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# STOCHASTIC PROPERTIES OF TURKISH REAL INTEREST RATES

***Real interest rate, that plays a central role in the decision-making of households, firms and government, has also some important implications on the basic assumptions of a number of financial and macroeconomic models. Time series properties of real interest rate have important policy implications as well. In this paper, we examine the degree of persistence in quarterly seasonally adjusted Turkish real interest rates using a set of econometric procedures. We use the Lee-Strazicich unit root test, modified to capture more than two structural breaks, to test for multiple structural breaks in the mean real interest rate of Turkey and to find extensive evidence of 3 structural breaks. These endogenous structural breaks are significant and meaningful in terms of economic development. We also find that allowing endogenously determined structural breaks in the data-generating process substantially reduces the degree of persistence. In order to have better evidence on the degree of persistence we estimate the half-life of shocks, calculate confidence interval for point estimates and investigate subsamples. Our results show that Turkish real interest rate is stationary and has a mean reverting behavior but is characterized by some degree of persistence.***

***Keywords:*** *real interest rate; persistence; unit root; structural breaks; half-life; Turkey.*
***Jel code: C22; E4.***

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# СТОХАСТИЧНІ ВЛАСТИВОСТІ ТУРЕЦЬКИХ РЕАЛЬНИХ ПРОЦЕНТНИХ СТАВОК

***У статті доведено, що реальна відсоткова ставка відіграє ключову роль при прийнятті економічних рішень домогосподарствами, фірмами та урядом, а також при побудові багатьох макроекономічних моделей. Характеристики часових рядів реальних відсоткових ставок також можуть стати суттєвим макроекономічним та фінансовим показником. З використанням економетричних прийомів досліджено ступінь стійкості щоквартальних реальних відсоткових ставок з урахуванням сезонних коливань. Зокрема, використано метод одиничних коренів Лі-Стразіціча, модифікований таким чином, щоб вловити більше двох структурних розривів для усередненої відсоткової ставки в Туреччині. Доведено існування 3 структурних розривів, які є суттєвими показниками динаміки економічного розвитку країни. Також доведено, що структурні розриви суттєво знижують ступінь стійкості відсоткової ставки. Для більш детального дослідження стійкості реальної відсоткової ставки розраховано періоди напіврозпаду шоків, довірчі інтервали та окремо досліджено підвибірки у досліджуваному періоді. Результати аналізу демонструють, що турецьку реальну відсоткову ставку можна назвати стаціонарною, до певної міри реверсивною та доволі стійкою.***

***Ключові слова:*** *реальна відсоткова ставка; стійкість; одиничний корінь; структурний розрив; період напіврозпаду; Туреччина.*
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# СТОХАСТИЧЕСКИЕ КАЧЕСТВА ТУРЕЦКИХ РЕАЛЬНЫХ ПРОЦЕНТНЫХ СТАВОК

***В статье показано, что реальная процентная ставка играет ключевую роль при принятии экономических решений домохозяйствами, фирмами и правительством, а также при построении многих макроэкономических моделей. Характеристики временных рядов***

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***реальных процентных ставок также могут быть существенным макроэкономическим и финансовым показателем. С использованием эконометрических приёмов исследована степень устойчивости ежеквартальных реальных процентных ставок с учётом сезонных колебаний. В частности, использован метод единичных корней Ли-Стразицича, модифицированный таким образом, чтобы уловить больше двух структурных разрывов в усреднённой реальной процентной ставке для Турции. Доказано существование 3 структурных разрывов, которые являются значимыми показателями динамики экономического развития страны. Также доказано, что структурные разрывы существенно снижают степень устойчивости процентной ставки. Для более детального исследования устойчивости реальной процентной ставки рассчитаны периоды полураспада шоков, доверительные интервалы и отдельно исследованы подвыборки в исследуемом периоде. Результаты анализа показывают, что турецкую реальную процентную ставку можно назвать стационарной, в определённой мере реверсивной и довольно устойчивой.***

***Ключевые слова:*** *реальная процентная ставка; устойчивость; единичный корень; структурный разрыв; период полураспада; Турция.*

