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Asymmetric Exchange Rate Pass-Through into Inflation in Turkey: A NARDL Approach

Türkiye'de Döviz Kurunun Enflasyona Asimetrik Geçişi: Bir NARDL Yaklaşımı

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Abstract

Inflation expectation resulting from the exchange rate increases is one of the widely discussed topics in the literature. When determining the disinflation policies, it is crucial to consider the size and duration of the exchange rate pass-through effect on inflation. The literature findings show that the high level of rises in the exchange rate pass-through much faster on inflation, especially in dollarized economies with high inflation inertia. On the other hand, it has been revealed that the relationship between exchange rate inflation is asymmetrical. The Turkish economy, which struggles with chronicle higher inflation, has experienced an exchange rate crisis in 2018. Therefore, to analyse the effect of exchange rate on inflation in Turkey is very important for the effectiveness of the fight against inflation and developing a policy proposal in this direction. This study examined the asymmetric relationships between exchange rate and inflation using a nonlinear autoregressive distributed lag model for 2004:Q1–2019:Q4. Findings indicate that the exchange rate pass-through into inflation is asymmetric in Turkey in the long run. 1% increase in the exchange rate increases the annual inflation by 0.11% in the long run, whereas a 1% decrease in the exchange rate decreases inflation by 0.28%. Besides, a decrease in the exchange rate has no statistically significant effect on inflation, but an increase also increases inflation in the short run.

Jel Codes: *C22, E31, F31.*
Keywords: *Exchange rate, Asymmetric Pass-Through, Inflation, Nonlinear ARDL.*

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Öz

Döviz kuru artışlarından kaynaklanan enflasyon beklentisi literatürde oldukça yaygın tartışma konularından birisidir. Dezenflasyon politikalarının belirlenmesinde döviz kurunun enflasyona geçiş etkisinin büyüklüğü ve süresinin dikkate alınması önem arz etmektedir. Literatür bulguları özellikle enflasyon ataletinin yüksek olduğu dolarize olmuş ekonomilerde, yüksek döviz kuru geçişkenliğinin enflasyonu daha hızlı etkilediğini göstermektedir. Diğer yandan, döviz kuru enflasyon arasındaki ilişkinin asimetrik olduğu ortaya konulmuştur. Kronik yüksek enflasyonla mücadele eden Türkiye ekonomisi, 2018 yılında döviz kuru krizi yaşamıştır. Bu nedenle, Türkiye'de döviz kurunun enflasyon üzerindeki etkisinin incelenmesi, enflasyonla mücadelenin etkinliği ve bu yönde bir politika önerisi geliştirilmesi açısından büyük önem taşımaktadır. Bu çalışma, döviz kuru ile enflasyon arasındaki asimetrik ilişkileri, 2004:Q1–2019:Q4 dönemi için doğrusal olmayan otoregresif dağıtılmış gecikme modeli kullanarak incelemektedir. Bulgular, Türkiye'de döviz kuru geçişkenliğinin uzun vadede asimetrik olduğunu göstermektedir. Döviz kurundaki %1'lik artış uzun dönemde yıllık enflasyonu %0,11 artırırken, döviz kurundaki %1'lik düşüş enflasyonu %0,28 oranında azaltmaktadır. Ayrıca, döviz kurundaki düşüşün enflasyon üzerinde istatistiksel olarak anlamlı bir etkisi olmamakla birlikte, kısa vadede döviz kurundaki artış enflasyonu artırmaktadır.

Jel Kodları: *C22, E31, F31.*
Anahtar Kelimeler: *Döviz Kuru, Asimetrik Geçiş Etkisi, Enflasyon, Doğrusal Olmayan ARDL.*

1. Introduction

The exchange rate is the ratio of the exchange of national currencies of countries and is considered an economic power indicator. The reaction of prices to a change in the nominal exchange rate is called the exchange rate pass-through (henceforth, ERPT). Goldberg and Knetter (1997) describe ERPT as the percentage change in prices due to a one percent change in the exchange rate between the exporting and importing countries. Low ERPT implies that exchange rate shocks have modest effects on prices, and the inflation targeting regime is proceeding successfully.

Emerging market economies such as Turkey, with high openness and uncontrolled foreign capital movements, face more volatile capital flows than developed economies. This volatility in capital flows causes fluctuations in exchange rates. Moreover, as an economy that implements inflation targeting and yet experiences high liability dollarization, Turkey has been dealing with the problems caused by the high exchange rate volatility mentioned in the "Fear of Floating" literature (Dağlaroğlu et al., 2018).

