Demirhan, B. ve Göksu, S. (2023). "The Linear and Nonlinear Effects of Macroeconomic Factors on the Nominal Exchange Rate in Türkiye", Eskişehir Osmangazi Üniversitesi İİBF Dergisi, 18(3), 730 – 747.
Doi: 10.17153/oguiibf.1290038

Başvuru: 30.04.2023 Kabul: 26.06.2023 *Araştırma Makalesi/Research Article*

The Linear and Nonlinear Effects of Macroeconomic Factors on the Nominal Exchange Rate in Türkiye

Banu Demirhan[1]
Serkan Göksu[2]

Türkiye'de Makroekonomik Faktörlerin Nominal Döviz Kuru Üzerindeki Doğrusal ve Doğrusal Olmayan Etkileri

Öz

Bu çalışma, ARDL ve NARDL yaklaşımlarını kullanarak Türkiye'deki nominal döviz kurları ile bazı temel makroekonomik göstergeler arasındaki simetrik ve asimetrik ilişkileri incelemektedir. Elde edilen bulgulara göre, değişkenler arasında asimetrik eş bütünleşme ilişkisi bulunmaktadır ama bu ilişki simetrik değildir. Döviz kuru üzerinde, en etkili faktörün enflasyon olduğu tespit edilmiştir. Uzun dönemde tüm değişkenler asimetrik etkilere sahipken kısa dönemde sadece ihracat asimetrik etkilere sahiptir. İhracat artışlarının döviz kuru üzerindeki etkisi düşüşlerden daha baskındır. Türkiye ile ABD faiz oranı arasındaki pozitif şoklar nominal döviz kurunu düşürmektedir. Genel olarak pozitif şokların etkileri negatif şoklardan daha baskındır.

Anahtar Kelimeler: Kapsanmamış Faiz Oranı Paritesi, Nominal Döviz Kuru, Doğrusal Olmayan Eşbütünleşme, ARDL ve NARDL, Uluslararası Fisher Etkisi

JEL Kodları: E43, E47, E00

The Linear and Nonlinear Effects of Macroeconomic Factors on the Nominal Exchange Rate in Türkiye

Abstract

This study examines the symmetrical and asymmetrical relationships between nominal exchange rates and some key macroeconomic indicators in Türkiye using ARDL and NARDL approaches. According to the findings, there is an asymmetric cointegration relationship between the variables, but this relationship is not symmetrical. Inflation is the most remarkable indicator of the exchange rate. While all variables have asymmetric effects in the long run, only exports have asymmetric effects in the short run. The effect of export increases on the exchange rate is more dominant than decreases. Positive shocks between Türkiye and the US interest rate decrease the nominal exchange rate. In general, the effects of positive shocks are more dominant than negative shocks.

Keywords: Uncovered Interest Rate Parity, Nominal Exchange Rate, Nonlinear Cointegration, ARDL and NARDL Methods, International Fisher Effect

JEL Codes: E43, E47, E00

Araştırma ve Yayın Etiği Beyanı	Bu çalışma bilimsel araştırma ve yayın etiği kurallarına uygun olarak hazırlanmıştır.
Yazarların Makaleye Olan Katkıları	Yazar 1'in makaleye katkısı %50, Yazar 2'nin makaleye katkısı %50'dir.
Çıkar Beyanı	Yazarlar açısından ya da üçüncü taraflar açısından çalışmadan kaynaklı çıkar çatışması bulunmamaktadır.

[1] Doç. Dr., Afyon Kocatepe Üniversitesi, Afyon Meslek Yüksekokulu, Muhasebe ve Vergi Bölümü, bdemirhan@aku.edu.tr
[2] Dr. Öğr. Üyesi, Afyon Kocatepe Üniversitesi, Dinar Uygulamalı Bilimler Yüksekokulu, Sigortacılık Bölümü, sgoksu@aku.edu.tr

1. Introduction

Uncertainties and instabilities in exchange rates continue to threaten economies. This problem can be hazardous, especially for countries like Türkiye, which are dependent on foreign energy and have a chronic current account deficit problem. Therefore, correctly determining the factors affecting the exchange rate is vital for the Türkiye economy. Increasing or decreasing exchange rates has advantages and disadvantages. These advantages and disadvantages will differ from country to country because each country's resources, foreign trade structures, geographical locations, etc., are different. For example, since Türkiye's exports depend on imports, it may not be able to obtain the positive effect of the increase in exchange rates on exports. Because importing most of the energy and intermediate goods from abroad in order to export erodes the positive effect of the increase in exchange rates on exports. From this point of view, we motivate the study to the factors that affect exchange rates.

There are many approaches to explain the change in exchange rates, such as Purchasing Power Parity (PPP) Theory, Uncovered Interest Rate Parity Theory, Balance of Payments Approach, and Monetary Approach. The exchange rate is generally related to elevated volatility in developing countries and can also be affected by economic variables like interest rates (Ruzima and Boachie, 2018). The connection between nominal exchange rate (NER) and interest rates is referred to as the international Fisher effect or the uncovered interest rate parity approach in the literature. According to this approach, the differences between foreign and domestic (nominal) interest rates are equivalent to the expected differences in the exchange rates of the respective countries. Due to the guiding effect of changes in US interest rates on developing countries (especially Türkiye interest rates), we included the interest rate difference between the US and Türkiye in the model. Considering the developments in financial markets as well as the sizes and intertwined structures of national economies, it is clear that exchange rates are affected by many factors, and a single theory will be insufficient to explain these changes. In this context, the present study determines the exchange rate in Türkiye; in addition to the Uncovered Interest Rate Parity (UIRP) Theory, it also considers the variables of the inflation rate and exports.

Inflation expectations also have a significant impact on NER. Inflationary expectations will cause economic agents to keep their savings in foreign currency to compensate for the decline in the purchasing power of local money, increasing the demand for foreign currency and, thus, the NER. If the risks have increased in economies such as Türkiye, where current account deficits have become a chronic problem and foreign borrowing is generally used to finance the deficit; It is expected to have the same near-positive relationship between interest rate and NER. It is also worth mentioning that there is a reciprocal relationship between the NER and the inflation rate. The depreciation of the domestic currency against the foreign currency in an economy causes imports to be more expensive and the costs of imported inputs to increase, leading to domestic inflation. It is also possible that the inflation rate will increase the NER. As the goods and services produced in the country will become more expensive than those made abroad due to increased inflation, the demand for them and domestic currency decreases. On the other hand, the demand for imported goods and services and the foreign currency required to buy them increases. These developments lead to NER increases. Moreover, if high inflation rates increase country risk, it will decrease net capital inflows and increase the NER. Generally, an exchange rate increase indicates raised investment opportunities, which can lead to increased short-term capital flows. Foreign investors can invest by exchanging currencies to take advantage of the exchange rate increase and earn higher returns. However, an excessive increase in the exchange rate may increase economic uncertainties and risks, leading to a decrease in short-term capital flows. These funds, which have a very fragile structure, tend to leave the country in the face of the slightest negative economic and political development. Moreover, in cases where current account deficits are mainly based on hot money movements, these mass foreign exchange outflows may make the country's current economic situation worse than before. This mechanism is very effective, especially in economies like Türkiye, with high openness levels, foreign-dependent energy, chronic current account deficit, and import-dependent exports.

