Araştırma Makalesi/Research Article DOI: 10.17065/huniibf.718677

A NONLINEAR UNIT ROOT APPROACH TO MODELLING NEW MONETARY POLICY: EVIDENCE FROM TURKEY

Hacettepe University
Journal of Economics and Administrative Sciences
Vol. 38, Issue 4, 2020
pp. 695-719

Şiyar CANPOLAT
PhD., Bitlis Eren University
Faculty of Economics and Administrative Sciences
Department of Economics
scanpolat@beu.edu.tr
https://orcid.org/0000-0002-6022-2882

Ayşen SİVRİKAYA
Assoc.Prof.Dr., Hacettepe University
Faculty of Economics and Administrative Sciences
Department of Economics
aysens@hacettepe.edu.tr
https://orcid.org/0000-0003-2199-3593

This study is derived from the PhD. Thesis entitled "Determinants of the Monetary Policy Reaction Function: An Application for Turkey", which is completed in Hacettepe University Institute of Social Sciences in 2018.

Abstract: In this study, we investigate the monetary policy reaction function regarding the post-2008 Global Financial Crisis using Turkish data over the period between 2009-2019. The novelty of this study is that we circumvent the unit root problem by applying the nonlinear unit root test, developed by Leybourne et al. (1998). The results imply that the Central Bank of the Republic of Turkey attaches more importance to price stability than the output gap. Moreover, we find that the Central Bank of the Republic of Turkey reacts to the real effective exchange rate, the gross foreign exchange reserves, the total credit volume of the banking sector, and the economic growth. This result is consistent with the new monetary policy in Turkey in the aftermath of the 2008 Global Financial Crisis.

Keywords: *Monetary Policy Reaction Function, Spread, Taylor Rule, Smooth Transition Regression (STR), LNV Methodology.*

Makale Başvuru Tarihi/Manuscript Received: 12/04/2020
Makale Kabul Tarihi/Manuscript Accepted: 06/07/2020

Araştırma Makalesi/Research Article DOI: 10.17065/huniibf.718677

YENİ PARA POLİTİKASININ DOĞRUSAL OLMAYAN BİRİM KÖK YAKLAŞIMI İLE MODELLENMESİ: TÜRKİYE ÖRNEĞİ

Hacettepe Üniversitesi
İktisadi ve İdari Bilimler
Fakültesi Dergisi
Cilt 38, Sayı 4, 2020
s. 695-719

Şiyar CANPOLAT
Dr., Bitlis Eren Üniversitesi
İktisadi ve İdari Bilimler Fakültesi
İktisat Bölümü
scanpolat@beu.edu.tr
https://orcid.org/0000-0002-6022-2882

Ayşen SİVRİKAYA
Doç.Dr., Hacettepe Üniversitesi
İktisadi ve İdari Bilimler Fakültesi
İktisat Bölümü
aysens@hacettepe.edu.tr
https://orcid.org/0000-0003-2199-3593

Bu çalışma, Hacettepe Üniversitesi Sosyal Bilimler Enstitüsünde 2018 yılında tamamlanan "Para Politikası Reaksiyon Fonksiyonunun Belirleyenleri: Türkiye için Bir Uygulama" başlıklı doktora tezinden üretilmiştir.

Öz: Bu çalışmanın amacı 2008 Küresel Finansal Krizi sonrası döneme ilişkin Türkiye'nin para politikası reaksiyon fonksiyonunu 2009-2019 dönemi verilerini kullanarak tahmin etmektir. Bu amaçla, politika değişkeni Leybourne vd. (1998) tarafından geliştirilen doğrusal olmayan birim kök testi ile durağan olmayan yapısı dışlanarak durağan hale getirilmiştir. Çalışmada yürütülen reaksiyon fonksiyonu tahminlerine göre Türkiye Cumhuriyet Merkez Bankası (TCMB) fiyat istikrarına çıktı açığına göre daha fazla önem vermektedir. Ayrıca, TCMB'nin reel efektif döviz kuruna, brüt döviz rezervlerine, bankacılık sektörü toplam kredi hacmine ve ekonomik büyümeye tepki verdiği bulgularına ulaşılmıştır. Bu bulgular, 2008 Küresel Finansal Krizi sonrasında Türkiye'de uygulanmaya başlanan yeni para politikası ile tutarlıdır.

Anahtar Sözcükler: *Para Politikası reaksiyon fonksiyonu, Spread, Taylor Kuralı, yumuşak geçiş regresyon (STR), LNV Metodolojisi.*

Makale Başvuru Tarihi/Manuscript Received: 12/04/2020
Makale Kabul Tarihi/Manuscript Accepted: 06/07/2020

INTRODUCTION

After the 2008 Global Financial Crisis (GFC), the central banks of the developed countries implemented quantitative easing (QE) policies upon that the policy rate was at the zero lower bound. As a result of QE, short-term capital flowed intensively to the developing countries, which in turn led to the appreciation of the local currency, weakening the country's international competitiveness. Then, monetary authorities in these countries became obliged either to revisit their goals or to react to financial instabilities they went through or both. In this regard, it got imperative to understand to what extent monetary policies react to which variables in the aftermath of the 2008 GFC, thus to estimate new monetary policy reaction functions known as "the Taylor rule" (Taylor, 1993).

The 2008 GFC had negative impacts on Turkey as the other developing countries. During the period between 2009 and 2013, the short-term capital inflow to Turkey was at the level of $ 151.6 billion and this was higher as much as $ 68 billion compared to the quantity during the period between 2003 and 2007. Since it became critical to limit the macro-financial risks that may arise from capital inflows on this scale, the monetary policy authority (Central Bank of the Republic of Turkey, CBRT) developed a new monetary policy approach, which is known as "unconventional" in the literature, towards the end of 2010. By reviewing the framework of the inflation-targeting regime that had been implemented since 2006 (Kara, 2012), the CBRT aims to contribute to financial stability without deviating from its goal of price stability. The fact that the CBRT simultaneously pursues two goals implies that only one policy instrument (the short-term interest rates) would not be sufficient to achieve both of them. Then, the CBRT started to use actively more than one policy instrument (interest rate corridor, liquidity management, required reserves, and reserve options mechanism). Besides, to monitor the monetary policy, the CBRT began to use two indicators, namely credit growth and exchange rate. Therefore, the framework of monetary policy such as its goals, instruments, and indicators has been changed since 2009 and these changes might be reflected by the CBRT's monetary policy reaction function.

In this study, we aim to investigate the new monetary policy reaction function (hereafter, MPRF), which is compatible with the framework of the monetary policy adopted in Turkey in the aftermath of the 2008 GFC. For this purpose, we use a model based on the extended Taylor rule with hybrid type and the data set covering the period between 2009: 01 and 2019: 12.[1] As the policy instrument, we utilize the "*spread*" between overnight lending and borrowing interest rates as the dependent variable in MPRF, following the studies that use the difference between various interest rates to indicate the stance of monetary policy (Laurent, 1988; Friedman, Kuttner, 1989; Stock, Watson, 1989; Bernanke, 1990; Taylor, Williams, 2008; Berument *et al*., 2014; Cukierman, Izhakian, 2015; Dutkowsky, VanHoose, 2020).

Several recent studies have examined the MPRF for the case of Turkey (e.g., Akyürek *et al*., 2011; Çebi, 2012; Yüksel *et al*., 2013; Çamlıca, 2016; Çevik, Yıldırım, 2018). Most of these studies use the first difference of the variables in order to model MPRFs since some of the variables at level are nonstationary and the authors make them stationary by taking their differences (e.g., Kayhan *et al*., 2013; Albayrak, Abdioğlu, 2015; Turkay, 2017). The parameter estimates of these models, then, provide information about the relationships between the differences of the dependent and the independent variables. In our study, we apply the method developed by Leybourne et al. (1998) (hereafter LNV) to the non-stationary variables. In fact, to the best of our knowledge, this study is the first to use LNV in the MPRF literature.

