Extended Essay: *Convergence across the U.S.*

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Name: Mikayel Tovmasyan

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Table of Contents

Introduction

A large part of the world's population lives under poverty level. Are there any prospects for them to ever come out of the dearth pit they are in now? The neoclassical growth theory gives hope in the following sense: Poor regions within a country tend to converge toward rich ones under the assumption of diminishing returns to capital. The first problem that arises when testing a hypothesis of this sort is the issue of time horizons. The systematic collection of data in the developing economics started only recently, and it is hard to find examples of reliable data that stretch back a half a century or more (Ray, 1998).

The empirical evidence which I provide in this paper confirms the prediction of the neoclassical theory in the context of the U.S. states (poor states and rich states), i.e. the U.S. states converge (absolute convergence) in terms of per capita income.

I use data from the BEA's regional accounts to analyze the convergence in per capita income among the U.S. states, controlling for regional patterns in convergence. The OLS estimates show that there is a β-convergence among the U.S. states/regions with the rate of 0.24%-0.7% / 1%.

Literature Review

The topic of convergence is the pinnacle of the subject of economic growth. It is important and attractive for researchers for several reasons. Mainly, the existence (or absence) of convergence gives the hope and bright prospects (or search for alternative solutions and policies) for poor countries and regions in the face of modern globalization.

The empirical evidence on the issue of income convergence is mixed, depending upon model characteristics, underlying assumptions, and the nature of data (e.g. cross section or time series). Studies using cross-section data generally provide evidence in support of the convergence hypothesis across nations (see, Baumol 1986, Dowrick and Nguyen 1989, Barro and Sala-i-Martin 1991, 1992, 1995, Mankiw, Romer and Weil 1992, Cashin, et al. 1996, Hossain 2006). On the other hand, studies based on time series data, usually do not support convergence (Bernard and Durlauf 1995, Quah 1992, Alvi and Rahman 2005).

One of the papers, along with some others I will review, is Barro and Sala-i-Martin (1991). The authors examine whether poor regions tend to converge toward rich ones. The overall evidence in the paper weights heavily in favor of convergence: both for sectors and for state aggregates. By examining the U.S. states per capita personal income for the period 1880-1988, the authors conclude that per capita income and product in poor states tend to grow faster than in rich states, but the gap between poor and rich states shrinks just at a rate of 2 percent per year. The same findings hold for the 73 regions of Western Europe.

The study improves upon the previous research by applying the convergence hypothesis to the U.S. states. The empirical evidence of convergence generated in previous research has been mixed, at best. For example, Pritchett (1997) finds that the growth rates of developing countries have been, on average, slower than those of the richer countries, producing divergence in relative incomes.

Barro and Sala-i-Martin base their main analysis on a growth equation that derives, as a log-linear approximation, from the transition path of the neoclassical growth model for closed economies. Later in the paper the authors consider how the model would be affected by open economy elements that are particularly important for the U.S. states. The authors use two concepts of convergence β-convergence (catching up in terms of per capita income) and σ-convergence (in terms of dispersion of real per capita GDP or GSP levels).

The empirical evidence the authors provide is that the speed of convergence among the U.S. states is about 2 percent a year which was derived by running a regression of average annual growth rates (1880-1988) on the log of 1880 per capita personal income. The results also indicate that within- and between-region rates of convergence are similar. The empirical results of net migration of persons among the U.S. states in the context of convergence are showing positive relationship between average annual migration rates (1900-1987) and log of 1900 per capita personal income. The results on convergence for Gross State Product are similar to those for personal income. The results for 73 regions of seven European countries (in terms of estimated rates of β-convergence) are similar to those of found for the United States; in particular, there is no evidence that poor regions are being systematically left behind in the growth process.

Barro and Sala-i-Martin (1991) base their empirical analysis on the neoclassical growth model. As Evans and Karras (1996) mention in their paper, the assumptions in their empirical methodology Barro and Sala-i-Martin (1991) make are very restrictive; namely, the dynamic structures of economies have identical first-order autoregressive representations; every economy affects every other economy completely symmetrically; and the vector variables control for all permanent cross-economy differences.

