witnessed over the years. Aside from this, the country is a net oil-exporting country that constantly imports refined petroleum products. An increase in oil prices can trigger an increase in the prices of imported refined petroleum products and also an increase in the prices of locally produced goods as firms use imported refined fuels to power their plants.

We now turn to the issue of whether there is an asymmetric relationship between changes in oil prices and unemployment in Nigeria. The null hypothesis of the short-run and long-run asymmetry is that there is no short-run and long-run asymmetric relationship between changes in oil price and the unemployment. The alternative hypothesis stipulates that there is the existence of asymmetry. Table 4 shows that asymmetric nexus between changes in oil prices and unemployment occurs in the long run. In the short run, the impacts of an increase and a decrease in oil prices are the same; hence, there is no short-run asymmetric effect of oil prices on unemployment rate. Several studies have documented different asymmetric effects of changes in oil prices on unemployment for different economies or regions. For instance, Nusair [40] found that changes in oil prices have asymmetric effect on unemployment rate for Canada and the USA in the short run and the long run. Alkhatteeb et al. [6] documented the existence of an asymmetric relationship between oil price and unemployment for Saudi Arabia. Similarly, Bocklet and Baek [14] also found an asymmetric nexus between oil price and the unemployment rate in the USA, albeit only in the short run.

Another set of findings in Table 4 is the one that relates to cointegration tests. To confirm the existence of cointegration, some a priori expectation must be fulfilled. First, the sign of the coefficient attached to error term must be negative. Second, the coefficient of the ECM

Table 4 Linear and nonlinear ARDL models of unemployment effect of oil price change without structural break. Source: Computed by the authors

Variable	Real oil price (Brent)		Real oil price (WTI)	
	ARDL	NARDL	ARDL	NARDL
d(lunempl_1)	0.447***	0.442***	0.459***	0.433***
d(lropbtr)	0.078*			
d(lropbtr_pos)		0.054		
d(lropbtr_neg)		0.105*		
d(lrwt)			0.065	
d(lrwtin_pos)				0.080*
d(lrwtin_neg)				0.074
d(lrgdp)	0.014	-0.168*	0.044	0.774
d(lcpi)	0.023**	-0.198*	-0.552***	-0.622***
d(lrate)	0.007	0.007	0.009	0.008
d(fdi)	0.032**	0.036***	0.025***	0.038***
ect(-1)	-0.051***	-0.078***	-0.056***	-0.086***
c	-5.613	66.873*	-21.417	95.592**
lropbtr	-0.126			
lropbtr_pos		0.691*		
lropbtr_neg		-0.252		
lrwti			-0.365	
lrwti_pos				0.939**
lrwti_neg				-0.319
lrgdp	0.272	-2.139*	0.791	-3.067**
lcpi	0.446**	-0.160	0.254	-0.278*
lrate	-0.083*	-0.058**	-0.067*	-0.056**
fdi	-0.275*	-0.180**	-0.115	-0.073
R-squared	0.9939	0.9941	0.9949	0.9952
Adjusted R-squared	0.9935	0.9936	0.9945	0.9947
F-statistic	2387.895 (0.0000)	2046.025 (0.0000)	193.579 (0.0000)	2113.660 (0.0000)
Durbin-Watson stat	1.998	1.947	1.949	1.889
ARDL bounds test	4.791***	4.622***	4.107**	4.805***
<i>Diagnostic tests</i>				
Jarque-Bera	141.573 (0.0000)	135.167 (0.0000)	259.084 (0.0000)	287.498 (0.0000)
B-G serial corr. LM test	1.515 (0.2233)	0.299 (0.5853)	0.241 (0.6241)	1.175 (0.2803)
Het. ARDL LM test	2.308 (0.1307)	2.617 (0.1078)	2.019 (0.1366)	1.487 (0.2296)
Ramsey RESET test	1.189 (0.2363)	0.427 (0.6699)	2.243 (0.0265)	0.661 (0.5095)
CUSUM test	Stable	Stable	Stable	Unstable
CUSUM Square test	Unstable	Unstable	Unstable	Unstable

