International Journal of Economics and Financial Research
ISSN(e): 2411-9407, ISSN(p): 2413-8533
Vol. 7, Issue. 2, pp: 28-42, 2021
URL: https://arpgweb.com/journal/journal/5
DOI: https://doi.org/10.32861/ijefr.72.28.42

Academic Research Publishing Group

Original Research **Open Access**

Is There a Change in the Money Demand Stability in Turkey? A Nonlinear Approach

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Article History
Received: 15 February, 2021
Revised: 7 April, 2021
Accepted: 27 April, 2021
Published: 3 May, 2021

Abstract

The details of a central bank's monetary policy are based on assumptions about the money demand. This requires researches that aim to investigate money demand dynamics. Knowing these dynamics will support the identification of risks that may pose a threat to price stability in the long run. This study aims to analyze the changes observed in the demand for money during the last 35 years (1986-2020) in Turkey. When the analyzing period is considered as a whole in the study, it is determined that the demand for money is not stable. However, the nonlinear cointegration analysis used within the framework of soft transition models indicates that the money demand model can be divided into two different regimes with stability. In this case, it is possible to talk about the existence of a transition period in which stability is lost in the demand for money. The analyzing technique used allows the coefficients obtained for money demand to change over time according to the regime in which the economy operates. Nonlinear estimation results indicate that there is a long-term relationship between the demand for money and its macroeconomic determinants such as price level, income, interest rate, and money holding preferences of economic agents.

Keywords: Money demand; STAR models; Nonlinear cointegration.

1. Introduction

It is seen that central banks, starting from the early 1990s, have moved away from using monetary aggregates as a tool while carrying out monetary policy. It is possible to state that in this process, many central banks adopted a monetary policy strategy for inflation targeting and started to use the short-term interest rate as the main monetary policy instrument. As a natural consequence of this process, money and monetary aggregates have taken a passive role in monetary policy conduct. This is because, in a monetary policy regime where the interest rate is used as the main instrument of monetary policy, the equilibrium amount of money phenomenon shifts to the residual position (MacCallum, 2004). In this case, monetary aggregates are out of the interest of policymakers aiming to stabilize economic growth and prices. On the other hand, the instability observed in monetary aggregates due to financial instabilities and financial innovations in the last two decades should be considered as another reason for the interest rate to come to the fore as a monetary policy tool. As pointed out by Poole (1970) in his seminal study on the choice of the monetary policy instrument, the use of interest rate as a monetary policy instrument is more appropriate when compared to monetary aggregates, if money demand instabilities predominate over spending instabilities. Although this policy proposal has been developed in another context, it has recently been widely accepted. However, as stated in Pool's study, under conditions of equal certainty, both tools produce equivalent results.

The details of the monetary policy to be followed by a central bank are based on assumptions about the money demand. In this case, it is possible to say that the dynamics of monetary aggregates and the factors determining these dynamics cannot be kept in the background within the monetary policy framework. Indeed, Friedman (1976) points out that monetary aggregates can function as an intermediate target in a monetary policy regime in which the interest rate is used as an instrument. In this context, Friedman emphasizes that understanding the demand for money is more important than academic interest.

It has become important to understand the role of monetary aggregates in the implementation of monetary policy, especially as a result of the developments after the 2008 global financial crisis and the Covid pandemic that has affected the whole world since the beginning of 2020. This requires studies aiming to analyze money demand dynamics. Knowing the dynamics of money demand is of key importance, although the current instruments used in monetary policy conducting are based on interest rates and the transmission mechanisms related to them work through various channels (such as asset prices, balance sheet, exchange rate, expectations, and asymmetric information). Knowledge of these dynamics will support the identification of risks that may pose a threat to price

stability in the long run (Jawadi and Sousa, 2013). Understanding the dynamics of money demand is also important since the money supply must be consistent with the money demand in ensuring the transmission of the monetary policy followed in a country in such a way that creates the desired results through the interest rate. Goldfeld and Sichel (1990), Sriram (2001), Barnett (2008) stand out among other studies emphasizing the importance of money demand. The common conclusion from these studies can be summarized as follows: Since monetary policy decision-makers have to make some assumptions about the money demand, they have to know whether the demand for money will gain stability under different scenarios. As the forecast models developed in the period before the inflation targeting regime became widespread were handled depending on the monetary equilibrium systematic errors arose when the demand for money was not determined appropriately. The "missing money" concept, raised by Goldfeld (1976), highlights these systematic errors. This situation led to the failure to obtain the expected results from the developed policy suggestions. As stated by Elgar, Jones & Nilsson (2006), estimation errors regarding the effects of monetary aggregates on inflation caused increased variability in inflation and interest rates and led to risks in real economic activity.

Whether or not it adopts the inflation targeting regime, achieving and maintaining price stability in the medium and long term is the main objective for a central bank, but the political environment, goals, and policy tools used are not always the same among countries. For example, the European Central Bank uses the M3 money supply within the framework of an implicit inflation target as an indicator of inflationary risk. However, although they do not set an implicit inflation target, the Federal Reserve and the Bank of England focus on M2 and M4, respectively, to monitor inflationary pressure. The Central Bank of the Republic of Turkey (CBRT) emphasizes that it follows the central bank money, a balance sheet aggregate consisting of reserve money and government deposits at the central bank, for the same purpose (CBRT, 2019).

Although the rate of increase in real monetary aggregates in the last decade is mostly higher than the economic growth rate in Turkey, there is no serious permanent jump in inflation. As seen in Figure 1, it is interesting that inflation did not return to the target range, especially in the 2017-2018 period, although monetary aggregates fell faster than economic activities. Figure 2 clearly illustrates these relationships. The shock caused by the drop in oil prices since 2014 has affected the terms of trade, economic activities, and national income. These developments occurred together with the slowdown in the expansion rate of monetary aggregates. These listed issues may point to changes in the elasticity of money demand against these macroeconomic variables. Considering the phenomenon of demand for money, which has recently responded to income at a higher rate than other factors, it becomes important to evaluate these elasticities affecting money demand.

Considering the issues we have tried to emphasize above, this study aims to analyze the changes observed in the demand for money over the last 35 years in Turkey (1986-2020). Therefore, the study covers a period in which important economic developments are experienced in the international and national context. On a national basis, for example, the 1994 and 2001 financial crises, the regulation on the independence of the Central Bank (2001), the transition to the inflation targeting regime (2003), and the change in this regime (2017) are some of the economic developments experienced in this period. In the international context, the review period includes a series of developments that have experienced economic difficulties such as 1987 Far East Asia, 1992 Argentina and Russia, 2008 Global and 2017 European crises. On the other hand, the strengthening of the globalization tendency experienced in this period and the acceleration of technological developments and financial innovations should be counted among the factors that caused the change in money demand dynamics over time. When the analyzing period is considered as a whole in the study, it is determined that the demand for money is not stable. However, the cointegration analysis used within the framework of smooth transition models indicates that the money demand model can be divided into two different regimes with stability. In this case, it is possible to talk about the existence of a transition period in which stability is lost in the demand for money. The analysis technique used allows the coefficients obtained for money demand to change over time according to the regime of the economy. According to the results, there is a long-term relationship between the demand for money and macroeconomic variables such as prices, income, interest rate, and money holding preferences of economic agents. The coefficients obtained for each of these elasticities have signs in the direction expected according to economic theory and are statistically significant.

This study is divided into five chapters, in addition to this introduction. The first chapter deals with the literature review related to empirical evidence of recent international and Turkey-specific money demand estimates. Second, a theoretical model that establishes a long-term relationship between the demand for money and its determinants is presented. Third, the econometric method used to estimate the proposed money demand function is considered. The last two chapters discuss the estimation results obtained for Turkey and the final concluding remarks of the study, respectively.