High exchange rate volatility, exchange rate shocks, or both may cause private sector balance sheets with high liability dollarization to break down and high inflation due to the pass-through effect (Hunt and Isard, 2003; Kandil and Morsy, 2009; Bhattacharya et al., 2011). These issues in the Turkish economy pose an external dominance problem on monetary policy, reduce instrument independence, impair policy effectiveness, and constrain the implementation of anti-cyclical monetary policy (Dağlaroğlu et al., 2018). This study ignores the impact of the exchange rate on the balance sheets, but it focuses on the effect of the exchange rate on inflation, a chronic problem in Turkey.

Monitoring the exchange rate pass-through coefficient is crucial for a central bank whose primary objective is to maintain price stability. Recent studies revealed that the ERPT is asymmetric and nonlinear, especially in emerging economies, while most studies for Turkey still ignore the nonlinearities and asymmetries. Therefore, to reveal the effects of increases and decreases in the exchange rate on inflation separately we use the nonlinear autoregressive distributed lag (NARDL) framework of Shin et al. (2014). This paper aims to measure the asymmetric ERPT into domestic inflation in Turkey for 2004:Q1 – 2019:Q4 period. The outline of the paper is as follows. The first section presents a theoretical framework of pass-through and discusses the related literature. Section 2 introduces the methodology, the data, and the model used in the analysis. Section 3 presents the empirical findings. The concluding remarks section discusses and interprets the results.

2. Theoretical framework and Literature review

2.1. Theoretical framework

It is agreed that a change in the exchange rate affects inflation through two channels, "direct channel" and "indirect channel". The exchange rate changes affect inflation directly via the prices of imported final goods and imported intermediate goods used in domestic production. The magnitude of direct effects depends on the import share (McCarthy, 2000, p.3). As small open economies depend on imported intermediate goods that domestic substitution is limited, ERPT is larger in these economies. Exchange rate increases (decreases) might directly increase (decrease) the production costs and then the inflation (Çiçek and Boz, 2013, p.46). On the other hand, the exchange rate increases (decreases) affect inflation indirectly via increases (decreases) in domestic demand for substitute goods, increases (decreases) in export demand, increases (decreases) in labor demand, other factors like wage rises, etc. (McFarlane, 2002, p. 5). The magnitude of the indirect effects depends on the elasticity of substitution between domestic and imported goods (Özata, 2019, p. 214).

The Turkish economy has experienced currency shocks in the last few years, and therefore measuring the ERPT effect came to the fore again. A standard linear model measures the ERPT symmetrically, assuming increases and decreases in the exchange rate affect inflation equally. However, several studies, such as Goldberg and Knetter (1997); Pollard and Coughlin (2004); Delatte and Lopez-Villavicencio (2012); Doğan (2013), have reported that the pass-through effect may not be symmetrical, especially in countries with high exchange rate volatility.

One of the primary sources of asymmetry and nonlinearity in pass-through is the direction of the change in the exchange rate. The appreciation and depreciation of the currency have an asymmetric impact on inflation. Central banks should measure the effect of positive and negative exchange rate shocks on inflation separately to maintain inflation at the desired level if the ERPT is asymmetric (Çiçek and Boz, 2013, p.45). Pollard and Coughlin (2004) revealed that pass-through is greater when the importer's currency appreciates than when it depreciates. When the importing country's currency appreciates, exporters tend to decrease their prices in that currency to increase the market share and import demand. On the other hand, in the case of depreciation of the importing country's currency, exporters tend to reduce their profit margins instead of raising the prices to avoid losing market shares (Pollard and Coughlin, 2004, p. 2). Another source of the asymmetry is the size of the change in the

exchange rate. Small changes in the exchange rate might not be reflected in prices due to menu cost. Additionally, asymmetry might also occur in a long-term relationship, short-term dynamics, or both (El Bejaoui, 2013: 30). This study focuses on the asymmetry caused by increases and decreases in the exchange rate.

2.2. Literature

Previous studies focusing on developed economies have generally examined the ERPT into import prices, while the ones focusing on developing economies have examined the ERPT into inflation. Since developing economies are heavily dependent on imported intermediate goods that have no domestic substitutes, exchange rate changes directly affect consumer prices. (Altıntaş, 2014, p. 166).

