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IS REAL GDP STATIONARY? EVIDENCE FROM SOME UNIT ROOT TESTS FOR THE ADVANCED ECONOMIES

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Abstract

In this study, some tests (Augmented Dickey - Fuller (ADF), Phillips - Perron (PP), Kwiatkowski, Phillips Schmidt, Shin (KPSS) and Elliot, Rothenberg and Stock (ERS) that allow unit root test was performed firstly in singular sense about the developed countries, and then the IPS tests (Im KS, Pesaran MH, Shin Y (2003)) that allow unit root test in unbalanced panels, and the unit root test Pesaran CADF (2006) that allows panel unit root test in case the horizontal section dependency exists were performed. This study deals with the unit root hypothesis related to the real GDP (Gross Domestic Product) for 35 advanced economies, for the period of 1960 -2011.The results obtained from the unit root tests in applied singular and panel structures suggest that the null hypothesis must not be rejected.

Keywords: Real GDP, Unbalanced Panel Unit Root Tests, Cross Sectional Dependency, First and Second Generation Unit Root Tests

JEL Classification: C22, C20, C40, C50

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1. Introduction

National income most probably ranks first among the performance indicators of an economy. As a concept, national income denotes the total value of the goods and services produced in an economy within a year. In this context, ensuring the increase in the national income with the increase in the amount of the goods and services produced is a preferable situation. The situation in which the increases in national income stem from the increases in the prices is related with the driving power of the inflationist pressures. Real national income, on the other hand, is a concept revealing the real production potential of the economy, and is expressed by depending on the abovementioned separation. Real national income shows the production power that is purified from inflationist influences. The macroeconomic variable taken as the basis in the growth in an economy is the real national income.

In this study, the purpose of using the Real GDP (Gross Domestic Product) data is handling the real production power of the developed economies; which is the subject matter of the study, within the context of Unit Root Analysis. Examining the stability of the Real GDP data within the context of Unit Root Analysis means examining the chronic structure of the national income activities in the abovementioned countries. The changes in the real GDP values in developed economies show a more stable and hard-shell structure than those in the undeveloped or developing countries. With the Unit Root Tests, the real aim in this study is this. In other words, providing a numerical identity for the stability in the increases or changes in national income with Unit Root Analysis is the basic aim.

In this study, the real GDP values of developed countries (Advanced Economies, 35 countries) has been examined with Unit Root Tests by taking the time periods given in Table 5 into consideration. In Unit Root analyses, some of the important Unit Root Tests (Augmented Dickey - Fuller (ADF), Phillips - Perron (PP), Kwiatkowski, Phillips, Schmidt, Shin (KPSS), Elliot, Rothenberg and Stock (ERS)) were applied. These Unit Root Tests differ from each other in terms of some statistical properties. In this way, Panel Unit Root Analysis was applied as the first and second generation tests after the relevant Unit Root Test was applied for each country.

2. Literature

There are many studies on unit root in the literature. Since the focused variables in the study areas constitute a time series, the possibility of nonstationarity must always be investigated. In this context, Nelson and Plosser (1982) stated their ideas by claiming that many time series included unit roots. This situation has made it compulsory to investigate whether there is a nonstationarity before making analysis with time series; and if there is, this problem must be resolved. Unit Root Tests may vary according to the characteristic structure of the time series in question. In this context, there are many Unit Root Tests and their applications in the literature. Unit Root Tests vary both in methodological terms and in terms of their macro-economic variables.

One of the most important macro variables examined in Unit Root Analyses is GDP (Gross Domestic Product). In addition, the issue whether real national series include unit roots or not in a certain country or in certain country groups has been examined by considering the permanent or temporary shocks. In this context, Cushman (2016) conducted a study for the United States and pointed out to the permanent shocks, and reported that the nonstationarity may not be rejected in favor of the Trend Stationary Process. As well as the studies in which permanent or temporary shocks in economies are considered, some other studies in which the cross-sectional dependence is also considered attract the attention. Aslanidis and Fountas (2012) conducted a study on the economies of 18 countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA) for the period 1870 - 2008, and rejected the existence of unit root, which is unlike many similar studies. The influence of considering the cross-sectional dependence in panel dataset is important in obtaining this result. Smyth (2003) conducted another study by considering the 1952 - 1998 period in various states of China (24 states) for GDP per capita variable, and applied ADF Unit Root Tests and IPS ADF panel Unit Root Tests for separate states. Smyth (2003) reported that the null hypothesis, which claimed that there was a unit root for the states in the study, could be rejected. This is unlike the findings reported by Rapach (2002), because Rapach (2002) determined the existence of unit root and nonstationarity in his study. In another similar study conducted by Chang et al. (2010), and the real GDP values per capital were used in the study. The study was conducted again for 25 states of Chine by considering the 1952-1998 period. Leybourne et al. (1998) used logistic smooth transition regression models in his study and rejected the null hypothesis, which indicated the existence of unit root. Again, Chang, Nieh and Wei (2005) conducted a study for 1960-2000 period in 26 African countries, and Leybourne et al. (1998) applied nonlinear (logistic) unit root test. According to the study findings, the null hypothesis which was in favor of the existence of unit root was accepted.

Hegwood and Papell (2006) conducted a study and reported different results from Rapach (2002) after considering the breakages in the real GDP values during war years and by making use of the Structural Breakage Unit Root Tests (Rapach (2002) had pointed out to the stable structure by rejecting the Null Hypothesis in his study).

The unit root analyses of the unbalanced panels were performed by using the Im, Pesaran, Shin (2003) and Fisher Phillips and Perron (Choi, 2001) tests; and the study that allows panel unit root test in case the horizontal section dependency exists were performed by Pesaran (2006).