## 1. Introduction

Real interest rate is one of the most powerful economic variables and a determinant of virtually all intertemporal decisions of households and firms. This variable is also important for GDP growth, international capital markets and economic fluctuations. Interest rate is the main policy tool of central banks, and it plays a crucial role for monetary transmission. Several macroeconomic and financial theories, including the neoclassical growth model (Koopmans, 1965), models of central bank policy (Taylor, 1993) and models of monetary transmission mechanism, are based on some assumptions about stochastic properties of real interest rates which makes this variable decisive for the validity of these theories. Hansen and Singleton (1983) claim that real interest rate must have the same persistence properties as consumption growth in a simple endowment economy for the validity of basic assumptions of consumption-based asset pricing model (Lucas, 1978; Breeden, 1979). The persistence incompatibility of these series casts doubt on the validity of this theory. Stationary of growth rate of per-capita consumption is almost sure. So, if real interest rate contains a unit root, there will be a disparity among the stochastic properties of these series, which will violate the intertemporal Euler equation. A similar equation is used for the general equilibrium growth model based on the stationary real interest rates assumption. Neoclassical growth model (Cass, 1965) is based on the assumption that real interest rate is a function of the stationary-state growth rate of technological change (Blanchard, Fischer, 1989; Neely, Rapach, 2008). So, investigation of stochastic properties of real rate could provide an implicit test for the validity of these models.

Taking into consideration the importance of stochastic properties of real interest rates for theoretical models and intertemporal decisions, it is not surprising that this topic has received considerable attention in literature. By using a variety of econometric models, time-series properties of real interest rates have been analyzed intensely especially for developed countries. However, for developing countries including Turkey, literature on this research area is relatively limited. This paper attempts to provide robust evidence relevant to the stochastic properties of Turkish real rates. To this aim we employ several econometric techniques including unit root tests, bootstrapping, half-life and sub-sampling.

The remainder of this paper is organized as follows. Section 2 presents literature review, Section 3 explains econometric methodology paying particular attention to LS, bootstrapping, half-life and sub-sampling techniques. Section 4 reports and discusses the results obtained by several econometric techniques. Section 5 concludes by summarizing our main findings.

**2. Literature review**

Early studies concentrate on unit root properties of interest rates and mostly employ conventional unit root tests. In his seminal and controversial paper Fama (1975) claims that US monthly ex-ante real interest rates are constant from 1953 to 1971. His finding is in accordance with the main assumptions of a number of economic models. However, this study has been criticized by several researchers for different reasons (Carlson, 1977; Nelson, Schwert, 1977; Shiller, 1980; Mishkin, 1981). Subsequent studies, some of which belong to Fama himself, reject the idea that real interest rate is constant (Fama, 1981; Fama and Gibbons, 1982). During the 1980's, some studies claim that interest rates are stationary (Huizinga, Mishkin, 1986), but others assert that this variable can be defined as I (1) process (Stock and Watson, 1988); and no consensus can be achieved.

In his provocative paper, Rose (1988) explores the integration properties of the real interest rates of 18 OECD countries. Rose claims that real rates have a unit root for each country investigated. However, nonstationary real interest rate is inconsistent with the basic assumptions of a number of popular theoretical models. Because of its important theoretical implications and controversial nature, his study becomes a motivation for new studies, which re-examine unit root properties of real interest rate and try to solve this puzzle. During 1990's several researchers examine the integration properties of the US real interest rates by employing conventional unit root tests and fail to reject the unit root hypothesis (King et al., 1991; Gali, 1992). However, Mishkin (1992) and Wallace and Warner (1993) find evidence for the cointegration between nominal interest rates and CPI which indicates that the US ex-post real rate is stationary for the periods investigated. There are several multistate researches as well, including Engsted (1995) and Koustas and Serletis (1999). Those studies provide ambiguous results for the unit root properties of the countries investigated.

The idea that some political or/and economic factors may change the properties of series was uttered almost half a century ago (Quandt, 1958; Chow, 1960). Afterwards determination of structural breaks and incorporating them into unit root tests became one of the most important aspects of econometric studies and several researchers have contributed to this process (Perron, 1989; Zivot and Andrews, 1992; Lumsdaine and Papell, 1997; Lee and Strazicich, 2003; Bai and Perron, 2003). Garcia and Perron (1996) test multiple structural breaks for the US real interest rate and find 3 structural breaks for the 1961:1—1986:3 period. Some studies test for multiple structural breaks in the mean of international real interest rates and find extensive evidence for breaks in the countries investigated (Rapacah, Wohar, 2005; Lai, 2008).