In this study, unlike most studies, we examined the effects of fundamental macroeconomic variables on NER in the Türkiye sample using symmetrical and asymmetrical methods. External shocks such as economic crises or financial instability, changes in economic policy practices, technological advances, industrial transformations, natural disasters, or political uncertainty can cause asymmetrical effects. The reasons why we use nonlinear methods in addition to the linear method as an empirical approach are as follows: (i) The shifts from the orthodox approach to heterodox policies in the economic policies implemented in Türkiye in recent years, (ii) Structural breaks present in the sample period examined, (iii) Inability to detect a significant relationship as a result of the linear ARDL test, (iv) The most important reason is that there is a non-linear relationship between the data according to the BDS (Brock-Dechert-Scheinkman) test results.

This study can be defined as complementary to the previous empirical study. However, it differs from the existing literature because it provides the asymmetric approach to determining the NER in Türkiye by analysing the impact of the increase and decrease in fundamental macro variables on NER separately, which contributes to the empirical literature. We investigate whether the NER is related to crucial macro variables using monthly data from 2005:M_{01} and 2020:M_{06} and employing linear and nonlinear autoregressive distributed lag models developed by Pesaran et al. (2001) and Shin et al. (2014), respectively. This study will provide information to policymakers in determining the policy tools to be used in changes in NER. In the rest of the research, the literature review is in section 2. The data and empirical method are given in section 3, while section 4 presents results and discussions. Section 5 concludes.

2. Literature Review

Exchange rates are accepted as a critical variable that has great importance in international financial markets and affects the macroeconomic performance of countries. Macroeconomic indicators such as inflation (Alba and Papell, 1998), interest rates differential (El Khawaga et al. 2013), current account balance (Were et al. 2013), trade policies (Nicita, 2013), and political stability (Nabi et al. 2021) are essential in determining exchange rates. The economics literature has developed various models and approaches to understand and estimate the complex relationship between the determinants of exchange rates, which are formed by combining many factors. In this section of the study, by examining the studies on the determinants of exchange rates, we aim to designate a framework to understand how these factors affect the movements of exchange rates and to forecast future exchange rate movements.

There are more studies in the literature investigating the effects of macroeconomic variables on NER using linear-symmetric methods (Reddan and Rice, 2017; Kaygısız, 2018; Kuncoro, 2020; Karabacak, 2023) than studies using nonlinear-asymmetric methods (Çiçek and Boz, 2013; Rincon and Rodriguez, 2016; Akosah et al. 2019; Kayamo, 2021). It has been observed that cointegration analysis and Granger causality analysis are mostly used in empirical studies. (Elbadawi and Soto, 1994; Montiel, 1997; Cardenas, 1997; Aron et al. 2000; McCarthy, 2007; Duma, 2008; Sek and Kapsalyamova, 2008; Dolores, 2009; Imam and Minoiu, 2011; An and Wang, 2012; Isnowati and Setiawan, 2017; Yenice and Yenisu, 2019).

According to the empirical literature on the determinants of the exchange rate, the inflation variable is the common point of many models created. According to studies that test this issue frequently in the literature, inflation may be one of the factors affecting the exchange rate, and the exchange rate seems to be one of the factors affecting inflation. Instances of studies showing bidirectional causality nominal exchange and rate to inflation can be given as follows: (Ülengin, 1995; Nourzad, 1997; Kim, 1998; Siregar, 1999; Maswana, 2006). Instances of studies that find unidirectional causality from NER to inflation are as follows: Rahman et al. (1996); Mihaljek and Klau (2001); Telatar and Telatar (2003). The studies that found unidirectional causality from inflation to NER are as follows: Rittenberg (1993); Altınay (1996); Korkmaz and Bayır (2015) can be given as examples. On the other hand, several studies conclude that there is no pass-through effect between NER and inflation (Manning and Andrianacos, 1993; Frimpong and Adam, 2010; Mohanty and Bhanumurthy, 2014).

NER fluctuations significantly impact the import and export behavior of countries, and these fluctuations have repercussions on the current account balance and the foreign exchange reserves of central banks (Wang and Barrett, 2007). A country's exchange rate value affects its trade balance by directly affecting its export and import costs. A country's exchange rate value changes affect import and export prices, affecting trade volume and competitiveness of preferred goods and services. We see that there is no consensus in the literature on the relationship between exports and exchange rates. Gondaliya and Dave (2015) found a positive relationship between exports and exchange rates for the period 2006-2015 in the sample of India and a negative relationship between imports and exchange rates. These findings highlight the impact of exports on the exchange rate, suggesting that exporters should consider exchange rate fluctuations.

On the other hand, the interest rate is another critical variable used most in determining the exchange rate. Monetary policy shocks may have different effects on the exchange rate, and the results are contradictory in nature. Theoretically, the increase in interest rates is expected to alleviate inflationary pressure by increasing savings and reducing aggregate demand. For this reason, it can be said that interest rates are an effective monetary policy tool in the fight against inflation and NER. Regarding the NER and interest rate relationship, Sarı (2018) found a bidirectional causality relationship between the NER and the interest rate. Karaca (2005) found a negative relationship between the interest rates and the NER and a positive relationship between inflation and the NER.

Asymmetric relationships are the difference in the direction or intensity of the interaction between the variables. In other words, in economic terms, an asymmetric relationship refers to situations where the effects of increases and decreases in the independent variables on the dependent variable lead to different results. For instance, the effect of increases in exports on exchange rates and the effects of decreases in exports on exchange rates may be different. Accurately detecting such asymmetrical relationships is vital to understand economic policies' impact and taking appropriate measures. Considering asymmetric effects in the design of monetary and fiscal policies brings about more specific and target-oriented economic policies. For example, the fiscal policy implemented due to asymmetric effects different economic actors and sectors differently. For example, applying tax deductions to specific sectors can increase companies' tendency to invest while reducing their competitive advantage in other sectors. On the other hand, due to asymmetric effects, monetary policies implemented by the central bank may create different effects among economic actors such as banks, financial institutions, sectors, and income groups. Therefore, since these asymmetric effects will complicate the implementation of economic policies, policymakers should pay close attention to these effects.

Uncovered interest rate parity (UIRP) is one of the classical theories frequently used in macroeconomics. Lothian and Wu (2005) consider UIRP as one of the critical approaches to understanding international financial relations. According to this approach, the interest difference between the two countries equals the expected value change in the exchange rate (Rowland, 2002). Studies examining exchange rates with asymmetric methods in the Türkiye sample are minimal (Karamelikli and Karimi, 2022). Furthermore, we encountered no study examining an asymmetrical approach in determining exchange rates based on UIRP theory in the Türkiye sample. The present study contributes to the literature by filling this gap.

