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Modelling oil price-inflation nexus: The role of asymmetries and structural breaks

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Abstract

In this paper, we model the relationship between oil price and inflation for selected OPEC and EU countries using monthly data from 2000 to 2014. We employ both the Linear (Symmetric) ARDL by Pesaran et al. (2001) and Nonlinear (Asymmetric) ARDL by Shin et al. (2014) and we also account for structural breaks using the Bai and Perron (2003) test that allows for multiple structural changes in regression models. Six findings are discernible from our analyses. First, the relationship between oil price and inflation tends to change over short periods. Secondly, the oil price-inflation nexus is stronger in oil exporting countries than oil importing countries. Thirdly, oil price asymmetries seem to matter more when dealing with oil exporting nations. Fourthly, it may be necessary to pre-test for structural breaks when modelling the relationship between oil price and inflation regardless of the category being analyzed. Fifth, while asymmetric effect for the oil exporting (OPEC) is not sensitive to structural breaks, the effect seems to diminish for oil-importing (EU) countries in the presence of breaks. Sixth, while the results are largely insensitive to the nature of data frequency, the behaviour of asymmetry suggests otherwise.

Key words: Oil price, Inflation, Asymmetry, Structural breaks, Linear ARDL, Non-linear ARDL

JEL Classification: C12, C22, E31

1.0 Introduction

The relationship between oil price and consumer price index has continued to generate debate both in the academic, business and policy circles. There are several reasons justifying the keen interest in the nexus. Oil serves as a major input in the economy - it is used in critical activities such as fuelling transportation [in form of gasoline for automobiles and jet fuel for air transport] and heating homes. Therefore, if input costs rise, the costs of end products are expected to follow suit. For example, if the price of oil rises, then, transportation and other related costs of conducting businesses/economic activities will increase which ultimately will be passed onto the final consumers. In essence, the producers are confronted with higher costs of production and the consumers are affected in form of higher prices on final goods and services when there is an increase in oil price.

From the policy perspective, there are compelling reasons for the analysis of oil price-inflation nexus. First, monetary policy authorities are concerned about ensuring price stability and therefore, they are constantly under pressure to understand and deal with macroeconomic shocks [both internal and external] that may affect the actualization of their mandate. Thus, knowledge of the inflationary effects of oil price shocks by relevant authorities will assist in the coordination of policies to accommodate these shocks when they arise. Secondly, inflation is considered as a prominent measure of macroeconomic stability in an economy and foreign investors often reflect this factor among others when making investment decisions. Thus, it becomes imperative for both fiscal and monetary authorities of an economy to promote price stability in order to attract substantial investments. In any case, as long as crude oil is considered a major input in an economy, discussions on the inflationary effects of oil price will remain prominent among policy makers.

Interestingly, several studies have empirically evaluated the nexus between oil price and inflation covering different regions and using different methodological approaches. Quite a reasonable number of them are reviewed in this paper [see

Section 3.0] and we find that the results are mixed. For instance, studies such as Baffles (2007), Bachmeier and Cha (2011), Ajmera et al. (2012), Nixon and Smith (2012) and Gao et al. (2014) find that oil prices can exert significant influences on inflation. On the other hand, some studies have found declining oil price pass-through to inflation [see for example, Hooker, 2002; Barsky and Kilian, 2004; LeBlanc and Chinn,2004; Gregario et al., 2007; van den Noord and Andre, 2007; Bachmeier et al., 2008; and Chen, 2009]. Factors such as the nature of countries analysed, the underlying statistical properties of the series, the models estimated, data coverage and estimation techniques employed may be responsible for the mixed findings [see also Cartwright and Riabko, 2015].

In this paper, we revisit the literature on oil price-inflation nexus from the following viewpoints. First, we consider both oil exporting (OPEC) and oil importing (EU) countries in order to gauge the nature of the nexus under the two categories. Secondly, we also account for asymmetries in the model using the nonlinear autoregressive distributed lags (NARDL) approach proposed by Shin et al (2014). The main advantage of this model lies in its ability to simultaneously capture the short- and long-run asymmetries through positive and negative partial sum decompositions of changes in the independent variable(s) which is oil price in this case [see Van Hoang et al., 2016]. In addition, the approach is less computationally intensive and also has computational advantages over other models [such as the Bayesian VECM or various other specifications of the error-correction models and smooth transition autoregressive models] particularly in terms of dealing with time series of different orders of integration. Nonetheless, we also consider the symmetric version of the Shin et al (2014) developed by Pesaran et al (2001) in order to justify whether asymmetry matters for oil price-inflation nexus. Thirdly, we modify the Shin et al. (2014) to account for structural breaks in the model as there appears to be evidence of some notable shifts in the series [see Figures 1 and 2]. Ignoring these breaks when they exist may bias regression results [see Salisu and Oloko, 2015]. The breaks are determined endogenously using the Bai-Perron (2003) test which allows for up to five (5) breaks in the test regression. The breaks obtained are included in the regression model to capture any possible shift that may bias the model. In all, we are able to estimate four regressions: (i) Symmetric ARDL without structural breaks (Model I); (ii) Asymmetric ARDL without structural breaks (Model II); (iii) Symmetric ARDL with structural breaks (Model III); and (iv) Asymmetric ARDL with structural breaks (Model IV). By symmetric impact, we mean identical impact of positive and negative changes in oil price on inflation. However, in the case of asymmetry, the impact is assumed to differ between positive and negative changes in oil price. In other words, the asymmetric model is used to test whether inflation reacts more to increases (decreases) than to decreases (increases) in the price of oil.

Dealing with asymmetry and structural breaks when modelling with oil price is becoming a standard practice. This may not be unconnected with the nature of the series as it is found to respond to supply shocks [which may arise as a result of political tensions in the oil producing nations] and demand shocks [possibly due to global economic crises]. For instance, political and economic crises [in the last four decades or so] such as the1973 Yom Kippur War, 1979 Iranian revolution (Iran-Iraq war), 1990 Iraq-Kuwait war, War on terror due to US September 11, 2001 terrorists attack with attendant invasion of Iraq in 2003, 2004/2005 OPEC's agreement to reduce official production, 2007 global financial crisis, and the current civil unrest in the middle east have been documented to have influenced the behaviour of oil price globally [see Noguera, 2013; Salisu and Fasanya, 2013; and Narayan and Liu, 2015]. Therefore, oil price is expected to exhibit significant structural breaks.

Also, the issue of asymmetry in oil price modelling has attracted the attention of researchers. Recent papers dealing with asymmetries in oil price modelling include Honarvar (2009) [with focus on retail gasoline and crude oil price movements], Herrera et al (2015) and Nusair (2016) [modelling oil price and the macroeconomy], Malikov(2016) [with focus on dynamic responses to oil price shocks], Venditti (2013) [dealing with oil and consumer energy prices], Bastianin et al. (2014) and Qin et al.

(2016) [with emphasis on oil-gasoline markets]. However, papers involving asymmetries and structural breaks jointly in oil price-inflation nexus are non-existent to the best of our knowledge. And if at all they exist, our analyses are more likely to be deeper and innovative in terms of choice of modelling approach and countries analysed. Also, as part of our robustness checks, we consider different data frequency in order to verify whether the estimates obtained are not sensitive to the nature of data frequency. All these considerations put together further strengthen the validity of statistical and economic inferences drawn from our results.

We structure the rest of the paper as follows. The next section explains the theoretical framework for the oil price-inflation nexus. Section 3 provides a review of the empirical literature. Section 4 analyses the methodology of this paper including data issues and preliminary analyses. In Section 5, we present and discuss our regression results including diagnostics and robustness tests. Section 6 concludes the paper.

2.0 Theoretical Framework

In analyzing oil price - inflation pass through, we modify the modern Keynesian formulation of the short-run aggregate supply, that is, the short run Phillip curve equation. This model is particularly chosen to define the short run relationship between output gap and inflation rate rather than imposing perfectly inelasticity restriction as suggested by the long run Phillip curve. Romer (1996) specifies the short run Phillip curve as below:

$$\pi_t = \pi_{t-1} + \lambda(InY - In\overline{Y}) + \varepsilon_t^s, \quad \lambda > 0$$

Where $\pi_t \equiv InP_t - InP_{t-1}$ is inflation, $(InY - In\overline{Y})$ is the output gap, and ε_t^s is the aggregate supply curve. The positive *a priori* of λ implies a positive relationship between output gap and inflation. Thus, inflation is expected to rise in the short run if actual output is greater than the expected output; or in other words, if unemployment is lesser than the natural rate of unemployment.

Meanwhile, in order to examine the oil price – inflation pass through, this model is modified to include oil price and the augmented lags values of the explanatory variables. Following Çatik and Önder (2011), the oil price augmented backward looking Phillip curve is specified as:

$$\pi_t = \Psi(L)\pi_t + \Upsilon(L)y_t + \Phi(L)\Delta oil_t + \varepsilon_t^s$$

Where $\Psi(L)$, $\Upsilon(L)$, and $\Phi(L)$ are the polynomial in the lag operator (L) of inflation rate, output gap and oil price inflation respectively. The estimated coefficients of all parameters; Ψ, Υ, and Φ are expected to be positive [see also, Çatik and Önder, 2011], while specifically, the magnitude of the coefficient of Φ depends on the structure of the economy [see Marquez, 1984]. In Marquez (1984), the world economy is classified into three, namely, the developed economies, the OPEC countries and the non-OPEC developing economies; and the effect of oil price pass through to inflation rate is expected to manifest differently on each category of the economy. However, one may argue based on the analysis of exchange rate pass-through effect that the magnitude of the coefficient of change in oil price Φ would range between 0 and 1, with the two extreme cases representing no pass-through effect and complete pass-through effect respectively. The closer the coefficient to 0, the lower the degree of oil price pass-through. However, the degree of oil price pass-through is higher as the coefficient tends towards 1.

3.0 Empirical Review

Several studies have been carried out on the effect of oil price on the aggregate economy [see for example, Hamilton, 1983; Papapetrou, 2001; Barsky and Kilian, 2004] and their findings are mixed. While Hamilton (1983) and Papapetrou (2001) find evidence of significant impact of oil price on the macro economy; Barsky and Kilian (2004) find oil price to be less important. However, in recent times, specific studies have been conducted on the impact of oil price changes on inflation.The term often referred to as oil price pass-through, has been analyzed empirically for the global economy [using aggregate values] [see Atil et al., 2014 and Wang et al., 2014] and for different countries [see for example, Chou and Lin, 2013 and Gao et al., 2014] using different analytical techniques. Meanwhile, for the study on the global economy, the impact of oil price changes is only observed on other internationally traded commodities such as Gasoline and Natural gas prices [Atil et al., 2014] and Agricultural commodity prices [Wang et al., 2014]. The country-specific studies on the other hand have increased over time. On developed economies for instance, Chen (2009) analyzed oil price pass-through for 19 industrialized countries;Valcarcel and Wohar (2013) and Gao et al. (2014) did for the US; Valadkhani (2014) considered both Canada and the U.S. while Cartwright and Riabica (2015) examined both the U.S. and France. Studies on emerging economies include the work of Lu et al. (2010) and Chou and Lin (2013) for Taiwan; Ibrahim and Chanchaoroenchai (2014) for Thailand; Çatik and Önder (2011) for Turkey; and Zhao et al. (2014) for China.

Furthermore, different econometric models have been used to analyse oil price pass-through. For instance, Lu et al. (2010) and Cartwright and Riabica (2015) adopted the bivariate BEKK GARCH and Diagonal GARCH models respectively whileAtil et al. (2014) and Chou and Lin (2013) employed the Nonlinear ARDL and Nonlinear ECM respectively. Other methodologies that have been adopted in the literature include; Markov Regime Switching model by Çatik and Önder (2011) and Valadkhani and Wohar (2013); Symmetric and Asymmetric Cointegration and ECM by Ibrahim and Chanchaoroenchai (2014); Dynamic Stochastic General Equilibrium (DSGE) model by Zhao et al. (2014); Vector Autoregression (VAR) by Gao et al. (2014); Structural VAR (SVAR) by Wang et al. (2014) and Bayesian SVAR by Valcarcel and Wohar (2013). The few papers that have employed the Nonlinear ARDL of Shin et al. (2014) are Van Hoang et al (2016) to analyse gold-inflation nexus and Nusair (2016) to examine oil price-growth relationship. With respect to oil price-nexus however, this paper seems to be the first to employ this novel methodology. In addition, we account for endogenous structural breaks in the NARDL and we further test whether their inclusion matters for oil price-inflation nexus.

In addition, various studies in the literature have used different proxies such as the WTI, Average global oil price and Brent oil price, for oil price; while aggregate and disaggregated consumer and producer price indexes have also been used as proxies for CPI inflation. Although, the results are mixed; however, the existence of oil price pass-through seems more prominent in the literature [see for example, Lu et al., 2010; Chou and Lin, 2013; Gao et al. 2014; and Ibrahim and Chanchaoroenchai, 2014].The few studies involving asymmetries report asymmetric effect in the oil price pass-through [see Çatik and Önder, 2011; Valadkhani and Wohar, 2013; Atil et al. 2014].

