

SL Publishing Co.

Econometrics Letters

ECONOMETRICS LETTERS

ISSN 2148-6212

Volume 2, Issue 1 | June 2015

Contents

1-21 Re-examining the PPP Hypothesis via Nonlinearity and Smooth Breaks

Banu Kurtaran

22-40 A Reinvestigation of the Hysteresis Hypothesis in the OECD Countries

Melis Tartak

Editorial Board

Editor in Chief

Mubariz Hasanov

Piri Reis University, Istanbul, Turkey

Editorial Board

Erdoğan Telatar

Okan University, Istanbul, Turkey

Haluk Erhat

Middle East Technical University (METU), Ankara, Turkey

Nezir Köse

Gazi University, Ankara, Turkey

Nicholas Apergis

University of Piraeus, Piraeus, Greece

Nicola Spagnolo

Brunel University London, UK

Michael Berlemann

Helmut Schmidt University, Hamburg, Germany

K. Peren Arin

Zayed University, Abu Dhabi, UAE

Yılmaz Akdi

Ankara University, Ankara, Turkey

Furkan Emirmahmutolu

Ankara Hacı Bayram Veli University, Ankara, Turkey

Managing Editors

Mustafa Can Küçük

Atılım University, Ankara, Turkey

Eref Uur Çelik

Atılım University, Ankara, Turkey



Re-examining the PPP Hypothesis via Nonlinearity and Smooth Breaks

Banu Kurtaran¹

Abstract

This study is investigated the PPP hypothesis for 16 OECD countries by using the newly proposed unit root tests which covers nonlinearity, structural break and nonlinear panel data structure. The results exhibits that the nonlinearity and structural break are important components of the PPP data.

Keywords: Smooth Break; Nonlinear Unit Root Test; Nonlinear Panel Unit Test; PPP.

JEL Codes: C12; C22; O47.

¹ **Corresponding Author :** banukurtaran@chocobons.com
ISSN: 2148-6212

1. Introduction

Purchasing Power Parity is one of the most important propositions in international economics. Whether or not PPP holds has important policy and theoretical implications. Although a considerable amount of literature has been devoted to testing the validity of PPP for developed countries, few researchers to date have analyzed the PPP proposition by using all unit root test available in the literature. Therefore, with the aim of contributing to the empirical literature in this area, we tested the validity of PPP for an extensive sample of 16 OECD countries by examining the stationarity properties of the real exchange rates vis-a-vis the US dollar.

In the literature it is well known that various exogenous shocks may cause the equilibrium value of the real exchange rate to change over time. For example, an oil price shock in 1973 has shifted the equilibrium real exchange rates of the most of the countries all over the world. Therefore, it is more suitable to include structural break components in to testing process of PPP hypothesis. In fact, Sollis (2005) and Papell and Prodan (2006) present some evidence in support of the PPP hypothesis after allowing for possible structural breaks in the real exchange rate series. On the other hand, Sercu et al. (1995) and Michael et al. (1997) stressed the importance of transactions costs in goods arbitrage models. They suggested that convergence of real exchange rates to the long-run equilibrium level might be non-linear². Taylor et al. (2001), Kapetanios et al. (2003), among others, report results maintaining the PPP hypothesis after allowing for nonlinearities in adjustment to the equilibrium level. Furthermore, Sollis (2004), Christopoulos and Leon-Ledesma (2010)³, Omay, Hasanov and Emirmahmutoğlu (2014) argued that structural breaks and nonlinearity are prevail together, and time series might be described more appropriately by simultaneous structural breaks and nonlinearities.

In this study we used unit root tests which covers linear, nonlinear, structural break and panel data features namely, Dickey and Fuller (1979), Enders and Granger (1998), Kapetanios, Shin, and Snell (2003), Sollis (2004), Omay and Yıldırım (2014) and Ucar and Omay(2009), henceforth, ADF, KSS, S, EG, OY and UO, respectively.

The remaining of the paper is organized as follows. In the next section we present the unit root tests used in this study. Empirical part presented in Section 3. Section 4 concludes and gives some policy recommendation.

² See, for example, Omay, Hasanov and Emirmahmutoğlu (2014), Flood and Marion (1998), Taylor and Allen (1992), Krugman (1991), Enders and Dibaoglu (2001), Taylor (2003).

³ See Omay (2015) for Fractional Frequency Flexible Fourier Form of the similiar test.

Table 1: Summary of Empirical Studies Matching Countries or Methodology Considered in the Literature

Authors	Time	Country	Methodology	Conclusion of Papers
Papell (2001)	Post 1973	20 Industrialized Countries	Bai (1999) test, univariate methods, panel unit root tests, Monte Carlo simulations	PPP holds for European countries, those follow the typical pattern of the rise and fall of the dollar in the 1980s. PPP does not hold for the other, almost all non-European, countries that do not follow the typical pattern.
Breitung and Candelon (2003)	From 1981, 3–20 years for South and Latin American countries and 20 years for Asian countries	Five countries in South and Latin America (Mexico, Venezuela, Colombia, Argentina, and Brazil) and five Asian countries (Thailand, Singapore, Malaysia, South Korea, and Hong Kong)	A new panel Unit root test that is robust to structural breaks; Breitung and Meyer (1994) and Breitung (2000)	PPP holds for the Asian countries. PPP does not hold for South and Latin American currencies.
Papell and Prodan (2003)	1870 -1998	16 Industrialized Countries	ADF extended AO model of Vogelsang and Perron (1998), Monte Carlo for size and power	PPP or TPPP holds for 14 countries out of 16.
Papell and Prodan (2005)	1970-2006	16 Industrialized Countries	Unit root tests that both account for structural change and maintain a long run mean or trend.	PPP holds for 14 countries out of 16.
Christopoulos and Leon-Ledesma (2009)	Period 1974:1-2006:4 for all countries except those that entered the European Monetary Union (EMU) for which we use the 1974:1-1998:4.	15 OECD Countries	Non-linear adjustment process with ESTAR modeling, a set of unit root tests that account for the presence of multiple smooth temporary breaks compatible with long-run PPP by means of a Fourier function. linear and two nonlinear specifications of the ESTAR form following the lead of previous literature.	PPP holds for 14 countries out of 15 except Canada.
Huang and Kuan (2009)	1885:01 - 1995:11	US/UK real exchange rate	Innovation Regime-Switching Model of Kuan, Huang and Tsay (2005,JBES)	PPP does not hold for US /UK real exchange rate.
Holmes et.al (2011)	1991-2005	26 OECD countries	Panel co-integration, Error correction model Hadri and Rao 82008)	PPP holds for 26 OECD countries

2. Nonlinear Unit Root tests and Panel Unit Root test

2.1 Kapetanios Shin and Snell Test (KSS) test and Ucar and Omay (UO) test

A brief discussion on the nonlinear unit root test procedures developed by Kapetanios *et al.* (2003) must be given at first⁴. Consider y_t follows univariate exponential smooth transition autoregressive (ESTAR)⁵ model of order 1:

$$y_t = \beta y_{t-1} + \gamma y_{t-1} [1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_t, \quad (2.1.1)$$

which after reparameterising can be written suitably as

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1} [1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_t, \quad (2.1.2)$$

where $\phi = \beta - 1$.

The global stationarity of the process y_t can be established by testing the null hypothesis $H_0 : \theta = 0$ against the alternative $H_1 : \theta > 0$. However, testing the null hypothesis directly is not feasible since the parameter γ is not identified under the null. In order to solve this problem, Kapetanios *et al.* (2003) use the method of Luukkonen *et al.* (1988) to replace the transition function by its suitable Taylor approximation to obtain a t-type test statistic. By using Taylor approximation the following auxiliary regression is obtained:

$$\Delta y_t = \delta y_{t-d}^3 + e_t, \quad (2.1.3)$$

where e_t comprises original shocks ε_t as well as the error term resulting from Taylor approximation.

The test statistic for $\delta = 0$ against $\delta < 0$ is obtained as follows:

$$t_{NL} = \hat{\delta} / s.e.(\hat{\delta}), \quad (2.1.4)$$

where $\hat{\delta}$ is the OLS estimate and $s.e.(\hat{\delta})$ is the standard error of $\hat{\delta}$.

In the more general case when errors are serially correlated, the auxiliary regression augmented by p^{th} order lag of dependent variable. The extended model can be seen as follows:

⁴ A more detailed explanation can be followed from Hasanov and Omay (2007).

⁵ For a discussion of STAR models see and Granger and Teräsvirta, (1993) and Teräsvirta, (1994).

$$\Delta y_t = \sum_{j=1}^p \rho_j \Delta y_{t-j} + \delta y_{t-d}^3 + e_t \quad (2.1.5)$$

We also applied the non-linear panel unit root test newly proposed by Ucar and Omay (2009), which we called as the UO test. The UO test has a good power when the series under investigation follow a non-linear process. A brief review of the UO test can be given as follows.

Let y_{it} be panel exponential smooth transition autoregressive process of order one (PESTAR(1)) on the time domain $t = 1, 2, \dots, T$ for the cross-section units $i = 1, 2, \dots, N$. Consider y_{it} generated by the following PESTAR process with fixed effect parameter α_i :

$$\Delta y_{it} = \alpha_i + \phi y_{it-1} + \gamma_i y_{it-1} \left[1 - \exp(-\theta_i y_{it-d}^2) \right] + \varepsilon_{it} \quad (2.1.6)$$

where $d \geq 1$ is the delay parameter and $\theta_i \geq 0$ represents the speed of revision for all units; ε_{it} is a serially and cross-sectionally uncorrelated disturbance term with zero mean and variance σ_i^2 .

