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STATIONARITY OF LONG-TERM REAL INTEREST RATES: FINDINGS FROM NONLINEAR FOURIER UNIT ROOT TEST

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Abstract

This study aims to investigate the stationarity of long-term real interest rates for the top 10 countries with the highest long-term real interest rates among OECD countries in order to determine the effectiveness of monetary policies to be implemented. The study is one of the first to consider both structural breaks and nonlinearity to determine the effectiveness of policies to be implemented regarding interest rates. As a result of the Ranjbar et al. (2018) unit root test allowing for both structural changes and nonlinearity, the long-term real interest rates are stationary at the level for Turkey and Colombia; whereas not stationary at the level for the USA, Chile, Hungary, Iceland, Korea, Norway, Poland, and Canada. According to the results, it was determined that the policies to be implemented regarding interest rates in Türkiye and Colombia would be ineffective because interest rates tend to be mean-reverting.

Keywords ***:*** *Monetary policy, Interest rate hysteresis, Fourier*

JEL Classification ***:*** *E43, E52, C01*

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UZUN DÖNEM FAİZ ORANLARININ DURAĞANLIĞI: DOĞRUSAL OLMAYAN FOURIER BİRİM KÖK TESTİNDEN BULGULAR

Öz

Bu çalışma, uygulanacak para politikalarının etkinliğini belirlemek amacıyla OECD ülkeleri arasında uzun vadeli reel faiz oranları en yüksek olan ilk 10 ülke için uzun vadeli reel faiz oranlarının durağanlığını araştırmayı amaçlamaktadır. Çalışma faiz oranlarına yönelik olarak uygulanacak politikaların etkinliğinin belirlenmesi için, hem yapısal kırılmaları hem de doğrusal olmamayı dikkate alarak yapılan ilk çalışmalardan birisidir. Ranjbar vd. (2018) hem yapısal değişikliklere hem de doğrusal olmamaya izin veren birim kök testi sonuçlarına göre uzun vadeli reel faiz oranlarının Türkiye ve Kolombiya için seviyede durağan olduğu; ABD, Şili, Macaristan, İzlanda, Kore, Norveç, Polonya ve Kanada için ise durağan olmadığı tespit edilmiştir. Elde edilen sonuçlara göre Türkiye ve Kolombiya'da faiz oranlarına yönelik olarak uygulanacak politikaların etkinsiz olacağını çünkü faiz oranlarının ortalamaya dönme eğiliminde olduğu belirlenmiştir.

Anahtar Kelimler **:** *Para politikası, Faiz oranları histerisi, Fourier*

JEL Sınıflandırması **:** *E43, E52, C01*

INTRODUCTION

In macroeconomic models, the interest rate is one of the most fundamental elements of the system. The interest rate directly influences key macroeconomic variables such as savings, investment, and consumption; in open economies, it indirectly affects the exchange rate and, consequently, foreign trade.

As noted by Snowdon and Vane (2005), macroeconomics can be broadly characterized as a conflict between Classical and Keynesian approaches. This conflict extends to the determination of interest rates and the mechanisms through which economic variables are influenced. In this context, we can essentially discuss two types of interest rate theories. The first is the Classical interest rate theory, and the second is the Keynesian interest rate theory.

Supporters of the Classical system view the economy as a system where all factors of production are fully employed. Therefore, they focus solely on how resources are allocated to production sectors and how the income generated from this production is distributed among the owners of production factors. Classical economists base their explanations on real variables. According to them, money is a variable used to represent the level of production in the system. Nonetheless, money does not affect this real level nor the relationships between real variables. The cornerstone of Classical theoretical explanations is Say's Law. According to Say's Law, every supply creates its own demand. In monetary economics, this means that all income generated from production will be spent. Classical economists perceive the savings made by economic agents, who do not wish to spend their entire income, as the basis for future spending and argue that these savings should be redirected towards investments by shifting them to producers. This ensures complete and flawless economic circulation. In this system, interest rates play a critical role in equalizing investments and savings. When there is a disturbance in this balance, interest rates can adjust to restore equilibrium (Bednarczyk, 2008).

