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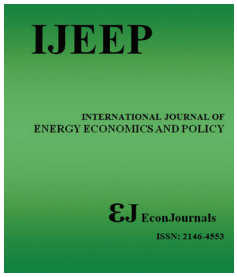

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Oil Price and Inflation in Iran: Non-linear ARDL Approach

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ABSTRACT

In this paper we study the relationship between oil price (or revenue) changes and inflation rate in Iran seasonally in 2003-2015. Method of the study was able to identify asymmetry of oil price and inflation which is recognized as nonlinear autoregressive distributed lag model. Estimated model clarified nonlinear effect of oil price on inflation. Clearly, we found out that there was significant relationship between the reduction in oil price and inflation growth while there was no significant relationship between increase in oil price growth and inflation rate.

Keywords: Inflation Behavior, Oil Price, Asymmetry
JEL Classifications: E31, Q4

1. INTRODUCTION

Due to considerable economic effects of oil price fluctuations, this subject has been studied intensively by academic members and government. Oil price increase is a good news for oil-exporting countries and it is a bad news for oil-importing countries if oil price is reduced it has reverse effect. Correlation between oil price and macro economy are studied. Davis and Altiwanger (2001) and Phelps (1994) proved effect of oil shocks on unemployment rate while Davis (1986) approved effect of oil price changes on alleviating role of technology shocks in business cycle models. Similarly, researches illustrated that oil price shocks have effect on inflation (Hamilton, 1983, 1988, 1996, 2000; Hooker, 1996, 1999, 2002; Huntington, 1998; Kahn & Hampton, 1990). However, situation of different countries as importer or exporter of oil and differential tax composition has different effect due to some variables such as divisional structures. Thus understanding experiential relationship between oil price and inflation rate is as important as monetary authorities attempt for controlling inflation. Being informed about effect of oil price and inflation increase is helpful for monetary authorities in enforcing policies in order to adjust with these shocks (Lacheheb and Sirag, 2016).

Sustainable increase of oil price in global market in recent decades enabled Iran to improve financial and macro-economic indices. Consequently, high revenue of oil and gas encountered Iran with commercial surplus. Real gross domestic product (GDP) is increased and government cost are also increased due to higher oil revenue. Although growth prospects and economic indices are satisfactory, the revenue is influenced by oil and gas price changes. Iran enjoys hydrocarbon resources abundance which makes it one of the main oil-exporting countries. Unfortunately, Iran suffers from a syndrome named resource curse (Auty, 1993). Iran is highly dependent on oil and gas; they are considered as a main economic factor. Oil revenue includes half of export income in 2016. Oil revenue are mostly invested on economic development projects. The question is if increase of oil price, state expenses and high general expenses enhance economic growth of Iran.

Recent high fluctuations of oil price caused main concerns especially about effect of oil price on inflation. For better prospect, consumer price and oil price inflation in 1996-2014 are indicated in effect of oil price fluctuations on inflation variables explained as follow: Increase of governmental budget or governmental expenses including civil and current expenses are along with growth of credit and bank facilities which are due to increase of price and oil revenue which consequently cause increase of total demand. And on the other hand, it causes significant supply and demand imbalance and gap and inflation pressures due to inflexibility of total supply proportion derived by fundamental and technical limits.

In middle term, increase of investment demand which is formed by motivation of accountability to demand pressure for goods and services increases demand of production factors and its costs, so inflation driven by cost pressure is added into inflation by demand pressure, then enhances total index of price of consumable good and services again. Since oil revenue has not been achieved by good production process and domestic economic services and it belongs to the state exclusively, by increase of exchange earnings driven by crude oil selling, state expenses are also increased due to providing developmental requirements of the country if they use exchange resource, and besides increases monetary base and liquidity and transfers total demand curve to the top and increases general level of prices due to net foreign assets of central band. In addition, increase of exchange revenue facilitates increase of import of intermediate goods and raw material because importing is a direct function of national revenue and increases production with time laps. However faster increase of demand rather than supply and production cause inflation. In exchange revenue reduction, intermediate goods and raw material import is restricted and shifts total demand curve to the left and reduces production and increases general price level. On the other hand, due to inflexibility of government costs to the lower level which is derived by government budget commitments, budget shortage happens and finally borrowing from central bank is the only choice which expands monetary base and increases liquidity. And this process shifts the curve to the right and causes inflation. Thus, in case of increase of revenue driven by oil selling which enhances exchange revenues inflation occurs. However, both inflations are due to liquidity that have different roots (Adeli et al., 2012).