Hence the obtained auxiliary regression is given by:

$$\Delta y_{it} = \alpha_i + \delta_i y_{it-1}^3 + \varepsilon_{it} \quad (2.1.7)$$

where $\delta_i = \theta_i \gamma_i$. In empirical application equation (2.1.7) augmented by lagged variables of dependent variable by using AIC and SIC criteria. Based on equation (2.1.7), hypothesis for unit root testing is

$$H_0 : \delta_i = 0, \quad \text{for all } i, \quad (\text{Linear Nonstationary})$$

$$H_0 : \delta_i < 0, \quad \text{for all } i, \quad (\text{Non-linear Stationary})$$

The UO test is constructed by standardizing the average of individual KSS statistics across the whole panel. First, the KSS test for the i^{th} individual is the t-statistics for testing $\delta_i = 0$ in equation (2.1.7) defined by:

$$t_{i,NL} = \frac{\Delta y_i' M_t y_{i,-1}^3}{\hat{\sigma}_{\hat{t},NL} \left(y_{i,-1}' M_t y_{i,-1} \right)^{3/2}} \quad (2.1.8)$$

Furthermore, when the invariance property and the existence of moments are satisfied, the usual normalization of $\bar{t}_{NL}$ statistic obtained⁶.

One of the contemporary problems of panel data estimation is cross-section dependency. Most of the panel data models assume that disturbances in panel models are cross-sectionally independent.

⁶ The normalization formula and the table values can be followed from Ucar and Omay (2009).

However, cross-section dependence may arise for several reasons which are given in most of the studies (e.g., Pesaran (2004) and Omay and Kan (2010)). In the presence of cross-section dependence, it is well known that neglecting cross-section dependence can lead to biased estimates and produce misleading inference. Thus, we have made a diagnostic check for cross-section dependency for non-linear panel models following Omay and Kan (2010).

The sample estimate of the pair-wise correlation of the residuals is:

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^T e_{it} e_{jt}}{\left(\sum_{t=1}^T e_{it}^2 \right)^{1/2} \left(\sum_{t=1}^T e_{jt}^2 \right)^{1/2}} \quad (2.1.9)$$

And the e_{it} is the OLS estimates of u_{it} defined by

$$e_{it} = \Delta y_{it} - \hat{\mu}_i - \hat{\beta}_i' x_{it} \quad (2.1.10)$$

The proposed CD test by Pesaran (2004) is:

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right) \quad (2.1.11)$$

The second CD test which is used in Pesaran (2004) is proposed by Breusch and Pagan (1980)

$$CD_{LM1} = T \cdot \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right) \quad (2.1.12)$$

following scaled version of CD_{LM1} can be considered for testing the hypothesis of cross dependence even for N and T large:

$$CD_{LM2} = \sqrt{\frac{1}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N (T \cdot \hat{\rho}_{ij}^2 - 1) \right) \quad (2.1.13)$$

2.2. Enders and Granger (EG) Test

Enders and Granger (1998) employ threshold autoregressive (TAR) models to propose tests of the null hypothesis of a unit root that allow under the alternative hypothesis for stationary asymmetric adjustment towards a fixed mean or deterministic linear trend.

$$\Delta y_t = \alpha + \rho_1 I_t y_{t-1} + \rho_2 (1 - I_t) y_{t-1} + \sum_{j=1}^k \hat{\delta}_j \Delta y_{t-j} + \hat{\eta}_t \quad (2.2.1)$$

where

$$I_t = \begin{cases} 1 & \text{if } y_{t-1} > 0 \\ 0 & \text{if } y_{t-1} < 0 \end{cases}$$

where $I_t=1$ if $y_{t-1} \geq 0$, $I_t=0$ if $y_{t-1} < 0$, and $\hat{\eta}_t$ is a zero-mean stationary process. if $\rho_1 = \rho_2 = 0$ in equation (2.2.1) then y_t contains a unit root, while if $\rho_1 = \rho_2 < 0$, y_t is a stationary TAR process with symmetric adjustment, and if $\rho_1 < 0$, $\rho_2 < 0$ and $\rho_1 \neq \rho_2$, y_t is a stationary TAR process displaying asymmetric adjustment. Enders and Granger (1998) propose testing for whether y_t contains a unit root using the F-statistic for testing $\rho_1 = \rho_2 = 0$ in (2.2.1), and/or the most significant of the t-statistics from those for testing $\rho_1 = 0$ and $\rho_2 = 0$. For the model (1), the relevant F and t-statistic will be referred to as $F_{1p,\alpha}$ and $t_{1p,\alpha}$. When the full model is trend term the relevant F and t-statistic will be referred to as $F_{2p,\alpha}$ and $t_{2p,\alpha}$.

2.3. Leybourne Newbold and Vougas (LNV) test

Leybourne, Newbold and Vougas (1998) develop unit root tests for time series where the alternative is stationary around a linear trend with smoothly changed break, and provide their small sample properties

Let y_t be panel with changing trend function with smooth transition on the time domain $t = 1, 2, \dots, T$.

$$y_t = \alpha + \alpha_2 S_t(\gamma, \tau) + \varepsilon_t \quad (2.3.1)$$

$$y_t = \alpha + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + \varepsilon_t \quad (2.3.2)$$

$$y_t = \alpha + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + \beta_2 t S_t(\gamma, \tau) + \varepsilon_t \quad (2.3.3)$$

where ε_t is a zero mean $I(0)$ process and $S_t(\gamma, \tau)$ is logistic smooth transition function.

$$S_t(\gamma, \tau) = \left[1 + \exp\{-\gamma(t - \tau T)\} \right]^{-1}, \quad \gamma_i > 0 \quad (2.3.4)$$

In this modeling strategy, the structural change is modeled as smooth transition between different regimes rather than instantaneous structural break Leybourne *et al.* (1996). The transition function

$S_t(\gamma, \tau)$ is continuous function bounded between 1 and 0. Thus the STR model can be interpreted as regime-switching model that allows for two regimes, associated with the extreme values of the transition function, $S_t(\gamma, \tau) = 0$ and $S_t(\gamma, \tau) = 1$, whereas the transition from one regime to the other is gradual. The parameter γ determines the smoothness of the transition, and thus, the smoothness of transition from one regime to the other. The two regimes are associated with small and large values of the transition variable $s_t = t$ relative to the threshold $c = \tau$. For the large values of γ , $S_t(\gamma, \tau)$ passes through the interval $(0, 1)$ very rapidly, and as γ approaches $+\infty$ this function changes value from 0 to 1 instantaneously at time $t = \tau T$. Therefore, if we assume that ε_t is zero mean $I(0)$ process, and then model 1 y_t is stationary process around a mean which changes from initial value α_i to final value $\alpha_i + \alpha_2$. Leybourne *et al.* (1998) also give similar conditions for model 2 and 3. In these specifications no change and one instantaneous structural change are limiting cases whereas this specification is more general which it covers gradual structural changes as well⁷.

Leybourne *et al.* (1998) establish the hypothesis for unit root testing based on equation 2.3.1, 2.3.2 and 2.3.3 as follows:

H_0 : Unit Root , (Linear Nonstationary)

H_a : Stationary (Stationary around smoothly changing trend and intercept)

Following Leybourne *et al.* (1996) the test statistics proposed here is calculated with a two-step procedure:

Step1. Using a nonlinear least squares (NLS) algorithm, estimate only deterministic component of the preferred model and compute the NLS residuals

$$\text{Model 1} \quad \hat{\varepsilon}_t = y_t - \hat{\alpha} - \hat{\alpha}_2 S_t(\gamma, \tau)$$

$$\text{Model 2} \quad \hat{\varepsilon}_t = y_t - \hat{\alpha} - \hat{\beta}_1 t - \hat{\alpha}_2 S_t(\gamma, \tau)$$

$$\text{Model 3} \quad \hat{\varepsilon}_t = y_t - \hat{\alpha} + \hat{\beta}_1 t + \hat{\alpha}_2 S_t(\gamma, \tau) + \hat{\beta}_2 t S_t(\gamma, \tau)$$

Step2. Compute the ADF statistic, the t ratio associated with $\hat{\rho}_i$ in the ordinary least squares (OLS) regression

⁷ For further discussion and the possible extension see Leybourne *et al.* (1996).

2.4 Solis (S) test

Solis (2004) developed a unit root test by combining Enders and Granger (1998) and Leybourne, Newbold and Vougas (1998). Enders and Granger (1998) employ threshold autoregressive (TAR) models to propose tests of the null hypothesis of a unit root that allow under the alternative hypothesis for stationary asymmetric adjustment towards a fixed mean or deterministic linear trend. In Solis (2002) study, the EG tests are extended to the case of a nonlinear attractor. Specifically, the smooth transition methodology utilized by Leybourne, Newbold and Vougas (1998), is combined with the TAR methodology of EG to develop unit-root tests that allow under the alternative hypothesis for a smooth transition between deterministic linear trends, around which stationary asymmetric adjustment may occur.