***, ** and * denote the 1%, 5% and 10% levels of significance, respectively

must be less than unity. Third, the coefficients must be statistically significant. If these conditions are satisfied, then there is cointegration between or among the variables. This shows the speed of adjustment from the short-run disequilibrium in the economy towards the long-run

equilibrium. From the results presented in Table 4, it is confirmed that cointegration exists in all the models considered because all the aforementioned conditions or criteria are met. Specifically, in the real Brent oil prices–unemployment model, the coefficients of the ECMs for ARDL and NARDL are -0.051 and -0.078 , respectively. This implies that about 5.10% and 7.80% of the disequilibria that occur in the labour market in Nigeria can be corrected for in the current year and it will take a long time to complete the adjustment towards the long-run equilibrium. We also find similar results in the real WTI oil prices–unemployment model. More precisely, the coefficients of ECM for ARDL and NARDL are 0.056 and 0.086, respectively. This also suggests that about 5.60% and 8.60% of disequilibria in the short run can be corrected for in the current year.

The results of ECM are corroborated by the bounds testing results of ARDL and NARDL. For bounds testing approach to cointegration, Pesaran et al. [49] stated that cointegration between or among variables occurs when the calculated value of F-statistics is greater than the critical value of upper bound (see [49]). In all the models, our results show that the computed values of F-statistics are greater than the critical values of upper bound of Pesaran et al., at least at 5% level of significance.⁵ This suggests that cointegration exists between oil prices and unemployment in Nigeria.

Having explained the main results, we now explain the effects of other explanatory variables, namely real GDP, inflation rate, real interest rate and foreign direct investment on the unemployment rate. In ARDL model, either the real Brent oil price–unemployment model or the real WTI oil price–unemployment model, it is found that real income (real GDP) has an insignificant impact on unemployment. However, in NARDL, real oil prices (Brent or WTI) exert a negative and significant effect unemployment rate. This suggests that the negative relationship between real GDP and real oil prices follows an a priori expectation under Okun's law. Inflation rate measured by natural logarithm of CPI has a positive effect on unemployment rate in linear model, whereas in nonlinear model, negative relationship between inflation and real oil prices is observed. The results from nonlinear model of oil prices–unemployment model are in tandem with Phillips curve hypothesis which postulates an inverse relationship between inflation and unemployment [50].

Irrespective of the models, interest rate, measured by prime lending rate, has a significant effect (negative) on unemployment rate. The negative effect of FDI on unemployment is only statistically significant in the real

Brent oil price–unemployment model. All these results are reported for the long run. In the short run, the negative effects of real income on unemployment are only observed in the real Brent oil price–unemployment model. Inflation rate still has a significant negative effect on unemployment except in the linear ARDL model of real Brent oil price–unemployment model. The short-run effect of interest rate on unemployment is positive but statistically insignificant. Similarly, FDI has a significant impact on unemployment in all the models in the short run. On the whole, the effects of most explanatory variables on unemployment follow an a priori expectation in the long run than in the short run.

A number of post-estimation diagnostic tests are equally conducted. These tests include Jarque–Bera normality test, Breusch–Pagan serial correlation LM test, ARCH LM test for heteroscedasticity, Ramsey RESET test for functional specification and CUSUM and CUSUM Squares for model stability. Jarque–Bera normality test assumes that the models are normally distributed. Serial correlation LM test assumes that there is no problem of serial correlation. ARCK LM test assumes homoscedasticity. Ramsey RESET test assumes that the models are rightly specified, while the CUSUM and CUSUM Square tests assume that the models are stable. If the tests are not statistically significant, we can accept that the estimated models have a good fit and are therefore suitable for policy formation and implementation. Given these conditions, our post-estimation tests yield mixed results. While the models suffer from normality problem, they, however, pass other diagnostic tests such as serial correlation test, heteroscedasticity ARCL LM test and Ramsey RESET test. Most of the CUSUM tests show that the models are stable, while CUSUM square tests show otherwise.

