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Modelling Asymmetric Cointegration of Money Demand in Türkiye: Bounds Testing Approach

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Abstract

This study empirically investigates stability of narrow money demand function and the asymmetric long-run cointegrating relationships between real money demand and its determinants in Türkiye with monthly data over the period between 2010:January and 2021:December by using modified version of traditional autoregressive distributed lag model, which captures nonlinearities. In money demand specification, this study uses M1 to measure real narrow money demand, real private consumption expenditure, weighted average interest rates for deposit in TL, and exchange rate to assess long-run relationships. We find that monetary aggregate is stable over the sample horizon, suggested by CUSUM and CUSUMQ parameter stability tests. While traditional autoregressive distributed lag model cannot observe a cointegration for money demand function, modified version, which considers nonlinearities, allows us to observe long-run level relationship for money demand function in Türkiye.

Keywords*: Nonlinearities, Bounds testing approach, Money demand, Türkiye*

JEL Classification*: C32, E41, E52*

Türkiye'de Para Talebinin Asimetrik Eşbütünleşme Modellemesi: Sınır Testi Yaklaşımı

Özet

Bu çalışma Türkiye'de dar para talebi fonksiyonunun istikrarlılığını ve para talebi ile para talebinin belirleyicileri arasındaki asimetrik uzun dönem ilişkisini 2010:Ocak ve 2021:Aralık dönemine ait aylık veri seti ile doğrusal dışılığı dikkate alan geleneksel olmayan gecikmesi dağıtılmış otoregresif modeli kullanarak incelemiştir. Uuzn dönemli ilişkiyi tespit etmek üzere kurulan para talebi modelinde bağımlı değişken olan reel para talebinin göstergesi olarak M1 kullanılırken açıklayıcı değişkenler olarak reel özel tüketim harcamaları, TL mevduatları için uygulanan ağırlıklı ortalama faiz oranı ve döviz kuru kullanılmıştır. Doğrusal dışılık dikkate alındığında söz konusu dönem için tahmin edilen para talebi fonksiyonuna ait katsayıların istikrarlı olduğu CUSUM ve CUSUMQ testleri ile tespit edilmiştir. Geleneksel gecikmesi dağıtılmış otoregresif model ile tahmin yapıldığında para talebi ile para talebinin belirleyicileri arasında uzun dönemli ilişkinin var olmadığı gözlemlenmişken doğrusal dışılığı dikkate alan geleneksel olmayan modein tahmin edilmesiyle para talebi ile para talebinin belirliyecileri arasında uzun dönemli ilişki tespit edilmiştir.

Anahtar Kelimeler*: Doğrusal dışılık, Sınır testi yaklaşımı, Para talebi, Türkiye*

JEL Sınıflandırması*: C32, E41, E52*

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1. Introduction

It is important to analyze and understand the money demand function because it is one of the most important building blocks in macroeconomic modelling and significant factors in monetary policy decisions. Due to its influence on the cost of the payment system and seigniorage revenues, central banks pay significant attention to demand for cash. Moreover, it allows monetary authority to understand for what motives agents in the economy hold money[2]. Having a stable money demand function in an economy implies that the money supply influences economic activity and inflation (Albulescu and Pepin, 2018). So, examination of the relationships between money demand and its determinants enables policy makers to identify what variables are important to conduct an effective of monetary policy. Therefore, money demand is one of the most attractive and interesting venues for those who are interested in monetary economics.

Analyzing the concept of money demand function is a significant task in the context of developing economies. After the stabilization program consulted by the International Monetary Fund (IMF), monetary policy framework in Türkiye has experienced several policy changes. Türkiye is a developing country suffering from high level of inflation along with high interest rates when compared to its peer economies. Therefore, investigating the stability of money demand in an environment with high levels of inflation and interest rate is worth to study.

Beside plenty of theoretical approaches on the notion of money demand, empirical studies in modelling the money demand have different specifications. The variables that should be in the demand function have been a long-lasting question. Meltzer (1963) studied alternative money demand functions in time series settings and evaluated outcomes. The general view supports that the long run money demand is a function of a scale variable that measures real transactions in the economy and a variable that captures opportunity cost of holding money. In addition to the scale and opportunity cost variable, Mundell (1963) highlighted the importance of exchange rate and suggested that money demand should also be a function of exchange rate, especially for open economies. Arango and Nadiri (1981) examined the role of foreign monetary developments and found that exchange rate expectations influence speculative motive of money demand.

