ISSN: 1306-3111/1308-7444
NWSA-Social Sciences
NWSA ID: 2013.8.3.3C0112

Status : Original Study
Received: February 2013
Accepted: July 2013

E-Journal of New World Sciences Academy

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http://dx.doi.org/10.12739/NWSA.2013.8.3.3C0112

IS THE REAL PER CAPITA GDP STATIONARY IN THE EUROPEAN UNION MEMBER STATES? NEW EVIDENCE FROM THE UNIT ROOT TEST IN NONLINEAR HETEROGENEOUS PANEL

ABSTRACT

It is important for policy makers and economists whether or not the real per capita GDP is stationary. Nowadays, because of the panel unit root tests have over traditional unit root tests, the presence of unit root in the GDP series is under re-examination. The research presented in this paper applies the recently developed unit root test for nonlinear heterogeneous panel in order to re-examine whether or not the real per capita GDP follows a stationary process for 15 European Union member states over the period 1970-2011. Empirical evidence shows that the real per capita GDP is nonlinear-stationary for the EU-15 member states.

Keywords: Real Per Capita GDP, EU Member States, Stationarity, Nonlinear Panel Unit Root Test, Bootstrap Critical Value

AVRUPA BIRLİĞİ ÜLKELEİNDE REEL KİŞİ BAŞINA GSYİH DURAĞAN MI? NON-LİNEAR PANEL BİRİM KÖK TESTİ

ÖZET

Reelkişi başına GDP serilerinin durağan olup olmadığı politika yapımcıları ve ekonomistler için önemlidir. Günümüzde panel birim kök testinin geleneksel birim kök testlerine göre sahip olduğu avantajlardan dolayı, günümüzde GSYİH serilerindeki birim kökün varlığı tekrar analiz edilmektedir.Bu çalışmada, son zamanlarda geliştirilmiş olan non-linear panel birim kök testi ile 1970-2011 dönem aralığında 15 Avrupa Birliği üye ülkesi için reel kişi başına GDP serisinin durağan bir süreç izleyip izlemediği incelenmektedir. Ampirik bulgular reel kişi başına GDP'nin 15 Avrupa Birliği ülkesi için doğrusal olmayan durağan bir yapıya sahip olduğunu göstermektedir.

Anahtar Kelimeler: Reel Kişi Başına GDP, AB Üye Ülkeleri, Durağanlık, Doğrusal Olmayan Birim Kök Testi, Bootstrap Kiritik Değer

1. INTRODUCTION (GİRİŞ)

The economic growth is a basic indicator used to measure any nation's economic prosperity. The best way to measure economic growth is to take into consideration the real per capita GDP. This variable is also used in the estimation of the economic growth's future trend and in the analysis of the effects of economic policies. However, as is known, the main problem related to the time series in the econometrics literature is the fact that the series have unit root and therefore are not stationary at their levels. This point in the series constitutes a serious problem for both economists and policy makers (Tiwari et al., 2012). Since the first study of Nelson and Plosser (1982), economists have researched the stationarity of significant macro-economic variables. Especially the real per capita GDP is the main factor that is examined because it is important in ensuring the stability of macro-economic programs.

GDP can follow a stationary trend or a different stationary process. If the real GDP follows a stochastic trend, shocks will have permanent effects. But, if the real GDP follows a deterministic path then shocks will have temporary effects. If the moments of the statistical distribution of a time-series or a data generating process depend on time, then the series is non-stationary at its levels; if that series receive any shocks or undergo policy interventions, then the series will not be able to return to its mean path, and the series will become divergent (Murthy and Anoruo, 2009). In other words, a trend stationary series may reach a steady state in the long run following a shock whereas a difference stationary series may carry the effect of a shock forever. At that point, stationarity of series plays a vital role for not only economists but also policy makers.

In the literature, there are many studies on the stationarity of real per capita GDP for different countries. In previous studies the stationarity of real per capita GDP was analyzed with the traditional unit root tests. However, these tests are inadequate in the analysis of the stationarity of GDP series because traditional unit root tests provide a less efficient estimation. The panel unit root tests are used in contemporary literature in order to strengthen these tests (Rapach, 2002).

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

In this study, the stationarity of the real per capita GDP in 15 EU member states is analyzed for the period 1970-2011 using the unit root test developed by Ucar and Omay (2009) for nonlinear heterogeneous panel data. The main purpose of the study is to contribute to the assessment of the stationarity of real per capita GDP series in the European Union member states using this newly developed test. The following section of the study presents the literature review on the subject. Then the econometric methodology is explained, followed by the data and the empirical results. The conclusion section includes the results of the empirical analysis and a general review of the research.