Robustness check: symmetric and asymmetric responses of unemployment to changes in oil prices (with structural break)

In this section, a robustness check analysis is conducted to account for structural break in the two models of ARDL and NARDL made up of real Brent oil price–unemployment model and real WTI oil price–unemployment model. As the dates picked for individual series from the Zivot–Andrews unit root tests vary, attempts are made to estimate the endogenous structural break for each model. Consequently, we estimate a robust ordinary least squares (OLS) and compute supremum Wald test proposed by Andrews [10] and Andrews and Ploberger [11]. The null hypothesis of supremum Wald test is that there is no structural break. This null hypothesis is tested against alternative hypothesis which states that there is structural break. The results of this exercise are

⁵ We used asterisks to denote the level of significance.

put in Table 8 in the Appendix. For real Brent oil price–unemployment model, the structural break occurs in the second of 1993, while in the real WTI oil price–unemployment model, a structural break takes place in the fourth quarter of 1995. The periods before these breaking point dates take zero value, while the periods afterwards take one value. The structural breaking point analysis is conducted at both intercept and slope. Using parsimonious approach, the most insignificant slope structural break variables are removed. The results of these exercises are presented in Table 5 for linear and nonlinear ARDL models of real Brent oil price–unemployment nexus and real WTI oil price–unemployment nexus, respectively.

The results in Table 5 show that accounting for structural break has little or no effect on the main results. In other words, the results are similar to those obtained when there was no provision for structural breaks (Table 4). For instance, in linear ARDL model for oil prices–unemployment relations, an increase oil prices still has a positive effect on unemployment rate in the short run and insignificant mixed results in the long run. With regard to the results of NARDL for both relations, short-run results show that both increases (positive and negative) in real oil prices (Brent or WTI) have positive effects on unemployment which suggests that there is no significant difference in the effect of an increase or decrease in oil prices on unemployment. However, as in the main results (Table 4), the positive impact of increase in oil prices on unemployment is statistically significant in the short run. Similar results are also observed in the main analysis, albeit with a slight difference in the long run. While an increase in oil prices continues to exert a positive effect on unemployment in the long run, the positive effect is only statistically significant in the model of real Brent oil price–unemployment relation. The negative effect of decrease in oil prices on unemployment is only statistically significant at 10% in the model of real WTI oil price–unemployment relation.

Discussion

This section focuses on the discussion of and provision of justification for our empirical findings. In this study, we have examined the symmetric and asymmetric nexus between changes in oil prices and unemployment using the instrumentalities of ARDL and NARDL techniques developed by Pesaran et al. [49] and Shin et al. [57], respectively. Briefly, ARDL results showed that an increase oil prices has a positive effect on unemployment rate in the short run with varying degrees of level of significance. However, in the long run an increase in oil prices reduces unemployment, albeit the negative effect of an increase in oil prices on unemployment is found

Table 5 Linear and nonlinear ARDL models of unemployment effect of oil price change with structural break. Source: Computed by the authors