The similarity of the EG and LNV approaches to testing for the presence of a unit root in the original series – both removing the deterministic components of the data prior to unit root testing – suggests that the models used by these authors might be combined. Let y_t be generated by Model 1, Model 2 or Model 3 with $\hat{\varepsilon}_t$ generated by the following TAR model. Combining the equation TAR model and the LNV Model 1, Model 2 or Model 3 we can obtain the Solis test.

$$\Delta \hat{\varepsilon}_t = \alpha + \rho_1 I_t \hat{\varepsilon}_{t-1} + \rho_2 (1 - I_t) \hat{\varepsilon}_{t-1} + \sum_{j=1}^k \hat{\delta}_j \Delta \hat{\varepsilon}_{t-j} + \hat{\eta}_t \quad (2.4.1)$$

where

$$I_t = \begin{cases} 1 & \text{if } \hat{\varepsilon}_{t-1} > 0 \\ 0 & \text{if } \hat{\varepsilon}_{t-1} < 0 \end{cases}$$

Where $I_t = 1$ if $\hat{\varepsilon}_{t-1} \geq 0$, $I_t = 0$ if $\hat{\varepsilon}_{t-1} < 0$, and $\hat{\eta}_t$ is a zero-mean stationary process. Thus y_t is a smooth transition TAR (ST-TAR) process. Irrespective of which model from Model 1, Model 2 or Model 3 is used to describe the deterministic components of y_t , if $\rho_1 = \rho_2 = 0$ in (2.4.1) then $\hat{\varepsilon}_t$ and therefore y_t contains a unit root, while if $\rho_1 = \rho_2 < 0$, y_t is a stationary ST-TAR process with symmetric adjustment, and if $\rho_1 < 0$, $\rho_2 < 0$ and $\rho_1 \neq \rho_2$, y_t is a stationary ST-TAR process displaying asymmetric adjustment. We propose testing for whether y_t contains a unit root using the F-statistic for testing $\rho_1 = \rho_2 = 0$ in (2.4.1) and/or the most significant of the t-statistics from those for testing $\rho_1 = 0$ and $\rho_2 = 0$.

For model 1, 2 and 3 we demonstrate t statistics for $\hat{\rho}_i$ as $\bar{t}_{br1}$, $\bar{t}_{br2}$, and $\bar{t}_{br3}$, respectively.

$H_0 : \rho_i = 0$, for all i , (Linear Nonstationary)

$H_0 : \rho_i < 0$, for some i , (Stationary around nonlinear trend and intercept)

2.5 Omay and Yildirim Test (OY) test

Omay and Yildirim (2014) have developed a unit root test by combining Kapetanios *et al* (2003) and Leybourne, Newbold and Vougas (1998). KSS (2003) employ exponential smooth transition autoregressive (ESTAR) models to propose tests of the null hypothesis of a unit root that allow under the alternative hypothesis for stationary asymmetric adjustment towards a fixed mean. In this study, they have extended the KSS tests to the case of a nonlinear attractor. Specifically, the smooth transition methodology utilized by Leybourne, Newbold and Vougas (1998), is combined with the ESTAR methodology of KSS to develop unit-root tests that allow under the alternative hypothesis for a smooth transition between deterministic linear trends, around which stationary asymmetric adjustment may occur. Following Leybourne *et al.* (1996) the test statistics proposed here is calculated with a two-step procedure on to model 1 model 2 and model 3.

3. Data and Unit Root Test Results

In this paper, 16 OECD countries are tested for PPP hypothesis. The investigated countries are Argentina, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Korea, Mexico, Saudi Arabia, South Africa, Turkey and United Kingdom. The data are monthly and sourced from Datastream. To test the PPP hypothesis in these countries, PPP index are searched for whether they contain unit root. A finding of unit root would imply that PPP hypothesis are not hold. For this purpose we carried out conventional ADF and PP unit root tests as well as nonlinear unit root tests recently proposed KSS, EG, LNV and Solis.

Following the univariate linear unit root test, which does not reject the unit-root null hypothesis we applied the same sample a multivariate unit root test (IPS). IPS results are given on the Table 10.

We searched for the break dates with the help of Bai Perron test for OECD sample. These results are given in Table 2.

Table 2: Periods and Break Dates for Every Country in the Data Set

Country	Break Number	TB1	TB2
Argentina	1	2002M01	—
Brazil	2	1999M01	2002M08
Canada	2	2002M11	2008M04
China	1	1998M07	—
France	1	2002M02	—
Germany	1	2002M02	—
India	1	2006M08	—
Indonesia	2	1998M06	2001M10
Italy	1	2002M02	—
Japan	0	—	—
Korea	2	1999M02	2003M11
Mexico	2	1997M07	2001M10
Saudi Arabia	2	1999M11	2007M03
South Africa	1	2001M11	—
Turkey	1	2002M05	—
UK	2	1999M11	2008M04

*Break dates are found by Bai and Perron

By using these break dates we have explored the results of linear unit root test (ADF). We firstly test the stationarity of the real exchange rate series ignoring possible structural changes and non-linearities in the series. For this purpose we apply the ADF unit root test, the results of which appear in Table 3. Irrespective of whether a linear time trend is involved or not, the ADF tests suggest that only the Indonesian and Mexican real exchange rate series are stationary, consistent with the PPP proposition. Since the ADF test takes account neither of structural changes nor of non-linearities in the series, conclusions drawn from this test may be misleading.

Table 3: Linear Unit Root Tests Considering Break Dates

Country	Full Sample		Before break		Inter Break		After Break	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Argentina	-1,615	-2,051	0,742	-1,239	-	-	-4,590	-8,519
Brazil	-1,445	-1,481	-0,039	-1,063	0,942	-0,404	-1,075	-3,181
Canada	-0,933	-2,067	-1,041	-3,218	-2,073	-3,182	-1,588	-2,527
China	-0,565	-0,514	-1,689	-1,257	-	-	-4,246	-1,260
France	-1,574	-1,804	-0,190	-3,223	-	-	-3,539	-3,151
Germany	-1,655	-1,849	-0,237	-3,168	-	-	-3,389	-3,098
India	-0,170	-1,615	-1,955	-1,882	-	-	-1,729	-1,717
Indonesia	-2,712	-2,907	-4,708	-3,919	-5,344	-5,318	-2,266	-3,384
Italy	-1,348	-1,766	-0,235	-3,290	-	-	-3,462	-3,154

Japan	-2,301	-1,712	-	-	-	-	-	-
Korea	-2,601	-2,575	-1,223	-2,286	-1,664	-1,638	-2,063	-2,237
Mexico	-3,570	-3,187	0,671	-4,967	-1,083	-2,591	-2,450	-3,128
Saudi Arabia	-1,657	0,549	1,243	-0,863	-1,994	-3,201	-1,097	-2,487
South Africa	-1,863	-1,833	1,253	-1,826	-	-	-2,583	-2,301
Turkey	-1,379	-2,524	-2,165	-2,342	-	-	-2,305	-1,540
UK	-2,014	-2,013	-2,703	-2,889	-0,815	-2,828	-3,455	-2,127

* , ** , *** are %1, %5 and %10 significance levels, respectively.

Next we consider the KSS (Kapetanios et al. 2003) unit root test, which allows for smooth transition-type non-linearity in the data generating process. Table 4 presents the results of the KSS unit root test. The KSS test results suggest that the null hypothesis of unit root can be rejected for the de-meaned real exchange rate series of Argentina, Indonesia, Korea and Mexico. If we further de-trend⁸ the series, there is no change. This finding suggests that taking account of non-linearities in the data generating process results in more rejection of the unit root null hypothesis in favour of PPP, consistent with earlier findings (e.g. Taylor and Sarno 1998, Taylor et al. 2001, Erlat 2004, Telatar and Hasanov (2009)).

Table 4: Nonlinear Unit Root Test Intercept Only

Countries	OY	KSS	LNV	Solis t	Solis F
Argentina	-2,857	-3,127**	-2,353	-2,517	3,229
Brazil	-2,606	-2,437	-1,950	-1,452	1,896
Canada	-2,689	-1,740	-2,946	-2,327	4,336
China	-1,349	-1,470	-2,426	-2,614	3,931
France	-1,597	-1,423	-2,087	-1,617	2,194
Germany	-1,682	-1,538	-2,122	-1,612	2,260
India	-2,755	-0,360	-3,772	-3,456**	7,874***
Indonesia	-6,791*	-6,862*	-2,933	-3,422**	6,150
Italy	-1,738	-1,507	-2,090	-1,557	2,189
Japan	-1,962	-1,625	-1,693	-1,852	1,753
Korea	-6,843*	-6,702*	-2,858	-3,044	5,253
Mexico	-3,828**	-5,971*	-4,024***	-3,375***	8,157***
Saudi Arabia	-0,564	-1,769	-0,660	-1,322	0,999
South Africa	-1,864	-1,668	-2,056	-1,554	2,105
Turkey	-2,166	-2,028	-3,369	-2,838	6,265
UK	-2,673	-2,490	-2,306	-1,682	2,658

* , ** , *** are %1, %5 and %10 significance levels, respectively.

We now turn to structural break models. The results of the LNV (Leybourne et al. 1998) unit root test are presented in Table 4 ,5 and 6. The results of the LNV test suggest that if we assume a gradual shift

⁸ See also Taylor (2000) de-trending approach is to de-trend the series q_{it} and examine the deviations of the resulting de-trended level q_{it} , that is, the error-correction term.

in the mean with no trend, then the null hypothesis of unit root is rejected only in the case of Mexico. When a linear trend is included, the null hypothesis of unit root is not rejected for any series. If we further assume that the trend function also changes gradually, then the null hypothesis is rejected for the India and Italy real exchange rate series. These results suggest that the equilibrium real exchange rate of the Selected OECD countries might have been shifted during the break dates as a result of globalization process.

Table 5: Nonlinear Unit Root Test Intercept and Trend

Countries	OY	KSS	LNv	Solis t	Solis F
Argentina	-3,341	-4,501*	-2,578	-2,563	3,669
Brazil	-3,117	-2,441	-2,008	-2,068	2,403
Canada	-2,768	-1,638	-2,922	-2,429	4,464
China	-1,517	-1,351	-1,643	-1,783	1,816
France	-2,316	-1,436	-2,319	-1,640	2,676
Germany	-2,366	-1,547	-2,179	-1,796	2,468
India	-3,225	-2,002	-2,475	-1,908	3,054
Indonesia	-6,825*	-6,846*	-3,120	-3,855**	7,568
Italy	-2,370	-1,460	-2,203	-1,699	2,455
Japan	-1,394	-1,457	-1,564	-1,922	1,850
Korea	-6,846*	-6,558*	-3,233	-3,257	5,590
Mexico	-7,152*	-6,636*	-3,170	-3,101	5,571
Saudi Arabia	-0,751	-0,671	-0,617	-0,835	0,349
South Africa	-2,282	-1,660	-1,980	-1,908	2,145
Turkey	-1,964	-1,807	-3,135	-2,588	5,395
UK	-2,363	-2,444	-3,135	-2,588	5,020

* , ** , *** are %1, %5 and %10 significance levels, respectively.