In this study, we prefer LNV since it has two advantages over the competing unit root tests. The first is regarding how the structural changes in mean and/or trend occur. On the one hand, the unit root tests, for instance, those proposed by Perron (1989; 1990; 1997), Rappoport and Reichlin (1989), Zivot and Andrews (1992) and Lumsdaine and Papell (1997), assume an instant deterministic structural change in mean and/or trend. However, this assumption may not be the most appropriate in economic time series analysis. Because it is not likely for all economic agents to simultaneously react to an economic stimulus. On the other hand, LNV, which has a smooth transition regression (STR) based model, permits gradual rather than instantaneous adjustment between two regimes. Second, LNV enables one to detect and remove the nonlinear structures of the variables that might cause the unit root problem. For this reason, unlike the methodology of "difference stationarity", this approach eliminates the necessity to take the differences of all the variables of the model including those that are already stationary at level.

In this study, we estimate the model after removing the nonlinear structure of the policy instrument which is found to be non-stationary by LNV. Therefore, the coefficient estimations explicitly reflect the reaction of the monetary authority to the changes in the independent variables. In particular, they correspond to the effects of a change in the value of the independent variables on the deviation of the policy instrument from its trend rather than the value of the first difference of the independent variables on the first difference of the policy instrument. Therefore, this study contributes to the literature by its results suggesting “a policy manual” for the market participants to easily understand the ongoing monetary policies in a developing country such as Turkey.

The remainder of the paper is structured as follows: In Section 1, we present the theoretical framework and the recent empirical literature. In Section 2, we explain MPRF and the empirical methodology we use in this study. In Section 3, we give the model estimation results. The last section concludes and provides the policy implications of this study.

1. THEORETICAL FRAMEWORK AND EMPIRICAL LITERATURE

MPRF is an equation (or equations) that shows the reaction of central banks to various macroeconomic variables through monetary policy instruments. The pioneering study modeling the monetary policy reaction function is Taylor (1993). Taylor (1993) proposes a rule, by which he claims to successfully explain the policies of the FED (Federal Reserve), the central bank of the United States. According to this rule, named as "Taylor Rule" in the related literature, the short-term interest rate (i_t) is adjusted as in Equation (1):

$$i_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5y_t^{gap} \quad (1)$$

Here, r^* is the equilibrium real interest rate. π_t is the inflation rate in the period of t and π^* is the desired long-term or target inflation rate. y_t^{gap} stands for the output gap, the percentage of the real gross domestic product's deviation from the potential level.

Taylor (1993) claims that the equilibrium real interest rate (r^*) and the target inflation rate (π^*) are equal to 2. When the equation is rearranged accordingly, the "Taylor Rule" expresses that the short-term interest rate should be 1.5 times the inflation rate and 0.5 times the output gap (namely, $i_t = 1.5\pi_t + 0.5y_t^{gap} + 1$). Increasing the nominal interest rate more than one-point in response to one-point increase in inflation refers to that monetary authority wants to reduce inflationist pressures through real interest rates (Taylor, Williams, 2010).

Taylor rule is described as backward-looking in the literature. The forward-looking version of MPRF includes expectations and it can typically be given as follows (Clarida *et al*., 1998; 1999; 2000):

$$i_t^* = \bar{i^*} + \beta(E[\pi_{t+n}|\Omega_t] - \pi^*) + \gamma(E[y_t|\Omega_t] - y_t^*) \quad (2)$$

where i_t^* is the short-term nominal interest rate target of the central bank for each operating period, $\bar{i^*}$ is the long-term equilibrium nominal interest rate, π_{t+n} is the inflation rate in the $t+n$ period, y_t is the real output, π^* and y_t^* are the inflation target and the potential output, respectively. E stands for the expectation operator and Ω_t

stands for the existing information while the central bank is setting the interest rates. β and γ are the parameters of the model. According to this function, in order to set the short-term nominal interest rate target, the central bank takes into account the long-term equilibrium nominal interest rate and the deviation of the expected inflation rate in the period of $t+n$ from the inflation target and the deviation of the expected real output from the potential output.

The type of MPRF of central banks has been investigated by numerous studies since Taylor (1993). For the case of Turkey, there are also several studies. As one among them, Berument and Malatyalı (2000) find that MPRF of CBRT is more backward-looking rather than forward-looking in terms of inflation. Omay and Hasanov (2006) find that the CBRT implements a backward-looking rather than a forward-looking monetary policy. In their study for Turkey and Israel, Yazgan and Yılmazkuday (2007) find that MPRF is forward-looking with respect to the inflation gap and the output gap.

According to Ball (1999), monetary policy in open economies affects the economy through the exchange rate as well as the interest rate channel. For this reason, Ball (1999) proposes the following monetary policy rule for an open economy:

$$wr_t + (1-w)\rho_t = ay_t + b(\pi_t + \gamma\rho_{t-1}) \quad (3)$$

where r_t is the real interest rate, ρ_t is the log of the real exchange rate, y_t is the log of real output and π_t is inflation. Equation (3) represents the optimal policy rule for an average of r_t and ρ_t where w, a, b and γ are the parameters of the model. w represents the weights given to the real interest rate and the real exchange rate. This equation is different from the Taylor rule in two ways. Firstly, the policy variable is a combination of r_t and ρ_t, which indicates that an average of r_t and ρ_t can be used as a policy instrument instead of r_t in open economies (for example, a monetary conditions index-MCI). Secondly, inflation is replaced by the term of $(\pi_t + \gamma\rho_{t-1})$, a combination of inflation and exchange rate lag. This term can be interpreted as a long-term inflation forecast under the assumption that the output is at its natural level. Investigating the heterogeneity among the reaction functions of different countries' central banks, Turkay (2017) finds that central banks act in accordance with the extended Taylor rule. In particular, the central banks react to the inflation gap, the output gap, the real exchange rate, and external financial conditions.

A large number of studies conducted in the literature to estimate countries' MPRF use linear and nonlinear modelling framework and many different dependent and independent variables (e.g., Castro, 2011; Castro, Sousa, 2012; Komlan, 2013;

Neuenkirch, 2014). Their results suggest that the factors determining MPRF vary according to countries and periods.

The variables the monetary authority reacts to for the case of Turkey have been investigated by numerous studies as well. There is still no consensus on them in the literature. For example, Berument and Taşçı (2004) argue that the CBRT reacts to foreign exchange reserves and M2 money supply along with the output whereas it does not react to inflation. By using the model of nonlinear smooth transition regression (STR), Omay and Hasanov (2006) find that the CBRT's targets and reactions to the output gap and inflation gap depend on whether it implements expansionary or contractionary monetary policy. On the one hand, the CBRT targets the output stability and does not take into account the inflation rate while implementing expansionary monetary policy. On the other hand, in the case of contractionary monetary policy, the CBRT only aims the price stability and does not consider the output gap. In their subsequent study, by employing the threshold autoregressive (TAR) model, Hasanov and Omay (2008) show that even though the CBRT reacts to foreign reserves, real exchange rate and short-term capital flows during both expansion and recession periods, it reacts to money supply growth, budget deficits, and net foreign assets only in expansion periods.

Regarding the period after the 2008 global financial crisis, relatively few studies have investigated the monetary policy reaction function for the case of Turkey. Çamlıca (2016) incorporates a financial stress index (the composite indicator of systemic stress) into MPRF of the CBRT and reaches the findings indicating that the monetary policy of the CBRT is more sensitive to financial stress compared to the period before the new policy approach was adopted. By employing an extension of existing Factor-Augmented Vector Autoregressive (FAVAR) models, Varlik and Berument (2017) find that selecting different policy tools for the CBRT provides an environment that allows determining the effects of each tool for differentiated economic outcomes. As policy tools, they use Borsa Istanbul interbank overnight repo and reverse repo auctions interest rate, average funding cost interest rate, overnight lending interest rate, and overnight borrowing interest rate.