Variable	Real oil price (Brent)		Real oil price (WTI)	
	ARDL	NARDL	ARDL	NARDL
d(lunempl_1)	0.452***	0.429***	0.415***	0.378***
d(lropbtr)	0.100**			
d(lropbtr_pos)		0.069*		
d(lropbtr_neg)		0.108*		
d(lrwti)			0.048	
d(lrwti_pos)				0.026
d(lrwti_neg)				0.083*
d(lrgdp)	−1.267***	−1.091**	−0.148	−0.221**
d(lcpi)	0.065	−0.114	−0.825***	−0.908***
d(lrate)	0.007	0.009	0.010**	0.009**
d(fdi)	−0.017	−0.013	0.024**	0.020*
d(z)	−1.425***	−1.375***	−0.397*	0.200***
d(z(-1))	0.198			
d(zlcp_i)			0.132**	
d(zlrate)	0.024***	0.024***	0.009*	
d(zfdi)	0.133***	0.123***	0.029**	0.035***
d(zfdi(-1))	−0.065***	−0.040***		
ect(-1)	−0.100***	−0.118***	−0.082***	−0.138***
c	23.454	52.532**	57.642	136.880*
lropbtr	0.093			
lropbtr_pos		0.584*		
lropbtr_neg		−0.011		
lrwti			−0.197	
lrwti_pos				0.514
lrwti_neg				−0.988*
lrgdp	−0.647	−1.636**	−1.803	−4.398*
lcpi	1.333***	0.567	0.525	0.235
lrate	−0.147***	−0.112***	−0.047	−0.089*
fdi	−0.173	−0.112	−0.125	−0.240
z	−7.916***	−5.735***	−8.681***	−2.745
zlcpi			1.602**	
zrate	0.250***	0.206***	0.114*	
zfdi	0.297	0.158	0.355*	0.698**
R-squared	0.9950	0.9950	0.9961	0.9961
Adjusted R-squared	0.9944	0.9944	0.9956	0.9957
F-statistic	1543.155 (0.0000)	1547.594 (0.0000)	2069.358 (0.0000)	2227.723 (0.0000)
Durbin–Watson stat	2.110	2.028	1.895	1.820
ARDL bounds test	3.064*	3.630**	3.489**	3.804**
<i>Diagnostic tests</i>				
Jarque–Bera	114.176 (0.0000)	133.367 (0.000)	162.823 (0.0000)	216.905 (0.0000)
B–G serial corr. LM test	0.670 (0.5136)	0.849 (0.4299)	0.776 (0.3802)	2.463 (0.1190)
ARCH LM test	1.1092 (0.2939)	0.623 (0.4311)	1.488 (0.2294)	1.532 (0.2198)
Ramsey RESET test	0.1402 (0.8887)	0.790 (0.3758)	0.059 (0.9531)	0.004 (0.9970)
CUSUM test	Stable	Stable	Unstable	Unstable
CUSUM square test	Unstable	Unstable	Unstable	Unstable

Table 5 (continued)

***, ** and * denote the 1%, 5% and 10% levels of significance, respectively

to be statistically insignificant. It appears that the results obtained from the NARDL models seem to present some sort of true picture of the effect of oil prices on unemployment. In the short run, the NARDL results show that an increase and a decrease in oil prices (Brent or WTI) have a positive effect on unemployment. This suggests that there is no evidence of asymmetric effect of oil prices on unemployment rate in Nigeria since it is impossible to distinguish between the effects of an increase in oil prices on unemployment and the effects of a decrease in oil prices on unemployment. In the long run, the NARDL results show that the impact of an increase in oil prices on unemployment, in most cases, is quite different from the effect of a decrease in oil prices on unemployment. Precisely, an increase in oil prices worsens unemployment, while a decrease in oil price on reduces unemployment. Comparing the findings in this study with those of recent studies on other oil-producing or oil-exporting countries, it is found that similar empirical findings have been documented for other oil-exporting countries of MENA extraction by Cheratian et al. [20]. While explaining the reasons behind what appears to be surprising findings (especially with respect to the positive effect of oil prices on unemployment), Cheratian et al. [20] attributed their findings to the problem of Dutch disease syndrome bedevilling many resource-endowed countries, especially oil-producing countries. Empirical evidence also abounds of the existence of Dutch disease syndrome in many oil-exporting countries ([44] for Russia; [36] for Iran; [47]; [2] for the Kingdom of Saudi Arabia). In fact, since the discovery of crude oil in 1956 at Oloibiri in Bayelsa State (Nigeria) and its commercialisation in the late 1960s, the fortunes of other sectors such as agricultural and manufacturing sector in terms of their contributions to the economy had declined (see [52]).

As stressed earlier in the Introduction section, the findings in this study can be further explained from two perspectives. Nigeria is a net oil-exporting country, exporting crude oil and importing refined petroleum products. For being an oil-exporting country, any fluctuation in oil price has a negative effect on the economy over the years as documented in a number of studies (see [8]). On the one hand, an increase in oil price should ordinarily bring additional revenue to the government to finance infrastructural development that can sort of guarantee a sustainable economic growth and development. Given the fact that the government is also an employer of labour, particularly in the formal sector, it is expected that such an increase should trigger employment creation.