The second approach to interest rate theory is the Keynesian explanation. Since its first publication in 1936, John Maynard Keynes' work, "The General Theory of Employment, Interest, and Money" has continued to profoundly influence the economic system. In Keynes' system, interest is the fundamental variable that determines the level of employment. The interest rate Keynes refers to is the market interest rate, which is the basic condition under which monetary funds are supplied. According to Keynes, the market interest rate is a completely monetary phenomenon determined by the supply and demand for money. Keynes views the interest rate as a price that determines whether wealth will be held in cash (Appelt, 2016). He rejected the classical notion that interest is a reward for deferring consumption today. In Keynes' model, the classical view that money is neutral is also rejected. Instead, an increase in the money supply, achieved by lowering the interest rate, can stimulate investments and, through the multiplier effect, total expenditures.

Real interest rates have been central in the modern macroeconomic literature and policy debates since the seminal work of Fisher (1930) was published. Real interest rates are among the most important variables that affect financial assets and macroeconomic dynamics (savings, investment, consumption, unemployment, etc.). The real interest rate variable may fluctuate considerably over time.

In the literature, the real interest rate is calculated by nominal interest rates minus the expected or current inflation rate. The ex-ante real interest rate (EARIR) is calculated by nominal interest rate minus inflation expectations; whereas the ex-post real interest rate (EPRIR) is calculated by nominal interest rate minus actual inflation rate.

Economic agents make their decisions according to the expected inflation level throughout the period during which they make these decisions. Therefore, EARIR can be considered as an appropriate measure to evaluate economic decisions. Nonetheless, since inflation expectations cannot be observed directly, EARIR would not be directly observable either. As a result, it is not possible to evaluate the time-series properties of EARIR. One of the solutions to this problem involves determining the expected inflation using the survey questionnaire data. However, economists do not have a consensus on whether or not to trust survey questionnaire data due to doubts about the quality of the surveys. Moreover, the inability to measure survey questionnaire-based inflation expectations at the desired frequency also poses an obstacle (Das et al., 2014).

There are two alternative approaches to the problem of unobservable expectations: using econometric forecasting methods and the current inflation rate as an indicator of expectations. The biggest deficiency in the first approach is that not all of the information used by economic units when creating inflation expectations can be included in econometric forecasting methods. (cited from Mishkin, 1981: Das et al., 2014).

In Das et al. (2014), by definition, the current inflation rate at time t (π_t) consists of the expected inflation rate and the forecast error term (ε_t).

$$\pi_t = E_{t-1}\pi_t + \varepsilon_t \tag{1}$$

If expectations are rationally constructed, $E_{t-1}\pi_t$ would be the optimal estimate of inflation and ε_t would be a zero-mean, constant variance white noise process. Therefore, EPRIR is calculated as shown in Equation 2.

$$r_t^{ep} = i_t - \pi_{t+1} \tag{2}$$

Equation 1 posits that under the rational expectations assumption, the only difference between EARIR and EPRIR would be the white noise component. Therefore, EARIR and EPRIR would have the same long-term properties.

According to Fisher (1930), the nominal interest rate and the expected inflation rate move concurrently in the long-run. In order for the Fisher equation to maintain validity in the long-run, the real interest rate must be mean-reverting. However, since Rose (1988), who determined that real interest rates contained unit roots, the mean reversion tendencies of real interest rates began to be questioned. Rose (1988) also asserted that the existence of unit root in real interest rates did not comply with the Lucas type consumption-based asset pricing model.

Two approaches are adopted to determine whether or not real interest rates tend to be mean-reverting. The first of these approaches involves the examination of the cointegration relationship between the nominal interest rates and the actual inflation under the assumption of stationary prediction errors. If inflation at the nominal interest rate is not stationary [I(1)], however, is cointegrated of order CI[1,1]; the EPRIR is in the I(0) process and thus possesses the mean-reverting feature. The second approach examines the unit root properties of real interest rates. Investigating the direct unit root properties of real interest rates is the same as examining the cointegrated relationship between the nominal interest rate and inflation (Lai, 1997: 226).

Investigating the stationarity characteristics of real interest rates has crucial macroeconomic consequences. Depending on whether or not real interest rates tend to exhibit mean reversion, the validity of models such as consumption-based intertemporal asset pricing model, Fisher equation, neo-classical growth model, investment model, and term structure model expressed by the intertemporal Euler equation models can be determined. Depending on the potential increase in output level, population growth, and risk perception of economic actors; stationary real interest rates may converge to the long-term equilibrium value. According to Taylor (1993), from a monetary policy point of view, stationary real interest rates can effectively guide the capability of the central bank to implement monetary policy by setting control on the real interest rate. If the real interest rate is stationary, a change in real interest rate as a result of a monetary policy change would merely have a temporary impact, hence, the impacts on the nominal interest rate and inflation rate would not be permanent. This inference indicates that the inflation rate does not have a permanent impact on interest rates, and therefore, money is neutral in the long-run. On the contrary, if the real interest rate is not stationary, monetary policy changes may have permanent impacts on the real interest rate (Canarella et al., 2020: 1-2).