Figure-1. Targeted and Actual Annual Inflation Rates in Turkey

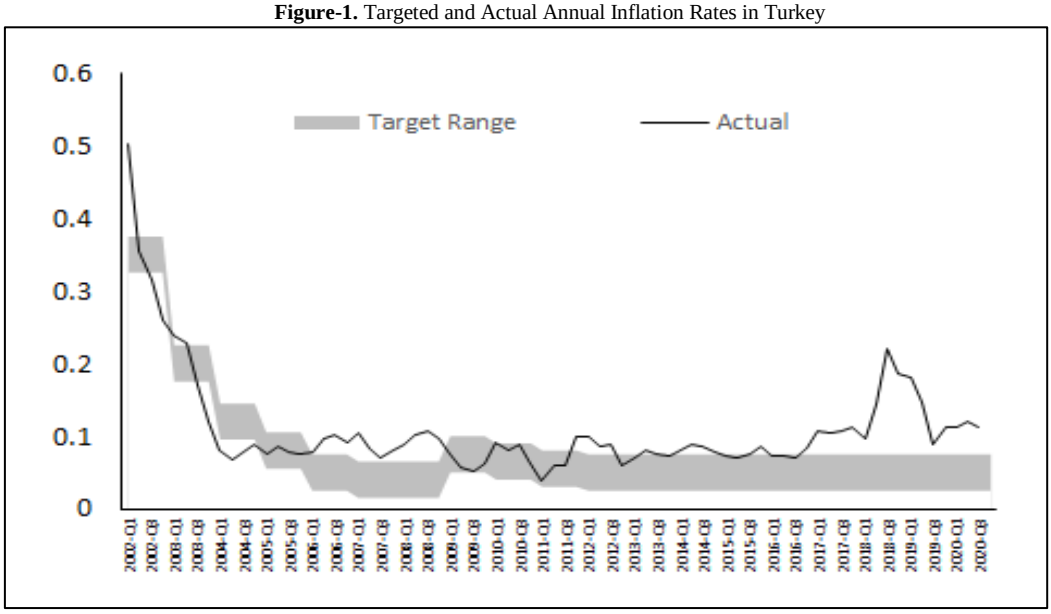
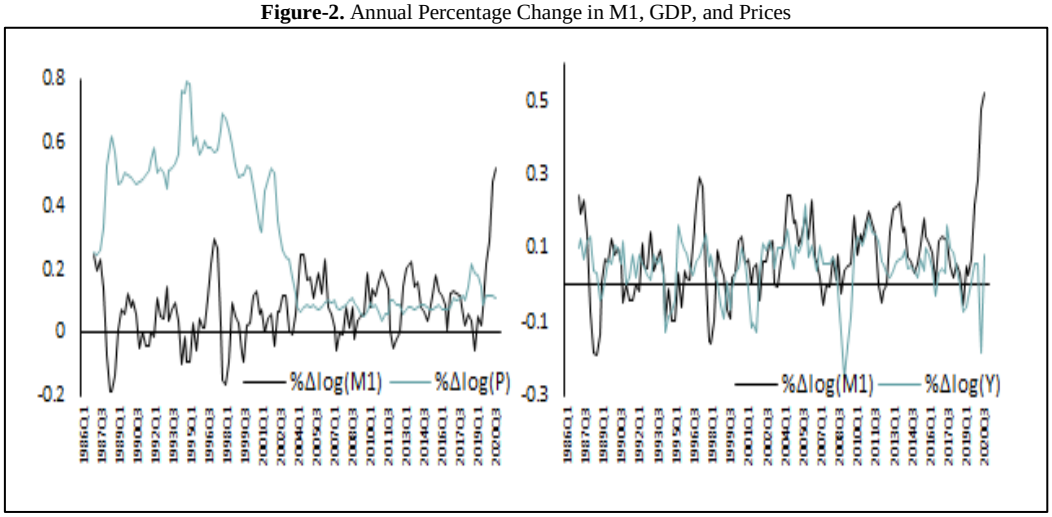


Figure-2. Annual Percentage Change in M1, GDP, and Prices



2. Recent International and Turkey Specific Empirical Lıterature

It is known that there is extensive international literature on money demand. Although there are many empirical studies in the last 50 years to determine money demand and the economic factors affecting it (or to support theoretical expectations), the results obtained do not allow us to reach a definite judgment on this issue.0020 Sriram (2001), and Knell and Stix (2006) compile the results of a significant number of applied studies on money demand. In these studies, the authors summarize various views on why it is important to study the demand for money and outline the main features that bring the developed theoretical models closer to each other. For example, in these studies, the authors show that in theoretical models based on the quantity theory of money, the income elasticity of the demand for money should be close to unity (Friedman, 1976). On the other hand, according to the inventory approach (Baumol, 1952), it is claimed that the value in question is significantly lower than the unit (close to 0.5) and significantly larger than the unit according to the portfolio approach.

In the context of factors affecting money demand, Knell and Stix (2005) draws attention to the importance of asset prices and wealth. As a result of the relationship between these variables and money demand, monetary aggregates can increase more than income without creating inflationary pressure. This leads to larger money demand elasticity estimates from the unity and is called the wealth effect on money demand. The mentioned study compiles the information and results of 381 empirical studies conducted for 16 OECD member countries between 1970 and 2000. It is striking that although the income elasticity of money demand in the average sense is close to unity, the standard deviation of the estimates is high (0.37). Knell and Stix (2006), expanding their previous study by including developing countries, determined that there is a greater dispersion (0.53 standard deviation) in terms of income elasticity in these economies. The median of the estimated money demand income elasticity in the analyzed studies is 1.12 for OECD member countries and 0.96 for non-member countries. According to the authors, this result is due to portfolio choice decisions that affect the behavior of money demand. In the study, by examining the semi-interest elasticity of money demand, a negative sign is determined in accordance with theoretical expectations. This elasticity value varies between -0.007 and -0.45 depending on the country, monetary aggregate, and estimation method used.

Hamori and Hamori (2008), examines the demand for money for 11 countries in the Euro area in terms of M1, M2, and M3 monetary aggregates in a sample covering the period 1999-2006. The results obtained indicate the

stability of money demand, while the elasticity values differ depending on the size of the economies studied and the degree of development of the financial markets. The highest income elasticity coefficient is obtained for France, the lowest for Ireland, while the highest semi-interest elasticity is estimated for Italy and the lowest for Luxembourg. In the panel of these countries, the income and interest elasticities of money demand are estimated to be 2.55 and -0.55, respectively.

Setzer and Wolff (2013), estimates the money demand function for the period 2003 - 2008 using the dynamic least squares method in a panel of Euro area countries. The statistical evidence obtained indicates an income elasticity coefficient of 1.67. In the estimated model, the opportunity cost elasticity varies between -0.09 and -0.23 depending on the indicator used (short-term interest rate, long-term interest rate, or interest rate differential). In the study, it is determined that when the sample is changed to cover the 2001 - 2008 and 2004 - 2008 periods, the results change in terms of income elasticity. The authors take this finding as an indication of the instability in the Euro area money demand in the mentioned decade. On the other hand, this study emphasizes that the behavior of the demand for money can be explained better by factors such as portfolio composition, wealth, and financial innovations that affect the preferences of economic agents other than traditional factors (like income and interest rate).

