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Crude Oil Price Pass-Through to Domestic Prices in Turkey: Asymmetric Nonlinear ARDL Approach

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Abstract

Increasing World population leads to an ever-rising energy need. For individuals in any economic activity and sectors of the economy one of the most important energy resources is oil. Oil is also one of the most important items in the trade between countries. Turkey is a mostly energy dependent country, and this dependency is also the case for oil. As it is the case for those countries with significant energy dependency, oil price is important for economic and price stability in Turkey. The effects of oil price changes on macroeconomic variables are discussed frequently in the related literature. There are empirical studies in the literature investigating the differing effects of oil price rise and fall on economic activity. Some of these studies conclude that the effect is asymmetric. On the other hand, there is no consensus in the literature about the causes of asymmetric price pass-through. This study aims at determining the effects of oil price changes on the inflation in Turkey and whether the price pass-through is symmetric or asymmetric.

Keywords: Oil Price, Asymmetric Price Pass-Through, Asymmetric ARDL, Turkey.

JEL classification: C13, C32, E31, Q43.

1. INTRODUCTION

In today's world the oil and its by-products are critical sources of energy for economic activity in all countries. The nominal and real effects of the fluctuations in the oil prices on major macroeconomic variables such as economic growth and inflation have been widely discussed by economists since the 1970 OPEC crises. The effects of oil prices on economic activity and inflation in the case of Turkey are of vital importance because Turkey is heavily depended on crude-oil import; Turkey produced only 13% of its crude-oil consumption in 2014, and it is expected that the amount of total crude - oil import of Turkey will be doubled in the next decade.[1]

The sharp changes of oil prices may have dramatic effects on the major macroeconomic variables and cause the consumer prices to increase and decrease considerably. The transmission of oil prices on the domestic prices is dubbed as oil price pass-through in the literature. The transition into domestic inflation generally occurs through two channels; through

[1] For more detail: U.S. Energy Information Administration, http://www.eia.gov/beta/international/analysis_includes/countries_long/Turkey/turkey.pdf (28.09.2015).

the changes in demand and prices of factors used in production process.[2] First channel is closely related to monetary and fiscal policies, while the second channel operates through the input costs, especially in oil-intensive sectors. In the second channel, the firms in these sectors decrease their supply and transmit the increases in the oil prices to their product prices, thereby decreasing the aggregate supply and generating pressure over the inflation to increase. However, oil price pass-through may not be operating symmetrically, that is, pass-through may be asymmetric. The symmetric pass-through implies that changes in the oil prices lead to changes in domestic prices in the same direction, while the asymmetric pass-through involves a larger effect of oil price increase on inflation than oil price decline.

The purpose of this study is to investigate the effects of oil price changes on the inflation in Turkey and whether the price pass-through is symmetric or asymmetric. After this introduction, the structure of this paper is as follows. Section 2 presents a short review of the related literature. Section 3 introduces mythology and data used in the analysis. Section 4 discusses empirical findings. Finally, Section 5 presents the main conclusions.

2. LITERATURE

The sharp changes in the oil prices in recent decades have aroused the interest in studying the effects of these changes on different dimensions of economic activity. Hence, there is a growing body of literature documenting the effects of oil price changes on domestic inflation. However, there is no consensus in the literature on the inflationary effects of oil price changes. For instance, Leblanck and Chin (2004) determine a modest effect for the main global economies. In addition, Blanchard and Gali (2007) argued that for Group 7 (G7) countries (except for Canada) the effect of oil price changes declined after 1980s. Their findings suggest that the effects of oil price shocks depend on the concurrent adverse shocks, share of oil in production, flexibility of labor markets, and stance of monetary policy. Killian (2008) also reaches to a similar conclusion for G7 countries; as a result of higher energy intensity and the modes of price setting and conduct of monetary policy, the effect of exogenous oil price shocks on inflation in G7 countries is negligible. In a broader study, De Gregorio et al. (2007) find a decline in pass-through for 24 industrialized and emerging market economies, and argue that a significant part of the decline in the oil pass-through around the world is explained by the reduction in the effects of exchange rate changes on inflation and by declining oil intensity.

There are similar conclusions in single country studies. In a good example Hooker (2002) finds that oil price changes do not affect inflation in the United States (US). In a more recent study Çatık and Karaçuka (2012) also ascertain that there is a substantial decline in pass-through from refined petroleum prices to inflation in Turkey as the economy moves from high to low inflation regimes.