The study will contribute to the literature in three ways. The first of these is that it is one of the first studies to determine the effect of monetary policies on interest rates, especially in the top 10 countries with the highest long-term real interest rates, thanks to the modern time series techniques applied. The second contribution is that each country is analyzed within its dynamics by using the time series analysis method, avoiding bias resulting from aggregation, and thus obtaining country-specific results. The third and final contribution is that more reliable results will be obtained as a result of the applied econometric method that includes both structural breaks and nonlinearity in the analysis.

This study aims to analyze the long-term stationarity properties of real interest rates of the top 10 countries (Turkey, Colombia, Chile, Iceland, Hungary, Korea, USA, Poland, Canada, and Norway) with the highest long-term real interest rates out of 37 member countries of the Organization for Economic Cooperation and Development (OECD) by performing the nonlinear unit root test developed by Ranjbar et al. (2018) using the Fourier function. The following parts of the study are comprised of the literature review, dataset, econometric methodology, empirical findings, and conclusion, respectively.

I. LITERATURE REVIEW

The determining feature and theoretical significance of the real interest rate in models such as consumption-based asset pricing models (Lucas, 1978; Breeden, 1979), neoclassical growth model (Cass, 1965; Koopmans, 1965), models based on central bank policies (Taylor, 1993) and monetary transmission mechanism have led to an increase in empirical studies examining the properties of the real interest rate with various econometric methods (Neely and Rapach, 2008:609).

Following Rose's (1988) pioneering study that examined the statistical properties of the real interest rate, it was seen that the studies on the long-term behavior of the real interest rate have been categorized into two different groups. The first group of studies focused on analyzing whether or not the real interest rate contains a unit root. Rose (1988), in which the annual, quarterly, and monthly data of 18 OECD countries were investigated conducting the Dickey-Fuller (1979) unit root test, concluded that the nominal interest rate was not stationary, the inflation rate was stationary, and the real interest rate was not stationary, hence, it contained a unit root. Studies that examined the stationarity of the real interest rate by performing different unit root tests such as Shapiro and Watson (1988), King et al. (1991), Gali (1992), Goodwin and Grennes (1994), Mishkin and Simon (1995), Koustas and Serletis (1999), Atkins and Serletis (2003), and Rapach and Weber (2004) concluded that the real interest rate was not stationary; whereas other studies such as Mishkin (1992), Wallace and Warner (1993), Engsted (1995), Crowder and Hoffman (1996), Atkins and Coe (2002), Granville and Mallick (2004), Lai (2004), Karanasos et al. (2006), and Lee and Tsong (2011) concluded that the real interest rate was stationary.

The second group of studies conducted the cointegration analysis to examine the relationship between the nominal interest rate and the inflation rate, as well as the mean-reverting tendency of the real interest rates. The cointegration of the non-stationary nominal interest rate and inflation rate series in the cointegration analysis indicated that the real interest rate was stationary, in other words, the real interest rate tends to be mean-reverting (Sekiouna and Zakane, 2007:64). Studies in this group that yielded different results include Mishkin (1992), Evans and Lewis (1995), Crowder and Hoffman (1996), Koustas and Serletis (1999), Coppock and Poitras (2000), Atkins and Coe (2002), and Rapach et al. Wohar (2004).

The fact that studies examining the stationarity of the real interest rate using conventional unit root tests yielded different results from each other and the developments in time-series econometrics have caused researchers to use methods that allow for fractional integration, nonlinearity, and structural breaks. Lai (1997), Tsay (2000), Gil-Alana (2004), Phillips (2005), Karanasos et al. (2006), Jensen (2009), Das et al. (2014), Balparda et al. (2015), and Canarella et al. (2020) are among the studies using fractional integration methods. Million (2004), Koustas and Lamarche (2010), Norrbin and Smallwood (2011), Guney et al. (2015), and Omay et al. (2017) investigated the statistical properties of the real interest rates using nonlinear methods.

It is also seen that methods that take into account regime changes and structural breaks are used in the analysis of the characteristics of the real interest rate. Clemente et al. (1998), Caporale and Grier (2000), Rapach and Wohar (2005), Lai (2008), Neely and Rapach (2008), Haug (2014), Ozdemir et al. (2015), and Omay et al. (2017) are among the studies in which structural breaks are taken into consideration.

