5. Asymmetric Oil Price and Exchange Rate Pass-Through in the Turkish Oil-Gasoline Markets

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Abstract

In this study, we examine the asymmetric effects of crude oil prices and exchange rate on retail gasoline and diesel prices in Turkey during the period of 2005-2018. We use nonlinear autoregressive distributed lags (NARDL) model to explore the pass-through of crude oil prices and the exchange rate to the retail gasoline and diesel prices. Our findings suggest that the effect of crude oil prices on retail gasoline and diesel prices varies for the short and long term. We determine the asymmetric relationship between crude oil and retail prices, especially on short term. The positive and negative shocks to oil prices have an increasing and decreasing impact on retail prices, respectively, on long term. However, both positive and negative shocks to oil prices have an increasing effect on retail prices on short term. We also obtain that there is a short-term asymmetric relationship between the exchange rate and retail prices in the Brent and WTI models. These findings imply that the increase in crude oil prices is reflected to consumers more rapidly, especially on short term.

Keywords: asymmetric effects, oil price, NARDL, exchange rate
JEL Classification: C22, E3, Q43

1. Introduction

Many people often believe that the price of gasoline increases quickly when crude oil prices rise, or that gasoline prices decrease slowly when crude oil price decreases. This asymmetric response of gasoline prices to crude oil prices is first discussed by Bacon (1991). Bacon defines this asymmetric price adjustment as “rockets and feathers effect." Bacon likens the rise in prices to the rocket while the decline in prices to the fall of a feather. In the analysis conducted for England over the 1982-1989 period, the asymmetric adaptation rate is examined with a non-quadratic function, and it is shown that the adaptation process is faster when the costs rise, and slower when the costs fall.

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It may be noticed that the explanations about the cause of asymmetry differ when the studies following the study of Bacon (1991) are examined. Borenstein *et al*. (1997) present the explanations of asymmetric price adjustments under three hypotheses. The first of these hypotheses is based on the oligopolistic coordination theory. According to the theory, the price asymmetry is since oligopolistic firms use the market power, the collusion with the hidden pricing strategy and want to keep the prices above the marginal cost for a long time. The increase in the crude oil price will trigger a rise in gas prices immediately, but when input prices are lower, costs will increase, and firms will be able to benefit more from the deal. Therefore, price decreases are not immediately realized (Borenstein *et al*., 1997; Pal and Mitra, 2015; Chou and Tseng, 2016).

The second explanation relates to the production delays and inventory cost adjustments of gasoline. The decrease in oil reserves will lead to an increase in gasoline prices; however, firms will not make price adjustments immediately. The price adjustment process usually takes at least two to four weeks. On the other hand, it may be said that the elasticity of the marginal cost of the increase in inventories is lower (Borenstein *et al*., 1997). In case the price-cost margin is higher, prices are set more slowly (Borenstein and Shepard, 2002).

Another explanation of the asymmetry in the literature is associated with the consumer search theory. Consumers may be looking for another retailer when there is an increase in gasoline prices. An increase in demand may cause other retailers to increase prices. On the other hand, it is thought that consumers will not carry out research efforts with the same intensity in the case of price decreases (Johnson, 2002). Reducing this research process leads to higher profits, and thus, reductions in costs may result in a slower price response than increases (Lewis, 2011). Therefore, according to the theory, it is claimed that the differences in the research behaviors of the consumers cause asymmetric price reactions.

These explanations of the asymmetries listed above aroused a growing interest in the question of the response of retail prices to crude oil prices, and many economists have studied this relationship using different samples and methods. The empirical investigations show that there is no consensus on the symmetric or asymmetric relationship between crude oil prices and gasoline prices. Some of the studies provide evidence of the asymmetric price relationship (*e.g*., Borenstein *et al*., 1997; Karrenbrock, 1991; Galeotti *et al*., 2003; Chen *et al*., 2005; Honarvar, 2009; Chou and Tseng, 2016); while there is no asymmetry between the crude oil prices and gasoline prices in other studies (*e.g*., Shin, 1994; Godby *et al*., 2000; Bettendorf *et al*., 2003; Kristoufek and Lunackova, 2015; Panagiotidis and Rutledge, 2007; Gautier and Le Saout, 2015).

We aim to empirically investigate the relationship between retail gasoline prices and crude oil price changes in Turkey. We consider that this study is important for some reasons. Firstly, this relationship has been questioned rarely in Turkey, but Turkey is an emerging market economy that is a net oil importer. Since January 1st, 2005, the retail prices in Turkey are determined by a free pricing system. The oil distribution companies in the sector are free to set the warehouse selling price according to different price policies. The dealers are also able to apply ceiling pump selling prices recommended by the distribution companies or to apply their pump selling prices according to the competition conditions of the region. The distributor price is determined by the Energy Market Regulatory Authority (EMRA) by taking into account factors such as the refinery price and assets within the scope of a specific formula. Therefore, the changes in the retail gasoline price are primarily determined by the state. Moreover, the share of taxes in the retail gasoline price is substantially high, and taxes such as Special Consumption Tax (SCT) and Value Added Tax (VAT) constitute approximately 70% of the retail price. Secondly, the changes in exchange rates, as well as crude oil prices, are one of the most critical factors that affect the retail prices in Turkey, because it is a net oil importer. The crude oil prices and exchange rate movements have a significant impact on the current account deficit and tax revenue by affecting the retail price and demand for gasoline. Therefore, the determination of retail prices is a crucial issue for Turkey's macroeconomic policy. For this reason, we also analyze the effect of exchange rate movements on retail prices and use the recently developed Nonlinear Autoregressive Distributed Lag Model (NARDL) and a monthly data set covering the periods from January 2005 to April 2018.

Our study consists of five sections. The second and the following section provides a brief summary of the literature. We introduce the method and data set in the third section. In the fourth section, the econometric estimations are presented, while the fifth section includes conclusion and evaluation.

2. Literature Review

Since the seminal paper of Bacon (1991), the “rockets and feathers effect” has been investigated by several studies, but there is still no consensus. The symmetric or asymmetric price movement from crude oil price to gasoline price may vary depending on market structure, pricing strategies, government decisions in different countries. Besides, these mixed results are based on the fact that the data set and the estimation methods are different. The examined studies can be categorized under two groups considering the obtained results.

