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IS PER CAPITA REAL GDP STATIONARY IN THE OECD COUNTRIES? EVIDENCE FROM A PANEL UNIT ROOT TEST

This paper examines the stationarity of real GDP per capita for 27 OECD countries during the period 1950 to 2004. Using ADF unit root test on single time series, it is found that real GDP per capita series of most OECD countries have unit root. This outcome, however, might be due to the generally low power of this test. The aim of this paper is to reconsider this issue by exploiting the extra information provided by the combination of the time-series and cross-sectional data and the subsequent power advantages of panel data unit root tests. We apply the test advocated by Im, Pesaran and Shin (1997). The results overwhelmingly indicate that real GDP per capita series among OECD countries are nonstationary.

Keywords: Real GDP per capita, Stationary, Panel Unit root tests

I. Introduction

Since Nelson and Plosser's (1982) seminal article, a large literature has evolved that investigates the potential nonstationarity of macroeconomic time series data. The question of whether real GDP can be characterized by unit roots has

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been an issue of particular interest (see, e.g., Wasserfallen, 1986; Ben-David & Papell, 1995; Cheung & Chinn, 1996; Rapach, 2002). Nelson and Plosser note that a unit root in real output is inconsistent with the notion that business cycles are stationary fluctuations around a deterministic trend; instead, it suggests that shocks to real output have permanent effects on the system. As also stressed by Smyth and Inder (2004), this has important implications for the effectiveness of government policies. If real output contains a unit root, the logical implication is that government-initiated structural reform is of limited value, because the impact of such reform on the long-run growth path will be ofset by other shocks. However, if real output is trend stationary, this implies that only large shocks such as government policies aimed at changing the fundamentals will have at least semipermanent effects on the growth path (Li, 2000:825). Thus, it is important to assess the validity of the unit root hypothesis as an empirical fact.

The empirical literature cited above reached the conclusion that real GDP levels are nonstationary by using either univariate unit root statistics (Cheung and Chinn, 1996) or panel unit root tests (Rapach, 2002) along the lines of the Augmented Dickey-Fuller (ADF) statistics. The key feature of all these tests is that they work upon the hypothesis that a symmetric adjustment process exists. However, a very recent and expanding empirical literature allows for non-linear dynamics for unit root testing procedures: see for example Caner and Hansen (2001), Shin and Lee (2001) and Kapetanios et al (2003). According to Enders and Granger (1998) all standard linear unit root tests have lower power in the presence of misspecified dynamics. International evidence using conventional univariate tests support the null of a unit root in GDP for OECD economies; see Kormendi and Meguire (1990), Cogley (1990), Fleissig and Strauss (1999)[1], and Rapach (2002).

A common criticism of unit root tests, notably the ADF test, is that they have low power against persistent, but stationary alternatives with normally available time spans of data. Recently, the panel unit root approaches developed by Abuaf and Jorion (SUR) (1990), Levin and Lin (LL) (1992, 1993), Levin, Lin, and Chu (2002), Im, Pesaran and Shin (IPS) (2003), and Maddala and Wu (1999) possess more power than univariate time series tests (Banerjee et al. 2005). These tests have been successful in finding evidence of stationarity that cannot be found by univariate methods. Thus the IPS method of testing is used here. According to Fleissig and Strauss (1999), to increase the power of univariate ADF regressions, the LL and SUR procedures impose identical first-order autoregressive coefficients on all series in the panel; whereas, the IPS test pools t-ratios and the Fisher Pz approach pools P-values from individual ADF regressions. The panel test statistics, however, depend on the degree of contemporaneous and serial correlation

[1] In the study of Fleissig and Strauss (1999), 15 OECD countries are used for the period 1900-1987. However, in this study, 27 OECD economies are studied for the period 1950-2004.

in the data. When the series are independent, the derived distributions are valid. In applications, however, series in the panel are often contemporaneously and serially correlated, which affects the critical values and power of the panel tests. To induce independence, most studies that adopt the LL and IPS methods follow the traditional approach of Hsiao (1986) by subtracting cross sectional means to eliminate common time specific effects. Alternatively, O'Connell (1998) and Maddala and Wu (1997) recommend bootstrapping the residuals to accommodate more general forms of cross correlation.