There have also been other research studies on the topic of convergence across regions. Lee (1996) finds that the convergence exists among Canadian provinces (in terms of dispersion of productivity) for the period of 1966-1992. The empirical approach used in this paper is similar to Barro and Sala-i-Martin (1991). Lee (1996) finds that the dispersion of productivity (measured by the unweighted cross-sectional standard deviation of the logarithm of output per worker) declines rather steadily over the years (1966-1992). Evans and Karras (1996) conclude that there is strong evidence that the contiguous U.S. states approach rapidly to per capita income levels that are disparate. In another paper, Bernat (2001) provides new evidence on convergence in per capita incomes which has been interpreted as supporting the neoclassical explanation of economic growth. Bernat (2001) finds that the convergence in state per capita income in 1950-99 occurred almost entirely during the first 29 years; since1979, there has been essentially no convergence.

The Hossain and Rahman (2007) paper presents a special interest since it examines the presence of a convergence for Bangladesh, a developing country. This paper tests the existence of per capita income convergence across six divisions of Bangladesh using annual data during 1977-2000. The simple OLS as well as sophisticated unit-root and co-integration approaches have been applied to test the convergence hypothesis. The findings do not provide enough evidence in favor of the convergence hypothesis. However the paper finds that the presence of cointegration between various economic factors and the leading regions suggests the presence of long-run equilibrium relationship among them. The paper concludes that the current strategy of pro-poor growth seems to be an appropriate way of expediting per capita income convergence across regions in Bangladesh.

Overall, the research results on the topic of convergence are mixed, but the presence of convergence is not far stretching idea that can be established empirically.

Theoretical Model

The convergence hypothesis implies that living standards across economic regions should move together over time. The neoclassical growth model implies that regions should converge over time. In its basic form, this model assumes an economy's output is determined by three inputs: capital, labor and technology. The model assumes diminishing returns to capital, exogenous technological process, full employment, a fixed relation between labor force and population, exogenous growth of population, endogenous savings rate (derived from the choices made by utility-maximizing households over an infinite horizon), open economy, perfect capital and labor mobility.

A production function of the following form is usually used to represent a typical neoclassical growth model:

$$Y_t = A_t F(K_{t,} L_t) \tag{1}$$

where,

Y_t = output at time t,

A_t = technology at time t,

K_t = level of physical capital at time t, and

L_t = level of labor at time t.

The neoclassical theorists assume the following properties for the above production function.

1. F(•) is concave in K and L that implies a positive and diminishing marginal productivity of each input.

$F_k(\bullet) > 0$ and $F_{kk}(\bullet) < 0$ for all K>0 and L>0;

$F_L(\bullet) > 0$ and $F_{LL}(\bullet) < 0$ for all K>0 and L>0.

2. F(•) exhibits constant returns to scale.

$F(\delta K_{t,}\ \delta L_t) = \delta.F(K_{t,}\ L_t)$ for all δ>0.

3. F(•) satisfies *Inada Conditions*:

$\text{Lim}_{k\rightarrow 0}\,(F_k) \Rightarrow \text{Lim}_{L\rightarrow 0}\,(F_L) \Rightarrow \propto$

$\text{Lim}_{k\rightarrow \propto}\,(F_k) \Rightarrow \text{Lim}_{L\rightarrow \propto}\,(F_L) \Rightarrow 0$

The key assumption of the production function is that capital is subject to diminishing returns (1. above). Diminishing returns contributes to convergence because each additional unit of capital raises output less in capital-abundant economies than in capital-scarce economies, so output per worker will rise (capital-to-labor ration rises) more in capital scarce economies (also the rate of investment will be higher here) than in capital-abundant economies.

The convergence coefficient depends on the productivity of capital and the willingness to save. So, the source of convergence is the assumed diminishing returns to capital. If the ratio of capital and, therefore the output, to effective labor declines relative to steady state ratio, then the marginal product of capital rises. Therefore, for a given saving behavior, an economy grows faster the further it is below the steady state. If production functions are different, the convergence coefficient is higher if diminishing returns to capital set in faster. Thus, the convergence is predicted in this setup of the neoclassical growth model.

The convergence hypothesis of the neoclassical model stipulates that in the long run all economies will converge to their path of steady state growth conditioned by savings and population. So, the prediction of this hypothesis is that other things being equal, the lagging poor economies would tend to grow faster than the rich economies and hence catch up in the long run.