In the first group, there are studies which provide evidence on the existence of the asymmetric relationship between crude oil and gasoline prices. It may be said that most of the papers in this group examine the relationship for the USA. Firstly, Karrenbrock (1991) tries to answer the question of whether the relationship between the retail price of gasoline and wholesale gasoline price is symmetric or asymmetric by using the USA monthly data of 1983-1990 period. There is evidence that the wholesale price increases are reflected in the consumer prices faster than the price decrease. Another study investigating the asymmetric relationships on short term with the ECM belongs to Borenstein *et al*. (1997). In the study conducted for the USA with weekly and two-week data of the 1986-1992 period, it is shown that the effect of increase in crude oil prices on gasoline prices is faster than that of decrease. The production adjustment delay and the market power of some sellers are among the reasons for the findings of asymmetry. Balke *et al*. (1998) use different models, such as Granger causality, VAR, and ECM models. The results of the analyses conducted with the weekly data of the USA covering the 1987-1996 period differ according to the methods used. There is strong evidence on the existence of an asymmetric relationship in the error correction model, while other models give mixed results. Another study investigating the asymmetric relationships on short term for USA belongs to Chen *et al*. (2005). The authors use the threshold cointegration test to obtain evidence of asymmetries for both the short and long term. Also, it is argued that asymmetry in retail gasoline price adjustments is primarily in the stage of distribution of gasoline, not in the stage between the refinery and crude oil markets. Another study investigating asymmetric relationships in crude oil, spot, wholesale, and retail gasoline prices for the USA is conducted by Al-Gudhea *et al*. (2007). The daily data from 1998:12-2004:01 is analyzed with Momentum Threshold Autoregressive method (M-TAR), TAR, and VECM methods. Unlike other studies, crude oil price shocks are classified as large and small shocks, and different results are obtained for both cases. In the case of large shocks, symmetric relationships except for retail gasoline prices are evident, whereas asymmetric relationships are more apparent in the case of small shocks. These results are explained by the limited power of the local market and consumer search costs. Oladunjoye (2008) focuses on the relationship between market structure and price adjustments with the USA daily data set of the 1987-2004 period. The study uses a model in which the basic input cost of wholesale gasoline prices is crude oil, and other costs are kept constant. The market concentration does not have a significant asymmetric effect on price adjustments, while the response of gasoline prices to crude oil shocks has a significant asymmetric effect in the short run. Similarly, Honarvar (2009) investigates the long-term asymmetric relationship between oil price and gasoline prices. This study conducts the Granger and Yoon (2002) hidden cointegration method with the monthly USA data of 1981: 09-2007: 12 period. Three types of retail gasoline prices are used, and the positive components of crude oil prices and the negative components of gasoline prices are only cointegrated. The long-term gasoline prices are more affected by the technological developments on the demand side rather than the increase and decrease in crude oil prices on the supply side.

One of the recent studies for the USA, Atil *et al*. (2014) analyzes how changes in crude oil prices are reflected in gasoline and natural gas prices by using the NARDL model. The monthly data for 1997:01-2012:09 period is used in the study, and it is demonstrated that the relationship between oil and gasoline prices is asymmetric in the short run, while the relationship between oil prices and natural gas prices is determined to be asymmetric in the long run. This difference is due to the fact that crude oil is the main ingredient of gasoline and its impact on natural gas is explained by the differences between global and regional markets. This difference is due to the fact that crude oil is the main ingredient of gasoline and its impact on natural gas is explained by the differences between global and regional markets. Finally, Qin *et al*. (2016) examine the price asymmetry in the gasoline market in the USA through the multiple threshold error correction model (MTECM). The presence of asymmetry depends on the size of the upstream shocks. It is concluded that the effect of medium shocks to the spot and future oil prices on retail gasoline prices are stronger than the lowering effect on retail gas prices, while the asymmetry cannot be obtained for large and small shocks.

In addition to these studies, there are also studies which provide evidence on the existence of the asymmetric relationship between crude oil and gasoline prices for different countries, even limited. One of these studies, Galeotti *et al*. (2003) uses the ECM model that differentiates between short- and long-term asymmetric effects and examine the effect of rockets and feathers effect for the period of 1985-2000 in five European countries, Germany, France, England, Spain and Italy. The presence of asymmetric responses to an increase or decrease in input prices is determined in all countries, particularly in the distribution stage of oil. Similarly, Grasso and Manera (2007) examine the asymmetric relations between oil and gasoline prices in France, Germany, Italy, Spain, and the UK with different econometric methods. The authors find evidence of asymmetric movements between prices in all models by using asymmetric ECM, TAR-ECM, ECM with threshold cointegration methods but, short and long-term asymmetric effects differ between models.

In addition to all these studies, there are also time series studies for different countries in the literature. Eckert (2002) formulates an econometric model of price cycles based on an alternating-move duopoly model of pricing. The model is tested by the ECM method for Windsor, and the existence of asymmetric relations is supported. According to the author, the reason for this result is that the firms are continuously reducing prices, and they are close to marginal cost during the price cycle. Therefore, the asymmetric responses are very important in terms of competition policy. Alper and Torul (2009) investigate the effect of crude oil prices on gasoline prices in Turkey. The structural VAR method is used in the analyses with monthly data of 1991-2007 period. When crude oil prices rise, gasoline prices increase in Turkey, but it is concluded that the gasoline prices did not react to a decrease in oil prices. On the other hand, when the analysis is repeated for the USA, the symmetric relationship is found. The authors explain the asymmetric relationship with the high rate of taxes applied to gasoline. Another study for Turkey belongs to Anavatan and Emeç (2018). The authors examine the asymmetric relationship between gasoline and crude oil prices in Turkey. The authors analyze the relationship between related variables by using linear and nonlinear cointegration method and the daily data set of 2005-2015 period. The findings indicate that there is no asymmetric relationship on short term. On the other hand, it is possible on long term. Pal and Mitra (2016) analyze the impact of crude oil price fluctuations on gasoline prices for India. The authors use the Multiple Threshold Nonlinear Autoregressive Distributed Lag Model (MTNARDL) and the monthly data set covering the period between 2005 and 2015. The price asymmetry is determined among all petroleum products in the analysis and the price of gasoline increases in the case of crude oil price increases, while the reverse effect is not fully reflected in the case of crude oil price decreases. Unlike other studies, Chou and Tseng (2016) examine the effect of exchange rate fluctuations on gasoline prices as well as oil prices by using the 2002-2013 weekly data set for Taiwan. The authors show the existence of asymmetry for retail gasoline prices and that gasoline prices react more slowly to shocks on the exchange rate fluctuations. However, unlike the literature, the findings on asymmetric adjustments suggest that gasoline prices are faster to adapt to cost decreases than in the case of cost increases.

In the second group, we included studies that do not find any evidence of price asymmetry. As in the first group, there are studies examining the relationship between these variables for the USA, as well in this group. In the study of Shin (1994), which is the first of these studies, the relationship between the wholesale price of gasoline and crude oil price is examined with monthly data of 1986-1992 for the USA, and there is no evidence of the short-term asymmetric relationship. Bachmeier and Griffin (2003) use the USA data for the period between 1985 and 1998 and the ECM model to examine the response of daily and wholesale gasoline prices to crude oil shocks. They find that there is no evidence of the existence of an asymmetric relationship between crude oil and regional wholesale gasoline prices. The gas and oil prices are moving together in the long run, and there is evidence that the relationship is linear. Different from other studies, Kristoufek and Lunackova (2015) review the effects of rockets and feathers from a different perspective for some countries, including the USA. The statistically significant asymmetry cannot be obtained in the analysis of the ECM model and two new tests for Belgium, France, Germany, Italy, the Netherlands, the UK, and the USA. Nevertheless, they note that asymmetry should not be denied and the results may vary due to the data set.