3. Data and Econometric Results I (Singular Unit Root Study)

In this study, firstly the Augmented Dickey - Fuller (ADF), Phillips - Perron (PP), Kwiatkowski, Phillips Schmidt, Shin (KPSS) and Elliot, Rothenberg and Stock tests will be applied to the panel members, and then the IPS test (Im KS, Pesaran MH, Shin Y (2003)) and Pesaran CADF (2006) *Unit Root Test* that allows unit root test in unbalanced panels will be applied.

3.1. Augmented Dickey - Fuller (ADF) Test:

$$\Delta y_t = \mu + \beta y_{t-1} - \sum_{j=1}^{p} \alpha_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

is the root test in which the pattern block is taken into consideration. Here, when Δ shows the difference operator; μ is constant, and while the unit root test is performed, the value of the β parameter which is the coefficient of the y_{t-1} term will give an idea on the stability.

The difference of the Augmented Dickey FullerTest from the usual normal unit root test is that it includes the delayed values of the dependent variable in the pattern, and takes the autocorrelation problem into consideration.

The hypotheses to be tested in the ADF test are as follows.

$H_0 : \beta = 0$

$H_1 : \beta < 0$

The null hypothesis expresses the existence of the unit root. The alternative hypothesis, on the other hand, shows the stable situation.

The ADF test statistics and critical values for the relevant 35 countries are given in the table below.

Table 1: The ADF Unit Root Test for Advanced Economies

Countries	Augmented Dickey-Fuller (ADF)		Critical Values		
	Trend	**Drift**	**%1**	**%5**	**%10**
Australia	-2.9167	-1.5029	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Austria	-2.1632	-2.9438**	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Belgium	-2.1307	-3.07**	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Canada	-2.4557	-2.2677	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Cyprus	0.4573	-3.055**	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
CzechRep.	-2.4173	-0.7275	[-4.38] [-3.75]	[-3.60] [-3.00]	[-3.24] [-2.63]
Denmark	-1.6271	-2.1714	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Estonia	-2.2704	-1.9635	[-4.38] [-3.75]	[-3.60] [-3.00]	[-3.24] [-2.63]
Finland	-2.6461	-1.7419	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
France	-2.1163	-3.4704**	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Germany	-1.822	-1.6613	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Greece	-2.0895	-2.7463*	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Hong Kong SAR, China	-1.2001	-2.7945*	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Iceland	-1.4228	-2.0311	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Ireland	-1.8184	-0.8905	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Israel	-2.527	-2.1414	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Italy	-0.8946	-4.5113***	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Japan	-1.5667	-4.2221***	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
KoreaRep.	-0.1299	-2.9929**	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Luxembourg	-2.3214	0.1142	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Malta	-3.8018**	-3.3209**	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Netherlands	-2.5856	-2.3616	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
New Zealand	-2.5232	-0.4159	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Norway	-0.7248	-2.4582	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Portugal	-0.9686	-3.5779***	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
San Marino	-1.8302	0.7888	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Singapore	-2.4557	-3.4077**	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Slovak Republic	-2.9934	-0.352	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
Slovenia	-2.6283	-1.5817	[-4.38] [-3.75]	[-3.60] [-3.00]	[-3.24] [-2.63]
Spain	-2.8729	-2.1206	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Sweden	-2.7257	-0.8865	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
Switzerland	-2.7909	-0.5387	[-4.15] [-3.58]	[-3.50] [-2.93]	[-3.18] [-2.60]
China	-1.5944	2.7031	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
United Kingdom	-2.7211	-0.9392	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]
United States	-2.5695	-1.9595	[-4.04] [-3.51]	[-3.45] [-2.89]	[-3.15] [-2.58]

The statistics values show that the null hypothesis can be rejected in the meaningful levels marked with * 10%; marked with ** 5%; and the ones marked with *** show 1% meaningfulness level (the critical values are taken from Hamilton (1994) and Dickey - Fuller (1979)).

3.2. Phillips, Perron (PP) Unit Root Test:

The Phillips, Perron (PP) Test is a modified application for the Dickey - Fuller test in taking the autocorrelation and the heteroscedasticity into consideration as an error term in the pattern. Another interesting point of the PP test is that it includes the delayed values of the error term in the patterns as a MA (Moving Average) process. The critical values determined in the study of Davidson and MacKinnon (1993) were used as the critical value for a comparison between the test statistics. In the study of Davidson and MacKinnon they reported that the PP test showed bad performance in finite samplings when compared with the ADF test.

The PP test statistics and the critical values for the relevant 35 countries are given in the table below.