Empirical Analysis

Data and Methodology

This paper replicates the main regression results found in Barro and Sala-i-Martin (1991) by using a different sample (1969-2005) as opposed to 1880-1988. This way I check the robustness of Barro and Sala-i-Martin (1991) results to the newer data sample. The data start from 1969 as BEA provides it starting from that year. I chose the end year of data to be 2005 in order to insulate against the effects of recent recession on the regression results as the actual recession starts before the official recession start date (as defined by NBER).

I use the U.S. states annual/quarterly inflation-adjusted per capita income for 1969-2005 from the Bureau of Economic Analysis (BEA) Regional Economic Accounts to analyze the convergence in per capita income among the U.S. states. The data are annual U.S. states per capita income. I adjust per capita income amounts for the states using implicit price deflator[1] for GDP in 2000 U.S. dollars.

I use the concept of β-convergence to estimate the income convergence among the U.S. states. The concept of β-convergence is related to studies with cross section samples. A group of regions/countries is said to be consistent with β-convergence if there exists a negative relationship between per capita income and subsequent growth rate in per capita income over the next several years (Hossain, Rahman (2007)).

I use Ordinary Least Squares (OLS) method to estimate the following equation :

$$\hat{Y}_{i,t} = \alpha + \beta Y_{i,0} + \varepsilon_{i,t} \qquad (2)$$

where,

$\hat{Y}_{i,t}$ = Average per capita income growth rate of i-th economy over period 0-t, and

$Y_{i,0}$ = Initial per capita income in i-th economy.

Any negative value of β in the above regression equation confirms the presence of income convergence across the regions under consideration.

Among some limitations there is the issue of measurement error. The existence of temporary measurement error in income tends to introduce an upward bias in the estimate of β; that is the elimination of measurement error over time can generate the appearance of convergence. One reason for measurement error is that each state's nominal income is deflated by a national price index, because accurate indexes do not exist at the state level (Barro, R. J., Sala-I-Martin, X., 2004, p.472).

[1] Implicit price deflator is broader measure that does not suffer from biases associated with CPI

Testing the convergence hypothesis across regions rather than across countries/nations is more appropriate because there are smaller differences in technology, tastes, culture, and institutions across regions within a country than across nations.

Empirical Results

Table 1. Regression for Personal Income across the U.S. States, 1969-2005

	Basic equation (Figure 1.)		Equation with regions (Figure 2.)	
Period	$\hat{\beta}$	R^2 [$\hat{\sigma}$]	$\hat{\beta}$	R^2 [$\hat{\sigma}$]
1969-2005	0.006945 (0.0025)	0.17	0.009839 (0.0046)	0.37

Source: Author's own calculations using Bureau of Economic Analysis data (2007)

The regression uses ordinary linear least squares (OLS) to estimate the equation of the form:

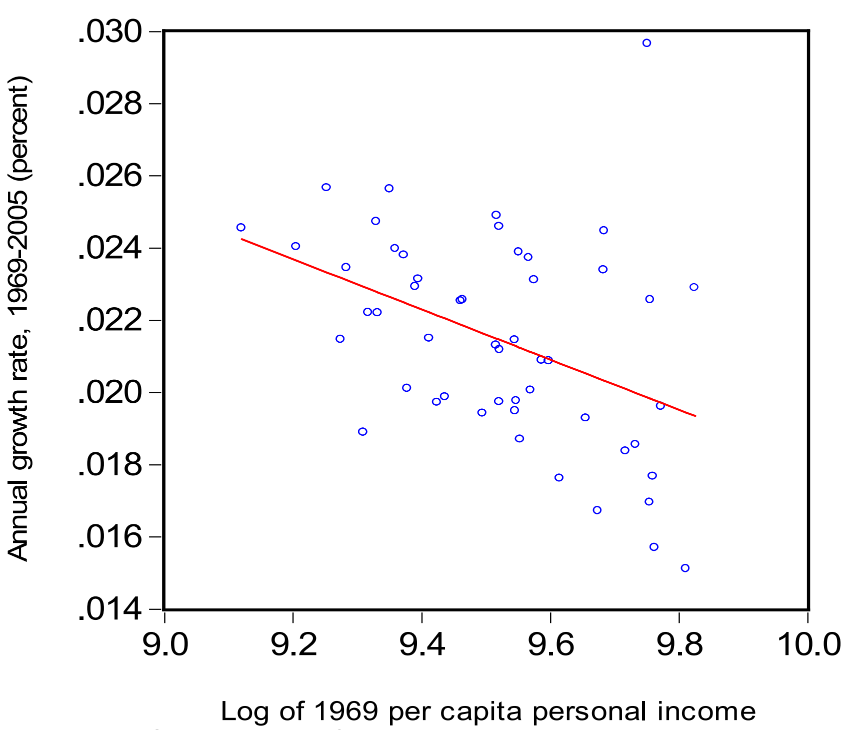
$$(1/T)*\log(y_{i,2005}/y_{i,1969}) = \alpha - \beta*\log(y_{i,1969}) \quad (1),$$