Finally, there are some studies which based on different countries in the literature. Godby *et al.* (2000) use the TAR model and the weekly data of 13 Canadian cities for the 1990-1996 period, and they cannot obtain any evidence that the retail gas market has asymmetric pricing. Bettendorf *et al*. (2003) examine adjustments in retail gasoline prices for the Dutch gas market. According to the results obtained by using the asymmetric error correction model and weekly data of the 1996-2001 period, they did not find any evidence of the presence of asymmetry. On the contrary, the symmetric relationship indicates the existence of efficient markets. Another study claiming the symmetric relationship between oil price and wholesale gas prices belongs to Panagiotidis and Rutledge (2007). In this study, the daily data of 1996-2003 period and the VECM and Breitung nonparametric methods are used in the analysis for England. Finally, Gautier and Le Saout (2015) examine the asymmetry of gasoline prices with the daily data of more than 8,500 gas stations in France for the 2007-2009 period. In addition, the role of adjustment costs as the cause of asymmetry is investigated. However, it is stated that there is no significant asymmetric relationship in the transfer of wholesale prices to retail prices.

3. Methodology and Data

In order to demonstrate the asymmetric effects of the WTI and Brent crude oil prices and exchange rates on the retail price of gasoline and diesel, we used nonlinear ARDL (NARDL) proposed by Shin *et al*. (2014). The NARDL model shows asymmetric long-run equilibrium relation as follows:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \tag{1}$$

u_t , represents a fixed zero mean error process representing long-term equilibrium deviations. β^+ and β^- are the asymmetric long-run parameters. x_t is defined as $x_t = x_0 + x_t^+ + x_t^-$ and it forms partial sum processes of positive and negative changes in x_t. The partial sum decompositions, respectively, are defined as follows:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0)\,,\ x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \tag{2}$$

Shin *et al*. (2014) obtain the NARDL (p, q) model by associating the linear ARDL (p, q) model with long-term asymmetric effects. Equation (3) shows the error correction model associated with the asymmetric cointegration:

$$\Delta y_t = \mu + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \alpha_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^+ \Delta x_{t-j}^+ + \varphi_j^- \Delta x_{t-j}^-) + \varepsilon_t \tag{3}$$

$\beta^+ = -\theta^+/\rho$ and $\beta^- = -\theta^-/\rho$ are the associated asymmetric long-run parameters in equation (3). p and q parameters denote the lag orders of the dependent variable and the exogenous variable in the distributed lag framework. The presence of the long-term symmetry relationship can be tested by the Wald test under the null hypothesis ($\beta^+ = \beta^-$). The coefficients, φ_j^+, φ_j^- denote short-term adjustment to a positive and a negative shock affecting gasoline prices. In addition to this, the presence of the short-term symmetry relationship is tested under the null hypothesis $\varphi_j^+ = \varphi_j^-$ $(j = 0,1,2 \ldots, q-1)$.

If the null hypothesis of the symmetry relationship tested in the long and short run cannot be rejected, then Equation 3 becomes the traditional ECM equation. Equation 3 can be divided into two equations as conditional ECM by following Shin *et al.* (2014). A rejection of short-run but not long-run symmetry gives us (long-run symmetry, short-run asymmetry model):

$$\Delta y_t = \mu + \rho y_{t-1} + \theta x_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^+ \Delta x_{t-j}^+ + \varphi_j^- \Delta x_{t-j}^-) + \varepsilon_t \tag{4}$$

On the other hand, a rejection of long-run but not short-run symmetry yields the following model (long-run asymmetry, short-run symmetry model):

$$\Delta y_t = \mu + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \alpha_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \varphi_j \Delta x_{t-j} + \varepsilon_t \tag{5}$$

After asymmetric relationships for long-run, short-run or both periods are determined in the NARDL model, the responses of the price of retail to the positive and negative shocks to crude oil prices and exchange rate are calculated with asymmetric dynamic multipliers:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+} \quad \text{ve} \quad m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-} \qquad h = 0,1,2 \ldots$$

where: $h \to \infty$ $m_h^+ \to \beta^+$ and $m_h^- \to \beta^-$ by construction. A dynamic adjustment process from initial equilibrium to the new equilibrium can be observed between system variables following a shock affecting the system based on the estimated multipliers.

The NARDL model in our study takes the following form:

$$\Delta Retail_t = \mu + \rho Retail_{t-1} + \theta^+ O_{t-1}^+ + \theta^- O_{t-1}^- + \pi^+ EXCH_{t-1}^+ + \pi^- EXCH_{t-1}^- + \sum_{j=1}^{p-1} \alpha_j \Delta Retail_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^+ \Delta O_{t-j}^+ + \varphi_j^- \Delta O_{t-j}^-) + \sum_{j=0}^{q-1} (\alpha_j^+ \Delta EXCH_{t-j}^+ + \alpha_j^- \Delta EXCH_{t-j}^-) + \varepsilon_t \quad (6)$$

In this model, the $Retail$ dependent variable is the retail price of gasoline and diesel. O denotes crude oil prices and the EX represents the exchange rate. O^+, O^-, EX^+, EX^- are the partial sums of positive and negative changes in each of the explanatory variables, respectively.

Table 1

Descriptive Statistics

	Gasoline Istanbul (GASI)	Gasoline Ankara (GASA)	WTI	BRENT	Exchange Rate (EXCH)	Diesel Istanbul (DIEI)	Diesel Ankara (DIEA)
Mean	3.942	3.950	73.966	77.736	1.980	3.761	3.787
Median	4.180	4.210	70.670	71.580	1.689	3.850	3.870
Maximum	5.780	5.830	141.060	140.670	3.946	5.140	5.190
Minimum	2.300	2.290	31.620	32.450	1.162	2.330	2.360
Std. Dev.	0.924	0.939	22.549	26.267	0.751	0.710	0.716
Skewness	-0.066	-0.069	0.273	0.293	1.118	-0.222	-0.210
Kurtosis	1.732	1.724	2.269	1.830	3.071	2.129	2.108
Jarque-Bera	10.758***	10.906***	5.515***	11.339***	33.178***	4.898*	4.977*

Note: JB denotes the empirical statistics of the Jarque–Bera test for normality. ***, **, and * indicate rejection of the null hypothesis of normality at 1%, 5% and 10%, significance level respectively.

To examine the impacts of crude oil prices and the exchange rate on the retail price of gasoline and diesel, we used monthly data from January 2005 to April 2018 for Turkey, but the retail price of diesel is available from January 2008. The WTI and Brent crude oil prices are obtained from the FRED database. The USD/TRY rate and the retail price of gasoline and diesel data are obtained from the Central Bank of the Republic of Turkey and the archives of Petrol Ofisi, respectively. The retail prices, which are used as dependent variables, are analyzed separately for gasoline and diesel prices in Ankara and Istanbul. All variables are used in the logarithm. Table 1 shows the descriptive statistics of the variables. The null hypothesis that the variables have a normal distribution is rejected for all variables. The results of the unit root test are shown in Table 2. The vast majority of variables become stationary in the first difference. After determining that none of the variables are I(2), we can estimate the non-linear ARDL model.