Jawadi and Sousa (2013), estimates the money demand function using the quantile regression method within the framework of smooth transition models in a study covering the USA, UK, and Euro Zone countries. The first result obtained in this study is that the income and interest elasticities of money demand differ according to the estimates obtained by the least-squares method. This situation indicates the presence of asymmetry in the responses of households to changes in macroeconomic factors such as inflation and economic growth. For example, according to the results obtained, while real money balances are low, the sensitivity of money demand against inflation tends to be high. The authors reveal the existence of asymmetry and nonlinearity in money demand by considering smooth transition models. All these findings reveal the existence of elasticity coefficients that change over time. This change occurs not only according to the regime in the economy but also depending on the country considered. In the study, it is emphasized that the income elasticity coefficients obtained in the range of 1.033 - 1.826 for the Euro Area and 1.712 - 2.055 for the UK indicate the presence of wealth effect. Evidence for the US shows that demand for money is first-order homogeneous with respect to income. Accordingly, the change in income will be reflected in the money demand in the same direction and at the same rate. However, to have a wealth effect, the increase in income must cause a higher increase in the demand for money. In the study, quite low-interest elasticity values varying between -0.0003 and -0.12 are obtained for all three countries.

It is quite common to obtain a greater income elasticity coefficient from unity, indicating the existence of a wealth effect for developing countries. Valadhani (2008) and Rao and Kumar (2009) state that financial innovations, institutional reforms, and financial market expansion in these countries after the 1990s are among the reasons for this situation. Carrera (2016), considers a panel of 15 Latin American countries and estimates the income and interest elasticity of money demand for this group of countries as 0.94 and -0.08, respectively. In this study, country-based estimates are also made and it is determined that while the interest rate elasticity of money demand does not differ greatly between countries, income elasticity values differ significantly. For example, income elasticity values are greater than 1 for Brazil, Guatemala and Venezuela, and smaller than unity for Mexico and Bolivia. In their analysis of money demand for Indonesia, Malaysia, and Singapore, Bahmani and Rehman (2005) estimates the income elasticity of money demand greater than 1 in all three of these countries and emphasizes the instabilities in money demand parameters. Ewing and Payne (1999) estimates the money demand function by considering the 1980-1996 period in their study for Chile. According to the estimation results, the income elasticity of the money demand is determined as 1.407 and the interest elasticity as -0.156. Rao and Kumar (2009) estimates income elasticities ranging from 0.85 to 3.12 and interest elasticities ranging from -0.01 to -0.06 using a panel of 14 emerging Asian economies. Narayan *et al.* (2009) estimate money demand functions for Bangladesh, India, Pakistan, Sri Lanka, and Nepal and determine a long-term equilibrium relationship between real money balances and income, real exchange rate, domestic interest rate, and international interest rate. Estimation results indicate the income elasticity of the demand for money in these countries as 1.269 and the interest rate elasticity as -0.02, on average.

There is also extensive literature related to Turkey which focuses on estimating money demand and analyzing the stability of it. Obtained results differ depending on estimation methodology, data set used and period considered. Prominent ones among these studies are briefly evaluated below.

Halicioglu and Ugur (2005), through the ARDL method for the 1950 - to 2002 period, estimate the money demand function in Turkey. As a result of estimation including the nominal foreign exchange rate in addition to income and interest rate among the explanatory variables, it is concluded that the demand for money is stable during the study period. According to the estimation results from which coefficients with signs consistent with theoretical expectations are obtained, income, interest, and nominal exchange rate elasticities are 0.94, -0.01, and -0.05, respectively. Ozcelik (2014), using the ARDL methodology, draws attention to the short and long-term stability of money demand in his estimation for the period 1995-2013, but does not include a variable that represents the effect of price changes among the explanatory variables. For this reason, the coefficient estimates obtained are far from reliable in terms of magnitude and sign. However, Altintas (2008) and Gencer and Arisoy (2013) obtain coefficients in line with the theoretical expectations with the same methodology and reach the conclusion that there is stable money demand. The first of the mentioned studies uses quarterly data covering the period 1985 - 2006, the second one uses data with the same frequency for the 1989 – 2010 period. The results obtained by Korkmaz and Topbas (2017), using the same methodology, point to the existence of stable money demand for narrowly defined monetary aggregate and an unstable money demand for broadly defined monetary aggregate. Atgur and Altay (2015) and

Tuzun *et al.* (2017), by using ARDL and time-varying cointegration techniques reach the conclusion that proves the presence of an unstable money demand function in Turkey.

In the study conducted by Altintas *et al.* (2013), the stability of the money demand is investigated through the CUSUM and MOSUM tests. In the estimates based on 2001-2011 data, a meaningful long-term equilibrium relationship among money demand, income, interest rate, and the real exchange rate is determined through linear cointegration tests, and the stability of the money demand hypothesis is rejected.

In the estimation of money demand by using dynamic least squares (DOLS), fully modified least squares (FMOLS) and vector error correction model (VECM), Dogru and Receroglu (2013) obtains elasticity values (0.873 for income, -0.992 for interest rate) in line with theoretical expectations and point out the existence of a rapid adjustment process. This situation is accepted as an indicator of instability in money demand for the 1980-2012 period. Using the same estimation method (DOLS), Tumturk (2017) concludes the existence of instability for various linear money demand functions through annual data for the 1970-2013 period. The income and interest elasticity coefficients are around 0.7 and -0.5, respectively.

Ozdemir and Saygili (2009), used various linear estimation methods (OLS, Hamilton DOLS, Stock-Watson DOLS, GLS, Kalman filter) to estimate money demand within the framework of the *P** model for the period 1990 - 2007. The estimation results produce income elasticity ranging from 1.64 to 2.090 for money demand, interest elasticity values varying between -0.001 and -0.008, and attention is drawn to the presence of wealth effect. The authors argue that the results obtained indicate the existence of a predictable (and therefore stable) long-term real money demand.

In his study inquiring about the homogeneity of money demand in terms of income and price level, Koralp (2010) rejects the hypothesis of unit income elasticity for broadly defined monetary aggregates. Findings obtained reveal that interest rate is statistically significant only in the cointegrating vector for the broad definition of monetary aggregates.

Mutluer and Barlas (2002), estimates the money demand function with the ECM method for the period 1987-2001 using the broad-defined money supply, including foreign currency deposits. According to the long-term results obtained, money demand is homogeneous in terms of income; exchange rate and inflation are the main macroeconomic determinants that adversely affect money demand. The obtained interest elasticity coefficients are statistically significant but quite close to 0. Civcir (2003), through a VAR model, examines the relationships among monetary aggregates, real income, interest rate, inflation, and expected exchange rate for the 1987-1999 period in Turkey. As a result of the estimates, the demand for money has a unitary income elasticity and exhibits stability. Saatcioglu and Koralp (2005), in their study covering the period 1987-2004, estimate the traditional money demand function through the VAR model using a broadly defined monetary aggregate including foreign currency deposits. In the study, which determines the long-term equilibrium relationship between money demand and income, interest rate, prices, exchange rate, the estimated VECM produces a statistically insignificant income elasticity coefficient and inflation is determined as the main variable affecting money demand. The authors provide empirical evidence that the demand for money was stable during the sample period. By using the VECM methodology, Bahmani and Karacal (2007) and Sevuktekin and Nargelecekenler (2007) reveals the existence of stable money demand functions for Turkey. However, in Akcaglayan and Atbasi (2008) study, which examines the money demand function through cointegration analysis, it is concluded that the demand for money is unstable. Covering the 1989 - 2010 period, Dritsaki and Dritsaki (2012) determine the presence of unstable money demand in Turkey through the VAR model. According to the authors, this is the most important factor limiting the effectiveness of the monetary policy. The long-term coefficients obtained have signs in line with theoretical expectations but are statistically insignificant. In a more recent study using a similar methodology (Akkus, 2019) estimated linear money demand function for M1, M2, and M3 monetary aggregates utilizing 2000 - 2017 data for Turkey. While the inflation rate stands out as the main variable that determines the money demand, the homogeneity of money demand in terms of income and prices is rejected. According to the author, all money demand functions estimated for the sample period are unstable.