3. Econometric Specification and Data

We employ a time series regression model involving nominal exchange rate, inflation rate, exports, and long-run interest rate differences between US and Türkiye to investigate symmetric or asymmetric relationships. For this purpose, following the empirical literature on the estimation of the NER with times series data, we estimate the following equation (1):

$$"exc_t = \beta_0 + \beta_1 dint_t + \beta_2 exp_t + \beta_3 cpi_t + \mu_t" \qquad (1)$$

Where *exc*, the dependent variable, is the logarithm of the nominal exchange rate. *dint* is the interest rate difference, *exp* is the logarithm of exports, and *cpi* is the consumer price index. The Autoregressive Distributed Lag (ARDL) of Pesaran et al. (2001) approach investigates the independent variables' long and short-run effects on the NER. The ARDL model is represented as the equation (2):

$$"\Delta exc_t = \alpha_0 + \delta_1 exc_{t-1} + \delta_2 dint_{t-1} + \delta_3 exp_{t-1} + \delta_4 cpi_{t-1} + \sum_{i=1}^{m=4} \beta_{1i}\, \Delta exc_{t-i} + \sum_{i=0}^{n=1} \beta_{2i}\, \Delta dint_{t-i} + \sum_{i=0}^{r=1} \beta_{3i}\, \Delta exp_{t-i} + \sum_{i=0}^{p=2} \beta_{4i}\, \Delta cpi_{t-i} + \varepsilon_i" \qquad (2)$$

Where Δ is the difference operator; *m, n, r*, and *p* are optimum lag length selected by Akaike's information criteria; α_0 is an intercept; δ's are long-run coefficients of related variables; β's are short-run coefficients of related variables; ε_i is error correction term. After determining the optimal lag length, we examine the existence of the cointegration relationship between the variables by testing the null hypothesis of $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ proposed by Pesaran et al. (2001) as the equation (3):

$$"\Delta exc_t = \varphi_0 + \sum_{i=1}^{m=4} \varphi_{1i}\, \Delta exc_{t-i} + \sum_{i=0}^{n=1} \varphi_{2i}\, \Delta dint_{t-i} + \sum_{i=0}^{r=1} \varphi_{3i}\, \Delta exp_{t-i} + \sum_{i=0}^{p=2} \varphi_{4i}\, \Delta cpi_{t-i} + \vartheta\, ECT_{t-1} + \mu_i" \qquad (3)$$

Where φ_{1i}, φ_{2i}, φ_{3i}, and φ_{4i} denote short term coefficients, and *ECT_{t-1}* represents error correction term. The error correction term coefficient is expected to be negative and the probability value to be less than 0,05 (statistically significant). The ARDL model is linear; therefore, the short-run and long-run impact of the independent variables on the NER is symmetric. NARDL model is used to estimate the asymmetric effects of independent variables on the NER, developed by Shin et al. (2014). NARDL model can be represented as the equation (4):

$$"\Delta exc_t = \beta_0 + \phi \mathrm{exc}_{t-1} + \psi_1^+ dint_{t-1}^+ + \psi_1^- dint^-_{t-1} + \psi_2^+ exp^+_{t-1} + \psi_2^- exp^-_{t-1} + \psi_3^+ cpi^+_{t-1} + \psi_3^- cpi^-_{t-1} + \sum_{i=1}^{k=4} \lambda_i \Delta exc_{t-i} + \sum_{i=0}^{l=1} \varphi_{1i}^+ \Delta dint^+_{t-i} + \sum_{i=0}^{m=0} \varphi_{1i}^- \Delta dint^-_{t-i} + \sum_{i=0}^{n=1} \varphi_{2i}^+ \Delta exp^+_{t-i} + \sum_{i=0}^{o=3} \varphi_{2i}^- \Delta exp^-_{t-i} + \sum_{i=0}^{p=2} \varphi_{3i}^+ \Delta cpi^+_{t-i} + \sum_{i=0}^{r=0} \varphi_{3i}^- \Delta cpi^-_{t-i} + \mu_t" \quad (4)$$

To explore the cointegration relationship, the null hypothesis of "$\phi = \psi_1^+ = \psi_1^- = \psi_2^+ = \psi_2^- = \psi_3^+ = \psi_3^- = 0$" is tested. Long and short-run asymmetric relationships will be determined by applying the Wald test for the following null hypothesis, represented as the equation (5) and (6) respectively:

$$"H_0 = \frac{\psi_1^+}{-\phi} = \frac{\psi_1^-}{-\phi};\ H_0 = \frac{\psi_2^+}{-\phi} = \frac{\psi_2^-}{-\phi};\ H_0 = \frac{\psi_3^+}{-\phi} = \frac{\psi_3^-}{-\phi};" \quad (5)$$

$$"H_0 = \sum_{i=0}^{b} \varphi_{1i}^+ = \sum_{i=0}^{c} \varphi_{1i}^- ; \sum_{i=0}^{d} \varphi_{2i}^+ = \sum_{i=0}^{e} \varphi_{2i}^- ; \sum_{i=0}^{f} \varphi_{3i}^+ = \sum_{i=0}^{g} \varphi_{3i}^- ;" \quad (6)$$

The period covered is from the first month of 2005 to the sixth of 2020. 2005 was chosen as the starting year because it was a stable year without severe structural problems for both the USA and Türkiye. The data is obtained from the website CBRT (The Central Bank of the Republic of Türkiye) and OECD stat. All data are seasonally adjusted using STL (Seasonal and Trend decomposition using Loess). Detailed information on the variables is given in the Appendix in Table A.1.

Moreover, the descriptive statistics of the variables used in this study and the correlation matrix are presented in the Appendix in Table A.2. Standard deviations of the variables show that the interest rate difference variable has more volatility than the other variables. All variables are generally not normally distributed at a 5% level because the probabilities of Jarque-Bera tests are smaller than 0,05. Exports variable is negatively skewed, while other variables are positively skewed. When the kurtosis value of the variables is examined, the kurtosis of the NER is sharper than the normal distribution. In comparison, the kurtosis of the remaining variables is flatter than the normal distribution. There is no problem with multicollinearity, which is a vital assumption of regression analysis since, between independent variables, the correlation coefficients are below 0,90 (Tabachnick and Fidell, 1996). In addition to, the robust positive relationship between the dependent variable NER and the independent variables exports and inflation is remarkable.

4. Empirical Results

To estimate the NER model, we first performed Augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) unit root tests are performed. Unit root test results are in Table 1. Traditional unit root test results are given in Table 1. This table shows that all variables have a unit root and are stationary at the first difference.

