Testing Income Convergence among OECD Countries using the TAR Panel Unit Root Test

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Abstract: In this paper, the convergence of per capita GDP in high and upper middle income OECD countries over the period 1970-2006 was examined. The TAR panel unit root test was employed and some evidence was found for the convergency among high income countries and between high and upper middle income countries with two separate models. Norway and Mexico are the transition countries in the models.

Keywords: Convergence, TAR Panel Unit Root Test, Threshold Model, Non-Linearity.

JEL Classification Number: O4, C33.

1. Introduction

The OECD promotes policies designed to achieve the highest sustainable economic growth and employment and enhances standard of living in member countries. Although all OECD countries are considered as high income countries, it is not clear that there is economic convergence among them. The objective of this study is to review if there is economic convergence among OECD countries.

Various tests have been developed to check the validity of convergence hypothesis. Examples for the time series studies related to convergence hypothesis are; Baumol (1986); Dowrick&Nguyen (1989); Mankiw et al. (1992); Quah (1993). Examples for the studies made for various groups of countries with cross section data and panel data are; Barro&Sala-i Martin (1991, 1992); Sala-i Martin (1994); Bernard&Durlauf (1995); Evans&Karras (1996); Coulombe (1999); Kangasharju (1999); Tsionas (2000); Nahar&Inder (2002) and Beyaert&Camacho (2008). The mentioned studies have been made for various periods of time and groups of countries using different econometric methods. While Bernard&Durlauf (1995) reject the convergence hypothesis for OECD countries, Evans&Karras (1996) have found evidence for convergence. On the other hand, Nahar&Inder (2002) have discovered strong evidence for absolute convergence in their studies covering 22 OECD countries. In addition to these, Beyaert&Camacho (2008) have suggested the TAR panel unit root test to test the convergence hypothesis and have performed these tests on 15 European countries in various groups; while there was

convergence among the rich and poorer West European countries, it was concluded that three eastern European countries did not converge with them.

In this study the TAR panel unit root test, developed by Beyaert & Camacho (2008), has been used for the 1970-2006 period for 26 OECD countries and the convergence hypothesis has been tested initially between the GDP of high income countries and later between the high and upper middle income countries. While evidence for convergence has been discovered in group 1, the conclusion has been reached to observe convergence in the 1st regime of group 2.

The outline of the paper is as follows. In Section 2, the methodology of TAR panel unit root is discussed. Section 3 presents the empirical application and empirical results are discussed. Finally, Section 4 concludes the paper.

2. Methodology

Beyaert&Camacho (2008) have adapted Evans&Karras's (1996) test proposed to test the real convergence in linear situations using panel data to the case where the situation is nonlinear and formed the model as follows:

$$\Delta g_{n,t} = \left[\delta_n^I + \rho_n^I g_{n,t-1} + \sum_{i=1}^{p} \varphi_{n,i}^I \Delta g_{n,t-i}\right] I_{\{z_{t-1}<\lambda\}} + \left[\delta_n^{II} + \rho_n^{II} g_{n,t-1} + \sum_{i=1}^{p} \varphi_{n,i}^{II} \Delta g_{n,t-i}\right] I_{\{z_{t-1}\geq\lambda\}} + \varepsilon_{n,t} \qquad (1)$$

Where, n shows units (n=1,…,N) and t shows time (t=1,…,T). $g_{n,t}$ is the difference of log of per capita GDP from the average in terms of time ($g_{n,t} = y_{n,t} - \overline{y}t$; $y_{n,t}$=log($Y_{n,t}$) and $\overline{y}_t = \frac{1}{N}\sum_{n=1}^{N} y_{n,t}$). $I_{\{z}$; x is an indicator that has the value of 1 if x true and 0 otherwise. There are two possible regimes in this model; when it is $I_{\{z_{t-1}<\lambda\}}$ regime 1 and when it is $I_{\{z_{t-1}\geq\lambda\}}$ regime 2. λ is the threshold parameter*.

Once the Model 1 is estimated using feasible generalized least square (FGLS), its superiority against the linear Evans&Karras model is checked. If its superiority is accepted, various unit root tests are applied to the ρ coefficient and tested whether convergence hypothesis is valid or not. If there is evidence of convergence, various tests are applied to the δ coefficient and convergence is determined to be absolute or conditional. In the case of $\rho_n^I = \rho_n^{II} = 0$, N is country divergence and in the case of $0 < -\rho_n^i < 1$ (i=I, II), it is global convergence. If $0 < -\rho_n^i < 1$ but $\rho_n^j = 0$ (i≠j), there is partial convergence.