Table 2: The PP Unit Root Test for Advanced Economies

Countries	Phillips, Perron (PP)		Critical Values		
	Intercept	Intercept and Trend	%1	%5	%10
Australia	-1.77	-2.02	[-3.562373][-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Austria	***-4.08	-1.76	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Belgium	***-4.64	-2.35	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Canada	***-3.71	-2.01	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Cyprus	***-5.21	*-3.28	[-3.622708] [-4.232433]	[-2.944606] [-3.538552]	[-2.610501] [-3.200915]
Czech Rep.	0.25	**-4.44	[-3.785493] [-4.469136]	[-3.011438] [-3.645364]	[-2.645735] [-3.260231]
Denmark	***-3.96	-2.06	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Estonia	-1.71	-1.19	[-3.922695] [-4.671175]	[-3.065881] [-3.734686]	[-2.674475] [-3.308634]
Finland	-2.13	-2.02	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
France	***-6.6	-2.37	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Germany	-2.10	-1.67	[-3.597217] [-4.195753]	[-2.933854] [-3.521719]	[-2.604838] [-3.191385]
Greece	***-3.98	-2.05	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Hong Kong SAR, China	-2.14	-0.48	[-3.577736] [-4.167807]	[-2.925573] [-3.508831]	[-2.600478] [-3.184047]
Iceland	-2.24	-1.64	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Ireland	-0.76	-1.36	[-3.597217] [-4.195753]	[-2.933854] [-3.521719]	[-2.604838] [-3.191385]
Israel	**-3.26	-2.76	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Italy	***-7.20	-1.20	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Japan	***-8.19	-2.19	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Korea Rep.	-2.56	0.50	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Luxembourg	0.04	-1.91	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Malta	*-2.88	-1.20	[-3.597217] [-4.195753]	[-2.933854] [-3.521719]	[-2.604838] [-3.191385]
Netherlands	**-3.38	-1.71	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
New Zealand	-0.28	-1.93	[-3.635244] [-4.250515]	[-2.949861] [-3.546818]	[-2.61327] [-3.205575]
Norway	***-3.63	-0.02	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Portugal	***-4.09	-0.80	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
San Marino	0.42	-1.56	[-3.611625] [-4.216469]	[-2.939942] [-3.531237]	[-2.608045] [-3.196781]
Singapore	-2.31	-0.98	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Slovak Republic	0.19	-1.25	[-3.695809] [-4.338246]	[-2.974975] [-3.586651]	[-2.626505] [-3.227853]
Slovenia	-0.24	*-3.52	[-3.785493] [-4.469136]	[-3.011438] [-3.645364]	[-2.645735] [-3.260231]
Spain	***-4.23	*-3.47	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Sweden	-1.91	*-3.17	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
Switzerland	-0.005	-2.32	[-3.657453] [-4.282617]	[-2.959122] [-3.561444]	[-2.618149] [-3.213788]
China	1.96	***-5.10	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
United Kingdom	-1.26	-2.21	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]
United States	-2.54	-1.57	[-3.562373] [-4.145823]	[-2.919] [-3.498651]	[-2.597018] [-3.178226]

The statistics values show that the null hypothesis can be rejected in the meaningful levels marked with * 10%; marked with ** 5%; and the ones marked with *** show 1% meaningfulness level.

3.3. Kwiatkowski, Phillips Schmidt, Shin (KPSS) Unit Root test:

KPSS test (1992),

$$y_t = \xi t + r_t + \varepsilon_t \qquad (2)$$

is the Unit Root Test that uses the Lagrange Multiplier (LM) test statistics based on the model above.

Here, r_t, shows the Rassal walk that is expressed as:

$$r_t = r_{t-1} + u_t \qquad (3)$$

In model (2), the ξt term shows the deterministic trend.

The partial additions over the ε_t and the smallest square remains in the model (2) are expressed as:

$$S_t = \sum_{i=1}^{t} e_i \quad , \quad t=1,2,\ldots..,T \qquad (4)$$

$\hat{\sigma}_\varepsilon^2$, to state the error variance obtained from the (2) model

LM test statistics (Lagrange Multiplier Test); will be expressed as:

$$LM = \sum_{t=1}^{T} \frac{S_t^2}{\hat{\sigma}_\varepsilon^2} \qquad (5)$$

In the KPSS test, the Barlet Kernel estimation that guarantees that the $s^2(l)$ is positive is used (Yavuz (2004)).

$$s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s} \qquad (6)$$

The KPSS test statistics value is expressed as:

$$\hat{\eta} = T^{-2}\sum_{t=1}^{T} \frac{S_t^2}{s^2(l)} \qquad (7)$$

The hypotheses for the KPSS test are formed as:

$$H_0 : \sigma_\varepsilon^2 = 0$$
$$H_1 : \sigma_\varepsilon^2 > 0$$

In the KPSS test, the acceptance of the stable situation of the null hypothesis shows the stable situation; and the rejection of it shows the non-stable situation (in case the test statistics $\hat{\eta}$ exceeds the critical value, the null hypothesis is rejected. In other words, it is accepted as not being stable).

The Kwiatkowski, Phillips Schmidt, Shin (KPSS) test statistics and critical values for the relevant 35 countries are given in the table below.

Table 3: KPSS Unit Root test for Advanced Economies

Countries	Kwiatkowski, Phillips, Schmidt,Shin (KPSS)	Critical Values		
		%1	%5	%10
Australia	0.1645 [3]**	0.216	0.146	0.119
Austria	0.2799 [3]***	0.216	0.146	0.119
Belgium	0.2833 [3]***	0.216	0.146	0.119
Canada	0.2797 [3]***	0.216	0.146	0.119
Cyprus	0.263 [3]***	0.216	0.146	0.119
Czech Rep.	0.154 [2]**	0.216	0.146	0.119
Denmark	0.2511 [3]***	0.216	0.146	0.119
Estonia	0.1348 [2]*	0.216	0.146	0.119
Finland	0.2408 [3]***	0.216	0.146	0.119
France	0.3137 [3]***	0.216	0.146	0.119
Germany	0.2254 [3]***	0.216	0.146	0.119
Greece	0.245 [3]***	0.216	0.146	0.119
Hong Kong SAR, China	0.3097 [3]***	0.216	0.146	0.119
Iceland	0.275 [3] ***	0.216	0.146	0.119
Ireland	0.1537 [3]**	0.216	0.146	0.119
Israel	0.2487 [3]***	0.216	0.146	0.119
Italy	0.3405 [3]***	0.216	0.146	0.119
Japan	0.3291 [3]***	0.216	0.146	0.119
Korea Rep.	0.2958 [3]***	0.216	0.146	0.119
Luxembourg	0.2351 [3]***	0.216	0.146	0.119
Malta	0.2204 [3]***	0.216	0.146	0.119
Netherlands	0.2161 [3]***	0.216	0.146	0.119
New Zealand	0.1409 [3]*	0.216	0.146	0.119
Norway	0.306 [3]***	0.216	0.146	0.119
Portugal	0.2968 [3]***	0.216	0.146	0.119
San Marino	0.2103 [3]**	0.216	0.146	0.119
Singapore	0.3027 [3]***	0.216	0.146	0.119
Slovak Republic	0.223 [2]***	0.216	0.146	0.119
Slovenia	0.0952 [2]	0.216	0.146	0.119
Spain	0.223 [3] ***	0.216	0.146	0.119
Sweden	0.1596 [3]**	0.216	0.146	0.119
Switzerland	0.0803 [3]	0.216	0.146	0.119
China	0.3224 [3]***	0.216	0.146	0.119
United Kingdom	0.0765 [3]	0.216	0.146	0.119
United States	0.1709 [3]**	0.216	0.146	0.119

