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Real Convergence in Selected OECD Countries

Seçilmiş OECD Ülkelerinde Gerçek Yakınsama

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ABSTRACT

The purpose of this study is to re-examine the convergence hypothesis both linear and nonlinear time series techniques for 21 OECD countries during the period of 1950-2008. The linear augmented Dickey Fuller (ADF) test results support the existence of a unit root which means that there is nonconvergence in both de-meaned output and the output gap series constructed as the difference between actual GDP series of each OECD country from that of the USA. We used a nonlinear test as an alternative procedure if there are nonlinearities in the series. The nonlinear testing procedures reject the null hypothesis that there is a unit root in the series providing some supportive evidence of a nonlinear output convergence among the selected OECD economies.

Keywords: Convergence hypothesis, nonlinear unit root, KSS test, LNV-sollis test.

ÖZET

Bu çalışmanın amacı, 1950-2008 periyodunda 21 OECD ülkesi için yakınsama hipotezini sınamaktır. Doğrusal Dickey Fuller (ADF) test sonuçları, hem ortalamadan çıkarılmış çıktı serilerinde ve hem de her bir OECD ülkesinin fiili GDP serilerinin ABD'nin GDP serilerinden farkını ifade eden serilerde yakınsamanın olmadığı anlamına gelen birim kökün varlığını desteklemektedir. Çalışmada kullanılan serilerin doğrusal olmaması halinde, doğrusal olmayan birim kök testleri ADF birim kök testine bir alternatif olarak kullanılmaktadır. Doğrusal olmayan test sonuçları, seçilmiş OECD ekonomileri arasında doğrusal olmayan çıktı yakınsaması kanıtlarını destekleyerek, serilerde birim kökün varlığını ifade eden boşluk hipotezini red etmektedir.

Anahtar Kelimeler: Yakınsama hipotezi, doğrusal olmayan birim kök, KSS testi, LNV-sollis testi.

1. INTRODUCTION

The question of whether per capita income inequality across countries narrows as time goes by is one of the main research topics in the growth theory. In the related literature, there are two major and competing models which are the names Solow-Swan model and the new endogenous growth model of growth which can be used to investigate if there is a tendency towards output convergence. The exogenous growth model, also known as the neoclassical growth model or Solow-Swan growth model (Solow, 1956), predicts that there is a strong pressure for convergence of income over time so that poor countries or regions can catch up with rich ones. This model is based on the assumption that the prevailing technology, the rates of saving, population and technical progress are exogenous variables. The main implication of the neoclassical model is that countries having higher saving rates tend to have higher levels of per capita income while countries with higher population growth rates tend to have lower levels of per capita income. Therefore, economic policy changes will not have a permanent effect on real economic activity since the growth rate is independent of any economic behavior. The new endogenous growth theory (Lucas, 1988; Romer, 1986), on the other hand, treats the factors, relegated as exogenous by neoclassical model, as endogenous and subject to decision making process at individual firms. Thus, rejection of the convergence hypothesis confirms the prediction of the endogenous growth model.

The present paper aims to test convergence hypothesis using time series of annual data for 21 OECD countries over the 1950-2008 period. Although there are an enormous number of papers (for instance, Carlino and Mills, 1993, Loewy and Papell, 1996, Dawson and Sen 2007, Kasman et al 2005 and Liew and Ahmad 2009, Dawson and Strazicich 2009, among others) in which time series techniques are used to test convergence hypothesis, our approach is different from them in several respects. First, except for Liew and Ahmad (2009), all of the above-mentioned studies test the convergence hypothesis by using linear unit root or cointegration tests within a linear framework. However, convergence among nations might be

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nonlinear due to some country-specific economic and political factors. Therefore, it is reasonable to say that possible nonlinearities inevitably make the conclusions drawn from a linear structure misleading. Second, though Liew and Ahmad (2009) allow for a nonlinear convergence, they do not consider the fact that there might be some structural breaks in the data set. Only Dawson and Strazicich (2009) allows for a structural break, but they fail to take account of nonlinearities in the adjustment process. In this study we utilize both conventional ADF (Dickey and Fuller, 1979) and Leybourne et al. (1998) unit root test procedures, which allow for gradual structural changes. Moreover, our paper employs Kapetanios et al. (2003) nonlinear unit root test and Sollis's (2004) unit root test procedure which gives consideration to the asymmetric adjustment with smooth structural changes in the data generating process. Our results of nonlinear unit root test procedures are able to reject a unit root in both demeanded output and the output gap from USA series for the selected OECD countries , whereas the standard ADF test fails to do so, providing some supportive evidence of nonlinear convergence in the outputs.