2. MODEL AND EMPIRICAL METHODOLOGY

2.1. Model

In this study, we use a linear Taylor type reaction function with hybrid type (both forward and backward looking) based on the model given in Equation (4), which is described as follows:

$$(Pol\_Ins)_t = \sum_{i=1}^{m} \alpha_m{}'(Pol\_Ins)_{t-m} + \sum_{i=1}^{n_1} \beta_{n_1}{}'([\pi - \pi^e]_{t-n_1}) + \sum_{i=1}^{n_2} \beta_{n_2}{}'(E_t[\pi - \pi^e]_{t+n_2} \mid \Omega_t) + \sum_{i=1}^{k_1} \theta_{k_1}{}'([y - y^*]_{t-k_1}) + \sum_{i=1}^{k_2} \theta_{k_2}{}'(E_t[y - y^*]_{t+k_2} \mid \Omega_t) + \gamma' z + \varepsilon_t \quad (4)$$

where Pol_Ins is the monetary policy instrument of the central bank, π is the actual (realized) inflation rate, π^e is the expected inflation rate, y is the real output, and y^* is the potential output. The deviation of the actual inflation from the expected inflation is called the inflation gap while the deviation of the real output from the potential output is the output gap. z represents the vector of the other policy variables. E refers to the expectation operator, Ω indicates the information set when the central bank determines the value of the policy instrument and ε_t shows error term. $\alpha, \beta, \theta,$ and γ are the vectors of the parameters.

According to the reaction function given in Equation (4), the central bank takes into account not only the past values of the policy instrument but also both the past ($t - n_1$ and $t - k_1$) (realized, backward-looking) and the future ($t + n_2$ and $t + k_2$) (expected, forward-looking) values of the inflation gap and the output gap.

2.2. Empirical Methodology

2.2.1. Stationarity and Unit Root Tests

Estimating MPRF given in Equation (4) requires the variables of the model to be stationary. A time series is stationary when there is no systematic change in its mean and its variance. The absence of a systematic change in the mean of a time series overtime is defined as "mean stationarity", while in the variance of a time series as “variance stationarity”. A time series is called “difference stationarity” or “trend stationarity” if it is made stationary by differencing and by detrending, respectively.

The stationarity of a time series can be examined by applying unit root tests. Unit root tests can be classified into three groups according to their theoretical models. These are (i) standard linear unit root tests, (ii) unit root tests using a nonlinear framework; and (iii) unit root tests which include a break in mean and/or trend (Omay, 2012).[2]

The first group of unit root tests, which are known as standard linear unit root tests, consists of Dickey and Fuller (1979), Phillips and Perron (1988) (PP), Kwiatkowski *et al*. (1992) (KPSS), Phillips and Ploberger (1994), Elliott *et al*. (1996), Perron and Ng (1996), Bierens (1997), and Im *et al*. (2003) among others.

The second group of unit root tests uses a nonlinear approach to the modeling of time series to take into account their dynamic behaviors (e.g., Enders and Granger, 1998 [EG]; Sollis *et al*., 2002; Kapetanios *et al*., 2003 [KSS]; Sollis, 2009). The dynamic behavior of a time series is called state-dependent when its statistical characteristics, such as mean, variance, and/or autocorrelation, depends on its state (Van Dijk, 1999).

The third group of unit root tests takes into consideration structural breaks in mean and/or trend (e.g., Perron, 1989; 1990; 1997; Rappoport and Reichlin, 1989; Zivot and Andrews, 1992; Lumsdaine and Papell, 1997; Leybourne *et al*., 1998 [LNV]; Sollis *et al*., 1999; Becker *et al*., 2006; Vougas, 2006). This group of the unit root tests overcomes the problem of falsely not rejecting the null hypothesis of unit root, which is caused by ignoring structural breaks that time series might exhibit. These tests vary with respect to the structural breaks to be one or more than one, predetermined or not predetermined, and abrupt or gradual. In this study, we apply the unit root test proposed by Leybourne et al. (1998) (LNV), which uses the models with deterministic structural changes, where the transition from one regime to the other occurs gradually.

2.2.2. LNV Methodology

Leybourne *et al*. (1998) propose the following three logistic smooth transition regression models for a time series x_t:[3]

$$\text{Model A: } x_t = \alpha_1 + \alpha_2 G_t(\gamma, \tau) + v_t \quad (5)$$

$$\text{Model B: } x_t = \alpha_1 + \beta_1 t + \alpha_2 G_t(\gamma, \tau) + v_t \quad (6)$$

$$\text{Model C: } x_t = \alpha_1 + \beta_1 t + \alpha_2 G_t(\gamma, \tau) + \beta_2 t G_t(\gamma, \tau) + v_t \quad (7)$$

where v_t is the zero-mean I(0) process. $G_t(\gamma, \tau)$ is a logistic smooth transition function representing the transition between the regimes. This function is given as follows:

$$G_t(\gamma, \tau) = [1 + exp\{-\gamma(t - \tau T)\}]^{-1}, \gamma > 0 \quad (8)$$

where T is the number of observations (sample size), t is the time trend, γ is the transition speed between regimes and τ is the midpoint of the transition (threshold-position parameter). Here, the time trend is considered as a transition variable ($s_t = t$). The transition between the regimes occurs gradually rather than suddenly. The transition function $G_t(\gamma,\tau)$ is a monotone continuous function ranging from 0 to 1. Therefore, the STR models given in (5), (6) and (7) can be interpreted as regime-switching models with two extreme regimes. While the extreme values of the transition functions are $G_t(\gamma,\tau) = 0$ and $G_t(\gamma,\tau) = 1$, the transition from one extreme regime to the other is gradual. The transition path is symmetric around the midpoint. In case γ is small, $G_t(\gamma,\tau)$ travels in a long time. For greater values of γ, $G_t(\gamma,\tau)$ travels in a very fast way. While γ goes to infinity, regime switch occurs instantly, as the value of the function changes from 0 to 1 instantly.

Under the assumption that v_t is a zero-mean I(0) process, x_t in Model A and B is stationary around a mean that changes smoothly from the initial value α_1 to the final value $\alpha_1 + \alpha_2$. In Model C, in addition to the change in the intercept term from α_1 to $\alpha_1 + \alpha_2$, the slope also changes from β_1 to $\beta_1 + \beta_2$.

LNV proposes the null hypothesis of unit root as H_0: $x_t = \mu_t, \mu_t = \mu_{t-1} + \varepsilon_t$ where ε_t is assumed to be a stationary process with zero mean, against its alternative hypothesis of $H_1: Model\ A, Model\ B\ or\ Model\ C$

The empirical procedure to calculate the test statistics consists of two steps. In Step 1, one may use the nonlinear least-squares–NLS methodology to estimate the deterministic component of the model. Then the residual is calculated. The estimated parameters are shown with hats in Equation (9), (10), and (11).

$$\text{Model A} \qquad \hat{v}_t = y_t - \hat{\alpha}_1 - \hat{\alpha}_2 G_t(\hat{\gamma},\hat{\tau}) \tag{9}$$

$$\text{Model B} \qquad \hat{v}_t = y_t - \hat{\alpha}_1 - \hat{\beta}_1 t - \hat{\alpha}_2 G_t(\hat{\gamma},\hat{\tau}) \tag{10}$$

$$\text{Model C} \qquad \hat{v}_t = y_t - \hat{\alpha}_1 - \hat{\beta}_1 t - \hat{\alpha}_2 G_t(\hat{\gamma},\hat{\tau}) - \hat{\beta}_2 t G_t(\hat{\gamma},\hat{\tau}) \tag{11}$$

In Step 2, $\hat{v}_t$ is modeled as in Equation (12), then the null hypothesis of $\hat{\rho} = 0$ is tested by using the ADF test statistics.

$$\Delta\hat{\boldsymbol{v}}_t = \hat{\boldsymbol{\rho}}\hat{\boldsymbol{v}}_{t-1} + \sum_{i=1}^{k} \hat{\boldsymbol{\delta}}_i \Delta\hat{\boldsymbol{v}}_{t-i} + \hat{\boldsymbol{\eta}}_t \tag{12}$$

The ADF test statistics of LNV are called s_α, $s_{\alpha(\beta)}$, and $s_{\alpha\beta}$ according to the model used to form $\hat{v}_t$. In particular, it is s_α if Model A is used, $s_{\alpha(\beta)}$ if Model B is used and $s_{\alpha\beta}$ if Model C is used. Obtained through Monte Carlo simulations, the critical values of these test statistics are tabulated by Leybourne *et al.* (1998).

