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Does convergence really matter for the environment? An application based on club convergence and on the ecological footprint concept for the EU countries

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ABSTRACT

The ecological footprint has currently become a highly popular environmental performance indicator. It provides the basis for setting goals, identifying options for action, and tracking progress toward stated goals. This paper investigates the convergence of the per capita ecological footprint by employing the annual data for the case of the European Union countries, spanning the period 1961 to 2013. The methodology follows the club clustering approach and the empirical findings document the presence of certain convergent clubs. These empirical results clarify the differences in terms of environmental quality, as well as the awareness strategies the EU members in each club need to follow.

1. Introduction

Convergence studies have attracted great attention in many areas of the macroeconomic theory, especially since the seminal work of Barro & Sala-i-Martin (1992). There are lot of convergence implications using various empirical methodologies, such as time series, cross-section and panel data. In relevance to these studies, the common ground is convergence regression through an economic growth equation within the context of the neo-classical growth theory developed by Solow (1956). These studies differ across the variables they search running from commodity prices to public expenditures on health, military, educational, to fiscal and monetary variables, foreign trade, tourism and energy consumption (Bukenya and Labys, 2005; Wang, 2009; Claustre and Kehoe, 2010; Apergis et al., 2013; Pjesky, 2013; Mishra and Smyth, 2014; Solarin and Lean, 2014; Su et al., 2014; Apergis, 2015; Ioana-Laura 2015; Hao et al., 2015; Lau et al., 2016; Chen et al., 2016). However, the studies that focus on threats, like global warming and climate change and or environmental convergence, which seriously affect the world have been receiving great attention.

There are primarily three reasons that can explain why countries converge in terms of environmental values. The first one is in relevance to the environmental catch-up hypothesis recommended by Brock and Taylor (2003). According to this hypothesis, it refers to the convergence of environmental quality between the rich and the poor countries at a point in time, which is fundamentally explained through the Environmental Kuznet's Curve (EKC) which highliths that at the initial stage of economic growth, it makes environmental quality worse, and, that, at a later stage of economic growth enhances environmental quality only after per capita income reaches a threshold (Brock and Taylor, 2003). According to the EKC, the countries which reach a spesific income level, reduce their emissions. As long as this is true, rises in income will get emissions per capita closer to each other. This is exactly what a convergence implies with regard to the EKC (Strazicich and List, 2003). Second, such convergence is based on global mitigation efforts in order to stop global warming and climate change under the guidence of Intergovernmental Panel on Climate Chance, IPCC, and international agreements, like that of the Kyoto Protocol (Aldy, 2006). Finally, the initial levels of pollution emissions, emissions intensity, or concentrations, are associated with slower growth in parallel with growth convergence (Stern, 2015). Such potential expectations provided in the relevant literature have led to the investigation of environmental convergence.

The contribution of this manuscript is twofold: First, the current literature is mostly based on per capita carbon dioxide emissions and does not consider any environmental degradation variables. Therefore, the relevant observations should also focus on resource stocks, such as soil stocks, forestry stocks, mining stocks, and oil stocks (Arrow et al., 1995; Stern 2015). Therefore, this study makes use of the ecological footprint concept, developed by Wachernagel & Rees (1996), as a comprehensive environmental degradation variable (i.e. Bartelmus,

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2008; Caviglia-Harris et al., 2009; Kitzes and Wackernagel, 2009; Wiedmann and Barrett, 2010; Ozturk et al., 2016), and (ii) the majority of the relevant literature consider a unit root approach or growth regressions to reach the conclusion on whether convergence is verified for their samples. However, pollution or the environmental degradation has spillover effects across regions or countries. Furthermore, certain countries have similar dynamics and conditions with regard to the drivers of environmental quality. Thus, convergence may be verified across countries with similar conditions, such as the growth process, the dependence on environmental resources, changes in the composition of energy production between renewables and nonrenewables, and changes in the composition of energy consumption. To this end, the study uses the club convergence approach developed by Phillips and Sul (2007), which considers that certain countries, states, sectors, or regions that belong to a club move from disequilibrium positions to their club-specific steady-state positions. The remaining of the manuscript is organised as follows. Convergence issues and their impact on the environment are explained in Section 2, while a brief literature review on environmental convergence is discussed in Section 3. Section 4 describes the data set, as well as the empirical methodology used, while estimation results are reported in Section 5. Finally, Section 6 concludes.