Although relationship between oil price and inflation has been approved, experiential findings are not similar enough. For example, Hooker (2002) ، Leblanc and Chin, (2004), De Gregorio et al.(2007), Nakov and Pescatori (2007) and finally Killian (2008) have proved little role of oil price fluctuations in consumer price index. By measuring effect of oil price changes on inflation rate in United States, Hooker (2002) found that oil price had considerable role in origin inflation before 1981. Subsequently, in some European countries such as France, Germany, Britain and United States and Japan, Leblanc and Chinn (2004) proved effect of low inflation of oil price in late 1990. In contrast to other researches which used Philips curve for determining disproportion, Killian (2008) applied unreal simulation in G7 countries and proved that similarity and uniformity might occur along with other possibilities. This study is compatible with other researches. Mork et al. (1994) proved that oil price shocks inclination to inflation need to be considered in formation of economic cycle of pioneer markets. Thus, oil price change process can be different based on country itself.

Different effect of oil price shocks on inflation can be due to some factors including effectiveness of higher energy of production processes, relationship between globalization and power of local markets in pricing formation and changes of monetary policies implementation. In addition, Cunado and De Gracia (2005) studied effect of oil price shocks in some Asian countries and found that oil price shocks have effect on inflation and growth (Lacheheb and Sirag, 2016).

These findings are very challenging but provide information and context for more researches. In order to experience appropriate political consequences for overcoming new emerging oil crisis, any analysis of oil price process toward consumer price index need to consider main factors including market price and general regulations. Identifying these factors lead to adopt political strategies.

Effects of oil price increase and decrease on inflation are comprehended theoretically and experientially. When oil price is high, companies prefer to reduce production rate or interpret it as higher level of output. Similarly, oil price reduction decreases production cost and price level. However, it does not reduce price level of goods in price stickiness condition and when suppliers keep the price high. From experiential view, there are various studies that approve relationship between oil shocks and inflation rate (Mork,1989; Mory, 1993; Hamilton, 1996). In addition, other researches explored business cycles in economic activities. Sichel (1993) advocated that contraction in recession time has larger slope. Certainly, reasons of asymmetry that is obtained for industrial and oil-importing countries cannot be good cause for approving asymmetry in oil-exporting countries such as Iran. However, there are some causes as base of experiential test of asymmetry of oil revenues on macro variables in oil exporting countries particular in Iran. One of the reasons is asymmetry of oil revenues in government budget and its reaction to oil revenue shocks. By positive oil shock, current expenses, civil costs and investment projects expenses are increased rapidly while its reduction may have political consequences in which civil expenses are main victims. According to main share of government in capital making, this can be on main reason of intensive reduction of economic growth in negative oil shocks rather than positive shocks. One other reason of asymmetry is related to combination of imported goods and dependence of industry on input of investing, intermediated goods and raw materials from foreign countries. By exposure of a positive oil shock, economic capacities for attracting additional revenues and converting them to physical capital are restricted and need time in order to adjust with new condition. So its positive effect on economy is emerged by delay. However, negative shock, investing good import, intermediate goods and raw materials from foreign countries are highly affected on that time and make main part of current capacity of industry useless which are dependent on investing good import, intermediate goods and raw mateials.so negative effect of oil revenue reduction shock is exposed faster than positive effect of oil revenue reduction shock (Samsami and Helali, 2011).