Unit root tests have difficulty to distinguish unit root and near unit root processes from each other (Blough, 1992). To alleviate this problem a confidence interval can be constructed for integration coefficient which will be more informative to understand stochastic properties of series. Rapach and Wohar (2004) analyze the persistence of real interest rates of several OECD countries by employing Hansens' (1999) grid bootstrap and Romano and Wolf (2001) sub-sampling methods. They report that lower bounds of the 95% confidence interval for the sum of AR coefficient estimates for ex post real rate are generally greater than 0.90, while upper bounds are greater than unity which implies a stationary but highly persistent process. Also the half-life of shocks is estimated with the help of impulse response function. Their findings indicate that real interest rate has long-term memory, shocks have temporary but long lasting affects and real rate ultimately returns to its long-term mean value but it takes considerable time. Karanasos et al. (2006) estimate 95% confidence interval for the point estimates of the US ex post real rate integration coefficient and [0.97, 0.99] interval is found.

Studies on Turkish real interest rate mostly investigate the impact of this variable on other economic variables and the economy as a whole. There are some articles on the stochastic properties of Turkish real interest rates, including Alper et al. (2007), Yavuz (2008), Onel (2005). However, this topic needs to be investigated further.

**3. Econometric methodology**

Unit root is one of the most important stochastic properties of a variable and it affects its behavior strongly. Unit root test basically depends on the equation (1) below in which $p = 0$ and $p = 1$ indicate stationary and unit root processes respectively. Because of implying an explosive process, the possibility that $p > 1$ is generally ignored.

$$Y_t = pY_{t-1} + u_t,\ -1 \le p \le 1 \quad (1)$$

Well-known Dickey-Fuller (1979) unit root test is typically based on the autoregressive (AR) representation of time series. ADF test can be applied in 3 different specifications, namely model without constant and trend, model with constant, model with constant and trend; those can be expressed as follows:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-1-i} + \varepsilon_t \quad (2)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-1-i} + \varepsilon_t \quad (3)$$

$$\Delta y_t = a_0 + a_2 t + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-1-i} + \varepsilon_t \quad (4)$$

The ADF test is based on the OLS estimation of $\gamma$ in these regression models. We first tested for a unit root in Turkish real interest rates by using two different specifications of the ADF test (Dickey and Fuller, 1979; Said and Dickey, 1984) represented by equations (3) and (4).

The specification of the lag length ($p$) is an important issue for the implementation of the unit root test. Lag length has to be determined empirically. A too small $p$ value cannot eliminate the serial correlation problem completely, which leads to biased results. On the other hand, a too large $p$ number lowers the power of the test. We determined the lag number by employing Campbell and Peron (1991) top-down approach that uses OLS method. We began the analysis with a 12 maximum possible lag value and estimated the equation (3) with $(p-1)_{max} = 12$. If t-statistics corresponds to $\beta$ is bigger than 1.64 in absolute value, it means that this lag value is not appropriate for the analysis, so the process continues to repeat the analysis and estimates equation (3) with $(p-1)_{max} = 11$. This process continues until a t-statistic smaller than 1.64 in absolute value is achieved.

We applied the Phillips and Perron (1988) unit root test (PP thereafter) based on equation (5) and KPSS stationary test (Kwiatkowski et al., 1992) for confirmatory analysis.

$$y_t = \tilde{a}_0 + \tilde{a}_1 y_{t-1} - \tilde{a}_2\left(t - \frac{T}{2}\right) + u_t \qquad (5)$$

For a highly persistent but stationary series conventional unit root tests have a low power to reject the null (DeJong et al., 1992). Incorporating structural breaks is a method to have better results than from ADF type tests. However, ADF type endogenous break unit roots tests suffer from serious power and size distortions due to the asymmetric treatment of breaks under the null and alternative hypotheses (Lee, Strazicich, 2001, 2003; Kim, Perron, 2009). These tests are prone to rejecting the unit root hypothesis when the true data generating mechanism is nonstationary with break (Nunes et al., 1997; Vogelsang, Perron, 1998). Also the ADF type endogenous break unit root tests cannot estimate break points correctly. Lagrange Multiplier (LM) unit root tests are more powerful and have a better performance in estimating break points (Schmidt, Lee, 1991; Amsler, Lee, 1995). Also, the magnitude and the location of breaks do not affect the performance of the LM unit root tests. The LM type test does not exhibit size distortion and lead to spurious rejections in the presence of unit root with break. So, then rejection of unit root null unambiguously shows stationary data generating mechanism.

In this paper, we follow the procedure of the Lee and Strazicich (2003) Lagrange multiplier unit root test. These tests use the minimum-$\tau$ criterion of Zivot-Andrews (1992) to identify break points. The null and alternative hypothesis for two breaks LS test are shown below:

$$H_0 : y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + d_3 D_{1t} + d_4 D_{2t} + y_{t-1} + \nu_{1t} \qquad (6)$$

$$H_A : y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + d_3 DT_{1t} + d_4 DT_{2t} + \nu_{2t}$$

$t = T_{Bj+1}$, $j = 1 \rightarrow B_{jt} = 1$ otherwise 0.