All of the studies summarized above estimate the money demand function using linear models. In the study employing a non-linear approach, Baktemur (2019) estimates the money demand function in Turkey with cointegration analysis. In this study, the nonlinear cointegration test technique proposed by Kapetanios *et al.* (2006) is used and the results are compared with the linear cointegration tests. While the long-term equilibrium relation is determined among money demand, income, interest rate, and prices in the nonlinear model, this equilibrium relation cannot be established in the linear model. Based on the existence of this long-term relationship, the author concludes that a broadly defined monetary aggregate will be a proper indicator for monetary policy.

3. Theoretical Model

The relationship among the amount of money (M), the level of production or income (Y), and a measure of the cost of money (such as inflation or interest rate) in the economy is an area that has been most extensively studied in the economics literature. As stated by Carrera (2016), there are several correct answers to the question of which theoretical approach explains the relationship among these variables best. While one of the possible answers is the aggregate demand theory ($\frac{M}{P} = \gamma Y$) according to Blanchard and Fisher (1989) and Blanchard (1997), another may be the quantity theory of money ($MV = PY$). If the relationship between these variables is explained by quantity theory, there is no single answer to the question as to which one will be used as an endogenous variable, too. The quantity theory can be evaluated as a money demand theory $\left(M = \frac{1}{V} PY\right)$ Friedman (2010) or as a theory for

determining the general level of prices $\left(P = \frac{MV}{Y}\right)$ Barro (2007). Apart from these, quantity theory can also be considered as a theoretical approach for determining the income level (MacCallum and Goodfriend, 1989).

In this study, the quantity theory of money is considered as a money demand theory, and a functional form of this theory is predicted. Bae *et al.* (2006) and Bae and DeJong (2007) discuss alternative functional specifications. In general terms, the functional form to be estimated is as follows:

$$M^d = f(P, Y, r) \quad (1)$$

$$M^d = \alpha_i + \beta_{1,i}P + \beta_{2,i}Y + \beta_{3,i}r \quad (2)$$

In these equations, M^d denotes nominal money balances, P the general level of prices, Y the volume of production or real income, and r the nominal interest rate. The i subscript in the coefficients means that the elasticities may change over time and will depend on the regime in which the economy operates. In order for these coefficients to express their elasticity values, the logarithmic transformation of the data to be used is required. In most money demand specifications (Ball, 2001; Lucas, 1988; Stock and Watson, 1993) the interest rate is included in the model without logarithmic conversion. However, considering the nonlinearity of the money demand function, it is seen that the interest rate is included in the model by making a logarithmic transformation (Bae *et al.*, 2006; Bae and DeJong, 2007). This issue is often associated with traditional models of cash demand (such as Baumol (1952) and Tobin (1956). Accordingly, although f in equation (1) is generally accepted as linear, it can be any functional form. Based on the existence of extensive literature dealing with the estimation and stability of the linear demand for money function, the nonlinear functional form is used in this study as emphasized by Lutkepohl (1993), Calza and Souza (2003), and Bahmani and Rehman (2005). Since this preference allows modeling money demand with time-varying coefficients it will contribute to the literature related to Turkey.

As we discussed when reviewing the recent Turkey-related empirical literature, mostly preferred methodology in the demand for money estimation is the use of linear techniques. Although alternative explanatory variables are used to represent factors determining the money demand in these studies, financial innovations are generally not included in the model. However, as stated by Ozdemir and Saygili (2010), the adjustment process to economic uncertainties and financial innovations is among the factors affecting the stability of money demand. In this study, the use of nonlinear function (f) in the estimation stage and the change in coefficients depending on the i regime allow modeling the changes in financial innovations mentioned by Sevuktekin and Nargelecekenler (2007) and (Ozdemir and Saygili, 2009). Apart from this, it is aimed to evaluate an alternative functional form by estimating one of the first-order conditions of the model proposed by Kim (2000). According to the model developed by Kim (2000), a consumer maximizing the utility function which is formed depending on the real consumption decision and the preference on the amount of real money held is considered:

$$max\ E_0 \sum_{t=0}^{\infty} \beta^t\, U\left(C_t, \frac{M_t}{P_t}\right) \quad (3)$$

Where β, C_t and M_t/P_t denote discount factor, real consumption, and real money balances, respectively. Utility maximization occurs under a budget constraint that considers two types of income: Real income equal to Y_t that the individual earns each period and real interest income equal to R_t from the bonds he/she owns (B_{t-1}). Although the individual has the ability to transfer his wealth from one period to another by holding money, this preference does not generate any interest or dividend income:

$$C_t + \frac{B_t}{P_t} + \frac{M_t}{P_t} = Y_t + R_t\frac{B_{t-1}}{P_t} + \frac{M_{t-1}}{P_t} \quad (4)$$

If we accept that the traditional Fisher equation holds, we can write the real interest rate as follows:

$$R_t = \frac{1 + r_t}{1 + \pi_{t+1}} = (1 + r_t)\frac{P_t}{P_{t+1}} \quad (5)$$

In this equation, r_t denotes the nominal interest rate and π_t indicates the inflation rate. According to this equation, the change in inflation resulting from a change in the quantity of money causes a change in the nominal interest rate in the same direction and rate. This means that inflation does not affect the real interest rate. In this case, the first-order conditions of the optimization problem allow us to obtain the marginal rate of substitution between real money balances and real consumption amount as follows:

$$\frac{U'_{\frac{M}{P}}}{U'_C} = \frac{r}{(1 + r)} \quad (6)$$

In order to obtain an analytical solution, as suggested by Setzer & Wolff (2013), we assume a constant relative risk aversion (CRRA) type of utility function to have:

$$U\left(C_t, \frac{M_t}{P_t}\right) = \frac{C_t^{1-\sigma} - 1}{1 - \sigma} + b_t^{\delta}\frac{\left(\frac{M_t}{P_t}\right)^{1-\gamma} - 1}{1 - \gamma} \quad (7)$$

In this utility function, in addition to those previously described, b_t^{δ} models the change in an individual's money holding preferences. Combining equations (6) and (7) and solving for real money balances allow us to obtain the following money demand function:

$$ln\left(\frac{M_t}{P_t}\right) = \frac{\sigma}{\gamma}ln(C_t) - \frac{1}{\gamma}ln\left(\frac{r_t}{1 + r_t}\right) + \frac{\delta}{\gamma}ln(b_t) \quad (8)$$

Nominal money balances will be written as:

$$lnM_t = lnP_t + \frac{\sigma}{\gamma} ln(C_t) - \frac{1}{\gamma} ln\left(\frac{r_t}{1+r_t}\right) + \frac{\delta}{\gamma} ln(b_t) \quad (9)$$

The above-specified model asserts that nominal money demand is determined depending on the price level, real income (given that Y = C in the long-term equilibrium), the opportunity cost of holding money, and an exogenous component related to the preferences to hold money. Considering the equations (1) and (9), the model which is nonlinear in parameters to be estimated in this study can be written as follows:

$$m_t^d = \beta_{0,i} + \beta_{1,i} p_t + \beta_{2,i} y_t + \beta_{3,i} \frac{r_t}{1+r_t} + \beta_{4,i} b_t \quad (10)$$

In the above model, there is no consensus on what variables should represent the opportunity cost of money and the money holding preferences of economic agents. For example, in some studies short and long term interest rate differential or one of them is used to represent opportunity cost (Gaab and Liedtke, 1990; Sarno, 1999), while in others, expected depreciation in the exchange rate is preferred (Bahmani, 1991; Hamburger, 1966). On the other hand, there are studies that use inflation expectations or inflation volatility to represent the opportunity cost of money (Austin *et al.*, 2007; Bahmani and Tanku, 2006; Budina *et al.*, 2006; Slovin and Sushka, 1983). Since it is a variable that cannot be directly observed, it is seen that different variables are used to represent the money holding preferences. For instance, ATM numbers in Sichei and Kamau (2012), ratio of private sector credits to GDP in (Michalopoulos *et al.*, 2009), M2/M1 ratio in Hye (2009) is used as a proxy to represent this unobservable component. In this study, the 90-day deposit rate (due to the availability of data covering the entire period) will be used to represent the opportunity cost of money while the ratio of currency in circulation to total deposits is used as a proxy representing money holding preferences of economic agents.