* Refer to Tong (1978) for TAR model details.

3. Empirical Application

The main purpose of this paper is to examine the convergence of per capita GDP in OECD countries with high and upper middle income. Annual balanced panel data from 1970 to 2006 for 26 OECD countries[†] have been used. The variables considered are the logarithm of the per capita GDP. The logarithm of the per capita GDP series is found as I (1) for the selected OECD countries using panel unit root test.

First the convergence in 24 high income OECD countries has been examined. The data of logarithm of the per capita GDP for these countries are illustrated in Figure 1. It is seen from the Figure 1 that a high convergence exists among these countries.

The statistical results are shown in Table 1 for the linear model, and the TAR model. The linear model reflects that there has been convergence among these countries during the last 25 years[‡].

If the outcome of the TAR model in Table 1 is reviewed, it can be seen that the linearity test supports the TAR specification. Both the unrestricted and the restricted bootstrap p-values are below the standard 5% critical value. According to the conclusions, Norway is a transition country whose economic evolution determines the switch from one regime to the other. The data for this country are identified with large black dots in Figure 1. Norway is one of the wealthiest countries in the world. The Norwegian economy which has developed fast in the 1970s has faced serious issues like unemployment and stagnation starting towards the end of 1980s. As it can be seen in Figure 1, the per capita GDP had increased fast until the 1980s and continued to increase from then on however at a lower rate for these reasons. It was part of the average among the countries undertaken; the fast increase of its GDP has moved it higher than many countries; in this state, Norway can be accepted as a representative of the intensive convergence process among the countries. This may explain why it has been picked to form the transition variable. The relative growth rate of Norway is estimated to be 3 and the estimated value of the threshold parameter is approximately 3.92. It means the years during which Norway's growth rate per capita income was below the average growth rate of the group (which takes place in 50% of the sample) that is less than 3.92 percentage points. Norway's growth was less than the average

[†] 24 of them are high income countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States and two of them are upper middle income countries; Mexico and Turkey, according to the Atlas Method by World Bank.

[‡] p-value for null of divergence is equal to 0.4390.

in %50 observations (observations in regime 1) during the 1970-2006 period but higher than average in %50 observations in regime 2. The threshold position and the value of the transition variable for each regime can be found in Figure II. In addition, divergencency test has also been performed for both regimes. While null of divergence is not rejected for regime 1, it has been rejected for regime 2 and both regimes with a p-value of 0.83803, 0.000 and 0.0160 respectively (see Table 1). In the 2nd regime and both regimes absolute convergence has been observed[§].

Table 1: Linear and TAR Model for High Income Countries

a. Linear Model

Divergence vs convergence	Absolute vs conditional convergence
0.4390	-

b. TAR Model

Linearity Test		Transition Country	d	λ	% observations in regime I
Unrestricted	Restricted				
0.0000	0.0000	Norway	3	3.9195	50

Convergence Tests

Divergence vs convergence			Absolute vs conditional convergence		
Regime I	Regime II	Both	Regime I	Regime II	Both
0.8380	0.0000	0.0160	-	0.9860	0.9890
Partial Convergence (regime II and both)			Absolute in regime II and both		

[§] p-values of 0.9860 and 0.9890 respectively.

Figure 1: High Income Countries

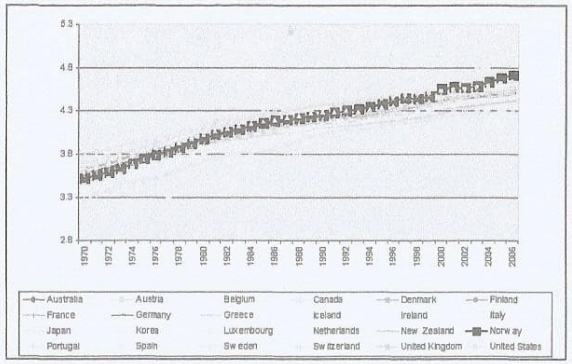
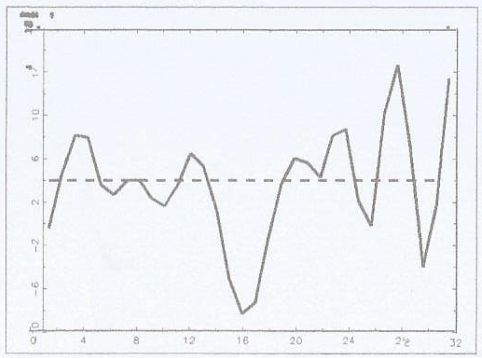