4.0 Methodology and Data

4.1 Methodology

As earlier mentioned, we consider the NARDL approach of Shin et al (2014) to model the relationship between oil price and inflation. Van Hoang et al (2016) highlight some of the advantages of using the NARDL approach as follows. First, it allows modelling the cointegration relation that could exist between the dependent and independent variables. Second, it permits to test both the linear and nonlinear cointegration. Third, it distinguishes between the short- and long-run effects from the independent variable to the dependent variable. Of course, these advantages may also be valid for nonlinear threshold Vector Error Correction Models (VECM) or smooth transition models; however, these models may suffer from the convergence problem due to the proliferation of the number of parameters. This is not the case with the NARDL model. Fourth, unlike other error correction models where the order of integration of the considered time series should be the same, the NARDL model relaxes this restriction and allows combining data series having different integration orders.

Nonetheless, for the purpose of robustness, we consider four regressions namely symmetric ARDL with and without breaks and asymmetric ARDL with and without structural breaks. We take each of these specifications in turn.

I. *Symmetric ARDL Model without Structural Breaks*

The specification of the symmetric ARDL model without structural breaks follows the standard framework of Pesaran et al. (2001) as given below:

$$\Delta p_t = \alpha_0 + \alpha_1 p_{t-1} + \alpha_2 oil_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta oil_{t-j} + \varepsilon_t \quad (1)$$

where p_t is the logarithm of consumer price index used as a proxy for inflation; oil_t is the logarithm of global oil price (proxied by Brent). The long run parameters for the intercept and slope coefficients are computed as $-\frac{\alpha_0}{\alpha_1}$ and $-\frac{\alpha_2}{\alpha_1}$ respectively since in the long run it is assumed that $\Delta p_{t-i} = 0$ and $\Delta oil_{t-j} = 0$. However, the short run estimates are obtained as λ_i and γ_j for inflation and oil price respectively. Since the variables in first differences can accommodate more than one lag, determining the optimal lag combination for the ARDL becomes necessary. The optimal lag length can be selected using Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HIC) or Schwartz Information Criterion (SIC). The lag combination with the least value of the chosen criterion among the competing lag orders is considered the optimal lag. Consequently, the preferred ARDL model is used to test for long run relationship in the model. This approach of testing for cointegration is referred to as Bounds testing as it involves the upper and lower bounds. The test follows an F distribution and therefore, if the calculated F-statistic is greater than the upper bound, there is cointegration; if it is less than the lower bound, there is no cointegration and if it lies in between the two bounds, then, the test is considered inconclusive. In the spirit of our model, the null hypothesis of no cointegration can be expressed as $H_0: \alpha_1 = \alpha_2 = 0$ while the alternative of cointegration is symbolized as $H_1: \alpha_1 \neq \alpha_2 \neq 0$. The Equation (1) can be re-specified to include an error correction term as follows:

$$\Delta p_t = \delta \upsilon_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta oil_{t-j} + \varepsilon_t \quad (2)$$

where $\upsilon_{t-1} = p_{t-1} - \varphi_0 - \varphi_1 oil_{t-1}$ is the linear error correction term; the parameter δ is the speed of adjustment while the underlying long run parameters have been previously defined as $\varphi_0 = -\frac{\alpha_0}{\alpha_1}$ and $\varphi_1 = -\frac{\alpha_2}{\alpha_1}$. Note that in both equations (1) and (2), there are no decompositions of oil price into positive and negative changes; hence, the assumption of symmetric behaviour of oil price on inflation under this scenario.

II. Asymmetric ARDL Model without Structural Breaks

Here, the oil price variable is decomposed into positive and negative changes such that in the analysis, we are able to capture probable asymmetric behaviour of oil price on inflation. The consideration of oil price asymmetry is premised on the fact that economic agents such as households, business entities and government, may respond differently to positive and negative changes in oil price. We have previously highlighted studies that have dealt with asymmetries in oil price although not explicitly for oil price-inflation nexus. However, the approach used here follows the NARDL of Shin et al. (2014) which appears less computationally intensive compared to other asymmetric models and does not require identical order of integration [i.e. *I*(1)] for all the series in the model. The NARDL is given as:

$$\Delta p_t = \alpha_0 + \alpha_1 p_{t-1} + \alpha_2 oil_{t-1}^{+} + \alpha_3 oil_{t-1}^{-} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \left(\gamma_j^{+} \Delta oil_{t-j}^{+} + \gamma_j^{-} \Delta oil_{t-j}^{-} \right) + \varepsilon_t \quad (3)$$

In equation (3), the oil price variable (oil_t) has now been decomposed into oil_t^{+} and oil_t^{-} denoting positive and negative changes of oil price respectively. These decomposed prices are defined theoretically as:

$$oil_t^{+} = \sum_{j=1}^{t} \Delta oil_j^{+} = \sum_{j=1}^{t} \max\left(\Delta oil_j, 0\right) \quad (4)$$

$$oil_t^{-} = \sum_{j=1}^{t} \Delta oil_j^{-} = \sum_{j=1}^{t} \min\left(\Delta oil_j, 0\right) \quad (5)$$

We can re-specify equation (3) to include an error correction term thus:

$$\Delta p_t = \tau \xi_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \left(\gamma_j^{+} \Delta oil_{t-j}^{+} + \gamma_j^{-} \Delta oil_{t-j}^{-} \right) + \varepsilon_t \quad (6)$$

In equation (6), the error-correction term that captures the long run equilibrium in the NARDL is represented as ξ_{t-1} while its associated parameter (τ) [the speed of adjustment] measures how long it takes the system to adjust to its long run when there is a shock. The error correction term can be expressed as $\xi_{t-1} = p_{t-1} - \phi_0 - \phi_1 oil_{t-1}^{+} - \phi_2 oil_{t-1}^{-}$ wherein the parameters $\phi_1\left(= -\dfrac{\alpha_2}{\alpha_1}\right)$ and $\phi_2\left(= -\dfrac{\alpha_3}{\alpha_1}\right)$ represent the long run parameters for positive and negative changes in oil pricerespectively while the short run parameters are γ_j^{+} and γ_j^{-}.

It is important to note here that, just like the linear ARDL, the long run is estimated only if there is presence of cointegration. Thus, pre-testing for cointegration is necessary even under NARDL and this involves the Bounds testing that is*F* distributed. However, the underlying hypotheses for cointegration involve the long run asymmetric parameters. In other words,the null hypothesis of no cointegration expressed as $H_0:\ \alpha_1 = \alpha_2 = \alpha_3 = 0$ is tested against the alternative hypothesis of cointegration given as $H_1:\ \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$. In addition, we also employ the Wald test for testing restrictions to ascertain whether the asymmetries matter both in the long run and short run. For the Wald test, the null hypothesis of no asymmetries - $H_0:\ \alpha_2 = \alpha_3$ (for long run) and $H_0: \sum_{j=0}^{N1} \gamma_j^{+} = \sum_{j=0}^{N2} \gamma_j^{-}$ (for short run) is tested against the alternative of presence of asymmetries - $H_1:\ \alpha \neq_2 \alpha$ (for long run) and $H_1: \sum_{j=0}^{N1} \gamma_j^{+} \neq \sum_{j=0}^{N2} \gamma_j^{-}$ (for short run).

III. Symmetric ARDL Model with Structural Breaks

Under this scenario, we extend the model in (I) [that is equations (1) and (2)] to include endogenous structural breaks. The model is specified below:

$$\Delta p_t = \alpha_0 + \alpha_1 p_{t-1} + \alpha_2 oil_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta oil_{t-j} + \sum_{r=1}^{k} D_r B_{rt} + \varepsilon_t \quad (7)$$

As shown in equation (7), the breaks are captured with the inclusion of $\sum_{r=1}^{k} D_r B_{rt}$ where B_{rt} is a dummy variable for each of the breaks defined as $B_{rt} = 1$ for $t \geq T_{B_r}$, otherwise $B_{rt} = 0$. The time period is represented by $t; T_{B_r}$ are the structural break dates where $r = 1, 2, 3, \ldots, k$ and D_r is the coefficient of the break dummy. All the other parameters have been previously defined. As earlier noted, the Bai-Perron(2003) test which determines breaks endogenously is used. This test is relevant when dealing with models with probable multiple structural changes over time. Apart from computational simplicity, the test allows for up to five (5) breaks in the regression model and is therefore considered a more general framework for detecting multiple structural changes in linear models. We also test for the existence of long run relationship in the presence of structural breaks using the Bounds test. In essence, we are also able to determine long run and short estimates for the oil price-inflation nexus in the presence of structural breaks. In addition, the results obtained are compared with those from equation (1) to see if accounting for breaks in the regression is necessary.Consequently, the Wald test is used to test for the joint significance of structural breaks in equation (7). That is, we test $\sum_{r=1}^{k} D_r = 0$ against $\sum_{r=1}^{k} D_r \neq 0$. The non-rejection of the null implies that structural breaks do not matter in the symmetric case while the rejection suggests the adoption of equation 7 (implying that the breaks are important and shouldbe included in the model).

IV. Asymmetric ARDL Model with Structural Breaks

Like the symmetric case in (III) above, the identified structural breaks are also captured in the asymmetric case. This involves extending equation (3) to include the relevant break dummies. The general framework is given as:

$$\Delta p_t = \alpha_0 + \alpha_1 p_{t-1} + \alpha_2 oil_{t-1}^{+} + \alpha_3 oil_{t-1}^{-} + \sum_{i=1}^{N1} \lambda_i \Delta p_{t-i} + \sum_{j=0}^{N2} \left(\gamma_j^{+} \Delta oil_{t-j}^{+} + \gamma_j^{-} \Delta oil_{t-j}^{-} \right) + \sum_{r=1}^{k} D_i B_{it} + \varepsilon_t \quad (8)$$

All the parameters are as defined earlier. We also conduct structural break test to ascertain the significance of including the breaks in the NARDL model. In addition, we further verify the presence (or otherwise) of long run relationship [using the Bounds test] and asymmetry [using the Wald test] in the presence of structural breaks.

4.2 Data and Preliminary Analyses

A statistical analysis of the CPI of industrialized oil importing countries and OPEC oil exporting countries is rendered here in order to elicit their statistical properties. For the main analyses, we adopt monthly data over a fifteen year period from 01/2000 to 12/2014 which are freely downloadable from the Food and Agriculture Organization of the United Nations (FAO) Statistical database (http://faostat3.fao.org/download/P/CP/E). The quarterly frequency is used for robustness checks. Sixteen (16) industrialized oil importing countries [namely Belgium, Croatia, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden and Switzerland] and seven (7) OPEC oil exporting countries [Algeria, Angola, Ecuador, Iran, Kuwait, Nigeria and Saudi Arabia] are selected for this study due to data availability.

Tables 1 and 2 present the mean, median and standard deviation for the CPI series for the EU and OPEC members respectively. The average CPI of each country over the considered time period is captured by the mean in both tables. Comparing tables 1 and 2, we see that on average, OPEC exporting countries record considerably higher CPI values compared with the industrialized oil importing countries over the sample period. This is supported with a mean group average of 563.0 for the OPEC CPI compared to 123.04 for the industrialized oil importing EU countries. However, this large disparity in mean values may be due to Angola which records a significantly higher CPI figure over the sample period. Hence, a group average is computed 'without Angola' [see Table 2] and the resulting value, although still higher than the EU's, falls considerably. Thus, including the Angola's data in a panel of OPEC countries may bias the estimates.

The standard deviation on the other hand reveals that variations in the CPI of OPEC oil exporting countries far exceed that of the industrialized oil importing nations. More so, the median of the CPI of OPEC oil exporting countries far exceeds that of the industrialized oil importing nations. Thus, on average, OPEC members have witnessed more variations in CPI than their EU counterparts. How much of these variations can be attributed to oil price changes? This is captured in subsequent sections of this paper.

Furthermore, Table 3 presents descriptive statistics of Brent and WTI crude oil prices [measured in U.S dollars]. We see that on average, Brent costs $67.58 while WTI costs $64.70. However, for the benefit of this research, we shall henceforth make use of Brent oil prices for further analyses as it is the most commonly used benchmark for pricing in the crude oil market.

We also evaluate trends in the CPIs of the two categories [OPEC and EU] combined with the oil price using graphical illustrations [see Figures 1 and 2]. Figure 1 depicts logged values of CPI for the selected EU countries graphed against the log of Brent crude oil price over the sample period. Most of the countries depict a steadily growing CPI with prominent positive correlations between the two series. Specifically, the CPIs of Belgium, Croatia, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Poland, Portugal, Spain, and Sweden seem to follow the same trend as the oil price. The few exceptions are Ireland, Netherlands and Switzerland the behaviour between CPI and oil price appears mixed.

Similarly, the Figure 3 presents logged values of CPI of OPEC oil exporting countries plotted against the log of Brent respectively. All the countries show steady increase in CPI over the years with the exception of Ecuador and Iran whose CPI plunged in early 2005 and 2007 respectively. Like the EU, most of the OPEC's CPIs seem to follow a similar pattern as the oil price. These are indications of possible interactions between the oil price and inflation although the extent of these interactions may vary from country to country and region to region.