Depending on time series properties of each variable, we have alternative estimation methods to conduct cointegration analysis. Algorithms of some techniques are designed to capture linear relationships. However, using a method that captures nonlinear relationships would be better to avoid misleading results. In

[2] Theoretical contributions on money demand suggest that there are three main reasons of holding money. Particularly, the literature considers transaction, speculative, and precautionary motives of money demand (Keynes, 1936; Tobin, 1956; Friedman, 1956; Sprenkle and Miller, 1980). According to transaction motive, money is held as cash for current transaction of exchanges. For the precautionary motive, people hold money to secure themselves against unexpected spending needs in the future. The speculative motive, which is also known as portfolio motive, proposes that the money is held to secure profit from knowing better than the market.

time series analysis, one of the main steps before moving forward is the stationarity of time series of a variable. Depending on the order of integration, the literature suggests alternative approaches. In case of an uncertainty in the order of integration of regressors in a model, the literature suggests us to use methods that consider this situation. Due to Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001), and Shin, Yu and Greenwood-Nimmo (2014), the empirical literature on cointegration employs bounds testing approach to uncover both linear and nonlinear relationships between variables in the long-run. These types of models are useful in case of an uncertainty in the order of integration of time series.

Therefore, this study considers modified version of traditional autoregressive distributed lag (ARDL) model that captures nonlinearities to test stability of money demand and to analyze cointegration between dependent variable, i.e., money demand, and independent variables, i.e., economic activity, interest rate, and exchange rate in Türkiye over the period from 2010: January to 2021: December. To the best of our knowledge, none of the empirical studies considering the cointegration analysis of money demand in Türkiye has used nonlinear version of ARDL (NARDL). Main findings are as follows. First, results of stability test suggest that narrow money demand in Türkiye is stable over the sample horizon. Second, estimation results show long run levels relationship for money demand function when nonlinearities are taken into account. Third, we observe both short- and long-run asymmetric impacts of interest rate and exchange rate on money demand.

The rest of this paper is organized as follows. Section 2 presents developments in monetary policy framework in Türkiye and a brief literature on money demand. Section 3 introduces data and methodology. Section 4 reports empirical findings. Finally, Section 5 concludes the paper.

2. Monetary Policy Framework in Türkiye and Literature Review

This paper aims to estimate a money demand function in Türkiye to test for its stability and to investigate whether cointegrating relationships exist with its determinants. Since the focus of this paper is Türkiye, first part in this section summarizes significant monetary policy developments in Türkiye after 2001. Then, the second part of this section reviews related literature on money demand equation estimation with an emphasize on the case of Türkiye.

2.1. Monetary Policy Framework in Türkiye

This part provides a short summary of changes in the monetary policy framework in Türkiye after the stabilization program consulted by the International Monetary Fund (IMF). Reforms address to improve accountability, transparency, and independency of the Central Bank of The Republic of Türkiye (CBRT).

Monetary policy framework of CBRT has experienced several changes since 2001 crisis[3]. These changes include a transition from exchange rate-based stability

[3] Dedeoglu and Ogut (2017) provide a good summary of recent monetary policy developments in Türkiye.

program to floating exchange rate regime, an adoption of the program of transition to strong economy, and several amendments to the Central Bank Law. In 2002, the CBRT set its ultimate objective as inflation targeting. During implicit inflation targeting regime between 2002 and 2005, the CBRT continued to take several actions including monetary aggregate target as an additional anchor together with inflation target. As of 2006, the inflation targeting regime was adopted. Right after the global financial crisis in 2008, the CBRT implemented unconventional actions to overcome adverse effects of the crisis. The CBRT revised its policy and introduced an asymmetric and wide corridor system with more than one interest rate to support financial stability. The CBRT took additional policy actions to improve its communication, as well (URL 1).

2.2. Literature on Money Demand Analyses in Türkiye

There are many studies analyzing the money demand function and its stability. Studies consider cases of major economies, i.e., among others, the US (Lucas, 1988; Hafer and Jansen, 1991; Lütkepohl, 1993; Cook and Choi, 2007; Scheibleker, 2012; Benchimol and Qureshi, 2019), Euro area (Brand and Cassola, 2004; Dreger and Wolters, 2010; Avouyi-Dovi, Drumetz, and Sahuc, 2012; Pérez, 2014), Japan (Bae, Kakkar, and Ogaki, 2006; Kurihara, 2016; Bahmani-Ooskee and Nayeri, 2020).

Since this paper focuses on the case of Türkiye, this part presents some empirical evidence on money demand equation in this framework**.**

Akıncı (2003) assesses the empirical relationship between real cash balances held by the public, final private consumption expenditure, interest rate on government securities, and the nominal exchange rate with a quarterly data from 1987:Q1 and 2003:Q3. Empirical analysis consists of conducting Johansen cointegration test and an error correction model. Estimation results reveal a long-run relationship between money demand and income, interest rate, and the exchange rate. According to estimation results of error correction model, the effects of income and interest rate are found to be more pronounced in the long run.