3. DATA AND EMPIRICAL ANALYSIS

3.1. Data

Since the 2008 Global Financial Crisis, the CBRT has been implementing the unconventional monetary policy in order to achieve both price stability and financial stability by affecting credit and exchange rate channels separately. To this end, as a policy instrument, the CBRT has been using not only the policy rate but also the interest rate corridor, liquidity operations, required reserves, and reserve options mechanism. This raises the question of which policy instrument is the best to be used in MPRF for CBRT.

The policy rate, CBRT sets, is one-week repo rate, which was not much variable during the period we use in this study. However, the CBRT used liquidity operations to make daily changes in the short-term market interest rates by aiming to ensure that they stay in "the interest rate corridor". The interest rate corridor refers to the range between the interest rate levels that central banks can borrow from banks and lend to banks on an overnight basis. It is used to prevent big deviations of market interest rates from the policy rate.[4] Within the framework of the new monetary policy, the CBRT set the width of the interest rate corridor in an asymmetric way around the policy rate until the simplification process of the monetary policy operational framework was completed on 28 May 2018. The interest rate corridor made it possible to react more quickly and flexibly to the volatility in the short-term capital flows and to have an effect on credit growth when needed (CBRT, 2012a; 2013).

There are two other policy instruments used by the CBRT on rare occasions. These are the Required Reserves Ratio (RRR) and Reserve Options Mechanism (ROM). First, the CBRT gradually increased RRR and cut the interest payments on the required reserves in the aftermath of the 2008 GFC. Moreover, The Central Bank differentiated RRR with respect to their maturities and extended the scope of the liabilities subject to the required reserves. As of August 2011, the CBRT has reduced RRR to meet the liquidity the banking system needs as a result of the increase in risk-avoidance tendency and the risk appetite volatility on the global scale (CBRT, 2012b). Second, the CBRT developed a new policy instrument called ROM, by which the banks can hold a certain percentage of the TL reserve requirements in foreign currency (dollar and / or euro) and standard gold. By implementing ROM, the CBRT aims at limiting the negative effects of excessive volatility in capital flows on macroeconomic and financial stability, strengthening its gross foreign exchange reserves, providing more flexibility to the banks in terms of liquidity management, reducing the sensitivity of loans to capital flows and bringing the under-the-mattress gold back to the economy. Therefore, by reducing the need for the interest rate corridor, ROM is expected to operate as an automatic stabilizer (CBRT, 2012a; 2012b; 2013).

The CBRT uses all policy instruments complementarily. For example, as explained above, the CBRT sets the interest rate corridor in such a way that short-term interest rates stay in it and it implements ROM so that the need for a rearrangement of the interest rate corridor is reduced. For this reason and since the interest rate corridor is more variable compared to other policy instruments, we assume the interest rate corridor as the indicative instrument of the monetary policy. Thus, we use the "*spread*" between overnight lending and borrowing interest rates as the dependent variable in MPRF.

In fact, in the literature, there are numerous studies used "spread" as the difference between various interest rates to indicate the stance of monetary policy. To this end, some of the spreads used in the literature are the differences between 20-year bond rate and the federal funds rate (Laurent, 1988), the commercial paper rate and the T-bill rate (Friedman, Kuttner, 1989), 1- and 10-year Treasury bond rates (Stock, Watson, 1989) and the long-term Baa credit rating corporate bond rate and the 10-year Treasury bond rate (Bernanke, 1990). For spread, more recent studies use Central Bank's interbank interest rate and the depreciation rate of the local currency (Berument, 2007), the Euler equation rate and the federal funds rate (Canzoneri *et al*., 2007), 1- and 3-month London interbank offer rate (Libor) and the overnight indexed swap (OIS) rate (Taylor, Williams, 2008), interbank overnight interest rates and Treasury auction interest rates (Berument *et al*., 2014), the borrowing rate that financial intermediaries charge to borrowers and the lending rate that they pay to lenders (Cukierman, Izhakian, 2015) and the federal funds rate and the interest rate on excess reserves (IOER) (Dutkowsky, VanHoose, 2020).

The main independent variables of the model we use in this study are the output gap and the inflation gap. The series for output gap ($y - y^*$ where y^* is output trend and $ygap$) is obtained by filtering the series of industrial production index (2015=100) through the methodology developed by Hodrick and Prescott (1997). The inflation gap ($\pi - \pi^e$ and $infgap$) series is the difference between the series of the inflation rate and inflation expectation. The monthly inflation rate (π) is calculated using CPI (consumer price index) while the current month's monthly CPI expectation survey of the CBRT is used as the inflation expectation (π^e) series. Other independent variables in the reaction function are the real effective exchange rate (% change) (CPI-based) (*rate*), the gross foreign exchange reserves of the CBRT (% change) (*res*), the total credit volume of the banking sector including the CBRT (% change) (*credit*), the industrial production index (2015=100) (% change) ($growth$) (as a proxy of economic growth). The expected values of the independent variables at time t are proxied by its actual values at time $t + i$, for $i = 1,..,12$. All series are seasonally adjusted by using the Tramo/Seats method.

We use monthly data and the data set covers the period between 2009:01 and 2019:12. All series are acquired from the CBRT Electronic Data Distribution System (EDDS).[5]

3.2. Unit Root Tests Results

Before estimating the model given in Equation (4), we investigate whether the variables used in the model are stationary. To this end, we use the ADF unit root test, whose results are given in Table 1. The results show that the null hypothesis of unit root cannot be rejected for *spread* at even 10% significance levels in any model applied. The ADF test results suggest that *ygap*, *infgap*, *rate*, *res*, *credit*, and *growth* do not have a unit root.

Table 1. ADF Unit Root Test Results of the Dependent and Independent Variables (Level)

Variable	Model without Intercept and Trend	Model with Intercept, without Trend	Model with Intercept and Trend
SPREAD	-0.786047 (0.3738)	-2.106387 (0.2426)	-3.087226 (0.1138)
YGAP	-5.010782 (0.0000)	-4.991065 (0.0000)	-4.969971 (0.0004)
INFGAP	-8.675638 (0.0000)	-8.789790 (0.0000)	-8.778825 (0.0000)
RATE	-9.070164 (0.0000)	-9.108517 (0.0000)	-9.139721 (0.0000)
RES	-12.42294 (0.0000)	-12.41404 (0.0000)	-12.55055 (0.0000)
CREDIT	-2.854552 (0.0046)	-9.716101 (0.0000)	-10.01885 (0.0000)
GROWTH	-3.630302 (0.0004)	-9.190576 (0.0000)	-9.477828 (0.0000)

Note: The figures in parenthesis are the p-values of the coefficient estimates.

The results of the ADF tests reveal that all series except for *spread* are stationary. The structural changes of the monetary policy framework after the 2008 GFC may have caused a structural break in policy instruments. For this reason, we pursue the unit root tests for *spread* using the LNV methodology, which takes into account possible structural breaks that the series might have. We estimate "Model C" given in Equation (7) and obtain the residual to calculate LNV statistics. The calculated t statistics ($s_{\alpha\beta}$) is 19.35159. Since it is greater than the absolute values of the critical values tabulated by Leybourne *et al*. (1998) (-5.650, -5.011 and -4.697 at the significance levels of 1%, 5%, and 10%, respectively), the null hypothesis of unit root can be rejected and the alternative hypothesis, "nonlinear stationarity", can be accepted. As can be seen in Figure 1, *spread* has a nonlinear deterministic trend, shown as the black line, which causes the unit root problem. We get *spread* trend stationary around a nonlinear trend by removing it.[6] Figure 2 demonstrates the trend stationary spread series, which is hereafter used as spread in short. Unlike the methodology of "difference stationarity", this way eliminates the necessity to take difference of the independent variables in spite of the fact that they are already stationary at level.