The relationship between monetary policy success and the pass-through effect is one of the main issues analyzed in the pass-through literature. The main finding of these studies is that high inflation leads to higher ERPT (Taylor, 2000; Obstfeld, 2002). It is revealed that inflation targeting reduces ERPT especially in emerging countries (Aleem and Lahiani (2014); Kabundi ve Has, 2018; Jasova et al. (2016); Karagöz et al. (2016); Winkelried (2014); Alvarez et al. (2012); Özkan and Erden (2015). Similarly, Soon et al. (2018) showed that the ERPT is high and asymmetrical in countries with high inflation, but low in countries with price stability and high predictability. Volkan et al. (2007) showed inflation targeting reduced ERPT almost by half in Turkey. Kara et al. (2005) revealed that after Turkey adopted the floating exchange rate regime, the decreasing effect of a decrease in the exchange rate on non-tradable goods' prices is higher than tradable goods. Nevertheless, in the long run, the effect of exchange rate changes on inflation is too high, especially for tradable goods.

The exchange rate pass-through into producer prices is higher and faster than consumer prices. Türkcan (2005); Özçiçek (2007); Volkan et al. (2007); Karaoğlu and Kılıçkaplan (2018) obtained similar findings for the Turkish economy. According to Türkcan (2005), the effect of exchange rate shocks on intermediate goods' prices is higher than on final goods' prices.

Another important issue discussed in the literature recently is whether the effect of inflation uncertainty, exchange rate volatility, or changes in the exchange rate on the ERPT is asymmetric. Soon et al. (2018) used inflation volatility as a proxy of inflation uncertainty and found that the ERPT is higher when inflation uncertainty is higher. If the inflation volatility exceeds a certain threshold, ERPT into inflation increases, but if it is below the threshold, the ERPT is low. Forbes et al. (2018) brought a different perspective to the subject by decomposing the shocks affecting exchange rate volatility. The shocks are decomposed into aggregate supply, aggregate demand, monetary policy shocks, as well as exogenous exchange rate shocks and global shocks. Thus, the degree of exchange rate pass-through into import prices and consumer prices is tried to be estimated depending on the source of the shock. Results show that the ERPT is low in response to domestic demand shocks and is relatively high in monetary policy shocks.

Eckstein and Soffer (2008), Nogueira and Ledesma (2008), Razafindrabe (2017), Baharumshah et al. (2017) found that the exchange rate increases and decreases affect the prices asymmetrically. Eckstein and Soffer (2008) revealed that an exchange rate increase affects inflation more than the exchange rate decrease. They argued that an increase in the exchange

rate passes through into inflation much faster in the higher volatility period. Findings also show that the pass-through weakens if the economy goes into recession following an exchange rate shock. Razafindrabe (2017) showed the importance of nominal rigidity for nonlinearity and asymmetry of ERPT. According to the study, the well-established fact that "prices rise faster than they fall" in response to exchange rate changes lies primarily with the presence of nominal rigidity. Nogueira and Ledesma (2008) also stated that price rigidity causes an asymmetric relationship. Their findings revealed that exporting firms' pricing power can lead to asymmetry in ERPT.

Fewer empirical studies examine asymmetric ERPT in Turkey than those examine symmetric ERPT. Doğan (2013) revealed that as the economy grows, the effect of exchange rate changes on manufacturing prices increases. Çiçek and Boz (2013) investigated asymmetric exchange rate pass-through on prices using the NARDL model for Turkey's inflation-targeting period. Their findings indicate that depreciation passes through into prices in the long run in the expansion cycle but, appreciation only passes through if the appreciation rate is calculated by more than four previous periods. In the short run, although depreciation passes-through into the prices, appreciation does not. They emphasized that prices are sticky downwards but flexible upwards in the short run, and the business cycle is the primary source of asymmetry in Turkey. Karamelikli and Korkmaz (2016) also investigated the exchange rate pass-through into Turkey's domestic prices by using the NARDL model. They found that the ERPT is asymmetric in the short-run, and both an increase and a decrease in the exchange rate increase the consumer prices. In the long run, the ERPT is symmetric, and there is a positive correlation between the exchange rate and consumer prices. Özkan and Erden (2015) analyzed the macroeconomic determinants of ERPT using nonlinear methods and found that it is higher when inflation exceeds the 14% threshold. In periods when inflation exceeds the threshold value, firms are willing to reflect exchange rates increases to prices. Karaoğlu and Kılıçkaplan (2018) also stated that there is a nonlinear mechanism in exchange rate pass-through into producer and consumer prices in Turkey. Taylor's (2000) hypothesis is valid in Turkey. When annual consumer inflation exceeds 7%, the exchange rate pass-through also increases. Özata (2019) examined the exchange rate pass-through into consumer prices in Turkey after the global financial crisis and found that ERPT is symmetric in the short-run, asymmetric in the long-run. Empirical findings show that an increase in the exchange rate increases consumer prices in the long run, but a decrease in the exchange rate does not affect prices significantly.