However, mismanagement of oil revenue over the years has led to inadequate infrastructural facilities, stunted or unstable economic growth and high rate of unemployment in the country. On the one hand, a decrease in oil prices in the international market has been associated with economic recession in the country [8]. The channel through which this occurs is that a decrease in oil price leads to a reduction in accrued oil revenue and government expenditure. Since the economy is a monoculture one, a fall in government revenue constrains the government ability to investment in key infrastructural facilities and this may instigate economic downturn. A case in point was the litany of problems associated with the 2016 economic recession in the country. It is on record that when oil price collapsed in the middle of 2014 from 109.78\$/barrel to about 53.93\$/barrel in the first quarter of 2015, economic growth eventually contracted in 2016 by 1.617%. Since high rate of unemployment is often associated with economic recession, unemployment figure rose from 25.10% in 2014 to 31.20% in 2016.

As an importer of refined petroleum products, the country imports these products because of inadequate domestic refining capacity. While the four local refineries have the capacity to produce about 446,000 bpd, annual domestic demand for petroleum products is about 4,455,000 bpd [45]. Thus, about 80% of petroleum products, a local demand, are imported from other countries. Apart from this, the country is battling energy crisis with electricity generation revolving around 4000 megawatts over the years. The consequence of this is the epileptic or erratic supply of electricity that has crippled or led to the extinction of many businesses/firms in the formal and informal sectors. Most of these businesses or firms are employers of labour in the country, and they depend to a large extent on imported refined petroleum products to power their generating plants. Hence, an increase in the price of crude oil in the international market will lead to an increase in the price of refined products which will then be passed down to the domestic firms. The inevitable increase in the price of refined petroleum will negatively affect the firms, and this can be in the forms of reduction in their outputs, profits and investment and in the end labour employment can as well be badly affected.

Conclusion

Despite the fairly large number of empirical studies that have been conducted on the relationship between oil price changes, shocks or fluctuations and macro-economic variables, little attention has been paid to an investigation into how the oil price shocks in the international market affect the unemployment rate, especially in Nigeria. It is against this backcloth that this study is conducted to examine whether the relationship between

the unemployment rate and oil prices (nominal and real oil prices) is symmetric or asymmetric. To achieve this objective, ARDL and NARDL estimation methods are used. The results from the linear ARDL show that a change in oil price has little or no effect on unemployment rate, particularly in the long run. The results of the NARDL models show that it is practically impossible to distinguish the effect of an increase in oil price on unemployment from that of a decrease in oil price in the short run as both have positive effects on unemployment irrespective of measures of oil prices used. In the long run, however, an increase in oil prices has a positive effect on unemployment, while a decrease in oil price has a negative effect on unemployment. The negative effect is not statistically significant. Aside from this, the asymmetric nexus between oil prices and unemployment is only confirmed in the long run. The results of bounds testing approach to cointegration reveal that cointegration exists between oil prices and unemployment including other control variables. Incorporating structural breaks into the ARDL and NARDL models (at intercept and slope) to add robustness to the analysis shows no improvement in the results obtained.

Against the background of the results from the models, two concluding remarks can be offered. First, the scope of this study is limited to an examination of symmetric and asymmetric effects of oil prices on unemployment in Nigeria. There is a need to extend the study in several ways. Accordingly, future studies should focus on investigating the role of institutional structure that can affect the relationship between oil prices and unemployment. Also, the impact of changes in oil prices on the components of (un)employment, especially sectoral employment and gender unemployment, can be investigated.

Second, since a rise in oil price brings in more revenues to the government, it is important that the government channels realised fund from the sales of crude oil into investment in critical infrastructure facilities such as the building of more energy plants to improve electricity generation in the country. Aside from this, there is a need to prioritise other sources of energy such as wind, solar and others with the goal to ensure that more sources of energy are available for use, not only for the big firms but also for the business community. However, if the government alone cannot guarantee sufficient provision of this infrastructure, public–private–partnership arrangement can be entered into either with local or international

agencies or even between private organisations and government that will form a synergy to ensure the provision of alternative sources of energy. When this is done, the cost of production of the firms will drastically reduce, production will soar and unemployment will also reduce greatly.