Figure 1. Spread and Nonlinear Deterministic Trend

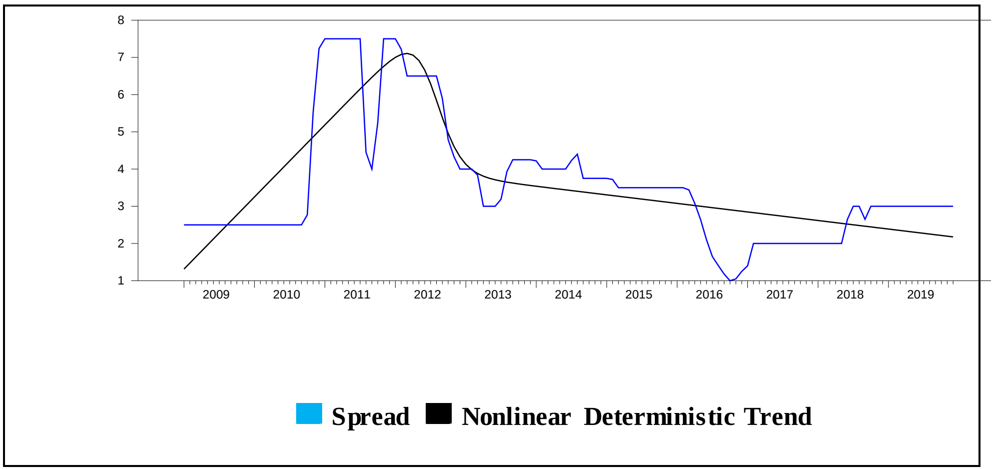
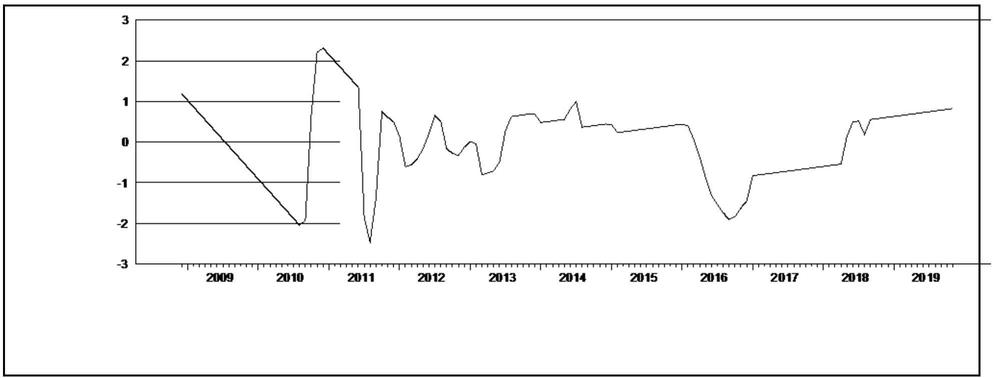


Figure 2. Trend Stationary Spread



3.3. Model Estimations

In this study, we estimate linear Taylor type reaction functions with the hybrid type (both forward and backward-looking) given in Equation (4) to examine the new monetary policy reaction in Turkey in the aftermath of the 2008 GFC. The data set covers the period between 2009:01 and 2019:12. We use the spread between overnight lending and borrowing interest rates as the policy instrument in MPRF.

First of all, we incorporate the current, the lag (back to 12 months), and the expected values (until 12 months) of the independent variables along with two lags of the dependent variable into the model, then we estimate it. Afterward, the variables with insignificant coefficients are removed from the model. Table 2 demonstrates the estimation results and diagnostic test statistics (diagnostic tests) of the final model.

As can be seen from Panel A of Table 2, all coefficients except the actual values of the output gap and the inflation gap (significant at 5%) and the expected values of the change in the CBRT's gross foreign exchange reserves (significant at 5%), inflation gap, the real effective exchange rate change and the economic growth (significant at 10%) are significant at 1% significance level and the signs of the coefficients are as expected. According to the estimation results, the CBRT follows both backward and forward-looking policies while determining the current value of the deviation of $spread$ from the trend. In particular, the CBRT takes into account the realized values ($t-1$ and $t-2$ periods) of $spread$, both the actual ($t-11$ period) and the expected ($t+1$ period) values of the output gap, both the actual ($t-2$ period) and the expected ($t+10$ period) values of the inflation gap, both the actual ($t-7$ period) and the expected ($t+9$ period) values of the real effective exchange rate change, the expected ($t+12$ period) value of the change in the CBRT's gross foreign exchange reserves, the actual ($t-7$ period) value of the change in the total credit volume of the banking sector including the CBRT, both the actual ($t-12$ period) and the expected ($t+5$ period) values of the economic growth.

The model estimation reveals the reactions of monetary policy to the changes in the independent variables. First of all, the estimation results suggest that a 1% increase in $spread$ of the sum of the previous two periods leads to a 0.78% increase in the current period $spread$. Secondly, CBRT increases the $spread$ by about 0.05% against a 1% increase in the expected output gap and by about 0.04% in the case of a 1% increase in the realized output gap. Thirdly, $spread$ is increased by about 0.14% for each in response to a 1% increase in both expected and realized inflation gap. The increase of the $spread$ is about 3 times more against a 1% increase in the inflation gap compared to the output gap, which implies that the CBRT attaches more importance to price stability than the output gap.

In this study, we find that the real effective exchange rate, the gross foreign exchange reserves, the total credit volume of the banking sector including the CBRT[7] and the economic growth are among the main factors that the monetary authority reacts to in Turkey.

The estimation results reveal that the reaction of monetary policy is backward and forward-looking to a change in the real effective exchange rate while it is forward-looking when it comes to a change in the gross foreign exchange reserves. While the *spread* is increased by about 0.09% and 0.03% in response to a 1% realized and expected appreciation in the exchange rate respectively, it is reduced by about 0.02% against a 1% expected increase in the foreign exchange reserves. On the one hand, the appreciation in the exchange rate means a depreciation of TL, which leads to an increase in the foreign debt burden. On the other hand, the increase in the foreign exchange reserves results in appreciation of local currency (TL), that the imported goods become cheaper relative to the domestic goods, leading to an increase in import-based consumption, and ultimately an increase in the current account deficit. If the consequence of changes in the exchange rate and the foreign exchange reserves are considered together, a 0.10% total increase in *spread* seems to be necessary to attract foreign capital for a developing country with a savings gap like Turkey.

Moreover, we find that the reaction of monetary policy is backward and forward-looking to the economic growth rate while it is backward-looking when it comes to a change in the total credit volume of the banking sector including the CBRT. While the *spread* is decreased by about 0.11% and 0.07% in response to 1% increase in realized and expected values in the economic growth rate respectively, it is increased by about 0.10% against 1% increase in a change in the realized total credit volume of the banking sector including the CBRT. The CBRT's reaction to the change in the total credit volume may be considered as reasonable due to the fact that this variable is one of the two indicators along with the exchange rate the CBRT monitors in the context of the new monetary policy. Finally, it can be seen that the CBRT reacts to the realized and expected growth rates. This finding indicates that the CBRT attaches extremely important to the economic growth besides price and financial stability.

We, then, confirm that the model used in this study is robust to a large number of control variables. We choose control variables not only from main economic indicators but also based on the benchmarks of the new monetary policy of the CBRT, which are the credit growth and exchange rate. Accordingly, these variables are composed of the general budget balance (% change), the general primary budget balance (% change), the general budget cash balance (% change), the short-term capital inflows (total of foreign direct investment and portfolio investment) (% change), M2 money supply (% change), the total short-term foreign debt stock (% change), current account (% change) and unemployment rate.[9] Estimating the models with the control variables, we find that their coefficient estimates are insignificant. This suggests that the CBRT does not react to control variables under investigation. On the other hand, CBRT (2014:66-69) and Alioğulları *et al.* (2015) find that the new monetary policy framework of the CBRT favorably affects the correction of the current account balance in Turkey.

