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Effect of Oil Price Pass-Through on Domestic Price Inflation: Evidence from Nonlinear ARDL Models

Summary: We intended to demonstrate that oil price can have a different pass-through effect into domestic prices at consumer and production levels subject to an oil dependency factor. The results were compared between oil-importing and oil-exporting countries. The nonlinear autoregressive distributed lags (NARDL) models were used to capture the asymmetric pass-through effects of oil price increases and decreases in consumer price and producer price respectively. Our results revealed that oil price changes can have asymmetric effect on consumer price index (CPI) inflation directly and indirectly with more influential impact of indirect effect. This result holds for both groups of countries. The effect on producer price is much larger especially in oil-importing group due to the high dependence of these countries on oil. Oil price changes did lead to increases in consumer prices in oil-importing countries. This may due to effective monetary policy that enhances price stickiness in the economy.

Key words: Inflation, Oil price, Asymmetric effects, Nonlinear ARDL models.

JEL: C23, E31, Q43.

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There are some issues/shortcomings in previous studies on the effects of oil price changes. Our study seeks to fill these gaps by contributing in three ways. Firstly, the impacts of oil price on domestic prices are evident through many studies. However, the effects may differ across countries due to economic structures, e.g. developing *versus* developed countries and oil dependency/intensity (oil-importing *versus* oil-exporting countries) (see Siok Kun Sek 2017). As claimed by Rebeca Jiménez-Rodríguez (2004), contradictory results may also be due to misspecification of the relationship using a linear functional form. Taking into account these claims (economic structures and modeling issues), we extended the study of the impact of oil price changes on domestic prices using nonlinear autoregressive distributed lags (NARDL) models by comparing results between the main oil-importing *versus* main oil-exporting countries.

Secondly, previous studies mainly investigated the direct effect of oil price changes on consumer price index (CPI) inflation alone. However, oil price changes may also pass-through into CPI inflation indirectly through an input cost channel. This indirect effect is ignored/missing in the previous studies. In this study, we extended the analysis to cover two domestic price levels: CPI (consumer level) and wholesale price index (WPI – producer level) using a panel data approach.

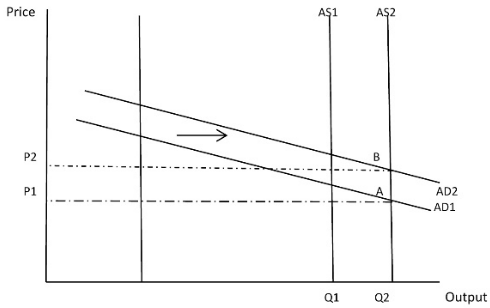
The third contribution of this study is that we extended the mean group (MG)/pooled mean group (PMG)/dynamic fixed effects (DFE) techniques developed by M. Hashem Pesaran, Yongcheol Shin, and Ron P. Smith (1999) that they had applied a (linear) autoregressive distributive lags (ARDL) model, to a NARDL model advanced by Shin, Byungchul Yu, and Matthew Greenwood-Nimmo (2011) that had been originally applied to time series data. Such application provides interpretation of the asymmetric effects of oil price changes (increases and decreases) on domestic inflation.

The remaining sections of this paper are organised as follows: Section 1 discusses the transmission effects of oil price based on economic theory; Section 2 provides a review of the literature; Section 3 explains the data; Section 4 discusses the methodology; Section 5 summarises the results; and the last section concludes the findings.

1. Theoretical Counterpart - The Transmission Channels of Oil Price Changes

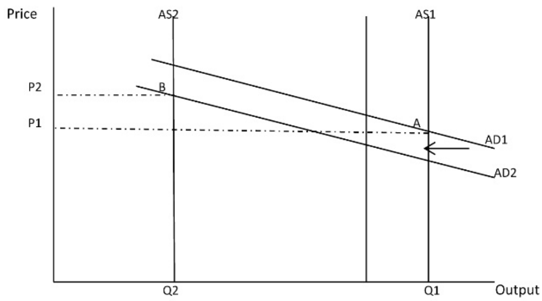
Study of transmission effects of oil price changes into domestic prices provides a better understanding of the dynamic effect of oil shock, and earlier action can be taken to reduce the impacts of such shock. In terms of oil price, the transmission effects can be captured through aggregate demand (input costs channel), aggregate supply (real income shifts channel) and policy responses (monetary and fiscal policies channel). From the supply side or production level, lower oil price indicates a lower cost of production as discussed in Mary G. Finn (2000). The reduction in production cost is then pass-through into lower consumer price, which will lead to lower inflation. From the demand side, lower oil price means consumers pay lower energy bills and have higher real income. This condition will stimulate higher consumption as indicated in James D. Hamilton (2003) and Lutz Kilian (2014). The opposite outcome will hold when there is an increase in oil price. Therefore, oil price changes may lead to higher inflation or recession. The impacts can be detrimental due to over fluctuation in oil price changes. To reduce the volatility in domestic prices due to fluctuation in oil price, the policymaker may implement a contractionary monetary policy to stabilize inflation and an expansionary policy to boost the economy during the recession (see Michael LeBlanc and Menzie D. Chinn 2004).

George Filis and Ioannis Chatziantoniou (2014) discussed the transmission effects of oil price oil-importing *versus* oil-exporting countries using the AD/AS framework. As depicted in Figure 1, an increase of oil price will lead to an increase of income in oil-exporting countries through the shift of aggregate supply curve AS_1 to AS_2 (income effect). At the same time, higher oil price may induce higher production cost, which will then lead to higher aggregate supply (production cost effect). Aggregate demand will also increase the value of export demand for oil increases. As a result, consumption and investment will increase which will lead to the increase in employment. Finally, prices may increase from P_1 to P_2, and output increases from Q_1 to Q_2.



Source: Sketch from the author.

Figure 1 Oil Price Effect on Oil-Exporting Countries



Source: Sketch from the author.

Figure 2 Oil Price Effect on Oil-Importing Countries

In oil-importing countries, higher oil price will lead to higher production cost (production cost effect, see Figure 2). In contrast to the oil-exporting group, higher oil price causes lower income and welfare through the lower output (income effect). Higher production cost will be transmitted to consumer prices. As a result, prices increase from P_1 to P_2 (cost-push inflation) and aggregate demand drops from AD_1 to AD_2. Due to lower consumption and output, unemployment is expected to increase. The negative effect of oil price increases will lead to the economic downturn in oil-importing countries.

Apart from these, Guillaume L'oeillet and Julien Licheron (2008) discussed three mechanisms about how the rising oil prices are transmitted into higher inflation rates. The first mechanism is through a direct impact from crude oil prices to the prices of refined products, for instance, heating oil and fuels that are used for transport, which are components of a basket of consumer price index. The second mechanism is the so-called indirect impact on consumer prices through producer prices, that is, producers will adjust the prices of final goods due to higher energy prices, which will then affect CPI inflation. Lastly, the impacts may translate into second-round effects and wage-price spiral: oil price increases may lead to higher inflation expectations and higher wages due to the first-round effects (the direct and indirect effects); households and labour unions may fight for higher wage rates to compensate for the decline in real income due to higher oil price. This will then lead to higher inflation rates.