In this study, the nonlinear ARDL model is used to examine the asymmetric ERPT in the Turkish economy.

3. Methodology, data and model

3.1. Methodology

The Autoregressive Distributed Lag (ARDL) model popularized by Pesaran and Shin (1998) and Pesaran et al. (2001) reveal both the short- and long-run relationships among variables by assuming that they are linear and symmetric. To capture the asymmetric and nonlinear relationships among the variables, Shin et al. (2014) developed the Nonlinear ARDL (NARDL) model based on the ARDL model.

One can use the threshold cointegration developed by Enders and Siklos (2001) for detecting only the long-run asymmetry but the NARDL model for detecting both the long- and short-run asymmetries simultaneously (Rezitis, 2019, p. 871). This study uses the NARDL model to examine the asymmetric relationships both in the long- and short-run.

The explanatory variable is decomposed into its positive and negative partial sums. The asymmetric long-run regression model of Shin et al. (2014) is as follows:

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

where β^+ and $\beta^-$are the asymmetric long-run parameters[3], x_t^+ and x_t^- are the partial sum processes of positive and negative changes in x_t. Schorderet (2003) identifies x_t^+ and x_t^- as follows:

$$x_t^+ = \sum_{i=0}^{t-1} \mathrm{I}(\Delta x_{t-i} > 0)\Delta x_{t-i}, \qquad x_t^- = \sum_{i=0}^{t-1} \mathrm{I}(\Delta x_{t-i} < 0)\Delta x_{t-i} \tag{2}$$

where $\mathrm{I}(\cdot)$ is the indicator function, and it takes the value 1 if the event in brackets occurs and 0 otherwise. Δ denotes the first-difference operator.

An NARDL(p, q)[4] model proposed by Shin et al. (2014) is written as:

$$y_t = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} \left(\boldsymbol{\theta}_j^{+\prime} \boldsymbol{x}_{t-j}^+ + \boldsymbol{\theta}_j^{-\prime} \boldsymbol{x}_{t-j}^-\right) + \varepsilon_t \tag{3}$$

where $\boldsymbol{x}_t$ is a $k \times 1$ vector of multiple regressors and $x_t = x_0 + x_t^+ + x_t^-$, ϕ_j is the autoregressive parameter, $\boldsymbol{\theta}_j^+$ and $\boldsymbol{\theta}_j^-$ are the asymmetrically distributed lag parameters, ε_t is the error term with zero mean and constant variance. NARDL model can be estimated by the Ordinary Least Squares (OLS) estimation method since it is linear in all parameters.

The conditional nonlinear error correction form of the NARDL(p, q) model is as follows:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \boldsymbol{\theta}^{+\prime} \boldsymbol{x}_{t-1}^+ + \boldsymbol{\theta}^{-\prime} \boldsymbol{x}_{t-1}^- + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\boldsymbol{\pi}_j^{+\prime} \Delta \boldsymbol{x}_{t-j}^+ + \boldsymbol{\pi}_j^{-\prime} \Delta \boldsymbol{x}_{t-j}^-\right) + e_t \tag{4}$$

$$\Delta y_t = \rho \xi_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\boldsymbol{\pi}_j^{+\prime} \Delta \boldsymbol{x}_{t-j}^+ + \boldsymbol{\pi}_j^{-\prime} \Delta \boldsymbol{x}_{t-j}^-\right) + e_t \tag{5}$$

[3]The long-run effect of one unit positive and negative change in x_t on y_t is $\beta^+$and β^-, respectively.