The plan of the study is as follows. Section 2 presents an overview of the econometric methodology. Data set and empirical analysis are given in section 3. Section 4 contains concluding remarks.

2. NONLINEAR UNIT ROOT TESTS

To test the convergence hypothesis in a nonlinear framework, we first employ Kapetanios et al's. (2003) ESTAR model:

$$\Delta q_t = \gamma q_{t-1}\left[1-\exp\left(-\theta q_{t-1}^2\right)\right]+\sum_{i=1}^{p}\beta_i \Delta q_{t-i}+\varepsilon_t \quad (1)$$

In eguation (1) the parameter θ determines the speed of transition between two regimes that correspond to extreme values of the transition function. The global stationarity of the process can be established by testing the null hypothesis $H_0:\theta=0$ against the alternative $H_1:\theta>0$. Since the parameter γ is not identified under the null, Kapetanios et al. (2003) replace the transition function $F\left(\theta,q_{t-1}\right)=1-\exp\left(-\theta q_{t-1}^2\right)$ by its first-order Taylor approximation around $\theta=0$, yielding the following auxiliary regression:

$$\Delta q_t = \delta q_{t-1}^3+\sum_{i=1}^{p}\beta_i \Delta q_{t-i}+e_t \quad (2)$$

where e_t contains ε_t and the error term resulting from Taylor approximation. The test statistic for $\delta=0$ against $\delta<0$ is obtained as $t_{NL}=\hat{\delta}/s.e.(\hat{\delta})$, where $\hat{\delta}$ is the OLS estimate of δ and s.e.($\hat{\delta}$) is the standard error of $\hat{\delta}$ .1

We next consider the nonlinear unit root test of Leybourne et al. (the LNV test) (1998) which develops a test procedure allowing for smooth shifts in the mean and/or trend of the data generating process. The framework for the test is given by the following regression model:

$$q_t=\alpha_1+\beta_1 t+\alpha_2 S_t(\gamma,\tau)+\beta_2 t S_t(\gamma,\tau)+\nu_t \qquad \gamma>0 \quad (3)$$

where ν_t is an iid process and $S_t(\gamma,\tau)$ is the transition function depending on a sample size of T, $S_t(\gamma,\tau)=\left[1+\exp\left\{-\gamma\left(t-\tau T\right)\right\}\right]^{-1}$, which governs the transition between regimes. The parameter γ determines the speed of the transition, and τ is the mid-point of the transition.

Two step procedures are used to perform the LNV test. In the first step, equation (3) is estimated using a nonlinear least squares algorithm, and in the second step the usual ADF test is implemented on the residuals $\hat{\nu}_t$ obtained from the first step. One of the advantages of the LNV test is that not only gradual but also instantaneous changes in the mean or trend of the series are allowed.

Sollis (2004) extends the LNV test by combining Enders and Granger's (1998) threshold autoregressive (TAR) adjustment model with the LNV's nonlinear structural change model, and calls the resultant model a smooth transition TAR (ST-TAR) model. This extension allows for asymmetric convergence to the nonlinear "attractor". The Sollis's (2004) test procedure goes as follows:

$$\Delta\hat{v}_t=I_t\alpha_1\hat{v}_{t-1}+\left(1-I_t\right)\alpha_2\hat{v}_{t-1}+\sum_{i=1}^{p}\beta_i\Delta\hat{v}_{t-1}+\eta_t \quad (4)$$

where the residuals $\hat{\nu}_t$ obtained from equation (3) and $I_t=1$ if $\hat{v}_{t-1}\geq 0$, $I_t=0$ if , $\hat{v}_{t-1}<0$ and η_t is a stationary process with zero-mean. Sollis (2004) suggests to test the null hypothesis of unit root in two different ways: Using the F-statistic for testing $\alpha_1=\alpha_2=0$ in (4) and/or the most significant of the t-statistics from those testing $\alpha_1=0$ and $\alpha_2=0$.