-Null hypothesis: Level stationarity and stationarity around a linear trend, Alternative hypothesis: Unit root

The statistics values show that the null hypothesis can be rejected in the meaningful levels marked with * 10%; marked with ** 5%; and the ones marked with *** show 1% meaningfulness level.

3.4. Elliot, Rothenberg and Stock Unit Root test

In cases where the deterministic polynomal trend exists, the approach that suggests that the ADF (Augmented Dickey-Fuller) test is converted in the scope of generalized small squares plays an efficient role in terms of the strength of the test. The process is defined as follows in the articles of Elliot, Rottenberg and Stock (1996) published in Econometrica.

$$y_t = \beta' D_t + u_t \tag{8}$$

$$u_t = \phi u_{t-1} + v_t \tag{9}$$

In model (8) the D_t variable includes deterministic terms ($D_t = 1$), and the $E\left[u_0\right] < \infty$ condition is valid.

y_ϕ shows the column vector with a dimension of T; D_ϕ shows a matrix with $T \times q$ dimension; and when the components whose half differences are taken by using $1-\phi L$ operator;

$$y_\phi = (y_1, y_2 - \phi y_1, ..., y_T - \phi y_{T-1})' \tag{10}$$

$$D_\phi = (D_1^{'}, D_2^{'} - \phi D_1^{'}, ..., D_T^{'} - \phi D_{T-1}^{'})' \tag{11}$$

$$\tilde{y}_\phi = y_\phi - D_\phi \widehat{\beta}_\phi \quad \text{and} \quad \widehat{\beta}_\phi = (D_\phi^{'} D_\phi)^{-1} D_\phi^{'} y_\phi \tag{12}$$

$$S(\phi) = \tilde{y}_\phi^{'} \tilde{y}_\phi \tag{13}$$

(6) the expression $P_T = \left[S(\bar{\phi}) - \bar{\phi} S(1) \right] / \widehat{w}^2$ (14)

the point optimal test statistics used in (7) was formed.

(Here the expression is like: $\widehat{w}^2 = \sum_{k=\infty}^{\infty} E(v_t v_{t-k})$).

The Elliot, Rothenberg, Stock Unit Root Test statistics and critical values for the relevant 35 countries are given in the table below.

Table 4: Elliot, Rothenberg, Stock Unit Root test for Advanced Economies

Countries	Elliot, Rothenberg, Stock	Critical Values		
		%1	%5	%10
Australia	-1.7541	-3.58	-3.03	-2.74
Austria	-0.9284	-3.58	-3.03	-2.74
Belgium	-0.9431	-3.58	-3.03	-2.74
Canada	-0.9816	-3.58	-3.03	-2.74
Cyprus	-0.1099	-3.58	-3.03	-2.74
Czech Rep.	-0.9473	-3.58	-3.03	-2.74
Denmark	-0.6197	-3.58	-3.03	-2.74
Estonia	-1.5863	-3.58	-3.03	-2.74
Finland	-1.2955	-3.58	-3.03	-2.74
France	-0.7501	-3.58	-3.03	-2.74
Germany	-1.046	-3.58	-3.03	-2.74
Greece	-0.9529	-3.58	-3.03	-2.74
Hong Kong SAR, China	-1.1053	-3.58	-3.03	-2.74
Iceland	-0.8706	-3.58	-3.03	-2.74
Ireland	-2.0839	-3.58	-3.03	-2.74
Israel	-1.1278	-3.58	-3.03	-2.74
Italy	-0.5608	-3.58	-3.03	-2.74
Japan	-0.8356	-3.58	-3.03	-2.74
Korea Rep.	-0.8914	-3.58	-3.03	-2.74
Luxembourg	-1.8561	-3.58	-3.03	-2.74
Malta	-1.1256	-3.58	-3.03	-2.74
Netherlands	-1.0173	-3.58	-3.03	-2.74
New Zealand	-1.8755	-3.58	-3.03	-2.74
Norway	-0.6981	-3.58	-3.03	-2.74
Portugal	-0.5299	-3.58	-3.03	-2.74
San Marino	-1.7364	-3.58	-3.03	-2.74
Singapore	-1.7006	-3.58	-3.03	-2.74
Slovak Republic	-1.6877	-3.58	-3.03	-2.74
Slovenia	-1.9064	-3.58	-3.03	-2.74
Spain	-1.1533	-3.58	-3.03	-2.74
Sweden	-1.4791	-3.58	-3.03	-2.74
Switzerland	-2.7555*	-3.58	-3.03	-2.74
China	-0.2264	-3.58	-3.03	-2.74
United Kingdom	-2.2036	-3.58	-3.03	-2.74
United States	-1.1528	-3.58	-3.03	-2.74

The statistics values show that the null hypothesis can be rejected in the meaningful levels marked with * 10%; marked with ** 5%; and the ones marked with *** show 1% meaningfulness level.