4. Estimation Methodology

The following smooth transition cointegration model proposed by Saikkonen and Choi (2004) will be used in the estimation of the nonlinear model in the parameters given in equations (9) and (10):

$$y_t = \mu + \alpha' x_t + (\mu_{nl} + \alpha'_{nl} x_t) g\left[(x_{s,t} - c); \gamma\right] + u_t \quad (11)$$

where y_t is an *I(1)* variable, x_t is a column vector of order k of non-stationary series, u_t the stationary error term with zero expected value and $g\left[(x_{s,t} - c); \gamma\right]$ is the smooth transition logistic function. This logistic function depends on the variable $x_{s,t}$ and the vector of parameters defined as $\theta \equiv (c, \gamma)'$. Consequently, smooth transition logistic function is described as:

$$g(x_{s,t}; \theta) \equiv \frac{1}{1 + e^{-\gamma(x_{s,t} - c)}} \quad (12)$$

For the model specified in (11), the consistent estimator is the nonlinear least-squares method. However, in the context of cointegration, there is a serial or simultaneous correlation between the explanatory variables (x_t) and the error term (u_t). As stated by Choi and Saikkonen (2004), the nonlinear least-squares method is a consistent but inefficient estimator due to the endogeneity problem in the estimation of the specified model. In order to solve this problem and obtain an estimator that allows for inference, the aforementioned authors propose a two-step estimator. In the first stage, the estimation of the specified model is performed by the nonlinear least-squares method and the first parameters group in terms of λ^{1s} and residuals $(\hat{u}_t)$ are obtained. In the second stage, $\lambda^{2s} = \lambda^{1s} + \beta$ becomes a consistent and efficient estimator. In this case, asymptotically, conventional statistics (such as t-test, autocorrelation, and heteroscedasticity tests) can be used to make inferences.

5. Estimation of Demand for Money

5.1. Data

In the estimation of the developed model, the monetary aggregate (m^d) is represented by the M1 money stock definition, the general price level (p) is represented by the consumer price index, income level (y) is presented by industry production index (due to lack of monthly GDP series), nominal interest rate (r) is represented by the 90-day deposit interest rate and money holding preferences of economic units (b) is represented by the ratio of currency in circulation to total deposits. All of the monthly data on the relevant variables covering 1986: January - 2020: December sample period were obtained from the Central Bank of the Republic of Turkey digital database. Appendix 1 at the end of the study provides a detailed description and sources of the data used. All of the raw data (excluding interest rate) are adjusted for seasonal fluctuations using the Tramo - Seats method and included in the model logarithmically (excluding interest rate). The general tendencies and statistical features of the relevant time series in the sample period can be followed in Appendix 2 at the end of the study.

5.2. Estimation Results

As stated while discussing the estimation method, the time series used should not be stationary and the dependent variable should exhibit the I(1) property. Table 1 shows the results of the traditional unit root tests and the unit root test results proposed by Breitung (2002), which is used to test the presence of a common unit root in time series. According to the results, all of the time series used are not stationary at individual and common levels. On the other hand, the *m1* series which is used to represent money demand does not have a unit root in the first difference of log level.

Table-1. Results of Unit Root Tests

Variable	ADF			PP			DF min-t		
	lag[a]	t-stat.	Probability	band[b]	t-stat.	Probability	lag[a]	t-stat.	Probability
m1	5	1.2420[c]	0.8997	13	1.1779[c]	0.9128	1	4.4992	0.1309
Δm1	5	3.6694	0.0049	14	18.2303	0.0000	0	18.1107	0.000
p	5	1.0156	0.9395	14	0.3684	0.9884	1	4.1024[c]	0.3119
y	4	0.3402	0.9160	5	0.4148	0.9037	4	2.1558	0.9683
r	0	2.0389	0.2702	18	1.4265	0.5698	0	4.0860	0.1457
b	0	1.5838	0.4900	6	1.5120	0.5268	0	3.9210[c]	0.2051
Common	0-5	2.5166[d]	0.9941						

Notes: a. Optimal lag length is determined by using Schwarz criteria.
b. Optimal bandwidth is determined by using Newey-West criteria.
c. Includes trend
d. Indicates the t-statistic for a common unit root proposed by Breitung (2002)

Table-2. Results of Cointegration Tests

Test	τ statistic	Probability	z statistic[a]	Probability
Choi – Saikkonen[b]	1.8250	0.3713	23.5475	0.4501
Phillips – Ouliaris[c]	6.9714	0.0000	89.9503	0.0000

Notes: a indicates normalized autocorrelation coefficient.
b H_0: Time series are cointegrated.
c H_0: Time series are not cointegrated

Table 2 summarizes the results of the tests to verify the existence of a cointegrated relationship among the time series used in the model. According to the results of both tests performed, the time series considered are cointegrated. At this stage, it is necessary to test whether the cointegrated relationship is linear or not. The tests suggested by Choi and Saikkonen (2010), Terasvirta (1994), and Escribano and Jorda (1997) will be used for this purpose. In fact, the Choi - Saikkonen and Teresvirta tests are similar because they use Taylor expansions to determine the effect of nonlinearity. The results of these tests are summarized in Table 3. All of the linearity tests performed prove that the relationship among the variables is not linear at a high level of statistical significance.

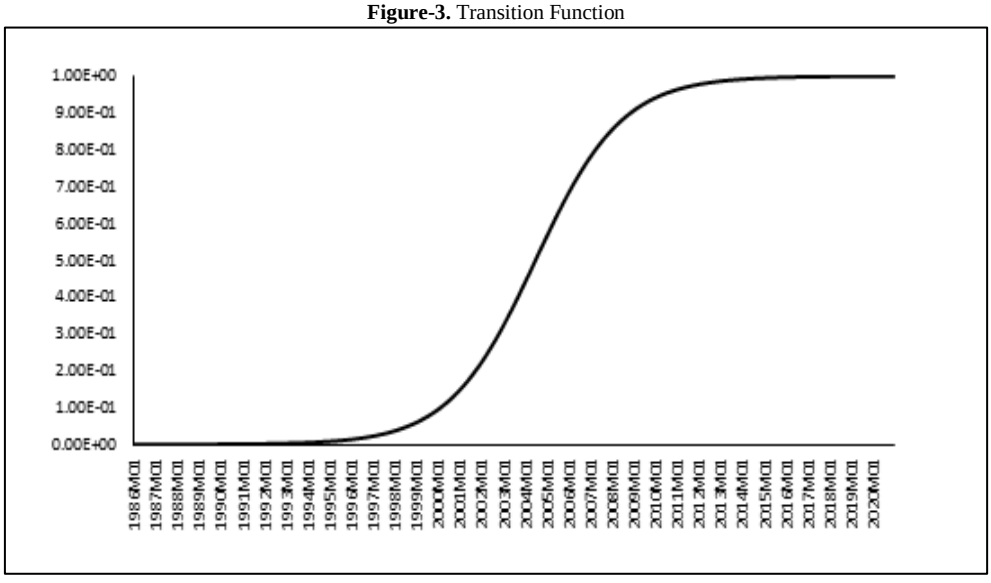
Table-3. Linearity Test Results for Cointegrating Relationship

Test	F statistic[a]	Degrees of Freedom	Probability
Choi - Saikkonen	27.3613	(9, 391)	0.0000
Terasvirta	15.7976	(5, 395)	0.0000
Escribano - Jorda	13.0591	(5, 390)	0.0000

Note: a For all three tests: H_0: Cointegrating relationship is linear.