Table 1: Descriptive statistics for the CPI seriesof Selected EU Countries, Period: Jan 2000 to Dec, 2014.

Countries	Mean	Median	Std. Dev.	Obs
Belgium	120.71	118.65	13.32	180
Croatia	119.78	115.8	15.11	180
Czech Republic	116.76	114.85	11.96	180
Finland	118.51	112.9	13.28	180
France	116.14	114.15	8.7	180
Germany	113.78	109.85	10.11	180
Greece	125.12	125.25	13.44	180
Hungary	162.42	159.7	40.7	180
Ireland	113.34	113.5	5.4	180
Italy	120.44	118.4	11.81	180
Netherlands	100.62	100.8	5.36	180
Poland	119.94	114.95	15.63	180
Portugal	115.03	115.2	6.91	180
Spain	122.5	124.95	13.97	180
Sweden	113.22	108	9.23	180
Switzerland	105.3	105.4	2.5	180
Group Average	123.04	119.88	15.95	180

Source: Computed by the authors

Table 2: Descriptive statistics for the CPI of Selected OPEC, Jan 2000 to Dec 2014

Countries	Mean	Median	Std. Dev.	Obs
Algeria	139.57	125.3	33.82	180
Angola	2926.28	2599.85	2004.92	180
Ecuador	135.37	141.05	22.57	180
Iran	194.69	159.3	103.99	180
Kuwait	139.21	129.1	33.22	180
Nigeria	276.51	240.25	130.7	180
Saudi_Arabia	129.4	119.65	27.9	180
Group Average	563	502.07	336.73	180
Group Average Without Angola	169.125	152.4417	58.7	180

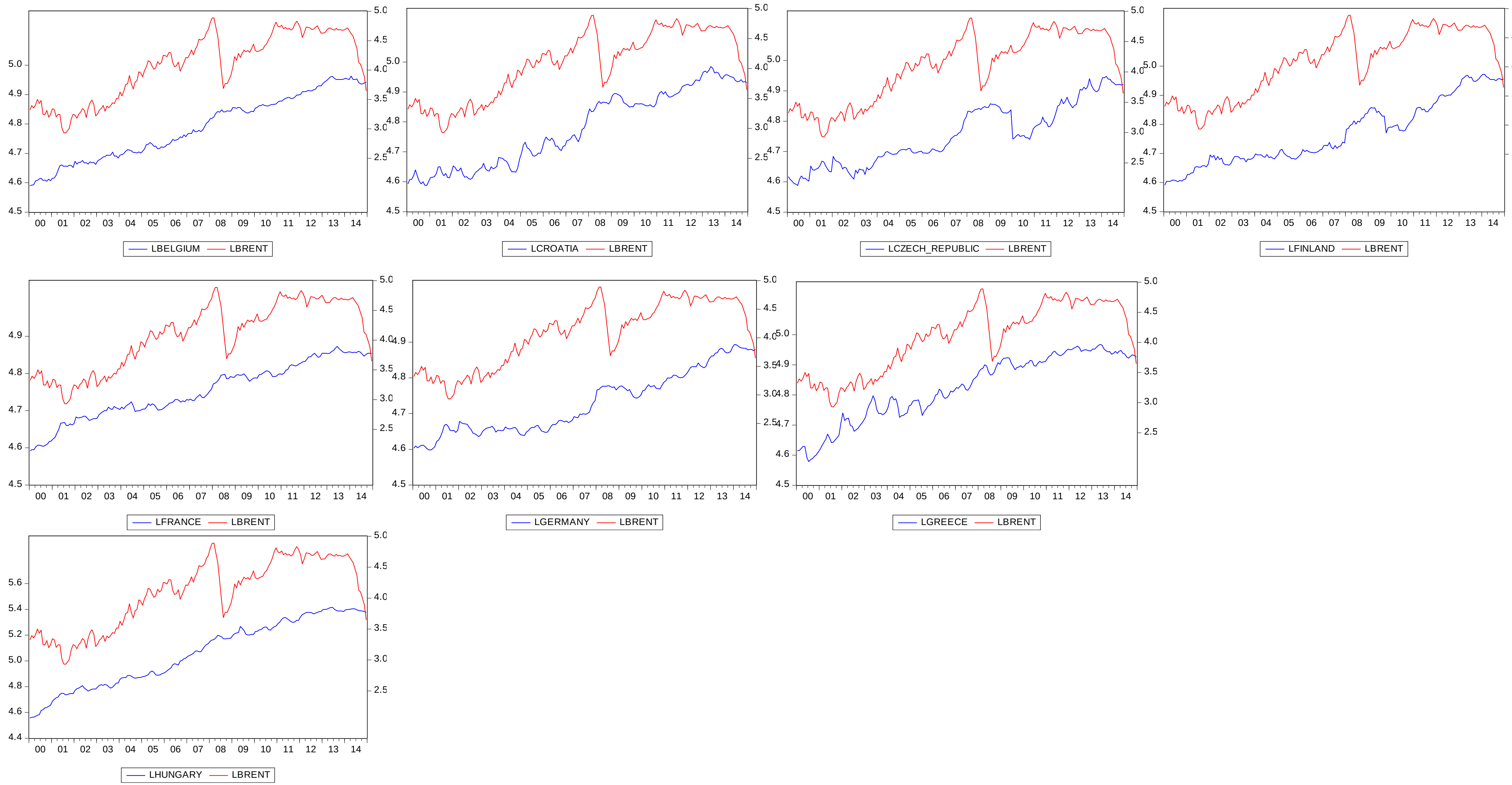
Source: Computed by the authors

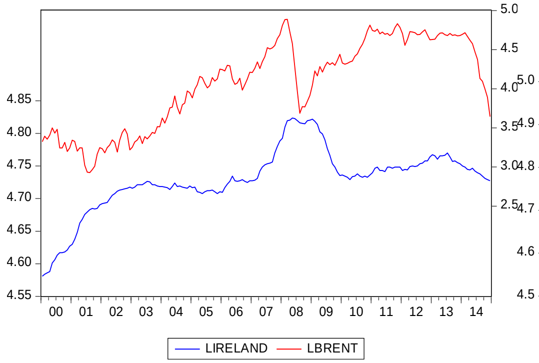
Table 3: Descriptive statistics for Oil Prices, Jan 2000 to Dec 2014

Statistics	BRENT	WTI
Mean	67.58	64.70
Median	64.21	64.57
Std. Dev.	33.18	29.14
Observations	180	180

Source: Computed by the authors

Figure 1: Graphs of log of CPI and log of BRENT crude oil price for individual oil importing countries

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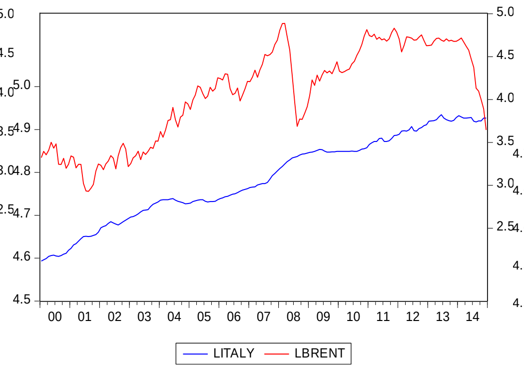
LBRENT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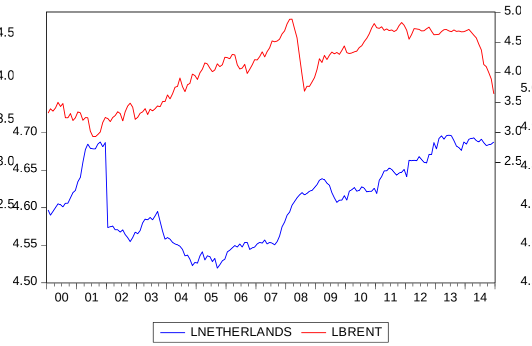
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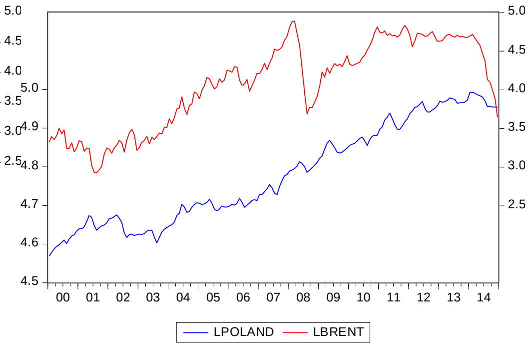
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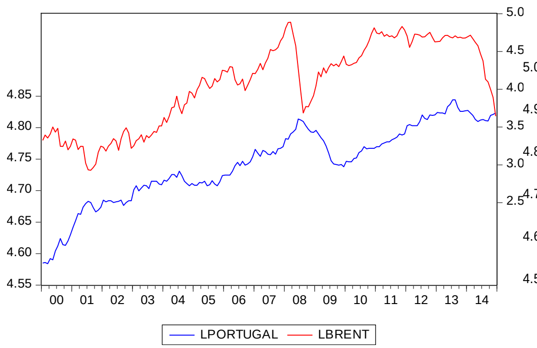
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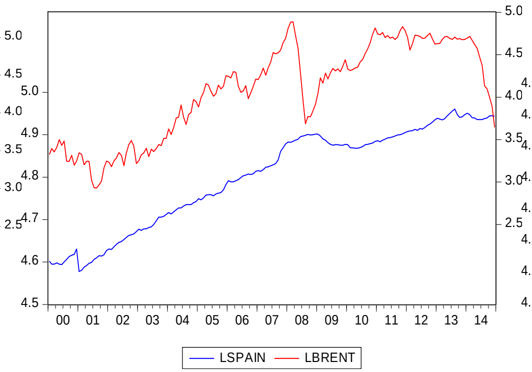
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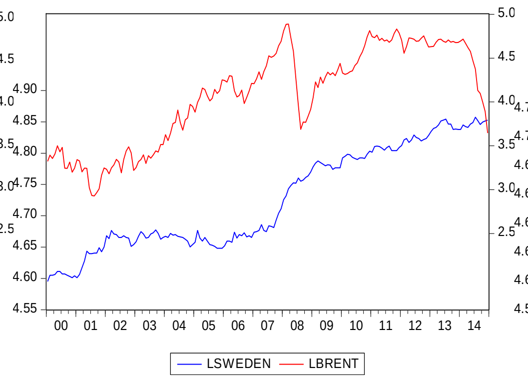
LSWEDEN
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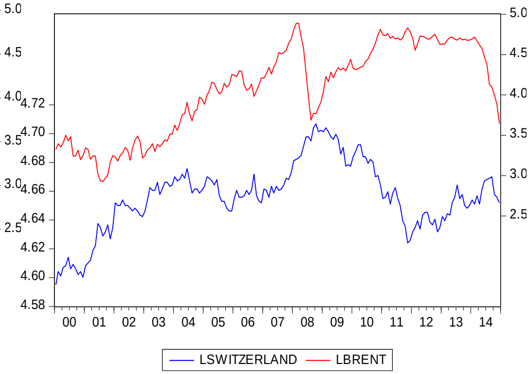
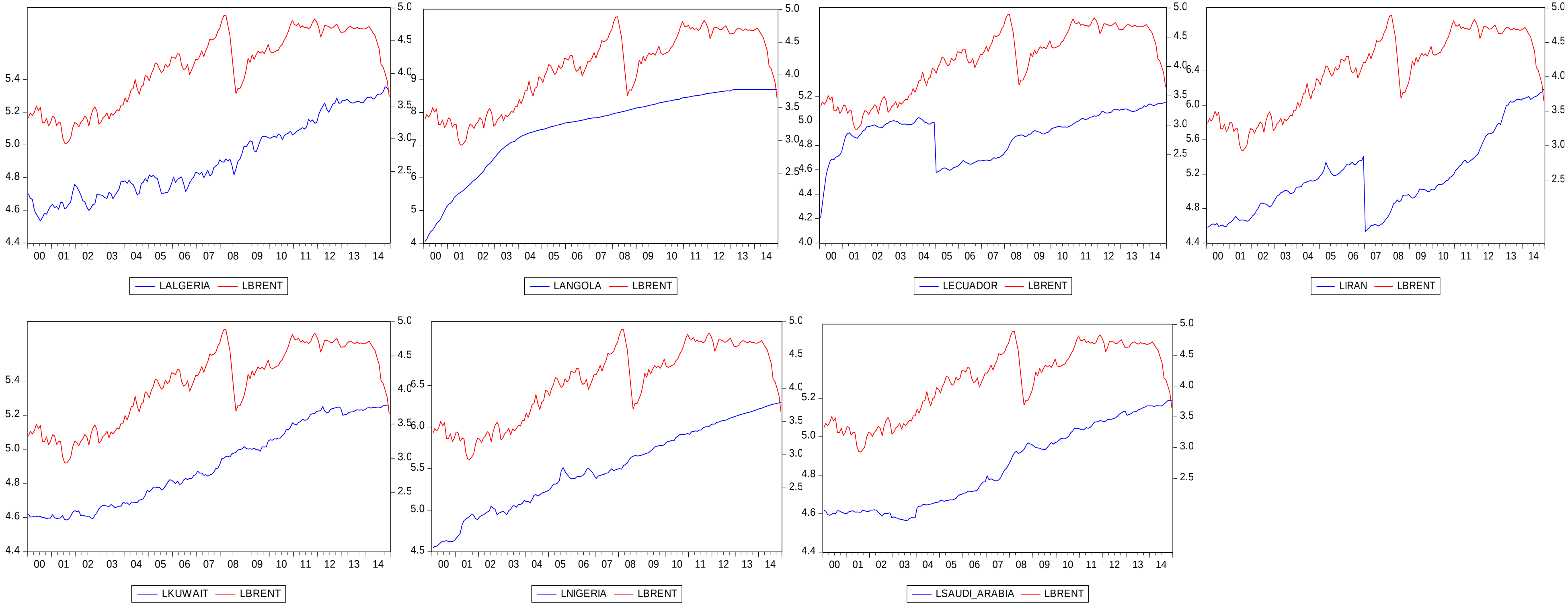

LSWITZERLAND
LBRENT

Figure 2: Graphs of log of CPI and log of BRENT crude oil price for individual OPEC oil exporting countries



As a precondition for most time series analyses, we also subject both the CPI and oil price variables for all the countries to unit root test. We use efficient unit root tests namely Dickey-Fuller GLS test and the Ng-Perron test. We also consider the Perron (2006) unit root test that accounts for structural breaks.The results are presented in Tables 4(a) and 4(b) for log of CPI and log of oil pricerespectively.Expectedly, the integration properties for the log of CPI vary across countries but hover between *I*(0) and *I*(1).Similarly,the oil price proxy exhibits non-stationarity. Thus, our choice of the ARDL framework is further justified by the integration properties exhibited by the variables of interest. In the next section, we discuss the regression results including diagnostics and robustness checks.