3. REVIEW OF THE LITERATURE (LİTERATÜRE BAKIŞ)

In the literature, there are many studies analyzing whether or not the real per capita GDP series have a unit root. Traditional unit root tests generally show that series have unit roots at real output levels. However, to increase the power of traditional unit root tests, panel unit root tests are used to reveal whether or not the real output levels of the countries characteristically have unit roots (Chang, 2011:82).

Stulz and Wasserfallen (1985); Cogley (1990); and De Haan and Zelhorst (1993) can be cited among the studies using the traditional unit root test for various countries; whereas Chang (2006); Zhang et al. (2007); Chen (2008), and Chang et al. (2010) are some of the studies that apply the panel unit root test. The following studies can be cited among the studies that applied the panel unit root test for various countries: Chang et al. (2007) and Murthy and Anoruo (2009) applied it for African countries; Ozturk and Kalyoncu (2007), Sycamore (2010), Hurl (2004), Rapach (2002), and Fleissing and Strauss (1999) applied it for the OECD countries; Narayan (2007) applied it for the G-7 countries; Tiwari et al. (2012) applied it for the SAARC countries; Guloglu and Ivrendi (2010) and Chang et al. (2008) applied it for the Latin America countries; and Chang and Su applied it for the Eastern European countries. Table 1 provides the detail and the summary of these studies focusing on the stationarity of the real per capita GDP for different countries.

Table 1. Summary of Some Studies on Stationarity of GDP Series
(Tablo 1. GSYİH Serilerinin Durağanlığı Üzerine Bazı Çalışmaların Özeti)

Studies	Countries	Methodology	Findings
Fleissig and Strauss (1999)	15 OECD countries / 1900-1987	Panel unit root test (Levin and Lin, Im, Peseran and Shin, Maddala-Wu)	Non-stationary
Rapach (2002)	OECD Countries/ Different time periods for different countries	Panel unit root tests (Levin and Lin, Im, Peseran and Shin and SURADF)	Non-stationary
Chang et al. (2006)	47 African Countries/1980-2004	Panel unit root test (SURADF)	Non-stationary for 45 countries
Zhang et al. (2007)	25 Chinese provinces /1952-1998	Panel unit root test (SURADF)	Non-stationary for 21 Chinese provinces; stationary for 4 Chinese provinces
Ozturk and Kalyoncu (2007)	27 OECD countries/ 1950- 2004	Panel unit root test (Im, IPS)	Non-stationary for all
Narayan (2007)	G7 countries/ 1870-2001	Panel unit root test (Lee and Strazicich LM test with Structural Breaks)	The unit root null hypothesis is rejected for all countries except Italy and Germany.
Hegwood and Papell (2007)	OECD Countries/ 13 Countries: 1956-1996; 21 Countries: 1950-1992; 15 Countries: 1900-1987	Panel unit root test (Unit root test with one break and two breaks)	Trend Stationary
Chang et al. (2008)	20 Latin American Countries/1960-2000	Panel unit root test (Structural break)	Stationary
Chen (2008)	19 Developed countries/1870-2003	Panel unit root test (Unit root test with one break and two breaks)	Stationary for six countries according to the unit root test with one break; stationary for 11 countries according to the unit root test with two breaks
Murthy and Anoruo (2009)	27 African Countries /1960-2007	Panel unit root test (Kapetanios et al., 2003; Non-linear unit root test)	Stationary for one third of the countries
Guloglu and Ivrendi (2010)	Latin American Countries/1965-2004	Panel Unit Root Test (SURADF and CADF)	Difference stationary for all (except Belize, Bolivia, Panama, Uruguay)

Chang et al. (2010)	11 Middle Eastern Countries/1980-2008	Non-Linear Panel unit root test	Stationary for five countries, non-stationary for the remaining
Cinar (2010)	27 OECD countries/ 1960-2008	Panel unit root test (SURADF and CADF)	SURADF; there is unit root for Belgium, France and Germany, CADF; there is unit root for Finland, Iceland and New Zealand
Furuoka (2011)	9 ASEAN countries/ 1970-2007	Panel Unit Root Test (First-generation and second-generation)	Stationary according to the first generation unit root test; non-stationary for the second generation unit root test
Chang and Su (2011)	7 Eastern-European countries/1980-2008	Panel Unit Root Test (Kapetanios et al., 2003; Non-linear panel unit root test/SURADF)	SURADF; Non-stationary for all seven countries except one
Genc et al. (2011)	GCC countries/ 1950-2004	Panel Unit Root Test (Levin, Lin and Chu, Im, Peseran and Shin, Hadri, Maddala and Wu, and Choi)	Difference stationary for all countries
Chang et al. (2011)	9 Central-Eastern European countries/ 1969-2009	Flexible Fourier stationary unit root (Nonlinear)	Nonlinear stationary for Bulgaria, Latvia, Romania;non-stationary for the remaining countries
Chang (2011)	16 Transition countries/ 1969-2009	Panel Unit Root Test (SURADF)	Non-stationary for Bulgaria, Poland, Slovenia, Albania and Serbia; stationary for the remaining
Tiwari et al. (2012)	SAARC countries/ 1980-2010	Panel Unit Root Test (First and second generation; Ucar and Omay nonlinear)	Nonlinear stationary for SAARC countries