The LS unit root test is conducted with the help of equation (7):

$$\Delta y_t = \delta' \Delta Z_t + \varphi' S'_{t-1} + u_t \qquad (7)$$

$$S'_t = y_t - \hat{\Psi}_x - Z_t \hat{\delta}_t, t = 2, \ldots, T$$

All possible structural breaks are determined as follows for the minimum $t$ stats.

$$Inf\tilde{\tau}(\lambda'_t) = Inf\tilde{\tau}(\lambda\ )\ \lambda = T_B / T \qquad (8)$$

Lee-Strazicich unit root test allows at most two structural breaks. However, Turkish real interest rates might have more than two breaks. In order to capture this possibility, we extend the break number to 3. The 3 break LS unit root test is a modified version of Perrons' (1989) approach. AAA model of LS test incorporates 3 breaks at a slope and intercept to Perrons' (1989) model A.

Unit root tests could only reveal limited information about the persistency of data generating mechanism. To have better information it is useful to determine a range of values for the integration coefficient. Bootstrapping (Efron, 1979) is an important re-sampling method and can be used to construct a confidence interval. However, conventional bootstrap confidence intervals may not be valid for the sum of AR coefficient in the local-to-unity framework (Inoue and Kilian, 2002). Hansens'

(1999) grid bootstrap has better first degree asymptotic coverage for the near unit root process; and when probabilistic distribution is dependent on parameter, this method is superior to conventional bootstrap. To have a better understanding about the persistency of Turkish real interest rate we compute 95% confidence intervals for the sum of the AR coefficients following the Hansen (1999) grid bootstrap and Romano and Wolf (2001) procedures, previously employed by Rapach and Wohar (2004).

To obtain more evidence we also calculate the half-life of shocks which is a popular measure of persistence. For the time series analysis, half-life measures the number of years required for a shock to dissipate by one-half, that is to say, persistence of shocks. This measure can be used to obtain an insight into the mean reversion speed of a series. If it is assumed that the reversion speed is constant, it can be calculated as follow:

$$1-\exp\left[\ln\left(\frac{1}{2}\right)/_h\right] \quad (9)$$

However, if the reversion speed is not constant, formula (9) will not be appropriate. We employ the impulse response function to estimate half-life, following the procedure developed by Cheung and Lai (2000). Persistence can be represented as the moving average process of variable $y$:

$$y_t = C(L)u_t \quad (10)$$

$$C(L) = 1 + C_1L + C_2L^2 + C_3L^3 \ldots$$

$$C(L) = B^{-1}(L)D(L)$$

Moving average coefficients $C_1$, $C_2$, $C_3$... show impulse responses. For the stationary process the effect of shocks is temporary and $C_\infty = 0$. In order to investigate the persistence, instead of evaluating all $C$ values, half-life can be used as a summary measure. We estimate half-life by employing the method developed by Gospodinov (2004). We also split the series according to the endogenously determined 3 break dates into 4 subperiods and the stochastic properties of these subperiods are analyzed to obtain more robust results.

**4. Data and empirical results**

We use the short-term treasury bonds rate and the consumer price index to obtain real rates for Turkey. For this purpose we first investigate seasonality at the series. After eliminating seasonality, and annual inflation series, real rates are calculated. Data is obtained from Central Bank of Republic of Turkey EVDS system. Our analysis is based on the quarterly real rate series and it covers the 1986:2—2010:4 period.

***4.1. Conventional unit root tests.*** To have a benchmark, unit root properties of Turkish real interest rates are investigated by conventional unit root and KPSS stationary tests. For this aim two specifications of these tests are used. Prior to ADF unit root test lag order was determined with the help of the procedure developed by Campbell and Perron (1991). Our analysis shows that the appropriate lag number for Turkish real interest rate is 7. ADF, PP and KPSS test results are reported in Table 1. We see that the unit root null hypothesis cannot be rejected for Turkish real interest rate using either the ADF or the PP tests at conventional significance levels. However, the result of the KPSS test does not confirm the previous ones, which indicates that the unit root finding of ADF and PP test might be misleading.