4. Data and Econometric Results II (Panel Unit Root Study)

The real GDP values for 1960-2011 have been investigated in 35 Advanced Economies that are panel members. The real GDP values here have been calculated by considering the 2000 basic annual prices.*

The panel member countries are given below.

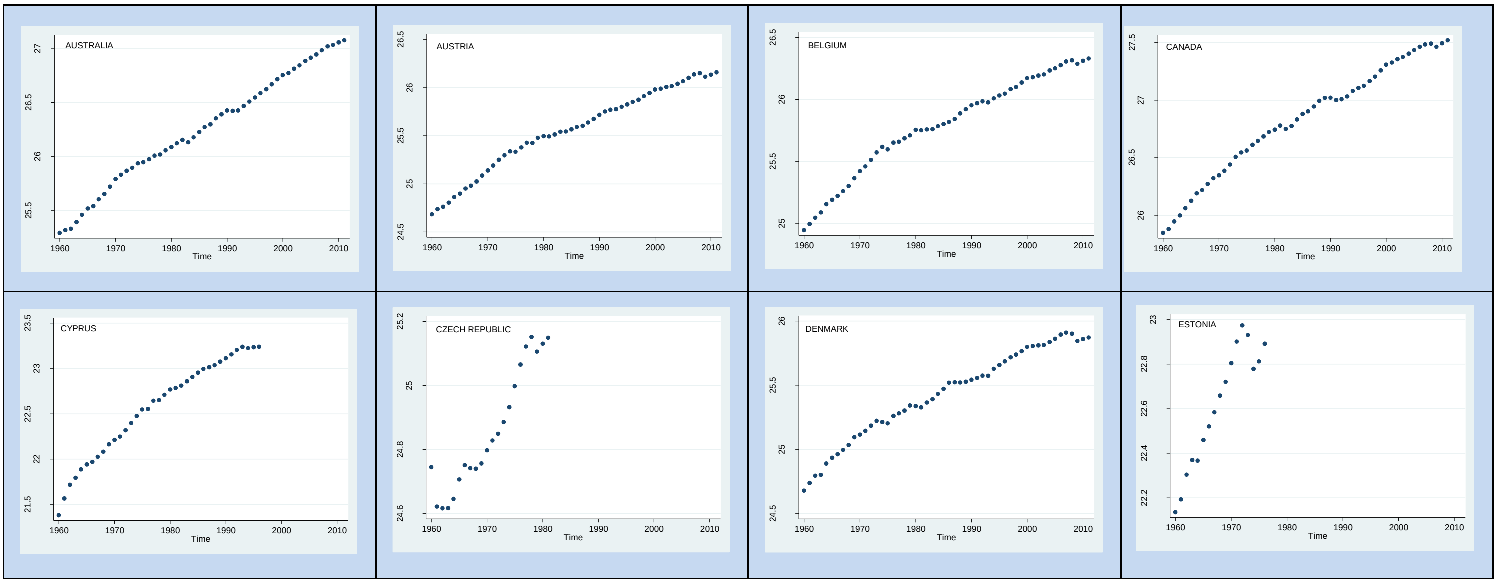
Table 5: Advanced Economies

35 countries					
Australia	Austria	Belgium	Canada	Cyprus[1975]	Czech Rep.[1990]
Denmark	Estonia[1995]	Finland	France	Germany[1970]	Greece
Hong Kong SAR, China[1965]	Iceland	Ireland[1970]	Israel	Italy	Japan
Korea Rep.	Luxembourg	Malta[1970]	Netherlands	New Zealand[1977]	Norway
Portugal	San Marino[1970]	Singapore	Slovak Republic[1984]	Slovenia[1990]	Spain
Sweden	Swirtzerland[1980]	China	United Kingdom	United States	