2. Literature Surveys - Empirical Findings

Although the impacts of oil price on domestic inflation are evident through many reports and studies, the impacts may vary across industries and countries and also evolve over time. From the aspect of timing, some studies showed that the impacts of oil price on economic activities have declined over time and that the oil pass-through effect into domestic prices is limited since the 1980s. For instance, Mark A. Hooker (2002) investigated the pass-through effect of oil price using the US data and he found that the oil pass-through effect has been negligible since 1980. Since then, many studies also reported the decline in the oil pass-through effects on domestic prices (e.g. see José De Gregorio et al. 2007; Mingyu Chen and Yi Wen 2011; Charles L. Evans and Jonas D. M. Fisher 2011). Economists and researchers have different explanations for the decline's inflationary effect of oil price. Among them, De Gregorio et al. (2007) provided the following explanations for the reduction effect of oil price: the decline in oil intensity, lower exchange rate pass-through, better inflationary environment and the increase in oil price due to strong world demand. On the other hand, Olivier J. Blanchard and Jordi Gali (2007) and Alan S. Blinder and Jeremy B. Rudd (2008) explained this condition as a result of a credible monetary policy, greater flexibility in wage and the structural change in industries. Among these factors, many researchers agreed that more effective and credible monetary policy can help to reduce the inflationary effect of oil price (e.g. Ben S. Bernanke, Mark Gertler, and Mark Watson 1997; Blanchard and Gali 2007; Shiu-Sheng Chen 2009; Luis. J. Álvarez et al. 2011).

The inflationary effects of oil price may differ across industries and sectors. Focusing the analyses at disaggregated prices, some studies detected significant pass-through from oil price into food prices (Mansor H. Ibrahim 2015), agricultural prices (Zibin Zhang et al. 2010; Abdul S. Abdul-Rahim and Mohd A. Zariyawati 2011) and air transportation industry (John Hansman et al. 2014). The pass-through rates of oil into prices may differ across industries/sectors, depending on their energy intensity. For instance, Brian M. Dillon and Christopher B. Barrett (2015) conducted an empirical study on the effect of oil prices on food prices in East Africa. Their results detected evidence on the impact of oil prices on food prices primarily through transport costs. They also revealed that oil prices have larger effects on local maize price compared with the effects on world maize prices. On the other hand, Jiménez-Rodríguez (2008) studied six Organization for Economic Co-operation and Development (OECD) countries (France, Germany, Italy, Spain, US and UK) using disaggregated data in eight industries. The results revealed evidence on the impacts of oil price shocks on the economy in these countries. However, they observed diverse output responses to oil price shocks across four Economic and Monetary Union (EMU) countries but similar responses in another two countries (UK and US). They concluded that the cross-industry heterogeneity effects of oil shock may be due to industrial structures and oil consumption.

A number of studies revealed different effects of oil price changes on the economic activity between oil-importing and oil-exporting countries. Previous studies showed that oil price increases imposed a positive effect on the economy in oil exporters Omar Mendoza and David Vera (2010) but the effect is negative in oil-importing countries in Jiménez-Rodríguez and Marcelo Sánchez (2005). On the other hand, Filis and Chatziantoniou (2014) detected oil price innovations that have significant effects on determining the inflation in both net oil-importing and net oil-exporting countries. However, stock markets in net oil-importing countries showed a reverse response towards oil price increases in contrast to the positive response in net oil-exporting countries. Similarly, Nicola Cantore, Alessandro Antimiani, and Paulo R. Anciaes (2012) found that energy prices have positive impacts on energy exporting countries whereas the effect is negative in energy importing countries. Although higher oil price leads to the flows of incomes from oil importers to oil exporters, how the oil exporters deploy their revenues has an important effect on the economy of oil importers. The recycle of petrodollars effect shows that when oil exporters increase their spending/consumption using revenues from oils to buy goods and services from oil importers, this may help to reduce the negative effect on growth in oil-importing countries as in Matthew Higgins, Thomas Klitgaard, and Robert Lerman (2006). Therefore, higher exports and other income flows may help to compensate the negative effect of higher oil prices in oil-importing countries in Tobias N. Rasmussen and Agustín Roitman (2011).

More recently, a number of studies were conducted on studying the impacts of oil prices based on the origin or nature of oil shocks. A study was pioneered by Kilian (2008, 2009) who decomposed the oil shocks into oil supply shock, an oil demand shock driven by economic activity and oil-specific demand shock. Focusing the analyses on US data, Kilian (2009) found that oil demand shocks accounted for major fluctuations in real oil prices in the US since the 1970s. Based on this result, he argued that traditional analysis that focused on the effects of oil supply shock is misleading as oil shock is led more by oil demand flows. Since then, more studies were conducted using the approach by Kilian as in Gert Peersman and Ine Van Robays (2012) and Alejandro Badel and Joseph McGillicuddy (2015). Applying the approach by Kilian (2009) to decompose oil shocks into three components on the extended US data, Badel and McGillicuddy (2015) found the same results as reported in Kilian (2009), that is, oil demand shock has a majority explanatory power relative to oil supply shock on determining domestic price changes.

Economic variables may react differently to the nature of oil shocks depending on whether the country is an oil exporter or an oil importer. Peersman and Van Robays (2012) conducted analyses on the impacts of oil shocks across a set of countries over time. Their results demonstrated three main outcomes. First, the source of oil price shift matters in determining the economic outcome. Higher oil prices due to higher global economic activity and oil-specific demand shocks may lead to a temporary increase and transitory decline in real gross domestic product (GDP). On the other hand, oil supply shocks may lead to different impacts across countries with a permanent fall in economic activity in oil-importing countries but with an insignificant or positive effect in oil exporters. Second, oil price pass-through into inflation may differ across oil-importing countries, depending on the second-round effects of wage increases.

Third, the effects of oil price shocks may change over time as the macroeconomic structure changes. Countries that have improved their net energy position will be less vulnerable to oil shocks over time.