[4]p and q are the lag orders of the dependent variable and the explanatory variable, respectively.

where ξ_t is the nonlinear error correction term. $\xi_t = y_t - \boldsymbol{\beta}^{+\prime}\boldsymbol{x}_t^{+} + \boldsymbol{\beta}^{-\prime}\boldsymbol{x}_t^{-}$, where $\boldsymbol{\beta}^{+}$ and $\boldsymbol{\beta}^{-}$ are the asymmetric long-run parameters and $\boldsymbol{\beta}^{+} = \boldsymbol{\theta}^{+}/_{\rho}, \boldsymbol{\beta}^{-} = \boldsymbol{\theta}^{-}/_{\rho}$

To test the presence of cointegration among the variables, Shin et al. (2014) developed two procedures. The first one is an F test developed by following the F Bounds-Testing procedure of Pesaran et al. (2001). In this approach, the joint null hypothesis of no cointegration, $H_0: \rho = \boldsymbol{\theta}^{+} = \boldsymbol{\theta}^{-} = 0$, is tested by using F_{PSS} statistic. The second one is the t-statistic testing procedure developed by following Banerjee et al. (1998). In this approach, $H_0: \rho = 0$, is tested against $H_1: \rho < 0$ by using the t_{BDM} statistic. The calculated t-statistic or F-statistic is compared with the critical values provided by Pesaran et al. (2001). When the calculated statistic is below the lower bound critical value, the null hypothesis is not rejected means there is no cointegration. When it is above the upper bound critical value, the null hypothesis is rejected means there is cointegration. If the calculated value is between the bounds, the test is inconclusive[5].

The Wald test is used to test both the short- and long-run symmetries. The null hypothesis of the long-run symmetry is $\beta^{+} = \beta^{-}$that of the short-run symmetry is $\sum_{i=0}^{q-1}\pi_i^{+} = \sum_{i=0}^{q-1}\pi_i^{-}$ or $\pi_i^{+} = \pi_i^{-},\ i = 1, \dots, q-1$.

Shin et al. (2014) derived the cumulative asymmetric dynamic multiplier effects of one unit change in x_t^{+} and x_t^{-} on y_t as follows:

$$m_h^{+} = \sum_{j=0}^{h}\frac{\partial y_{t+j}}{\partial x_t^{+}} m_h^{-} = \sum_{j=0}^{h}\frac{\partial y_{t+j}}{\partial x_t^{-}} \qquad (6)$$

$h \to \infty, m_h^{+} \to \beta^{+}$and $m_h^{-} \to \beta^{-}$. β^{+}andβ^{-} are the asymmetric long-run coefficients.

The NARDL model has some significant advantages over existing methodological approaches. It allows the joint modelling of asymmetries and cointegration dynamics and can be estimated readily. It can also determine cointegrating relationships efficiently in small samples. The NARDL does not require that all the regressors with the same order of integration; in other words, it allows for the inclusion of I(0) and I(1) (but not I(2)) regressors (Rezitis, 2019, p. 871).

3.2. Data and model

This study used quarterly data obtained from the TurkStat and the CBRT, for 2004:Q1–2019:Q4 to estimate the asymmetric exchange rate pass-through.

The model used by Goldberg and Knetter (1997), Campa and Goldberg (2006), and Nogueira-Júnior and León-Ledesma (2008) was followed to estimate the ERPT. The long-run model is as follows: $NARDL(p, q_1, q_2, q_3, q_4)$

$$inf_t = \mu + \sum_{i=1}^{p}\phi_i inf_{t-i} + \sum_{i=0}^{q_1}\boldsymbol{\theta}_i^{+}\boldsymbol{ex}_{t-i}^{+} + \sum_{i=0}^{q_2}\boldsymbol{\theta}_i^{-}\boldsymbol{ex}_{t-i}^{-} + \sum_{i=0}^{q_3}\alpha_i imp_{t-i} + \sum_{i=0}^{q_4}\delta_i growth_{t-i} + \varepsilon_t \qquad (7)$$

[5] Lower and upper bounds critical values were computed based on the assumption that all of the variables are purely I(0) and I(1), respectively.

where inf is annual consumer inflation. In this paper, CPI_D was used instead of CPI to measure the inflation rate[6]. ex is the natural logarithm of the nominal exchange rate between the US dollar and the Turkish lira[7]. It is decomposed into ex_t^+ and ex_t^- around a threshold zero. ex_t^+ and ex_t^- are partial sum processes of positive and negative changes in the exchange rate, respectively. imp is the import unit value index (2010=100) expressed in the US dollars. imp is seasonally adjusted and in natural logarithm form. $growth$ is the annual growth rate of the real GDP of Turkey[8] and is used as a proxy of domestic demand. θ_i^+ and θ_i^- are the coefficients of the asymmetric exchange rate pass-through and $0 \leq |\theta_i^+|, |\theta_i^-| \leq 1$. If the pass-through coefficient is 0, the exchange rate changes do not affect prices. If the pass-through coefficient is equal to 1, the changes in the exchange rate affect the prices by 100%. If the coefficient is between 0 and 1, the exchange rate changes partially affect the prices[9].

