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Cross-country output convergence and growth: Evidence from varying coefficient nonparametric method

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ABSTRACT

This article uses a nonparametric varying coefficient panel data model to study the convergence of real GDP per capita among 120 world economies for the sample period of 1980–2010. The estimates show that the indirect contribution of initial income via the control variables is important. The mediating effect of control variables to affect growth is positive. The conditional speed of convergence is larger than the absolute counterpart at all levels of initial income. The convergence hypothesis does not hold for economies with extremely low level of development. The conclusion is robust for regional subsamples of Europe, Asia, Latin America and Africa.

1. Introduction

The world economy since the turn of the 21st century has been troubled by financial crises among the developed countries and terrorist attacks originated from the unstable 'fragile' states (Fund for Peace, 2015). These events have led to a reiteration in the discussion and debate on growth and convergence among world economies. Having noted the multifaceted nature of convergence, Spence (2011) for example, argued that economies are moving in a "multispeed" world. Income convergence which simply argues that low income countries will catch up with the richer countries has given rise to numerous theoretical and empirical studies (Islam, 2003).

In the literatures on income convergence, the two prominent areas concerned the definition and process through which convergence can be achieved. In the definition of income convergence, Bernard and Durlauf (1995) defined convergence within a group of countries that show "identical long-run trends", while Sala-i-Martin (1994) and Quah (1996a, 1996b) considered the importance of cross-sectional distribution of economies. Sala-i-Martin (1996a, 1996b) considered the relevance of speed, absolute and conditional features of convergence. Chatterji (1992), Quah (1997) and Fischer and Stirböck (2006) employed "club-convergence" that concentrated on regional income growth.

With reference to the process of income convergence, there are studies that relate convergence to endogenous growth, while others considered the relevance of technological adaptation, carbon dioxide emissions, legal aspects, use of neoclassical growth models with steady-state characteristics and wage distribution hypothesis (Tamura, 1991; Zind, 1991; Barro and Sala-i-Martin, 1992; Kocherlakota and Yi, 1995; Caselli et al., 1996; Durlauf, 1996; Maasoumi et al., 2007; Hashemi, 2013; Chen et al., 2014; Yang et al., 2016). There are also studies based either on a region prospective or a particular country (Cárdenas and Pontón, 1995; Quah, 1996c; Dobson and Ramlogan, 2002; King and Ramlogan-Dobson, 2015).

The empirical literature using parametric regression analysis has concentrated on convergence of per capita income growth when structural differences across economies are considered. Parametric regression analyses show that a negative estimate of the initial income coefficient is interpreted as evidence of convergence. The methodology used included construction of stochastic, dynamic panel and Bayesian spatial models and autoregressive dynamic structures. Other studies have conducted panel unit root test on the convergence hypothesis, and used the system-generalized method of moments for the dynamic panel data model to show that earlier results might be seriously biased due to weakness of the instruments in the first-differenced generalized method of moments approach (Baumol, 1986; Mankiw et al., 1992; Levin and Lin, 1993; Quah, 1994; Islam, 1995; Evans and Karras, 1996; Im et al., 2003; Bond et al., 2001; Evans and Kim, 2005; Ho, 2006; Ucar and Guler, 2010; Seya et al., 2012).

A key assumption in parametric models is that cross-country growth is linear with identical rate of convergence and the test of convergence is based on the parametric estimate of the income coefficient. However, new growth theories have shown that cross-country growth can be non-linear and is characterized by multiple steady states. As such, the implied rates of convergence could differ between different groups of economies (Azariadis and Drazen, 1990; Durlauf and John, 1995). Consequently, nonparametric approaches that pre-specify neither the income distribution form nor the functional form of the regression

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function have been applied to the study of convergence (Bianchi, 1997; Wang, 2004; Juessen, 2009). However, these nonparametric analyses have concentrated on absolute convergence and excluded other steady state growth determinants.

To control for structural differences across countries in the steady state, recent empirical research used semiparametric methods to test the conditional convergence hypothesis and estimated the implied rate of convergence as a function of the initial income. Kumer and Ullah (2000) developed a local linear instrumental variable method with a kernel weight function, and applied the smooth varying coefficient function to estimate the per capita output convergence of a panel of countries. Both Dobson et al. (2003) and Azomahou et al. (2011) presented semiparametric analysis on the cross-country convergence and provided evidence for nonlinear convergence.

The strength of nonparametric estimation approaches stems from their ability to relax functional form assumptions in regression model and let the data to determine the convergence process. The nonlinearity and heterogeneity in structural economies can be accounted for even though there is little prior knowledge on a particular convergence process. Nonparametric models can be more flexible than parametric models in describing the nonlinearity in the convergence process and the multiple steady states in the economy (Henderson et al., 2008; Chambers and Dhongde, 2011).

In light of the nonlinearity in the convergence process and the heterogeneity of cross-country structural economies, this article proposes the use of nonparametric panel data models to study and compare the two cases of absolute convergence and conditional convergence. By using an unbalanced panel data set of 120 world economies over the period 1980–2010, this article examines whether differences in macroeconomic and institutional factors, endowments, and other country characteristics have played a role in per capita income growth and convergence among world economies. Panel data analysis on income convergence can incorporate heterogeneity across economies. The fixed and random effects are specified in the growth model for unobservable heterogeneity in the economies. There is no agreement as to which kind of effects is more suitable to use.[1] However, in order to obtain consistent estimates for the nonparametric function of the lagged output and the speed of convergence, no matter whether the individual effect is random or fixed, fixed effects specification are applied in the nonparametric and semiparametric models (Henderson et al., 2008).