[2] See Abounoori et al. (2014) for the working these transmission channels in the case of an oil exporting country.

On the other hand, there are studies that reach to opposite findings. For instance, Cologni and Manera (2008) find that for G7 countries, except for Japan and United Kingdom (UK), there is an influence of oil prices on inflation rate. On the other hand, Barsky and Kilian (2004) argue that although oil price shock and inflation relationship is not as apparent as one might have expected, one can observe a stronger relationship by focusing on medium term trends in inflation. For example, Chou and Tseng (2011) ascertain that the pass-through in Taiwan takes place in the long run. Cunado and Gracia (2005) also find significant effect of oil prices on price indexes for six Asian countries, but their results suggest that the impact is limited to the short run and more significant when oil price shocks are defined in local currencies.

The pass-through may be contingent on specific conditions. For instance, Alvarez et al. (2011) argue that oil price changes are a major driver of inflation variability; however, inflationary effects of oil price changes depend on the share of oil and oil products in households' budgets. Bernanke and et al. (1997) also relate this relationship to the conduct of the monetary policy and argue that an important part of the effect of oil price shocks on the economy results not from the change in oil prices, per se, but from resulting modifications in monetary policy.

As an example of unidirectional pass-through, Bhanumurth et al. (2012) find out that for a major oil importing country such as India, international oil price shocks result in higher inflation. For the period of 1990-2000 Dedeoglu and Kaya (2014) find an increasing trend in the pass-through of oil prices to domestic prices in Turkey. Furthermore, their study shows that the impact on producer prices is almost two times higher than the impact on domestic consumer prices and the gap increased during the period under investigation.

One of the liveliest discussions in the literature on oil price pass-through is whether pass-through is symmetric or asymmetric. In a multi-country study of six Asian countries, Cunado and Gracia (2005) find evidence of asymmetries in the oil prices–macroeconomy relationship for some of the countries. Güney and Hasanov (2013) affirm that oil price increases have positive and significant effect on inflation, however, oil price declines have not a significant effect on inflation. Öksüzler and İpek (2011)'s impulse reaction analysis also reveals that a positive oil price shock leads to higher inflation in Turkey.

3. METHODOLOGY AND DATA

The channels, degree, direction, and implications of oil price pass-through to macroeconomic variables depend on whether the country is an oil importing or exporting country. An increase in oil prices leads to a rise in incomes in an oil exporting country, it raises input costs in oil importing countries. Empirical studies show that the effects of an increase and a decrease in oil prices may have different effects on the macroeconomic variables.[3] In this

[3] See Mork (1989) and Hamilton (1996) for more details.

study we aim at investigating whether oil price shocks have symmetric or asymmetric effects on domestic prices through input prices in a major oil importing country, Turkey.

3.1. Non-linear Autoregression Distributed Lag (NARDL) Model

In recent years new methods have been developed to study asymmetric pass-through. The NARDL approach developed by Shin et al. (2011) does not depend on the degree of the integration of the variables. They develop a cointegrating NARDL model in which short- and long-run nonlinearities are introduced via positive and negative partial sum decompositions of the explanatory variables. Asymmetric decomposition is designed by the application of partial sum process to represent increases and decreases in the variables. By using partial sum process we can define the increase (oil_t^+) and decrease (oil_t^-) in oil price (oil_t) as follows:

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

The NARDL cointegration model including oil prices' asymmetric dynamics in the short and long run (Eq. (3)) can be derived from the linear ARDL model given in Eq. (2):

$$\Delta inf_t = \alpha_0 + \lambda_1 inf_{t-1} + \lambda_2 exc_{t-1} + \lambda_3 gap_{t-1} + \lambda_4 oil_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \varphi_i \Delta exc_{t-i} + \sum_{i=0}^{q-1} \phi_i \Delta gap_{t-i} + \sum_{i=0}^{q-1} \beta_i \Delta oil_{t-i} + u_t \quad (2)$$

$$\Delta inf_t = \alpha_0 + \lambda_1 inf_{t-1} + \lambda_2 exc_{t-1} + \lambda_3 gap_{t-1} + \lambda_4 oil_{t-1}^+ + \lambda_5 oil_{t-1}^- + \sum_{i=1}^{p-1} \tau_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \varphi_i \Delta exc_{t-i} + \sum_{i=0}^{q-1} \phi_i \Delta gap_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta oil_{t-i}^+ + \beta_i^- \Delta oil_{t-i}^-) + u_t \quad (3)$$

where inf_t, exc_t, gap_t are inflation rate, dollar/TL exchange rate, and industrial production index (IPI) based output gap, respectively. Δ is the difference operator. We test the following hypothesis for the estimated NARD model given in Eq. (3) (Nguyen and Shin 2011:21; Shin et al. 2011:13-17):