Bahmani-Oskooee and Karacal (2006) consider a money demand equation in Türkiye and examine its stability with a monthly data over the period 1987:January and 2004:June. To construct the model, the authors use M1 and M2 as measures of money supply, real GDP, exchange rate, and weighted average of 1-, 3-, 6-, and 12-month rate on TL deposits. To investigate the long run relationship between variables and the stability of money demand equation, they use bounds testing approach and parameter stability tests (CUSUM and CUSUMQ), respectively. They find that M1 and M2 are cointegrated with their determinants. While the former is cointegrated with its all determinants, the latter has weak cointegration with its determinants. As regard to stability, both M1 and M2 are found to be stable.

Algan and Gencer (2011) model alternative money demand functions in Türkiye for the period between 1987:Q1 and 2007:Q2. Their examination relies on both narrow and broad monetary aggregates and their determinants. Quarterly data on real GDP, interest rate, inflation, and exchange rate are used to estimate models by employing Johansen and Juselius cointegration method. To test for the stabilities of the models, they use recursive eigenvalue estimation based on error correction model. After empirical estimations, they find evidence on stable M1 with GDP, interest rate, and inflation.

Yılancı (2012) empirically investigates the stability of broad money in Türkiye with quarterly data over the period between 1989:Q1 and 2011:Q2. The author follows bounds testing and rolling bounds testing approaches as methodology. The study employs real M2, real GDP, closing index prices, and weighted average of 3-month deposit rates. Findings show that the money demand is not stable in Türkiye over the sample horizon.

Özcan and Arı (2013) test whether money demand in Türkiye is stable between 2005:December and 2012:October. To do so, they conduct Johansen cointegration test and parameter stability test. They use M2 as a measure of broad money, industrial production index, interest rate, and exchange rate. Estimation results suggest a long run cointegrating relationship for money demand. However, stability test fails and suggests that the M2 is not stable in Türkiye over the sample period.

Tümtürk (2017) estimates a long run money demand function in Türkiye over the period between 1970 and 2013. The author considers annual data for real M1 as monetary aggregate, real GDP, and nominal interest rate to test for the cointegration between these variables by using Johansen cointegration test and dynamic ordinary least squares (DOLS). Findings suggest evidence of cointegrating relationships in money demand function, which is found to be stable.

General results deduced from these studies are as follows. Existence of long-run relationships between monetary aggregate and its determinants, and the stability of money demand function depends on functional form of money demand, sample period, the choice of variables, i.e., monetary aggregate (narrow or broad), and the estimation methodology. Although some studies support the existence of cointegration between variables and stability of money demand function, some studies do not.

3. Data and Methodology

The basic form of money demand specification in real terms in this paper is as follows: $M/P = f(Y/P, r, er)$, where M/P is real money demand, Y/P is real economic activity, r is interest rate, and er is exchange rate.

Since we aim to model narrow money demand, we use M1, which is composed of currency in circulation and demand deposits, to proxy money demand (Tümtürk, 2017). To measure the economic activity, we employ final private consumption expenditure (EXP) because it is an expenditure-based proxy and therefore it is an appropriate measure to determine the demand for real cash balance in an economy (Akıncı, 2003). To reflect the opportunity cost of holding money, we include weighted average interest rates for deposits in TL (INT) (Bahmani-Oskooee and Karacal, 2006). To take the currency substitution into account, we use real effective exchange rate (REER) to proxy exchange rate consistent with the literature.

3.1. Data

Table 1 presents the variables with their construction and sources. For M1 and EXP, we use consumer price index (CPI) to deflate nominal values to achieve real values. Since we observe a seasonality in EXP, we use seasonally adjusted series of EXP. One thing that should be noted that the EXP is available in quarterly frequency. Since we use monthly data, we interpolate the EXP to get monthly observations. We use logarithmic form of all variables except for the INT. Sources of data are electronic data delivery system (EVDS) of the CBRT and Turkish Statistical Institute (TURKSTAT).

Table 1. Construction of Variables and Sources of Data

Variables	Construction	Source
M1	Logarithm of narrow monetary aggregate deflated by CPI	EVDS
EXP	Logarithm of seasonally adjusted private consumption expenditure deflated by CPI	TURKSTAT
INT	Weighted average interest rates for deposits in TL	EVDS
REER	Logarithm of real effective exchange rate	EVDS

Figure 1 plots the time series of these variables. While M1 and EXP exhibit an increasing trend, REER has a decreasing trend. Both M1 and EXP have a sudden decrease in the second quarter of 2018 when the economy experienced a depreciation in national currency. We also observe that EXP declines significantly in the middle of 2020 because of pandemic. Although there was a slight increase in INT until the beginning of 2018, we observe a dramatic increase between 2018 and 2019. In response to a currency depreciation, the economy witnessed an increase in interest rates.