The estimated transition function related to the developed model to see the regime properties of the variables that direct the money demand dynamics in Turkey is given in Figure 3. The transition variable ($x_{s,t}$ in Equation 11) used is the consumer price index. The statistical evidence and transition function obtained clearly point to a regime change that started in the mid-90s. This situation confirms the existence of nonlinear elements that characterize the demand for money.

Figure-3. Transition Function



Considering the fact that the estimated transition function reaches unity at the end of the sample period and varies between zero and 1 throughout the analyzing period, it is confirmed that the demand for money in Turkey has

an unstable structure. In fact, switching between regimes (the period between the end of 1994 and the end of 2012) shows the time-varying nature of the relationship demand for money and its determinants. Despite the instability we have determined for the entire sampling period, we can decompose 3 periods in Figure 3: (1) Stability period before 1995 (we will call this period lower regime), (2) Transition period covering years between 1995 and 2012 in which transition function fluctuating between 0 and 1 clearly points out instability, and (3) Stability period since 2013 (we will call this period the upper regime).

Table 4 shows the coefficients of the non-linear money demand function estimated for the two specified regimes. As seen in the table, the factors determining the money demand have statistically significant coefficients in both regimes. According to the literature review discussed earlier, the signs of the coefficients are consistent with theoretical expectations. While income and price elasticities show that these variables affect money demand positively, the existence of inverse relationships between the interest rate and money holding preferences and money demand are proved. The numerical magnitude of the determined relationships changes over time depending on the regime. This situation can be considered as an indication of the instability in the demand for money. If it is remembered, the upper regime denotes a stable period in the demand for money, corresponding to the 2013-2020 period in Figure 3. This situation can be evaluated as the inflation targeting strategy contributes to the stability of money demand, albeit with a delay.

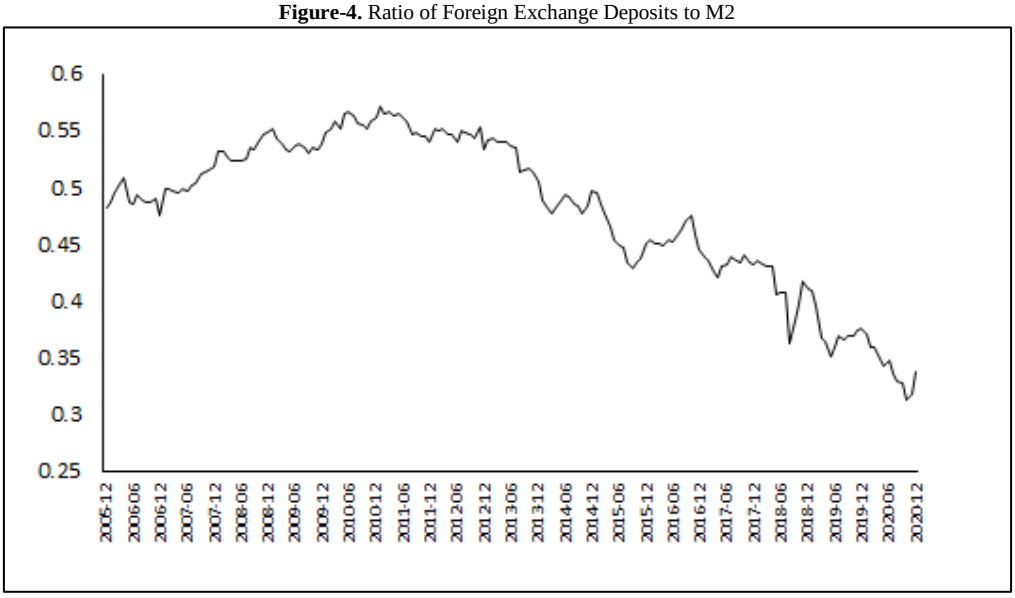
Table-4. Money Demand Function Estimation Results

Coefficient	Lower Regime			Upper Regime		
	Estimate	t statistic	Marginal Significance	Estimate	t statistic	Marginal Significance
β_0	-4.5390	2.1846	0.0024	-0.2789	2.6086	0.0096
β_1	0.9379	6.9088	0.0000	0.8511	3.1240	0.0021
β_2	1.7458	3.8480	0.0000	3.0019	1.8532	0.0650
β_3	-0.3344	3.4201	0.0001	-0.5521	2.3513	0.0195
β_4	-6.5217	4.1721	0.0000	-1.6404	4.3392	0.0000
Estimated nonlinear model: $m_t^d = \beta_{0,i} + \beta_{1,i} p_t + \beta_{2,i} y_t + \beta_{3,i} \frac{r_t}{1+r_t} + \beta_{4,i} b_t$						

When the first-order homogeneity of the demand for money in prices and income is examined, the statistical evidence obtained is not certain to make a judgment. The hypothesis $\beta_{1,i} = 1$, which states that the demand for money is first-order homogeneous in terms of prices, needs to be tested. Hypothesis testing states that the demand for money for the lower regime is first-order homogeneous and not homogeneous for the upper regime. The hypothesis $\beta_{2,i} = 1$ tested in terms of income is rejected for both regimes.

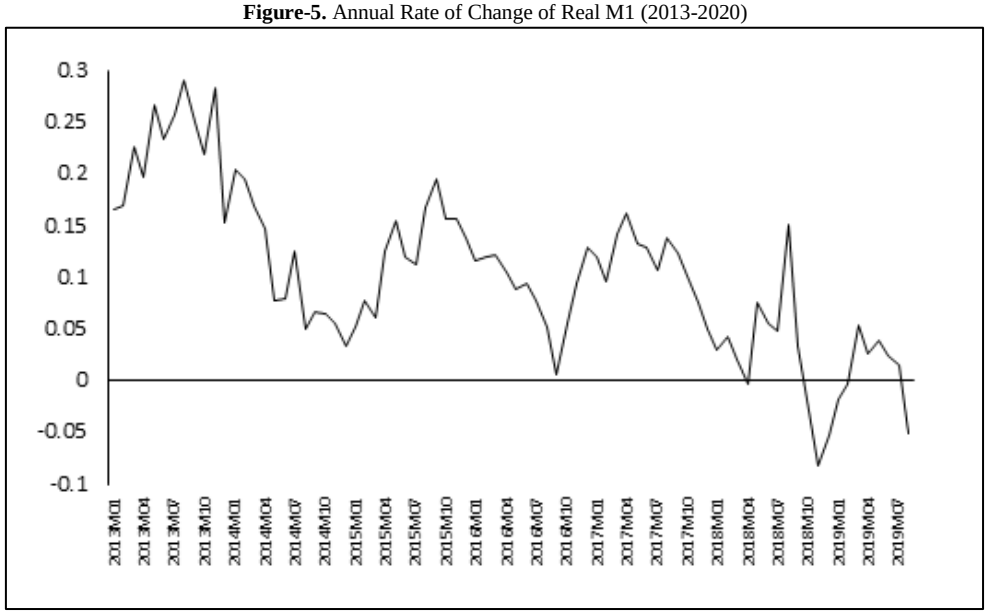
When a comparison is made between the determined regimes, the following results are observed: The price and opportunity cost elasticities of the demand for money do not differ greatly between the two regimes. However, the effect of the constant term and money holding preferences on money demand decreases in absolute terms, while the effect of income increases. The change indicating the decrease (from 4.54 to 0.28 in absolute terms) in autonomous money demand and the change indicating the decrease (from 6.52 to 1.64 in absolute terms) in money holding preferences are the changes that play a significant role in stabilizing money demand during the regime process. This situation is a reflection of the financial innovations, the acceleration in financial development, the decline in the inflation rate, and the decrease in political and economic uncertainties experienced in the post-2003 period in Turkey. The indicator that best summarizes these developments in the Turkish economy is the reverse currency substitution experienced in the upper regime period (Figure 4). The figure has been drawn since the end of 2005 in order to give an idea about the situation before the upper regime.