Table 1: Unit root tests

		PP test at level			
		exc	dint	exp	cpi
C	t-Statistic	1.2968	-2.2965	-2.5473	2.0827
	Prob.	0.9986	0.1742	0.1061	0.9999
C&T	t-Statistic	-1.6327	-2.3934	-3.1292	-0.0480
	Prob.	0.7764	0.3818	0.1026	0.9954
		PP test at first difference			
		Δexc	Δdint	Δexp	Δcpi
C	t-Statistic	-9.1076	-9.3184	-17.6643	-9.9538
	Prob.	0.0000***	0.0000***	0.0000***	0.0000***
C&T	t-Statistic	-9.0106	-9.3228	-18.3394	-10.0963
	Prob.	0.0000***	0.0000***	0.0000***	0.0000***
		ADF test at level			
		exc	dint	exp	cpi
C	t-Statistic	1.4951	-2.3140	-2.5367	1.6980
	Prob.	0.9993	0.1687	0.1085	0.9996
C&T	t-Statistic	-1.3330	-2.4225	-3.3639	-0.3922
	Prob.	0.8765	0.3667	0.0595*	0.9872
		ADF test at first difference			
		Δexc	Δdint	Δexp	Δcpi
C	t-Statistic	-10.5319	-9.2715	-16.9250	-10,1103
	Prob.	0.0000***	0.0000***	0.0000***	0,0000***
C&T	t-Statistic	-10.8390	-9.2693	-16.9875	-10,3173
	Prob.	0.0000***	0.0000***	0.0000***	0,0000***
Decision		I(1)	I(1)	I(1)	I(1)

Notes: "C: With Constant; C&T: With Constant & Trend; (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. *MacKinnon (1996) one-sided p-values."

The Lee and Strazicich (LS) (2003) unit root test results, which consider the structural breaks, are given in Table 2 and support the traditional unit root test findings except for the export variable. Because the export variable is I(0). In addition, according to the LS unit root test results, the break given by the dependent variable for the date 2019:M_{06} was added to the model as a dummy variable. Since the variables are stationary at different levels and not stationary at the second difference, the ARDL model can be used to determine linear and nonlinear (asymmetric) relationships.

Table 2: LS unit-root test

Variables	Level			First difference			Decision
	Lag	Break Years	t-statistic	Lag	Break Years	t-statistic	
exc	3	2006:M_{07}	-2.002923	2	2019:M_{06}	-7.389842***	I(1)
dint	4	2006:M_{02}	-2.160756	1	2019:M_{07}	-7.980524***	I(1)
exp	1	2006:M_{10}	-3.493316**				I(0)
cpi	1	2016:M_{12}	-1.370402	0	2005:M_{09}	-9.969036***	I(1)

Note: (**)Significant at the 5% and (***) Significant at the 1%.

After performing the unit root tests, the F-bound test considering equation (2) determines the long-term cointegration relationships between the variables. First, the optimal lag length is determined using the Akaike Information Criterion, and the optimal model is detected as ARDL (4, 1, 1, 2). The results of the F-bound test performed within the framework of this model are shown in Table 3. Accordingly, we detect no cointegration relationship between the variables since the calculated statistical value of F_{PSS} and t_{BDM} is smaller than the lower and upper limit values.

Table 3: Bounds results of the linear ARDL

$f\,(exc \mid dint, exp, cpi)$ ARDL (4, 1, 1, 2)				F-critical values asymptotic n=1.000		F-critical values finite n=80		t-critical values	
k	m	Statistic		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3	4	F_{PSS} : 1.92 t_{BDM} : -1.77	10%	1.95	3.06	2.548	3.644	-2.57	-3.46
			5%	2.22	3.39	3.01	4.216	-2.86	-3.78
			1%	3.74	5.06	4.096	5.512	-3.43	-4.37

Notes: k: Defines the number of independent variables. m: Defines the number of lag.

Table 4 shows the estimation results of the linear ARDL model. Panel A shows the long-term elasticity estimations, and panel B shows the short-term estimation results. Panel A shows a positive relationship between NER and the consumer price index in the long run. An increase (decrease) in the consumer price index will increase (decrease) the NER by 1.7% in the long run. The coefficients of the other independent variables in the model are statistically insignificant. For equation (3), the short-term estimation results in panel B indicate that nearly all variables are statistically significant. Moreover, the coefficient of the error correction term, which is the adjustment coefficient, has a negative sign and is statistically significant. It means that short-term disequilibrium is corrected in the long term.

Diagnostic test results are presented in the C-panel. There is no model specification error, heteroskedasticity, and autocorrelation problem. However, it is specified that the error terms were not convenient for the normal distribution. CUSUM and CUSUMSQ graphs are created to test the stability of the model established for ARDL analysis presented in the Appendix in Figure A.1 CUSUM and CUSUMQ statistics are located between the lines expressing the critical limit at the 5% significance level. This result indicates that the parameters in the ARDL model are stable. That is, the short- and long-term coefficients are reliable.

Table 4: ARDL estimation

A) Long- Run	**Coefficient**	**t-statistic**	**p-value**
dint	0.004394	0.336018	0.7373
exp	-0.471407	-1.470023	0.1434
cpi	1.663230	7.936829	0.0000
B) Short- Run	**Coefficient**	**t-statistic**	**p-value**
constant	-0.204705	-2.770026	0.0062
Δexc_{t-1}	0.409851	5.476071	0.0000
Δexc_{t-2}	-0.234513	-3.218159	0.0015
Δexc_{t-3}	0.119471	1.808110	0.0724
$\Delta dint$	-0.004319	-1.420940	0.1572
Δexp	-0.138184	-3.989299	0.0001
Δcpi	1.744204	5.285035	0.0000
Δcpi_{t-1}	-0.887771	-2.601634	0.0101
dummy	-0.094701	-3.048878	0.0027
ECT_{t-1}	-0.054155	-2.795139	0.0058
C) Diagnostic Tests	**Test value**		**p-value**
B-G LM test	0.578555		0.7488
Ramsey RESET	0.340535		0.5595
Jarque–Bera	145.0507		0.0000
ARCH	2.016575		0.1556
CUSUM	Stable		
CUSUM of Squares	Stable		

The fact that the variables do not move together linearly in the long run and BDS (Brock-Dechert-Scheinkman) test results (see Table A.3) brought the question of whether there is a nonlinear relationship between the variables (Broock et al. 1996). We used the NARDL method to detect possible asymmetric relationships. A nonlinear cointegration relationship between the variables used in the study is tested according to equation (4) and employed to detect the robustness of the NARDL model. Table 5 shows the NARDL Bounds test results. The calculated F_{PSS} statistical value (4.94) is greater than the upper limit (4.43). This value shows a nonlinear cointegration relationship between the variables at the 1% significance level. The t_{BDM} test also supports this finding. These results are similar to recent studies (Kassi et al. 2019; Karamelikli and Karimi, 2022) that found an asymmetrical relationship between financial variables and exchange rates.