3. DATA AND ESTIMATION RESULTS

In the empirical analysis, we use a data set consisting of real GDP per capita (in 1990 US Dollars) for 21 OECD countries from 1950 to 2008. All data series were obtained from the Groningen Growth and Development Centre. A visual inspection of the plot of the data in Fig.1 gives a preliminary information indicating that GDP per capita series of the countries converge to a common mean over the sample period.

Similarly, the plot of the cross-sectional standard

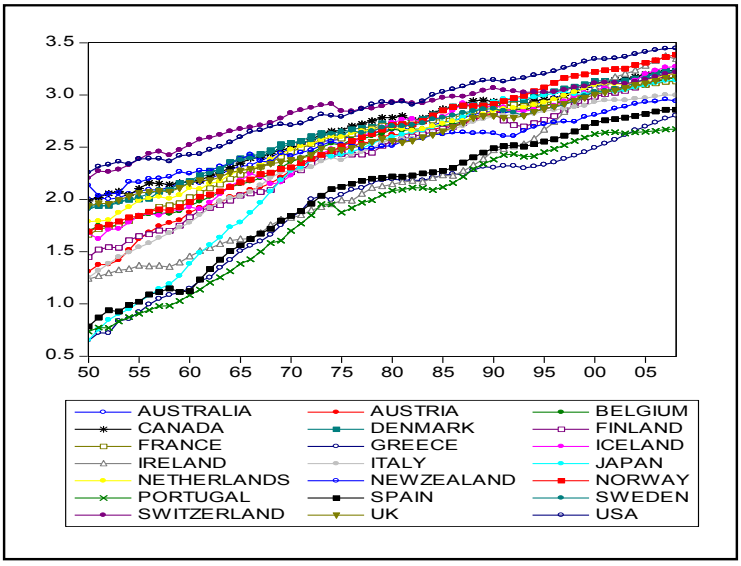

Figure 1: Log of Real Per Capita GDP for 21 OECD Countries

deviation against time in Fig.2 reveals that the convergence among themselves is σ-type as defined in Sala-i. Martin (1996).

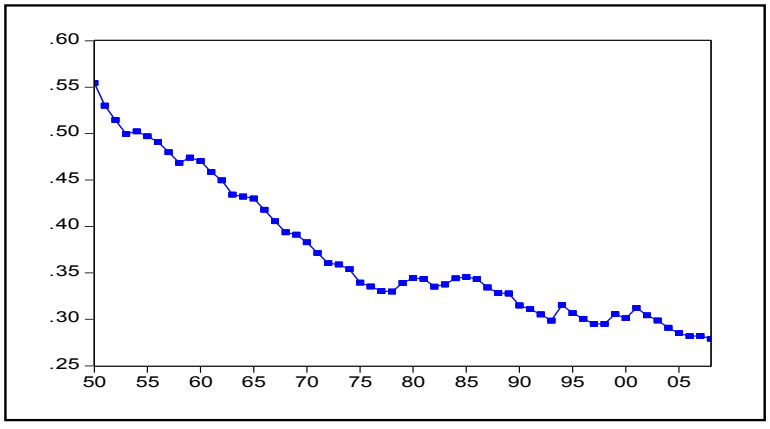

Figure 2: Standart deviation of log real per capita GDP for 21 OECD Countries.

The demeaned per capita GDP is depicted in Fig.3, and almost all of the deviations approach to zero.

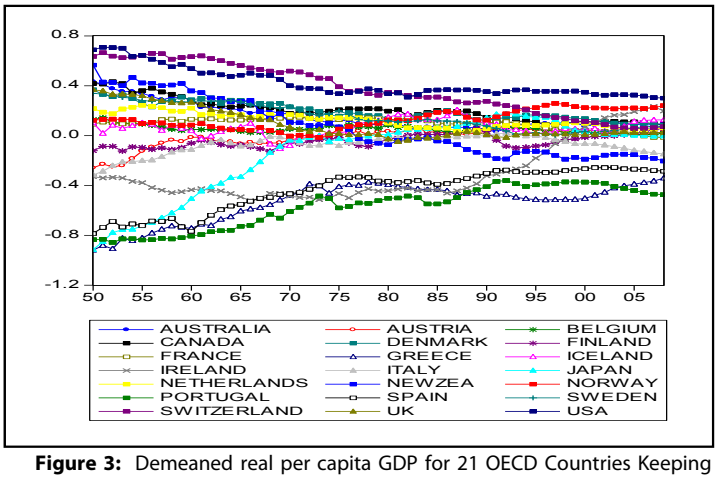

Figure 3: Demeaned real per capita GDP for 21 OECD Countries Keeping the results of the visual inspections in mind, we now turn to formal analysis. We first test the squared demeaned output and output gaps from USA series for stationarity by ignoring possible non-linearities in the series.