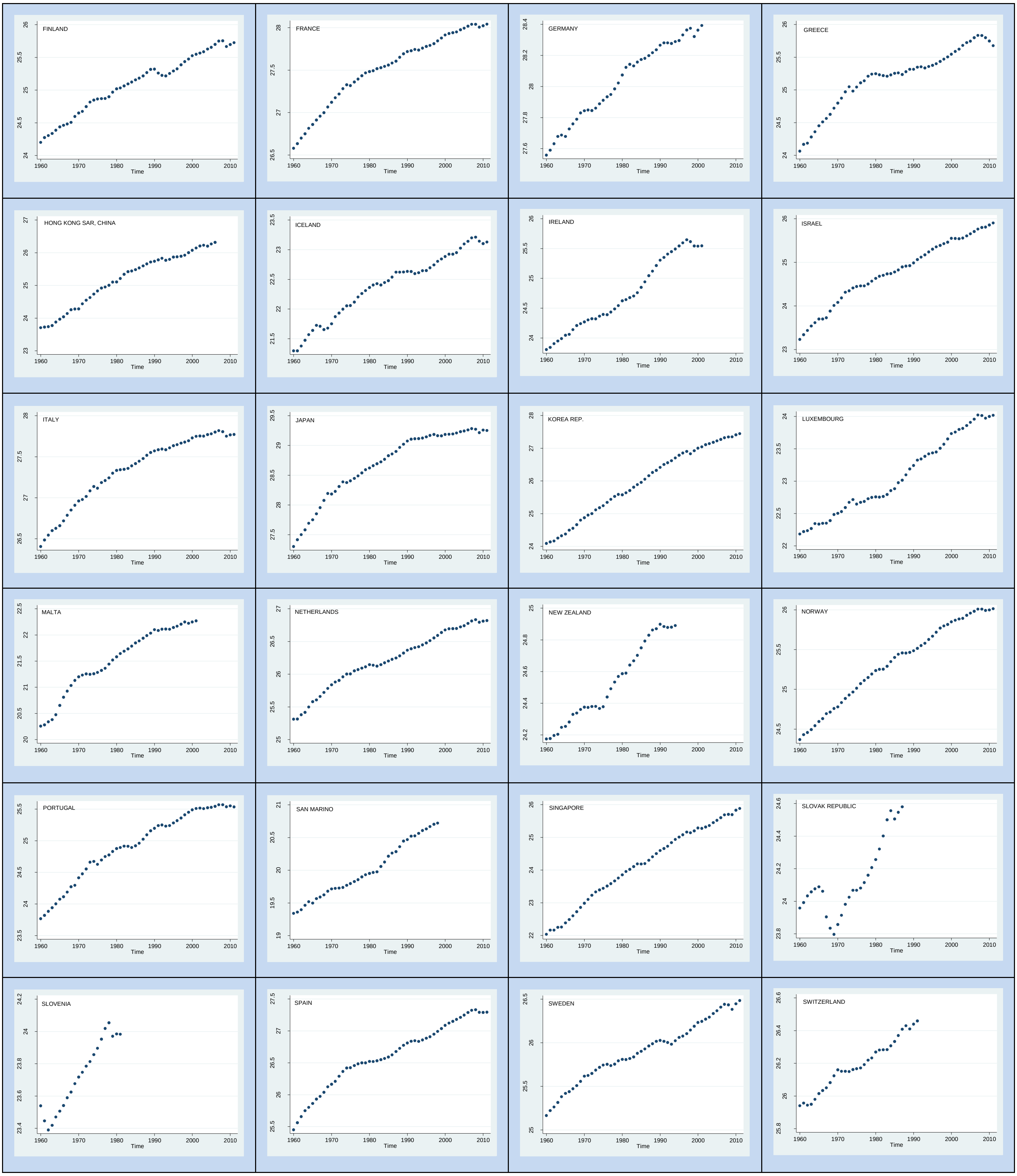
*Since the beginnings years of data belonging to some countries differ vary, they are written in bold characters.

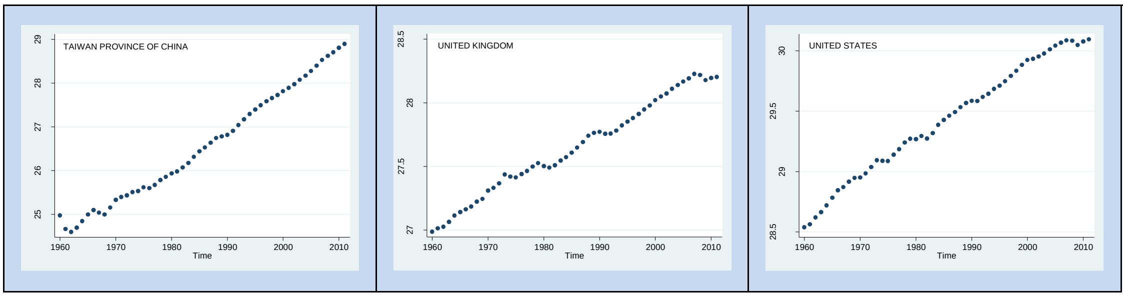
The flourishing diagrams of panel members are given below:

Table 6: LN Real GDP Graphs for Advanced Economies



*Real GDP values were obtained from the World Bank official website.


FINLAND
FRANCE
GERMANY
GREECE
HONG KONG SAR, CHINA
ICELAND
IRELAND
ISRAEL
ITALY
JAPAN
KOREA REP.
LUXEMBOURG
MALTA
NETHERLANDS
NEW ZEALAND
NORWAY
PORTUGAL
SAN MARINO
SINGAPORE
SLOVAK REPUBLIC
SLOVENIA
SPAIN
SWEDEN
SWITZERLAND



4.1. Panel unit root tests

The panel unit root tests are divided into two classes as the first generation and the second generation. Although the first generation tests underestimate the correlation among the panel members, the second generation tests accept that the shock occurring in one of the members of the panel may affect the other members and take this situation into consideration. The most important unit root tests of the first and second generation panel unit tests are shown in Table 7 below (Tatoğlu, 2013).

Table 7: First and Second Generation Panel Unit Root Tests

First Generation Panel Unit Root Tests	Second Generation Panel Unit Root Tests
Maddala and Wu (1999) (Fisher ADF)	Phillips and Sul (2003)
Harris and Tzavalis (1999)	Bai and Ng (2004)
Breitung (2000)	Moon and Perron (2004)
Hadri (2000)	Pesaran (2004)
Fisher Phillips and Perron (Choi, 2001)	
Levin, Lin and Chu (2002)	
Im, Pesaran and Shin (2003)	

4.2. Unbalanced panels

When the units in the panels are observed at all times, it is expressed as a *balanced panel*; but if some of the data of the panel members are missing for some periods, it is expressed as an *unbalanced panel*.