Studies that examined the extent to which the persistence of the real interest rate would change when regime changes are in question include Huzinga and Mishkin (1986), Garcia and Perron (1996), Caporale and Grier (2000), Bai and Perron (2003), and Rapach and Wohar (2005).

II. DATASET and ECONOMETRIC METHODOLOGY

II.I. Dataset

For econometric analysis, the monthly data of the top 10 countries with the highest long-term interest rates among 37 member countries of the OECD are utilized. Nevertheless, although they are among the top 10 countries, Mexico, New Zealand, and Australia are excluded from the analysis due to the lack of monthly data of inflation rates. Instead of these countries, the countries in the eleventh, twelfth and thirteenth rows (Poland, Canada, and Norway) are included in the sample. The data range is set as January 2008 – December 2023 for all countries.

Studies in the literature [Caporale et al. (2021); Berument and Froyen (2021); Kiley (2019)], in general, examined 10-year government bond yields pertaining to long-term interest rates. Therefore, depending on the relevant literature, the monthly nominal interest rates of 10-year government bonds are included in the analysis by obtaining real interest rate by courtesy of the Consumer Price Index (CPI) as stated in Equation 2. Table 1 presents the descriptive statistics regarding the data.

According to the explanatory statistics presented in Table 1, Colombia has the highest mean value of the long-term real interest rates among the countries included in the analysis, followed by Turkey and Iceland. Canada has the lowest mean value of the long-term real interest rates.

II.II. Econometric Methodology

Since the monthly data used in the study may exhibit seasonal effects, it is essential to conduct the analyses utilizing the seasonally-adjusted data. For this purpose, the data are first examined through the seasonality test which was developed by Ollech and Webel (2020) [OW]. OW seasonality test considers the definition of the seasonal status of a certain time-series as a classification task and tries to avoid the problem of different tests yielding different results by using the machine learning method that considers the result of different seasonality tests as the estimator. The long-term real interest rates of the countries, which are determined to have seasonal effects as a result of the OW seasonality test, are seasonally adjusted by using the Tramo-Seats filter before they are included in the analysis.

Regarding the testing of the mean-reverting tendency of real interest rates, it is determined that there is a tendency to include less evidence supporting the mean-reverting tendency in studies using the conventional unit root tests such as Dickey-Fuller, Kwiatkowski, Phillips, Schmidt, Shin (KPSS). It is stated that the conventional unit root tests have lower explanatory power than modern nonlinear unit root tests that allow structural change and may incorrectly detect that the series contains a unit root (Diebold and Rudebusch, 1991:159-160).

For this reason, first of all, the KPSS unit root test, a conventional unit root test that does not take into account structural breaks and nonlinearity, then the Augmented KPSS test with the Fourier function (FKPSS), which takes into account structural breaks, and finally the unit root test developed by Ranjbar et al. (2018) with the Fourier function, which allows both structural breaks and taking into account nonlinearity, are performed in the study.

II.II.I. Ranjbar et al. (2018) Unit Root Test

Ranjbar et al. (2018: 51) developed a new unit root test that allows breaks in deterministic components and asymmetric nonlinear corrections. In the study, the asymmetric exponential smooth transition autoregressive (AESTAR) unit root test developed by Sollis (2009) was extended with the Fourier function, and it was ensured that it would have also taken structural breaks into account.

Table 1. Descriptive Statistics

Country	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
USA	2.291	2.284	5.725	0.122	0.886	0.304	4.234
Chili	4.643	4.498	7.730	1.795	1.202	-0.077	2.733
Colombia	7.426	7.077	13.418	4.795	1.566	1.356	5.115
Hungary	4.967	4.745	10.850	0.980	2.479	0.239	1.801
Iceland	5.621	5.589	13.276	1.492	1.892	0.639	5.011
Korea	3.030	2.878	6.209	0.709	1.316	0.383	2.248
Norway	2.194	1.981	4.826	-0.152	1.189	0.401	2.257
Poland	3.839	3.555	6.850	-0.010	1.564	-0.096	2.151
Canada	2.027	1.969	4.578	-0.257	0.927	0.202	2.720
Turkey	6.049	9.739	22.419	-59.950	3.575	1.100	3.780

In Ranjbar et al. (2018), the data generation process began as shown in Equation 3.

$$y_t = \alpha(t) + \varepsilon_t \quad (3)$$

The Fourier function developed by Gallant (1981) was added as shown in Equation 4 to include breaks of unknown number and form in *α(t),* which expresses a deterministic component that changes over time.

$$\alpha(t) = Z_t\lambda + \sum_{k=1}^{n} \gamma_{1,k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{n} \gamma_{2,k} \cos\left(\frac{2\pi kt}{T}\right) \quad (4)$$

To estimate Equation 3, appropriate n, and appropriate t values need to be determined. As stated in Enders and Lee (2012), limiting the value of n to 1 allows preserving the degrees of freedom, and preventing the overfitting problem.