Table 2. Model Estimation and Diagnostic Tests

Panel A: Forward and Backward-Looking (Hybrid) Taylor-Type Reaction Function

Data Period: 2009:01-2019:12 (Monthly Data-132 Observations)

Variables	Coefficient Estimates	P-Values
$(Spread)_{t-1}$	1.1187 (12.9593)	0.0000
$(Spread)_{t-2}$	-0.3380 (-3.8516)	0.0002
$(y-y^*)_{t-11}$	0.0414 (2.1344)	0.0354
$(y-y^*)_{t+1}$	0.0486 (2.6870)	0.0085
$(\pi-\pi^e)_{t-2}$	0.1431 (2.3097)	0.0230
$(\pi-\pi^e)_{t+10}$	0.1377 (1.9542)	0.0536
$(Rate)_{t-7}$	0.0900 (4.3893)	0.0000
$(Rate)_{t+9}$	0.0268 (1.6806)	0.0961
$(Res)_{t+12}$	-0.0244 (-2.1442)	0.0345
$(Credit)_{t-7}$	0.0977 (3.8470)	0.0002
$(Growth)_{t-12}$	-0.1068 (-2.9017)	0.0046
$(Growth)_{t+5}$	-0.0672 (-1.8426)	0.0685
DW: 1.7994		$\mathbf{R^2}$ **:** 0.8479

Panel B: Diagnostic Tests[8]

Panel B1: Multicollinearity (Variance Inflation Factor-VIF)		
Variables	**Coefficient Variances**	**VIF**
$(Spread)_{t-1}$	0.0075	4.7643
$(Spread)_{t-2}$	0.0077	4.9174
$(y-y^*)_{t-11}$	0.0004	1.4438
$(y-y^*)_{t+1}$	0.0003	1.4418
$(\pi-\pi^e)_{t-2}$	0.0038	1.1947
$(\pi-\pi^e)_{t+10}$	0.0050	1.7050
$(Rate)_{t-7}$	0.0004	1.4409
$(Rate)_{t+9}$	0.0003	1.6007
$(Res)_{t+12}$	0.0001	1.2166
$(Credit)_{t-7}$	0.0006	2.3590
$(Growth)_{t-12}$	0.0014	2.3059
$(Growth)_{t+5}$	0.0013	1.9700

Panel B2: Autocorrelation (Breusch-Godfrey-LM Test)	
Lag Length	**P-χ^2 Value**
1	0.1043

Panel B3: Heteroscedasticity (White Test)
P-χ^2 Value: 0.0000

Note: The figures in parentheses are the t-statistics of the coefficient estimates.

Table 3. Model Estimation and Diagnostic Tests before 2009

Panel A: Forward and Backward-Looking (Hybrid) Taylor-Type Reaction Function **Data Period:** 2005:03-2008:12 (Monthly Data-46 Observations)		
Variables	**Coefficients and T-Statistics (in parenthesis)**	**P-Values**
$(Policy)_{t-1}$	0.8977 (8.8700)	0.0000
$(y-y^{*})_{t-9}$	0.0950 (6.4593)	0.0000
$(\pi-\pi^{e})_{t+1}$	0.1883 (2.0018)	0.0563
$(Rate)_{t+1}$	0.0275 (2.5950)	0.0156
$(Credit)_{t-1}$	0.1501 (2.6038)	0.0153
$(Res)_{t+4}$	-0.0752 (-2.2475)	0.0337
$(Unemp)_{t-1}$	-0.5924 (-2.0555)	0.0504
DW: 1.6626		$\mathbf{R^2}$ **:** 0.8585

Panel B: Diagnostic Tests

Panel B1: Multicollinearity (Variance Inflation Factor-VIF)		
Variables	**Coefficient Variances**	**VIF**
$(Policy)_{t-1}$	0.0102	1.8680
$(y-y^{*})_{t-9}$	0.0002	1.9375
$(\pi-\pi^{e})_{t+1}$	0.0089	1.7932
$(Rate)_{t+1}$	0.0001	1.1267
$(Credit)_{t-1}$	0.0033	2.5047
$(Res)_{t+4}$	0.0011	1.3823
$(Unemp)_{t-1}$	0.0831	1.2908

Panel B2: Autocorrelation (Breusch-Godfrey-LM Test)	
Lag Length	**P-χ^2 Value**
1	0.2358
Panel B3: Heteroscedasticity (White Test)	
P-χ^2 Value: 0.9051	

In this study, we also estimate an MPRF as given in Equation (4) for the period before 2009 to investigate how it has changed since then. To this end, we utilize the data set covering the period between 2005:03 and 2008:12. We use the same independent and control variables while the policy rate of the CBRT is used as the dependent variable.[10] Table 3 demonstrates the estimation results (in Panel A) and diagnostic test statistics (diagnostic tests) of the final model (in Panel B). The estimation results suggest that a 1% increase in policy rate ($policy$) of the previous period and the actual output gap leads to 0.90% and 0.10% increase in the current period policy rate, respectively. The results also show that the policy rate is increased by about 0.19% to respond to %1 increase in the expected inflation gap. The increase of the $policy$ is about 2 times more against a 1% increase in the inflation gap compared to the output gap, which implies that the CBRT attaches more importance to price stability than the output gap. On the other hand, compared to the period after 2009 when it is 3 times, this result implies that the level of importance that the CBRT attaches to price stability has become higher after 2009. Moreover, we find that the real effective exchange rate, the total credit volume of the banking sector, and the gross foreign exchange reserves are among the main factors that the monetary authority reacts to in Turkey as after 2009. Nevertheless, we see that the CBRT reacts to the unemployment rate before 2009, but reacts to the growth rate after 2009. Furthermore, we see that the CBRT determines the policy rate considering the realized (backward-looking) or the expected (forward-looking) values of the variables before 2009. However, it's taken into consideration both the realized and the expected values of the variables except the gross foreign exchange reserves and the total credit volume after 2009.

CONCLUSION

In the aftermath of the 2008 Global Financial Crisis (GFC), the central banks of developing countries have had to review their policy reaction to the ongoing financial instabilities on a global scale. In this study, we investigate the monetary policy reaction function (MPRF) in the aftermath of the 2008 GFC using the Turkish data for 2009:01-2019: 12. The model we use is based on the hybrid type MPRF. We use spread between overnight lending and borrowing interest rates as a policy instrument (dependent variable). Before estimating the model, we first apply the linear unit root tests (ADF) to the variables of the model. The ADF tests' results suggest that all series except for policy instrument spread are stationary. Then, we employ the nonlinear unit root test (developed by Leybourne $et\ al.$ (1998), LNV) to spread. LNV test's result reveals that it has a nonlinear trend, which causes the series to have a unit root. By removing its nonlinear structure, we get spread stationary around its nonlinear trend. This approach to MPRF is the contribution of our study to the existing literature. Unlike the methodology of "difference stationarity", this approach eliminates the necessity to take difference of the independent variables before estimating the model even though they are already stationary at level.

The results of this study provide "a policy manual" for the market participants both in Turkey and in other developing countries to follow ongoing monetary policies conducted in the aftermath of the 2008 GFC. In particular, the model estimations yield three main results, which have important policy implications. Firstly, we find that MPRF is not only backward but also forward-looking. This result suggests that the CBRT adjusts the current value of spread based on a hybrid type reaction function, implying that the CBRT makes decisions by using all the elements that form the existing information set. Secondly, the result of this study reveals that the CBRT increases spread 3 times more against a 1% increase in the inflation gap compared to the output gap. Being compatible with the results of Taylor (1993), this finding indicates that the CBRT attaches more importance to price stability than the output gap. Finally, this study shows that the monetary authority in Turkey reacts not only to the output gap and to the inflation gap as in the original Taylor rule but also the real effective exchange rate, the gross foreign exchange reserves, the total credit volume of the banking sector including the CBRT, and the economic growth. This result is consistent with the new monetary policy of the CBRT as it aims at financial stability along with price stability after the 2008 GFC. We note that it is not a surprise for a small open developing country like Turkey to implement monetary policy by taking into account exchange rate and credit channels of the monetary transmission mechanism.

NOTES

[1] The importance of the analysis period chosen for this study can be dealt with from two perspectives. Firstly, this period reflects the relationships between the economic variables after the 2008 GFC. Secondly, this period enables us to examine the impacts of the new monetary policy which is implemented by the CBRT in late 2010 to eliminate the effects of the 2008 crisis over the MPRF.