Table 5: Bounds results of the NARDL

$f(exc \mid dint_t^{+}, dint_t^{-}, exp_t^{+}, exp_t^{-}, cpi_t^{+}, cpi_t^{-}$ NARDL (4, 1, 0, 1, 3, 2, 0)				F-critical values asymptotic n=1.000		F-critical values finite n=80		t-critical values	
k	m	Statistic		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
6	4	F_{PSS} : **4.94*** ** t_{BDM} :**-4.80*** **	10%	2.12	3.23	2.236	3.381	-2.57	-4.04
			5%	2.45	3.61	2.627	3.864	-2.86	-4.38
			1%	3.15	4.43	3.457	4.943	-3.43	-4.99

Notes: k: Defines the number of independent variables. m: Defines the number of lag.*** p<0,01

Table 6 consists of panels A, B, C, and D. Panel A shows estimation results, panel B long-term asymmetric coefficient estimates, panel C asymmetric tests, and panel D diagnostic tests. Considering panel Panel B, it is seen that the long-run positive coefficient (L_{dint}^{+}) of the interest rate difference between Türkiye and the USA is negative and statistically significant at a 1% significance level $[-\,dint\,_{t-1}^{+}\,/\,exc\,_{t-1} = -(-0.004290/-0.233699 = -0.018358]$. The long-term negative coefficient (L_{dint}^{-}) of the same variable is positive and statistically significant at a 1% significance level $[-\,dint^{-}\,/\,exc\,_{t-1} = -(-0.004688/-0.233699 = -0.020061]$. These results demonstrate that a 1 percent positive shock in the interest rate difference between Türkiye and USA leads to a decrease by approximately 0,018 percent in the NER in the long run. The 1 percent negative shock in the interest rate difference decreases by approximately 0.02 percent in the NER in the long run. This result differs from those obtained from the studies of Long et al (2022).

The export variable's long-term positive (L_{exp}^{+}) and negative (L_{exp}^{-}) coefficients are statistically significant at 1% and negative. In the long run, the coefficients of increases and decreases in exports are about -0.54 and -0.41. $[-exp_{t-1}^{+}/\,exc\,_{t-1} = -(-0.125226/-0.233699 = -0.535843]$; $[-exp_{t-1}^{-}/\,exc\,_{t-1} - (-0.095848/-0.233699 = -0.410135]$. These results states that a 1 percent positive shock in the export will cause a decrease of approximately 0.54 percent in the NER. On the other hand, a 1 percent negative shock in the export will cause an increase of approximately 0.41 percent in the NER. In other words, the effect of increases in exports on NER is more dominant than decreases. This result contradicts those obtained from the studies of Sevim and Doğan (2016).

The long-term positive coefficient of consumer price index (L_{cpi}^{+}) is positive and statistically significant at the 1% significance level. In the long run, the positive consumer price index coefficient is 2.71 $[-cpi_{t-1}^{+}/\,exc\,_{t-1} = -(0.632614/-0.233699 = 2.706960]$. It will cause an increase of 2.71 percent; that is, it will react to increases in the inflation rate in Türkiye by increasing the NER. Although the effect size is different, there is a similar result in the studies of Joof and Jallow (2020). On the other hand, the long-term negative coefficient of the consumer price index (L_{cpi}^{-}) is positive and statistically insignificant. Another important finding in the analysis results is that the coefficient of the dummy variable is statistically significant and negative.

Table 6 Panel C represents both short-term and long-term asymmetry tests. According to long-term asymmetry test results, all variables have an asymmetric effect on NER in the long run. In the short run, only the export variable has asymmetric effects, while the remaining variables have linear effects in the short run.

Table 6: NARDL Model Results

A) Estimation results	**Coefficient**	**t-statistic**	**p-value**
Constant	0.081134	3.930218	0.0001
exc_{t-1}	-0.233699	-4.799033	0.0000
$dint_{t-1}^{+}$	-0.004290	-3.448018	0.0007
$dint^{-}$	0.004688	2.945995	0.0037
exp_{t-1}^{+}	-0.125226	-2.616637	0.0097
exp_{t-1}^{-}	-0.095848	-2.861516	0.0048
cpi_{t-1}^{+}	0.632614	4.726968	0.0000
cpi^{-}	0.662219	1.223932	0.2227
Δexc_{t-1}	0.528603	6.790303	0.0000
Δexc_{t-2}	-0.173043	-2.477079	0.0143
Δexc_{t-3}	0.171008	2.656567	0.0087
$\Delta dint^{+}$	-0.010174	-2.460667	0.0149
$\Delta \mathrm{exp}^{+}$	0.041753	0.526904	0.5990
Δexp^{-}	-0.202585	-4.739629	0.0000
Δexp_{t-1}^{-}	0.112134	2.186109	0.0302
Δexp_{t-2}^{-}	0.093291	2.145930	0.0333
Δcpi^{+}	1.689522	4.915797	0.0000
Δcpi_{t-1}^{+}	-1.264530	-3.554496	0.0005
dummy	-0.109437	-3.616040	0.0004
B) Long-run coefficients			
$L_{dint}{}^{+}$	-0.018358	-3.244472	0.0014
$L_{dint}{}^{-}$	0.020061	3.359973	0.0010
$L_{exp}{}^{+}$	-0.535843	-3.792359	0.0002
$L_{exp}{}^{-}$	-0.410135	-4.373526	0.0000
$L_{cpi}{}^{+}$	2.706960	10.14315	0.0000
$L_{cpi}{}^{-}$	2.833641	1.196554	0.2332
C) Asymmetry tests			
$W_{LR,\ dint}$	65,61406		0,0000
$W_{SR,\ dint}$	0,385868		0,5345
$W_{LR,\ exp}$	17,98034		0,0000
$W_{SR,\ exp}$	21,28139		0,0000
$W_{LR,\ cpi}$	1,683285		0,0000
$W_{SR,\ cpi}$	0,366449		0,5449
D)Diagnostic tests			
R^2	0.539600	R-Bar^2	0.507101
B-G LM test	0.307333 [0.8576]	Ramsey RESET	1.574850 [0.2095]
Jarque–Bera	68.40251 [0.0000]	ARCH	0.064232 [0.7999]
CUSUM of Squares	Stable	CUSUM	Stable

Diagnostic test results presented in Table 6 panel D show no model misspecification, heteroskedasticity, and autocorrelation problems. However, it detected that the error terms were not distributed normally. Moreover, about 53 percent of the changes in the NER are explained by the explanatory variables included in the model. To test the stability of the model, CUSUM and CUSUMSQ graphs were created and presented in appendix Figure A.2. Since the CUSUM and CUSUMQ statistics are between the lines expressing the critical limit at the 5% significance level, it can be said that the coefficients in the NARDL model are stable; that is, the short and long-term coefficients are reliable.