Due to the failure of linear models to explain the transmission of oil price shocks in explaining the US real activity, more studies started to emphasize on asymmetries or nonlinear modeling (Ana María Herrera, Latika Gupta Lagalo, and Tatsuma Wada 2011). Earlier studies that applied asymmetries in their modeling include Prakash Loungani (1986) and Knut A. Mork (1989). Applying the asymmetries/nonlinear modeling, some studies detected the asymmetric effects of oil price changes on economic activities, that is, increases in oil price have larger impacts on economic activity than the effects of decreases in oil price. An earlier study was conducted by Javier F. Mory (1993) and Mork, Øystein Olsen, and Hans T. Mysen (1994). They found that increases in oil price reduce economic activity with larger impact relative to the boost of the economy due to the decline in oil price. Other papers also found the same conclusion using asymmetric modeling, among them are Kiseok Lee, Shawn Ni, and Ronald A. Ratti (1995), Perry Sadorsky (1999), Jungwook Park and Ratti (2007), Pelin Öge Güney (2013), and Ibrahim (2015). However, such asymmetric effects of oil price changes may not hold in the oil-exporting countries. The reverse condition may hold in oil-exporting countries. For instance, Charles N. O. Mordi and Michael A. Adebiyi (2010) focused their investigation on the asymmetric effects of oil price shocks on output and prices in Nigeria. The results showed that oil price decreases have larger impacts than oil price increases. Oil price increases led to a 15.5% variation in real GDP, account for 15% variation in prices and explain 35.3% variation in deposit rate. On the other hand, decreases in oil price contribute to 93.2% in real GDP, 85% variation in prices and 94% variation in deposit rate in Nigeria. These previous findings indicate that nonlinear models may provide the better explanation on the dynamic effects of the oil price shock on the economies.

3. Data

The study included four variables, namely CPI, GDP in US$ (the constant year 2005), WPI and Brent crude oil price (US$ per barrel). All data were collected from the World Bank (2016)[1] except the data for Brent crude oil price which was collected from the US Energy Information Administration (EIA 2016)[2]. The data were in annual frequency, ranging from 1965 to 2014. Some series had a shorter range because of data availability. All variables were transformed into log form for consistency. Table 1 provides the data description. The oil price series (*LOIL*) was decomposed into *LPOS* and *LNEG* to proxy for oil price increases and decreases respectively (see methodology for further explanation).

[1] **World Bank.** 2016. Indicators. http://data.worldbank.org/indicator/ (accessed April 15, 2016).
[2] **US Energy Information Administration (EIA).** 2016. Data. http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm (accessed April 15, 2016).

Table 1 Data Description

No.	Name	Description
1.	*LCPI*	Log of consumer price index
2.	*LGDP*	Log of gross domestic products (constant US$, base year = 2005)
3.	*LWPI*	Log of wholesale price index
4.	*LOIL*	Log of Brent crude oil price (US$ per barrel)
5.	*LPOS*	Log of oil price increases
6.	*LNEG*	Log of oil price decreases

Source: Information provided by the author.

The study focused on ten countries. These main oil-importing and oil-exporting countries were selected by data availability. To make better comparisons, we divided the countries into two main groups:

a) Oil-exporting countries: Canada, Iran, Kuwait, Norway and Saudi Arabia;
b) Oil-importing countries: India, Japan Korea, Singapore and US.

The classification of the countries into oil-exporting and oil-importing groups was based on the World Factbook (2016)[3].

4. Methodology

The study applied the NARDL model on the panel data. The NARDL model is the extension of the conventional ARDL model introduced by Pesaran and Shin (1999) which was applied to time series data. Such linear ARDL model was then extended by Shin, Yu, and Greenwood-Nimmo (2011) to include nonlinearity elements. The NARDL model was applied to time series data. On the other hand, the linear ARDL model was further applied to heterogeneous panel data using pooled mean group estimation by Pesaran, Shin, and Smith (1999). This study, however, further applied the NARDL model to the panel data using PMG, MG and DFE estimations.

The analysis involved several steps. First, panel unit-root tests were performed on checking the stationarity and level of integration of each variable. This step is to ensure that no variable is integrated larger than 1. In addition, it is also important to ensure that the dependent variable must be I(1) so that the model can perform better (Noman Arshed 2014). This is because the ARDL and NARDL model require no variable with I(2) or higher but allows a combination of I(0) and I(1) of variables in the model (R. Sultan 2010). This condition also implies that dependent variable should be I(0) to ensure the significance of the cointegrating relationship. This step was followed by NARDL model specification test to select the optimal lag length through Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC). In the third step, the NARDL models were estimated (based MG, PMG and DFE methods) and the cointegration test was performed based on the NARDL output. The cointegration test helps to detect the long-run relationship in the NARDL model. If no cointegrating relationship is detected, the NARDL model is not valid. In the fourth step, the Hausman test was performed to decide on the best estimator.

[3] **World Factbook.** 2016. http://www.cia.gov/library/publications/resources/the-world-factbook/ (accessed April 15, 2016).

4.1 ARDL Model

According to Mohsen Bahmani-Oskooee and Hadise Fariditavana (2015), ARDL has three advantages over other cointegration models. First, the short-run and long-run effects of all exogenous variables on an endogenous variable can be estimated using one step ordinary least square (OLS). Second, this model can be applied when there are a mixture of I(0) and I(1) variables. This is a very flexible condition compared to other models such as vector error correction model (VECM) that is only applicable when all variables are I(0). Third, this model performs better than other cointegration approaches when the sample sizes are small. Pesaran and Shin (1999) found that ARDL model is reliable for small sample size using time series data. On the other hand, when applied to panel data, Pesaran, Shin, and Smith (1997, 1999) also demonstrated that PMG estimator (using panel ARDL model) is robust to the choice of lag order, sample, outliers and estimation method where the panel sample size is small.

In modeling the oil pass-through into CPI, we assumed *LCPI* can be explained by *LWPI*, *LOIL* and *LGDP*, using the ARDL (p, q_1, q_2, q_3) specification (p as the lag order for the dependent variable (*LCPI*) while q_1, q_2, q_3 are lag orders for independent variables of *LWPI*, *LOIL* and *LGDP* respectively):

$$LCPI_t = \sum_{j=1}^{p} \lambda_{ij}\, LCPI_{it-j} + \sum_{j=0}^{q1} a_{ij}\, LWPI_{it-j} + \sum_{j=0}^{q2} b_{ij}\, LOIL_{it-j} + \sum_{j=0}^{q3} c_{ij}\, LGDP_{it-j} + \varepsilon_{it}, \quad (1)$$

where $i = 1, 2, \ldots, N$ indicates the number of countries; $t = 1, 2, \ldots, T$ indicates the number of periods; *LCPI* is the dependent variable; *LWPI, LOIL* and *LGDP* are the independent variables that take the $k \times 1$ vector of independent variables ($k = 3$); a_{ij}, b_{ij}, c_{ij} are $k \times 1$ coefficient vectors; λ_{ij} is the vector of scalars and ε_{it} is a disturbance term distributed with a zero mean and a finite variance. Equation (1) can be written in an error correction format as below:

$$\Delta LCPI_{it} = \emptyset_i LCPI_{it-1} + \beta'_{ai} LWPI_{it} + \beta'_{bi} LOIL_{it} + \beta'_{ci} LGDP_{it} + \sum_{j=1}^{p} \lambda_{ij}\, \Delta LCPI_{it-j} + \sum_{j=0}^{q1} a'_{ij}\, \Delta LWPI_{it-j} + \sum_{j=0}^{q2} b'_{ij}\, \Delta LOIL_{it-j} + \sum_{j=0}^{q3} c'_{ij}\, \Delta LGDP_{it-j} + \varepsilon_{it}, \quad (2)$$

where $\phi_i = -1\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right)$, ; $\beta_{ni} = \sum_{j=0}^{q\ell} n_{ij}$; $n = a, b, c$; $\ell = 1, 2, 3$;

$\tilde{\lambda}_{ij} = \sum_{m=j+1}^{p} \lambda_{im}$, $j = 1, 2, \ldots, p-1$; $\tilde{n}_{ij} = \sum_{m=j+1}^{q\ell} n_{im}$; $n = a, b, c$; $j = 1, 2, \ldots, q_\ell - 1$.