Table 4: Unit Root Results

Table 4(a): Log of CPI

Net Oil-Exporting Countries	Unit Root without Structural Break						Unit Root with Structural Break		
	DFGLS			Ng-P			Perron (2006)		
	Level	*First Diff.*	*I(d)*	*Level*	*First Diff.*	*I(d)*	*Break Date*	*Coeff.*	*T-stat.*
Algeria	-1.719[b]	-9.335[b***]	*I(1)*	1.163[a***]		*I(0)*	2005:04	-0.2987	-5.649
Angola	-1.087[b]	-5.550[b***]	*I(1)*	-1.484[b]	-4.383[b***]	*I(1)*	2002:03	-0.0624	-9.769
Ecuador	-0.992[b]	-3.730[b***]	*I(1)*	-0.936[b]	-3.435[b***]	*I(1)*	2004:11	-0.3423	-11.989
Iran	-1.458[b]	-13.557[b***]	*I(1)*	-1.441[b]	-6.668[b***]	*I(1)*	2006:11	-0.4506	-9.313
Kuwait	2.855[a*]		*I(0)*	2.941[a***]		*I(0)*	2002:01	-0.1362	-4.138
Nigeria	2.587[a*]		*I(0)*	2.814[a***]		*I(0)*	2006:08	-0.1450	-3.768
Saudi Arabia	2.615[a*]		*I(0)*	2.862[a***]		*I(0)*	2002:03	-0.0916	-3.667
Oil-Importing Countries									
Belgium	2.820[a***]		*I(0)*	2.935[a***]		*I(0)*	2007:08	-0.1827	-4.334
Croatia	1.677[a*]		*I(0)*	1.816[a*]		*I(0)*	2007:06	-0.1555	-4.177
Czech Rep.	-2.366[b]	-12.036[b***]	*I(1)*	-2.298[b]	-6.636[b***]	*I(1)*	2009:11	-0.1206	-3.417
Finland	-2.691[b*]		*I(0)*	-2.772[b*]		*I(0)*	2007:11	-0.1013	-2.966
France	-1.841[b]	-10.564[b***]	*I(1)*	-1.867[b]	-6.410[b***]	*I(1)*	2004:05	-0.1197	-3.467
Germany	-2.351[b]	-8.744[b***]	*I(1)*	-2.345[b]	-6.120[b***]	*I(1)*	2002:04	-0.0755	-2.888
Greece	-1.502[b]	-2.414[a**]	*I(1)*	-2.158[b]	-6.243[b***]	*I(1)*	2003:04	-0.1646	-3.922
Hungary	-2.214[b]	-2.163[a**]	*I(1)*	-6.792[b***]		*I(0)*	2006:07	-0.1163	-3.789
Ireland	-0.945[b]	-5.465[b***]	*I(1)*	-1.059[b]	-4.756[b***]	*I(1)*	2009:04	-0.0498	-3.305
Italy	2.451[a**]		*I(0)*	2.738[a***]		*I(0)*	2007:07	-0.0496	-2.803
Netherland	-1.423[b]	-12.611[b***]	*I(1)*	-1.403[b]	-6.660[b***]	*I(1)*	2001:11	-0.1541	-5.667
Poland	-3.226[b**]		*I(0)*	-8.460[b***]		*I(0)*	2002:03	-0.1538	-4.492
Portugal	1.505[a]	-11.245[a***]	*I(1)*	1.594[a]	-6.576[a***]	*I(1)*	2008:12	-0.1127	-4.241
Spain	2.068[a**]		*I(0)*	2.250[a**]		*I(0)*	2009:01	-0.1002	-4.247
Sweden	2.158[a**]		*I(0)*	2.238[a**]		*I(0)*	2007:08	0.1063	-4.396
Switzerland	-1.119[b]	-4.731[b***]	*I(1)*	-1.085[b]	-3.695[b***]	*I(1)*	2010:08	-0.1021	-3.366

Note: [a]Indicates a model with constant but without deterministic trend; [b] is the model with constant and deterministic trend. Exogenous lags are selected based on Schwarz Information Criterion. ***, **, * imply that the series is stationary at 1%, 5% and 10% respectively. DFGLS and Ng-p denote Dickey-Fuller_GLS and Ng-Perron Unit Root tests. The null hypothesis for DFGLS and Ng-P and PP is that an observable time series is not stationary (i.e. has unit root). Also, break points/dates as well as the stationarity property of the series using Perron (2006) test are determined via appropriate Critical values from Table 1(e) model 2 in Perron (1997), which are -5.28 and -4.6 for 1% and 5% level of significance respectively.

Table 4(b): Log of Oil Price (USD per Barrel)

Oil Prices	Unit Root without Structural Break						Unit Root with Structural Break		
	DFGLS			Ng-P			Perron (2006)		
	Level	*First Diff.*	*I(d)*	*Level*	*First Diff.*	*I(d)*	*Break Date*	*Coeff.*	*T-stat.*
Brent	-1.891[b]	-6.361[b]***	*I(1)*	-2.043[b]	-5.008[b]***	*I(1)*	2008:02	-0.0891	-2.715

Note: [a]Indicates a model with constant but without deterministic trend; [b] is the model with constant and deterministic trend. Exogenous lags are selected based on Schwarz Information Criterion. ***, **, * imply that the series is stationary at 1%, 5% and 10% respectively. DFGLS and Ng-p denote Dickey-Fuller_GLS and Ng-Perron Unit Root tests. The null hypothesis for DFGLS and Ng-P and PP is that an observable time series is not stationary (i.e. has unit root). Also, break points/dates as well as the stationarity property of the series using Perron (2006) test are determined via appropriate Critical values from Table 1(e) model 2 in Perron (1997), which are -5.28 and -4.6 for 1% and 5% level of significance respectively.

5.0 Discussion of Result

Our discussion of results is partitioned into four as follows based on the motivation for our paper:

(i) The role of asymmetries in oil price-inflation nexus

(ii) The role of structural breaks in oil price-inflation nexus

(iii) The behaviour of asymmetries in the presence of structural breaks

(iv) The nature of relationship between oil price and inflation

Let us consider each in turn.

5.1 The role of asymmetries in oil price-inflation nexus

The results for the joint tests for asymmetries are presented in Tables 5(a) and 5(b) for OPEC and EU countries respectively. The null hypothesis of the test is that the inclusion of partial sums of positive and negative changes in oil price is not significant, and the alternative is that the decomposition of oil price changes matters. We find that asymmetries only matter for two countriesnamely Algeria and Angola(about 30%) among the seven selected OPEC member countries. On the other hand, about three countries [Greece, Poland and Portugal equivalent to 20%] of the sixteen selected (EU) oil importing countries respond differently to positive and negative oil price changes. More noticeably, the recorded asymmetries for oil exporting countries seem consistent both in the long run and short run. This suggests that oil price asymmetries may matter in oil price-inflation nexus when dealing with oil exporting nations. In the case of oil importing nations, the recorded asymmetries are only observed in the short run. In other words, positive and negativeshocks to oil priceseem to matter only in the short run for the affected oil importing countries.

Table 5(a): Asymmetry Wald Test - OPEC

Country	Wald Statistic		Is there Presence of Asymmetry?	
	Short-run	Long-run	Short-run	Long-run
Algeria	4.6748** [0.0320]	3.8240* [0.0521]	Yes	Yes
Angola	4.2892** [0.0398]	4.1468** [0.0432]	Yes	Yes
Ecuador	2.3505 [0.1271]	2.1213 [0.1471]	No	No
Iran	1.8511 [0.1754]	No long run relationship	No	No long run relationship
Kuwait	2.7707* [0.0978]	No long run relationship	No	No long run relationship
Nigeria	1.9359 [0.1659]	1.6439 [0.2016]	No	No
Saudi Arabia	0.0014 [0.9698]	0.0014 [0.9696]	No	No

***, **, and * indicate significance at 1%, 5% and 10% respectively

Table 5(b): Asymmetry Wald Test – EU Members

Country	Wald Statistic		Is there Presence of Asymmetry?	
	Short-run	Long-run	Short-run	Long-run
Belgium	0.8567 [0.3559]	No long run relationship	No	No long run relationship
Croatia	0.2266 [0.6347]	No long run relationship	No	No long run relationship
Czech Rep.	0.4623 [0.4975]	No long run relationship	No	No long run relationship
Finland	0.9912 [0.3209]	No long run relationship	No	No long run relationship
France	2.3352 [0.1283]	No long run relationship	No	No long run relationship
Germany	0.1015 [0.7504]	No long run relationship	No	No long run relationship
Greece	3.1799* [0.0763]	2.6211 [0.1060]	Yes	No
Hungary	0.0103 [0.9193]	0.0102 [0.9197]	No	No
Ireland	0.5291 [0.4680]	No long run relationship	No	No long run relationship
Italy	1.9841 [0.1608]	No long run relationship	No	No long run relationship
Netherlands	0.1281 [0.7208]	No long run relationship	No	No long run relationship
Poland	4.3095** [0.0394]	No long run relationship	Yes	No long run relationship
Portugal	2.7798* [0.0973]	1.9723 [0.1647]	Yes	No
Spain	0.3140 [0.5760]	No long run relationship	No	No long run relationship
Sweden	1.0207 [0.3138]	No long run relationship	No	No long run relationship
Switzerland	0.7570 [0.3855]	No long run relationship	No	No long run relationship

5.2 The role of structural breaks in oil price-inflation nexus

The evaluation of the significance of structural breaks in the oil price-inflation nexus involves a three-step procedure. We first determine the breaks endogenously using the Bai-Perron test; then, we incorporate the break dummies as fixed regressors in both the symmetric and asymmetric ARDL models and thereafter, we use the Wald test to jointly evaluate the statistical significance of the breaks. The results of the Bai-Perron are reported in Table 6 and at least three breaks are recorded for each of the countries analysed. The break dates identified coincide with the 2003/2004 Iraqi invasion, 2004/2005 deliberate reduction of OPEC oil production, 2007/2008 global financial crisis and its aftermath effects between 2009 and 2012.

The results of the post-estimation structural break test are presented in Table 7. For this joint break test, we find that structural breaks matter for oil price-inflation nexus as at least 50% of the countries considered show evidence of structural breaks in the regression. For the OPEC members, four (4) countries [equivalent to about 60%] namely Algeria, Angola, Ecuador and Iran show evidence of structural breaks. In the case of oil importing countries, about eight (8) of them – equivalent to 50% [namely Croatia, Germany, Hungary, Netherlands, Poland, Spain, Sweden and Switzerland] show sensitivity to breaks.

One prominent advantage of using the Bai-Perron test is that it also produces regression results for each of the break ranges identified including the sign, size and statistical significance of relevant variables. The striking evidence from the Bai-Perron regressions is that the oil price-inflation nexus seems to change over short periods [see the Sign column in Table 6]. Therefore, it may be necessary to pre-test for structural breaks when modelling the relationship between oil price and inflation.