The paper is organized as follows. The econometric methodology is given in Section 2. The data and empirical results are discussed in Section 3. Section 4 concludes the paper.

2. Econometric Methodology

Stationarity of countries real GDP per capita variables is tested by using the Augmented Dickey-Fuller (ADF) unit root test procedure then panel unit root tests are applied. In recent years some new tests for unit root within panels are developed in the literature, such as; Levin and Lin (1992, 1993), IPS (1997), Maddala and Wu (1999), Kao (1999) and Quah (1994) panel unit root tests. In this study IPS panel are used because it is easier to use IPS test and it is more powerful than Levin and Lin's test[2]. The IPS model is briefly described as follows:

Suppose that there is a group of N real GDP per capita, GDP_{it}, which have the following time-series representation:

$$\Delta GDP_{it} = \alpha_i + \beta_i GDP_{it-1} + \sum_{j=1}^{w_{ij}} \delta_{ij} \Delta GDP_{it-j} + \varepsilon_{it}, \quad i = 1,....,N \; and \; t = 1,.....,T. \tag{1}$$

The IPS test examines the null hypothesis:

$H_0 : \beta_1 = \beta_2 = ... = \beta_N = 0,$ against

$H_a : \beta_i < 0, \; for \; some \; i.$ Rejecting the null implies that series in the panel are stationary.

The IPS statistic is defined as:

$$\bar{z} = \sqrt{N}\left[\bar{t} - E(\bar{t})\right] / \sqrt{Var(\bar{t})}, \tag{2}$$

[2] see Maddala and Kim, (2000, p.133-137) for a detailed discussion on the comparison of panel unit root tests.

where $\bar{t} = (1/N)\sum_{i=1}^{N} t_i$. t_i is the t statistics of $\hat{\beta}_i = 0$, E($\bar{t}$) and Var($\bar{t}$) are the mean and variance of $\bar{t}$, respectively. The t-bar procedures uses N univariate ADF regression from Eq. (2) to calculate $\bar{t} = (1/N)\sum_{i=1}^{N} t_i$ where the t-ratio for each series, $t_i = \beta_i / \sqrt{Var(\beta_i}$, is from T observations.

3. Data and Empirical Results

3.1. Data

This empirical study uses annual real GDP per capita for 27 selected OECD countries over the 1950 – 2004. Structural similarity of countries played an important role in the choice of sample. The data are obtained from the Penn World Tables (PWT) 6.2 of Heston, Summers and Aten (2006). Real GDP per capita is coded in Penn World Tables as *rgdpl (Constant Prices: Laspeyres)*. The data for Germany, Hungary and Poland starts from 1970, 1951 for Greece, 1953 for Korea and 1950 for the others. Eviews 5.1 econometric software is used in this study. The countries included in the study are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

3.2. Empirical Results

We have conducted the classical unit root tests, namely, the Augmented Dickey-Fuller (ADF) test. ADF test is based on the null hypothesis that a unit root exists in the time series. This unit-root test is performed on the level of variable. The model without trend and with trend is adopted in the empirical analysis. Optimal lag lengths for ADF were chosen by Schwarz Information Criterion (SIC). ADF test results are presented in Table 1.

Table 1 indicates that all univariate test results cannot reject the null hypothesis of a unit root at the model without trend. The null hypothesis of a non-stationary real GDP per capita is rejected for Austria, Finland, Germany, Portugal and Turkey at the model with trend. For these countries, test statistics exceed the critical values. In the cases of other countries, it was not possible to reject the null hypothesis of non-stationary.

After the stationary of real GDP per capita is investigated by applying ADF unit root test, IPS panel unit roots test is performed. The IPS panel unit root test result is reported in Table 2. According to the test results, IPS test don't reject the unit root null, which indicates that real GDP per capita series are nonstationary for the two models (with and without trend). We exclude five countries (Austria, Finland, Germany, Portugal and Turkey) from the panel unit root tests which exhibit stationary in ADF test at the model with trend and performed IPS unit root test. The test results exhibit nonstationarity more strongly when we exclude these mentioned countries.