Table 6: Nonlinear Unit Root Test Intercept, Trend and Smooth Trend

Countries	OY	KSS	LNv	Solis t	Solis F
Argentina	-2,909	-	-2,920	-2,488	4,247
Brazil	-4,966**	-	-3,979	-3,384	8,111
Canada	-2,614	-	-4,167	-3,320	8,639
China	-2,036	-	-2,687	-2,421	3,633
France	-3,368	-	-4,555	-4,261**	11,723***
Germany	-3,402	-	-4,500	-4,208**	11,433***
India	-2,848	-	-4,630***	-3,809***	10,839
Indonesia	-4,524**	-	-4,279	-4,243**	9,324
Italy	-3,553	-	-4,609***	-4,326**	11,978***
Japan	-2,669	-	-2,427	-2,177	2,948
Korea	-7,304*	-	-3,653	-3,962***	7,994
Mexico	-7,271*	-	-4,372	-3,266	9,541
Saudi Arabia	-2,230	-	-2,229	-1,808	2,472
South Africa	-3,505	-	-3,830	-3,065	7,301
Turkey	-3,028	-	-3,616	-3,068	6,880
UK	-2,385	-	-3,205	-2,639	5,207

* , ** , *** are %1, %5 and %10 significance levels, respectively.

All the tests results give different conclusions for different countries. We have summarized these findings in the below table. The first general conclusion; in Canada, China, Japan, Saudi Arabia, South Africa, Turkey and UK PPP hypothesis do not hold by using all alternative tests in full sample. Even if

we removed the break-dates from the data set the linear univariate ADF test is not able to reject unit root null hypothesis. Only in Mexico the PPP hypothesis holds in all these 5 nonlinear unit root tests.

Table 8: Summary Table of Nonlinear Unit Root Tests Results

Countries	OY	KSS	LNV	Solis t	Solis F
Argentina		x xx			
Brazil	x				
France				xxx	xxx
Germany				xxx	xxx
India				x xx xxx	x
Indonesia	x xx xxx	x xx -	xxx	*	
Italy			xxx	xxx	xxx
Korea	x xx xxx	x xx -		xxx	
Mexico	x xx xxx	x xx -	x	x	x

* , ** , *** are %1, %5 and %10 significance levels, respectively.

Although the LNV test procedure allows for proper modeling of structural changes, it ignores possible asymmetries in adjustment of real exchange rates towards their equilibrium level. Therefore, we also consider the ST-TAR (Sollis 2004) unit root test, which allows for both gradual structural change and asymmetric adjustment towards equilibrium. The results of ST-TAR unit root tests are presented in Table 8. If we assume that the data are not trending and the mean of the series changes gradually in the asymmetric adjustment model, then the null hypothesis of unit root is rejected only for the real exchange rates of India, Indonesia and Mexico. When a linear trend is added, then the unit root null hypothesis is rejected for the left with only Indonesia real exchange rate series. If we further allow the trend function to change gradually, then the null hypothesis of unit root is rejected in the cases of India, Indonesia, Mexico, France, Germany, Italy and Korea providing evidence in favour of the PPP proposition in these countries. This finding once more shows the importance of allowing for both structural breaks and asymmetric adjustment in real exchange rate series of 16 selected OECD countries.

Table 9: Cross Section Dependency Tests

	Test statistics	P value
CD_{LM1}	27.675	0.000
CD_{LM2}	1741.370	0.000
CD_{LM3}	104.659	0.000

Notes: Under the null hypothesis the CD statistics converge to a normal standard distribution. The values in the parentheses are p values.

We have mentioned in section to that one of the contemporary problems of panel data estimation is cross-section dependency. Most of the panel data models assume that disturbances in panel models are cross-sectionally independent. However, cross-section dependence may arise for several reasons which are given in most of the studies (e.g., Pesaran (2004) and Omay and Kan (2010)). In the presence of cross-section dependence, it is well known that neglecting cross-section dependence can lead to biased estimates and produce misleading inference. Thus, we have made a diagnostic check for cross-section dependency for non-linear panel models following Pesaran (2004). The test results in Table 10 provide that there is a serious cross section dependency in the series. Therefore we have employed the cross section dependent version of the panel unit root test which we have used sieves bootstrap following Ucar and Omay (2009).

Table 10: Panel Unit Root Tests Cross Section Dependency

	IPS		UO	
	Intercept	Intercept And Trend	Intercept	Intercept And Trend
Test values	-1.500	-2.069	-1.681	-2.790*

● *, **, *** are %1, %5 and %10 significance levels, respectively.

The panel unit root test suggest that only the PPP hypothesis hold in UO test which we de-meaned and de-trended data . This finding once more shows the importance of allowing for both structural breaks and asymmetric adjustment in real exchange rate series.

3. CONCLUSION AND POLICY IMPLICATIONS

Purchasing Power Parity is one of the most important propositions in international economics. Whether or not PPP holds has important policy and theoretical implications. Although a considerable amount of literature has been devoted to testing the validity of PPP for developed countries, few researchers to date have analyzed the PPP proposition by using all unit root test available in the

literature. Therefore, with the aim of contributing to the empirical literature in this area, we tested the validity of PPP for an extensive sample of 16 OECD countries by examining the stationarity properties of the real exchange rates vis-a-vis the US dollar.

The 16 OECD countries have faced structural breaks which we have tested by using the Bai and Peron (1998) procedure. Such structural breaks might have caused a shift in the equilibrium real exchange rates during the sample period. Therefore, testing PPP for transition countries within a linear framework might be problematic. In this thesis in order to provide more accurate and reliable results we tested the validity of PPP for 16 selected OECD countries using recently developed test procedures that allow proper modeling of structural changes and non-linearities in the data generating process. When structural changes and non-linearities are not taken into account, the null hypothesis of unit root is rejected only in two out of 16 series, namely for the Indonesia and Mexican real exchange rates. However, allowing for structural changes and/or nonlinearities in the data generating process results in more rejections of the unit root null hypothesis, consistent with the PPP proposition. Specifically, the null hypothesis of unit root against the globally stationary ESTAR model, which allows for smooth transition-type non-linearities, was rejected for Argentina, Indonesia, Korea and Mexico. After taking into account the gradual structural changes and asymmetric adjustment in the series we were able to reject the null hypothesis of unit root in seven cases, namely for Indonesia, Korea, Mexico, France, Germany, Italy and Korea series. Although several important shocks have hit these countries during the period analyzed, our results imply that these shocks have had no persistent effects on the real exchange rates of the sample 16 OECD countries.

Our findings supporting PPP in 16 OECD countries may be interpreted as evidence of integration into the world economy. Furthermore, the results suggest no misalignment in nominal exchange rates of the countries considered, implying that these countries implemented successful exchange rate policies in compliance with economic developments and reform strategies during the sample period considered in this study. We should note that one must be cautious and take into account both structural changes and asymmetries in the data generating process when examining real exchange rate series. Moreover, the panel unit root tests suggest that only the PPP hypothesis holds when the UO test is applied for which we have used de-meaned and de-trended data. This finding once more shows the importance of allowing for both structural breaks and asymmetric adjustment in real exchange rate series.

References

- Abuaf, N., and P. Jorion. 1990. "Purchasing Power Parity in the Long Run." *Journal of Finance* 45, no. 1: 157–174.
- Bahmani-Oskooee, M.; A.M. Kutan; and S. Zhou. 2007. "Testing PPP in the Nonlinear STAR Framework." *Economics Letters* 94, no. 1: 104–110.
- Christopoulos, D. K. and León-Ledesma, M. A., 2010. "Smooth breaks and non-linear mean reversion: Post-Bretton Woods real exchange rates," *Journal of International Money and Finance*, 29(6), pages 1076-1093
- Corbae, D. and Ouliaris, S., 1988. Cointegration and tests of purchasing power parity. *Review of Economics and Statistics*, 70, 508–521.
- Cuddington, J. T. and Liang, H. (2000). Purchasing power parity over two centuries? *Journal of International Money and Finance* 19, 753–757.
- Çorakcı A., Emirmahmutoglu, F., Omay, T., (2016) "Re-examining the real interest rate parity hypothesis (RIPH) using panel unit root tests with asymmetry and cross-section dependence" *Empirica: Journal of European Economics*, 44, 2.
- Dickey, D.A., Fuller W.A., (1979), Distribution of the estimates for autoregressive time series with a unit Root, *Journal of the American Statistical Association*, 74, 427-431.
- Dornbusch, R., 1976. Expectations and exchange rate dynamics. *Journal of Political Economy* 84, 1161–1176.
- Dumas, B. 1992. "Dynamic Equilibrium and the Real Exchange Rate in a Spatially Separated" World." *Review of Financial Studies* 5, no. 2: 153–180.
- Emirmahmutoglu, F., Omay, T. 2014 "Reexamining the PPP hypothesis: A nonlinear asymmetric heterogeneous panel unit root test" *Economic Modelling*, 40(c), 184-190.
- Enders, W., Granger, C. W. J., (1998), Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates, *Journal of Business and Economic Statistics*, 16, 304-11.
- Enders, W., Dibooglu, S., 2001. Long-run purchasing power parity with asymmetric adjustment. *Southern Economic Journal*. 68(2), 433–445.
- Fisher, E. O'N. and Park, J., 1991. Testing purchasing power parity under the null hypothesis of cointegration. *The Economic Journal*, 101, 1476–1484.
- Frankel, J.A. and Rose, A.K., 1996. A panel project on purchasing power parity: mean reversion within and between countries. *Journal of International Economics*, 40, 209–224.
- Flood, R., Marion, N., 1998. Perspectives on the recent currency crisis literature. NBER Working Paper Series, No. 6380.
- Granger, C.W.J., Teräsvirta, T., 1993. *Modelling nonlinear economic relationships. Advanced Texts in Econometrics*. Oxford University Press, New York, USA.
- Hasanov, M. and Omay, T., (2007) "Are the transition stock markets efficient? Evidence from non-linear unit root tests", *Central Bank Review*, vol:7(2), 1-7.