Table 6: Bai-Perron (2003) structural break dates

Country	*Breaks*	*Range*	*Sign*	*Country*	*Breaks Period*	*Break Range*	*Sign*	*Country*	*Breaks*	*Range*	*Sign*
Algeria	2002M11	2000M01-2002M10	-	Belgium	2002M04	2000m01-2002m03	-	Ireland	2002m04	2000m01-2002m03	-
	2008M08	2002M11-2008M07	+		2006M03	2002m04-2006m02	+		2007m05	2002m04-2007m04	+
	2012M01	2008M08-2011M12	+		2008M06	2006m03-2008m05	+		2009m08	2007m05-2009m07	-
		2012M01-2014M12	-		2012M02	2008m06-2012m01	+			2009m08-2014m12	+
						2012m02-2014m12	-				
Angola	2002M04	2000M01-2002M03	-	Croatia	2002m04	2000m01-2002m03	-	Italy	2002m04	200m01-2002m03	-
	2004M08	2002M04-2004M07	+		2004m12	2002m04-2004m11	+		2006m03	2002m04-2006m02	+
	2008M06	2004M08-2008M05	+		2008m04	2004m12-2008m03	+		2008m06	2006m03-2008m05	+
	2012M01	2008M06-2011M12	+		2012m02	2008m04-2012m01	+		2012m02	2008m06-2012m01	+
		2012M01-2014M12	-			2012m02-2014m12	+			2012m02-2014m12	-
Ecuador	2002m04	2000m01-2002m03	-	Czech	2002m04	2000m01-2002m03	-	Netherlands	2002m04	2000m01-2002m03	-
	2005m01	2002m04-2004m12	+	Rep.	2007m10	2002m04-2007m09	+		2004m08	2002m04-2004m07	-
	2008m05	2005m01-2008m04	+		2012m01	2007m10-2011m12	-		2008m04	2004m08-2008m03	+
	2011m11	2008m05-2011m10	+			2012m01-2014m12	-		2012m02	2008m04-2012m01	+
		2011m11-2014m12	-							2012m02-2014m12	-
Iran	2002m04	2000m01-2002m03	-	Finland	2002m04	2000m01-2002m03	-	Poland	2003m10	2000m01-2003m09	-
	2007m01	2002m04-2006m12	+		2008m01	2002m04-2007m12	+		2008m06	2003m10-2008m05	+
	2009m04	2007m01-2009m03	-		2012m02	2008m01-2012m01	+		2012m01	2008m06-2011m12	+
	2012m05	2009m04-2012m04	+			2012m02-2014m14	-			2012m01-2014m14	+
		2012m05-2014m12	-								
Kuwait	2002m12	2000m01-2002m11	+	France	2002m04	2000m01-2002m03	-	Portugal	2002m04	2000m01-2002m03	-
	2005m10	2002m12-2005m09	+		2006m02	2002m04-2006m01	+		2007m01	2002m04-2006m12	+
	2008m06	2005m10-2008m05	+		2008m05	2006m02-2008m04	+		2009m06	2007m01-2009m05	-
	2011m05	2008m06-2011m04	+		2012m01	2008m05-2011m12	+		2012m01	2009m06-2011m12	+
		2011m05-2014m12	-			2012m01-2014m12	+			2012m12-2014m12	+
Nigeria	2002m04	2000m01-2002m03	-	Germany	2002m04	2000m01-2002m03	-	Spain	2002m04	2000m01-2002m03	-
	2005m07	2002m04-2005m06	+		2006m01	2002m04-2005m12	+		2006m02	2002m04-2006m01	+
	2008m07	2005m07-2008m06	+		2008m04	2006m01-2008m03	+		2008m05	2006m01-2008m04	+
	2012m02	2008m07-2012m01	+		2012m02`	2008m04-2012m01	+		2012m08	2008m05-2012m07	+
		2012m02-2014m12	-			2012m02-2014m12	-			2012m08-2014m012	-
Saudi	2002m12	2000m01-2002m11	-	Greece	2002m04	2000m01-2002m03	-	Sweden	2002m04	2000m01-2002m03	-
Arabia	2006m03	2002m12-2006m02	+		2006m02	2002m04-2006m01	+		2006m02	2002m04-2006m01	-
	2008m06	2006m03-2008m05	+		2008m05	2006m02-2008m04	+		2008m05	2006m02-2008m04	+
	2012m02	2008m06-2012m01	+		2011m03	2008m05-2011m02	+		2012m02	2008m05-2012m01	+
		2012m02-2014m12	-			2011m03-2014m12	+			2012m02-2014m12	-
				Hungary	2002m04	2000m01-2002m03	-	Switzerland	2002m04	2000m01-2002m03	-
					2006m03	2002m04-2006m02	+		2005m07	2002m04-2005m06	+
					2008m06	2006m03-2008m05	+		2007m12	2005m07-2007m11	+
					2012m01	2008m06-2011m12	+		2011m01	2007m12-2010m12	-
						2012m01-2014m12	+			2011m01-2014m12	-

Table 7: Do Structural Breaks Matter in Oil Price-Inflation Nexus?

OPEC Countries		EU Countries			
Country	**Presence of Structural Breaks**	**Country**	**Presence of Structural Breaks**	**Country**	**Presence of Structural Breaks**
Algeria	13.4934***	Belgium	1.2300	Ireland	1.3027
	[0.0003]		[0.3000]		[0.2753]
Angola	9.1343***	Croatia	3.4418***	Italy	0.7052
	[0.0000]		[0.0098]		[0.5502]
Ecuador	37.2903***	Czech Rep.	1.3123	Netherlands	3.8374***
	[0.0000]		[0.2720]		[0.0052]
Iran	44.6759***	Finland	1.6253	Poland	3.0339**
	[0.0000]		[0.1701]		[0.0308]
Kuwait	0.9946	France	0.9756	Portugal	0.9316
	[0.4120]		[0.4224]		[0.4470]
Nigeria	0.3329	Germany	2.0750*	Spain	2.3857*
	[0.8556]		[0.0862]		[0.0531]
Saudi Arabia	1.5573	Greece	1.5916	Sweden	2.5483**
	[0.1880]		[0.1788]		[0.0411]
		Hungary	2.2107*	Switzerland	2.1065*
			[0.0699]		[0.0821]

The test for joint significance of the break is carried out using the Wald test. The null hypothesis is that the breaks are jointly insignificant; hence, they are not different from zero, with the alternative that the breaks are jointly significant.***, **, and * indicate significance at 1%, 5% and 10% respectively

5.3 The behaviour of asymmetries in the presence of structural breaks

We also determine the behaviour of asymmetries in the presence of breaks for all the selected countries. In other words, are the reported asymmetries not over(under)reported due to the absence (or otherwise) of structural breaks? There is a plethora of studies in the literature suggesting that ignoring structural breaks when they exist may bias results[see for example, Narayan and Liu, 2011;Salisu and Fasanya, 2013; Narayan, Liu, and Westerlund, 2015 and Salisu and Oloko, 2015].

Looking at Table 8(a), we observe that the asymmetries for OPEC members are robust to structural breaks. The result shows that, with the inclusion of breaks, asymmetry modelling of pass through effect of oil price movement on inflation is still valid for Algeria and Angola among the OPEC members. In essence, accounting for the breaks does not appear to alter markedly the results of the asymmetric case without breaks.Thus, the results are similar in both cases for the selected OPEC members.

However, for the EU (non-oil importing) countries, we find a significant departure from the asymmetric case that fails to account for structural breaks [see Table 8(b)]. More specifically, the asymmetric effects previously reported for the EU almost disappear after accounting for structural breaks. Recall that three countries [Greece, Poland and Portugal] are observed to respond differently to positive and negative oil price changes without structural breaks. However, after accounting for the breaks, the asymmetric behaviour is only evident for Greece while the effect for the other two countries wanes. Thus, Greece is the only country with different inflationary reaction to upward and downward oil price movement when the breaks are included in the regression.

In sum, while asymmetric effect for the oil exporting countries (OPEC) is not sensitive to structural breaks, the effect seems to diminish for oil-importing (EU) countries in the presence of breaks.

Table 8(a): Wald Test for Asymmetry with Structural Breaks – OPEC Members

Country	Wald Statistic		Is there Presence of Asymmetry?	
	Short-run	Long-run	Short-run	Long-run
Algeria	3.6201* [0.0588]	3.3059* [0.0708]	Yes	Yes
Angola	3.2126* [0.0749]	3.1234* [0.0790]	Yes	Yes
Ecuador	1.2767 [0.2601]	1.2550 [0.2642]	No	No
Iran	0.4194 [0.5181]	0.4132 [0.5212]	No	No
Kuwait	1.4966 [0.2229]	No long run cointegration	No	No long run cointegration
Nigeria	2.2589 [0.1347]	1.8840 [0.1717]	No	No
Saudi Arabia	0.8050 [0.3709]	No long run cointegration	No	No long run cointegration

Table 8(b): Wald Test for Asymmetry with Structural Breaks - EU Countries

Country	Wald Statistic		Is there Presence of Asymmetry?	
	Short-run	Long-run	Short-run	Long-run
Belgium	0.8331 [0.3627]	No long run cointegration	No	No long run cointegration
Croatia	0.0802 [0.7773]	No long run cointegration	No	No long run cointegration
Czech Rep.	0.4600 [0.4985]	No long run cointegration	No	No long run cointegration
Finland	1.1508 [0.2849]	No long run cointegration	No	No long run cointegration
France	3.3241 [0.1293]	No long run cointegration	No	No long run cointegration

Germany	0.2234 [0.6370]	No long run cointegration	No	No long run cointegration
Greece	0.2750* [0.0991]	2.3413 [0.1279]	Yes	No
Hungary	0.0284 [0.8664]	0.0282 [0.8668]	No	No
Ireland	0.4132 [0.5212]	0.3785 [0.5393]	No	No
Italy	1.7045 [0.1935]	No long run cointegration	No	No long run cointegration
Netherlands	0.9703 [0.3260]	0.9498 [0.3312]	No	No
Poland	2.6073 [0.1082]	2.0750 [0.1516]	N0	No
Portugal	1.9820 [0.1610]	1.3456 [0.2477]	No	No
Spain	0.3872 [0.5346]	No long run cointegration	No	No long run cointegration
Sweden	0.8050 [0.3709]	No long run cointegration	No	No long run cointegration
Switzerland	1.7405 [0.1888]	No long run cointegration	No	No long run cointegration

5.4 The nature of relationship between oil price and inflation

In addition to interpreting the role of asymmetries and structural breaks, we also dig further into the nature of relationship between oil price and inflation in terms of sign and statistical significance. The results are presented in Tables 9(a) and 9(b) for OPEC and EU countries respectively. One obvious thing to notice from the two tables is that we only present the preferred model for each country. Note that we consider four regressions for each country; however, we are able to determine the most preferred based on the tests for asymmetry as well as structural breaks.[1]

Looking at the sign of the coefficients, we find that virtually all the coefficients are correctly signed (i.e. positive) and statistically significant. In essence, a higher oil price may drive a higher level of consumer prices and by extension, a higher rate of inflation. However, in terms of statistical significance, about eight of the countries analysed [three (about 45%)for OPEC and five (about 30%) for EU] reveal a strong link between oil price and inflation. OPEC members in this category are Kuwait, Saudi Arabia and Nigeria while the affected EU members are Belgium, Croatia, Hungary, Ireland and Poland.

[1]Nonetheless, all the regression results for each country including data utilized are available on request.

In terms of long run and short run dynamics of oil price-inflation nexus, we find that all the OPEC members have both long run and short run relationships while about half of the oil importing EU countries reveal the same behaviour. EU countries like Belgium, Czech Republic, Finland, France, Germany, Italy, Spain and Sweden only exhibit short run inflationary reaction to oil price changes. Thus, the oil price-inflation nexus is stronger inoil exporting countries than oil importing countries.