Figure A.3 in the appendix shows the asymmetric responses of the NER to the positive and negative shock to the interest rate difference between Türkiye and the USA. A positive shock to interest rate difference (solid black line) decreases the NER in line with the expectations. However, this response gradually decreases and converges to the equilibrium state. As it can be understood from the analysis of the figure, when the positive shock becomes stationary, it converges to -0.02 as a numerical value and is consistent with the coefficient obtained from the NARDL model (-0.018). Likewise, one-unit standard deviation negative shock to the interest rate difference between Türkiye and the USA leads to a decrease in the NER, and when the negative shock becomes stable, its value is between -0.02 and -0.04 and reaches an equilibrium value which supports the coefficient obtained from the NARDL model (0.02). Figure A.3 also shows that the negative shock is more dominant than the positive shock both in the short term and in the long term. This inference is that the asymmetry line (dashed red line) is below the horizontal axis and even below the negative shock. When shocks appear, the model reaches equilibrium after about (6) months. Regarding the magnitude of the asymmetry, it is seen that the negative shock is more dominant than the positive shock in the short run. In the long run, it is seen that the positive shock is more dominant than the negative shock.

5. Conclusions

In this study, the symmetrical and asymmetrical relations between the NER and the main macroeconomic variables (interest rate difference, export, consumer price index) in Türkiye for the period 2005:M_{01}-2020:M_{06} were empirically examined. We first included descriptive statistics and a correlation matrix in the analysis procedure. Then we applied unit root tests to the time series. Then, we investigated the cointegration relationship between the variables using ARDL and NARD methods. Finally, we tested whether the constructed model was structurally stable and smooth with various diagnostic tests. The findings can be summarized as follows:

Firstly, in the analyses made by establishing ARDL and NARDL models, there is a robust asymmetric cointegration relationship between the variables, but not symmetrical. The economic meaning of this result; The effect of increases and decreases in interest rates, exports, and consumer price index variables on NER is not the same. This result indicates that changes in NER may differ according to key macroeconomic indicators, and we suggest that policymakers consider these findings.

The second remarkable finding the effect of the decrease in the interest rate differentials between Türkiye and the USA on the exchange rate is greater than the increase in the interest rate differentials. When Türkiye's deposit rates are higher than the US, foreign investors will want to invest more in Türkiye. In the next stage, foreign capital inflows will cause the Turkish lira to appreciate and the exchange rate to fall. This study empirically confirms this situation. When the long-term dynamic effects in Türkiye are examined in terms of interest rate difference, the situations where the increase in the interest difference between the USA and Türkiye reduces the exchange rate are as follows: (1) Interest rates in Türkiye increase and interest rates remain constant or decrease in the USA. (2) The rate of increase in interest rates in Türkiye is higher than in the USA. (3) Interest rates in Türkiye remained constant, and interest rates decreased in the USA (4) Interest rates in the USA decreased more than in Türkiye.

The third important finding from the study is that increases in exports will decrease the exchange rate, while decreases in exports will increase the exchange rate. However, the effect of these variables is different. The impact of increases in exports on the exchange rate is more significant than the effect of decreases in exports on exchange rates. In addition, the most influential variable on the exchange rate is inflation.

The increase in the exchange rate is a significant risk factor for Türkiye. Because Türkiye's exports are highly dependent on imports and foreign-dependent for energy, the increase in the exchange rate involves high costs. Consequently, considering all these results, policymakers can suggest that a perspective that prioritizes a permanent decrease in inflation through structural reforms is necessary for suppressing the exchange rate. In addition, it should not forget that these results are valid for Türkiye. For future studies, it may be suggested to analyse the model for country groups with different development scales.

References

Akgül, I.; Özdemir, S. (2018), "Inflation-Interest Rate-Exchange Rate Dilemma: Turkish Reality During the GEG Program", *Ege Academic Review*, Vol. 18 No. 1: 53-166.

Akosah, N.K.; Alagidede, P.; Schaling, E. (2020), "Interest Rate and Exchange Rate Volatility Spillovers: Multiscale Perspective of Monetary Policy Transmission in Ghana", *Journal of Central Banking Theory and Practice*, Vol. 9 No. 1: 135-167.

Alba, J. D.; Papell, D. H. (1998), "Exchange Rate Determination and Inflation in Southeast Asian Countries", *Journal of Development Economics*, Vol.55 No.2: 421-437.

Altınay, G. (1996), "Exchange Rates and Domestic Prices: A Test of Causality"*, Dokuz Eylül Üniversitesi İİBF Dergisi,* Vol. 11 No. 1: 175-190.

An, L.; Wang, J. (2012), "Exchange Rate Pass-through: Evidence Based on Vector Autoregression with Sign Restrictions", *Open Econ Rev,* Vol.23: 359-380.

Aron, J.; Elbadawi, I.; Kahn, B. (1997), "Real and Monetary Determinants of the Real Exchange Rate in South Africa", *Development Issues in South Africa*, edited by Ibrahim Elbadawi I., Hartzenberg T. London: Macmillan Chapter 8:195-236.

Broock, W.A.; Scheinkman, J.A.; Dechert, W.D.; LeBaron, B. (1996), "A test for independence based on the correlation dimension", *Econometric Reviews*, Vol.15 No.3: 197-235.

Cardenas, M. (1997), La Tasa de Cambio en Colombia, Cuadernos de Fedesarrollo, No. 012740.

Ca'Zorzi, M.; Hahn, E.; Sánchez, M. (2007), "Exchange Rate Pass-through in Emerging Markets", *European Central Bank*, Working Paper No. 739.

Çiçek, S.; Ç, Boz. (2013), "Küçük ve Dışa Açık Bir Ekonomide Döviz Kuru Geçişkenliğine Ilişkin Yeni Bir Test: Asimetrik ARDL Sınır Yaklaşımı Üzerinden Bir Değerlendirme", *İktisat, İşletme ve Finans Dergisi,* C. 28 S. 333: 43-64.

Demez, S. (2021), "Türkiye’de Döviz Kuru ve Enflasyonla Mücadelede Faiz Oranlarının Etkinliği: Fourier Eşbütünleşme Analizi", *Karamanoğlu Mehmetbey Üniversitesi Sosyal ve Ekonomik Araştırmalar Dergisi*, C. 23 S. 40: 132-144.

Dickey, D.A.; Fuller, W.A. (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", *Journal of the American Statistical Association*, Vol. 74 No. 366: 427-431.

Duma, N. (2008), "Pass-through of External Shocks to Inflation in Sri Lanka", *International Monetary Fund*, Washington, DC, IMF Working Paper No.78.

Elbadawi, I.A.; Soto, R. (1994), "Capital Flows and Long-term Equilibrium Exchange Rates in Chile", *The Word Bank, Policy Research,* Working Paper No.1306.

Frimpong, S.; Adam, A.M. (2010), "Exchange Rate Pass-through in Ghana". *International Business Research*, Vol. 3 No. 2: 186-192.