Supposedly that there is over dependency on oil revenue in Iran, it is necessary to perform stability analysis in which main channels of oil shocks shifting to inflation rate are regarded. This research is set of studies that review oil exporting countries by econometric methods. In this study, we investigate descriptive role of oil price changes in CPI from Iran point of view and related studies. We used econometric framework called NARDL developed by Shin et al. 2011. We believe that this method is the most appropriate one because it may cause potential short term and long-term asymmetries related to oil price and consumer price index. Rest of the study is designed as follow: Section 2 is methodology, Section 3 is results and Section 4 is related to discussion and conclusion in addition to main data and recommended policies.

2. RESEARCH METHODOLOGY AND RESULTS

2.1. Non-linear Auto Regression with Distributed Lag Model

One dynamic model that is used for investigating relationship between dependent and independent variable is regression model with distributed lags. One main features of these models is that they estimate long term relationship between model variables and also short term dynamism of model. In addition, it enables researcher to identify how much time is needed for an effect of one shock on model to be adjusted. Pesaran and shin proved that if integration vector is obtained by using least square method on self-explaining relationship with expanded ARDL lags, in addition that it has estimator of least square of normal distribution, in small samples it has lower slope and higher efficacy. Regression model with standard distributed lags have following characteristics:

1. This model can identify long term integration relationships between variables.
2. It facilitates to test both linear and non-linear integration relationship between model variables.
3. It is able to distinct short term and long term effects of estimation variables and measuring them. In compare to vector error correction models which have these three features, main characteristic of this model is non duplication of model parameters.
4. In contrast to other models of error correction which need to have similar cointegration rank of variables. In this model, cointegration rank does not need to be equivalent and this facilitates freedom in using different variable in model.

Model specification with distributed lag without considering asymmetric effects is as follow:

$$\Delta y_t = \mu + \rho_y y_{t-1} + \rho_x x_{t-1} + \sum_{i=1}^{r} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{s} \beta_i \Delta x_{t-1} + \varepsilon_t$$

In this model, long term effect between variables is the same size either in reduction or in increase case. In contrast, when effects of increase or reduction are not the same (in other word, when we have asymmetric effects in increase and decrease of variables) we need to use a model developed by Shin (2014). In nonlinear autoregressive distributed lag developed by Shin (2014), short term and long term effect are calculated asymmetrically. In fact, in this model, x_t is analyzed into two positive variable including (Δx_t^-) and (Δx_t^+)which is defined as follow:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max\left(\Delta x_j .0\right),\ x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min\left(\Delta x_j .0\right)$$

In order to describe long term and short asymmetric relationships in standard ARDL model, general form of NARDL model is used:

$$\Delta y_t = \mu + \rho_y y_{t-1} + \rho_x^+ x_{t-1}^+ + \rho_x^- x_{t-1}^- + \sum_{i=1}^{r} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{s} (\beta_i^+ \Delta x_{t-i}^+ + \beta_i^- \Delta x_{t-i}^-) + \varepsilon_t$$

Superscript (+) and (-) in second equation distinct effect in both groups. Long term asymmetric relationship is obtained by ρ^+ and ρ^- and short term asymmetric relationship is obtained by β^+ and β^-. On one hand long term analysis means considering middle effect of change in exogenous variable on endogenous variable and on the other hand long term analysis means time reaction value and adjustment velocity in order to obtain long term balance. Long term symmetric effect are tested by Wald test when $\rho^+=\rho^-$. Long term coefficient are obtained by positive and negative changes by $L^+ = -\rho_x^+ / \rho_y$ and $L^- = -\rho_x^- / \rho_y$. These coefficients show long term influence ability.

Short term adjustment of dependent variable with positive and negative difference of independent variable is obtained by β^+ and β^-. For short term symmetric test, Wald test is used when $\beta^+ = \beta^-$.