*Table 1.* **Results of ADF, PP and KPSS tests,** *calculated by the authors*

| | t-statistics | Prob. | LM-Stat. |
|---|---|---|---|
| ADF (with constant) | -2.020621 | 0.2777 | - |
| ADF (with constant and trend) | -3.151978 | 0.1004 | - |
| PP (with constant) | -1.451529 | 0.5539 | - |
| PP (with constant and trend) | -2.811552 | 0.1968 | - |
| KPSS | - | - | 0.73958 |

***4.2. Lee and Strazicich unit root test.*** As mentioned above if economic time series have structural breaks and these breaks are not taken into account, findings of unit root tests could be misleading. When we analyze the graph of Turkish real interest rates we suspect there are structural breaks at series. Lee and Strazicich unit root test allows at most two structural breaks. However, there might be more than two structural breaks. In order to capture this possibility we extend Lee and Strazicich unit root test to incorporate more than two structural breaks.

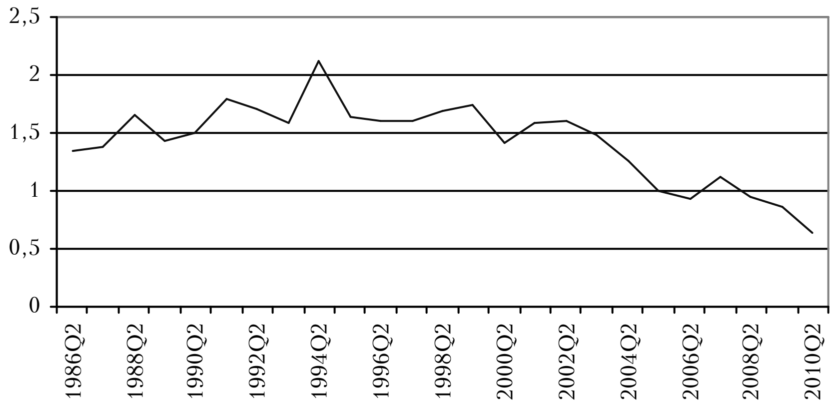


*Figure 1.* **Time series plot of Turkish real interest rates for the sample period (Log value),** *developed by the authors*

In Table 2 we report the results of the Lee-Strazicich unit root test. This table reveals there are 3 structural breaks in the mean of Turkish real interest rates. These breaks are incompatible with the historical developments in Turkey. The first two breaks, 1994 and 2001, represent two economic crises. The third break happens in 2006 and this year represents the period when interest rates come to an end in their 5-year long downward movement.

*Table 2.* **Endogenously determined structural change dates,** *calculated by the authors*

| |
|---|
| set dumt1 = 0<br>set dumt1 1993:4 2010:4 = (time+1-31) |
| set dumt2 = 0<br>set dumt2 2001:1 2010:4 = (time+1-60) |
| set dumt3 = 0<br>set dumt3 2006:2 2010:4 = (time+1-81) |

***4.3. OLS point estimates, bootstrapping and half-life analysis.*** By employing the Lee-Strazicich unit root test with 3 structural breaks we obtain a point estimate of 0,573 for the integration coefficient of AR representation of Turkish real rate. We observe a reduction in the degree of integration in series once structural breaks are taken into account. For the series the probabilistic distribution of which is not known, the reliability of the point estimate is arguable. We use the bootstrap methodology to construct the 95% confidence intervals for the OLS point estimate of Turkish real interest rates. To construct the 95% confidence interval, then grid bootstrap method is employed and upper and lower bounds are found as [0.455–1.08] respectively. This finding reveals that Turkish real interest rate most probably does not have a unit root. On the other hand, even when we look at the lower bound of the 95% confidence interval for integration coefficient, it seems that Turkish real rate is persistent to some degree. This result shows that shocks to Turkish real rate are temporary and they decay in time.

We further investigate the persistence of Turkish real interest rate by estimating the half-life. Also for a point estimate of the half-life, the 95% confidence interval is estimated by using grid bootstrap methods. Applying the impulse response function and integrating 3 structural breaks into the analysis we estimate half-life of shocks as 0.25 years. Lower and upper bounds for the 95% confidence interval for the half-life are found as 0.25 and 10 years respectively. These results reveal that shocks do not have infinite effects on Turkish real rate. Turkish real rate tends to return its long-term mean, the data are not inconsistent with a high degree of persistence. Overall, our results show that Turkish real interest rate could be characterized by a high degree of persistence.

***4.4. Subsamples.*** To have more evidence we also use the subsampling techniques. For this we divide series into 4 subsamples with the help of 3 structural break dates obtained before. For all these subsamples we apply unit root tests, estimate half-life and construct confidence intervals with the help of grid bootstrap. The results are displayed in Table 3. Observe that OLS point estimates of integration coefficient are less than one for every subsample. Also, even upper bounds of the grid bootstrap are less than one for every subsample, which is another proof that subsamples do not have unit root but are persistent to some degree. Half-life point estimates are 0.38 year for the first subsample and 0.25 year for others. Confidence intervals for subsamples show that the effects of shocks are finite. In this context, the subsamples are mean reverting, with shocks having temporary effects, and disappearing in the long run. So, in the long-run even without a policy measures series will return to their long run mean. However, for the short run there might be dispersion from the long run unconditional mean value, which could explain the irrelevance of some macroeconomic theories in the short run.