Table 2

Unit Root Tests

	Levels			
	Constant		Constant & Trend	
	ADF	PP	ADF	PP
GASI	-1.298	-1.310	-2.582	-2.796
GASA	-1.376	-1.383	-2.600	-2.810
WTI	-2.679*	-2.598	-2.892	-2.799
BRENT	-2.608	-2.538	-2.674	-2.610
EXCH	0.509	0.604	-2.036	-2.075
DIEI	-1.038	-1.203	-1.727	-2.026
DIEA	-0.986	-1.143	-1.744	-2.033
	First Difference			
	Constant		Constant & Trend	
	ADF	PP	ADF	PP
GASI	-11.430***	-11.385***	-11.398***	-11.350***
GASA	-11.543***	-11.410***	-11.426***	-11.380***
WTI	-9.387***	-9.359***	-9.388***	-9.362***
BRENT	-9.350***	-9.350***	-9.353***	-9.353***
EXCH	-11.417***	-11.368***	-11.504***	-11.503***
DIEI	-6.391***	-9.840***	-6.368***	-9.802***
DIEA	-6.358***	-9.944***	-6.337***	-9.905***

Note: The values demontrate t statistics for ADF and PP tests. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively.

4. Results

The models presented in Equations (4) – (5) are estimated for the oil price and exchange rate pass-through to gasoline prices and diesel price. The results obtained from these estimates are shown in Table 3 and Table 4 for the WTI and Brent, respectively. We first examine the model in which the WTI oil prices are used. When the asymmetry statistics based on the Wald test in Table 3 are examined, we may see that the null hypothesis that the effect of WTI oil prices on retail prices is symmetric cannot be rejected for all models. Therefore, this relationship is not asymmetric on long term. On short term, the effect of WTI oil prices on gasoline prices is asymmetric, while the effect on diesel prices is symmetric as on long term. Table 4 shows the relationship between the Brent oil prices and retail prices, and we observe similar results here as for the WTI. It is reported that the relationship for diesel prices is not asymmetric in both Istanbul and Ankara. Again, we find that the relationship between Brent oil prices and gasoline prices is asymmetric only on short term.

We also examine the asymmetric effects of exchange rates on retail prices in both models. The Wald tests cannot reject the short-run and long-run symmetry with respect to the exchange rate for the diesel price in both models based on the WTI and Brent oil price. These findings indicate that the pass-through from the exchange rate to the retail price of diesel is not asymmetric in the short-run and long-run. Turning to the gasoline price, the effect of the exchange rate on gasoline price is entirely different in the Brent model. While the effect of the exchange rate on gasoline prices is determined asymmetric on both the long term and short term in the Brent model, there is evidence that this effect is only asymmetric on short term for the WTI model.

When we examine the short-term coefficients of oil prices and exchange rate, we find that the oil prices and exchange rate have a significant and increasing effect on retail prices regardless of whether the shocks are positive and negative. These findings support the results showing the presence of short-term asymmetries. Our results suggest that the effect of exchange rate shocks on gasoline and diesel prices is larger than the effect of shocks in oil prices on short term. Moreover, irrespective of the direction of the shocks, the former exchange rate shocks have a higher impact than the latter exchange rate shocks in almost all models, whereas these impacts are the opposite for oil prices. The impact of a negative shock to oil prices on retail prices is higher than the impact of positive shocks in almost all gasoline and diesel models. The impact of negative shocks on gasoline prices is larger than the effect of positive shocks, whereas this effect reverses for the diesel prices. The negative shocks to the exchange rate are transmitted to the retail prices slower, but more extensive than the positive shocks. In addition, these findings reflect that the transition effect of the exchange rate is larger and more persistent than the transition effect of oil prices.

Table 3

Nonlinear ARDL Model Estimation Results for the WTI Oil Price and Exchange Rate Pass-Through to Gasoline Prices

	Dependent Variables							
	Gasoline İstanbul		Gasoline Ankara		Diesel İstanbul		Diesel Ankara	
	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.
$Retail_{t-1}$	-0.345***	0.064	-0.344***	0.064	-0.244***	0.064	-0.242***	0.063
Wti^{+}_{t-1}	0.098***	0.029	0.099***	0.030	0.159***	0.044	0.152***	0.043
Wti^{-}_{t-1}	0.099***	0.025	0.096***	0.025	0.084**	0.033	0.088***	0.033
$Exch^{+}_{t-1}$	0.110***	0.041	0.106***	0.041	0.005	0.058	0.021	0.060
$Exch^{-}_{t-1}$	0.010	0.051	0.014	0.051	0.107	0.102	0.099	0.102
$\Delta Retail_{t-1}$	-0.131*	0.075	-0.124	0.076	-0.180**	0.087	-0.175**	0.088
$\Delta Retail_{t-2}$					0.087	0.076	0.077	0.078
$\Delta Retail_{t-3}$					-0.172**	0.077	-0.170**	0.078
ΔWti^{+}_{t}	0.165***	0.045	0.162***	0.045	0.193***	0.061	0.192***	0.062
ΔWti^{+}_{t-1}	-0.030	0.045	-0.032	0.045	0.014	0.055	0.012	0.055
ΔWti^{-}_{t}	0.260***	0.037	0.257***	0.037	0.274***	0.046	0.266***	0.046
ΔWti^{-}_{t-1}	0.172***	0.044	0.170***	0.044	0.097*	0.057	0.083	0.058
$\Delta Exch^{+}_{t}$	0.232***	0.075	0.228***	0.075	0.332***	0.116	0.343***	0.117
$\Delta Exch^{+}_{t-1}$	0.045	0.080	0.040	0.080	0.071	0.122	0.061	0.123
$\Delta Exch^{-}_{t}$	0.324***	0.117	0.324***	0.118	0.313*	0.185	0.286	0.187
$\Delta Exch^{-}_{t-1}$	0.349***	0.121	0.347***	0.121	0.291	0.178	0.287	0.179
$Constant$	0.305***	0.054	0.302***	0.053	0.249***	0.063	0.247***	0.062
	Long Run Coefficients							
	Coeff.	F-Stat.	Coeff.	F-Stat.	Coeff.	F-Stat.	Coeff.	F-Stat.
$L_{O^{+}}$	0.286***	22.11	0.288***	22.15	0.651***	14.83	0.627***	13.47
$L_{O^{-}}$	-0.288***	57.82	-0.281***	54.04	-0.348***	21.87	-0.363***	23.99
$L_{EX^{+}}$	0.319***	12.19	0.311***	11.39	0.023	0.009	0.087	0.132