The exchange rate is decomposed into positive and negative partial sums, according to Shin et al. (2014), as follow:

$$ex_t^+ = \sum_{j=1}^{t} \Delta ex_j^+ = \sum_{j=1}^{t} \max(\Delta ex_j, 0), \qquad ex_t^- = \sum_{j=1}^{t} \Delta ex_j^- = \sum_{j=1}^{t} \min(\Delta ex_j, 0) \qquad (8)$$

Augmented Dickey Fuller (ADF) unit root test was performed to ensure that none of the variables are $I(2)$. The results are given in Table 1.

[6]CPI_D is the CPI excluding unprocessed food, alcoholic beverages, and tobacco. By using CPI_D, the effects of temporary external factors are excluded. inf calculated as the year difference of the natural logarithm of CPI_D, $[ln(CPI\_D_t) - ln(CPI\_D_{t-4})]$

[7]An increase in the exchange rate means a depreciation of Turkish lira.

[8]$growth$ is calculated as the year difference of the natural logarithm of real GDP, $[ln(GDP_t) - ln(GDP_{t-4})]$

[9] Gopinath et al. (2008) stated that in the case of prices are sticky; the pass-through effect will be 100% if imported goods' prices are priced entirely in the reserve currency (Dollars or Euros) in the short run, besides that, the pass-through effect will be 0% if they are priced entirely in local currency.

Table 1 ADF unit root test results

Variable		ADF	
		Level	First difference
inf	intercept	-3.82*** (0.0045)	-
	trend and intercept	-4.04*** (0.0122)	-
	none	0.82 (0.8859)	-5.77*** (0.0000)
ex	intercept	1.36 (0.9987)	-6.82*** (0.0000)
	trend and intercept	-1.24 (0.8926)	-5.74*** (0.0000)
	none	3.19 (0.9995)	-6.26*** (0.0000)
imp	intercept	-2.09 (0.2493)	-5.50*** (0.0000)
	trend and intercept	-1.96 (0.6126)	-5.70*** (0.0001)
	none	0.20 (0.7415)	-5.55*** (0.0000)
growth	intercept	-3.29** (0.0197)	-
	trend and intercept	-3.22* (0.0910)	-
	none	-1.85* (0.0615)	-

Given values are the Augmented Dickey-Fuller (ADF) test statistics. The values in brackets are MacKinnon (1996) one-sided p values. ***, **, and * indicate the rejection of the null hypothesis that the variable has a unit root at 1%, 5%, and 10% significance level, respectively.

inf and $growth$ are stationary at level, ex and imp are stationary at the first difference. That is, inf and $growth$ are $I(0)$, ex and imp are $I(1)$. Since none of the variables are $I(2)$, the NARDL approach can be used.

4. Empirical findings

The general-to-specific modelling strategy was carried out. The maximum lag length was selected as 8 for all regressors, initially. The optimal lag length was determined by the Schwarz Info Criterion (SIC), and the final NARDL model was specified as $NARDL(2,1,0,1,0)$.

$$inf_t = \mu + \phi_i \sum_{i=1}^{2} inf_{t-i} + \boldsymbol{\theta}_i^{+} \sum_{i=0}^{1} \boldsymbol{ex}_{t-i}^{+} + \boldsymbol{\theta}_i^{-} \sum_{i=0}^{0} \boldsymbol{x}_{t-i}^{-} + \alpha_i \sum_{i=0}^{1} imp_{t-i} + \delta_i \sum_{i=0}^{0} growth_{t-i} + \varepsilon_t \quad (9)$$

The estimation results and the diagnostics are shown in Tables 2 and 3.