Table 9a: Oil Price – Inflation Nexus - OPEC

Variable	Algeria	Angola	Ecuador	Iran	Kuwait	Nigeria	Saudi Arabia
Model	Asymmetry^A	Asymmetry^A	Symmetry^A	Symmetry^A	Symmetry^B	Symmetry^B	Symmetry^B
Constant	1.3200*** (6.8741)	0.2334*** (7.9183)	1.5442*** (11.0395)	2.6653*** (12.6940)	0.2728*** (2.89990	0.5169*** (3.8841)	0.1241** (2.1163)
Trend	0.0007*** (3.9136)	0.0002 (1.4613)	0.0015*** (6.3354)	0.0074*** (11.6054)	0.0003** (2.5577)	0.0010*** (3.6881)	0.0001* (1.7442)
ΔINF_{t-1}	02617*** (3.8267)	0.1064 (1.5058)				0.3108*** (4.3386)	
ΔINF_{t-2}							
ΔP_t			0.0076 (0.8699)	-0.0268* (-1.8265)	0.0058** (2.0195)	0.0002*** (3.6881)	0.0048** (2.1724)
ΔP_t^+	0.0023 (0.3401)	0.0050 (1.1490)					
ΔP_t^+	0.0038 (0.5309)	0.0041 (0.9258)					
D^1	0.0038 (0.5309)	0.0328*** (4.8801)	-0.0010 (-0.1070)	-0.0279 (-1.5883)			
D^2	0.0406*** (3.1248)	0.0223** (2.4873)	-0.1697*** (-10.0110)	-0.5379*** (-11.5212)			
D^3	0.0762*** (4.0668)	0.0335*** (3.0300)	-0.1384*** (-6.3322)	-0.5009*** (-9.6610)			
D^4		0.0307** (2.2616)	-0.1505*** (-5.2384)	-0.3154*** (-5.9929)			
ECM_{t-1}	-0.2890*** (-6.8397)	-0.0361*** (-7.4953)	-0.3283*** (-11.7573)	-0.5752*** (-13.1214)		-0.1095*** (-3.8454)	-0.0309** (-2.4286)
F_{Bounds}	15.5159***	18.2440***	75.2889***	85.3642***	5.7321†	7.5512**	5.9925†
F-Stat.	2710.81	168289.9	1079.54	2076.06***	27050.7***	26025.12***	37269.8***
Adj. R²	0.992	0.999	0.977	0.988	0.998	0.998	0.998
JB. Stat.	1.1505 [0.5626]	244.70 [0.0000]	33120.17 [0.0000]	4615.83 [0.0000]	6.4730 [0.0393]	371.76 [0.0000]	379.7186 [0.0000]
LM	0.1314 [0.8769]	4.8473 [0.0090]	11.7406 [0.0000]	56.8710 [0.0000]	0.2073 [0.8130]	0.1371 [0.8720]	2.8550 [0.0603]
ARCH	0.0383 [0.8450]	1.0091 [0.3165]	0.0033 [0.9546]	0.0175 [0.8948]	0.0641 [0.8004]	0.2449 [0.6213]	0.0718 [0.7891]
Reset Test	0.0003 [0.9869]	0.9757 [0.3247]	15.2764 [0.0001]	11.6242 [0.0008]	0.0440 [0.8340]	2.0134 [0.1577)	1.3915 [0.2398]
Lag Selection (SIC)	(2, 0, 0)	(2, 0, 0)	(,1, 0)	(1, 0)	(1, 0)	(2, 0)	(1, 0)
P_t^{LR}			0.0231 (0.8534)	-0.0466* (-1.8265)	0.0017 (0.0353)	0.0017 (0.0353)	0.1554 (1.5094)
P_t^{LR+}	0.0079 (0.3417)	0.1384 (1.1325)					

P_t^{LR-}	0.0026 (0.0171)	0.1144 (0.9161)					

Symmetry^A and Symmetry^B represent symmetric model with structural breaks and symmetric without structural breaks respectively, while Asymmetry^A and Asymmetry^{B}denote asymmetric model with structural breaks and asymmetric without structural breaks respectively. D1-D4 represents dummies for corresponding break dates for each countries as identified in the BP test presented in Table 7. P_t^{LR} is the long run coefficient of oil price, while P_t^{LR+} and P_t^{LR-} respectively capture positive and negative changes in oil price. Standard errors are presented in brackets and probability values are presented in parentheses. The critical values for the Lower and Upper Bounds respectively are 5.59 and 6.26 for the symmetric models at 10% significance level, while they are 4.19 and 5.06 for the asymmetric models.†indicates that bounds test for cointegration is inconclusive, hence both the short run and long run results are reported; ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.

Table 9(b): Oil Price – Inflation Nexus - EU

Variable	Belgium	Croatia	Czech Rep.	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Netherlands	Poland	Portugal	Spain	Sweden	Switzerland
Model	Symmetry[B]	Symmetry[A]	Symmetry[B]	Symmetry[B]	Symmetry[B]	Symmetry[A]	Asymmetry[B]	Symmetry[A]	Symmetry[B]	Symmetry[B]	Symmetry[A]	Symmetry[A]	Symmetry[B]	Symmetry[A]	Symmetry[A]	Symmetry[A]
Constant	0.2571* (1.8642)	0.7986*** (4.9182)	0.2705** (2.0938)	0.3150** (2.2818)	0.2997** (2.5877)	0.2831** (2.2401)	0.4293*** (3.5295)	0.3188*** (2.8556)	0.1035*** (2.7267)	0.1337* (1.9085)	1.0528*** (3.9417)	0.4803*** (3.3024)	0.2354*** (2.7737)	0.1900* (1.8038)	0.1469 (1.0100)	0.6881*** (3.4559)
Trend	8.31E−05 (1.2492)	0.0001 (1.6023)	8.46.E-05 (1.2615)	0.0002* (1.8795)	6.80E-05* (1.6942)	8.74E-05 (1.5511)	0.0002** (2.7526)	0.0001 (1.1848)	-2.20E-05* (-1.8590)	4.04E-05 (1.3448)	0.0002 (1.6308)	8.05E-05 (1.1086))	5.51E-06 (0.2151)	8.74E-05* (1.6745)	3.08E-05 (0.5671)	5.39E-05 (1.3264)
ΔINF_{t-1}		0.3911*** (5.5334)		0.0055 (0.0716)	0.2378*** (3.22870	0.312*** (4.099)	0.3843*** (5.4503)	0.2685*** (3.6499)	0.3404*** (4.6265)	0.3722*** (5.2718)	0.1371 (1.6440)	0.4786*** (6.7368)				
ΔINF_{t-2}				0.2768*** (3.6708)					0.1977*** (2.7223)		0.2564*** (3.0964)	-0.1689** (-2.3867)				
ΔP_{t}	0.0033** (2.3131)	0.0078** (2.4253)	0.0034 (1.0220)	-0.0009 (-0.2842)	0.0018 (1.4581)	0.0023 (1.2004)		0.0085** (2.6050)	0.0025** (2.4650)	0.0009 (1.2083)	-7.4E-05 (-0.0205)	0.0266*** (4.1605)	-0.0120*** (-2.6170)	0.0010 (0.5007)	0.0006 (0.3287)	-0.0009 (-0.5130)
ΔP^{+}_{t}							0.0033 (1.1546)									
ΔP^{+}_{t}							0.0026 (0.8826)									
D^{1}		-0.0017 (-0.5336)				-0.004** (-2.221)		-0.0015 (-0.4131)			-0.0202*** (-3.2103)	-0.0011 (-0.3926)		0.0029 (1.2945)	-0.0037* (1.9058)	0.0031 (1.3143)
D^{2}		0.0061 (1.2047)				-0.0036 (-1.116)		0.0078 (1.3011)			-0.0297*** (-3.0546)	0.0091* (1.9145)		0.0040 (1.0132)	-0.0006 (-0.1978)	0.0012 (0.3465)
D^{3}		0.0220** (2.6371)				-0.0039 (-0.867)		0.0113 (1.3082)			-0.0193* (-1.9093)	0.0154** (2.2674)		0.0002 (0.0355)	-0.0006 (-0.1163)	0.0039 (0.8399)
D^{4}		0.0283* (2.5424)				-0.0020 (-0.322)		0.0141 (1.2568)			-0.0135 (-1.1132)			-0.0008 (-0.1170)	-0.0006 (-0.0842)	-0.0042 (-0.7278)
ECM_{t-1}		-0.1787*** (-5.0011)					-0.094*** (-3.5174)	-0.0730*** (-2.9907)	-0.0235*** (-2.8699)		-0.2276*** (-3.9977)	-0.1095*** (-3.3673)	-0.0526*** (-2.8838)			-0.148*** (-3.4629)
F_{Bounds}	4.8822	12.1630***	3.4654	3.8418	4.9526	4.2296	4.7862†	6.2458†	5.9253†	2.5369	8.9025**	6.5032*	7.2192*	1.9721	0.6659	6.0527†
F-Stat.	23047.98***	3914.01	3604.02***	4723.42***	11043.12***	5.34.44	3880.25***	14617.84**	5175.98	51076.68***	527.86***	5700.06	5358.67***	11095.30***	5197.84***	443.58***
Adj. R^2	0.997	0.994	0.984	0.993	0.996	0.996	0.991	0.999	0.993	0.999	0.964	0.997	0.992	0.998	0.995	0.946
JB. Stat.	3.5632 [0.1684]	0.8611 [0.6501]	2594.30 [0.0000]	667.62 [0.0000]	2.5779 [0.2756]	77.0226 [0.0000]	31.0778 [0.0000]	69.9575 [0.0000]	18.1882 [0.0001]	105.03 [0.0000]	30301.99 [0.0000]	0.6917 [0.7076]	1.2651 [0.5312]	18504.89 [0.0000]	3.7993 [0.1496]	0.1090 [0.9470]
LM	3.6138 [0.0290]	1.5539 [0.2145]	0.2685 [0.7649]	0.4140 [0.6617]	0.1398 [0.8696]	0.0636 [0.9384]	2.3140 [0.1020]	0.1429 [0.8670]	0.8015 [0.4504]	2.7670 [0.0657]	0.2539 [0.7761]	0.0822 [0.9211]	1.0106 [0.3661]	0.2203 [0.8025]	0.2000 [0.8189]	0.4699 [0.6259]
ARCH	4.1113 [0.0441]	0.8343 [0.3623]	0.0582 [0.8097]	0.0001 [0.9910]	1.0636 [0.1629]	1.8405 [0.1766]	7.8207 [0.0057]	3.9833 [0.0475]	0.4035 [0.5261]	0.0686 [0.7936]	0.0147 [0.9038]	0.8480 [0.3584]	0.2260 [0.6351]	0.2687 [0.6049]	1.8861 [0.1714]	0.4845 [0.4873]
Reset Test	0.5764 [0.4487]	0.8437 [0.3597]	1.2220 [0.2705]	2.1969 [0.1410]	0.0393 [0.842]	0.3532 [0.5531]	2.2904 [0.1320]	4.4399 [0.0366]	0.2825 [0.7779]	0.8414 [0.3603]	3.3110 [0.0706]	0.2350 [0.6285]	0.1335 [0.8940]	1.1282 [0.2897]	4.0157 [0.0467]	0.6964 [0.4052]
Lag Selection (SIC)	(1, 0)	(2, 0)	(1, 0)	(3, 0)	(2, 0)	(2, 0)	(2, 0, 0)	(2, 0)	(3, 0)	(2, 0)	(3, 0)	(3, 1)	(1, 1)	(1, 0)	(1, 0)	(1, 0)
P_{t}		0.0438** (2.4094)						0.1167** (2.1454)	0.1048** (2.0273)		-0.0003 (-0.0205)	0.0717*** (2.7679)	0.0699* (1.8797)			-0.0061 (-0.5326)

P_t^{LR+}							0.0185 (0.8532)									
P_t^{LR-}							0.0140 (0.6261)									

Symmetry^A and Symmetry^B represent symmetric model with structural breaks and symmetric without structural breaks respectively, while Asymmetry^A and Asymmetry^B denote asymmetric model with structural breaks and asymmetric without structural breaks respectively. D1-D4 represents dummies for corresponding break dates for each countries as identified in the BP test presented in Table 7. P_t^{LR} is the long run coefficient of oil price, while P_t^{LR+} and P_t^{LR-} respectively capture positive and negative changes in oil price. Standard errors are presented in brackets and probability values are presented in parentheses. The critical values for the Lower and Upper Bounds respectively are 5.59 and 6.26 for the symmetric models at 10% significance level, while they are 4.19 and 5.06 for the asymmetric models.†indicates that bounds test for cointegration is inconclusive, hence both the short run and long run results are reported; ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.

5.5 Robustness Checks

Under this section, we evaluate the robustness of the regression results in terms of the number of identified break points, number of significant asymmetries with and without structural breaks, and number of countries with evidence of significant breaks, as well as the nature of the relationship between oil price and inflation. Recall that in the main estimation, we considered monthly data frequency. For robustness purpose however, we utilize quarterly data in order to verify whether the relationship between oil price and inflation is sensitive to data frequency[2].

The evidence of structural breaks using the quarterly data reveals few instances of variations with the main analysis. For instance, Algeria, Angola, Czech Republic, Greece and Kuwait all have between three and four structural breaks in the main analysis, but the quarterly data estimation reveals that these countries have only two breaks. Nonetheless, the break periods obtained using quarterly largely fall within the respective months obtained from the monthly series. Thus, the structural break periods are virtually similar using the monthly and quarterly data frequencies. Thus, it can be deduced that the presence of structural breaks in oil price – inflation nexus is not sensitive to difference in data frequencies.

The test for asymmetry with and without the inclusion of the structural breaks reveals a somewhat different result using quarterly data. The results of the Wald test support asymmetry in the model for some of the countries using monthly data but this changed when quarterly data are considered.For instance, in the short run, the results for Algeria and Greece support asymmetry in the oil price - inflation model using both monthly and quarterly data (without structural breaks). In the case of Angola, there is evidence of asymmetry using monthly series; however, this is not true when quarterly data is adopted as results suggest symmetry in the model. Other countries such as Nigeria, Croatia, France, Italy, Portugal and Sweden support the asymmetric model when quarterly data series is used, contrary to the symmetric model using monthly series. These findings suggest that the choice of model

[2] See the Appendix for estimation results involving quarterly data.

between symmetric and asymmetric when modelling the pass through effects of oil price to inflation is sensitive to the frequency of data used for different countries.