By regrouping, the error correction Equation (2) can be rewritten as:

$$\Delta LCPI_{it} = \emptyset_i(LCPI_{it-1} \text{-} \theta'_{ai}LWPI_{it} + \theta'_{bi}LOIL_{it} + \theta'_{ci}LGDP_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}\,\Delta LCPI_{it-j} + \sum_{j=0}^{q1-1} a'_{ij}\,\Delta LWPI_{it-j} + \sum_{j=0}^{q2-1} b'_{ij}\,\Delta LOIL_{it-j} + \sum_{j=0}^{q3-1} c'_{ij}\,\Delta LGDP_{it-j} + \varepsilon_{it}, \tag{3}$$

$\theta_i = -\left(\frac{\beta_{ni}}{\phi_i}\right)$; $n = a,b,c$ indicates the long-run or equilibrium relationship among the dependent and independent variables in Equation (3). λ_{ij} is the short-run coefficient of the independent variable while $n_{ij} = (a,b,c)_{ij}$ are the short-run coefficients which show the short-run effects of dependent variables on *LCPI* in Equation (3). ϕ_i refers to the error-correction coefficient, which is used to measure the speed of adjustment of independent variable in converging to its long-run equilibrium due to changes in the exogenous variables. This parameter should be in the negative value to confirm a convergence or stability in the long-run relationship. θ_i is the rate of pass-through from independent variables into the dependent variable for Equation (3).

Equation (3) is the linear ARDL model that only permits symmetric analysis on the effect of oil price and other variables on CPI inflation. To capture the asymmetric effects on the increases and decreases of oil prices on CPI, we considered the NARDL (p, q_1, q_2, q_3, q_4) model given as:

$$\Delta LCPI_{it} = \emptyset_i(LCPI_{it-1} \text{-} \theta'_{ai}LWPI_{it} + \theta^{+\prime}_{bi}LPOS_{it} + \theta^{-\prime}_{bi}LNEG_{it} + \theta'_{ci}LGDP_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}\,\Delta LCPI_{it-j} + \sum_{j=0}^{q1-1} a'_{ij}\,\Delta LWPI_{it-j} + \sum_{j=0}^{q2-1} b^{+\prime}_{ij}\,\Delta LPOS_{it-j} + \sum_{j=0}^{q3-1} b^{-\prime}_{ij}\,\Delta LNEG_{it-j} + \sum_{j=0}^{q4-1} c'_{ij}\,\Delta LGDP_{it-j} + \varepsilon_{it}, \tag{4}$$

where q_3 and q_4 are the lag orders for oil price increases (*LOIL*_POS) and oil price decreases (*LOIL*_NEG) respectively.

$$LPOS_t = \sum_{t=1}^{T} \Delta LPOS_t = \sum_{t=1}^{T} \max\left(\Delta LPOS_t, 0\right)$$

$$LNEG_t = \sum_{t=1}^{T} \Delta LNEG_t = \sum_{t=1}^{T} \min\left(\Delta LNEG_t, 0\right)$$

$\sum_{j=0}^{q2-1} b'_{ij}$ measures the short-run impacts of oil price increases on CPI inflation while $\sum_{j=0}^{q3-1} c'_{ij}$ measures the short-run impacts of oil price decreases on CPI inflation.

$\theta^{+'}_{bi}$ and $\theta^{-'}_{bi}$ are the long-run effects of oil price increases and oil price decreases on CPI inflation respectively. The other variables are as defined in Equation (3). As discussed in Bahamani-Oskooee and Fariditavana (2015), one can judge the asymmetric effects by comparing the sign and size of the two partial sums. If both partial sums are the same sign and size, the oil price effects are symmetric. Otherwise, they are asymmetric.

Applying the same specification, we then constructed the oil pass-through into WPI equation. See Equation (5) and (6) for ARDL and NARDL models, respectively.

$$\Delta LWPI_{it} = \emptyset_i(LWPI_{it-1} - \theta'_{ai}LCPI_{it} + \theta'_{bi}LOIL_{it} + \theta'_{ci}LGDP_{it}) + \sum_{j=1}^{p-1}\lambda_{ij}\,\Delta LWPI_{it-j} + \sum_{j=0}^{q1-1}a'_{ij}\,\Delta LCPI_{it-j} + \sum_{j=0}^{q2-1}b'_{ij}\,\Delta LOIL_{it-j} + \sum_{j=0}^{q3-1}c'_{ij}\,\Delta LGDP_{it-j} + \varepsilon_{it}, \tag{5}$$

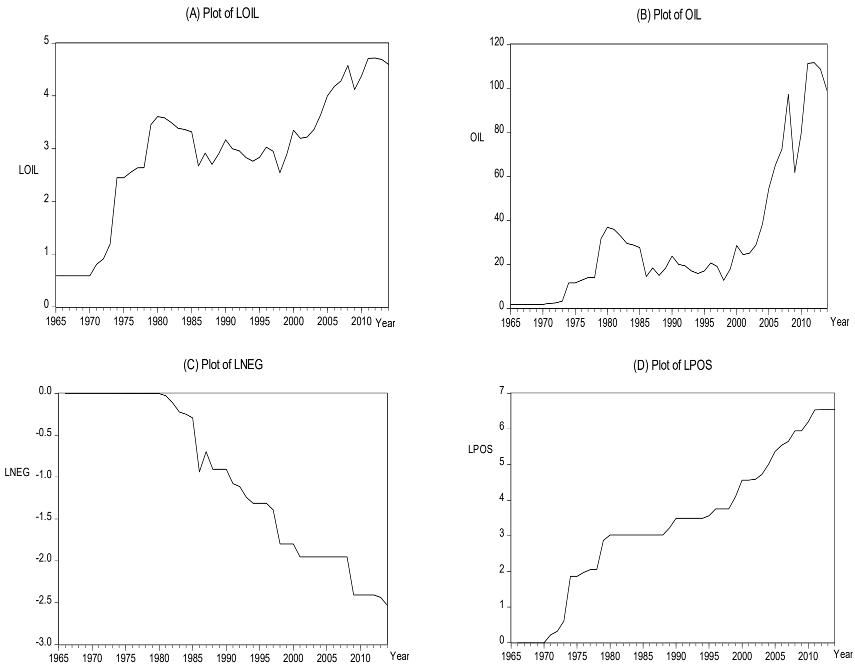
$$\Delta LWPI_{it} = \emptyset_i(LWPI_{it-1} - \theta'_{ai}LCPI_{it} + \theta^{+\prime}_{bi}LPOS_{it} + \theta^{-\prime}_{bi}LNEG_{it} + \theta'_{ci}LGDP_{it}) + \sum_{j=1}^{p-1}\lambda_{ij}\,\Delta LWPI_{it-j} + \sum_{j=0}^{q1-1}a'_{ij}\,\Delta LCPI_{it-j} + \sum_{j=0}^{q2-1}b^{+\prime}_{ij}\,\Delta LPOS_{it-j} + \sum_{j=0}^{q3-1}b^{-\prime}_{ij}\,\Delta LNEG_{it-j} + \sum_{j=0}^{q4-1}c'_{ij}\,\Delta LGDP_{it-j} + \varepsilon_{it}. \tag{6}$$