Table 2 NARDL estimation results (Dependent variable $\mathbf{inf_t}$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
inf_{t-1}	1.050618	0.110329	9.522561	0.0000
inf_{t-2}	-0.558510	0.078625	-7.103458	0.0000
ex_t^+	0.136791	0.024179	5.657519	0.0000
ex_{t-1}^+	-0.082061	0.030160	-2.720875	0.0088
ex_t^-	0.144084	0.034874	4.131521	0.0001
imp_t	0.193746	0.032501	5.961180	0.0000
imp_{t-1}	-0.106297	0.037394	-2.842657	0.0063
$growth_t$	-0.073402	0.037218	-1.972204	0.0538
C	-0.334377	0.096127	-3.478504	0.0010

Table 3 Diagnostics

R^2	0.934824
Adj. R^2	0.924986
χ^2_{SC}	2.384434 [0.3035]
χ^2_H	0.169846 [0.6802]
χ^2_N	0.413931 [0.8130]

χ^2_{SC}, χ^2_H, and χ^2_N denote LM test statistics for serial correlation, heteroskedasticity, and normality, respectively. Figures in square parentheses are the corresponding p-values.

Error Correction representation of the model is as follows:

$$\Delta inf_t = \mu + \rho inf_{t-1} + \theta^+ ex_{t-1}^+ + \theta^- ex_{t-1}^- + \phi imp_{t-1} + \delta growth_{t-1} + \sum_{i=1}^{1} \varphi_i \Delta inf_{t-i} + \sum_{i=0}^{0} \pi_i^+ \Delta ex_{t-i}^+ + \sum_{i=0}^{0} \omega_i \Delta imp_{t-i} + \varepsilon_t \quad (10)$$

The error correction representation of the estimated NARDL model is as in Table 4.

Table 4 Conditional Error Correction (Dependent variable $\Delta\mathbf{inf_t}$)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.344377	0.096127	-3.478504	0.0010
inf_{t-1}^{*}	-0.507892	0.092469	-5.492584	0.0000
ex_{t-1}^{+}	0.054730	0.012698	4.309999	0.0001
ex_{t}^{-}	0.144084	0.034874	4.131521	0.0001
imp_{t-1}	0.087449	0.023693	3.690982	0.0005
$growth_t$	-0.073402	0.037218	-1.972204	0.0538
Δinf_{t-1}	0.558510	0.078625	7.103458	0.0000
Δex_{t}^{+}	0.136791	0.024179	5.657519	0.0000
Δimp_t	0.193746	0.032501	5.961180	0.0000

The F-Bounds testing procedure is used to test the presence of cointegration among the variables. The null hypothesis of F-Bounds test is $\mu = \rho = \theta^{+} = \theta^{-} = \phi = \delta = 0$. The results are given in Table 5.

Table 5 F-Bounds test results

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Significance Level	I(0)	I(1)
F-statistic	9.587227	10%	2.323	3.273
k	4	5%	2.743	3.792
		1%	3.71	4.965

Since the calculated F statistic value is greater than the upper bound critical value at a 5% significance level, the null hypothesis is rejected. There is cointegration.

Table 6 Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ex^+	0.107759	0.012841	8.391614	0.0000
ex^-	0.283690	0.038938	7.285697	0.0000
imp	0.172181	0.033204	5.185468	0.0000
$growth$	-0.144523	0.060280	-2.397541	0.0201
C	-0.658362	0.144464	-4.557268	0.0000

$$EC = inf - (0.1078\ ex^+ + 0.2837\ ex^- + 0.1722\ imp - 0.1445\ growth - 0.6584)$$

To test the long-run asymmetry Wald test is used. The null hypothesis of long-run symmetry is $\boldsymbol{\beta}^+ = -\boldsymbol{\theta}^+/\rho, \boldsymbol{\beta}^- = -\boldsymbol{\theta}^-/\rho$

$$W_{ex^+=ex^-} \qquad 42.86291\ [0.0000]$$

$W_{ex^+=ex^-}$ denotes the Wald test for the null of long-run symmetry for ex^+ and ex^-. Figure in square parentheses is the corresponding p-value. As the p-value of the calculated Wald statistic is less than 0.05, the null hypothesis is rejected. Inflation does not respond to appreciation and depreciation of the Turkish lira equally. The positive sign of ex^+ indicates a positive correlation between the exchange rate increase and inflation. So, when the exchange rate increases, inflation increases. Similarly, the sign of the coefficient of ex^- is also positive. This positive correlation between the exchange rate decreases and inflation means that the reduction of the exchange rate decreases inflation.

Table 6 implies that a 1% increase in the exchange rate increases the annual inflation by 0.11% in the long run, whereas a 1% decrease in the exchange rate decreases inflation by 0.28%. The sign of the coefficient of $growth$ is negative, whereas that of imp is positive. All the long-run coefficients are statistically significant at a 5% significance level.