In terms of the balanced/unbalanced panels, the classification shown in Table 8 becomes possible; (Stata Longitudinal Data/Panel Data Reference Manual, Release 14)

Table 8: First Generation Panel Unit Root Tests and Balanced/Unbalanced Panels

Test	*Options*	*Asymptotics*	ρ under H_a	*Panels*
LLC	*Noconstant*	$\frac{\sqrt{N}}{T} \to 0$	*Common*	*balanced*
LLC		$\frac{N}{T} \to 0$	*Common*	*Balanced*
LLC	*Trend*	$\frac{N}{T} \to 0$	*Common*	*Balanced*
HT	*Noconstant*	$N \to \infty, T$ *fixed*	*Common*	*Balanced*
HT		$N \to \infty, T$ *fixed*	*Common*	*Balanced*
HT	*Trend*	$N \to \infty, T$ *fixed*	*Common*	*Balanced*
Breitung	*Noconstant*	$(T, N) \to_{seq} \infty$	*Common*	*Balanced*
Breitung		$(T, N) \to_{seq} \infty$	*Common*	*Balanced*
Breitung	*Trend*	$(T, N) \to_{seq} \infty$	*Common*	*Balanced*
IPS		$N \to \infty, T$ *fixed or* N *and* T *fixed*	*Panel-Specific*	*Unbalanced*
IPS	*Trend*	$N \to \infty, T$ *fixed or* N *and* T *fixed*	*Panel-Specific*	*Unbalanced*
IPS	*Lags()*	$(T, N) \to_{seq} \infty$	*Panel-Specific*	*Unbalanced*
IPS	*Trend Lags()*	$(T, N) \to_{seq} \infty$	*Panel-Specific*	*Unbalanced*
Fisher-Type		$T \to \infty, N$ *finite or infinite*	*Panel-Specific*	*Unbalanced*
Hadri LM		$(T, N) \to_{seq} \infty$	*(not applicaple)*	*Balanced*
Hadri LM	*Trend*	$(T, N) \to_{seq} \infty$	*(not applicaple)*	*Balanced*

(**Source**: Stata Longitudinal Data/Panel Data Reference Manual, Release 14)

As it may be understood from Table 8, only two of the first generation unit root tests are suitable for the unit root test in unbalanced panels. These are the Im, Pesaran and Shin (2003) and Fisher Phillips and Perron (Choi, 2001) tests.

A separate classification was made within the first generation unit roots, and this is expressed as "First Group Panel Unit Root Tests" and "Second Group Panel Unit Root Tests" (Tatoğlu, 2013).

In this classification, the first group panel unit rot tests assume that the autoregressive parameter ρ does not change among the panel members. Therefore, the null hypotheses express that at least one of the panel members include unit root. The second group panel unit root tests deal with the approach that allows the existence of a parameter for each of the panel members instead of a mutual autoregressive parameter (ρ). While the null hypothesis for the second group unit tests is like "None of the panel members is stable", the alternative hypothesis is like "At least one of the panel members is stable".

Table 9: First and Second Group Panel Unit Root Tests

First Group Panel Unit Root Tests	Second Group Panel Unit Root Tests
Harris veTzavalis (1999)	Maddalave Wu (1999) (Fisher ADF)
Breitung (2000)	Fisher Phillips vePerron (Choi, 2001)
Hadri (2000)	Im, Pesaran ve Shin (2003)
Levin, Lin ve Chu (2002)	

When the fact that the data set in our study are unbalanced panel and the strength of the test is considered, and when the first and second group panel unit root tests are assessed as a whole, it is accepted that the Im, Pesaran and Shin (2003) tests are more proper. Based on this acceptance, the IPS test, which is one of the first generation and the second generation tests, will be used for the relevant data set.

4.2.1. Im, Pesaran, Shin (IPS) Test[†]

The second group is included in the panel unit root tests among the Panel unit root tests. The ADF (Augmented Dickey-Fuller), which is calculated separately for each country that is member of the panel, may be defined as the average of the test statistical values. In addition, while N and T go to infinity, there is a process that converges to standard normal distribution. The IPS test, which considers the heterogeneous structure among the panel members, is different from the Levin and Lin (1993) test both in terms of this aspect and in terms of the testing power score..[‡] The test statistics that is in the forms of the average of the ADF scores of the panel members, which is the subject of IPS Test, have been expressed as follows.

$$\tilde{t} - bar_{NT} = \frac{1}{N}\sum_{i=1}^{N}\tilde{t}_{iT} \tag{15}$$

When $N \to \infty$, the standardized $\tilde{t} - bar_{NT}$ test statistics converging to the standard normal distribution is shown in the equation (16) below:

[†] In Im, Pesaran, Shin (IPS) Test has benefited from my paper in Josunas (Fırat, E.H., Halisdemir, N., Gürcan M., "Is Real GDP Stationary In the Advanced Economies? Evidence *From An Unbalanced Panel Unit Root Test*", Journal of Selçuk University Natural and Applied Science, ISDS Symposiun (2014).

[‡]Monte Carlo simulations reveal this pleasing situation that when the Augmented Dickey Fuller regressions contain a big enough delay within themselves, the IPS test statistics (t_{bar}test) display better small sample characteristics than Levin and Lin test statistics. In the LLC test, as the alternative hypothesis, the same individual stability with autoregressive coefficient is valid; however, in the IPS test, a stability with different individual autoregressive coefficients is valid. Tatoğlu states in his book that the LLC test shows an inclination for the rejection of the null hypothesis so long as the N increases in the existence and nonexistence of the autocorrelation among the errors; and the IPS test is stronger than the LLC test in this context.

$$Z_{\tilde{t}bar} = \frac{\sqrt{N}\left\{\tilde{t} - bar_{NT} - E(\tilde{t}_T)\right\}}{\sqrt{\text{var}(\tilde{t}_T)}} \qquad (16)$$

The hypotheses to be tested in the IPS' are formed as follow,

$H_0 : \beta_i = 0$

$H_1 : \beta_i < 0 \quad , \quad i = 1, 2, ..., N_1$

IPS test was applied to the real GDP values for 35 Advanced Economies, which are mentioned by Fırat et al. (2014), for the same time period (1960-2011), and the following findings were obtained.