1. Hypothesis: No co-integration relationships between variables.
$H1_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$

$H1_A: Parameters\ are\ not\ simultaneously\ equal\ to\ zero$

This hypothesis represents the bound test approach developed by Pesaran et al. (2001). The rejection of the hypothesis implies the existence of a cointegration relationship between the variables.

2. Hypothesis: Long-run parameters are equal.
$H2_0: \theta^+ = \theta^-$
$H2_A: \theta^+ \neq \theta^-$
The long run parameters are calculated as $\theta^+ = \lambda_4/-\lambda_1$ ve $\theta^- = \lambda_5/-\lambda_1$. The rejection of the hypothesis implies that the long run parameters are different from each other, and therefore, the inflationary effect of oil prices is asymmetric in the long run.

3. Hypothesis: Aggregate short-run effects are symmetric.
$H3_0: \beta_i^+ = \beta_i^-\ , \quad i = 0, \ldots q-1$
$H3_A: \beta_i^+ \neq \beta_i^-$
Rejection of the hypothesis indicates asymmetric adjustment in the short run.

Rejected second hypothesis and not rejected third hypothesis indicate that effects of oil price changes are asymmetric in the long-run and symmetric in the short-run, Eq. (4) employed in this case.

$$\Delta inf_t = \alpha_0 + \lambda_1 inf_{t-1} + \lambda_2 exc_{t-1} + \lambda_3 gap_{t-1} + \lambda_4 oil_{t-1}^+ + \lambda_5 oil_{t-1}^- + \sum_{i=1}^{p-1} \tau_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \varphi_i \Delta exc_{t-i} + \sum_{i=0}^{q-1} \phi_i \Delta gap_{t-i} + \sum_{i=0}^{q-1} \beta_i \Delta oil_{t-i} + u_t \quad (4)$$

Rejection of the third hypothesis and rejection of the second hypothesis demonstrate that effects of oil price changes are asymmetric in the short-run and symmetric in the long-run. Thus Eq. (5) employed in this case.

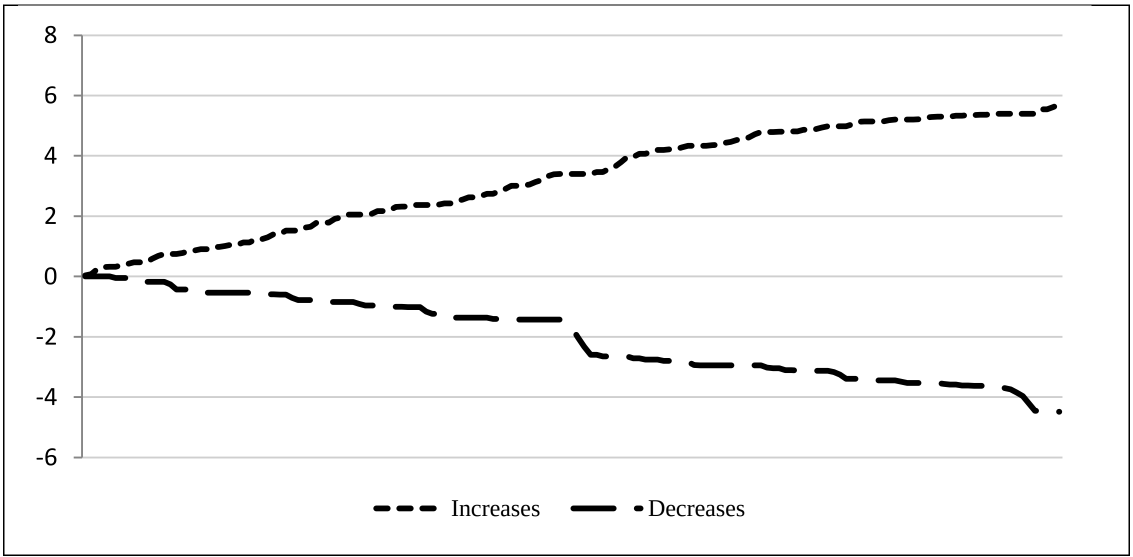
$$\Delta inf_t = \alpha_0 + \lambda_1 inf_{t-1} + \lambda_2 exc_{t-1} + \lambda_3 gap_{t-1} + \lambda_4 oil_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \varphi_i \Delta exc_{t-i} + \sum_{i=0}^{q-1} \phi_i \Delta gap_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta oil_{t-i}^+ + \beta_i^- \Delta oil_{t-i}^-) + u_t \quad (5)$$