4. ECONOMETRIC METHODOLOGY (EKONOMETRİK METHODOLOJİ)

In this paper we study Uçar and Omay (2009) panel unit root test which is a unit root test for nonlinear heterogeneous panels. This test is nonlinear version of Im, Peseran and Shin (2003)[hereafter, IPS] unit root test for heterojen panels. IPS(2003) unit root tests based on the mean of individual unit root statistics for dynamic heterogeneous panels. It is also a standardized t-bar test statistic which based on the augmented Dickey–Fuller statistics averaged across individuals. They show that this average statistic is shown to converge in probability to a standard normal variate sequentially with $T \to \infty$ followed by $N \to \infty$.

Let $y_{i,t}$ be panel exponential smooth transition autoregressive process of order one (PESTAR(1)) on the time domain $t = 1,2,...,T$ for the cross section units $i = 1,2,...,N$ (Uçar and Omay,2009,pp:5). In this two-regime STAR model, the transition function in the regime-switching behavior is exponential function. It is assumed that $y_{i,t}$ follows the data generating process (DGP) with fixed effect (heterogeneous intercept) parameter α_i:

$$\Delta y_{i,t} = \alpha_i + \phi_i y_{i,t-1} + \gamma_i y_{i,t-1}\left[1 - \exp\left(\theta_i y_{i,t-d}^2\right)\right] + \varepsilon_{i,t} \qquad (1)$$

In (1), $d \geq 1$ is the delay parameter and $\theta_i > 0$ implies the speed of mean reversion for all i (Uçar and Omay,2009,pp:5).

They set $\phi_i = 0$ for all i and $d = 1$, which gives specific PESTAR(1) model :

$$\Delta y_{i,t} = \alpha_i + \gamma_i y_{i,t-1}\left[1-\exp\left(-\theta_i y_{i,t-1}^2\right)\right]+\varepsilon_{i,t} \quad (2)$$

For testing the existence of nonlinear panel unit root in (2) null hypothesis is follows:

$H_0 : \theta_i = 1$ for all i

Against the possibly alternatives is follows:

$H_1 : \theta_i > 0$ for some i

Under the null γ_i is not identified, therefore it is problematic direct testing of the $\theta_i = 0$. Uçar and Omay (2009,pp:5) emphasized that this problem is achieved by applying first-order Taylor series approximation to the PESTAR(1) model around $\theta_i = 0$ for all i. Thus, Uçar and Omay (2009,pp:5) obtain the following auxiliary regression

$$\Delta y_{i,t} = \alpha_i + \delta_i y_{i,t-1}^3 + \varepsilon_{i,t} \quad (3)$$

where $\delta_i = \theta_i \gamma_i$.

Further, Uçar and Omay (2009,pp:6) established the hypotheses for unit root testing based on regression (3) as follows:

$H_0 : \delta_i = 0,$ for all i (linear nonstationarity)

$H_1 : \delta_i < 0,$ for some i (nonlinear stationarity)

Uçar and Omay (2009:6) propose panel unit root tests which is calculated as taking the average of individual KSS (Kapetanios et.al. 2003) statistics. The KSS statistic for the $i.$ individual is simply $t-$ratio of δ_i in regression (3) and is defined follows as(Uçar and Umay,2009,pp:6)

$$t_{i,NL} = \frac{\Delta y_i' M_\tau y_{i,-1}^3}{\hat{\sigma}_{i,NL}\left(y_{i,-1}' M_\tau y_{i,-1}\right)^{3/2}} \quad (4)$$

where $\hat{\sigma}_{i,NL}^2$ is the consistent estimator and defined follows as

$$\hat{\sigma}_{i,NL} = \Delta y_i' M_\tau \Delta y_i$$

Also in (4) the other terms is defined follows as:

$M_\tau = I_T - \tau_T\left(\tau_T' \tau_T\right)^{-1}\tau_T'$, $\Delta y_i = \left(\Delta y_{i,1}, \Delta y_{i,2}, ..., \Delta y_{i,T}\right)'$, $y_{i,-1}^3 = \left(y_{i,0}^3, y_{i,1}^3, ..., y_{i,T-1}^3\right)'$ and $\tau_T = (1,1,...,1)'$.