4. Conclusion

The main aim of this paper is to reconsider the issue of non-stationarity of per capita real GDP for the 27 OECD countries using an extended dataset and a recent panel unit root test. We apply the test advocated by Im, Pesaran and Shin (1997). The results overwhelmingly indicate that real GDP per capita series among OECD countries are nonstationary. The results here are not consistent with those of Fleissig and Strauss (1999) who used three different panel-based unit root tests and determined that the per capita real GDP for OECD countries is trend stationary. Our results are consistent with those of Cheung and Chinn (1996) and Rapach (2002), which support the notion of non-stationarity in real GDP for various panels of OECD countries.

Table 1.

ADF UNIT ROOT TEST RESULTS

Country	τ_{τ}	***k***	τ_{μ}	***k***
Australia	-1.3444	0	2.3887	0
Austria	-3.3164*	0	0.6816	0
Belgium	-2.7156	0	1.2394	0
Canada	-2.4053	1	0.9403	1
Denmark	-2.3393	0	0.3641	0
Finland	-3.5068**	1	0.1051	1
France	-2.9347	1	0.5044	0
Germany	-3.3226*	1	-0.5077	1
Greece	-1.4147	1	-0.1715	1
Hungary	-0.6466	0	0.3541	0
Iceland	-2.7860	1	0.6200	0
Ireland	-0.5229	1	1.3249	1
Japan	-2.2852	1	-0.5499	1
Korea	-0.4428	0	4.2994	0
Luxembourg	-0.3090	0	3.7215	0
Mexico	-1.4673	0	-1.0736	0
Netherlands	-2.6585	1	-0.2199	1
New Zealand	-1.5330	0	0.6219	0
Norway	-1.7850	1	1.3761	1
Poland	-2.4838	1	0.1084	2
Portugal	-3.1892*	1	0.1638	1
Spain	-2.4974	1	0.6527	1
Sweden	-2.4634	1	0.3718	1
Switzerland	-2.2063	1	-1.2339	1
Turkey	-3.5628*	0	-0.2503	0
United Kingdom	-0.8193	1	2.0879	1
United States	-1.9359	1	2.0412	0

Notes: 1- $\tau_{\mu,}$ denotes with constant. 1%, 5%, 10% critical values for ADF test are –3.55, -2.91 and -2.59 respectively. $\tau_{\tau,}$ denotes with constant and trend. 1%, 5%, 10% critical values for ADF test are –4.13, -3.49 and -3.17, respectively. The ***, ** and * indicate significance at the 1%, 5%, 10% level, respectively.

2- ***k,*** denotes the lags and the k was determined using the Schwarz criterion.

Table 2.

RESULTS OF THE PANEL UNIT ROOT TEST

	Individual trend and intercept		Individual intercept	
	$\overline{Z}_{INT}$ *	Probability	$\overline{Z}_{INT}$ *	Probability
All countries	0.45272	0.6746	13.3597	1.0000
All countries except Austria, Finland, Germany, Portugal and Turkey	2.09536	0.9819		

* $\overline{Z}_{INT}$ is the test statistic of Im et al. (1997)

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DA LI JE REALNI BDP PO STANOVNIKU U ZEMLJAMA OECD STACIONARAN?

DOKAZI IZ TESTA O JEDINIČNIM KORIJENIMA VREMENSKIH PRESJEKA I VREMENSKIH SERIJA

Sažetak

U članku se istražuje stacionarnost realnog BDP po stanovniku za 27 zemalja OECD, u razdoblju 1950.-2004. Primjenom ADF testa o jediničnim korijenima na jednostruke vremenske serije, došlo se do zaključka da serije realnog BDP po stanovniku većine zemalja OECD imaju jedinični korijen. Taj bi zaključak, međutim, mogao biti rezultat općenito slabe jakosti ovog testa. Cilj je članka ponovno razmotriti taj problem, koristeći posebne informacije koje se dobivaju kombinacijom podataka vremenskih serija i vremenskog presjeka i veće snage testova o jediničnim korijenima za združene vremenske serije i vremenske presjeke. Primijenjen je test kojeg zagovaraju Im, Pesaran i Shin (1997.). Rezultati nadmoćno ukazuju da su u zemljama OECD serije realnog BDP po stanovniku nestacionarne.

Ključne riječi: realni BDP po stanovniku, stacionarnost, testovi o jediničnim korijenima