*Table 3.* **Point estimates and 95% confidence intervals for sub samples,** *calculated by the authors*

| Subsamples | OLS Point Estimate | Grid Bootstrap | Half-Life Point Estimate | Grid Bootstrap for Half-Life |
|---|---|---|---|---|
| Subsample 1 | 0.73201 | 0.65590<br>0.90366 | 0.38 | 0.28<br>0.53 |
| Subsample 2 | 0.94783 | 0.93816<br>0.96087 | 0.25 | 0.25<br>10.00 |
| Subsample 3 | 0.86992 | 0.82495<br>0.90199 | 0.25 | 0.25<br>10.00 |
| Subsample 4 | 0.50365 | 0.04607<br>0.91660 | 0.25 | 0.25<br>10.00 |

**5. Discussion, implications and conclusion**

Stochastic properties of real rate are well documented for developed countries; however for the developing ones there are fewer studies. Our research aims to fill this gap and to obtain extensive evidence on the stochastic properties of Turkish real interest rates by employing a number of different econometric techniques.

To investigate the potential multiple structural breaks in the mean Turkish real interest rate for Turkey we use the Lee-Strazicich unit root test, by extending the number of breaks more than two. Test results indicate there are 3 structural breaks: those that happened in 1994, 2001 and 2006 in the mean of the series investigated and these breaks are compatible with economic developments. The Lee-Strazicich unit root test that incorporates 3 structural breaks estimates the integration coefficient as 0,573. The upper bound of 95% confidence intervals for the sum of the AR coefficients is lower than unity. To have a better understanding half-life estimates and subsampling techniques are employed. All the findings show that Turkish real interest rate does not have a unit root but is persistent to some degree. So, our analysis reveals that Turkish real interest rate displays a long memory behavior; shocks are long-lasting but temporary and the series is ultimately mean-reverting. Structural breaks in unconditional means characterize Turkish real interest rates and the incorporation of these breaks reduce within-regime persistence significantly. These facts lead us to claim that Turkish real interest rate is best viewed as a persistent but ultimately mean-reverting process that contains multiple structural breaks.

Stationary Turkish real interest rate implies that disruptions in real rates will have a temporary impact on the economic activity which has some implications for economic stability. This finding has implications for the effectiveness of government intervention and monetary policy, so the results of this paper are important for policy implications as well. Stochastic properties of real rates are important for monetary models and the money transmission mechanism. Decisions about the application of monetary policy should take into consideration the stochastic properties of real rate. Determining integration properties of real rates is relevant in the formulation of the central bank interest rate-related policy as well as government stabilization policies. So policy makers should distinguish the nature of shocks and form their policy by taking into account this information. According to our findings, the half-life of a shock is a quarter year which means that shocks loose half of their impact in 3 months. This variable is mean reverting in the long run, but for the short run it is persistent to some degree and an active monetary policy may be required to restore the economy. The central bank may find it useful to determine the frequency and the calibration of its intervention according to this finding. This finding is also important for model building and forecasting models, those that use real interest rates.

Our findings have theoretical importance as well. They reveal that in the long run the stochastic properties of Turkish real rate do not contradict the basic assumptions of these macroeconomic theories such as PPP, Fisher hypothesis, and capital-based asset pricing model etc. It seems that the puzzle Rose brought into the agenda might be a result of low power of the unit root test and that it is not relevant for Turkish case.

This paper discusses the stochastic properties of Turkish real interest rate; however, it does not explore the causes of persistence. Sources of the persistence in real interest rates should be investigated by means of structural analysis. Furthermore, the effects of these findings on some major theoretical models is another important area for researchers.

**References:**

*Alper, E.C., Kazimov, K., Akdemir, A.* (2007). Forecasting the term structure of interest rates for Turkey: A factor analysis approach. Applied Financial Economics, 17(1–3): 77–85.

*Amsler, C., Lee, J.* (1995). An LM test for unit root in the presence of a structural change. Econometric Theory, 11: 359–368.

*Bai, J., Perron, P.* (2003). Computation and analysis of multiple structural change models. Journal of Applied Econometrics, 18(1): 1–22.