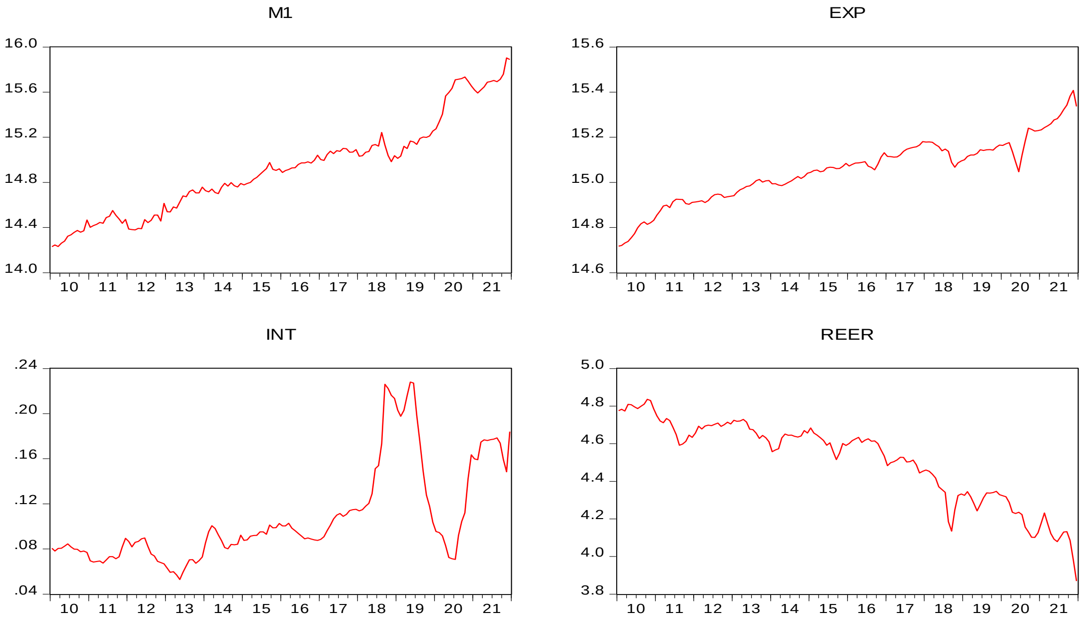

Figure 1. Time Series of Variables

Table 2 reports the descriptive statistics of variables. Skewness measures the asymmetry of the distribution of the series around mean. While the distributions of M1 and INT have a long-right tail, the distributions of EXP and REER have a long-left tail. As regard to kurtosis, which measures flatness of the series, the distributions of M1 and REER are platykurtic relative to the normal. For the case of INT, kurtosis exceeds 3 implying that the distribution is peaked (leptokurtic) relative to normal. Since the kurtosis of EXP is very close to 3, the distribution is assumed to be normal. This situation is also supported by the Jarque-Bera test result, and we fail to reject the hypothesis of normal distribution at 5% level.

Table 2. Descriptive Statistics

	M1	EXP	INT	REER
Mean	14.92148	15.05253	0.107580	4.511091
Median	14.91762	15.06660	0.092000	4.599342
Maximum	15.90369	15.40762	0.228000	4.836129
Minimum	14.23053	14.71688	0.052900	3.869406
Std. Dev.	0.422735	0.139007	0.043256	0.218256
Skewness	0.457238	-0.160502	1.327725	-0.717417
Kurtosis	2.468805	2.976989	3.740978	2.505490
Jarque-Bera	6.710618	0.621438	45.60278	13.81974
Probability	0.034899	0.732920	0.000000	0.000998
Observations	144	144	144	144

3.2. Methodology

This paper aims to investigate long run cointegration between M1, EXP, INT and REER in Türkiye with a monthly data over the period between 2010: January and 2021: December.

Due to Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001), and Shin, Yu and Greenwood-Nimmo (2014), we employ bounds testing approach to uncover both linear and nonlinear relationships between variables in the long-run.

Following Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001), we first estimate the following regression:

$$M1_t = c_0 + \sum_{i=1}^{p-1} c_1 \Delta M1_{t-i} + \sum_{i=0}^{q-1} c_2 \Delta EXP_{t-i} + \sum_{i=0}^{q-1} c_3 \Delta INT_{t-i} + \sum_{i=0}^{q-1} c_4 \Delta REER_{t-i} + \gamma_1 M1_{t-1} + \gamma_2 EXP_{t-1} + \gamma_3 INT_{t-1} + \gamma_4 REER_{t-1} + \varepsilon_t \qquad (1)$$

This linear ARDL model as shown by equation (1) is useful in determining the linear long run relationship between selected variables. While c_1, c_2, c_3, and c_4 represent short run coefficients, γ_1, γ_2, γ_3 and γ_4 are the long run coefficients for variables. Δ indicates the first difference of the variables.