Figure 2: Threshold Country - Norway



After proving that there is a convergence in GDP among high income OECD countries, the convergence between average of high income per capita GDP (using the population as a weight) and upper middle income OECD countries (Mexico and Turkey) has been examined. Table 2 offers the results concerning the study of the convergence process of Mexico and Turkey and the average of the high income countries. The per capita GDP data is displayed as logarithm in Figure 3. These upper middle income countries have narrowed the gap between themselves and the first group during this period. It shows that the linear model results in Table 2 do not support the convergence because p-value for the null of divergence is 0.6590. As a result the test to discriminate between absolute and conditional convergence is not applied for the linear model. It is observed in Table 2 that linear model is superior to the TAR model[**].

Table 2: Linear and TAR Models for Average of High Income and Middle Income Countries

a. Linear Model						
Divergence vs convergence			Absolute vs conditional convergence			
0.6590			-			
b. TAR Model						
Linearity Test		**Transition Country**	**d**	**λ**	**% observations in regime I**	
Unrestricted 0.0400	Restricted 0.0370	Mexico	1	-1.8949	20.5882	
Convergence Tests						
Divergence vs convergence			**Absolute vs conditional convergence**			
Regime I	Regime II	Both	Regime I	Regime II	Both	
0.2330	0.0160	0.6910	-	0.9310	-	
Partial Convergence in regime II			Absolute in regime II			

The transition country is Mexico (estimated d is 1) and the estimated value of the threshold parameter is -1.8949. This implies that regime I which takes place in 20.58% of the sample, during the years when Mexico's growth rate was below the average growth rate of the group by more than 1.89 percentage points. Regime II takes place when the relative growth rate of Mexico was above this level. The results of the convergence tests reveal that divergence cannot be excluded under regime I (p-value of 0.2330), whereas convergence takes place under regime II (p-value of 0.0160). So there is partial convergence under this

[**] p-values of 0.0400 and 0.0370 for the unrestricted and restricted bootstrap respectively.

Figure 3: Average of High Income and Middle Income Countries

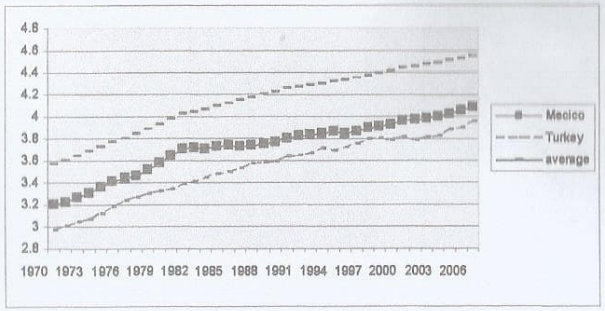
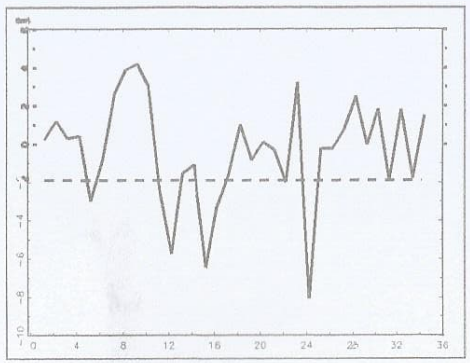


Figure 4: Threshold Country: Mexico



last regime. The periods during which regime II prevail can be easily located in Figure 4. It can be seen in Figure III that the countries grew closer together during these years. On the opposite, regime I completely dominates the decades of the 80s and 90s which coincide with the period when Mexico grew much slower than the other countries and progressively ended up in the worst situation. The per capita in come has started to increase with the positive developments in the economy and the advantages provided by the oil during early 1980s however it still lags when compared to other OECD countries. Mexico's GDP had been close to the average of the high income countries until the 1980s and moved away from then on; it had followed a course close to Turkey's GDP except for the 1979-85 period. Finally, the test of absolute convergence against conditional convergence gives a p-value of 0.9310 under regime II which is favorable to absolute convergence.

4. Conclusion

Economic convergence has been analyzed in high income and upper middle income OECD countries using the panel TAR model with 2 regimes in this study. Logarithm of the per capita GDP of 24 high income countries has been utilized in the 1st group. In addition to high income countries, upper middle income OECD countries have been included in the 2nd group and the convergence among them has been reviewed. Divergence has been accepted in the 1st regime and absolute convergence in regime 2.

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