Figure-4. Ratio of Foreign Exchange Deposits to M2



The estimated income elasticity value of the money demand function is 1.75 for the lower regime and 3.00 for the upper regime. Income elasticity values greater than the unity obtained for both regimes indicate the presence of the wealth effect. This situation is consistent with the results obtained by Ozdemir and Saygili (2009) and Sevuktekin and Nargelecekenler (2007). The fact that the macroeconomic factor that most strongly affects the money demand in the upper regime is income partially explains the slowdown in the rate of increase in monetary aggregates recently in Turkey (see Figure 5). The instability in economic growth experienced in the same period caused the economy to grow below its potential. Combined with the supply shocks arising from the recent pandemic, this situation caused inflation to remain above the target in this period and consequently caused a reaction in monetary policy interest rates. In this environment, the effect of the fall in income seems to be more dominant than the effect of weak behavior observed in monetary aggregates.

Figure-5. Annual Rate of Change of Real M1 (2013-2020)



In future studies, variables such as exchange rate, asset prices (especially housing and stock prices) can be included in the model to be estimated, and the reasons for the above-explained situation can be revealed more clearly. It is known that increasing capital inflows to Turkey since the second half of 2020 caused increasing asset prices and increasing volatility in exchange rates. This point may be in a strong connection with changes in the value of wealth stock in the Turkish economy.

6. Conclusion

In the last two decades, a transformation has taken place in the form of using interest rates as an instrument instead of monetary aggregates in the implementation of monetary policy within the framework of inflation targeting strategy. The main reason behind this transformation in the international literature is the instability of the estimated money demand function for various monetary aggregates. Other factors behind this instability include the increase in household savings and credit use and the change in the money balances of firms. Apart from this, increasing borrowing opportunities, difficulties in finding low-risk assets, and complexity of risk management are among the factors that affect the demand for money. These factors, together, have led to difficulties for monetary authorities since the use of monetary aggregates as intermediate targets is a very complex task in the inflation targeting regime. On the other hand, as the changes in interest rates create changes in the value of assets and portfolios, it has become difficult to determine the wealth effect, which is one of the factors affecting the money demand function, especially in developing economies.

This study reveals the statistical evidence regarding the instability of money demand in Turkey covering the 1986-2020 period. This result is obtained through the nonlinear cointegration model including the soft transition function. The method shows that there are two separate regimes in the analyzing period. These regimes can be associated with changes in money holding preferences and financial innovations. The model used allows us to determine the changes that will occur according to the regime in the parameters related to price, income, interest elasticities, and money holding preferences.

It was observed that the coefficients obtained in all of the realized estimates were statistically significant. In accordance with the international literature, changes in the preference of economic agents to hold money appear to have an adverse effect on money demand. In the upper regime, which is related to the last decade, the effect of the preference changes on the demand for money is lower than in the late 80s and early 90s. The evidence to confirm the hypothesis that demand for money is first-order homogeneous with respect to prices is uncertain. Conversely, in terms of income, there was no evidence to support this hypothesis in either regime. The elasticity of opportunity cost (the interest rate used in this study) supports that it has a negative effect on money demand. Like the price elasticity, the opportunity cost of money elasticity does not display a big change between lower and upper regimes although there is a small increase in absolute terms as expected. Since the main instrument is the interest rate within the

framework of inflation targeting strategy applied in Turkey, this conclusion in our opinion is crucial for implementing the monetary policy. That is the reason why we insist that monetary transmission mechanisms should be investigated in a more detailed manner. Evidence regarding income elasticity of demand for money in Turkey implies the existence of the wealth effect.

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Appendices

Appendix 1: Definitions and Sources of the Data Used

Symbol	Explanation
M1	Definition: Narrow definition of the money stock Content: Currency in circulation + Demand deposits in the banking system* Transformation: Seasonal adjustment** – logarithm Period: 1986: January – 2020: December Source: CBRT – EDDS and EDDS Archive***
P	Definition: Consumer price index (1986=100) Content: Built by using 1987=100, 1994=100 and 2003=100 indices. Transformation: Seasonal adjustment – logarithm Period: 1986: January – 2020: December Source: CBRT – EDDS and EDDS Archive
Y	Definition: Industrial production index (1986=100) Content: Built by using 1992=100, 1997=100 and 2015=100 indices. Transformation: Seasonal adjustment – logarithm Period: 1986: January – 2020: December Source: CBRT – EDDS and EDDS Archive
r	Definition: Nominal interest rate Content: 90-day deposit interest rate Transformation: None Period: 1986: January – 2020: December Source: CBRT – EDDS and EDDS Archive
b	Definition: Money holding preferences of economic agents Content: Ratio of currency in circulation (CUR) to total deposits (TD) Transformation: First difference of seasonally adjusted log level of CUR and TD Period: 1986: January – 2020: December Source: CBRT – EDDS and EDDS Archive

Notlar: * Considering the definition changes made by the CBRT in 2006, it has been updated for the current definition.

** All seasonal adjustments have been carried out by using the Tramo-Seats methodology.

*** EDDS refers to the electronic data delivery system of CBRT.

Appendix-2. General Tendencies and Descriptive Statistics of the Time Series Used