Second specification is equals to long term relationship in first specification when null hypothesis which is related to symmetric long term and shot term is not rejected. If symmetric long term and shot term is not rejected, long term NARDL integration relationship in third model and short term NARDL relationship in number 4 are created. Which are:

$$\Delta y_t = \mu + \rho_y y_{t-1} + \rho_x x_{t-1} + \sum_{i=1}^{r} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{s} (\beta_i^+ \Delta x_{t-i}^+ + \beta_i^- \Delta x_{t-i}^-) + \varepsilon_t$$

$$\Delta y_t = \mu + \rho_y y_{t-1} + \rho_x^+ x_{t-1}^+ + \rho_x^- x_{t-1}^- + \sum_{i=1}^{r} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{s} \beta_i \Delta x_{t-i} + \varepsilon_t$$

In NARDL framework, asymmetric reaction of variable dependent on positive and negative changes in independent variable is calculated as follow:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+},\quad m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-}\ h = 0.1.2$$

When $h \to \infty$ so $m_h^+ \to L^+$ and $m_h^- \to L^-$ in which by $L^+ = -\rho_x^+ / \rho_y$ and $L^- = -\rho_x^- / \rho_y$ which are asymmetric long term relationships in model. In this type short relationship are connected to long term relationship by adjustment velocity. And in other word a long term balance can reach to other long term balance by adjustment coefficient.

2.2. Estimation of Short-term and Long-term Model

In this study, we investigate asymmetric relationship between oil revenue and consumer price index. In order to prevent specification error, variables including liquidity and GDP are used as control variables which are stated as follow:

$$g(CPI)_t = F(g(OILREVENU)_t, g(GDP)_t, g(M2)_t$$

In above equation, M2 is liquidity value, CPI is consumer price index and GDP is GDP and OILREVENU is oil revenue. In second step, in order to prevent spurious regression, we analyze variables stationary by Augmented Dickey Fuller test. Results are in following Table 1:

Based on results, it is clarified that with 5% probability, all variables ranged from 0 to 1° which facilitate condition of using NARD model which is accumulation of variables from 0 to 1.

Equation number 1 indicates long term relationship between variables. Placing this equation in error correction model enable us to regard short term relationship along with long term relationship. Error correction mode is as follow:

$$\Delta g(CPI)_t = \alpha + \sum_{K=1}^{n1} \beta_k \Delta g(CPI)_{t-k} + \sum_{k=0}^{n2} \delta_k \Delta g(GDP)_{t-k} + \sum_{k=0}^{n3} \varphi_k \Delta g(OILREVENU)_{t-k} + \sum_{k=0}^{n5} \pi_k \Delta M2_{t-k} + \lambda_2 GDP_{t-1} + \lambda_3 OILREVENU_{t-1} + \lambda_4 CPI_{t-1} + \lambda_5 M2_{t-1} + \mu_t$$

New equation is similar to Engle and Granger (1987). This model is more advantageous than Engle and Granger because in which short term and long term relationship is estimated in one step. In this equation, main hypotheses are that exogenous variable is effective on dependent variable symmetrically. In order to study asymmetric effect, exchange rate variable need to be divided into two groups including positive changes $\Delta OILREVENU_t^+$ and negative changes $\Delta OILREVENU_t^-$ which is defined as follow:

$$OILREVENU_t^+ = \sum_{j=1}^{t} \max\left(\Delta OILREVENU_j .0\right), OILREVENU_t^- = \sum_{j=1}^{t} \min\left(\Delta OILREVENU_j .0\right)$$