Table 1: ADF Test Results of 21 OECD Countries

	Demeaned Output		Output Gap From USA	
Country	Lag Length	t-Statistics	Lag Length	t-Statistics
Australia	2	-3.8339**	1	-2.5518
Austria	5	-2.2270	4	-3.0473**
Belgium	2	-2.5159	0	-1.9647
Canada	1	-2.1064	1	-2.1247
Denmark	7	-0.4983	3	-3.4613**
Finland	1	-1.9280	1	-1.7214
France	1	0.9809	1	-3.0089**
Greece	3	-1.5123	0	-3.0736**
Iceland	1	-2.5082	2	-1.7404
Ireland	3	-0.6412	1	1.0078
Italy	0	-3.9500**	4	-3.5683**
Japan	1	-2.7263	1	-3.7407**
Netherlands	0	-1.3674	1	-3.5011**
NewZealand	0	-2.2501	0	-1.6272
Norway	1	-0.8309	0	-0.9286
Portugal	5	-1.7984	4	-2.1959
Spain	2	-1.3581	4	-2.3858
Sweden	2	-1.6426	2	-2.1640
Switzerland	1	-0.4402	4	-0.2519
UK	2	-2.7813	3	-1.8542
USA	4	-2.5450		

(**Notes:** * and ** denotes 1% and 5% levels, respectively. Lag length determined by AIC. As seen from Table 1, the ADF test results suggest that the squared demeaned output series for Australia and Italy are I(0), whereas the rest of the series are found to be nonstationary. Moreover, the ADF test results indicate that there is no strong evidence of convergence between USA and sample countries. The null hypothesis of a unit root in the series of output gaps from USA is rejected for Austria, Denmark, France, Greece, Italy, Japan and Netherlands,asconsistent with the convergence hypothesis. Since the conventional ADF test does not take into account neither possible nonlinear adjustments nor structural breaks in data generating processes, the policy implication of this test might be misleading.[2] Therefore, we next consider nonlinear unit root tests of KSS and ST-TAR.)

Table 2: KSS Test Results of 21 OECD Countries

	Demeaned Output		Output Gap from USA	
Country	Lag Length	t-Statistics	Lag Length	t-Statistics
Australia	0	-4.2846**	3	-1.6910
Austria	4	-5.0266**	3	-5.6673**
Belgium	1	-3.0529**	3	-2.9942**
Canada	2	-4.2314**	4	-1.7574
Denmark	0	-3.0386**	0	-4.8044**
Finland	3	-3.0251**	3	-3.3786**
France	0	-0.8271	3	-3.7752**
Greece	0	-3.9190**	0	-4.8838**
Iceland	2	-1.6081	1	-3.0098**
Ireland	3	-1.0945	0	-1.8904
Italy	0	-4.0454**	0	-5.0951**
Japan	0	-5.2430**	0	-5.8866**
Netherlands	5	-2.7649	2	-3.9037**
NewZealand	0	-3.9883**	3	0.5600
Norway	2	-0.0057	3	-3.1784**
Portugal	0	-2.2085	2	-3.4914**
Spain	0	-3.5478**	0	-4.2824**
Sweden	0	-2.7313	3	-1.9844
Switzerland	1	-2.4603	1	-0.1128
UK	0	-3.2326**	1	-1.0069
USA	3	-4.6267**		

(**Notes**:* and ** denotes 1% and 5% levels, respectively. Lag length determined by AIC.Table 2 presents the results of KSS unit root tests for the demeaned outputs and the output gaps from the USA. As Table 2 shows, in 13 of the 21 demeaned income series the null of a unit root is strongly rejected. France, Iceland, Ireland, Netherlands, Norway, Portugal, Sweden and Switzerland are the countries for which we cannot reject the null of unit root in the series. Similarly, the null of nonconvergence can be rejected in 13 of 21 output gap from the USA series (Austria, Belgium, Denmark, Finland, France, Greece, Iceland, Italy, Japan, Netherlands, Norway, Portugal, and Spain).