Regarding the proposed cointegration analysis, the null and the alternative hypotheses are as follows:

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$$

$$H_1: at\ least\ one\ of\ them\ is\ not\ equal\ to\ 0$$

The null states that there is no cointegrating equation between variables. The decision rule depends on computed F-statistics with respect to the two sets of asymptotic critical lower and upper bounds. This testing approach has three possible outcomes. First, if the F-statistics is lower than the critical value associated with the I (0) bound, we fail to reject the null hypothesis. Second, if the F-statistics is in between the lower and upper bound, we have inconclusive result. Third, if the F-statistics is greater than the critical value associated with the I (1), we reject the null and conclude that there is a long-run relationship between variables.

As previously stated, linear models sometimes lead misleading results because they do not take asymmetric interactions into account. The pioneering work by Shin, Yu and Greenwood-Nimmo (2014) is essential to investigate asymmetric cointegration relationship between variables. Nonlinear version of traditional ARDL method takes positive and negative partial sums of regressors into account to uncover the dynamic asymmetric interactions between variables in the short- and long-run. Equation (2) introduces asymmetric long run regression:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \tag{2}$$

In this fashion, the long-run parameters are described by β^+ and β^-. The regressors, x_t^+ and x_t^- indicate increases and decreases as computed by the positive and negative partial sums shown below:

positive partial sum:

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0)$$

negative partial sum:

$$x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0)$$

After this modification, the nonlinear ARDL model can be written as follows:

$$\Delta M1_t = c_0 + \sum_{i=1}^{p-1} \tau \Delta M1_{t-i} + \sum_{i=0}^{q-1} \phi_1{}^+ \Delta EXP_{t-i}{}^+ + \sum_{i=0}^{q-1} \phi_1{}^- \Delta EXP_{t-i}{}^- + \sum_{i=0}^{q-1} \phi_2{}^+ \Delta INT_{t-i}{}^+ + \sum_{i=0}^{q-1} \phi_2{}^- \Delta INT_{t-i}{}^- + \sum_{i=0}^{q-1} \phi_3{}^+ \Delta REER_{t-i}{}^+ + \sum_{i=0}^{q-1} \phi_3{}^+ \Delta REER_{t-i}{}^+ + ɣ M1_{t-1} + \omega_1{}^+ EXP_{t-1}{}^+ + \omega_1{}^- EXP_{t-1}{}^- + \omega_2{}^+ INT_{t-1}{}^+ + \omega_2{}^- INT_{t-1}{}^- + \omega_3{}^+ REER_{t-1}{}^+ + \omega_3{}^- REER_{t-1}{}^- + \varepsilon_t \tag{3}$$

We now have $\phi_1{}^+$, $\phi_1{}^-$, $\phi_2{}^+$, $\phi_2{}^-$, $\phi_3{}^+$ and $\phi_3{}^-$ as the short run coefficients and ɣ, $\omega_1{}^+$, $\omega_1{}^-$, $\omega_2{}^+$, $\omega_2{}^-$, $\omega_3{}^+$ and $\omega_3{}^-$ as the long run coefficients in the model.

The null and alternative hypotheses as shown below:

$$H_0: ɣ = \omega_1{}^+ = \omega_1{}^- = \omega_2{}^+ = \omega_2{}^- = \omega_3{}^+ = \omega_3{}^- = 0$$

$$H_1: at\ least\ one\ of\ them\ is\ not\ equal\ to\ 0$$

The decision rule of the test is same as in the linear version of ARDL model.

With NARDL model, we are now able to test both long- and short-run asymmetries. To do so we conduct Wald test. For the long-run asymmetry test, following hypotheses are formed for $j = 1,2,3$:

$H_0: \frac{-\omega_j^{+}}{ɣ} = \frac{-\omega_j^{-}}{ɣ}$

$H_1: \frac{-\omega_j^{+}}{ɣ} \neq \frac{-\omega_j^{-}}{ɣ}$

As the decision rule, we reject the H_0 and conclude that there is evidence on long-run asymmetry if the p-value of the computed test statistic is less than 5%.

Short run asymmetry test is also carried out by Wald test. At this time, we test the following hypotheses, which are based on the partial sums of short run coefficients:

$H_0: \sum_{i=0}^{q-1} \phi_j^{+} = \sum_{i=0}^{q-1} \phi_j^{-}$

$H_1: \sum_{i=0}^{q-1} \phi_j^{+} \neq \sum_{i=0}^{q-1} \phi_j^{-}$

The decision rule is same as in the long-run asymmetry test. If the p-value of the test statistic is less than 5%, we reject the H_0 and conclude that there is evidence on short-run asymmetry.

4. Empirical Evidence

This section presents the estimation results of both linear ARDL and nonlinear ARDL models to analyze both symmetric and asymmetric impacts of regressors on the dependent variable.

4.1. Stationarity of Times Series

In the first step, we investigate the stationarity characteristics of the variables. To do so, we observe correlograms of each time series to have a first insight. Then, we conduct Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests to determine order of integration.