Gondaliya, V.; Dave, P. (2015), "The Impact of Exports and Imports on Exchange Rates in India", *International Journal of Banking, Finance and Digital Marketing*, Vol.1 No.1: 1-8.

Imam, P.; Minoiu, C. (2011), "The Equilibrium Exchange Rate of Mauritius: Evidence from Two Structural Models", *Emerging Markets Finance and Trade*, Vol. 47 No. 6: 134-147.

Isnowati, S.; Setiawan, M.B. (2017), "Exchange Rate Pass through to Import Prices in Indonesia: Evidence Post Free-Floating Exchange Rate", *International Journal of Economics and Financial Issues*, Vol. 7 No. 1: 323-328.

Karabacak, M. (2023), "Türkiye’de Enflasyonun Dinamikleri ve Döviz Kurunun Yurtiçi Fiyatlara Geçiş Etkisi", *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, C. 18 S. 1:252-270.

Karaca, O. (2005), "Türkiye'de Faiz Oranı ile Döviz Kuru Arasındaki Ilişki: Faizlerin Düşürülmesi Kurları Yükseltir mi? ", *Turkish Economic Association Discussion Paper,* No.14.

Karamelikli, H.; Karimi, M.S. (2022), "Asymmetric Relationship Between Interest Rates and Exchange Rates: Evidence from Turkey", *International Journal of Finance & Economics*, Vol. 27 No. 1: 1269-1279.

Kassi, D.F.; Rathnayake, D.N.; Edjoukou, A.J.R.; Gnangoin, Y.T.; Louembe, P.A.; Ding, N.; Sun, G. (2019), "Asymmetry in exchange rate pass-through to consumer prices: New perspective from sub-Saharan African countries", *Economies,* Vol. 7 No. 1: 1-33.

Kayamo, S.E. (2021), "Asymmetric Impact of Real Exchange Rate on Inflation in Ethiopia: A Non-linear ARDL Approach", *Cogent Economics & Finance*, Vol. 9 No. 1: 1-16.

Kaygısız, A.D. (2018), "Döviz Kuru Dalgalanmalarının Enflasyon Üzerindeki Geçiş Etkisi: Türkiye Örneği", *Internetional Review of Economics and Management,* C. 6 S. 2: 117-137.

Kim, K.H. (1998), "US inflation and the dollar exchange rate: a vector error correction model", *Applied Economics,* Vol. 30 No. 5: 613-619.

Korkmaz, S.; Bayır, M. (2015), "Döviz Kuru Dalgalanmalarının Yurt İçi Fiyatlara Etkisi", *Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, C. 8 S. 4: 69-85.

Kuncoro, H. (2020), "Interest Rate Policy and Exchange Rates Volatility Lessons from Indonesia", *Journal of Central Banking Theory and Practice*, Vol. 9 No. 2: 19-42.

Lee, J.; Strazicich M.C. (2003), "Minimum lagrange multiplier unit root test with two structural breaks", *The Review of Economics and Statistics,* Vol. 85 No. 4:1082-1089.

Long, S.; Zhang, R.; Hao, J. (2022), "Asymmetric impact of Sino-US interest rate differentials and economic policy uncertainty ratio on RMB exchange rate", *Journal of International Financial Markets, Institutions and Money*, Vol. 78.

María-Dolores, R. (2009), "Exchange Rate Pass-through in Central and East European Countries: Do Inflation and Openness Matter?", *Eastern European Economics*, Vol. 47 No. 4: 42-61.

Maswana, J. (2006), "Granger Non-causality Test of the Inflation-Exchange Rate in the Democratic Congo", *Congo Economic Review*, Vol. 25 1-12.

McCarthy, J. (2007), "Pass-through of Exchange Rates and Import Prices to Domestic Inflation in some Industrialized Economies", *Eastern Economic Journal*, Vol. 33 No. 4: 511-537.

Mihaljek, D.; Klau, M. (2001), A Note on the Pass Through from Exchange Rate and Foreign Price Changes to Inflation in Selected Emerging Market Economies. BIS Papers.

Mohanty, B.; Bhanumurthty, N.R. (2014), "Exchange Rate Regimes and Inflation: Evidence from India", *International Economic Journal*, Vol. 28 No. 2: 311-332.

Monfared, S.S.; Akın, F. (2017), "The relationship between Exchage Rates and Inflation: The Case of Iran", *European Journal of Sustainable Development,* Vol. 6 No. 4: 329-340.

Montiel, P.J. (1997), "Exchange Rate Policies and Macroeconomic Management in ASEAN Countries", In Macroeconomic Issues Facing ASEAN Countries, ed. J. Hicklin, D. Robinson, and A. Singh. *International Monetary Fund*, Washington, DC.

Nabi, G.; Bhat, K.; Ghazanfar, F. (2021), "Does Budget Deficit and Political Stability Effect Real Exchange Rate in South Asian Countries", *Glob. Manag. Sci. Rev*, Vol. 6 26-38.

Narayan, P.K. (2005), "The Saving and Investment Nexus for China: Evidence from Cointegration Tests", *Applied Economics*, Vol. 37 No. 17: 1979-1990.

Nicita, A. (2013), "Exchange Rates, International Trade and Trade Policies", *International Economics*, Vol.135 47-61.

Nourzad, F. (1997), "The Short and Long-run Relationships between the Dollar and Producer Prices in the U.S. ", *International Economic Journal*, Vol. 11 No. 2: 59-71.

Pesaran, M.H.; Shin, Y.; Smith, R. (2001), "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics*, Vol. 16 No. 3: 289-326.

Phillips, P.C.; Perron, P. (1988), "Testing for a Unit Root in Time Series Regression", *Biometrika*, Vol. 75 No. 2: 335-346.

Rahman, M.; Mustafa, M.; Bailey, E.R. (1996), "US Budget Deficits, Inflation and Exchange Rate: A Cointegration Approach", *Applied Economics Letters*, Vol. 3: 365-368.

Reddan, P.; Rice, J. (2017), "Exchange Rate Pass-through to Domestic Prices", *Central Bank of Ireland Economic Letter Series*.

Rincon, H.; Rodriguez, N. (2016), "Nonlinear Pass-through of Exchange Rate Shocks on Inflation: A Bayesian Smooth Transition VAR Approach", *Graduate Institute of International and Development Studies*, Working Paper.

Rittenberg, L. (1993), "Exchange Rate Policy and Price Level Changes: Causality Tests for Turkey in the Post Liberalization Period", *The Journal of Development Studies,* Vol. 2 No. 2: 245-259.

Ruzima, M.; Boachie, M.K. (2018), "Exchange Rate Uncertainty and Private Investment in BRICS Economies", *Asia-Pacific Journal of Regional Science*, Vol. 2 No. 1: 65-77.

Salvatore, D. (1999), International Economics, Sixth Edition, New York, John Willey and Sons.