Table 7 Error Correction Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δinf_{t-1}	0.558510	0.067688	8.251251	0.0000
Δex_t^+	0.136791	0.018177	7.525649	0.0000
Δimp_t	0.193746	0.025628	7.559897	0.0000
ECT_{t-1}^*	-0.507892	0.064014	-7.934109	0.0000

Although a decrease in the exchange rate does not affect inflation in the short-run, an increase raises inflation. This finding is in line with that of Çiçek and Boz (2013). A 1% increase in the

exchange rate increases inflation by 0.14%, in the short-run. Δinf_{t-1}, whose sign is positive, is statistically significant. Hence, inflation is highly inertial in Turkey.

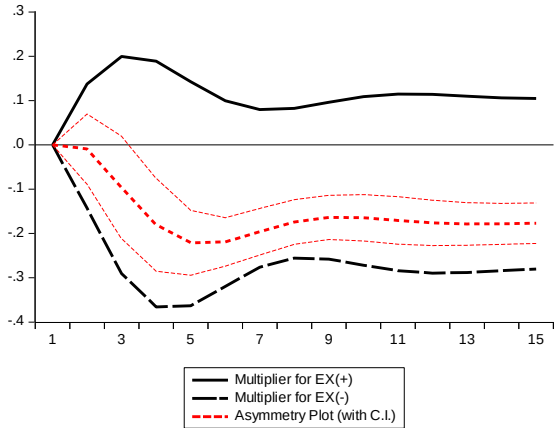

Figure 1 Dynamic Multipliers

The dynamic multipliers show the evolution of inflation over time in response to a positive and a negative shock to the exchange rate. Inflation adjustment to a positive local currency depreciation (ex^+) shock is mild. Full adjustment to the new equilibrium is achieved within nine quarters. By contrast, inflation responds strongly to local currency appreciation (ex^-) shock. However, full adjustment of inflation to the new equilibrium is achieved almost within eleven quarters.

5. Concluding Remarks

This study analyzed the pass-through of increases and decreases in the exchange rate into consumer inflation. The empirical findings support that the exchange rate pass-through is asymmetric in Turkey. Inflation does not respond equally to local currency depreciation and appreciation.

In the short run, although an increase in the exchange rate has an increasing impact on inflation, a decrease in exchange rates does not have a statistically significant effect on inflation. Due to a high inflationist environment, there may be a perception that the exchange rate increases are permanent but that the exchange rate decreases are temporary. The exchange rate increases raise the production costs, but producers partially reflect this cost on consumer prices in the short run. Producers do not reduce their products' prices to recoup the losses experienced previously, even if the exchange rate decreases. Thus, an exchange rate decrease cannot make the desired positive impact on inflation in the short run. This situation may be due to the market structure, or it may result from anti-inflationary policies.

Unlike many studies, the findings we obtained for the long run are that the effect of exchange rate decreases on inflation is higher than that of exchange rate increases. An appreciation of the Turkish lira leads to a higher pass-through effect than depreciation in the long run. This situation may be arising from the price elasticity of demand is high in the long run. It also implies a highly competitive environment.

The changes in import prices affect inflation positively both in the short and long run. As the weight of imported goods in the consumer basket is high, an increase in the exchange rate directly increases inflation. Inflation is highly inertial in Turkey, so this causes the central bank to deviate from the inflation target. The failure of inflation targeting increases price uncertainty, and that increasing price uncertainty causes a higher pass-through. In other words, when the realized inflation exceeds the target inflation, the pass-through effect increases. Therefore, firms adjust their prices, not to the central bank's inflation target but the past inflation data. The findings of Karaoğlu and Kılıçkaplan (2018), Özkan and Erden (2015), Aleem and Lahiani (2014) support this view.

There is a negative correlation between growth and inflation in the long run, whereas no statistically significant relationship was found between the two in the short run. It means an increase in production reduces inflation in the long-run, but an increase in supply (output growth) does not significantly affect inflation in the short-run. This situation may stem from inflation inertia.

High inflation is one of Turkey's major economic issues. Chronic inflation causes the loss of confidence in the central bank policies and lowers the central bank's credibility. As a result, the local currency depreciates, and dollarization increases. That increasing dollarization also increases the degree and speed of exchange rate pass-through. The findings of Honohan and Shi (2001) support this view.

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