If long-run and short-run symmetry hypotheses (second and third hypotheses) are not significant, it implies that there is no asymmetric pass-through from oil price changes to inflation. In other word oil price pass-through is symmetric. Therefore, the linear ARDL approach using Eq. (2) should be preferred for the pass-through research.

3.2. Data

The two important feature of economic policy implementations in Turkey for the period following the 2001 economic crises are floating exchange rate policy and inflation targeting. In this study we aim to measure the effects of oil price changes on domestic prices for this period. We utilize monthly data for 2002:1 – 2015:5 the period and follow Phillips curve approach of Hooker (2002). The variables include in our analysis are oil prices, inflation rate, output gap, and exchange rate. The fact that Turkey is a major oil importing country makes the exchange rate a crucial variable for our analysis. Oil price index (oil) is a simple average of three spot prices (2005=100), Dated Brent, Dubai Fateh, and West Texas Intermediate. Oil price index is transformed to natural logarithm and obtained from International Monetary Fund database.[4] Increases and decreases (oil_t^+ and oil_t^-) in oil prices calculated by the partial sum process is given in Figure 1.

Figure 1 Increases ($\mathbf{oil_t^+}$) and Decreases ($\mathbf{oil_t^-}$) in Oil Price



Source: Author's calculations

Inflation rate represents consumer price inflation calculated from consumer price index (CPI). As mentioned above, output gap is derived from IPI, detrended by Hodrick-Prescott filter. CPI and IPI series are compiled from Turkish Statistical Institute (TSI)' database. The TL/dollar exchange rate is obtained from the Electronic Data Dissemination System (EVDS) of the Central Bank of the Republic of Turkey (CBRT).

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[4] IMF Database, http://www.imf.org/external/np/res/commod/index.aspx, 12.08.2015.

4. EMPIRICAL RESULTS

We utilize nonlinear ARDL approach proposed by Shin et al. (2011) in order to determine if the oil price changes have an effect on inflation, and if so, the effect is asymmetric. This method is important because it can be used for the asymmetric decomposition of the explanatory variable and it comprises the bounds test approach, which is employed to investigate long run relations without worrying about the degree of integration of the variables. Although the degree of integration is not important, in the bounds test approach it is required that the variables are not I(2), i.e., integrated of order 2. It is because when the variables are I(2), the F-statistics developed by Pesaran et al. (2001) is invalid (Ouattara 2004:9).[5] We employ Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests and provide the results in Table 1.

Table 1 Unit Root Test Results

Series	*Deterministic Component*	*ADF*	*PP*	*Decision*
INF_t	*C*	-9.325*	-9.389*	I(0)
	C&T	-9.658*	-9.568*	
GAP_t	*C*	-3.916*	-9.785*	I(0)
	C&T	-3.900*	-9.753*	
EXC_t	*C*	0.833	0.972	I(1)
	C&T	-1.149	-0.572	
OIL_t	*C*	-2.491	-2.486	I(1)
	C&T	-2.425	-2.101	
OIL_t^+	*C*	-2.629	-2.459	I(1)
	C&T	-0.626	-0.760	
OIL_t^-	*C*	-0.026	0.276	I(1)
	C&T	-2.902	-2.425	

Source: Author's calculations. The lag length in ADF test is determined by SIC. In PP test, we use Bartlett Kernel estimation method and band width is taken to be Newey-West. * shows 1% significance level.

Inflation and output gap variables are stationary, but exchange rate and both of oil price variables are not stationary in level.[6] After determining that there is no variable with I(2), we estimate NARDL to test the above three hypotheses. For this purpose we find the best model using Schwarz Information Criteria (SIC) in Eq. (3). We provide the results in Table 2.