Sarı, S. (2018), "Döviz Kuru ile Faiz Oranları Arasındaki Nedensellik İlişkisi: 2006-2018 Dönemi", *Sosyal Bilimler Araştırma Dergisi*, C. 7 S. 4: 219-230.

Sek, S.K.; Kapsalyamova, Z. (2008), "Exchange Rate Pass-through and Volatility: Impacts on Domestic Prices in Four Asian Countries", *Munich Personal RePEc Archive*, MPRA Paper No. 11130.

Sevim, C.; Doğan, T.T. (2016), "Türkiye ekonomisinde ihracat ve döviz kuru oynaklığı ilişkisi", *Ege Academic Review*, Vol. 16 No.2: 283-298.

Shin, Y.; Yu, B.; Greenwood-Nimmo, M. (2014), Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. In R. C. Sickles & W. C. Horrace (Eds.), Festschrift in Honor of Peter Schmidt, New York, Springer.

Siregar, R.Y. (1999), "Real Exchange Rate Targeting and Inflation in Indonesia: Theory and Empirical Evidence", *Southern Economic Journal,* Vol. 61 No. 4: 991-1005.

Tabachnick, B.G.; Fidell, L.S. (1996), Using multivariate statistics, Northridge, Cal, Harper Collins.

Telatar, F.; Telatar, E. (2003), "The Relationship Between Inflation and Different Sources of Inflation Uncertainty in Turkey", *Applied Economic Letters*, Vol. 10 No. 7: 431-436.

Ülengin, B. (1995), "Bütçe Açığı, Parasal Büyüme, Enflasyon, Döviz Kuru ve Üretim Arasındaki Nedensellik İlişkileri: Türkiye Üzerine bir Uygulama", *ODTÜ Gelişme Dergisi*, C. 22 S. 1: 101-116.

Wang, K.L.; Barrett, C.B. (2007) "Estimating the Effects of Exchange Rate Volatility on Export Volumes", *Journal of Agricultural and Resource Economics*, Vol. 32 No. 2: 225-255.

Were, M.; Kamau, A. W.; Kisinguh, K. N. (2013), "An Empirical Investigation of Exchange Rate Determination in Kenya: Does Current Account Imbalance Play a Role? ", *Advances in Management and Applied Economics*, Vol.3 No.2: 165.

Yaprakli, S. (2011), "Açık Enflasyon Hedeflemesi Döneminde Parasal Aktarım Mekanizmasının Döviz Kuru Kanalı: Türkiye Üzerine Ekonometrik Bir Analiz", *Istanbul University Econometrics and Statistics e-Journal*, C. 15: 15-37.

Yenice, S.; Yenisu, E. (2019), "Türkiye'de Döviz Kuru, Enflasyon ve Faiz Oranlarının Etkileşimi", *Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, C. 21 S. 4: 1065-1086.

Appendix

Table A.1

Definitions of Variables

	Variable Name	Definition	Source
exc	Nominal exchange rate	Log of buying TL price of USD Dollar (Seasonally adjusted)	CBRT
dint	Interest rate difference	Difference of Long Term TL Deposit Interest Rate and US Long Term Interest Rate (Seasonally adjusted) (Türkiye -US)	CBRT OECD
exp	Export	Log of export (as million USD Dollar and seasonally adjusted	CBRT
cpi	Consumer price index	The base year is 2003=100. It is defined as logarithmic form and seasonally adjusted.	CBRT

CBRT: The Central Bank of the Republic of Türkiye: https://evds2.tcmb.gov.tr/ and https://stats.oecd.org/

Table A.2

Summary statistics

	exc	dint	exp	cpi
Mean	0,789422	9,897577	9,355655	5,377815
Median	0,588642	8,804062	9,443271	5,352492
Maximum	1,934997	21,00772	9,690388	6,154803
Minimum	0,156213	4,685805	8,718483	4,734907
Std. Dev.	0,511460	3,720828	0,252507	0,390508
Skewness	0,786227	1,128662	-0,915952	0,238941
Kurtosis	2,373821	3,977699	2,813586	2,081691
Jarque-Bera	22,32087	47,15052	26,41858	8,350030
Probability	0,000014	0,000000	0,000002	0,015375
Observations	187	187	187	187
Correlation Matrix	exc	dint	exp	cpi
exc	1.000000			
dint	0.356345	1.000000		
exp	0.629138	-0.031463	1.000000	
cpi	0.957807	0.214479	0.797608	1.000000

Figure A.1

ARDL CUSUM and CUSUM of Squares Graph

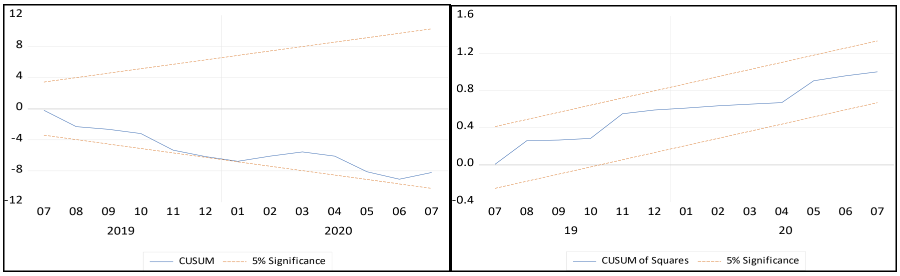

Table A.3

BDS Nonlinearity Results

BDS statistic	Embedding dimensions = m				
	m=2	m=3	m=4	m=5	m=6
exc	0.193613***	0.325925***	0.417218***	0.480841***	0.526386***
dint	0.180718***	0.301172***	0.378257***	0.424643***	0.450056***
exp	0.179465***	0.308937***	0.397633***	0.456398***	0.497224***
cpi	0.203700***	0.344915***	0.443983***	0.514328***	0.564945***

Figure A.2

NARDL CUSUM and CUSUM of Squares Graph

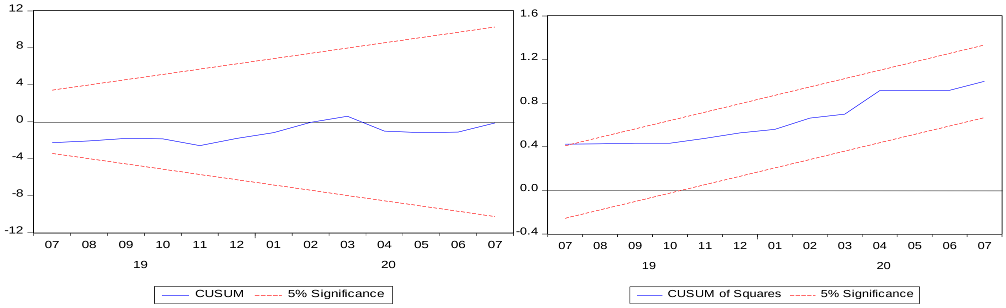

Figure A.3

NARDL impulse response