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Authors' contributions

IAR addressed the issues raised by the reviewers. AA proofread and edited the revised version of the manuscript. AOF provides guidelines on how to address the issues raised by the authors. He also proofread and edited the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The data would be made available during the submission of the article. The unemployment data were sourced from National Bureau of Statistics various years, and it is compiled by the authors. Oil prices data are sourced from World Bank Commodity Price Data Sheet and St Louis FED database (<https://www.worldbank.org/en/research/commodity-markets>). The rest of the variables used in this study are sourced from World Development Indicators (<https://datacatalog.worldbank.org/dataset/world-development-indicators>).

Competing interests

There is no conflicting interest among the authors.

Appendix

See Tables 6, 7 and 8.

Table 6 Meaning of some acronyms. *Source: Computed by the authors*

Abbreviation	Full meaning
ARCH LM test	Autoregressive conditional heteroscedasticity LM test
ARDL	Autoregressive distribution lag
B-G serial Corr. LM test	Breusch–Pagan serial correlation LM test
ECM	Error correction model
FDI	Foreign direct investment
NARDL	Nonlinear autoregressive distribution lag
OPEC	Organisation of petroleum exporting countries
SVAR	Structural vector autoregressive
WTI	West Texas international

Table 7 Correlation analysis results. Source: Computed by the authors

Brent oil price–unemployment nexus model						
Variables	lnempl	lropbrt	lrgdp	lcpi	lrate	fdi
lnempl	1.000					
lropbrt	0.349*** (0.000)	1.000				
lrgdp	0.861*** (0.000)	0.388*** (0.000)	1.000			
lcpi	0.775*** (0.000)	0.012 (0.883)	0.874*** (0.000)	1.000		
lrate	0.057 (0.474)	− 0.578*** (0.000)	0.138* (0.082)	0.439*** (0.000)	1.000	
fdi	− 0.019 (0.812)	− 0.278*** (0.000)	0.059 (0.456)	0.246*** (0.002)	0.595*** (0.000)	1.000
WTI oil price–unemployment nexus model						
	lnempl	lropwtl	lrgdp	lcpi	lrate	fdi
lnempl	1.000					
lrwti	0.547*** (0.000)	1.000				
lrgdp	0.872*** (0.000)	0.479*** (0.000)	1.000			
lcpi	0.742*** (0.000)	0.229*** (0.005)	0.908*** (0.000)	1.000		
lrate	− 0.151* (0.067)	− 0.481*** (0.000)	0.043 (0.604)	0.258*** (0.002)	1.000	
fdi	− 0.173** (0.035)	− 0.140* (0.089)	− 0.006 (0.943)	0.098 (0.237)	0.538*** (0.000)	1.000

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 8 Computation of unknown structural break date.
Source: Computed by the authors

Variable	Coefficient
<i>Brent oil price-unemployment nexus model</i>	
Constant	-29.132***
lropbtr	0.099
lrgdp	1.007***
lcpi	0.163***
lrate	-0.020*
fdi	-0.042
Test for a structural break: Unknown break date-Ho: no structural break	
Full sample: 1979q1–2018q4	
Trimmed sample: 1985q1–2013q1	
Estimated break date: 1993q2	
Test statistic <i>p</i> value	
Supremum Wald test 697.143 0.0000	
<i>WTI oil price-unemployment nexus model</i>	
Constant	-44.001***
lrwti	0.184**
lrgdp	1.504***
lcpi	-0.004
lrate	-0.015
fdi	-0.080**
Test for a structural break: Unknown break date-Ho: no structural break	
Full sample: 1982q1–2018q4	
Trimmed sample: 1987q4–2013q2	
Estimated break date: 1995q4	
Test statistic <i>p</i> value	
Supremum Wald test 685.240 0.0000	

****p* < 0.01; ***p* < 0.05; **p* < 0.1Received: 14 August 2019 Accepted: 13 August 2020
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