- Kapetanios, G., Shin, Y. and A. Snell (2003). Testing for a Unit Root in the Nonlinear STAR Framework. *Journal of Econometrics*, 12, 359–379.
- Koop, G., Potter, S. (2010) A flexible approach to parametric inference in nonlinear and time varying time series models. *Journal of Econometrics* 159, 134–150
- Krugman, P.R., 1991. Target zones and exchange rate dynamics. *The Quarterly Journal of Economics* 106, 669–682.
- Lin, C.J., Teräsvirta, T., 1994. Testing the constancy of regression parameters against continuous structural change. *Journal of Econometrics* 62, 211–228.
- Lothian, J.R., and M.P. Taylor. 1996. “Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries.” *Journal of Political Economy* 104, no. 3: 488–509.
- Leybourne, S., Newbold, P., Vougas D., 1998. Unit roots and smooth transitions. *Journal of Time Series Analysis* 19, 83–9.
- Lundbergh, S., Teräsvirta, T., van Dijk, D., 2003. Time-varying smooth transition autoregressive models. *Journal of Business and Economic Statistics* 21, 104–121.
- Luukkonen, R., Saikkonen, P., Teräsvirta, T., 1988. Testing linearity against smooth transition autoregressive models. *Biometrika* 75, 491–499.
- Michael, P., Nobay, A.R. and Peel, D.A., 1997. Transactions costs and nonlinear adjustment in real exchange rates: an empirical investigation. *Journal of Political Economy*, 105, 862–879.
- Oh, K.-Y., 1996, Purchasing power parity and unit root test using panel data, *Journal of International Money and Finance* 15, 405–418.
- Omay, T. and Kan E. O., (2010) “Re-examining the Threshold Effects in the Inflation-Growth Nexus: OECD Evidence” *Economic Modelling*. 27(5), 996-1005.
- Omay, T. (2015) “Fractional Frequency Flexible Fourier Form to approximate smooth breaks in unit root testing”, *Economics Letters*, 134(C), 123-126.
- Omay, T., Çorakcı A., Emirmahmutoğlu, F., (2016) “Real interest rates: nonlinearity and structural breaks” *Empirical Economics*, 50,3,
- Omay, T., Hasanov, M., Emirmahmutoglu, F. (2014), "Structural Break, Nonlinearity, and Asymmetry: A re-examination of PPP proposition," MPRA.
- Omay, T., Yıldırım, D., (2014) Nonlinearity and Smooth Breaks in Unit Root Testing *Econometrics Letters* (1), 1 2-9.
- Peel D. A. and Venetis I. A. (2003) Purchasing power parity over two centuries: trends and nonlinearity. *Applied Economics*, 35:5, 609-617
- Perron, P. 1989. “The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis.” *Econometrica* 57, no. 6: 1361–1401.
- Sercu, P., Uppal, R. and Van Hulle C. 1995. “The Exchange Rate in the Presence of Transaction Costs: Implications for Tests of Purchasing Power Parity.” *Journal of Finance* 50, no. 4:1309–1319.
- Sollis, R. (2005). Evidence on purchasing power parity from univariate models: the case of smooth transition trend-stationarity. *Journal of Applied Econometrics*, 20(1), 79–98

Rogoff, K., 1996. The purchasing power parity puzzle. *Journal of economic literature*, 34,647- 648.

Taylor, M.P., 2003. Purchasing power parity. *Review of International Economics*, 11, 436–452.

Taylor, M.P., Allen, H., 1992. The use of technical analysis in the foreign exchange market. *Journal of International Money and Finance* 11, 304–314.

Taylor, M.P. and Sarno, L., 1998. The behavior of real exchange rates during the post Bretton Woods period. *Journal of International Economics*, 46, 281–312.

Taylor, M.P., Peel, D.A. and Sarno, L., 2001. Nonlinear mean-reversion in real exchange rates: toward a solution to the purchasing power parity puzzles. *International economic review*, 42,1015–1042.

Telatar E. and Hasanov M. 2009. Purchasing Power Parity in Central and East European Countries *Eastern European Economics*, vol. 47, no. 5, pp. 25–41.

Wu, Y., 1996, Are real exchange rates nonstationary? Evidence from a panel-data test, *Journal of Money, Credit, and Banking* 28, 54–63.

Uçar N. and Omay T.,(2009) “Testing For Unit Root In Nonlinear Heterogeneous Panels” *Economics Letters*. 104(1), 5-7.



A Reinvestigation of the Hysteresis Hypothesis in the OECD Countries

Melis Tartıcı¹

Abstract

This study re-investigates the hysteresis hypothesis in unemployment for 24 OECD countries. The results obtained in the literature are quite mixed for the OECD countries, with the findings highly sensitive to the econometric methodology applied and data used. Therefore, to shed some light on this debate in addition to the conventional unit root tests, a variety of other tests that allow for asymmetric adjustment, structural breaks or both simultaneously are also considered. Our results show that the hysteresis effect in unemployment was confirmed for most of the countries studied according to all tests applied. Thus, the labor markets of the OECD countries calls for urgent reform, especially if they want their jobless rates to return to their pre 2008-2009 global financial crisis levels.

Keywords: Hysteresis in unemployment; Nonlinear unit root test; Unit root test with structural break; Unit root test with both structural break and asymmetric nonlinearity.

JEL Codes: C22; C23, J64

¹ melistartici@gmail.com

1. Introduction

Unemployment is one of the primary issues in an economy. Since the unemployment rate is relevant to the welfare of a society, governments pursue policies aiming to reduce it. The studies on unemployment are quite essential to guide these policies, as it would be a hopeless effort for the governments to take actions in the right way against unemployment without knowing the dynamics of the issue. As in our case, it is crucial to know the persistency of the effect of a shock in the economy on unemployment rates to take precautions, or to address the problem properly. For instance, if the effect of the shock does not persist after the shock fades there is no need for extreme precautions or actions since the unemployment rate would go back to its initial rate all by itself. This particular situation is known as the natural rate hypothesis in the literature. On the other hand, if the effect of the shock persists even after the shock fades then the unemployment rate would remain high instead of going back to its initial value. In this case, the economy would be in a much direr situation and it would demand extreme actions or precautions in order to reduce the unemployment rate back. This exact opposite situation is called hysteresis in unemployment.

There are numerous studies in the literature on this subject. We divided them into three groups according to their results as studies in favor of the natural rate hypothesis, studies with hysteresis results, and studies with mixed results. We briefly summarized them in the following Tables 1, 2 and 3;

Natural Rate Hypothesis

The natural rate hypothesis, also known as the non-accelerating inflation rate of unemployment (NAIRU) hypothesis was firstly proposed by Phelps (1968) and Friedman (1968). The natural rate of unemployment is the equilibrium unemployment rate in the long run. In their simultaneous and independent studies Phelps (1968) and Friedman (1968) claimed that the shocks that happened in the economy can increase the unemployment rate for a period, but effects of the shock cannot persist through time and the unemployment rate will eventually revert back to the actual natural rate of unemployment. In other words, the effects of the shocks on the economy are temporary and the unemployment rate is mean-reverting. Therefore the unemployment series do not follow a random walk, which means they are stationary and do not contain a unit root.

Table 1: Natural Rate of Unemployment

<i>Researcher</i>	<i>Sample</i>	<i>Period</i>	<i>Method</i>	<i>Result</i>
Camarero et al. (2006)	19 OECD countries	1956-2001	Panel data	NR
Chang et al. (2007)	21 regions of Taiwan	1993:6-2001:8	Levin et al. (2002), Im et al. (2003) and Taylor and Sarno (1998) Panel datas	NR
Camarero et al. (2008)	Transition countries	1991-2003	Panel data	NR
Mohan et al. (2008)	3 regions of Massachusetts		Panel unit root tests	NR
Lee et al. (2009)	19 OECD countries		Panel LM unit root test	NR
Akay et al. (2011)	23 OECD countries	1963-2007	Univariate time series test, panel unit root test	NR
Çınar et al. (2014)	Turkey	1988-2008	Univariate time series unit root tests with and without structural break	NR

- **NR denotes Natural Rate**

Hysteresis Hypothesis

In the late 1970s, the high and persistent unemployment rates in European countries caused questioning and the reevaluation of the natural rate hypothesis (Saraç, 2014). This led to the suggestion of the hysteresis hypothesis. The term hysteresis is originally an Ancient Greek word, which means “state of being behind or late”. It was first coined by the Scottish physicist Sir James Alfred Ewing for scientific purposes. However, the term was first used in economics literature by Phelps (1972). Later, Blanchard and Summers (1986) were the first ones to come up with an econometric model to test the hysteresis hypothesis in unemployment.

This concept suggests that after the temporary shocks in the economy fades the equilibrium unemployment rate that has been increased due to the effect of the shock would not go back to its former rate. In other words, even though the shocks are temporary, their effects on the unemployment rate persist even after they fade and the unemployment rate remains at this increased level.

According to Blanchard and Summers (1986) one of the main reasons of the hysteresis effect in unemployment is the power of labour unions. They called this the insider-outsider model, with the insiders being the union member workers and outsiders being the unemployed people. This theory suggests that in the event of a shock in the economy the insiders would enforce the wage negotiations in their best interest using strike as a threat. Considering the

strike threat and the high costs of hiring and training new workers, the employers would have to agree on the wage level that the unions demand. This would prevent the wages to drop and thereby cause the unemployment rates to remain high. Thus, the unemployment rate cannot go back to its equilibrium rate and it would become persistent.