IPS Panel Unit Root Test Results I (STATA 12)

Table 10: Test statistics for Unbalanced Panel

MODEL**		Intercept						Intercept and Trend					
		t_{bar}	**p**	**$t_{tildebar}$**	**p**	**Z_{tbar}***	**p**	**t_{bar}**	**p**	**$t_{tildebar}$**	**p**	**Z_{tbar}***	**p**
Adv. Econ.	Cross-sectional Means Included	-2.788	-	-2.308	-	-6.200	0.0000	-1.881	-	-1.570	-	-0.771	0.220
	Cross-sectional Means Removed	-1.826	-	-1.732	-	-1.959	0.0251	-1.378	-	-1.282	-	1.348	0.911

*Z_{tbar} : Z-t-tilde-bar

** The analysis was done based on a 95 % confidence level.

When the model with fixed-term in Table 10 is considered, the null hypothesis, which claims that unit root exists according to Ztbar values, may be rejected (Cross-sectional Means Included, p value= 0.000; Cross-sectional Means Removed, p value= 0.0251). When the model with trend is considered, it is possible to claim that the 35 Advanced Economies countries include unit root (Cross-sectional Means Included, p value= 0.220; Cross-sectional Means Removed, p value= 0.911).

When serial correlation is considered, the $W_{t\text{-}bar}$ scores obtained are given in the table below.[§]

[§]As N and T get close to infinite, they converge to the standard normal distribution as asymptotic.

IPS Panel Unit Root Test Results II (STATA 12)

Table 11: W_{tbar} Test Statistics for Unbalanced Panel

MODEL*		Intercept		Intercept and Trend	
		W_{tbar}	**p**	**W_{tbar}**	**p**
Advanced Economies	Cross-secitonal Means Included	-5.9300	0.0000	1.9652	0.9753
	Cross-sectional Means Removed	-2.0987	0.0179	5.8159	1.0000

** The analysis was done based on a 95 % confidence level*

The observance in Table 10 is confirmed in Table 11 in such a way that the null hypothesis claiming that the unit root exists may be rejected in the model with fixed term (Cross-sectional Means Included, p value= 0.000; Cross-sectional Means Removed, p value= 0.0179). In the model with trend, the null hypothesis claiming that the unit root exists cannot be rejected (Cross-sectional Means Included, p value= 0.9753; Cross-sectional Means Removed, p value= 1).

4.2.2. The Pesaran Test

It is among the second generation panel unit root tests which are applied in cases where a horizontal section dependency is valid among the panel members (Pesaran (2006)) In this method, the delayed horizontal section averages and their expanded states are used **(**Tatoğlu, 2013). The CADF (Cross Sectional Augmented Dickey Fuller) regression used in this test is as follows.

$$\Delta y_{i,t} = \beta_i + \rho_i y_{i,t-1} + D_0 \bar{y}_{t-1} + D_1 \Delta \bar{y}_t + \varepsilon_{i,t} \tag{17}$$

Here in model (17), the $\bar{y}_t$ is the mean value of the horizontal section according to t time. The (19) model will be able to be expanded in case there is an autocorrelation and when the first delay differences of the $\bar{y}_t$ is added to the pattern. With the mean value of the t statistics of the delayed variables in the CADF regressions, the CIPS value will be found.

$$CIPS = \frac{1}{N} \sum_{i=1}^{N} CADF_i \tag{18}$$

When the horizontal section dependency is considered in terms of the 35 panel member countries, the Pesaran CADF test results will be as follows in Table 12.

Table 12: Pesaran CADF Unit Root Test for Advanced Economies*

Countries	Pesaran CADF	
	p. value	p
Australia*	0.04062234	1
Austria	0.50391534	0
Belgium	0.36254432	0
Canada	0.39639111	1
Cyprus	0.98922038	0
Czech Rep.	0.28635917	1
Denmark	0.78199931	0
Estonia	0.52800021	1
Finland	0.29562668	1
France	0.48760281	1
Germany	0.80518882	0
Greece	0.32219091	1
Hong Kong SAR, China	0.93825243	0
Iceland	0.60201134	2
Ireland	0.62180050	1
Israel	0.31003053	1
Italy	0.96591963	0
Japan	0.62107851	0
Korea Rep.	0.99591895	0
Luxembourg	0.60441499	1
Malta	0.24860430	1
Netherlands	0.33680868	1
New Zealand	0.39436205	2
Norway	0.96516060	1
Portugal	0.92561019	1
San Marino	0.86017868	0
Singapore	0.90579071	0
Slovak Republic	0.44083544	1
Slovenia	0.98439404	0
Spain	0.42775776	1
Sweden	0.07578933	1
Switzerland	0.15194138	1
China	0.63955249	2
United Kingdom	0.14825718	1
United States	0.39346591	1

*Results are obtained using Hartung (1999) correction and represents model with trend.

The ADF test statistics of Pesaran 1.2209743 (p value= 0.8889521). With the findings shown in Table 12, it is understood that all the countries except one country (Australia) include unit roots.

5. Conclusion

In the advanced economies, in which there are 35 countries, and in the unit root tests conducted for each country for the years 1960 - 2011, various unit root tests were applied, and we can suggest in terms of the real GDP that in the models where the trend variable does not exist, some countries show a stable structure. When the trend variable is added to the patterns that are subject to unit root analysis, a pattern which is not stable is valid for most of the countries.

When the analysis is performed by taking the unbalanced panel structure into consideration, it might be possible to talk about a structure that is not stable in the pattern where the trend variable exists. When Table 6 is examined in detail, it is possible to see the existence of the trend in most of the observation values of 35 countries.

The breaking points in real GDP values of the panel members in 2008 and in early 1970s are interesting. The importance of this activity, which may be explained with the fluctuations in oil prices, in terms of unit root test is that it is possible to apply unit root tests that consider the breaking points.

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