*Bai, J., Perron, P.* (2001). Multiple structural change models: a simulation analysis. (Edited by: Dean Corbae, Steven N. Durlauf and Bruce Hansen). Econometric Theory and Practice. Frontiers of Analysis and Applied Research. Cambridge: Cambridge University Press.

*Bai, J., Perron, P.* (1998). Estimating and testing linear models with multiple structural changes. Econometrica, 66: 47–78.

*Blanchard, O.J., Fischer, S.* (1989). Lectures on Macroeconomics. Cambridge, Massachusetts: The MIT Press.

*Blough, S.R.* (1992). The relationship between power and level for generic unit root tests in finite samples. Journal of Applied Econometrics, 7(3): 295–308.

*Breeden, D.T.* (1979). An intertemporal asset pricing model with stochastic consumption and investment opportunities. Journal of Financial Economics, 7(3): 265–96.

*Campbell, J.Y., Perron P.* (1991). Pitfalls and opportunities: what macroeconomists should know about unit roots. NBER Macroeconomics Annual, 6: 141–201.

*Caporale, T., Grier, K.B.* (2000). Political regime change and the real interest rate. Journal of Money, Credit, and Banking, 32: 320–334.

*Carlson, J.A.* (1977). Short-term interest rates as predictors of inflation: Comment. American Economic Review, 67(3): 469–475.

*Cass, D.* (1965). Optimum growth in a model of capital accumulation. Review of Economic Studies, 32(3): 233–240.

*Chow, G.C.* (1960). Tests of equality between sets of coefficients in two linear regressions. Econometrica, 28: 591–605.

*Dickey, D.A., Fuller, W.A.* (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74: 427–431.

*DeJong, D., Nankervis, J.C., Savin, N.E., Whiteman, C.H.* (1992). The power problems of unit root test in time series with autoregressive errors. Journal of Econometrics, 53(1–3): 323–343.

*Efron, B.* (1979). Bootstrap methods: Another look at the jackknife. Annals of Statistics, 7(1): 1–26.

*Engsted, T.* (1995). Does the long-term interest rate predict future inflation? A multi-country analysis. Review of Economics and Statistics, 77(1): 42–54.

*Fama, E.F., Gibbons, M.R.* (1982). Inflation, real returns, and capital investment. Journal of Monetary Economics, 9: 297–324.

*Fama, E.F.* (1981). Stock returns, real activity, inflation and money. American Economic Review, 71: 545–565.

*Fama, E.F.* (1975). Short-term interest rates as predictors of inflation. American Economic Review, 65: 269–282.

*Gali, J.* (1992). How well does the IS-LM model fit postwar U.S. data? Quarterly Journal of Economics, 107(2): 709–738.

*Garcia, R., Perron, P.* (1996). An analysis of the real interest rate under regime shifts. Review of Economics and Statistics, 78: 111–125.

*Gospodinov, N.* (2004). Asymptotic confidence intervals for impulse responses of near-integrated processes. Manuscript, Concordia University, Montreal.

*Hansen, B.E.* (1999). The grid bootstrap and the autoregressive model. Review of Economics and Statistics, 81: 594–607.

*Hansen, L.P., Singleton, K.J.* (1983). Stochastic consumption, risk aversion, and the temporal behavior of asset returns. Journal of Political Economy, 91(2): 249–265.

*Hansen, L.P., Singleton, K.J.* (1982). Generalized instrumental variables estimation of nonlinear rational expectations models. Econometrica, 50(5): 1269–1286.

*Huizinga, J., Mishkin, F.S.* (1986). Monetary regime shifts and the unusual behavior of real interest rates. Carnegie-Rochester Conference Series on Public Policy, 24: 231–274.

*Inoue, A., Kilian, L.* (2002). Bootstrapping autoregressive processes with possible unit roots. Econometrica, 70: 377–391.

*Karanasos, M., Sekioua, S.H., Zeng, N.* (2006). On the order of integration of monthly US ex-ante and ex-post real interest rates: New evidence from over a century of data. Economics Letters, 90(2): 163–169.

*Kim, D., Perron, P.* (2009). Unit root tests allowing for a break in the trend function at an unknown time under both the null and alternative hypotheses. Journal of Econometrics, 148: 1–13.

*King, R.G., Plosser, C.I., Stock, J.H., Watson, M.W.* (1991). Stochastic trend and economic fluctuations. American Economic Review, 81(4): 819–840.

*Koopmans, T.C.* (1965). On the concept of optimal economic growth. In the Economic Approach to Development Planning, Elsevier: Amsterdam.

*Koustas, Z., Serletis A.* (1999). On the Fisher Effect. Journal of Monetary Economics, 44(1): 105–130.

*Kwaitkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y.* (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54: 159–178.

*Lai, K.S.* (2008). The puzzling unit root in the real interest rate and its inconsistency with intertemporal consumption behavior. Journal of International Money and Finance, 27: 140–155.

*Lee, J., Strazicich, M.C.* (2003). Minimum Lagrange Multiplier unit root test with two structural breaks. The Review of Economics and Statistics, 85(4): 1082–1089.

*Lee, J., Strazicich, M.C.* (2001). Break point estimation and spurious rejections with endogenous unit root tests. Oxford Bulletin of Economics and Statistics, 63(5): 535–558.

*Lucas, R.E.* (1978). Asset prices in an exchange economy. Econometrica, 46(6): 1429–1445.

*Lumsdaine, R., Papell, D.* (1997). Multiple trend breaks and the unit root hypothesis. Review of Economics and Statistics, 79: 212–218.

*Mishkin, F.S.* (1992). Is the Fisher Effect for real? A reexamination of the relationship between inflation and interest rates. Journal of Monetary Economics, 30(2): 195–215.

*Mishkin, F.S.* (1981). The real rate of interest: An empirical investigation. Working Paper. NBER. No. 622.

*Neely, C.J., Rapach, D.E.* (2008). Real interest rate persistence: Evidence and implications. Working Paper. Research Division Federal Reserve Bank of St. Louis. No. 2008–018A.

*Nelson, C.R., Schwert, W.G.* (1977). Short-term interest rates as predictors of inflation: On testing the hypothesis that the real rate of interest is constant. American Economic Review, 67: 478–486.

*Nunes, L., Newbold, P., Kuan, C.* (1997). Testing for unit roots with breaks: Evidence on the great crash and the unit root hypothesis reconsidered. Oxford Bulletin of Economics and Statistics, 59: 435–448.

*Onel, G.* (2005). Testing for multiple structural breaks: An application of Bai-Perron test to the nominal interest rates and inflation in Turkey. D.E.U.II.B.F. Dergisi, 20(2): 81–93.

*Perron, P.* (1989). The Great Crash, the oil price shock, and the unit root hypothesis. Econometrica, 57: 1361–1401.

*Phillips, P.C., Perron, P.* (1988). Testing for a unit root in time-series regression. Biometrica, 75: 335–346.

*Quandt, R.E.* (1958). The estimation of parameters of a linear regression system obeying two separate regimes. Journal of the American Statistical Association, 55: 873–880.

*Rapach, D.E., Wohar, M.E.* (2004). The persistence in international real interest rates. International Journal of Finance and Economics, 9: 339–346.

*Rapach, D.E., Wohar, M.E.* (2005). Regime changes in international real interest rates: Are they a monetary phenomenon? Journal of Money, Credit, and Banking, 37(5): 887–906.

*Romano, J.P., Wolf, M.* (2001). Subsampling intervals in autoregressive models with linear time trends. Econometrica, 69: 1283–1314.

*Rose, A.K.* (1988). Is the real interest rate stable? The Journal of Finance, 43(5): 1095–1112.

*Said, S.E., Dickey, A.D.* (1984). Testing for unit roots in autoregressive-moving average models of unknown order. Biometrika, 71(3): 599–607.

*Schmidt, P., Lee, J.* (1991). A modification of the Schmidt-Phillips unit root test. Economics Letters, 36(3): 285–289.

*Shiller, R.J.* (1980). Can the FED control real interest rates. (Edited by: Stanley Fischer). Rational Expectations and Economic Policy. Chicago: University of Chicago Press.

*Stock, J.H., Watson, M.W.* (1988). Testing for common trends. Journal of the American Statistical Association, 83: 1097–1107.

*Taylor, J.B.* (1993). Discretion versus policy rules in practice. Carnegie-Rochester Conference Series on Public Policy, 39: 195–214.

*Vogelsang, T., Perron, P.* (1998). Additional tests for a unit root allowing for a break in the trend function at an unknown time. International Economic Review, 39: 1073–1100.

*Yavuz, N.C.* (2008). Is real exchange rate stationary for Turkey? Evidence from the two break LM unit root test. Economics Bulletin, 28(15).

*Zivot, E., Andrews, D.* (1992). Further evidence of the great crash, the oil-price shock and the unit root hypothesis. Journal of Business and Economic Statistics, 11: 251–270.

*Wallace, M.S., Warner, J.T.* (1993). The Fisher Effect and the term structure of interest rates: Tests of cointegration. Review of Economics and Statistics, 75(2): 320–324.

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