Since the main objective of this study is to analyze the asymmetric effect of oil price changes into domestic prices, we only provided results on NARDL models (Equations 4 and 6). These equations are estimated based on the two groups of countries, using MG, PMG and DFE techniques, respectively. These techniques were applied for long panel data where $T > N$. MG is the least restrictive approach as it imposes no restriction on cross-country and assumes homogeneity of all parameters. The MG estimator derives the long-run estimates by averaging the individual country-specific coefficients from ARDL model which are consistent estimates of the long-run coefficients as in the study of Evans and Fisher (2011). MG approach might sensitive to outliers when the sample sizes are small (Giovanni Favara 2003). On the other hand, PMG restricts the long-run parameters to be homogeneous across countries but imposes no restriction on the intercepts, short-run coefficients and error variances to be different across countries. The PMG estimator is subject to some basic assumptions (Pesaran, Shin, and Smith 1999): (i) there is no correlation in the error terms; (ii) there exist a long-run relationship between dependent and independent variables; and (iii) all long-run parameters are restricted to be same across countries. PMG is used widely as it is more likely to capture the nature of data. It is also reasonable to assume that all countries share the same long-run equilibrium level although they exhibit the heterogeneous dynamics in the short-run in Kang Y. Tan (2006). According to Anupam Das (2011), the PMG estimator is consistent and more efficient when the restriction on homogeneous long-run coefficient is valid. On the other hand, DFE constraints the long-run and short-run coefficients to be same but allows the intercepts to differ across countries (Marta C. N. Simões 2011). DFE also restricts the error variances and speed of adjustment coefficient to be identical across countries. This approach may subject to simultaneous equation bias when the sample sizes are small (Badi H. Baltagi, James M. Griffin, and Xiong Weiwen 2000).

Hausman test was used to select the most appropriate estimator. First, Hausman test was performed to decide between MG and PMG estimators based on the null hypothesis of homogeneity in the long-run slope (PMG restriction is valid). If the test is not significant, we opt for PMG estimators. However, if the null hypothesis is rejected, we further to conduct a second test to decide between MG and DFE with null hypothesis DFE restriction is valid. Therefore, the rejection of null hypothesis implies that MG is more efficient than DFE. Otherwise, if the test is not significant, we may opt for DFE.

4.2 Results - Oil Price Changes

As the main interest of the current study is focused on the asymmetric effect of oil price changes, Figure 3 provides some plots of the oil price series. Panel (A) and (B) are oil price plots in level and log form, respectively. As observed, oil price stayed constant from 1965-1970 but there was a high spike in the mid-1970s. Another big spike was observed in the mid-2000s. The oil price crises could be causal to the high fluctuation in global crude oil prices. Among them include the 1973 oil crisis, the 1979



Source: Graphs are sketched by the author.

Figure 3 Plots of Oil Price

energy crisis (Iranian Revolution), the 1990 oil price spike and the 2000s energy crisis. The oil price plot series in Panel (A) and (B) show that oil price increases are much larger than oil price decreases. In order to view the oil price increases and decreases alone, we provided the plots of *LPOS* and *LNEG* as constructed in the NARDL models. Panel (C) and (D) provide the plots of the accumulative decreases and increases of oil price, separately, based on the series defined in the NARDL models (Equations 4 and 6). Large increases were observed in the mid-1970s while large decreases were detected in the mid-1980s and mid-2000s. Both *LPOS* and *LNEG* are not smooth due to the fluctuation in oil price changes.

5. Results - Preliminary and Diagnostic Tests

Prior to the estimation, panel unit-root tests were performed to check for the stationarity of variables and to ensure no variable with integration higher than 1. For robustness checking, we compared the results of panel unit-root test using first generation – MW (Gangadharrao Soundalyarao Maddala and Shaowen Wu 1999) and second generation – Pesaran (2007). The difference between both tests is that the first generation tests assume cross-sectional independence while the second generation tests assume cross-sectional dependencies. Table 2 summarizes the test statistics and *p*-value (in parentheses) of unit-root tests using Maddala and Wu (1999) and Pesaran (2007). Both tests are based on the null hypothesis that the series is I(1). The results from both tests are consistent, i.e. fail to reject the null hypothesis and conclude that all variables are integrated with order 1.

Table 2 Unit-Root Tests

Variable	Lag	1st generation test - MW		2nd generation test - Pesaran	
		Without trend	With trend	Without trend	With trend
LCPI	1	14.184 (0.165)	12.864 (0.231)	-1.419 (0.078)	-0.430 (0.334)
	3	13.561 (0.194)	9.911 (0.448)	-1.052 (0.146)	0.856 (0.804)
	5	14.201 (0.164)	10.830 (0.371)	-0.283 (0.389)	1.842 (0.967)
LWPI	1	6.287 (0.791)	9.074 (0.525)	0.079 (0.532)	-0.423 (0.336)
	3	6.286 (0.791)	6.162 (0.802)	-0.436 (0.332)	-0.421 (0.337)
	5	9.218 (0.512)	7.883 (0.640)	-1.084 (0.139)	0.087 (0.535)
LGDP	1	6.891 (0.736)	8.232 (0.606)	0.282 (0.611)	-1.404 (0.080)
	3	7.356 (0.691)	8.124 (0.617)	0.989 (0.839)	-0.721 (0.235)
	5	5.883 (0.825)	7.667 (0.661)	1.977 (0.976)	1.523 (0.936)
LPOS	1	1.869 (0.997)	6.867 (0.738)	10.366 (1.000)	10.133 (1.000)
	3	2.425 (0.992)	6.419 (0.779)	10.366 (1.000)	10.133 (1.000)
	5	3.650 (0.962)	17.610 (0.062)	10.366 (1.000)	10.133 (1.000)
LNEG	1	1.977 (0.997)	13.231 (0.211)	10.366 (1.000)	10.133 (1.000)
	3	2.380 (0.993)	12.323 (0.264)	10.366 (1.000)	10.133 (1.000)
	5	2.825 (0.985)	11.211 (0.341)	10.366 (1.000)	10.133 (1.000)

Source: Results provided by the author.