Figure A2 displays correlogram of each time series at their level and first difference. Correlograms exhibit that all series at their levels contain unit root as autocorrelations do not die immediately. On the other hand, correlograms of first-differenced series give a sign of stationarity of each time series. So, we may conclude that the time series of each variable under consideration seems to be I (1). However, we should proceed with legitimate unit root tests to see whether the time series are stationary in their first differences.

There are several tests that can be used to check for the stationarity of the times series. Among others, both the ADF and PP unit root tests are for the I (1) series under the null hypothesis. The decision rule for both tests is to reject the null hypothesis stating there is a unit root in the time series if the associated p-value of the test statistic is less than 0.05.

Table 3 displays the results of the ADF and PP unit root tests. The lag length selection was carried out using Schwarz Information Criterion (SIC). Following the decision rule of both tests, we fail to reject the null hypothesis of a unit root in all the series at their levels except for the EXP and INT. Therefore, we conclude that there is an uncertainty in the order of integration of some regressors. Given these results, we are allowed to follow and estimate ARDL models by Pesaran and Shin

(1999) and Pesaran, Shin and Smith (2001), and Shin, Yu and Greenwood-Nimmo (2014).

Table 3. Results of Unit Root Tests

	ADF				PP			
	Constant		Constant & Trend		Constant		Constant & Trend	
Variables	t-Statistic	p-value	t-Statistic	p-value	t-Statistic	p-value	t-Statistic	p-value
Level								
M1	0.5010	0.9863	-1.6758	0.7570	0.4838	0.9857	-1.8571	0.6714
EXP	-1.5397	0.5107	-3.4384	0.0504*	-1.3188	0.6199	-2.9119	0.1619
INT	-1.5851	0.4876	-3.5582	0.0372**	-1.6011	0.4794	-2.6975	0.2393
REER	0.8715	0.9949	-1.6033	0.7871	1.4319	0.9991	-1.2951	0.8851
*First Difference****								
M1	-12.808	0.0000	-12.858	0.0000	-12.776	0.0000	-12.822	0.0000
EXP	-8.3028	0.0000	-8.2746	0.0000	-5.6896	0.0000	-5.6068	0.0000
INT	-6.5911	0.0000	-6.5912	0.0000	-6.6836	0.0000	-6.6850	0.0000
REER	-8.4571	0.0000	-8.6117	0.0000	-6.6787	0.0000	-6.7160	0.0000

Note: *, **, and *** significant at 0.1, 0.05, and 0.01 respectively. MacKinnon (1996) one-sided p-values.

4.2. Estimation of ARDL Models

In this section, we present estimation results. We first run traditional ARDL model to investigate cointegration between variables by using critical bounds. We consider Akaike Information Criterion (AIC) for the model selection method and construct the model with a max of 4 lags. The best model suggested by the AIC is an ARDL (4, 0, 1, 3). This model is successful in passing diagnostic tests including LM test (associated p-value is 0.25), heteroskedasticity test (associated p-value is 0.55), and CUSUM and CUSUMQ tests. Then, we test for the cointegration by using critical lower and upper bounds. Table 4 displays the results of F-bounds test. According to Panel A in Table 4, the value of F-statistic is 0.72, which is below critical lower bounds for any significance levels. Since we fail to reject the null hypothesis, this finding suggests us that there is no cointegrating equations. Then, we move to modified version of ARDL (NARDL) that takes nonlinearities into account and reconduct the hypothesis test. For the model construction, we again consider AIC. Now the selected model becomes an ARDL (4, 0, 3, 1, 4, 2, 1). This model passes diagnostic tests, as well. The results are available in Table A1. For the cointegration, Panel B in Table 4 displays the test results. The computed F-statistic is now 7.92, which now exceeds critical upper bound. So, we reject the null and conclude that the cointegration exists when we take possible nonlinearities into account.

Table 4. Results of Bounds Tests

	F-Statistic	Significance Level	I (0)	I (1)	H_0	Decision
Panel A: ARDL	0.72	10%	2.82	3.88	No levels relationship	Fail to Reject H_0
		5%	3.63	4.51		
		1%	4.56	5.96		
Panel B: NARDL	7.92	10%	2.23	3.38	No levels relationship	Reject H_0
		5%	2.62	3.86		
		1%	3.45	4.94		

Table 5 presents the estimation results of NARDL model in equation (3). Panel A and Panel B in Table 5 presents the long-run and short-run components of asymmetric error correction model, respectively. Long-run asymmetric coefficients are displayed in Panel C in Table 5.