[5] Pesaran et al. (2001) F-statistics is constructed on the basis of the assumption I(0) and I(1) variables.
[6] Exchange rate and all of oil price variables are transformed first differences and tested the same unit root tests and then they are found I(1).

Table 2 Estimation Results of NARDL with LR and SR Asymmetry

Dependent Variable: ΔINF_t		
Variable	*Coefficient*	*t-Statistic*
INF_{t-1}	-0.741	-10.249 (0.000)
EXC_{t-1}	2.054	3.506 (0.000)
OIL_{t-1}^{+}	1.357	2.569 (0.011)
OIL_{t-1}^{-}	0.863	2.135 (0.034)
GAP_{t-1}	-0.002	-0.122 (0.903)
ΔEXC_t	2.999	2.417 (0.017)
ΔOIL_t^{+}	2.506	1.452 (0.148)
ΔOIL_t^{-}	-0.432	-0.354 (0.724)
ΔGAP_t	-0.005	-0.517 (0.606)
C	-2.326	-2.503 (0.013)
T	-0.039	-2.283 (0.024)
$LR_{OIL_t^{+}}$	1.832	2.573 (0.011)
$LR_{OIL_t^{-}}$	1.165	2.131 (0.035)
LR_{EXC_t}	2.773	3.631 (0.000)
LR_{GAP_t}	-0.002	-0.122 (0.903)
Adjusted R^2=0.403		BG-LM Statistic (1): 2.965 (0.085)
F-Statistic: 11.725 (0.000)		White-Statistic: 68.284 (0.334)
JB-Statistic: 3.283 (0.194)		DW-Statistic: 1.865

Source: Author's calculations. The p-values of statistical tests are in parenthesis.

According to the estimation results of the NARDL model, the coefficients of oil price increases and decreases are not significant in the short-run, but they are statistically significant in the long-run. The long run coefficient implies that an increase in oil prices leads to an increase in inflation. On the other hand, a decrease in oil prices leads to a decrease in inflation. However, output gap has no statistically significant effect on inflation in both short and long run. Conversely, exchange rate's short run and long run coefficients are statistically significant, and exchange rate has an important impact on inflation. On the basis of estimated model we can test the first hypothesis.

1. Hypothesis: No co-integration relationships among variables.

$H1_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$

$H1_A : Parameters\ are\ not\ simultaneously\ equal\ to\ zero$

On the basis of Pesaran, Shin and Smith (2000) F statistic (F_{PSS}) for bounds test, first hypothesis is rejected.[7] This results implies that the variables have a nonlinear relationship in

[7] F_{PSS}: 21.470 and critical values are I(0): 4.40 & I(1): 5.72 for k=4 and 1% level of significance (Pesaran et al. 2001:301).

levels. In other words, asymmetrically decomposed oil prices and other variables have a long-run co-integration relationship.

2. Hypothesis: Long-run parameters are equal.

$H2_0: \theta^+ = \theta^-$

$H2_A: \theta^+ \neq \theta^-$

Second hypothesis is tested using long-run coefficients (1.832 and 1.165), and the test statistics value is calculated as 1.412 with a p-value of 0.237. Therefore, the second hypothesis is not rejected, implying that oil price changes have symmetric effects on inflation in the long-run.

3. Hypothesis: Aggregate short-run effects are symmetric.

$H3_0: \beta_i^+ = \beta_i^- \;, \quad i = 0, \dots q-1$

$H3_A: \beta_i^+ \neq \beta_i^-$

Calculated test statistics is 1.427 with a p-value of 0.234. Therefore, the third hypothesis is not rejected, implying that oil price changes are not asymmetric in the short-run.

These results show that although there is co-integration relationship among the variables, the inflation rate adjusts symmetrically to oil price changes in both short run and long run. That is, the pass-through effects of oil prices increases and decreases on inflation are not statistically different. Therefore, we use linear ARDL model in order to investigate oil price pass-through to inflation. At the first stage, we estimate the model in Eq. (2) with up-to-12 lags and find out that the optimum lag length is 1 on the basis of SIC. We provide the results in Table 3.

Table 3 Lag-Length Selection of the Bounds Test

Lag	*SIC*	*Breusch- Godfrey (1)*
1	**2.560**	2.523 (0.112)
2	2.650	0.009 (0.924)
3	2.781	9.767 (0.002)

Source: Author's calculations. The p-values of statistical tests are in parenthesis.