The hysteresis in unemployment approach states that the unemployment rates follow a random walk and do not exhibit mean reverting behavior. So, in case of a shock or disturbance the series will not revert back to their mean. This means that the unemployment rate series are non-stationary, and they contain a unit root.

Table 2: Hysteresis of Unemployment Rate

Researcher	Sample	Period	Method	Result
Barişık and Çevik (2008)	Turkey	1923-2006	Unit root test with structural break, semi-parametric long memory models	H
Romero-Ávila and Usabiaga (2008)	Spain	1976-2004	Panel unit root test with structural breaks	H
Yılancı (2009)	Turkey	1923-2007	Perron, ZA, LP, LM unit root tests with structural breaks	H
Ener and Arıca (2011)	Turkey and 15 EU countries	1985-2005	Panel unit root test	H
Gözügör (2012)	Turkey	2004-2011	Panel unit root test	H
Niclas (2012)	8 OECD countries		Univariate unit root tests(ADF and KSS),ARFIMA approach	H
Özcan (2012)	23 OECD countries		Lee and Strazicich (2003) and Im et al. (2005 and 2010) unit root tests	H

*** H denotes Hysteresis**

Table 3: Mix of Hysteresis and Natural Rate of Unemployment

Researcher	Sample	Period	Method	Result
Smyth (2003)	Australia	1982-2002	Panel unit root tests	2 tests gave natural rate results, 1 test gave hysteresis result
Camarero and Tamarit (2004)	19 OECD countries		Multivariate ADF test, panel unit root test	Hysteresis in 7 countries, Natural rate in 12 countries
Chang et al. (2005)	10 European countries	1961-1999	Panel SURADF	Hysteresis in all countries except Belgium and Netherlands
Yılancı (2008)	17 OECD countries		New unit root test developed by KSS(2003)	Hysteresis in 11 countries, Natural rate in 6 countries
Mednik et al. (2008)	13 Latin American countries	1980-2005	Time series tests (ADF, KPSS, LM) and Panel unit root tests (IPS 2003, Choi 2001 and 2002, Pesaran)	Hysteresis in 7 countries, Natural rate in 6 countries
Gustavsson and Österholm (2010)	17 OECD countries		Mean-reverting Autoregressive model	Hysteresis in 7 countries, Natural rate in 10 countries
Lee, Cheng-Feng (2010)	29 OECD countries		Nonlinear panel unit root test, SPSM	Hysteresis in 6 countries, Natural rate in 23 countries
Chang and Lee (2011)	G-7 countries	1992-2008	Threshold unit root test	Hysteresis in 3 countries, Natural rate in 4 countries
Chang (2011)	17 OECD countries	1960-2009	Stationary test with a Fourier function (Becker et al. 2006)	Hysteresis in 11 countries, Natural rate in 6 countries
Furuoka (2012)	12 countries in the East Asia Pacific Region		Multivariate Augmented Dickey Fuller test (MADF), Seemingly Unrelated Regression ADF test (SURADF)	Hysteresis in all countries except South Korea and New Zealand
Furuoka (2014)	14 regions of Czech Republic		SURADF, FADF tests	Hysteresis in 9 regions, Natural rate in 5 regions
Bolat et al. (2014)	17 Eurozone countries	2000-2013	New nonlinear panel unit root tests	Panel unit root test and SPSM without fourier: All countries have hysteresis

				Panel KSS with fourier: 6 countries have hysteresis, 11 countries have natural rate
Marjanovic and Mihajlovic (2014)	10 OECD countries and 10 countries in transition	2000 – 2013	Univariate and Panel unit root tests, structural break analysis	Mixed results

2. Unit Root tests

Enders and Granger (EG) Test

Enders and Granger (1998) use threshold autoregressive (TAR) models to suggest tests of the null hypothesis of a unit root that allow under the alternative hypothesis for stationary asymmetric adjustment towards a fixed mean or deterministic linear trend.

$$\Delta y_t = \beta + \alpha_1 I_t y_{t-1} + \alpha_2 (1 - I_t) y_{t-1} + \sum_{i=1}^p \hat{\lambda}_i \Delta y_{t-i} + \hat{\varepsilon}_t \quad (1)$$

where $I_t = 1$ if $y_{t-1} \geq 0$, $I_t = 0$ if $y_{t-1} < 0$, and $\hat{\varepsilon}_t$ is a zero-mean stationary process.

Leybourne Newbold and Vougas (LNV) test

Leybourne, Newbold and Vougas (1998) propose unit root tests for time series where the alternative is stationary around a linear trend with smoothly changed break.

$$y_t = \delta + \delta_2 G_t(\gamma, \tau) + \varepsilon_t \quad (2)$$

$$y_t = \delta + \beta_1 t + \delta_2 G_t(\gamma, \tau) + \varepsilon_t \quad (3)$$

$$y_t = \delta + \beta_1 t + \alpha_2 G_t(\gamma, \tau) + \delta_2 t G_t(\gamma, \tau) + \varepsilon_t \quad (4)$$

where ε_t is a zero mean $I(0)$ process and $G_t(\gamma, \tau)$ is logistic smooth transition function.

$$G_t(\gamma, \tau) = \left[1 + \exp\{-\gamma(t - \tau T)\} \right]^{-1}, \quad \gamma_i > 0 \quad (5)$$

Leybourne et.al. (1998) establish the hypothesis for unit root testing based on equation 2, 3 and 4 as follows:

H_0 : Unit Root , (Linear Nonstationary)

H_a : Stationary (Stationary around smoothly changing trend and intercept)

Following Leybourne *et al.* (1996) the test statistics proposed here is calculated with a two-step procedure:

Step 1. Using any nonlinear least squares (NLS) algorithm, estimate any model below compute the NLS residuals

$$\text{Model 1} \quad \hat{\varepsilon}_t = y_t - \hat{\delta} - \hat{\delta}_2 G_t(\gamma, \tau)$$

$$\text{Model 2} \quad \hat{\varepsilon}_t = y_t - \hat{\delta} - \hat{\beta}_1 t - \hat{\delta}_2 G_t(\gamma, \tau)$$

$$\text{Model 3} \quad \hat{\varepsilon}_t = y_t - \hat{\delta} + \hat{\beta}_1 t + \hat{\alpha}_2 G_t(\gamma, \tau) + \hat{\delta}_2 t G_t(\gamma, \tau)$$

Step 2. Compute the ADF statistic

And finally, Solis (2004) developed a unit root test by combining Enders and Granger (1998) and Leybourne, Newbold and Vougas (1998). In the first step again it uses the Model 1, 2 and 3 and in the second step instead of ADF statistics Solis (2004) uses the EG test.

3. Data and Empirical Results

The hysteresis of unemployment is examined using the monthly data of 24 OECD member countries over the period 1998:04 and 2013:09. The countries involved are Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Spain, Sweden, and US. The monthly harmonized unemployment rate data were taken from the OECD database. The definition of unemployed according to harmonized unemployment rates is the people of working age who are without work, are available for work, and have taken specific steps to find work. Harmonized unemployment rate is seasonally adjusted, and it is measured in numbers of unemployed people as a percentage of the labour force.

The results of the various unit root test that are applied are presented and discussed in this section of the study. We first present the results of the conventional ADF unit root test. Second, the results of the nonlinear unit root test, EG, is discussed. Third, the findings regarding the unit root test with smooth structural breaks (LNV test) are conveyed. Finally, we consider the Sollis (2004) test which allows for both structural breaks and nonlinearity.

The results of the ADF test which is the only linear unit root test applied in this study are reported in Table 4.

Table 4: ADF Test Results

	Intercept only	Intercept and Trend
Australia	-1.794	-0.820
Austria	-1.506	-1.710
Belgium	-4.316***	-4.184***
Canada	-2.429	-2.666
Chile	-1.047	-2.187
Denmark	-1.516	-2.172
Finland	-2.024	-1.846
France	-3.503***	-3.840**
Germany	-0.685	-1.694
Greece	-2.003	-2.832
Hungary	-1.084	-1.792
Ireland	-1.534	-2.337
Italy	-0.897	-0.530
Japan	-1.499	-1.746
Korea	-3.711***	-3.232*
Luxembourg	-0.965	-2.206
Mexico	-0.899	-2.814
Netherlands	-1.983	-2.788
Norway	-2.176	-2.276
Poland	-2.103	-2.787
Portugal	-0.430	-2.862
Spain	-0.424	-1.272
Sweden	-2.491	-3.340*
US	-1.938	-3.136*

Notes: The superscripts *, **, *** represent significance at the 10%, 5% and 1% levels respectively using the ADF critical values for T=250 (the sample size is 186). We use Akaike Information Criteria (AIC) with a maximum lag length of 12. The ADF t-statistic critical values for the intercept only case are -2.57, -2.88 and -3.46 at 10%, 5% and 1% significance levels, respectively. The ADF t-statistic critical values for the intercept and trend case are -3.13, -3.69 and -3.99 at 10%, 5% and 1% significance levels, respectively.

As Table 4 demonstrates; for Belgium, France, and Korea the standard ADF test rejects the null hypothesis when only intercept is included, which means there is no unit root in the unemployment rates of these countries. In other words, only 3 countries out of all 24 OECD countries have natural rate where for other 21 countries the null hypothesis is accepted and they have hysteresis. So the ADF test with only intercept included gives us a remarkable low percentage of countries that have natural rate, which is 12.5% while the remaining 87.5% have hysteresis.