	Dependent Variables							
	Gasoline İstanbul		Gasoline Ankara		Diesel İstanbul		Diesel Ankara	
	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.
L_{EX^-}	-0.031	0.045	-0.042	0.078	-0.441	0.987	-0.408	0.844
	Asymmetry Statistics							
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
$W_{LR,\ O}$	0.001	0.972	0.009	0.923	2.424	0.123	1.838	0.178
$W_{LR,\ EX}$	2.158	0.144	1.863	0.174	0.600	0.440	0.358	0.551
$W_{SR,\ O}$	9.526	0.002	9.43	0.003	1.862	0.175	1.42	0.236
$W_{SR,\ EX}$	2.698	0.103	2.771	0.098	0.254	0.615	0.176	0.675
	Cointegration Test Statistics							
t_{BDM}	-5.320		-5.325		-3.795		-3.818	
F_{PSS}	6.536		6.574		4.199		4.126	
	Model Diagnostics							
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
χ^2_{SC}	40.71	0.438	40.95	0.428	26.28	0.953	25.36	0.965
χ^2_{HET}	0.002	0.961	0.0002	0.986	0.017	0.894	0.007	0.930
χ^2_{RESET}	0.543	0.653	0.499	0.683	1.158	0.329	1.067	0.366
χ^2_{JB}	0.263	0.876	0.269	0.874	6.815	0.033	9.516	0.008

***Note**:* ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The SIC information criterion selects p=2, q=2 for the gasoline model and p=4, q=2 for diesel model as the optimal lag length. L_{O^+}, L_{O^-}, L_{EX^+}, and L_{EX^-} denote the long-run coefficients associated with positive and negative changes of WTI oil price and positive and negative changes in the exchange rate, respectively. $W_{LR,\ O}$, and $W_{SR,\ O}$, denote the Wald test for long-run and short-run symmetry restrictions of WTI oil price while $W_{LR,\ EX}$, and $W_{SR,\ EX}$ represent the Wald test for long-run and short-run symmetry restrictions of the exchange rate. The critical values of the t_{BDM} and F_{PSS} tests obtained by Pesaran *et al*. (2001). The critical values [lower bound: I(0); upper bound: I(1)] for t_{BDM} test with k = 4 are [-3.43; -4.60] at 1% , [-2.86; -3.99] at 5% and [-2.57; -3.66] at 10% significance levels. Similarly, the critical values [lower bound: I(0); upper bound: I(1)] for F_{PSS} test with k = 4 are [3.74; 5.06] at 1% , [2.86; 4.01] at 5% and [2.45; 3.52] at 10% significance levels. χ^2_{SC}, χ^2_{HET}, χ^2_{RESET}, and χ^2_{JB} denote Breusch Godfrey LM test for serial correlation, White heteroscedasticity test, functional form (Ramsey RESET test) and statistics of the Jarque–Bera test for normality, respectively.

Table 4

Nonlinear ARDL Model Estimation Results for the Brent Oil Price and Exchange Rate Pass-Through to Gasoline Prices

	Dependent Variables							
	Gasoline İstanbul		Gasoline Ankara		Diesel İstanbul		Diesel Ankara	
	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.
$Retail_{t-1}$	-0.462***	0.073	-0.450***	0.072	-0.282***	0.065	-0.278***	0.066
$Brent^+_{t-1}$	0.135***	0.027	0.132***	0.027	0.148***	0.034	0.137***	0.033
$Brent^-_{t-1}$	0.131***	0.023	0.125***	0.023	0.116***	0.030	0.117***	0.030
$Exch^+_{t-1}$	0.162***	0.034	0.157***	0.033	0.108**	0.051	0.121**	0.054
$Exch^-_{t-1}$	0.065	0.046	0.066	0.046	0.132	0.084	0.120	0.085
$\Delta Retail_{t-1}$	-0.091	0.076	-0.090	0.076	-0.081	0.087	-0.076	0.089
$\Delta Retail_{t-2}$					0.106	0.068	0.105	0.070

	Dependent Variables							
	Gasoline İstanbul		Gasoline Ankara		Diesel İstanbul		Diesel Ankara	
	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.	Coeff.	Std. Er.
$\Delta Retail_{t-3}$					-0.176**	0.069	-0.173**	0.071
$\Delta Brent_t^+$	0.209***	0.039	0.210***	0.040	0.255***	0.054	0.254***	0.055
$\Delta Brent_{t-1}^+$	-0.028	0.040	-0.026	0.040	-0.002	0.047	-0.0002	0.047
$\Delta Brent_t^-$	0.259***	0.035	0.256***	0.036	0.260***	0.046	0.251***	0.047
$\Delta Brent_{t-1}^-$	0.091**	0.044	0.091**	0.044	0.005	0.059	-0.002	0.060
$\Delta Exch_t^+$	0.263***	0.069	0.259***	0.069	0.343***	0.107	0.350***	0.109
$\Delta Exch_{t-1}^+$	-0.011	0.074	-0.014	0.074	-0.044	0.113	-0.052	0.115
$\Delta Exch_t^-$	0.315***	0.108	0.317***	0.109	0.327*	0.169	0.306*	0.171
$\Delta Exch_{t-1}^-$	0.367***	0.105	0.370***	0.106	0.375**	0.156	0.378**	0.158
$Constant$	0.394***	0.061	0.381***	0.06	0.281***	0.065	0.278***	0.066
	Long Run Coefficients							
	Coeff.	F-Stat.	Coeff.	F-Stat.	Coeff.	F-Stat.	Coeff.	F-Stat.
L_{O^+}	0.294***	69.01	0.295***	65.13	0.525***	23.96	0.495***	19.99
L_{O^-}	-0.285***	211.9	-0.280***	191.7	-0.412***	77.18	-0.420***	74.87
L_{EX^+}	0.352***	75.51	0.349***	69.7	0.382 ***	7.323	0.437***	9.079
L_{EX^-}	-0.141	2.12	-0.148	2.196	-0.468	2.225	-0.430	1.796
	Asymmetry Statistics							
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
$W_{LR,\ O}$	0.086	0.768	0.204	0.652	1.367	0.245	0.578	0.449
$W_{LR,\ EX}$	4.434	0.037	3.801	0.053	0.087	0.769	0.0004	0.982
$W_{SR,\ O}$	3.977	0.048	3.681	0.057	.01376	0.907	0.002	0.960
$W_{SR,\ EX}$	3.846	0.052	3.996	0.048	1.257	0.265	1.127	0.291
	Cointegration Test Statistics							
t_{BDM}	-6.327		-6.236		-4.295		-4.185	
F_{PSS}	8.269		8.047		4.969		4.701	
	Model Diagnostics							
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
χ^2_{SC}	39.28	0.502	39.48	0.493	16.29	0.999	18.54	0.998
χ^2_{HET}	0.019	0.889	0.008	0.927	3.36	0.066	3.236	0.072
χ^2_{RESET}	0.535	0.658	0.485	0.693	1.827	0.147	2.104	0.104
χ^2_{JB}	0.133	0.935	0.092	0.954	2.475	0.290	3.137	0.208