In Equation 4, t denotes the trend term, T represents the number of observations, and k stands for the optimal frequency value. The optimal frequency value is the frequency that yields the smallest SSR, as in the FKPSS test. Depending on these limitations and deterministic components, the null hypothesis in Equation 5 is tested. In Equation 5, u_t is assumed to be zero-mean I(0). The test statistic required to test the null hypothesis is calculated in a three-stage process, following the methodology used by Christopoulos and Leon-Ledesma (2010).

$$H_0: \varepsilon_t = v_t,\ \ v_t = v_{t-1} + u_t \quad (5)$$

In the 1st stage, the frequency value in Equation 4, limited to the maximum value of 5, is determined as the optimal frequency value that yields the minimum SSR value by estimating with the ordinary least squares (OLS), Equation 6 is estimated, and error terms are calculated with the help of Equation 7.

$$\hat{\alpha}\,(t) = Z_t\hat{\lambda} + \widehat{\gamma_1}\sin\left(\frac{2\pi k^* t)}{T}\right) + \widehat{\gamma_2}\cos\left(\frac{2\pi k^* t)}{T}\right) \quad (6)$$

$$\widehat{\varepsilon_t} = y_t - \hat{\alpha}\,(t) \quad (7)$$

In the 2nd stage, the stationarity test of the error term obtained from Equation 7 is estimated using the AESTAR model. In the 3rd stage, if the null hypothesis implying the unit root in the 2nd stage is rejected, the existence of the asymmetric structure in the model is examined following Becker et al. (2006) by the F test. If the series is determined to be stationary at the level, the null and alternative hypotheses of the F test are indicated in Equation 8.

$$H_0: Symmetrical\ ESTAR\ Nonlinearity \quad (8)$$

$$H_a: Asymmetric\ ESTAR\ Nonlinearity$$

III. EMPIRICAL FINDINGS

First of all, the KPSS and ADF tests, as a traditional unit root tests, was performed in the study. The KPSS and ADF unit root test results are presented in Table 2 and 3 respectively. According to the KPSS and ADF test results, the long-term real interest rates in all countries included in the analysis, except for Turkey, are not stationary at the level. According to these results, while the impacts of changes in monetary policy on the long-term real interest rate would be permanent for all countries except for Turkey, they would be temporary for Turkey, and the series tend to be mean-reverting.

Since the KPSS and ADF unit root tests are conventional tests and do not consider structural changes or nonlinearity, the Fourier KPSS (FKPSS) test is performed. The FKPSS test results are presented in Table 4.

Table 2. KPSS Test Results

		Critical Values		
Country	Test Statistics	0.01	0.05	0.10
USA	0.844 (9)	0.739	0.463	0.347
Chile	1.374 (10)	0.739	0.463	0.347
Colombia	1.209 (10)	0.739	0.463	0.347
Hungary	1.425 (10)	0.739	0.463	0.347
Iceland	1.106 (10)	0.739	0.463	0.347
Korea	1.395 (10)	0.739	0.463	0.347
Norway	1.264 (10)	0.739	0.463	0.347
Poland	1.422 (10)	0.739	0.463	0.347
Canada	1.185 (10)	0.739	0.463	0.347
Turkey	0.345 (10)*	0.739	0.463	0.347

Note: The values in parentheses indicate the optimal lag lengths. * denotes stationarity at the 5% significance level.

Table 3. ADF Test Results

Country	Test Statistics	Probability Values
USA	-1.665	0.764
Chile	-2.709	0.329
Colombia	-3.004	0.118
Hungary	-1.960	0.822
Iceland	-2.568	0.443
Korea	-1.692	0.780
Norway	-1.557	0.850
Poland	-1.618	0.745
Canada	-2.943	0.150
Turkey	-4.104*	0.006

Note: * denotes stationarity at the 5% significance level.