When we include both an intercept and a trend together the results for the 3 countries with natural rate doesn't change, however, 2 more countries turns into natural rate from hysteresis. These countries are Sweden and the US. The results for the other 19 countries remain unchanged. After these changes, the percentage of countries with natural rate increases to approximately 20.8%, and the percentage of countries with hysteresis drops to 79.2%. Still, however, for a majority of the countries in our sample the natural rate hypothesis is rejected in favor of the hysteresis hypothesis. Thus, using the conventional ADF unit root test we can conclude that hysteresis holds for most of the OECD countries. However, the results of the conventional ADF tests will be biased if the unemployment rates display nonlinear behavior and/or are subject to breaks. Thus, in the rest of the thesis we present the results of the nonlinear unit root tests and unit root tests that allow for structural breaks.

The nonlinear unit root test used in this study was the EG test. The EG test allows for asymmetry. The results of this test are tabulated in Tables 5, respectively.

Table 5: EG Test Results

	Intercept only	Intercept and Trend
Australia	3.194	2.181
Austria	2.575	3.249
Belgium	4.709*	4.356
Canada	2.559	2.405
Chile	2.793	9.034*
Denmark	0.781	1.608
Finland	3.018	2.350
France	3.476	4.053
Germany	0.814	1.119
Greece	0.692	0.432
Hungary	0.146	5.788*
Ireland	1.232	3.296
Italy	0.861	0.750
Japan	1.210	2.247

Korea	3.377	2.915
Luxembourg	0.771	3.427
Mexico	0.531	3.646
Netherlands	0.710	1.680
Norway	2.252	2.387
Poland	1.569	4.379
Portugal	0.797	2.703
Spain	0.712	1.621
Sweden	1.363	4.786
US	1.595	4.268

Notes: The superscripts *, ** and *** represent significance at the 10%, 5% and 1% levels respectively using the EG critical values for T=250 (the sample size is 186). We used Akaike Information Criteria (AIC), and a lag selection criterion is 12 lag with an upper bound. The EG critical values for the nonzero mean case and T=250 are 3.74, 4.56 and 6.47 for 10%, 5% and 1% significance levels, respectively. The EG critical values for the nonzero mean and trend case are 5.18, 6.12 and 8.23 for 10%, 5% and 1% significance levels, respectively (Enders and Granger,1998).

To see whether allowing for asymmetry adjustment changes the results of our tests, we also considered the EG test. As shown in the Table 5, for only one country the null hypothesis of a unit root is rejected when only an intercept term is included. This country is Belgium and it is the only country for which the natural rate hypothesis holds. For all of the other countries the null hypothesis is accepted meaning they have hysteresis according to this test. The rate of the countries with hysteresis has now increased to 95.8%, while only 4.2% of the countries support the natural rate hypothesis.

With the addition of a trend term to the EG test regression, Belgium joins to the countries with hysteresis as well. However, Chile and Hungary do not contain a unit root this time. Therefore, they have natural rate. After the inclusion of the trend term, the rate of the countries with natural rate increases to 8.3%, and the rate of the countries with hysteresis decreases to 91.7%.

The implementation of the EG test has considerably decreased the number of countries for which the natural rate hypothesis holds. Thus, the OECD unemployment rate series seems to display rather less asymmetry than it was suspected at the beginning of the study.

Up to now our results verify the hysteresis hypothesis for a majority of the OECD countries, whether linear or nonlinear unit root tests are applied. However, the EG test implemented above considers only the possibility of nonlinear adjustment in the unemployment series. But, it is equally likely that the series under question will be subject to

structural breaks during the time period analyzed. Thus, to see whether accounting for the potential structural breaks in the unemployment series changes our results, now we present the results of the LNV unit root test with structural breaks. The results of this LNV unit root test are reported in Table 6.

Table 6: LNV Test Results

	Model 1
Australia	-2.037
Austria	-2.608
Belgium	-3.706
Canada	-2.836
Chile	-2.835
Denmark	-1.781
Finland	-3.198
France	-3.512
Germany	-2.571
Greece	-1.586
Hungary	-3.140
Ireland	-3.288
Italy	-0.227
Japan	-2.485
Korea	-3.178
Luxembourg	-1.797
Mexico	-3.042
Netherlands	-1.797
Norway	-2.677
Poland	-3.262
Portugal	-2.877
Spain	-3.283
Sweden	-3.616
US	-1.293

Notes: The superscripts *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively using the LNV critical values for T=200 (the sample size is 186) and Model 1. The LNV critical values for T=200 are -3.851, -4.161 and -4.761 for 10%, 5% and 1% significance levels, respectively.

As it can be seen from Table 6, when smooth structural breaks are allowed the entire sample now contains a unit root. Thus, all of the OECD countries have hysteresis according to the LNV test. Accounting for structural breaks has caused us to conclusively reject the natural rate hypothesis for all the OECD countries included in our sample.

Finally, we consider the possibility that the unemployment series under question may display both asymmetry and structural breaks by applying the Sollis (2004) test. The results of the Sollis (2004) test are reported in Table 7.

Table 7: Sollis (2004) Test Results

	t-test	F-Test
Australia	-1.198	5.723
Austria	-1.492	5.425
Belgium	-0.404	2.537
Canada	0.405	1.855
Chile	1.050	5.807
Denmark	-0.142	2.163
Finland	-1.588	4.987
France	0.634	3.458
Germany	0.485	2.692
Greece	-0.632	1.581
Hungary	1.428	4.306
Ireland	0.765	4.538
Italy	1.495	1.268
Japan	1.585	4.055
Korea	2.261	13.517***
Luxembourg	1.703	2.195
Mexico	1.311	3.327
Netherlands	0.848	0.821
Norway	0.173	3.581
Poland	-1.804	4.712
Portugal	-0.708	5.934
Spain	0.833	3.682
Sweden	-0.612	3.506
US	-1.530	1.538

Notes: The superscripts *, ** and *** represent significance at the 10% 5% and 1% levels respectively using the Sollis (2004) critical values for T=200 (the sample size is T=186).. The Sollis (2004) t-statistic critical values for Model 1 are are -3.140, -3.385 and -3.890 for 10%, 5% and 1% significance levels, respectively. The Sollis (2004) F-statistic critical values for Model 1 are 7.759, 9.029 and 11.789 for 10%, 5% and 1% significance levels, respectively

Sollis (2004) test has two different indicators to look at t-test and F-test. According to the results of the test with t-test, none of the countries have natural rate as they all contain a unit root². So we can say that the null hypothesis is accepted for 100% of the countries. As for the F-test results, only Korea has natural rate but the remaining 23 countries still have hysteresis. The rate of the countries with hysteresis is 95.8%.

² See also for panel unit root application of nonlinear tests Emirmahmutoglu and Omay (2014).

Overall, our results have verified the hysteresis hypothesis for a majority of the OECD countries included in our study. The natural rate hypothesis is accepted at most in 5 countries (corresponding to only 20.8% of our sample) with the application of the ADF unit root test when both intercept and trend were included.

4. Concluding Remarks

The main aim of this thesis was to re-investigate the hysteresis hypothesis in unemployment. The reason why we chose this subject is to provide reliable information to understand how persistent the effect of the shocks in an economy on unemployment rates is. For this purpose, we studied 24 OECD countries. We analyzed the monthly unemployment rate data of these countries for the period 1998:04 to 2013:09. We applied various unit root tests. We implemented both linear and nonlinear unit root tests. Besides the conventional Augmented Dickey Fuller (ADF) test, we applied the univariate nonlinear unit root test, to allow for business cycle asymmetries we implemented the Enders and Granger (EG) unit root test. It is well known that the non-rejection of the unit root hypothesis may be caused by the misspecification of the deterministic components (Perron, 1989). Therefore, to consider the existence of structural breaks in the individual unemployment series of the OECD countries we applied the Leybourne, Newbold, Vougas (LNV) unit root test. The LNV test allows one to test whether a series is $I(1)$ against the alternative of $I(0)$ around a deterministic component which changes gradually and smoothly between regimes. Finally, to allow for structural breaks and asymmetry to occur simultaneously in the unemployment series we used the Sollis (2004) unit root test.

First the ADF test was applied to the OECD unemployment rates. We applied the ADF test twice, first taking only the intercepts into consideration, and then by adding also trend terms to the test regressions. This was the procedure we followed for most of the tests in our study. ADF test, considering intercept only, was able to reject the null hypothesis of hysteresis in favor of the natural rate hypothesis, for only 3 countries, which include Belgium, France and Korea. For the remaining 21 countries however, there were enough evidence to accept the null hypothesis of hysteresis. This gives us an 87.5% rate of acceptance of the null hypothesis of unit root or hysteresis. When we add trend terms to the test equations 2 additional countries, namely Sweden and US, started to show natural rate characteristics, with

the other 3 countries with natural rate remain unchanged. As a result of these changes, we get a rate of 79.2% proved hysteresis effect. When we look into both of these methods, we see that when we include trends the rate of countries with hysteresis effect drops slightly.

To see whether the strong hysteresis result obtained above using the conventional ADF test was because of preserving the linearity assumption, second, nonlinear unit root tests were utilized. It is well known that linear models have important drawbacks in terms of matching the properties of most economic variables including the unemployment rates. Unemployment rates tend to display asymmetric behavior during business cycles; they fall more sharply in recessions than they rise during expansions. If nonlinearity is present in the individual unemployment series, then the standard linear unit root tests will suffer from low power and may often falsely accept the null hypothesis of a unit root (i.e., verifying the hysteresis hypothesis).

When applying our nonlinear unit root test, the EG test, the same procedure with ADF test was followed. This test had high percentage of hysteresis results. With the intercept only method EG test found only for a single country (Belgium). Hence, we get a 95.8% acceptance rate of hysteresis effect with the EG test. These rates drop for EG tests when we include trends. For EG test, 2 countries (Chile and Hungary) turn into natural rate, while 1 country (Belgium) switches to hysteresis. These changes cause a decrease in the rate of hysteresis for EG to 91.7%.