Figure-App.2.1. M1 Money Stock

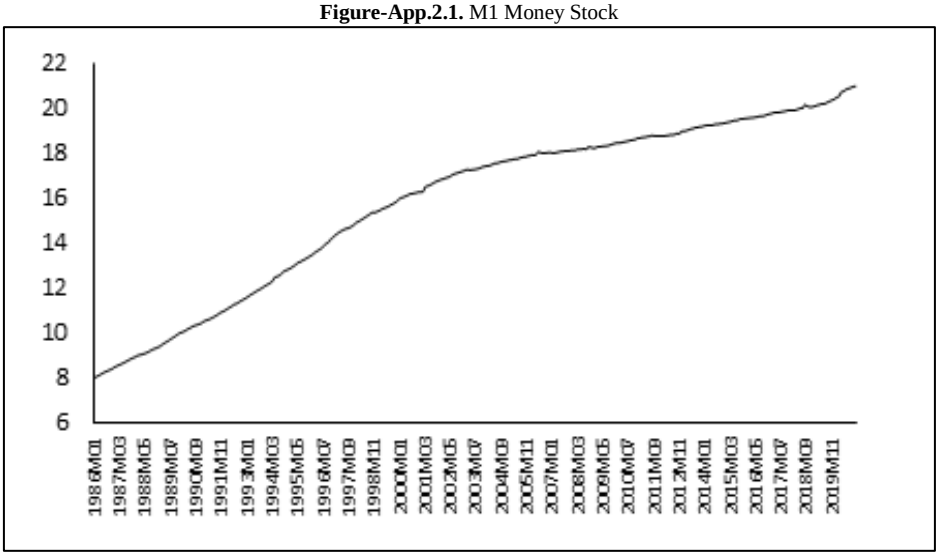

Figure App-2.2. General Price Level

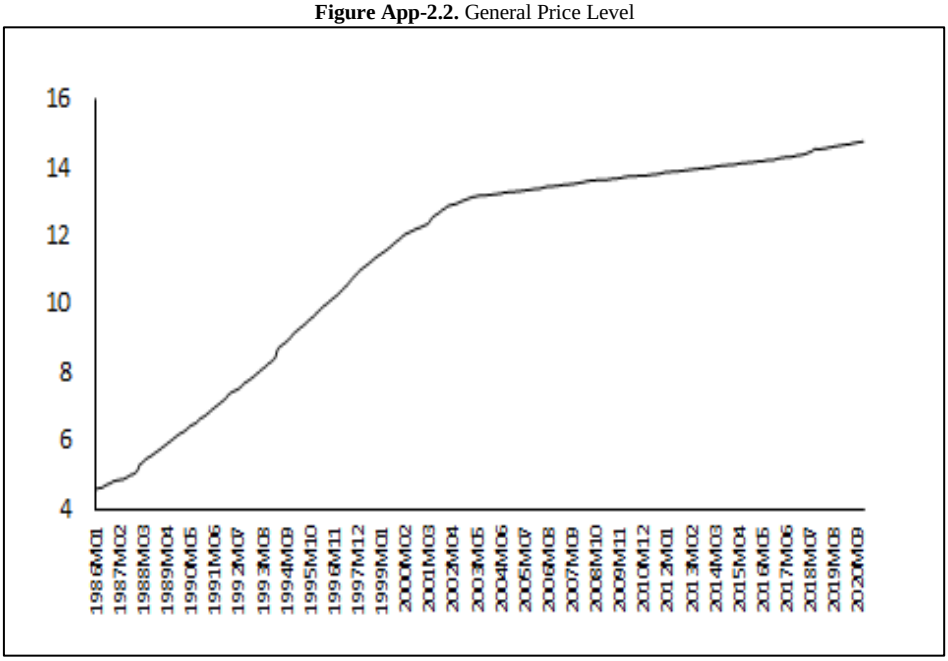

Figure App-2.3. Industrial Production Index

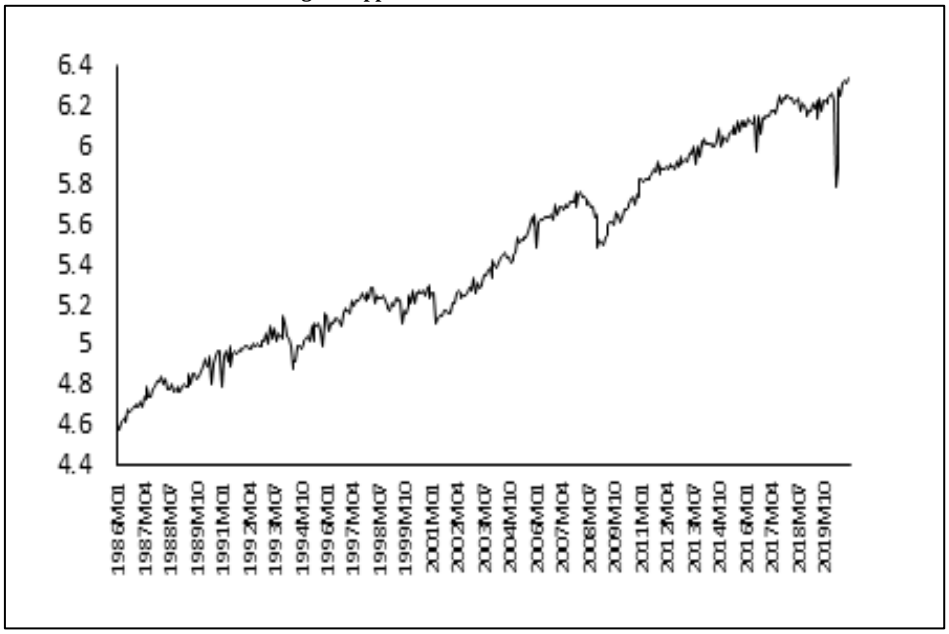

Figure App-2.4. Interest Rate

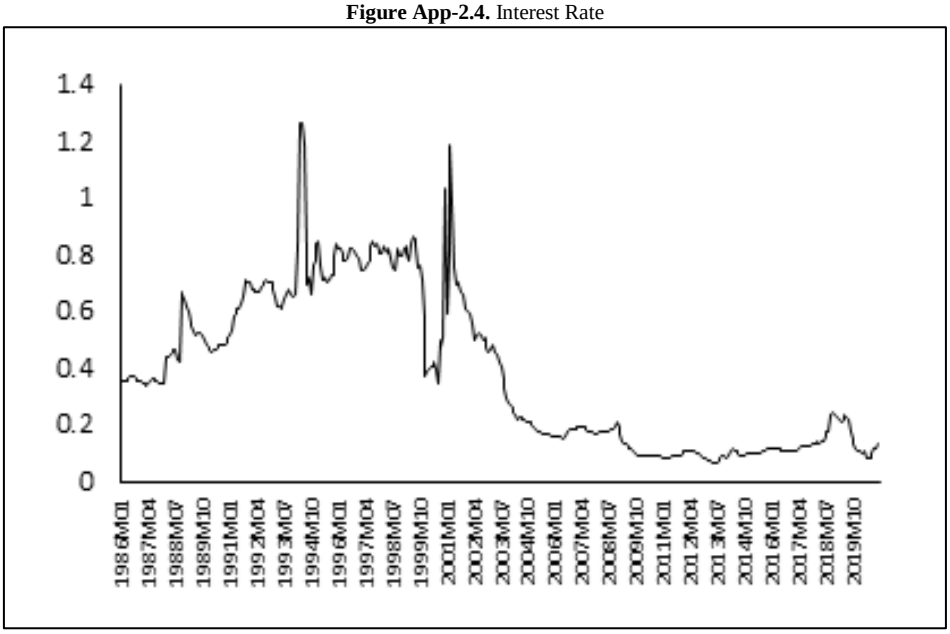

Figure App-2.5. Money Holding Preferences

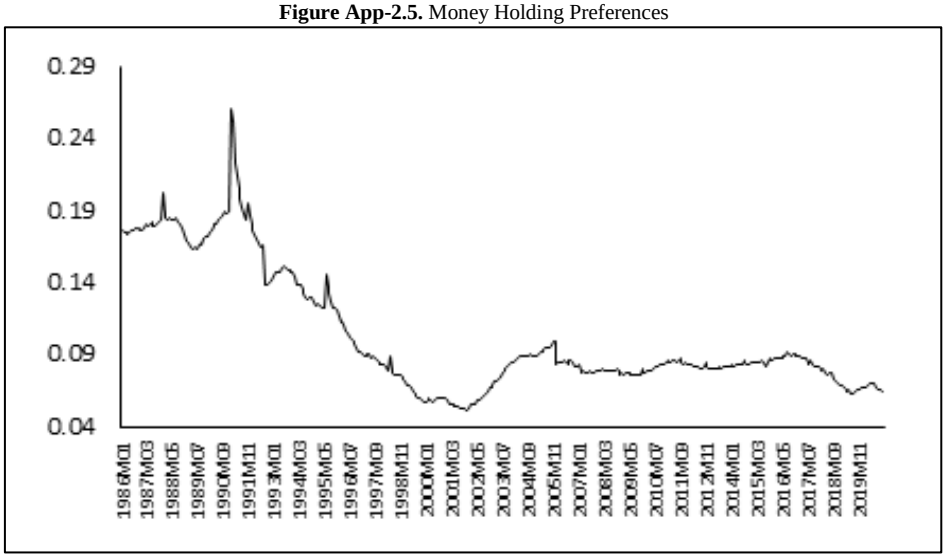

Table-App.2.1. Descriptive Statistics of Time Series Used

Indicator	***m1***	***p***	***y***	***r***	***b***
Mean	15.82246	11.40649	5.448478	0.384374	0.103564
Median	17.27801	13.17544	5.338419	0.343262	0.084841
Maximum	20.97173	14.75489	6.334024	1.265682	0.260791
Minimum	7.976136	4.588871	4.573923	0.064609	0.050890
Standard Dev.	3.763777	3.174766	0.479623	0.278621	0.043115
Skewness	-0.649870	-0.859923	0.180834	0.586103	1.113479
Kurtosis	2.065561	2.260287	1.803432	2.206397	3.074601
Jarque-Bera	44.73703	61.19228	27.28002	34.98426	86.67908
(Probability)	(0.000000)	(0.000000)	(0.000001)	(0.000000)	(0.000000)
Num. of Obs.	419	419	419	419	419