Note: ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The SIC information criterion selects p=2, q=2 for the gasoline model and p=4, q=2 for diesel model as the optimal lag length. L_{O^+}, L_{O^-}, L_{EX^+}, and L_{EX^-} denote the long-run coefficients associated with positive and negative changes of Brent oil price and positive and negative changes in the exchange rate, respectively. $W_{LR,\ O}$, and $W_{SR,\ O}$, denote the Wald test for long-run and short-run symmetry restrictions of Brent oil price while $W_{LR,\ EX}$, and $W_{SR,\ EX}$ represent the Wald test for long-run and short-run symmetry restrictions of the exchange rate. The critical values of the t_{BDM} and F_{PSS} tests obtained by Pesaran *et al*. (2001). The critical values [lower bound: I(0); upper bound: I(1)] for t_{BDM} test with k = 4 are [-3.43; -4.60] at 1% , [-2.86; -3.99] at 5% and [-2.57; -3.66] at 10% significance levels. Similarly, the critical values [lower bound: I(0); upper bound: I(1)] for F_{PSS} test with k = 4 are [3.74; 5.06] at 1% , [2.86; 4.01] at 5% and [2.45; 3.52] at 10% significance levels. χ^2_{SC}, χ^2_{HET}, χ^2_{RESET}, and χ^2_{JB} denote Breusch Godfrey LM test for serial correlation, White heteroscedasticity test, functional form (Ramsey RESET test) and statistics of the Jarque–Bera test for normality, respectively.

Tables 3 and 4 also report the t_{BDM} and F_{PSS} statistics. If the t_{BDM} and F_{PSS} statistics are higher than the upper limit critical values, the existence of cointegration relationship is confirmed. The critical values for the t_{BDM} and F_{PSS} tests are reported in the note part of the tables. The t_{BDM} and F_{PSS} statistics and critical values indicate that all models have a cointegration relationship for at least 10% significance level. We also calculate the long-term positive and negative coefficients that show the effect of positive and negative shocks to oil prices and exchange rate on retail prices. Taken together, the positive shocks to oil prices have a significant and increasing impact on retail prices in all estimated models. Similarly, negative shocks to oil prices decrease the retail prices significantly. One may see that the long-term positive and negative effects of both oil prices on gasoline prices are very close to each other. The coefficients for gasoline prices express that the increase (decrease) in the gasoline prices is approximately 0.29% when oil prices increase by 1% (decrease) in both Istanbul and Ankara. Turning to the diesel price, the magnitudes of the effect of positive and negative shocks are substantially different. The effect of a 1% positive and negative shock to the WTI oil prices on Istanbul diesel prices is 0.65% and –0.34%, respectively, while this effect is 0.62% and –0.36% for Ankara diesel prices, respectively. The effect of the Brent oil prices on diesel prices decreases for positive shocks and increases for negative shocks as compared to the WTI. These values are 0.52% and –0.41% for Istanbul and 0.49% and –0.42% for Ankara, respectively.

Similarly, when we examine the effects of long-term positive and negative shocks to the exchange rate on retail prices, it is observed that the long-term coefficients for negative shocks are statistically insignificant in all models. The coefficients for the positive shocks are significant in all models where gasoline prices are dependent variables. The effect of a 1% increase in the exchange rate on gasoline prices is approximately 0.31% and 0.35% in both models, respectively. The findings on the effects of exchange rates on diesel prices are not clear.

The asymmetric dynamic multipliers can reveal the responses of the retail price to the positive and negative shocks to crude oil prices and the exchange rate. Finally, the dynamic adjustment processes are shown in Figure 1 to Figure 8. We may see the effect of positive shocks and negative shocks as well as the asymmetry curve that represents the linear combination of the dynamic multipliers based on positive and negative shocks. The blue bands indicate the 95% bootstrap confidence intervals for the asymmetry curve based on 1000 replications. Many of the figures support our previous findings. A positive shock to oil prices and exchange rates has an increasing effect on the retail prices while a negative shock has a decreasing effect on the retail prices. These effects are shown by the green (short dashed) and red (long dashed) lines, respectively. It may also be observed here that in most cases, the effect of negative shocks to oil prices and the exchange rate on retail prices is equal or higher than the effect of positive shocks. Besides, the duration for adjustments of gasoline prices to equilibrium is almost the same with the following positive and negative shocks to oil prices, but this duration for negative shocks lasts longer in the case of exchange rate shocks. There are no noticeable differences between positive and negative shocks in terms of the adjustment of diesel prices to equilibrium.

Firstly, when the analysis results on the effect of oil prices on the retail prices of gasoline and diesel are compared with the literature, our results support the studies of Borenstein *et al*. (1997), Oladunjoye (2008), Atil *et al*. (2014), Galeotti *et al*. (2003) that demonstrate the existence of asymmetry between oil prices and retail prices on short term. On the other hand, our results are consistent with the study of Alper and Torul (2009) examining the effects of gasoline prices on crude oil prices in Turkey. Secondly, the results relationship to the effects of the exchange rate on retail price are also consistent with a study in the literature. Similar to our results, Chou and Tseng (2016), who examine the effect of the exchange rate as well as oil prices on gasoline prices obtain asymmetric relationship. However, the results of this study, unlike our findings, suggest that asymmetric adjustments are more rapid in decline. The findings of the study generally indicate evidence of the validity of asymmetric effects, thus relatively support the "rockets and feathers effect" on short term. It may be said that the increase in the price of crude oil is reflected in the consumer price over a short time, and thus, the increasing producer costs are directly transferred to the consumers.

Figure 1

The Cumulative Asymmetric Effects of the WTI Oil Price and Exchange Rate Shocks on the Istanbul Gasoline Price

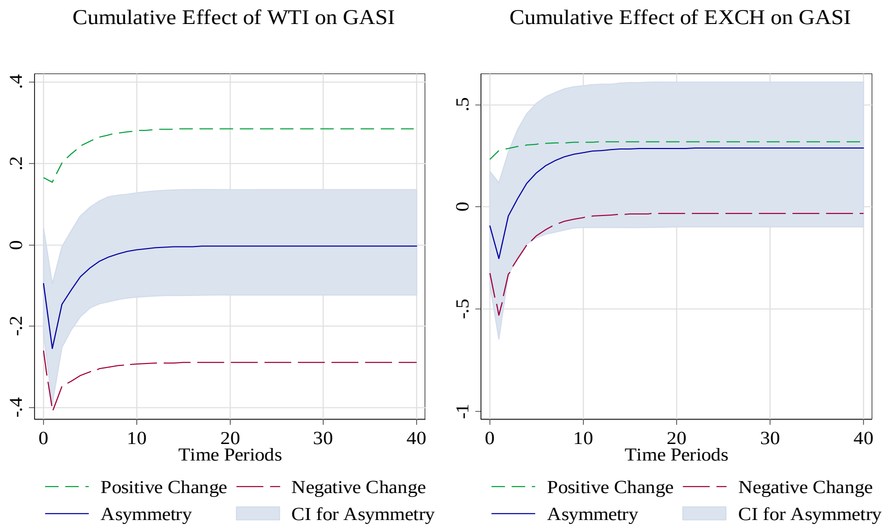


Figure 2

The Cumulative Asymmetric Effects of the Brent Oil Price and Exchange Rate Shocks on the Istanbul Gasoline Price