Since no variable is integrated with I(2) and the dependent variables (*LWPI* and *LCPI*) are integrated with I(1), we fulfilled the requirement of ARDL/NARDL model. We further conducted the cointegration test to reveal if there exists any long-run relationship between the dependent and explanatory variables. The results of the test are summarized in Table 3. Kao's test has strongly rejected the null hypothesis of no cointegrating relationship in both linear and nonlinear specifications for all groups of countries. Since there are evidences on the long-run relationship in these four models, we continued with our NARDL model estimations.

Table 3 Panel Cointegration - Kao's Test

Model	Exporting group	Importing group
1	-2.0889**	-4.4146***
2	-2.1147**	-3.5999***
3	-2.2396**	-4.4146***
4	-2.1527**	-3.5999***

Notes: *** significance at 1% level; ** significance at 5% level; and * significance at 10% level.

Source: Results provided by the author.

AIC and BIC were used to search for optimal lag length for the NARDL models. The search was up to a maximum of four lags due to small sample sizes. The search applied the default by EViews, Version 9.0, by setting the lag numbers for independent variables to be the same $q_1 = q_2 = q_3 = q_4$ in each combination with p (lag number of dependent variable). The results are summarised in Tables 4a and 4b. Both AIC and BIC suggested different lag lengths (the optimal lag was selected for the model with the smallest AIC/BIC). The final decision was based on the smallest value of the AIC or the BIC's lag specification that fulfilled the diagnostic test for heteroskedasticity (see Tables 4a and 4b).

Table 4a Lag Length Selection - CPI Equation

ARDL specification	Oil-exporting		Oil-importing	
	AIC	BIC	AIC	BIC
ARDL(1,1,1,1,1,1)	-5.4437	-4.7545	-5.1733	-4.6437
ARDL(2,1,1,1,1,1)	-5.5323	**-4.7547**	-5.7976	**-5.1902**
ARDL(3,1,1,1,1,1)	-5.5012	-4.6353	-5.7984	-5.1131
ARDL(4,1,1,1,1,1)	-5.5006	-4.5464	-5.7929	-5.0297
ARDL(1,2,2,2,2,2)	-5.5899	-4.5473	-5.3762	-4.5351
ARDL(2,2,2,2,2,2)	-5.5973	-4.4663	-5.9058	-4.9868
ARDL(3,2,2,2,2,2)	-5.6160	-4.3967	-5.9682	-4.9713
ARDL(4,2,2,2,2,2)	-5.6461	-4.3384	**-5.9913**	-4.9166
ARDL(1,3,3,3,3,3)	-5.5801	-4.1841	-5.3995	-4.2469
ARDL(2,3,3,3,3,3)	-5.6529	-4.1685	-5.8601	-4.6326
ARDL(3,3,3,3,3,3)	-5.6458	-4.0731	-5.8625	-4.5542
ARDL(4,3,3,3,3,3)	-5.6569	-3.9926	-5.8876	-4.5014
ARDL(1,4,4,4,4,4)	-5.5037	-3.7543	-5.3743	-3.9102
ARDL(2,4,4,4,4,4)	-5.7552	-3.9174	-5.8258	-4.2838
ARDL(3,4,4,4,4,4)	-5.7819	-3.8557	-5.8760	-4.2562
ARDL(4,4,4,4,4,4)	**-6.0071**	-3.9926	-5.9070	-4.2092
Final decision	ARDL(2,1,1,1,1)		ARDL(4,2,2,2,2)	

Source: Results provided by the author.

Table 4b Lag Length Selection - WPI Equation

ARDL specification	Oil-exporting		Oil-importing	
	AIC	BIC	AIC	BIC
ARDL(1,1,1,1,1,1)	-4.0861	-3.3969	-4.6759	-4.0684
ARDL(2,1,1,1,1,1)	-1.1930	**-3.4154**	-4.7555	**-4.0702**
ARDL(3,1,1,1,1,1)	-4.1891	-3.3232	-4.7818	-4.0186
ARDL(4,1,1,1,1,1)	-4.1815	-3.2273	-4.7628	-3.9217
ARDL(1,2,2,2,2,2)	-4.0468	-3.0042	-4.9584	-4.0395
ARDL(2,2,2,2,2,2)	-4.1899	-3.0589	-4.9153	-3.9185
ARDL(3,2,2,2,2,2)	-4.1879	-2.9686	-4.9066	-3.8319
ARDL(4,2,2,2,2,2)	-4.2369	-2.9292	-4.8773	-3.7247
ARDL(1,3,3,3,3,3)	-3.9667	-2.5707	-4.9957	-3.7653
ARDL(2,3,3,3,3,3)	-4.2281	-2.7437	-5.0023	-3.6940
ARDL(3,3,3,3,3,3)	-4.2477	-2.6749	-4.9773	-3.5911
ARDL(4,3,3,3,3,3)	-4.2840	-2.6228	-4.9441	-3.4800
ARDL(1,4,4,4,4,4)	-4.1481	-2.3987	-5.0046	-3.4626
ARDL(2,4,4,4,4,4)	-4.4057	-2.5679	-5.0021	-3.3822
ARDL(3,4,4,4,4,4)	-4.4659	-2.5397	-5.0443	-3.3466
ARDL(4,4,4,4,4,4)	**-4.5940**	-2.5794	**-5.1131**	-3.3375
Decision	ARDL(2,1,1,1,1)		ARDL(4,4,4,4,4)	

Source: Results provided by the author.

Table 5 summarises the test statistics together with the p-values (in parentheses) of diagnostic tests on residuals for detecting heteroskedasticity. All tests failed to reject the null hypothesis of no cross-sectional dependence on residuals (no heteroskedasticity) and we concluded that the results are reliable and have no heteroskedasticity problem.

Table 5 Cross-Sectional Dependence Test on Residuals (Heteroskedasticity)

Test	CPI equation		WPI equation	
	Oil-exporting	Oil-importing	Oil-exporting	Oil-importing
Breusch-Pagan LM	7.9629	10.8042	9.5018	16.2571
	(0.6325)	(0.3730)	(0.4852)	(0.0925)
Pesaran scaled LM	-0.4555	0.1798	-0.1114	1.3991
	(0.6487)	(0.8573)	(0.9113)	(0.1618)
Bias-corrected scaled LM	-0.5087	0.1243	-0.1646	1.3423
	(0.6110)	(0.9011)	(0.8693)	(0.1795)
Pesaran CD	1.0307	1.5916	0.7179	2.6782
	(0.3027)	(0.1115)	(0.4728)	(0.0074)

Source: Tests performed by the author.

As indicated before, the NARDL models for CPI and WPI (Equations 4 and 6) were estimated using MG, PMG and DFE techniques. In order to decide on the most efficient estimator, the Hausman test was applied and the results are summarised in Table 6. In all cases, the Hausman test failed to reject the null hypothesis to decide between MG and PMG, and hence suggested the best estimator to be PMG. Therefore, there was no need to perform the second hypothesis to decide between MG and DFE. The result was as expected because PMG is more robust to outliers and model specification when the sample size is small.