For a fixed T , they defined following panel unit root test

$$\bar{t}_{NL} = \frac{1}{N}\sum_{i=1}^{N} t_{i,NL} \quad (5)$$

Individual statistics $t_{i,NL}$ are iid random variables with finite means and variances, thus average statistics $\bar{t}_{NL}$ have the limiting standard normal distribution as $N \to \infty$ such that (Uçar and Omay, 2009, pp:6)

$$\bar{Z}_{NL} = \frac{\sqrt{N}\left(t_{NL} - E\left(t_{i,NL}\right)\right)}{\sqrt{Var\left(t_{i,NL}\right)}} \xrightarrow{d} N(0,1) \quad (6)$$

4. DATA AND EMPIRICAL RESULTS (VERİLER VE AMPİRİK SONUÇLAR)

This empirical study is based on the real per capita gross domestic product (hereafter GDP) annual data from 1970 to 2011 for 15 European Union member states (EU-15), namely, Belgium, Sweden, Austria, Finland, France Denmark, Ireland, Spain, Luxembourg, Germany, Greece, Italy, the Netherlands, Portugal and the United Kingdom. The entire dataset was converted into natural logarithmic form before conducting the empirical analysis. The data used in the paper were sourced from the World Development Indicators (WDI) provided by the World Bank (WB).

We employed the Uçar and Omay (2009)[hereafter, UO] panel unit root test in order to determine whether the GDP was stationary or not. Ucar and Omay (2009) suggested using the sieve bootstrap approach, which was introduced in their paper, in the existence of cross dependence over cross-section units. For this reason, initially we applied the cross-section dependence test on the GDP variable. For this purpose, we used the LM tests developed by Breusch and Pagan (1980) and Pesaran (2004) [Please see this references for the econometric methodology about this test]. Test results are given in Table 2.

Table 2. The Results of Cross-Section Dependence Test for GDP
(Tablo 2. GSYİH Için Yatay-Kesit Bağımlılık Testi Sonuçları)

Tests	Intercept	Intercept and Trend
CD LM1(Breush-Pagan 1980)	265.065 (0.000)	279.388 (0.000)
CD LM2(Peseran-2004)	11.046 (0.000)	12.034 (0.000)

Note: The values in parentheses are $p-$values.

According to the results in Table 2, it is observed that the cross section independence hypothesis is rejected at 1% and 5% significance level. Therefore, the unit root test results should be evaluated according to the bootstrap critical value [Please See Appendix for the procedure regarding how bootstrap critical value are generated]. We also used the linear panel unit root test of Im-Peseran-Shin (2003) [hereafter, IPS] in order to compare with the results of the UO nonlinear panel unit root test. [Please see Im-Peseran-Shin (2003) for the econometric methodology about to the IPS test]. Test results are given in Table 3.

Table 3. The Results of Panel Unit Root Tests
(Tablo 3. Panel Birim Kök Test Sonuçları)

	UO Panel Unit Root Test		IPS Panel Unit Root Test	
	$\bar{t}^{*}_{NL}$	$\bar{Z}^{*}_{ANL}$	t^{*}_{nbar}	W^{*}_{nbar}
Intercept	-1.8448 (0.0062)	-0.9949 (0.006)	-1.8280 (0.002)	-1.6785 (0.002)
Intercept and Trend	-1.9948 (0.0278)	-1.6762 (0.0278)	-1.9467 (0.2322)	2.2459 (0.2322)

Note: $p-$values in parenthesis with 10,000 bootstrap replications. Maximum lag order is four, which is selected based on the Schwartz criterion.

It is concluded from Table 3 that when model includes only constant terms in the regression, the null hypothesis of linear non-stationarity is rejected by both the UO test and IPS test at the 1%

level. According to UO test, the GDP variable is nonlinear stationary. Further, when a trend variable is added to the model, we found that the null hypothesis of linear non-stationarity is rejected the UO tests reject while the IPS (2003) test does not reject this hypothesis. As is highlighted before, the alternative hypothesis in the UO test is nonlinear stationary. Therefore we could conclude that the UO test results are more accurate. But, the alternative hypothesis in the IPS test is linear stationary. Thus, in this paper we find that per capita gross domestic product for the EU-15 member states is nonlinear stationary.