Our next robustness check evaluates the simultaneous significance of the structural breaks using quarterly data series. The null hypothesis that the breaks are not simultaneously significant is rejected for almost all the countries. Hence, the presence of structural breaks matters in the relationship between oil price and inflation for both OPEC and EU countries, irrespective of the data series used whether monthly or quarterly.

Finally, although the difference in data frequencies used in evaluating the nexus between oil price and inflation matters in terms of the magnitude of influence, however, the sign and significance of the coefficients are largely the same forall the countries. The results of the bounds test for cointegration also seem very similar for the countries when different data frequency is used. We also observed that the behaviour of oil price on inflation virtually remains the same except in few cases with variationsin the choice of optimal lag length, signs and significance.

6.0 Concluding Remarks

This paper examines the relationship between oil price and inflation including the role of asymmetries and structural breaks for selected OPEC and EU countries. The OPEC members serve as the oil exporting countries while the EU countries represent the oil importing countries. In other words, we are able to determine the inflationary response of the two categories to oil price changes and whether asymmetries and structural breaks matter for the nexus. We utilize both monthly and quarterly data in which case the former is used for the main analyses while the latter is for robustness checks. We render preliminary analyses involving descriptive statistics and graphical analyses. We also consider unit root test to verify the integration properties of the series under consideration. The preliminary analyses reveal some level of positive correlations between oil price and inflation. The series are also found to exhibit integration properties of $I(0)$ and $I(1)$. Thus, we employ both the

Linear (Symmetric) ARDL by Pesaran et al (2001) and Nonlinear (Asymmetric) ARDL by Shin et al. (2014) that allow for both $I(0)$ and $I(1)$ when modelling economic relationships. The computational advantages of the two models over other models are well documented in this paper. The symmetric model assumes identical impact of positive and negative changes in oil price on inflation while the asymmetric model assumes differing inflationary responses of positive and negative oil price changes. We further modify these two models to account for structural breaks obtained from the Bai-Perron endogenous structural break test. This paper outlines some of the computational advantages of using this test to determine multiple structural changes in linear regressions. Thus, in all, we estimate four regressions for each country: symmetric model with and without structural breaks and asymmetric model with and without structural breaks. Nonetheless, based on relevant tests for asymmetries and structural breaks [Wald tests], we are able to determine the preferred model for each country and our final interpretation is drawn from the parsimonious model. In addition, we are able to evaluate whether inflationary effects of positive and negative oil price changes are asymmetric and we also test jointly the significance of the included break dummies in the regression models.

Some of the discernible findings from our analyses are rendered as follows. First, the relationship between oil price and inflation tends to change over short periods. Secondly, the oil price-inflation nexus is stronger in oil exporting countries than oil importing countries. Thirdly, oil price asymmetries seem to matter more when dealing with oil exporting nations. Fourthly, it may be necessary to pre-test for structural breaks when modelling the relationship between oil price and inflation regardless of the category being analysed. Fifth, while asymmetric effect for the oil exporting (OPEC) is not sensitive to structural breaks, the effect seems to diminish for oil-importing (EU) countries in the presence of breaks. Sixth, while the results are largely insensitive to the nature of data frequency, the behaviour of asymmetry suggests otherwise.

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APPENDIX

Table A1: Bai-Perron (2003) Structural Break Dates - Quarterly Data

Country	*Break Periods*	*Break Range*	*Country*	*Break Periods*	*Break Range*	*Country*	*Break Periods*	*Break Range*
Algeria	2008Q3 2012Q1	2000Q1 - 2008Q2 2008Q3 - 2011Q4 2012Q1 - 2014Q4	Belgium	2002Q2 2006Q2 2008Q3 2012Q4	2000Q1 - 2002Q1 2002Q2 - 2006Q1 2006Q2 - 2008Q2 2008Q3 - 2012Q3 2012Q4 - 2014Q4	Ireland	2002Q2 2007Q2 2009Q3	2000Q1 - 2002Q1 2002Q2 - 2007Q1 2007Q2 - 2009Q2 2009Q3 - 2014Q4
Angola	2002Q2 2008Q3	2000Q1 - 2002Q1 2002Q2 - 2008Q2 2008Q3 - 2014Q4	Croatia	2005Q1 2008Q2 2012Q1	2000Q1 - 2004Q4 2005Q1 - 2008Q1 2008Q2 - 2011Q4 2012Q1 - 2014Q4	Italy	2002Q2 2008Q2 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2008Q1 2008Q2 - 2011Q4 2012Q1 - 2014Q4
Ecuador	2002Q2 2005Q1 2008Q2 2011Q4	2000Q1 - 2002Q1 2002Q2 - 2004Q4 2005Q1 - 2008Q1 2008Q2 - 2011Q3 2011Q4 - 2014Q4	Czech Rep.	2007Q4 2012Q1	2000Q1 - 2007Q3 2007Q4 - 2011Q4 2012Q1 - 2014Q4	Netherlands	2002Q2 2008Q1 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2007Q4 2008Q1 - 2011Q4 2012Q1 - 2014Q4
Iran	2002Q2 2007Q1 2009Q2 2012Q2	2000Q1 - 2002Q1 2002Q2 - 2006Q4 2007Q1 - 2009Q1 2009Q2 - 2012Q1 2012Q2 - 2014Q4	Finland	2002Q2 2008Q1 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2007Q4 2008Q1 - 2011Q4 2012Q1 - 2014Q4	Poland	2003Q4 2008Q3 2012Q1	2000Q1 - 2003Q3 2003Q4 - 2008Q2 2008Q3 - 2011Q4 2012Q1 - 2014Q4
Kuwait	2008Q3 2011Q2	2000Q1 - 2008Q2 2008Q3 - 2011Q1 2011Q2 - 2014Q4	France	2002Q2 2008Q2 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2008Q1 2008Q2 - 2011Q4 2012Q1 - 2014Q4	Portugal	2002Q2 2007Q1 2009Q3 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2006Q4 2007Q1 - 2009Q2 2009Q3 - 2011Q4 2012Q1 - 2014Q4
Nigeria	2002Q2 2005Q3 2008Q3 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2005Q2 2005Q3 - 2008Q2 2008Q3 - 2011Q4 2012Q1 - 2014Q4	Germany	2002Q2 2006Q1 2008Q2 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2005Q4 2006Q1 - 2008Q1 2008Q2 - 2011Q4 2012Q1 - 2014Q4	Spain	2002Q2 2008Q2 2012Q3	2000Q1 - 2002Q1 2002Q2 - 2008Q1 2008Q2 - 2012Q2 2012Q3 - 2014Q4
Saudi Arabia	2006Q2 2008Q3 2012Q2	2000Q1 – 2006Q1 2006Q2 – 2008Q2 2008Q3 – 2012Q1 2012Q2 – 2014Q4	Greece	2002Q2 2008Q2	2000Q1 - 2002Q1 2002Q2 - 2008Q1 2008Q2 - 2014Q4	Sweden	2002Q2 2006Q2 2008Q3 2012Q4	2000Q1 - 2002Q1 2002Q2 - 2006Q1 2006Q2 - 2008Q2 2008Q3 - 2012Q3 2012Q4 - 2014Q4
			Hungary	2002Q2 2006Q2 2008Q3 2012Q1	2000Q1 - 2002Q1 2002Q2 - 2006Q1 2006Q2 - 2008Q2 2008Q3 - 2011Q4 2012Q1 - 2014Q4	Switzerland	2002Q2 2008Q1 2011Q1	2000Q1 - 2002Q1 2002Q2 - 2007Q4 2008Q1 - 2010Q4 2011Q1 - 2014Q4

Compiled by the Authors

Table A2: Asymmetry Wald test without breaks

Country	Wald Statistic		Is there Presence of Asymmetry?	
	Short-run	Long-run	Short-run	Long-run
Algeria	2.4951 [0.1205]	1.3261 [0.2550]	NO	NO
Angola	0.0016 [0.9686]	0.0016 [0.9685]	NO	NO
Ecuador	0.0599 [0.8077]	0.0588 [0.8093]	NO	NO
Iran	0.1930 [0.6622]	0.1995 [0.6569]	NO	NO
Kuwait	5.753 [0.0206]**	1.9278 [0.1717]	YES	NO
Nigeria	2.9531	2.0076	YES	NO

	[0.0917]*	[0.1625]		
Saudi Arabia	0.1662 [0.6852]	0.1488 [0.7012]	NO	NO
Belgium	6.0694 [0.0174]**	No long run relationship	YES	No long run relationship
Croatia	1.3098 [0.2588]	0.7626 [0.3874]	NO	NO
Czech Rep.	0.9739 [0.3281]	No long run relationship	NO	No long run relationship
Finland	0.0135 [0.9081]	No long run relationship	NO	No long run relationship
France	0.9677 [0.3298]	No long run relationship	NO	No long run relationship
Germany	1.1058 [0.2983]	No long run relationship	NO	No long run relationship
Greece	3.1422 [0.0824]*	2.0684 [0.1566]	YES	NO
Hungary	0.888 [0.3507]	0.7824 [0.3808]	NO	NO
Ireland	0.207 [0.6510]	0.219 [0.6417]	NO	NO
Italy	6.1501 [0.0167]**	No long run relationship	YES	No long run relationship
Netherlands	1.6571 [0.2035]	0.6823 [0.4124]	NO	NO
Poland	1.5649 [0.2163]	0.6551 [0.4219]	NO	NO
Portugal	0.9833 [0.3264]	0.8523 [0.3605]	NO	NO
Spain	0.2005 [0.6561]	0.1683 [0.6833]	No long run relationship	No long run relationship
Sweden	0.0985 [0.7548]	0.0843 [0.7716]	No long run relationship	No long run relationship
Switzerland	0.0727 [0.7885]	0.0644 [0.8007]	NO	NO

Table A3: Asymmetry Wald test with breaks – Quarterly Data

Country	**Wald Statistic**		**Is there Presence of Asymmetry?**	
	Short-run	**Long-run**	**Short-run**	**Long-run**
Algeria	3.0809 [0.0856]*	2.3772 [0.1297]	YES	NO
Angola	0.2302 [0.6335]	0.2251 [0.6373]	NO	NO
Ecuador	0.2518 [0.6180]	0.2523 [0.6177]	NO	NO
Iran	0.1672 [0.6844]	0.1677 [0.6839]	NO	NO
Kuwait	0.1694 [0.6823]	0.1778 [0.6750]	NO	NO
Nigeria	4.5320 [0.0382]**	2.6281 [0.1113]	YES	NO
Saudi Arabia	0.1280 [0.7220]	0.1067 [0.7439]	NO	NO
Belgium	0.0041	No long run	NO	No long run

	[0.9490]	relationship		relationship
Croatia	22.5928 [0.0000]***	22.6649 [0.0000]***	YES	YES
Czech Rep.	2.5712 [0.1149]	No long run relationship	NO	No long run relationship
Finland	0.8492 [0.3611]	No long run relationship	NO	No long run relationship
France	6.1633 [0.0171]**	No long run relationship	YES	No long run relationship
Germany	0.3636 [0.5496]	No long run relationship	NO	No long run relationship
Greece	3.5933 [0.0640]*	0.975 [0.3284]	YES	NO
Hungary	0.6931 [0.4094]	0.4598 [0.5011]	NO	NO
Ireland	1.1415 [0.2910]	1.1382 [0.2917]	NO	NO
Italy	6.8049 [0.0123]**	No long run relationship	YES	No long run relationship
Netherlands	0.3703 [0.5455]	0.3286 [0.5690]	NO	NO
Poland	0.6843 [0.4120]	0.552 [0.4609]	NO	NO
Portugal	2.9184 [0.0957]*	2.2236 [0.1442]	YES	NO
Spain	0.5261 [0.4718]	No long run relationship	NO	No long run relationship
Sweden	3.4129 [0.0709]*	No long run relationship	YES	No long run relationship
Switzerland	0.1016 [0.7512]	0.0973 [0.7563]	NO	NO

Table A4: Structural Breaks Significance – Quarterly Data

OPEC Countries		**EU Countries**			
Country	**Presence of Structural Breaks**	**Country**	**Presence of Structural Breaks**	**Country**	**Presence of Structural Breaks**
Algeria	4.1169** (0.0224)	Belgium	2.3745* [0.0871]	Ireland	9.6907*** [0.0000]
Angola	6.6334** [0.0130)]	Croatia	1.7491 [0.1935]	Italy	1.5237 [0.2213]
Ecuador	47.7981*** [0.0000]	Czech Rep.	7.0852** [0.0103]	Netherlands	4.3011** [0.0188]
Iran	43.9760*** [0.0000]	Finland	5.2583*** [0.0031]	Poland	3.9950** [0.0125]
Kuwait	2.8989* [0.0640]	France	6.6311*** [0.0009]	Portugal	3.7748** [0.0111]
Nigeria	0.5466 [0.7023]	Germany	4.3121*** [0.0050]	Spain	1.5998 [0.2017]
Saudi Arabia	0.2791 [0.7578]	Greece	1.2875 [0.2853]	Sweden	2.9442** [0.0296]
		Hungary	7.8917*** [0.0001]	Switzerland	2.2676* [0.0918]