2. Convergence issues

The discussion on convergence has been initiated with that on the neo-classical growth theory developed by Solow (1956). One of the most critical assumptions of the Solow growth model is the presence of diminishing returns, implying that the marginal product of capital is large when the capital stock is small and that it is small when the capital stock is large by considering the Inada (1963) $lim_{k\to 0}f'(k) = \infty$conditions, symbolised by $lim_{k\to\infty}f'(k) = 0$ and $lim_{k\to\infty}f'(k) = \infty$. This critical assumption leads to test convergence within an economy or across economies by modelling a negative correlation between initial income levels and subsequent growth rates. This negative correlation has been tested by growth-initial level regressions, i.e. the β-convergence approach. The presence of this negative coefficient states that countries with less capital stocks tend to grow faster than those with more capital given that the presence of diminishing returns to capital come into play as the economy grows (Barro and Sala-i-Martin, 1992). Considering that the Solow model is based on a Cobb-Douglass production function, including capital, labor and total factor productivity, economic growth turns out to be a function of the initial levels of the capital stock, labur and total factor productivity, as well as the saving rate, the growth rate of population and the growth rate of technology. One may emprically document that poor countries are expected to catch up the rich countries in the long run when each component of this growth (accounting) function shares the same characteristics across all countries (Baumol, 1986). However, these growth components are not the same across all countries in the real world. Hence, convergence is potential across countries with the same conditions in terms of factors which affect economic growth (Kormendi and Meguire, 1985; De Long, 1988; Grier and Tullock, 1989). Moreover, due to the presence of increasing returns as supported by the endogeneous growth theories, the income gap between poor and rich countries may widen (Romer, 1986). These arguments necessiate that the initial conditions and basic dynamics of economic growth should be regarded for the process of country selection in the convergence analysis (Durlauf and Johnson, 1995; Galor, 1996). This approach is the so called conditional convergence, with each individual economy possessing a particular steady state equilibrium which attempts to approach. Similarly, if economies are grouped by common characteristics (Durlauf and Johnson, 1995), each group is expected to illustrate the same steady state equilibrium, which also attempts to approach. According to the sigma σ-convergence, introduced by (Quah, 1993; Friedman, 1992), the series under investigation have a decreasing behavior in the cross-sectional variation. In other words, it focuses on the dispersion of the cross-sectional growth distribution (Islam, 2003).

A great number of papers have used various unit root tests to provide evidence on convergence. Brock & Taylor (2010) transformed the Solow (1956) model into an environmental growth model by amending it with carbon emissions and showed the presence of convergence in the frame of growth equations. Their study has an important place within the environmental convergence literature. In their study, the motion equation of emissions is defined as: $E = \Omega F - \Omega A(F, F^A)$, where it is asssumed that every economic activity, F, produces Ω unit of pollution, while the pollution abatement, ΩA, is a strictly concave function of total economic activity, F, and the economy's efforts at abatement, F^A. The above equation is rearranged with a common factor, ΩF, and rewritten as: $E = \Omega F[1 - A(1, F^A/F)]$. When θ is used instead of F^A/F and combined with the Solow model, the output equation yields: $Y = [1\text{-}\theta]F$. Then, the Solow model is transformed into a 'green' Solow model as follows:

$$y = f(k)[1 - \theta] \quad (1)$$

$$\dot{k} = sf(k)[1 - \theta] - (n + g + \delta)k \quad (2)$$

Next, they use Eq. (3) to define the growth of emissions per capita as a negative function of the technological progress in abatement (Ω) and a positive function of growth in per capita income in order to derivate the emissions convergence equation:

$$e^c(t) = \Omega(t)a(\theta)y^c(t) \quad (3)$$

In the following step, three applications are applied to transform the emissions per capita equation into a convergence equation. First, both the emissions per capita, e_t^c and the growth rate of income per capita, y_t^c are determined over a discrete time period of size N by their average log changes. In that sense, Eq. (3) turns to be:

$$[1/N]\log(e_t^c/e_{t-N}^c) = -g_A + [1/N]log(y_t^c/y_{t-N}^c) \quad (4)$$

where g_A is the growth rate of technological progress in abatement.

In the following application, the discrete N period growth rate of income per capita near the model's steady state is determined (Mankiw et al., 1992; Barro, 1991) in order to eliminate income growth:

$$[1/N]\log[y_t^c/y_{t-N}^c] = b - \frac{[1 - \exp[-\lambda N]]}{N}\log[y_{t-N}^c] \quad (5)$$

where b is a constant term and λ is the speed of convergence in the Solow growth model. The speed of convergence is determined as: $\lambda = [1 - a][n + g + \delta]$, where a is the output elasticity of capital, n is the growth rate of labor, g is the growth rate of technology, and δ denotes the depreciation rate.

Next, income growth in Eq. (4) is replaced by Eq. (5) through considering: $y_{t-N}^c = e_{t-N}^c/\Omega_{t-N}a(\theta)$ from Eq. (3) and a convergence equation of emissions per capita is generated across i countries to a constant, β_0, while the initial period of emissions per capita in the panel regression form with an error term μ_{it}yields:

$$[1/N]log[e_{it}^c/e_{it-N}^c] = \beta_0 + \beta_1 log[e_{it-N}^c] + \mu_{it} \quad (6)$$

3. Literature review

The research on environmental convergence has been a widespread subject of many empirical studies that have followed different methodologies used in the relevant literature. Certain estimation methodologies range from time series analyses to panel data or cross section analyses, as well as different notations of convergence have been also analysed. The results support different conclusions on whether emissions emitted by countries converge or not. The findings seem to be in favor of convergence, implying that emissions are expected to reach the same size across countries. A number of novel studies focusing on the convergence issue are shown in Table 1, which briefly summurizes