[2] In the literature, there are also other unit root tests which combine the different type of unit root tests. For example, Sollis (2004), Uçar and Omay (2009), and Omay and Yıldırım (2013) develop unit root tests that combine EG and LNV methodologies, KSS and Im et al. (2003) methodologies, and KSS and LNV methodologies, respectively.

[3] The use of smooth transition models as a tool representing the deterministic structural changes in time series regressions was first suggested by Bacon and Watts (1971), and Maddala (1977). This topic has been more recently reconsidered by Granger and Terasvirta (1993), Lin and Terasvirta (1994), Greenaway et al. (1997), Leybourne et al. (1998) (LNV), Sollis et al. (1999), Vougas (2006), Omay (2012), and Omay and Yıldırım (2013).

[4] The interest rate corridor is used by many central banks that implement conventional inflation targeting. This policy instrument was being used by the European Central Bank (ECB), England, Sweden, Norway, Japan, Canada, Australia, and New Zealand before the 2008 global financial crisis; following the crisis, Hungary, Poland, Romania, Serbia, Indonesia, Iceland, and Turkey started to use this instrument besides the countries aforesaid (Vural, 2013).

[5] The series for $spread$ has daily frequency in the source, EDDS. Its frequency is converted to monthly by using the method of weighted arithmetic mean.

[6] After removing its nonlinear deterministic trend, we again apply the ADF tests to $spread$. The results suggest that the null hypothesis of unit root can be rejected at a 1% significance level in three models, without intercept and trend, with intercept and without trend and with both intercept and trend (p-values are 0.0000, 0.0001 and 0.0008, respectively). That is, after removing the nonlinear trend, *spread* becomes trend stationary.

[7] The relationship that the CBRT has established between credit growth and the current account balance in the new monetary policy period is an important issue. For some related studies, see CBRT (2014), Alioğulları et al. (2015), and Ekinci et al. (2015).

[8] Table 2 Panel B shows the results of the diagnostic tests we carry out. On the one hand, the variance inflation factors are between 1 and 5, suggesting that there is no multicollinearity among the independent variables. The LM test's result implies that there is no autocorrelation problem. On the other hand, the result of the White test reveals that the error terms of the model are heteroscedastic. Nevertheless, in the case of heteroscedasticity, the least-squares estimators are unbiased and consistent.

[9] The series are acquired from the CBRT Electronic Data Distribution System (EDDS).

[10] The policy rate (*Policy*) which the CBRT used as a policy instrument before June 2010 is overnight borrowing interest rates of the CBRT. The base year of the industrial production index used for this period is 2005. *Unemp* denotes the unemployment rate. All series are seasonally adjusted and stationary.

REFERENCES

Akyürek, C., A.M. Kutan, H. Yılmazkuday (2011), "Can Inflation Targeting Regimes be Effective in Developing Countries?, The Turkish Experience", Journal of Asian Economics, 22, 343-355.

Albayrak, N., Z. Abdioğlu (2015), "Geriye ve İleriye Dönük Para Politikası Reaksiyon Fonksiyonlarının Tahmini: Taylor Kuralı [Estimating backward and forward-looking monetary policy reaction functions: Taylor rule]", Suleyman Demirel University the Journal of Faculty of Economics and Administrative Sciences, 20(4), 141-163.

Alioğulları, Z.H., Y.S. Başkaya, Y.E. Bulut, M. Kılınç (2015), The Relationship of Consumer and Commercial Loans with Current Account Deficit in Turkey, CBT Research Notes in Economics 1519, Research and Monetary Policy Department, Central Bank of the Republic of Turkey.

Bacon, D.W., D.G. Watts (1971), "Estimating the Transition between two Intersecting Straight Lines", Biometrika, 58(3), 525-534.

Ball, L.M. (1999), "PolicyRrules for Open Economies", in J.B. Taylor (ed.), Monetary Policy Rules, University of Chicago Press, Chicago, 127-156.

Becker, R., W. Enders, J. Lee (2006), "A Stationarity Test in the Presence of an unknown Number of Smooth Breaks", Journal of Time Series Analysis, 27(3), 381-409.

Bernanke, B. (1990), On the Predictive Power of Interest Rates and Interest Rate Spreads, NBER Working Paper No: 3486.

Berument, H. (2007), "Measuring Monetary Policy for a Small Open Economy: Turkey", Journal of Macroeconomics, 29, 411-430.

Berument, H., K. Malatyalı (2000), "The Implicit Reaction Function of the Central Bank of the Republic of Turkey", Applied Economics Letters, 7, 425-430.

Berument, H., H. Taşçı (2004), "Monetary Policy rules in Practice: Evidence from Turkey", International Journal of Finance and Economics, 9, 33-38.

Berument, M.H., N.B. Ceylan, B. Doğan (2014), "An Interest-Rate-Spread-Based Measure of Turkish Monetary Policy", Applied Economics, 46(15), 1804-1813.

Bierens, H.J. (1997), "Testing the Unit Root with Drift Hypothesis Against Nonlinear Trend Stationarity, with an Application to the US Price Level and Interest Rate", Journal of Econometrics, 81, 29-64.

Canzoneri, M.B., R.E. Cumby, B.T. Diba (2007), "Euler Equations and Money Market Interest Rates: A Challenge for Monetary Policy Models", Journal of Monetary Economics, 54, 1863–1881.

Castro, V. (2011), "Can Central Banks' Monetary Policy be Described by a Linear (augmented) Taylor Rule or by a Nonlinear Rule?", Journal of Financial Stability, 7, 228-246.

Castro, V., R.M. Sousa (2012), "How do Central Banks React to Wealth Composition and Asset Prices?", Economic Modelling, 29, 641-653.

Central Bank of the Republic of Turkey (2012a), 2013 Yılı Para ve Kur Politikası [Monetary and exchange rate policy for 2013], Ankara: Central Bank of the Republic of Turkey. http://www.tcmb.gov.tr, E.T.: 11.04.2020.

Central Bank of the Republic of Turkey (2012b), Rezerv Opsiyonu Mekanizması [Reserve options mechanism], Bulletin, 28, 2-4, Ankara, http://www.tcmb.gov.tr, E.T.: 11.04.2020.

Central Bank of the Republic of Turkey (2013), Parasal Aktarım Mekanizması [Monetary transmission mechanism], Ankara: Central Bank of the Republic of Turkey. http://www.tcmb.gov.tr, E.T.: 11.04.2020.

Central Bank of the Republic of Turkey (2014), Inflation Report 2014-III, Ankara: Central Bank of the Republic of Turkey, http://www.tcmb.gov.tr, E.T.: 11.04.2020.

Clarida, R., J. Gali, M. Gertler (1998), "Monetary Policy Rules in Practice Some International Evidence", European Economic Review, 42, 1033-1067.

Clarida, R., J. Gali, M. Gertler (1999), "The Science of Monetary Policy: A new Keynesian Perspective", Journal of Economic Literature, 37, 1661-1707.

Clarida, R., J. Gali, M. Gertler (2000), "Monetary policy rules and macroeconomic stability: Evidence and some theory", The Quarterly Journal of Economics, 115, 147-180.

Cukierman, A., Y. Izhakian (2015), "Bailout Uncertainty in a Microfounded General Equilibrium Model of the Financial System", Journal of Banking & Finance, 52, 160–179.

Çamlıca, F. (2016), "Responsiveness of Monetary Policy to Financial Stress in Turkey", Central Bank Review, 16, 143-150.

Çebi, C. (2012), "The interaction between monetary and fiscal policies in Turkey: An estimated new Keynesian DSGE model", Economic Modelling, 29, 1258-1267.

Çevik, E.İ., D.Ç. Yıldırım (2018), "Para Politikası Tercihleri ile İşsizlik Oranları Arasındaki İlişki [The relation between monetary policy preferences and unemployment rate]", Ege Academic Review, 18(1), 31-46.

Dickey, D.A., W.A. Fuller (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", Journal of the American Statistical Association, 74(366), 427-431.

Dutkowsky, D.H., D.D. VanHoose (2020), "Equal Treatment under the Fed: Interest on Reserves, the Federal Funds Rate, and the 'Third Regime' of Bank Behavior", Journal of Economics and Business, 107, 105860.