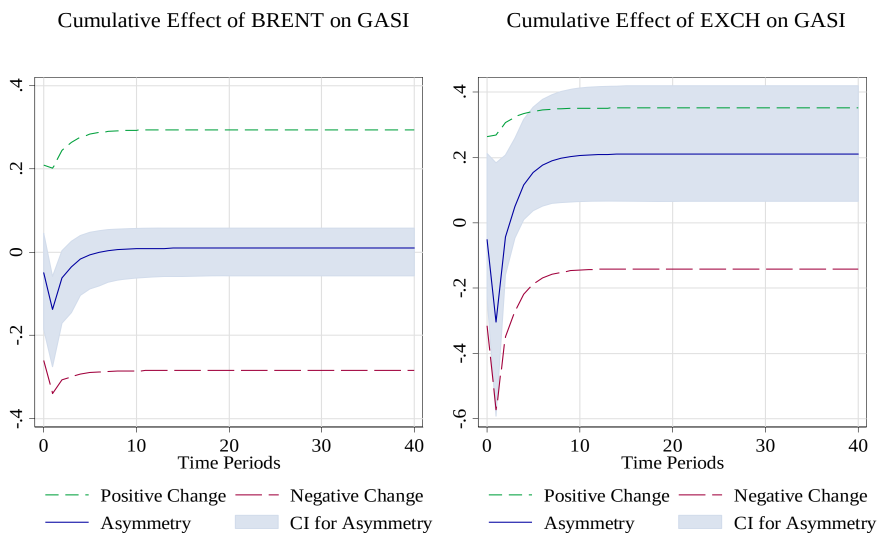


Figure 3

The Cumulative Asymmetric Effects of the WTI Oil Price and Exchange Rate Shocks on the Ankara Gasoline Price

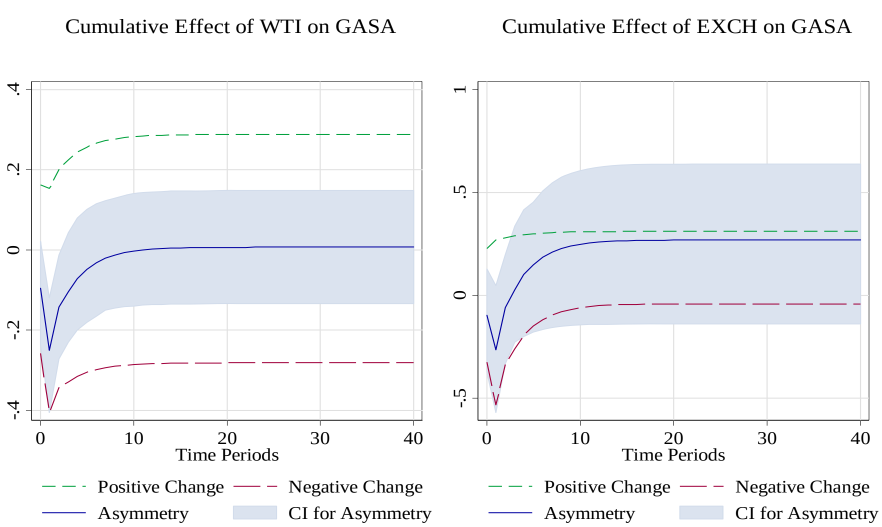


Figure 4

The Cumulative Asymmetric Effects of the WTI Brent Price and Exchange Rate Shocks on the Ankara Gasoline Price

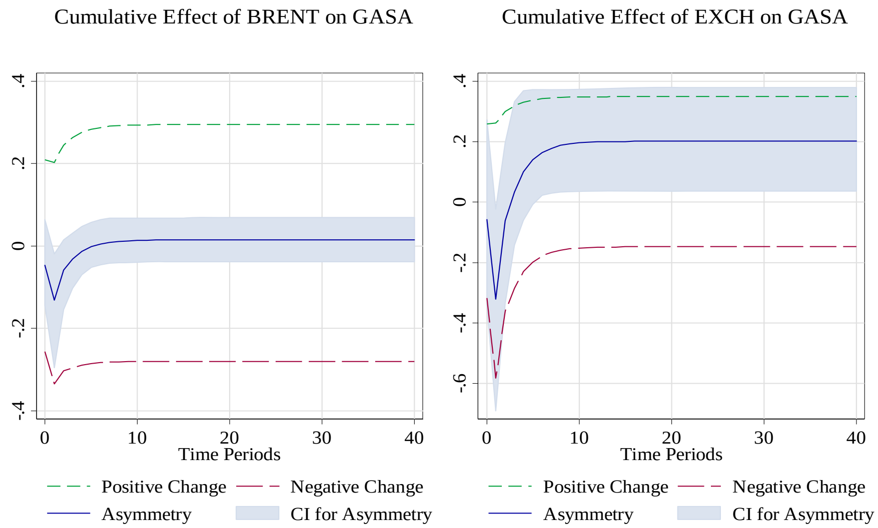


Figure 5

The Cumulative Asymmetric Effects of the WTI Oil Price and Exchange Rate Shocks on the Istanbul Diesel Price

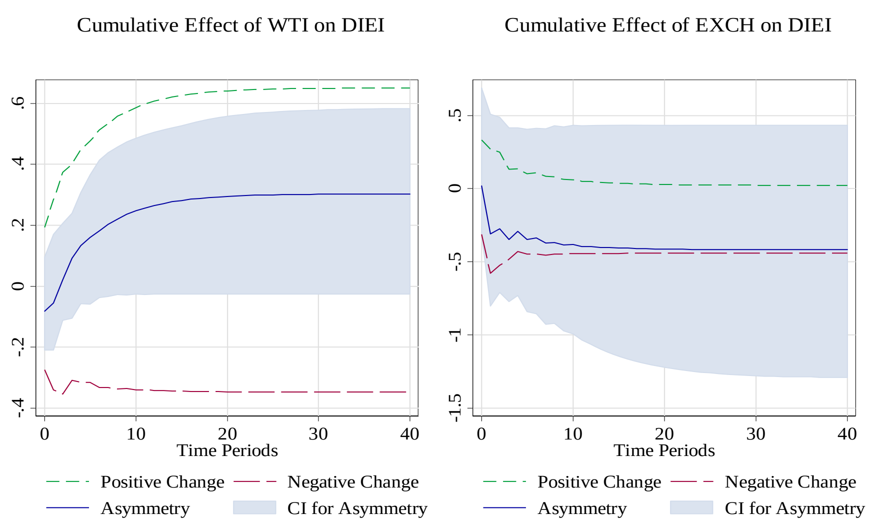


Figure 6
The Cumulative Asymmetric Effects of the Brent Oil Price and Exchange Rate Shocks on the Istanbul Diesel Price