The bounds test for linear ARDL with 1 lag is as follows: No linear level relationships between variables; $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$. On the basis of F_{PSS}, hypothesis is rejected.[8] This results implies that there is a linear cointegration relationship among the variables. We provide the estimation results for the model minimizing SIC value in Table 4.

Table 4 Linear ARDL Model Results and Long-Run Coefficients

Dependent Variable: INF_t

[8] F_{PSS}: 26.248 and critical values are I(0): 5.17 & I(1): 6.36 for k=3 and 1% level of significance (Pesaran et al. 2001:301).

Variable	*Coefficient*	*t-Statistic*
INF_{t-1}	0.273	3.809 (0.000)
EXC_t	1.567	3.393 (0.001)
OIL_t	0.698	1.856 (0.065)
GAP_t	0.001	0.064 (0.949)
GAP_{t-1}	0.003	0.276 (0.783)
GAP_{t-2}	-0.021	-2.196 (0.030)
GAP_{t-3}	-0.007	-0.740 (0.460)
GAP_{t-4}	0.047	4.973 (0.000)
C	-3.883	-1.931 (0.055)
T	-0.017	-3.199 (0.002)
LR_{OIL_t}	0.960	1.876 (0.063)
LR_{EXC_t}	2.156	3.535 (0.001)
LR_{GAP_t}	0.031	1.225 (0.223)
Adjusted R^2=0.324		BG-LM Statsitic (1): 0.803 (0.370)
F-Statistic: 9.290 (0.000)		White-Statistic: 51.292 (0.579)
JB-Statistic: 9.602 (0.011)		DW-Statistic: 1.923

Source: Author's calculations. The p-values are given in parenthesis.

The long run coefficients of the estimated ARDL model show that the output gap has no statistically significant effect on inflation. On the other hand, exchange rate and oil prices have statistically significant and positive impacts on inflation. An increase (decrease) in oil prices leads to an increase (decrease) inflation.

The error correction model obtained from linear ARDL model is estimated in order to determine how long it takes for the shocks to be eliminated. The results are given in Table 5.

Table 5 Linear Error-Correction Model

Dependent Variable: ΔINF_t		
Variable	*Coefficient*	*t-Statistic*
ΔEXC_t	3.737	3.371 (0.001)
ΔOIL_t	1.033	1.452 (0.149)
ΔGAP_t	-0.001	-0.151 (0.880)
ΔGAP_{t-1}	0.005	0.508 (0.612)
ΔGAP_{t-2}	-0.041	-4.156 (0.000)
ΔGAP_{t-3}	-0.049	-5.687 (0.000)
ECT_{t-1}	-0.691	-9.834 (0.000)
T	-0.022	-0.374 (0.709)
Adjusted R^2=0.456		BG-LM Statsitic (1): 0.279 (0.597)
F-Statistic: 17.236 (0.000)		White-Statistic: 44.082 (0.139)
JB-Statistic: 7.428 (0.024)		DW-Statistic: 1.946

Source: Author's calculations. The p-values of statistical tests are in parenthesis.

The error correction model results show that error-correction term is statistically significant and has a negative sign as expected. The system corrects 70% of an oil price shock in about one-to-two months.

5. CONCLUSIVE REMARKS

Oil prices exert its effects on domestic economy through two main channels; oil income or oil expenditures depending on whether the country in question is oil exporting or importing one; and production costs. Turkey is a major oil importing country, importing 87% of its oil need, and its oil need will be double in the next decade. Therefore, changes in the oil prices have significant effects on production costs, and through which on domestic prices. The basic question in this pass-through is if the increases and decreases in oil prices lead to symmetric and similar size effects on inflation. That is, whether pass-through is symmetric or asymmetric.

To answer this question for the case of Turkey, we employ an asymmetric modeling approach, which allows us to use partial sum process in order to decompose long run and short effects. Our analysis covers 2001:1-2015:5 period. Our findings based on estimated non-linear ARD model indicate that oil prices have an impact on inflation in Turkey in the long run, but not in the short run. Moreover, in the long run, the pass through is symmetric. Therefore, we switch to a linear ARD model which assumes a symmetric pass-through. The findings from the linear ARDL model also illustrate that an increase (decrease) in oil prices lead to an (increase (decrease) in inflation rate. Furthermore, our findings on the basis of an error correction model estimation indicate that in the short run 70% of an ail price shock is eliminated in one to two months.

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