By these two defined variables, NARDL model is as follow:

$$\Delta g(CPI)_t = \alpha + \sum_{K=1}^{n1} \beta_k \Delta g(GDP)_{t-k} + \sum_{k=0}^{n2} \delta_{1.k} \Delta g(OILREVENUX)_{t-k}^+ + \sum_{k=0}^{n3} \delta_{2.k} \Delta g(OILREVENUX)_{t-k}^+ \sum_{k=0}^{n5} \theta_k \Delta g(CPI)_{t-k} + \sum_{k=0}^{n6} \pi_k \Delta g(M2)_{t-k} + \lambda_1 g(GDP)_{t-1} + \lambda_2 g(OILREVENUX)_{t-1}^+ + \lambda_3 g(OILREVENUX)_{t-1}^- + \lambda_5 g(CPI)_{t-1} + \lambda_6 g(M2)_{t-1} + \mu_t$$

Now, long term relationship between variables are need to be measured. So in this research, bound test is used. In this model choosing optimum lag has main role and based on Pesaran, M. Hashem, Yongcheol Shin, and Richard J. Smith. (2001) and Mont Carlo simulation, accurate determining lags in ARDL is enough for simultaneous correction of correlation between error components and intrinsic problem of explanatory variables. Thus, for choosing the model, long term relationship and choosing optimum model are considered based on standards of choosing the model. Determining lags and model by standards of choosing model (such as AIC and SBC Schwartz-Bayesian) is achieved and, in small samples of Schwartz-Bayesian, it has higher efficacy due to economic choosing of lag. In following Table 2, results of short term relationship of variables are indicated. And then bound test is tested. It should be mentioned that short term model is guesswork ARDL (6,6,6,5,6).

Table 1: ADF unit root test

Variable	Test statistic	Probability value	Result
G (GDP)	−2.33	0.16	Non-stationary
G (CPI)	−3.39	0	Stationary
G (OILREVENU)	−4.84	0.0002	Stationary
g (M2)	−7.5	0	Stationary
D (g (GDP))	−32.79	0.0001	Stationary

Reference: Research findings. GDP: Gross domestic product

Table 2: Results of bound test for co-integration

Value (%)	Upper bound	Lower bound	Statistic F
In 10	−3.13	−4.04	−4.75
In 5	−3.41	−4.36	
In 2.5	−3.65	−4.62	

Reference: Research findings

Based on bound test result in Table 2, long term relationship between variables is approved in level of significance including 10, 5 and 2.5. In other word, null hypothesis which asserts "there is no long term relationship between variables" is rejected:

These findings (as shown in Table 3) indicate that although oil revenue reduction has positive and significant effect on inflation in long term, oil revenue increase has no significant effect on inflation in long term. This proves asymmetric effect of oil revenue on consumer price index in short term and long term.

2.3. Estimating ECM Model

Integration between economic variables provides statistical bases of using error correction models. The main reason of popularity of error correction model is short term fluctuations of variables that are made related to long term balance values. These models are detailed adjustment models in that effective forces in short term and velocity of closing to long term balance value are measured by entering durable residual from long term relationship. ECM coefficient indicated that in each period some percentage of imbalance of dependent variable is adjusted and it is getting close to long term relationship. Results of model estimation is providing in Table 4.

Coefficient of error correction model is −4.20 which is statistically significant. Based on error correction coefficient in ECM model, it can be stated that adjustment is explosive.

2.4. Structural Stability Tests

In order to study structural stability of estimated models in Iran, CUSUM (cumulative sum test) has been use. These results are indicated in Figure 1.

As Figure 1 indicated that CUSUM did not cross from determined bounds in level of 0.05. Figure 2 indicates stability of estimated coefficient in mean time because CUSUM is in level of significance of 5 in determined bounds.