Table 4. Fourier KPSS Test Results

Country	Frequency	Min. SSR	FKPSS Test Statistics	Optimal Lag	F test Statistics
USA	3	89.259	1.002	9	29.722
Chile	1	118.655	0.552	9	54.323
Colombia	1	516.664	0.565	10	62.585
Hungary	1	288.105	0.507	9	182.201
Iceland	2	115.873	1.010	10	27.461
Korea	1	97.946	0.506	10	113.375
Norway	1	214.087	0.546	10	80.337
Poland	1	177.771	0.513	10	86.602
Canada	1	84.674	0.483	9	39.066
Turkey	1	1875.502	0.445	10	35.895

Note: The critical values at 5% significance level for frequency values 1, 2 and 3 are 0.1720, 0.4152 and 0.4480, respectively.

The FKPSS test results indicate that in all countries included in the analysis, the long-term real interest rate variable is not stationary at the level, and therefore, the impacts of monetary policy changes on interest rates would be permanent, and the series does not tend to be mean-reverting. There is a difference between the standard KPSS and ADF test results and the FKPSS test results for Turkey. The main reason for this difference is thought to be that the FKPSS test allows for structural changes.

Although the FKPSS test allows for structural breaks, it does not take into account asymmetric changes. Thus, consequently, an AESTAR type unit root test developed by Ranjbar et al. (2018) that was extended with the Fourier function would be performed in the study.

This test allows for both structural and asymmetrical changes. Table 5 presents the Ranjbar et al. (2018) unit root test results.

Table 5. Ranjbar et. al (2018) Unit Root Test Results

Country	Frequency	Test Statistics	Optimal Lag	F test Statistics
USA	3	0.474	11	6.733
Chile	1	1.490	11	3.692
Colombia	1	9.842*	11	4.140
Hungary	1	2.244	12	2.636
Iceland	2	2.043	11	3.003
Korea	1	0.968	3	0.781
Norway	1	2.356	10	3.092
Poland	1	0.663	12	3.303
Canada	1	1.437	12	4.353
Turkey	1	7.520*	12	11.405

Note: * denotes stationarity at the 5% significance level.

Ranjbar et al. (2018) unit root test results indicate that the long-term real interest rate is not stationary at the level for the USA, Chile, Hungary, Iceland, Korea, Norway, Poland and Canada. It is determined that changes in monetary policy in these countries would have permanent impacts on the interest rate and the series do not tend to be mean-reverting. Furthermore, in these countries, future values of interest rates cannot be predicted by taking their past values into account.

Nonetheless, for Colombia and Turkey, the long-term real interest rates are found to be stationary at the level. Monetary policies to be implemented in these countries would not have permanent impacts since interest rates tend to be mean-reverting. Therefore, monetary policies to change long-term real interest rates would be ineffective in both countries with the highest interest rates among the OECD member countries. It is also possible to predict the future movements of interest rates in these countries by taking their historical values into consideration.

The results of the F test in Colombia and Turkey, in which the interest rates are stationary, indicate that the null hypothesis is rejected in both countries, the series exhibits asymmetrical properties, and the Fourier functions are significant.

CONCLUSION

Policymakers and economists claim that the lower level of real interest rate is one of the most important factors in maintaining macroeconomic stability, especially in investments. For this purpose, they make effort to direct interest rates through monetary policies. Therefore, it is critically crucial to figure out whether the shocks on interest rates are permanent or temporary in order to determine the effectiveness of the implemented monetary policies on interest rates.

To this end, the Ranjbar et al. (2018) unit root test, which is a nonlinear unit root test that allows structural changes, is performed to determine whether shocks on interest rates are permanent or temporary in the top 10 countries with the highest long-term real interest rates among OECD countries in this study as opposed to previous studies.

According to the Ranjbar et al. (2018) unit root test results, the long-term real interest rates in Turkey and Colombia are determined to be stationary at the level, therefore they tend to be mean-reverting, and that the shock that would occur due to the implemented monetary policy is temporary, and that monetary policy cannot be an effective instrument in affecting interest rates.

The long-term real interest rate for the USA, Chile, Hungary, Iceland, Korea, Norway, Poland, and Canada is determined to be nonstationary at the level and the monetary policies to be implemented would be successful in affecting the interest rates.

Another conclusion drawn as a result of the study is that the performed analyses with conventional unit root tests would not be sufficient to determine the effectiveness of monetary policies. Consequently, it is thought that the performance of unit root tests that allow structural changes and take into account the asymmetric and nonlinear nature of the interest rate determined in financial markets where many heterogeneous economic actors operate would yield more reliable results.

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