Ekinci, M.F., F.P. Erdem, Z. Kilinc (2015), "Credit Growth, Current Account and Financial Depth", Applied Economics, 47(17), 1809-1821.

Elliott, G., T.J. Rothenberg, J.H. Stock (1996), "Efficient Tests for an Autoregressive Unit Root", Econometrica, 64(4), 813-836.

Enders, W., C.W.J. Granger (1998), "Unit-Root tests and Asymmetric Adjustment with an Example Using the Term Structure of Interest Rates", Journal of Business & Economic Statistics, 16(3), 304-311.

Friedman, B.M., K.N. Kuttner (1989), Money, Income and Prices after the 1980s, NBER Working Paper No: 2852.

Granger, C.W.J., T. Terasvirta (1993), Modelling Nonlinear Economic Relationships, Oxford: Oxford University Press.

Greenaway, D., S. Leybourne, D. Sapsford (1997), "Modeling Growth (and liberalization) Using Smooth Transitions Analysis", Economic Inquiry, 35, 798-814.

Hasanov, M., T. Omay (2008), "Monetary Policy Rules in Practice: Re-examining the Case of Turkey", Physica A, 387, 4309-4318.

Hodrick, R.J., E.C. Prescott (1997), "Postwar U.S. Business Cycles: An Empirical Investigation", Journal of Money, Credit and Banking, 29(1), 1-16.

Im, K.S., M.H. Pesaran, Y. Shin (2003), "Testing for Unit roots in Heterogeneous Panels", Journal of Econometrics, 115, 53-74.

Kapetanios, G., Y. Shin, A. Snell (2003), "Testing for a Unit Root in the Nonlinear STAR Framework", Journal of Econometrics, 112, 359-379.

Kara, H. (2012), Küresel Kriz Sonrası Para Politikası [Monetary policy after the global crisis], CBRT Working Paper No: 12/17, Ankara. http://www.tcmb.gov.tr.

Kayhan, S., T. Bayat, A. Koçyiğit (2013), "Enflasyon Hedeflemesi Rejiminde Öğrenme Süreci ve Asimetri: Markov Awitching Yaklaşımı [Learning process and asymmetry in inflation targeting regime: Markov switching approach]", Eskisehir Osmangazi University Journal of Economics and Administrative Sciences, 8(1), 191-212.

Komlan, F. (2013), "The Asymmetric Reaction of Monetary Policy to Inflation and the Output Gap: Evidence from Canada", Economic Modelling, 30, 911-923.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt, Y. Shin (1992), "Testing the Null Hypothesis of Stationarity Sgainst the Alternative of a unit root: How Sure are we that Economic Time Series have a Unit Root?", Journal of Econometrics, 54, 159-178.

Laurent, R.D. (1988), "An Interest Rate-Based Indicator of Monetary Policy", Economic Perspectives, 12, 3-14.

Leybourne, S., P. Newbold, D. Vougas (1998), "Unit Roots and Smooth Transitions", Journal of Time Series Analysis, 19(1), 83-97.

Lin, C.F.J., T. Terasvirta (1994), "Testing the Constancy of Regression Parameters Against Continuous Structural Change", Journal of Econometrics, 62, 211-228.

Lumsdaine, R.L., D.H. Papell (1997), "Multiple Trend Breaks and the Unit-Root Hypothesis", The Review of Economics and Statistics, 79(2), 212-218.

Maddala, G.S. (1977), Econometrics, New York: McGraw-Hill.

Neuenkirch, M. (2014), "Are Public Preferences Reflected in Monetary Policy Reaction Functions?", Journal of Macroeconomics, 40, 60-68.

Omay, T. (2012), The Comparison of Optimization Algorithms on Unit Root Testing with Smooth Transition, Munich Personel RePEc Archive (MPRA) Paper No: 42129.

Omay, T., M. Hasanov (2006), A Nonlinear Estimation of Monetary Policy Reaction Function for Turkey, Munich Personel RePEc Archive (MPRA) Paper No: 20154.

Omay, T., D. Yıldırım (2013), Nonlinearity and Smooth Breaks in Unit Root Testing, Munich Personal RePEc Archive (MPRA) Paper No: 62334.

Perron, P. (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", Econometrica, 57(6), 1361-1401.

Perron, P. (1990), "Testing for a Unit root in a Time series with a Changing Mean", Journal of Business & Economic Statistics, 8(2), 153-162.

Perron, P. (1997), "Further Evidence on Breaking Trend Functions in Macroeconomic Variables", Journal of Econometrics, 80, 355-385.

Perron, P., S. Ng (1996), "Useful Modifications to Some Unit Root tests with Dependent Errors and Their local Asymptotic Properties", Review of Economic Studies, 63, 435-463.

Phillips, P.C.B., P. Perron (1988), "Testing for a Unit Root in Time Series Regression", Biometrika, 75(2), 335-346.

Phillips, P.C.B., W. Ploberger (1994), "Posterior odds Testing for a Unit Root with Data-Based Model Selection", Econometric Theory, 10(3/4), 774-808.

Rappoport, P., L. Reichlin (1989), "Segmented Trends and Non-Stationary Time Series", The Economic Journal, 99(395), 168-177.

Sollis, R. (2004), "Asymmetric Adjustment and Smooth Transitions: A Combination of some unit Root Tests", Journal of Time Series Analysis, 25(3), 409-417.

Sollis, R. (2009), "A simple unit root test against asymmetric STAR Nonlinearity with an Application to Real Exchange Rates in Nordic Countries", Economic Modelling, 26, 118-125.

Sollis, R., S. Leybourne, P. Newbold (1999), "Unit Roots and Asymmetric Smooth Transitions", Journal of Time Series Analysis, 20(6), 671-677.

Sollis, R., S. Leybourne, P. Newbold (2002), "Tests for Symmetric and Asymmetric Nonlinear Mean Rversion in real Exchange Rates", Journal of Money, Credit and Banking, 34(3), 686-700.

Stock, J.H., M.W. Watson (1989), "New Indexes of Coincident and Leading Economic Indicators", NBER Macroeconomics Annual, 4, 351-394.

Taylor, J.B. (1993), Discretion Versus Policy Rules in Practice, Carnegie-Rochester Conference Series on Public Policy, 39, 195-214.

Taylor, J.B., J.C. Williams (2008), A Black Swan in the Money Market, NBER Working Paper No: 13943.

Taylor, J.B., J.C. Williams (2010), Simple and Robust rules for Monetary policy, NBER Working Paper Series No: 15908.

Turkay, M. (2017), “Heterogeneity Across Emerging Market Central Bank Reaction Functions”, Central Bank Review, 17, 111-116.

Uçar, N., T. Omay (2009), “Testing for Unit Root in Nonlinear Heterogeneous Panels”, Economics Letters, 104, 5-8.

Van Dijk, D. (1999), Smooth Transition Models: Extensions and Outlier Robust Inference, Tinbergen Institute Research Series No: 200.

Varlik, S., M.H. Berument (2017), “Multiple Policy Interest Rates and Economic Performance in a Multiple Monetary-Policy-Tool Environment”, International Review of Economics and Finance, 52, 107-126.

Vougas, D.V. (2006), “On Unit Root Testing with Smooth Transitions”, Computational Statistics & Data Analysis, 51, 797-800.

Vural, U. (2013), Geleneksel Olmayan Para Politikalarının Yükselişi [The rising of unconventional monetary policies], Dissertation, Ankara: Central Bank of the Republic of Turkey Communications and Foreign Relations Department.

Yazgan, M.E., H. Yılmazkuday (2007), “Monetary policy rules in practice: Evidence from Turkey and Israel”, Applied Financial Economics, 17, 1-8.

Yüksel, E., K. Metin-Özcan, O. Hatipoğlu (2013), “A Survey on Time-Varying parameter Taylor rule: A Model Modified with Interest Rate Pass-Through”, Economic Systems, 37, 122-134.

Zivot, E., D.W.K. Andrews (1992), “Further Evidence on the Great Crash, the Oil-Orice Shock, and the Unit-Root Hypothesis”, Journal of Business & Economic Statistics, 10(3), 251-270.