Long run coefficients are displayed in Panel A in Table 5. These are the coefficients that are being tested jointly in bounds test. The results suggest that positive shock on EXP has negative casual effect on M1. The negative causal impact on M1 is also observed when there is a negative shock on EXP. However, these impacts are statistically insignificant. As regard to the changes in INT, both positive and negative shocks have negative impact on M1. While the positive shock is statistically insignificant, the negative impact of INT on M1 is statistically significant. This result implies that the M1 and INT are inversely related. Regarding the impact of positive shock on REER, the response of M1 is positive and statistically significant. On the other hand, a negative shock on REER has statistically insignificant impact on M1.

Estimated short run components are displayed in Panel B in Table 5. Regarding the impact of short run component of EXP, negative shock on EXP in the past period has statistically significant and negative casual effect on M1. For the case of interest rate, a positive INT shock has statistically significant and positive impact on M1 in the current period only. On the other hand, a negative shock on lagged term of INT has positive impact on M1, which is statistically significant. We observe that both positive and negative shocks on REER in the current period have negative impacts on M1. Moreover, a positive shock in the past period has also negative effect on M1. An increase in REER is followed by an increase in M1 and vice versa. The error correction term (ECT) reflects the speed of adjustment in long-run equilibrium. It is expected to have a negative sign and be statistically significant. We have 27%, which states that the long-run equilibrium can be achieved in less than 6 months.

Table 5. Estimation Results of Asymmetric Error Correction Regression Model

Panel A: Long-run components				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
$M1$	-0.271955	0.053405	-5.092305	0.0000
EXP^{+}	-0.102451	0.110360	-0.928329	0.3551
EXP^{-}	0.293776	0.187143	1.569793	0.1192
INT^{+}	-0.087951	0.212471	-0.413945	0.6797
INT^{-}	-0.932340	0.174354	-5.347400	0.0000
$REER^{+}$	0.211666	0.070194	3.015437	0.0031
$REER^{-}$	-0.065892	0.072282	-0.911587	0.3639

Panel B: Short-run components				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta M1_{t-1}$	-0.275906	0.085643	-3.221565	0.0017
$\Delta M1_{t-2}$	0.001364	0.079486	0.017155	0.9863
$\Delta M1_{t-3}$	0.156121	0.066049	2.363729	0.0197
$\Delta EXP_{t}{}^{-}$	-0.057577	0.369964	-0.155630	0.8766
$\Delta EXP_{t-1}{}^{-}$	0.520562	0.418795	1.243001	0.2164
$\Delta EXP_{t-2}{}^{-}$	-1.289580	0.415119	-3.106529	0.0024
$\Delta INT_{t}{}^{+}$	-1.022742	0.511369	-2.000008	0.0478
$\Delta INT_{t}{}^{-}$	-0.107256	0.759945	-0.141137	0.8880
$\Delta INT_{t-1}{}^{-}$	0.321071	0.878811	0.365347	0.7155
$\Delta INT_{t-2}{}^{-}$	0.657813	0.875260	0.751563	0.4538
$\Delta INT_{t-3}{}^{-}$	3.479079	0.853727	4.075167	0.0001
$\Delta REER_{t}{}^{+}$	-0.772523	0.224730	-3.437565	0.0008
$\Delta REER_{t-1}{}^{+}$	-0.667811	0.221875	-3.009860	0.0032
$\Delta REER_{t}{}^{-}$	-0.737153	0.133598	-5.517685	0.0000
ECT_{t-1}	-0.271955	0.035605	-7.638092	0.0000

Panel C: Long-run asymmetric coefficients				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
EXP^{+}	-0.376720	0.447624	-0.841598	0.4017
EXP^{-}	1.080238	0.703882	1.534687	0.1276
INT^{+}	-0.323405	0.770406	-0.419785	0.6754
INT^{-}	-3.428291	0.603270	-5.682850	0.0000
$REER^{+}$	0.778314	0.276737	2.812470	0.0058
$REER^{-}$	-0.242289	0.269362	-0.899493	0.3702

Long run asymmetric coefficients displayed in Panel C in Table 5 help us to construct asymmetric cointegrating equation. These coefficients are calculated with the help of coefficients displayed in Panel A in Table 5. These terms are the ratios between lagged terms of independent variables and dependent variable. For example, the coefficient -0.37 is the ratio between the (-0.10) and (-0.27) with a negative sign. To interpret the long-run asymmetric coefficients, we need to have asymmetric cointegrating equation as shown below:

$$1 = -0.37EXP^{+} + 1.08EXP^{-} - 0.32INT^{+} - 3.42INT^{-} + 0.77REER^{+} - 0.24REER^{-} \quad (4)$$

Given coefficients in equation (4), we now investigate the impacts of positive and negative changes in regressors on dependent variable. Then, we conduct Wald coefficient restriction test to investigate whether the differences between the coefficients of the positive and negative changes are statistically significant.