5. CONCLUSION (SONUÇ)

Macroeconomic variables such as the real per capita GDP are important indicators to be analyzed the effects of economic policies. Policy makers and economists are very interested in whether or not the real per capita GDP have a unit root because temporary or permanent nature of shocks is informative in estimation and implementation of models for the stability of the economic policies. If the fluctuations in the real GDP are considered to be temporary, the economy will return to it's a steady level in the long term. This situation results in describing the real GDP as trend stationary. If the effects of the shocks are continuous, then the real GDP is considered to follow a difference stationary process.

This study investigates the real per capita GDP stationarity for fifteen European Union member states. For this purpose, we used the panel unit root test which is introduced by Ucar and Omay (2009). They construct this test in the nonlinear framework for the heterogeneous panel. The results of non-linear unit root tests pointed that the real per capita GDP is nonlinear-stationary. Our empirical findings imply that the real per capita GDP will return to its natural level and fiscal/monetary policies are not effective. In addition, our results are consistent with the study findings by Aslanidis and Fountas (2012) for the EU-12 member states. Thus, it is concluded that the shocks have temporary effects on the real per capita GDP for the EU-15 member states.

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APPENDIX (EKİ): THE BOOTSTRAP PROCEDURE (BOOTSTRAP İŞLEMİ)

Uçar and Umay (2009:7-8)show that the procedure to generate the bootstrap samples and the critical values. This is consists of the following five steps.

1. They consider the following OLS regression for each country with different lag orders p_i:

$$\Delta y_{i,t} = d_i + \delta_i y_{t-1}^3 + \sum_{j=1}^{p_i} \beta_{i,j} \Delta y_{i,t-j} + \varepsilon_{i,t} \quad \text{(A1)}$$

where d_i is deterministic component which is considered for α_i and $\alpha_i + \beta_i t$. Also they emphasized that lag orders selected by the Schwartz criterion. These is starting pi=6 and applying top to down strategy.

2. For generate bootstrap samples of residuals, they imposed the unit root null. The obtained the errors as:

$$\hat{\varepsilon}_{i,t} = \Delta y_{i,t} - \hat{d}_i - \sum_{j=1}^{p_i} \hat{\beta}_{i,j} \Delta y_{i,t-j} \quad \text{(A2)}$$

3. They suggests that residuals have to be centered with according to Stine (1987)'s proposes

$$\tilde{\varepsilon}_t = \hat{\varepsilon}_t - (T-p-2)^{-1} \sum_{t=p+2}^{T} \hat{\varepsilon}_t \quad \text{(A3)}$$

Where $\hat{\varepsilon}_t = (\hat{\varepsilon}_{1,t}, \hat{\varepsilon}_{2,t}, ..., \hat{\varepsilon}_{N,t})'$ and $p = \max(p_i)$. Also they created $N \times T$ $\{\varepsilon_{i,t}\}$ matrix from these residuals and selected randomly a full column with replacement from this matrix at a time to preserve the cross covariance structure of the errors. The bootstrap residuals indicate as $\tilde{\varepsilon}_{i,t}^*$, where $t = 1,2,...,T^*$ and $T^* = 2T$

4. They produce bootstrap $\Delta y_{i,t}^*$ recursively from following equation

$$\Delta y_{i,t}^* = \hat{d}_i + \sum_{j=1}^{p_i} \hat{\beta}_{i,j} \Delta y_{i,t-j}^* + \tilde{\varepsilon}_{i,t}^* \quad \text{(A4)}$$

Where $\hat{d}_i$ and $\hat{\beta}_{i,j}$ are the estimations which is obtained from step 2 and $\Delta y_{i,t-p_i}^* = 0$ for $p_i = 1,2,...,6$.

5. They suggested that nonstationary bootstrap samples is generated from following partial sums

$$y_{i,t}^* = \sum_{j=1}^{t} \Delta y_{i,j}^* \quad \text{(A5)}$$

The bootstrap statistics $\bar{t}_{NL}^*$ and $\bar{z}_{ANL}^*$ are obtained from for each bootstrap replication by running following the regression

$$\Delta y_{i,t}^* = d_i + \gamma_i (y_{i,t-1}^*)' + \sum_{j=1}^{p_i} \theta_{i,j} \Delta y_{i,t-j}^* + v_{i,t} \quad \text{(A6)}$$

They emphasized that the last T observations of $y_{i,t}^*$ and $\Delta y_{i,t}^*$ are used in this regression. In this study, we obtained the bootstrap empirical distribution $\bar{t}_{NL}^*$ and $\bar{z}_{ANL}^*$ statistics from 10,000 bootstrap replications. Also this bootstrap empirical distribution are used for their corresponding to p-values. This procedure is also applied for the IPS statistics t_{nbar}^* and W_{tbar}^*.