Figure 1: Results of CUSUM test

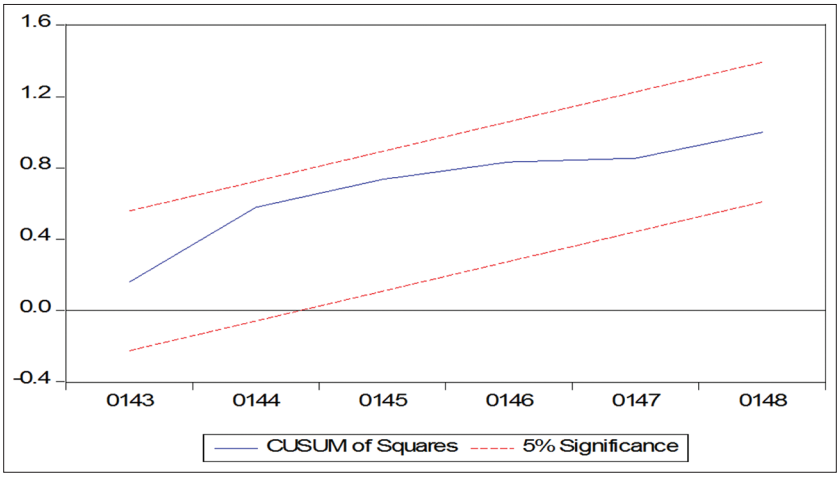

Figure 2: Results of CUSUM and CUSUM of squares test

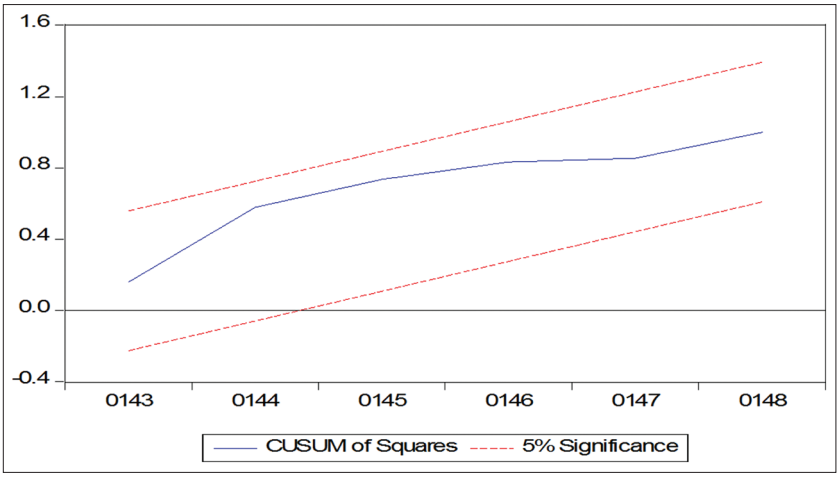

Table 3: Long-run model

Variable	Coefficient	Statistic t	P
G (OILREVENU_POS)	0.01	0.63	0.54
G (OILREVENU_NEG)	0.07	2.67	0.03
G (M2)	0.04	0.69	0.51
G (GDP)	−0.92	−11.39	0

Reference: Research findings

Table 4: ECM coefficient

Variable	Coefficient	t-Statistic	P
ECM	−4.20	−6.56	0.0006

3. CONCLUSION

High increase of oil price has been regarded as main factor in policy maker and economist's point of view since 2004. So many researches have been made about inflation effect of oil price increase on macro economy indices including consumer price index. In addition, intensive oil price decrease has been considered as very important factor for oil exporting countries in OPEC. Hence, understanding experiential relationship between oil price and inflation rate is as important as monetary authorities attempt for controlling inflation. Being informed about effect on oil price and inflation increase is helpful for monetary authorities in enforcing policies aiming at adjusting with these shocks.

This paper analyses effect of oil price changes on CPI for which non-linear ARDL model has been used for recording asymmetric short term and long term relationships between oil price and CPI. Estimated results approved asymmetric long term behavior of CPI. In other word, in long term reduction of oil revenue growth decreases inflation level but it seems that increase of oil revenue growth has no relationship with inflation level.

From political view, different approaches which consider increasing inflation of consumer price are used. These approaches include financial support of small economic firms and improving agricultural production through using technology. By political attention needs to include market power and cover all suppliers (importers, retailers and wholesalers) in order to be more effective. In addition, using producer technology in local market is recommended in order to use cheap oil products and subsequently higher commercial surplus is obtained in adjusting with payments via importing decrease.

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