According to the long run asymmetric coefficients, M1 is a negative function of positive changes in EXP and a positive function of negative changes in EXP. M1 decreases by 0.37 in response to an increase in EXP. For the negative changes in EXP, M1 decreases by 1.08. However, the impacts of both changes in EXP on M1 are not statistically significant. M1 is a negative function of both positive and negative changes in INT. Negative changes have statistically significant impact on M1. If INT decreases by one unit, M1 increases by 3.42. For the impact of positive changes in REER, M1 increases by 0.77. This impact is statistically significant.

We now conduct Wald test to assess whether the differences between long- and short-run coefficients are statistically significant. The null hypothesis is that the two impacts are the same. The decision rule is to reject the null if the associated p-value is less than 0.05 and conclude that there is a nonlinear relationship between regressors and dependent variable.

H_0: No asymmetry

H_1: $Asymmetry$

Table 6 displays the result of asymmetry tests. The long-run asymmetry tests for INT and REER reject the null hypothesis of no asymmetry and conclude that there is evidence of long-run asymmetry. However, there is no evidence of long-run asymmetry for EXP. While there are nonlinear relationships between M1 and the former two variables, there is no nonlinear relationship between M1 and EXP. Regarding the short run asymmetry, we have evidence on short run asymmetry for INT and REER.

Table 6. Results of Asymmetry Tests

Asymmetry Tests					
	Variables	χ^2	p-value	H_0	Decision
Long-run asymmetry	EXP	1.91	0.16	No asymmetry	Fail to reject H_0
	INT	10.63	0.001	No asymmetry	Reject H_0
	REER	8.33	0.004	No asymmetry	Reject H_0
Short-run asymmetry	EXP	-	-	-	-
	INT	16.67	0.00	No asymmetry	Reject H_0
	REER	3.5	0.06	No asymmetry	Reject H_0

5. Conclusion

Due to its importance in macroeconomic modelling and monetary policy, analysis of money demand is still an attractive venue for researchers. Central banks conduct monetary policies by addressing arguments in money demand function. Assessing money demand function in an economy with high level of inflation and interest rate is interesting. Therefore, this study considers the case of Türkiye to analyze the stability of narrow money demand and long run level relationships between its determinants.

In our analysis, we use monthly M1, real private consumption expenditure, weighted average interest rate for deposit in TL, and exchange rate between 2010:January and 2021:December. Time series properties of variables lead us to use bounds testing approach. We consider both the traditional ARDL model and the modified ARDL to investigate the cointegration.

Main findings of this study are consistent with the findings in Algan and Gencer (2011) and Tümtürk (2017). Although we find stability of money demand in both approaches, we achieve cointegration of narrow money with its determinants through nonlinear ARDL model. Asymmetry test results imply that the narrow money demand has significant nonlinear relationships with interest rate an exchange rate both in short- and long-run.

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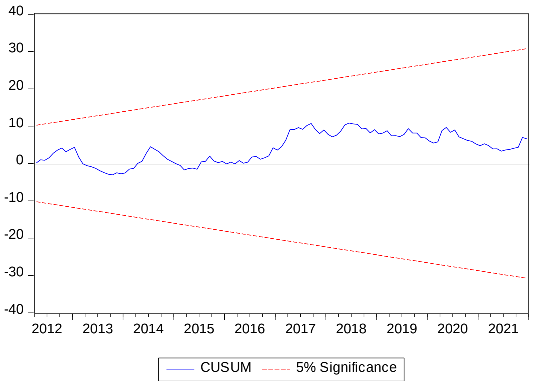
Appendix

Table A1. Results of Diagnostic Tests

Test	p-value	H_0	Decision
Breusch-Godfrey LM	0.4209	No serial correlation	Fail to Reject H_0
Breusch-Pagan-Godfrey	0.3610	Homoscedasticity	Fail to Reject H_0
Jarque-Bera	0.2976	Normal distribution	Fail to Reject H_0
CUSUM*	Parameter stability is satisfied		
CUSUM of squares*	Parameter stability is satisfied		

* See Figure A1



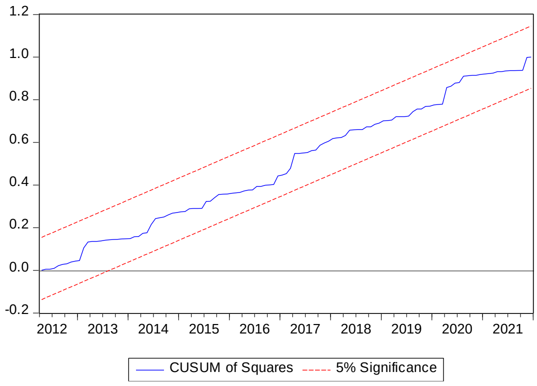


Figure A1. CUSUM and CUSUMQ

Level / **First Difference**

M1

Level

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First Difference

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EXP

Level

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INT

Level

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REER

Level

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Figure A2. Correlograms