In the unit root test implemented so far, no structural break was assumed. However, as mentioned before, the violation of the assumption of parameter constancy may lead to improper inference and thereby to incorrect policy implications from the miss-specified models. Hence, in performing unit root tests, special care must be taken if it is suspected that structural change has occurred. Thus, to allow for structural breaks, we used the LNV test. The LNV test was used because it assumes that the change in parameters over time is smooth rather than instantaneous or abrupt. This is important because structural changes in economic variables which are affected by the changes in the behavior of many economic agents are more likely to follow a smooth rather than an instantaneous time path. According to LNV test, there was no evidence to reject the null hypothesis of hysteresis for any of the countries. In other words, LNV test results gave us a 100% acceptance rate of hysteresis in unemployment.

The last test used in this study was Sollis (2004) which is a unit root test that accounts for both smooth breaks and asymmetry. Sollis (2004) test was applied twice as well. However, dissimilar to the tests with intercept and trend procedures, Sollis (2004) test was conducted considering T-test and F-test. According to T-test results, no countries showed natural rate characteristics; therefore we accept the hysteresis effect for 100% of the countries. On the other hand, F-test was able to reject the null hypothesis for a single country (Korea). Consequently, the rate of hysteresis according to F-test results was 95.8%.

Overall, LNV and Sollis (2004) were the tests with the highest hysteresis results, as they led us to conclusively reject the natural rate hypothesis for all the OECD countries included in the study. Including the trends dropped the rate of acceptance of hysteresis for all tests. According to these empirical results, we found hysteresis effect in unemployment for the vast majority of the countries at all tests.

From the policy perspective, since the majority of the OECD unemployment rates are found nonstationary, the shocks affecting the labor markets of these countries, like the recent 2008-2009 global financial crisis, certainly will have permanent effects. The equilibrium unemployment rate may have no tendency to revert back to its equilibrium level and can stay at its currently high level for a long period of time. If this is the case, then urgent stability policy measures are required to return the unemployment to its original level.

References

- Akay, H., Nargelecekenler, M., & Yılmaz, F. (2011). *Ekononicky Casopis*, 59(5), 488-505.
- Barışık, S. & Çevik, E.İ. (2008) Yapısal Kırılma Testleri ile Türkiye’de İşsizlik Histerisinin Analizi: 1923- 2006 Dönemi. *KMU Sosyal ve Ekonomik Araştırmalar Dergisi*, 10(14), 109-134.
- Bianchi, M., and G. Zoega (1998). Unemployment persistence: Does the size of the shock matter? *Journal of Applied Econometrics*, 13, 283–304.
- Blanchard, O.J. & Summers, L.H. (1986) “Hysteresis and the European Unemployment Problem” Fischer, S. (ed.) *NBER Macroeconomics Annual*, Cambridge, MIT Press.
- Bolat, S., Tiwari, A.K., & Erdayi, A.U. (2014). *Applied Economic Letters*, 21(8), 536-540.
- Camarero, M., Carrion-I-Silvestre, J.L., & Tamarit, C. (2006). *Oxford Bulletin of Economics and Statistics*, 68(2), 167-182.

Camarero, M., Carrion-I-Silvestre, J.L., & Tamarit, C. (2008). Review of Development Economics, 12(3), 620-635.

Chang, T., Lee, K.C., Nieh, C.C., & Wei, C.C. (2005). An empirical note on testing hysteresis in unemployment for ten European countries: panel SURADF approach. 12(4), 881-886.

Chang, T., Yang, M.J., Liao, H.C., & Lee, C.H. (2007). Hysteresis in unemployment: empirical evidence from Taiwan's region data based on panel unit root tests. *Applied Economics*, 39(10), 1335-13340.

Chang, T. (2011). Hysteresis in unemployment for 17 OECD countries: Stationary test with a Fourier function. *Economic Modeling*, 28(5), 2208-2214.

Cross, R. B. (1994). The macroeconomic consequences of discontinuous adjustment: Selective memory of non-dominated extrema. *Scottish Journal of Political Economy*, 41, 212–221.

Cross, R. B. (1995). *The Natural Rate of Unemployment: Reflections on 25 Years of the Hypothesis*. Cambridge: Cambridge University Press.

Ener, M., & Arica, F. (2011). Unemployment Hysteresis in Turkey and 15 EU Countries: A Panel Approach, Vol (1).

Friedman, M. (1968). The Role of Monetary Policy. *The American Economic Review*, 58(1), 1-17.

Emirmahmutoglu, F. Omay, T., (2014) "Reexamining the PPP hypothesis: A nonlinear asymmetric heterogeneous panel unit root test," *Economic Modelling*, 40(C), 184-190.

Gözüör, G. (2012). Hysteresis in Regional Unemployment Rates in Turkey. *International Journal of Economics and Finance*, 4(9), 175-181.

Gujarati, D.N. (2004). *Basic Econometrics*, 4th edit. MC-Graw-Hill, Inc.USA.

Gustavsson, M. & Österholm, P. (2010). The presence of unemployment hysteresis in the OECD: what can we learn from out-of-sample forecasts? *Empirical Economics*, 38(3), 779-792.

Kapetanios, G., Shin, Y., & Snell, A. (2003). Testing for a Unit Root in the Nonlinear STAR Framework. *Journal of Econometrics*, 112(2), 359 - 379.

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

MacKinnon, J. (1991). Critical Values for Cointegration Tests in R.F. Engle and C.W.J. Granger, eds., *Long –Run Economic Relationships* (Oxford: Oxford University Press).

Marjanovic, G. & Mihajlovic, V. (2014). Analysis of Hysteresis in Unemployment Rates with Structural Breaks: the Case of Selected European Countries. *Inzinerine Ekonomika-Engineering Economics*, 25(4), 378-386.

Mednik, M., Rodriguez, C., & Ruprah, I. (2008). Hysteresis in Unemployment: Evidence from Latin America, Inter-American Development Bank Office of Evaluation and Oversight Working Paper: OVE/WP-04/08.

Mohan, R., Kemegue, F. & Sjuib, F. (2008). Hysteresis In Unemployment: Panel Unit Roots Tests Using State Level Data. *Journal of Business & Economics Research*, 6(2).

Niclas, L. (2012). *Is There Hysteresis in Unemployment Rate*, unpublished Bachelor Thesis, Department of Statistics, Lund University, Sweden.

OECD (2009), *Employment Outlook 2009*, OECD Publishing.
http://dx.doi.org/10.1787/empl_outlook-2009-en.

OECD (2012), *Employment Outlook 2012*, OECD Publishing.
http://dx.doi.org/10.1787/empl_outlook-2012-en.

OECD (2013), *Employment Outlook 2013*, OECD Publishing.
http://dx.doi.org/10.1787/empl_outlook-2013-en.

OECD (2014), *OECD Employment Outlook 2014*, OECD Publishing.
http://dx.doi.org/10.1787/empl_outlook-2014-en.

OECD (2015), *OECD Employment Outlook 2015*, OECD Publishing.
http://dx.doi.org/10.1787/empl_outlook-2015-en.

OECD (2015), Harmonized unemployment rate (HUR) (indicator). doi: 10.1787/52570002-en (Accessed on 12 April 2015)

Omay, T., & Yıldırım, D. (2014). Nonlinearity and Smooth Breaks in Unit Root Testing. *Econometrics Letters*, (1), 1, June.

Özcan, B. (2012). İşsizlik Histerisi Hipotezi OECD Ülkeleri İçin Geçerli Mi? Yapısal Kırılmalı Birim Kök Analizi, *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 40, 95-117.

Papell, D. H., C. J. Murray, and H. Ghiblawi (2000). The structure of unemployment. *Review of Economics and Statistics*, 82(2), 309-315.

Perron, P. (1989). The great crash, the oil price shock and the unit root hypothesis. *Econometrica* 57, 1361–401.

Petrucelli, J. & Woolford, S. (1984). A threshold AR (1) model. *J. Appl. Prob.* 21, 270–286.

Phelps, E. (1968). Money, Wage Dynamics and Labor-Market Equilibrium. *Journal of Political Economy*, 76(4), 678-711.

Phelps, E.S. (1972). *Inflation Policy and Unemployment Theory*, London, Macmillan.

Romero-Ávila, D. & Usabiaga, C. (2008). On the Persistence of Spanish Unemployment Rates, *Empirical Economics*, 35(1), 77-99.

Saraç, T. B. (2014). İşsizlikte Histeri Etkisi: Türkiye Örneği, *EGE AKADEMİK BAKIŞ*, 14(3), 335-344.

Smyth, R. (2003). Unemployment Hysteresis in Australian States and Territories: Evidence from Panel Data Unit Root Tests. *The Australian Economic Review*, 36(2), 181-192.

Sollis, R. (2004). Asymmetric Adjustment and Smooth Transitions: A Combination of Some Unit Root Tests. *Journal of Time Series Analysis*, 25, 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.

Yılancı, V. (2008). Are Unemployment Rates Nonstationary or Nonlinear? Evidence from 17 OECD Countries, 3(47), 1-5.

Yılancı, V. (2009). Yapısal Kırılmalar Altında Türkiye için İşsizlik Histerisinin Sınanması, *Doğuş Üniversitesi Dergisi*, 10(2), 324-335.

Zivot, E. & Andrews, D. W. K. (1992). Further evidence on the great crash, the oil price shock and the unit root hypothesis. *J. Bus. Econ. Statist.* 10, 251–270.

Zeng, J. H., Chang, C. & Lee, C. (2011). Are Fruit and Vegetable Prices Non-linear Stationary? Evidence from Smooth Transition Autoregressive Models. *Economics Bulletin*, 31(1), 189-207.