Table 6 Hausman Test

Hausman test	CPI equation		WPI equation	
	Oil-exporting	Oil-importing	Oil-exporting	Oil-importing
MG versus PMG				
Chi-square	0.27	5.72	3.11	4.25
p-value	0.9914	0.2213	0.5398	0.3729
Decision	PMG	PMG	PMG	PMG

Source: Results provided by the author.

5.1 Estimation Results - Panel Data NARDL

After conducting the necessary tests mentioned above, the results of the estimation for the NARDL models (Equations 4 and 6) were summarised in Tables 7a and 7b. As the Hausman test suggested PMG as the best estimator in all cases, the interpretation was based on PMG. However, when we compared the results of these three estimators (MG, PMG and DFE), it was observed that the values of the coefficients were quite different across estimators. In some cases, the coefficient of the speed of adjustment (*EC*) was either not significant or non-negative under MG/DFE estimation, indicating no convergence to the equilibrium in the long-run. Such biases/deviations could be because both MG and DFE are sensitive to outliers when sample sizes are small. We continued to interpret the results based on the PMG estimator.

Table 7a NARDL Model for CPI

Coefficient	Exporting group			Importing group		
	PMG	MG	DFE	PMG	MG	DFE
Long-run						
LWPI(t-1)	0.8397***	1.1456**	1.3272***	0.8695***	1.1241***	0.9521***
LGDP(t-1)	0.7638***	0.1362	0.5831**	0.3391***	0.0740	0.2094***
LPOS(t-1)	0.0216	0.1107***	0.1085	-0.0379***	-0.1320	-0.0318
LNEG(t-1)	-0.0585	0.3042**	0.8982**	-0.0342	-0.1458	0.4483
Short-run						
EC	-0.1083***	-0.1600***	-0.0437**	-0.1620*	0.0689	-0.0733***
DLCPI(t-1)	0.1956***	0.2646***	0.2460***	0.7357***	0.8551***	0.8425***
DLCPI(t-2)	-	-	-	-0.2451***	-0.4850***	-0.5450***
DLCPI(t-3)	-	-	-	0.1183***	0.1815***	0.1731***
DLWPI	0.2409***	0.1117	0.3919***	0.3269***	0.5396***	0.5036***
DLWP(t-1)	-	-	-	-0.1548***	-0.2848***	-0.2556***
DLGDP	-0.2160***	-0.2260**	-0.0055	-0.0090	0.0825	0.0775
DLGDP(t-1)	-	-	-	-0.0178	-0.4547	-0.0158
DLPOS	-0.0022	-0.0102	-0.0167	0.0034	-0.0250*	-0.0300***
DLPOS(t-1)	-	-	-	-0.0024	0.0123***	0.0151**
DLNEG	0.0051	-0.0143	0.0313**	-0.0195**	-0.0549	-0.0548***
DLNEG(t-1)	-	-	-	0.0001	0.02542	0.0255**
C	-2.0127***	-0.4519	-0.6551***	-1.4101*	-0.0079	-0.3829**

Notes: *** significance at 1% level; ** significance at 5% level; and * significance at 10% level.

Source: Results provided by the author.

Referring to the CPI equation (Equation 4) as shown in Table 7a, we observed that production cost (WPI) and GDP were the main determinants contributing to higher CPI inflation in the long-run for both oil-exporting and oil-importing countries. The results implied that oil price has a large and influential impact on CPI inflation through the indirect channel (input cost channel) which pass-through into WPI and finally affect CPI inflation.

On the other hand, oil price changes had a very limited direct effect on CPI inflation. There was no significant oil price pass-through effect into CPI inflation in the both short-run and long-run for the oil-exporting group. For the oil-importing group, oil price increases had a minor long-run effect of reducing CPI inflation while oil price decreases only had a short-run effect to reduce CPI inflation in this group. Higher oil price does not pass-through into higher CPI inflation as predicted, but indeed, reduces CPI inflation. This might be due to effective monetary policy that leads to a low inflationary environment and price stickiness that further absorbs the negative effect of oil price shock.

Turning to WPI, in Table 7b it is observed that consumer demand (CPI) and output/GDP are the main determinants of CPI inflation in the long-run. Higher aggregate demand or consumer price stimulates higher production and WPI, while higher GDP/output implies a higher aggregate supply, which leads to lower WPI. All these hold in both oil-exporting and oil-importing countries. Also, as expected, oil price has a closer relationship with WPI, as oil price changes directly pass-through into production cost but the effect may vary across groups of countries. In the oil-exporting group, WPI inflation only reacts to oil price decreases in the long-run, i.e. oil price decreases

Table 7b NARDL Model for WPI

Coefficient	Exporting group			Importing group		
	PMG	MG	DFE	PMG	MG	DFE
Long-run	1.0619***	1.0829**	1.1502***	0.6726***	1.1977***	1.1654***
LCPI(t-1)	-0.6190***	-0.1039	1.7378	-0.1589**	0.1725	0.1622
LGDP(t-1)	0.0030	0.3781*	-0.0155	0.0478***	0.2321	0.2408**
LPOS(t-1)	0.1489**	0.1896	-1.1184	0.3397***	-0.2949	-0.6266**
LNEG(t-1)						
Short-run						
EC	-0.1919***	-0.1431	0.0188	-0.2432**	0.1980***	0.0575***
DLWPI(t-1)	0.1523**	0.2912***	0.3601***	0.2783***	1.5900***	1.4998***
DLWPI(t-2)	-	-	-	-0.0583	-0.9797***	-0.9813***
DLWPI(t-3)	-	-	-	0.0808	0.2345***	0.2438***
DLCPI	0.9936***	0.7810***	0.8838***	1.1953***	1.1321***	0.8633***
DLCP(t-1)	-	-	-	-1.1076***	-1.5593***	-1.1155***
DLCPI(t-2)	-	-	-	0.7318**	0.9798***	0.7366***
DLCPI(t-3)	-	-	-	-0.3933	-0.2061*	-0.1805***
DLGDP	0.3864**	0.2008*	-0.0018	-0.1964*	-0.2700***	-0.2344***
DLGDP(t-1)	-	-	-	-0.1153	0.4000***	0.4699***
DLGDP(t-2)	-	-	-	-0.1466	-0.2860***	-0.3309***
DLGDP(t-3)	-	-	-	-0.1017	0.0737***	0.0754**
DLPOS	0.0602*	0.0299	0.0319**	0.0429*	0.1812**	0.1272***
DLPOS(t-1)	-	-	-	0.0177	-0.2254***	-0.1815***
DLPOS(t-2)	-	-	-	0.0050	0.1279***	0.1098***
DLPOS(t-3)	-	-	-	-0.0094	-0.0285***	-0.0254***
DLNEG	0.0232	-0.0160	0.0296	0.0058	0.0657	0.0481
DLNEG(t-1)	-	-	-	-0.0491***	-0.1056	-0.1028**
DLNEG(t-2)	-	-	-	-0.044	0.0707	0.0714**
DLNEG(t-3)	-	-	-	-0.0084	-0.0184*	-0.0177*
C	2.9240***	1.2277	0.5359	1.3729**	-1.6603	-0.3165
Trend	0.0062***	0.0084	0.0029	0.0056*	0.0123	0.0055***

Notes: *** significance at 1% level; ** significance at 5% level; and * significance at 10% level.