Section 2 presents the theory on growth and convergence and specifies the varying coefficient model to estimate the convergence speed. Section 3 describes the data and variables. Section 4 presents the estimation of the varying coefficient nonparametric models and the model specification test with unbalanced panel data. Section 5 reports the empirical results and analysis, while Section 6 shows the results based on regional performances. Section 7 concludes the paper.

2. Speed of convergence and nonparametric estimation

By employing the neoclassical growth model as in Rassekh (1998), the assumption of diminishing returns implies that the economy will eventually reach the steady state values of output per capita. Using the output specification in Mankiw et al. (1992) and Islam (1995), we specify:

$$Y_{it} = K_{it}^{\alpha_1} H_{it}^{\alpha_2} (A_{it}L_{it})^{1-\alpha_1-\alpha_2} \tag{1}$$

where Y denotes output, K and H depict physical and human capital, respectively, A represents technology, and L denotes labor, we can derive that the steady state value of $y_{it} = Y_{it}/(A_{it}L_{it})$, the output in effective units of labor, is:

$$y^* = \left[\left(\frac{s_K}{x+n+\delta_K}\right)^{\alpha_1}\left(\frac{s_H}{x+n+\delta_H}\right)^{\alpha_2}\right]^{1/(1-\alpha_1-\alpha_2)}$$

or

$$\ln(y^*) = \frac{1}{1-\alpha_1-\alpha_2}[\alpha_1 \ln s_K + \alpha_2 \ln s_H - \alpha_1 \ln(x+n+\delta_K) - \alpha_2 \ln(x+n+\delta_H)], \tag{2}$$

where s_K and s_H are the fractions of output invested in K and H, x and n are the exogenous constant growth rates of A and L, and δ_K and δ_H are the depreciation rates of K and H, respectively. If all the parameters in (2) are identical across economies, the steady state output per capita in different economies converges to the same value. However, before reaching the steady state, the economies necessarily grow at different rates. The essence of the convergence in the neoclassical model is that the farther the actual values of y_{it} are from y^* the faster the economies with the same initial output y_{i0} will grow. The speed of convergence λ is defined by:

$$e^{-\lambda\tau} = \frac{\ln(y_{i,t_2}) - \ln(y^*)}{\ln(y_{i,t_1}) - \ln(y^*)}, \tag{3}$$

where $\tau = t_2 - t_1$. To estimate the speed in empirical study, we usually set $t_2 = t$ and $\tau = 1$ or some other fixed integer, and transform (3) to its stochastic version:

$$\ln(y_{it}) - \ln(y_{i,t-\tau}) = \beta \ln(y_{i,t-\tau}) - \beta \ln(y^*) + u_i + v_{it}, \tag{4}$$

where $\beta = -(1-e^{-\lambda\tau})$, u_i is the individual effect allowed to be correlated with $\ln(y_{i,t-\tau})$, and v_{it} is an error term with a zero mean and a finite variance. One can derive from (2) and (4) and obtain:

$$\ln(y_{it}) - \ln(y_{i,t-\tau}) = \beta \ln(y_{i,t-\tau}) + \gamma_1 \ln x_{1,it} + \gamma_2 \ln x_{2,it} + \gamma_3 \ln x_{3,it} + \gamma_4 \ln x_{4,it} + u_i + v_{it}, \tag{5}$$

where

$$\gamma_1 = -\frac{\alpha_1\beta}{1-\alpha_1-\alpha_2}, \quad \gamma_2 = -\frac{\alpha_2\beta}{1-\alpha_1-\alpha_2}, \gamma_3 = \frac{\alpha_1\beta}{1-\alpha_1-\alpha_2}, \gamma_4 = \frac{\alpha_2\beta}{1-\alpha_1-\alpha_2},$$

and

$$x_{1,it} = \ln s_K, \quad x_{2,it} = \ln s_H, \quad x_{3,it} = \ln(x+n+\delta_K), \quad x_{4,it} = \ln(x+n+\delta_H). \tag{6}$$

We distinguish between the case of absolute or unconditional convergence and the case of conditional convergence. In absolute or unconditional convergence, all economies share the same steady state; namely, all variables in (6) are constant and whether economies converge or not will depend only on their initial income level. In conditional convergence, on the contrary, the steady state is conditional on the variables in (6); namely whether economies converge or not will depend on both their initial income level and the control variables in (6).

The negative value of β in (5) shows that the economies with lower initial income will grow faster as implied in the meaning of convergence. If the convergence speed (hence β) is assumed to be a constant, then Eq. (5) is a linear parametric model with parameters $\beta, \gamma_1, \gamma_2, \gamma_3$ and γ_4. Once the coefficient β is estimated (denoted as $\hat{\beta}$), the speed of convergence λ is calculated as:

$$\hat{\lambda} = -\ln\left(1+\hat{\beta}\right). \tag{7}$$

[1] When the individual effect is independent of the regressors, the estimation of both the random effects model and the fixed effects model is consistent with each other, except that the random effects estimator is more efficient. However, when the individual effect is correlated with any of the regressors, the random effects estimator is biased and inconsistent whereas the fixed effects estimator still leads to consistent estimates and is appropriate for the estimation of regression functions.