The test for joint significance of the break is carried out using the Wald test. The null hypothesis is that the breaks are jointly not statistically significant, hence, they are not different from zero, with the alternative that the breaks are jointly significant. ***, **, and * indicate significance at 1%, 5% and 10% respectively

Table A5[1]: Oil Price – Inflation NexusQuarterly Data- OPEC

Variable	Algeria	Angola	Ecuador	Iran	Kuwait	Nigeria	Saudi Arabia
Model	**Asymmetry^A**	**Asymmetry^A**	**Symmetry^A**	**Symmetry^A**	**Symmetry^B**	**Symmetry^B**	**Symmetry^B**
Constant	1.3200*** (6.8741)	0.2334*** (7.9183)	1.5442*** (11.0395)	2.6653*** (12.6940)	0.2728*** (2.89990	0.5169*** (3.8841)	0.1241** (2.1163)
Trend	0.0007*** (3.9136)	0.0002 (1.4613)	0.0015*** (6.3354)	0.0074*** (11.6054)	0.0003** (2.5577)	0.0010*** (3.6881)	0.0001* (1.7442)
ΔINF_{t-1}	02617*** (3.8267)	0.1064 (1.5058)				0.3108*** (4.3386)	
ΔINF_{t-2}							
ΔP_t			0.0076 (0.8699)	-0.0268* (-1.8265)	0.0058** (2.0195)	0.0002*** (3.6881)	0.0048** (2.1724)
	0.0023 (0.3401)	0.0050 (1.1490)					
ΔP_t^{+}	0.0038 (0.5309)	0.0041 (0.9258)					
D^1	0.0038 (0.5309)	0.0328*** (4.8801)	-0.0010 (-0.1070)	-0.0279 (-1.5883)			
D^2	0.0406*** (3.1248)	0.0223** (2.4873)	-0.1697*** (-10.0110)	-0.5379*** (-11.5212)			
D^3	0.0762*** (4.0668)	0.0335*** (3.0300)	-0.1384*** (-6.3322)	-0.5009*** (-9.6610)			
D^4		0.0307** (2.2616)	-0.1505*** (-5.2384)	-0.3154*** (-5.9929)			
ECM_{t-1}	-0.2890*** (-6.8397)	-0.0361*** (-7.4953)	-0.3283*** (-11.7573)	-0.5752*** (-13.1214)		-0.1095*** (-3.8454)	-0.0309** (-2.4286)
F_{Bounds}	15.5159***	18.2440***	75.2889***	85.3642***	5.7321†	7.5512**	5.9925†
F-Stat.	2710.81	168289.9	1079.54	2076.06***	27050.7***	26025.12***	37269.8***
Adj. R^2	0.992	0.999	0.977	0.988	0.998	0.998	0.998
JB. Stat.	1.1505 [0.5626]	244.70 [0.0000]	33120.17 [0.0000]	4615.83 [0.0000]	6.4730 [0.0393]	371.76 [0.0000]	379.7186 [0.0000]
LM	0.1314 [0.8769]	4.8473 [0.0090]	11.7406 [0.0000]	56.8710 [0.0000]	0.2073 [0.8130]	0.1371 [0.8720]	2.8550 [0.0603]
ARCH	0.0383 [0.8450]	1.0091 [0.3165]	0.0033 [0.9546]	0.0175 [0.8948]	0.0641 [0.8004]	0.2449 [0.6213]	0.0718 [0.7891]
Reset Test	0.0003 [0.9869]	0.9757 [0.3247]	15.2764 [0.0001]	11.6242 [0.0008]	0.0440 [0.8340]	2.0134 [0.1577)	1.3915 [0.2398]
Lag Selection (SIC)	(2, 0, 0)	(2, 0, 0)	(,1, 0)	(1, 0)	(1, 0)	(2, 0)	(1, 0)
P_t^{LR}			0.0231 (0.8534)	-0.0466* (-1.8265)	0.0017 (0.0353)	0.0017 (0.0353)	0.1554 (1.5094)
P_t^{LR+}	0.0079 (0.3417)	0.1384 (1.1325)					
P_t^{LR-}	0.0026 (0.0171)	0.1144 (0.9161)					

Symmetry^A and Symmetry^B represent symmetric model with structural breaks and symmetric without structural breaks respectively, while Asymmetry^A and Asymmetry^B denote asymmetric model with structural breaks and asymmetric without structural breaks respectively. D1-D4 represents dummies for corresponding break dates for each countries as identified in the BP test presented in Table 7. P_t^{LR} is the long run coefficient of oil price, while P_t^{LR+} and P_t^{LR-} respectively capture positive and negative changes in oil price. Standard errors are presented in brackets and probability values are presented in parentheses. The critical values for the Lower and Upper Bounds respectively are 5.59 and 6.26 for the symmetric models at 10% significance level, while they are 4.19 and 5.06 for the asymmetric models.†indicates that bounds test for cointegration is inconclusive, hence both the short run and long run results are reported; ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.

Table A5[2]: Oil Price – Inflation NexusQuarterly Data- EU

Variable	Belgium	Croatia	Czech Rep.	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Netherlands	Poland	Portugal	Spain	Sweden	Switzerland
Model	**Symmetry^B**	**Symmetry^A**	**Symmetry^B**	**Symmetry^B**	**Symmetry^B**	**Symmetry^A**	**Asymmetry^B**	**Symmetry^A**	**Symmetry^B**	**Symmetry^B**	**Symmetry^A**	**Symmetry^A**	**Symmetry^B**	**Symmetry^A**	**Symmetry^A**	**Symmetry^A**
Constant	0.2571* (1.8642)	0.7986*** (4.9182)	0.2705** (2.0938)	0.3150** (2.2818)	0.2997** (2.5877)	0.2831** (2.2401)	0.4293*** (3.5295)	0.3188*** (2.8556)	0.1035*** (2.7267)	0.1337* (1.9085)	1.0528*** (3.9417)	0.4803*** (3.3024)	0.2354*** (2.7737)	0.1900* (1.8038)	0.1469 (1.0100)	0.6881*** (3.4559)
Trend	8.31E−05 (1.2492)	0.0001 (1.6023)	8.46.E-05 (1.2615)	0.0002* (1.8795)	6.80E-05* (1.6942)	8.74E-05 (1.5511)	0.0002** (2.7526)	0.0001 (1.1848)	-2.20E-05* (-1.8590)	4.04E-05 (1.3448)	0.0002 (1.6308)	8.05E-05 (1.1086))	5.51E-06 (0.2151)	8.74E-05* (1.6745)	3.08E-05 (0.5671)	5.39E-05 (1.3264)
ΔINF_{t-1}		0.3911*** (5.5334)		0.0055 (0.0716)	0.2378*** (3.22870	0.312*** (4.099)	0.3843*** (5.4503)	0.2685*** (3.6499)	0.3404*** (4.6265)	0.3722*** (5.2718)	0.1371 (1.6440)	0.4786*** (6.7368)				
ΔINF_{t-2}				0.2768*** (3.6708)					0.1977*** (2.7223)		0.2564*** (3.0964)	-0.1689** (-2.3867)				
ΔP_t	0.0033** (2.3131)	0.0078** (2.4253)	0.0034 (1.0220)	-0.0009 (-0.2842)	0.0018 (1.4581)	0.0023 (1.2004)		0.0085** (2.6050)	0.0025** (2.4650)	0.0009 (1.2083)	-7.4E-05 (-0.0205)	0.0266*** (4.1605)	-0.0120*** (-2.6170)	0.0010 (0.5007)	0.0006 (0.3287)	-0.0009 (-0.5130)
ΔP_t^{+}							0.0033 (1.1546)									
ΔP_t^{+}							0.0026 (0.8826)									
D^1		-0.0017 (-0.5336)				-0.004** (-2.221)		-0.0015 (-0.4131)			-0.0202*** (-3.2103)	-0.0011 (-0.3926)		0.0029 (1.2945)	-0.0037* (1.9058)	0.0031 (1.3143)
D^2		0.0061 (1.2047)				-0.0036 (-1.116)		0.0078 (1.3011)			-0.0297*** (-3.0546)	0.0091* (1.9145)		0.0040 (1.0132)	-0.0006 (-0.1978)	0.0012 (0.3465)
D^3		0.0220** (2.6371)				-0.0039 (-0.867)		0.0113 (1.3082)			-0.0193* (-1.9093)	0.0154** (2.2674)		0.0002 (0.0355)	-0.0006 (-0.1163)	0.0039 (0.8399)
D^4		0.0283* (2.5424)				-0.0020 (-0.322)		0.0141 (1.2568)			-0.0135 (-1.1132)			-0.0008 (-0.1170)	-0.0006 (-0.0842)	-0.0042 (-0.7278)
ECM_{t-1}		-0.1787*** (-5.0011)					-0.094*** (-3.5174)	-0.0730*** (-2.9907)	-0.0235*** (-2.8699)		-0.2276*** (-3.9977)	-0.1095*** (-3.3673)	-0.0526*** (-2.8838)			-0.148*** (-3.4629)
F_{Bounds}	4.8822	12.1630***	3.4654	3.8418	4.9526	4.2296	4.7862†	6.2458†	5.9253†	2.5369	8.9025**	6.5032*	7.2192*	1.9721	0.6659	6.0527†
F-Stat.	23047.98***	3914.01	3604.02***	4723.42***	11043.12***	5.34.44	3880.25***	14617.84**	5175.98	51076.68***	527.86***	5700.06	5358.67***	11095.30***	5197.84***	443.58***
Adj. R^2	0.997	0.994	0.984	0.993	0.996	0.996	0.991	0.999	0.993	0.999	0.964	0.997	0.992	0.998	0.995	0.946
JB. Stat.	3.5632 [0.1684]	0.8611 [0.6501]	2594.30 [0.0000]	667.62 [0.0000]	2.5779 [0.2756]	77.0226 [0.0000]	31.0778 [0.0000]	69.9575 [0.0000]	18.1882 [0.0001]	105.03 [0.0000]	30301.99 [0.0000]	0.6917 [0.7076]	1.2651 [0.5312]	18504.89 [0.0000]	3.7993 [0.1496]	0.1090 [0.9470]
LM	3.6138 [0.0290]	1.5539 [0.2145]	0.2685 [0.7649]	0.4140 [0.6617]	0.1398 [0.8696]	0.0636 [0.9384]	2.3140 [0.1020]	0.1429 [0.8670]	0.8015 [0.4504]	2.7670 [0.0657]	0.2539 [0.7761]	0.0822 [0.9211]	1.0106 [0.3661]	0.2203 [0.8025]	0.2000 [0.8189]	0.4699 [0.6259]

ARCH	4.1113 [0.0441]	0.8343 [0.3623]	0.0582 [0.8097]	0.0001 [0.9910]	1.0636 [0.1629]	1.8405 [0.1766]	7.8207 [0.0057]	3.9833 [0.0475]	0.4035 [0.5261]	0.0686 [0.7936]	0.0147 [0.9038]	0.8480 [0.3584]	0.2260 [0.6351]	0.2687 [0.6049]	1.8861 [0.1714]	0.4845 [0.4873]
Reset Test	0.5764 [0.4487]	0.8437 [0.3597]	1.2220 [0.2705]	2.1969 [0.1410]	0.0393 [0.842]	0.3532 [0.5531]	2.2904 [0.1320]	4.4399 [0.0366]	0.2825 [0.7779]	0.8414 [0.3603]	3.3110 [0.0706]	0.2350 [0.6285]	0.1335 [0.8940]	1.1282 [0.2897]	4.0157 [0.0467]	0.6964 [0.4052]
Lag Selection (SIC)	(1, 0)	(2, 0)	(1, 0)	(3, 0)	(2, 0)	(2, 0)	(2, 0, 0)	(2, 0)	(3, 0)	(2, 0)	(3, 0)	(3, 1)	(1, 1)	(1, 0)	(1, 0)	(1, 0)
P_t		0.0438** (2.4094)						0.1167** (2.1454)	0.1048** (2.0273)		-0.0003 (-0.0205)	0.0717*** (2.7679)	0.0699* (1.8797)			-0.0061 (-0.5326)
P_t^{LR+}							0.0185 (0.8532)									
P_t^{LR-}							0.0140 (0.6261)									

Symmetry^A and Symmetry^B represent symmetric model with structural breaks and symmetric without structural breaks respectively, while Asymmetry^A and Asymmetry^B denote asymmetric model with structural breaks and asymmetric without structural breaks respectively. D1-D4 represents dummies for corresponding break dates for each countries as identified in the BP test presented in Table 7. P_t^{LR} is the long run coefficient of oil price, while P_t^{LR+} and P_t^{LR-} respectively capture positive and negative changes in oil price. Standard errors are presented in brackets and probability values are presented in parentheses. The critical values for the Lower and Upper Bounds respectively are 5.59 and 6.26 for the symmetric models at 10% significance level, while they are 4.19 and 5.06 for the asymmetric models.†indicates that bounds test for cointegration is inconclusive, hence both the short run and long run results are reported; ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.