Source: Estimation results provided by the author.

induce higher WPI inflation due to lower government income and a lower subsidy. On the other hand, both oil price increases and decreases pass-through into higher WPI inflation in the long-run in the oil-importing group. The net long-run effect of oil price changes was 0.0478 + 0.3397 = 0.3875 in the oil-importing group, which is much larger than the oil price impact experienced in the oil-exporting group. The results imply that the oil dependency factor matters. Oil-importing countries are highly dependent on oil. Therefore, the production cost of the oil-importing group is very sensitive to oil price changes. On the other hand, oil price changes have limited/insignificance effect on WPI inflation in the short-run in both groups of countries.

5.2 Estimation Results - Time Series NARDL

So far we discussed the results based on panel data for two groups of countries. In order to have a deeper analysis, we performed the NARDL models for individual countries using time series data. Applying the procedure mentioned above, we obtained the results for individual countries and the results on long-run estimates were summarized in Tables 8a and 8b.

As observed from Table 8a, the impact of asymmetric oil price changes on CPI inflation in the oil-exporting group can be observed indirectly through production cost or WPI and directly pass-through into CPI. The indirect effect is much larger relative to that of direct effect which is very small. The same applies to oil-importing group (see Table 8b), but CPI inflation is more reactive to oil price increases in which oil price increases may induce lower CPI inflation due to low inflationary/effective monetary policy.

Table 8a Long-Run Estimates - Oil-Exporting Countries

Model	Coefficient	Canada	Iran	Norway	Kuwait	Saudi Arabia
CPI	*LWPI*	0.9218***	0.7763***	0.3048	0.7296***	1.6787**
	LGDP	0.1622	0.0362	0.1448***	0.0319***	-0.1136
	LPOS	-0.0122	0.1456***	-0.0051	0.0947***	0.0432
	LNEG	0.0234	-0.2725*	0.1478	0.0343	0.1032
WPI	*LCPI*	1.0348***	1.1250***	0.5079	1.2544***	0.1454
	LGDP	-0.1210	0.0218	-2.6214***	-0.0266	0.7379***
	LPOS	0.0310	-0.1346**	-0.0982	-0.0887***	-0.1265**
	LNEG	0.0246	0.0796	1.0062***	-0.0023	-0.0543

Notes: *** significance at 1% level; ** significance at 5% level; and * significance at 10% level.

Source: Estimation results provided by the author.

However, the main determinants of WPI inflation in both groups of countries were aggregate demand (CPI) and output (GDP) as reported by the panel data estimations. Also, oil price decreases stimulate higher WPI inflation in oil-exporting countries, while both oil increases and decreases lead to higher WPI inflation in the oil-importing group. The time series NARDL model estimates also showed very similar results. In addition, the time series estimation (Table 8a) revealed that oil price increases might lead to lower WPI inflation in the oil-exporting group. This may be due to higher government income (such as tax revenues) and subsidy, which benefit the producer.

Combining our results with the panel data and the time series estimates, we detected evidence of the asymmetric effects of oil price increases and decreases on inflation at consumer and producer levels across countries. However, the effects may be influenced by the oil dependency factor (oil importer or oil exporter), the level of price (consumer or producer level) and effective monetary policy that create low inflationary pressure. We also detected the impacts of oil price on CPI inflation through second-round effect (production cost). The impact of oil price on CPI inflation can be influential through its impact on production cost.

Table 8b Long-Run Estimates - Oil-Importing Countries

Model	Coefficient	India	Japan	Korea	Singapore	US
CPI	*LWPI*	0.9103***	1.5585***	0.7819***	0.7479**	1.30620***
	LGDP	0.5810**	0.0197	0.3792***	0.4654***	0.60960***
	LPOS	-0.0932	-0.2253***	-0.0412***	-0.1019	-0.06041*
	LNEG	0.1066	-0.0641	-0.0528	0.0420	-0.33270**
WPI	*LCPI*	0.4750**	0.4816***	1.0109***	0.4272*	0.72520***
	LGDP	-0.9194***	0.1887*	-0.1543	-0.0937	-0.54170***
	LPOS	0.0622	0.1303***	0.0793***	0.2194***	0.10370***
	LNEG	-0.1330	0.1599***	0.2427***	0.3368***	0.15770***

Notes: *** significance at 1% level; ** significance at 5% level; and * significance at 10% level.

Source: Estimation results provided by the author.

6. Conclusion

In this paper, empirical analyses were conducted to examine the asymmetric pass-through effect of oil price changes (increases and decreases) into domestic price inflation at consumer and producer levels, respectively. In particular, our main objective was to reveal if oil dependency between oil-importing and oil-exporting countries matters in determining the pass-through effects of oil into domestic prices/inflation. We focused the analyses on five main oil-importing and oil-exporting countries, respectively, by extending the MG, PMG and DFE approaches to the nonlinear ARDL model estimations.

Our results revealed significant pass-through asymmetric effect from oil price changes into domestic price inflation that may vary across countries and price levels. Oil price changes may affect CPI inflation directly and indirectly. The indirect effect of oil price is through an input cost channel where changes in oil price may pass-through into changes in production cost and this changes will then transmit to final goods/consumer price level. Our results revealed that the direct effect of oil price changes on CPI inflation is very limited/ignorance for both groups of countries. However, oil price may influence CPI inflation through an input cost channel, as production cost is the main determinant of CPI inflation in the majority of countries. On the other hand, oil price had a closer relationship with WPI/production price as changes in oil price induce changes in production cost. The impact of oil price changes in production price level was much larger in oil-importing countries in the long-run due to the high dependency of these countries on energy and oil. Both oil price increases and decreases caused higher production cost in the oil-importing group. Oil price increases (decreases) tended to reduce (increases) production price in the oil-exporting group due to changes in government income and spending. The domestic prices in oil-exporting countries are more reactive to oil price decreases, while those in oil-importing countries were more influenced by oil price increases. The results indicated that oil dependency matters in determining the effects of oil price on domestic inflation.

Although oil price changes may have a detrimental effect at production level in oil-importing groups, its impact at the consumer level is insignificant. Indeed, there was evidence that oil price increases lead to lower CPI inflation in this group of countries. A possible explanation/reason is the effectiveness of the monetary policy that enhances low inflationary pressure and price stickiness, which absorb the oil shock. Monetary policy that emphasises low inflation helps to delay and limit the pass-through from oil price changes into fluctuating prices at consumer level so that price stability is enhanced.

While an effective monetary policy is important to maintain price stability and sustainable growth, reducing the dependence on oil by replacing non-renewable energy with renewable energy (biomass, wind and solar) may also help reduce the impact of oil shock on an economy.

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