Table 3: LNV-Sollis Test Results of 21 OECD Countries

Country	Demeaned Output			Output gap from USA		
	Model A1 (F-Stat.)	Model B1 (F-Stat.)	Model C1 (F-Stat.)	Model A2 (F-Stat.)	Model B2 (F-Stat.)	Model C2 (F-Stat.)
Australia	6.9216	13.9496**	20.3351**	6.5244	6.5002	16.4084**
Austria	8.9995	3.1650	6.7635	8.6091	8.9613	8.9612
Belgium	2.5802	3.9794	9.0415	6.8092	7.5196	10.1953
Canada	4.1013	6.4859	7.6778	1.9706	7.3996	3.2600
Denmark	4.8103	7.7086	7.4670	9.9519	12.7948	16.0186**
Finland	6.0047	5.7754	5.6581	4.5287	4.8727	15.7848**
France	4.1813	13.7781**	16.2209**	2.1755	7.2355	13.7944
Greece	2.6765	7.1328	6.4156	1.1162	2.3646	8.9083
Iceland	4.9031	6.1777	7.8396	4.8440	4.7212	5.8449
Ireland	4.7615	2.1844	6.2340	2.8974	2.9091	5.3585
Italy	1.8242	2.7192	5.5717	4.3964	11.1496	12.3270
Japan	2.6570	4.9620	4.9444	4.3885	8.5742	8.8941
Netherlands	4.4928	2.0687	8.7962	4.6974	4.6386	11.0907
NewZealand	9.6693	12.4481	8.2305	13.1428**	15.4466**	8.5282
Norway	4.7959	7.5447	10.3714	4.8237	4.7042	12.1636
Portugal	4.8518	6.0575	6.4247	6.6731	7.0394	7.1318
Spain	4.5583	5.0416	6.4005	4.3225	7.8101	11.5241
Sweden	4.8377	3.6058	8.0382	2.8685	3.0912	3.4623
Switzerland	3.7712	3.3362	7.0652	12.5680**	103.6391**	15.2150**
UK	6.6128	7.0686	16.0183**	3.4279	8.2449	11.1832
USA	4.8551	5.2017	11.5616			

(**Notes:** * and ** denotes 1% and 5% levels, respectively. Models A1 and A2 imply that series are stationary around a mean which changes from initial value to final value. Models B1 and B2 are similar, with the intercept changing from initial value to final value, but allows for a fixed slope term. In models C1 and C2, in addition to change in intercept from initial value to final value, the slope also changes simultaneously, and with the same speed of transition.)

As the results of ST-TAR unit root tests presented in Table 3 clearly shows, the null hypothesis is rejected in all considered countries for demeaned series but is not rejected only in the case of New Zealand and Switzerland for the output gap series if it is assumed that the data are not trending and the mean of the series changes gradually in the asymmetric adjustment model as shown in Table 3-Model A1 and Model A2. When a trend term is included (Table 3-Model B1 and Model B2), the null of the nonconvergence is rejected for two countries, namely Australia and France for demeaned series but is not rejected for the output gap series of New Zealand and Switzerland. If we further allow the trend term to change gradually (Table 3-Model C1 and Model C2), the null hypothesis is rejected in the case of Australia, France and the UK, and is rejected for Australia, Denmark, Finland and Switzerland for demeaned series and the output gap series, respectively.

4. CONCLUSION

In this paper we investigate the convergence hypothesis for 21 OECD countries during the period of 1950-2008. This study employs not only a linear but also nonlinear time series techniques. Overall estimation results of the nonlinear unit root test procedures are able to reject a unit root in both demeanded output and the output gap from USA series for several OECD countries whereas the linear ADF test fails to do so, providing some supportive evidence of nonlinear convergence in the outputs. Also, when we employ sigma convergence on these series, we explore that demeaned per capita GDP deviations approach to zero. We might conclude that one must be cautious to possible structural changes and nonlinearities, and take into account for them when examining the convergence hypothesis.

END NOTES

1 See, , Kapetanios et al. (2003) for more detailed discussion.

2 We employ the formal linearity test of Luukkonen et al. (1988) which is available upon request. The results support the use of nonlinear tests.

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