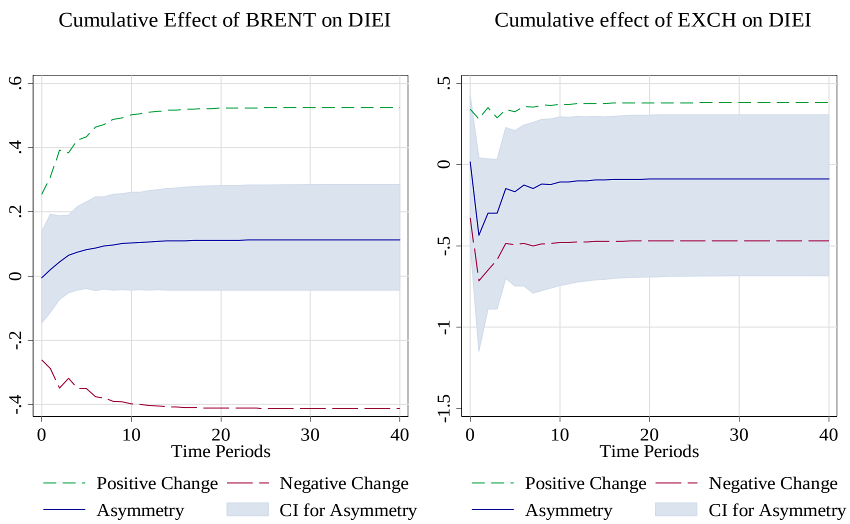


Figure 7
The Cumulative Asymmetric Effects of the WTI Oil Price and Exchange Rate Shocks on the Ankara Diesel Price

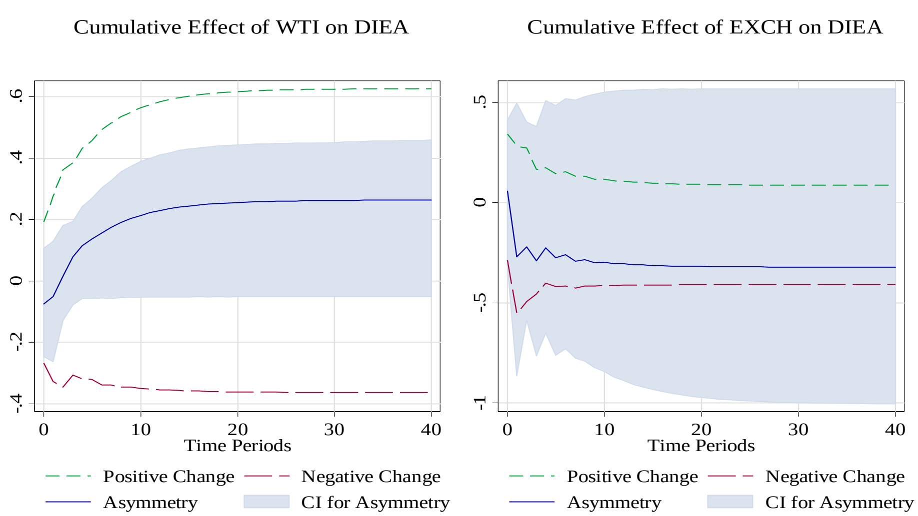
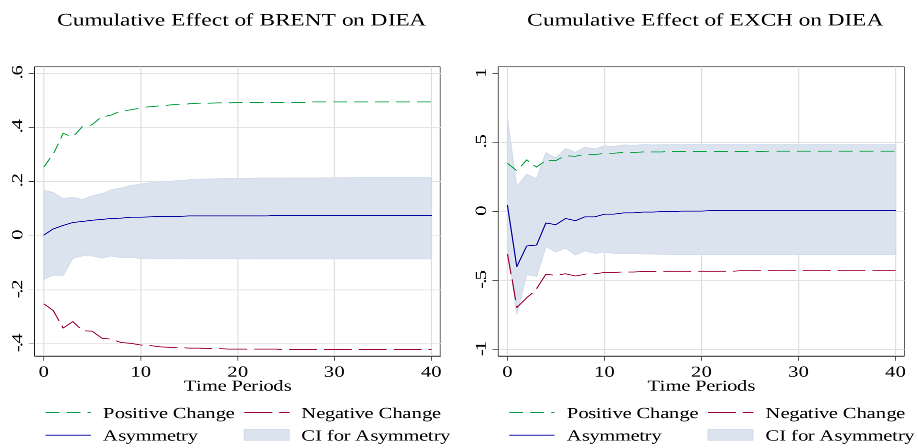


Figure 8
The Cumulative Asymmetric Effects of the Brent Oil Price and Exchange Rate Shocks on the Ankara Diesel Price



5. Conclusion

The crude oil prices and exchange rate are the main determinants of the retail price of gasoline and diesel. It is quite reasonable for someone to associate changes in retail prices of gasoline and diesel with these variables. However, the common perception of people and the media is that the retail prices increase rapidly when oil prices and exchange rates increase but decrease slowly when they decrease. This research explores the potential asymmetric effect of crude oil prices and exchange rate fluctuations on retail prices in Turkey. The non-linear ARDL model reveals that the effects of crude oil prices on retail gasoline and diesel prices differ on short and long term. The findings show that the effect of the WTI and Brent oil prices on retail prices is symmetric in the long run, while its effect on gasoline and retail diesel prices is different on short term. In the short run, the relationship between the WTI prices and gasoline prices is asymmetric, but we cannot obtain similar evidence for the relationship between the diesel prices and the WTI prices. Similarly, there are asymmetric effects on retail gasoline prices in the model in which Brent oil prices are used. The findings also show how the positive and negative shocks to oil prices affect the retail prices of gasoline and diesel. The positive and negative shocks to oil prices have an increasing and decreasing impact on retail prices, respectively, on long term. However, both positive and negative shocks to oil prices have an increasing effect on retail prices on short term.

The study also investigates the asymmetric relationship between the exchange rate and retail prices. Our findings indicate that the exchange rate and retail price of gasoline have an asymmetric relationship on short term for the Brent and WTI models. The short-term relationship between the exchange rate and the retail price is positive and significant irrespective of the direction of shocks. The negative shocks to the exchange rate are transmitted to the retail prices slower, but higher than the positive shocks, and the exchange rate affects the retail prices more than oil prices on short-term. The exchange rate emerges as an essential element in determining retail prices, and it may be the primary source of asymmetry. The retail prices respond to negative shocks, especially to the exchange rate, later than the positive shocks.

These asymmetries in retail prices are more likely to occur when the oil markets are not competitive. In oligopolistic and monopolistic competitive markets, the firms' efforts to keep the price above the marginal cost by using market power may lead to asymmetric price rigidities. The upward price rigidity may be higher than downwards price rigidity in such market conditions. Although there are many small dealers and local fuel companies in the market, we observe that the structure of the market share is mostly dominated by several international and national companies in Turkey. The structure of the Turkish fuel market, which has features of monopolistic competition, can be a major cause of the asymmetry in retail prices.

On the other hand, the asymmetry in the retail prices may be based on the high rate of taxes in Turkey. Tax revenues from fuel oil are one of the major sources of the government budget. Even if the retail prices are determined under free competition, the government determines the size and timing of price changes due to the authority to adjust the prices of the distributors and the tax rates. The main reason for the asymmetry is the fact that the state has adjusted its gasoline prices in a way not to reduce the tax revenues.

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