where $y_{i,1969}$ is the per capita personal income in state i at the beginning of the sample (1969); $y_{i,2005}$ is the per capita personal income in state i at the end of the sample (2005); $(1/T)*\log(y_{i,2005}/y_{i,1969})$ is the annual growth rate of per capita income in state i for the period of 1969-2005 where T is the number of years (2005-1969).

The OLS regressions are done with robust standard errors leading to White's heteroskedastic-consistent estimate of variance-covariance matrix of the OLS estimator, as the results of Breusch-Pagan /Cook-Weisberg test for heteroskedasticity show that heteroskedasticity appears to be present at 5% significance level (as Prob. > $\chi^2 = 0.0008 < 0.05$). Figure 4 corrects for heteroskedasticity.

Table 1. shows regression estimates of the convergence coefficient β from regression equation (1) for the period of the U.S. sample from 1969 to 2005. The coefficient β in regression equation (1) is defined with negative sign, so a positive $\hat{\beta}$ means that poor states/regions grow faster than rich ones, i.e. a convergence exists. The column represents the regression equation (1) results with fifty U.S. states and District of Columbia. $\hat{\beta} = 0.006945$ (about 0.7 %) is statistically significant at 1% (standard errors are in parenthesis), which suggests that there is a slow convergence among the U.S. states though there is a small goodness of fit ($R^2 = 0.17$).

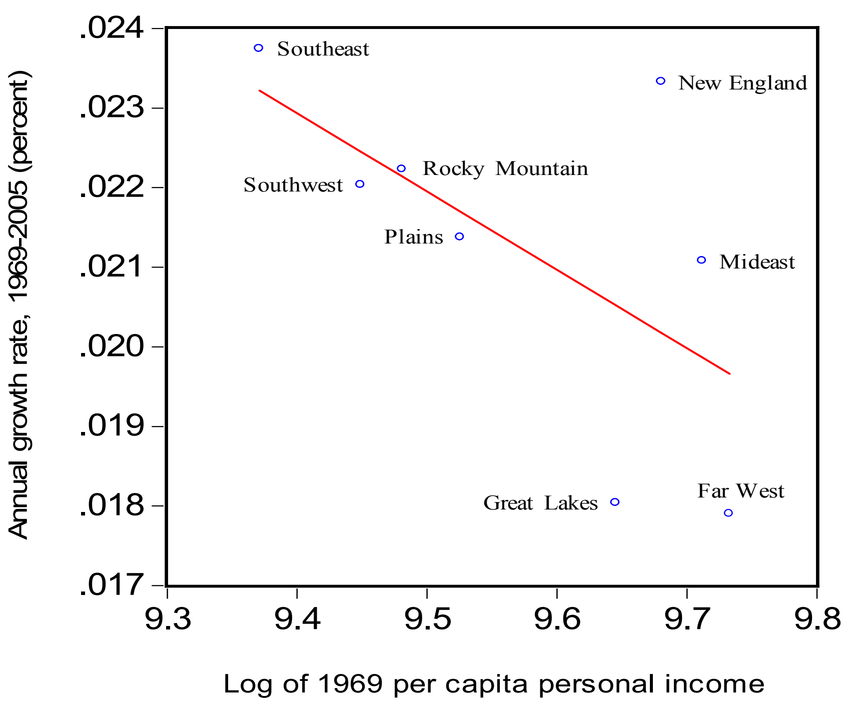
Figure 1. Convergence of Personal Income across the U.S. States: 1969 Income and Income Growth from 1969 to 2005



Source: Bureau of Economic Analysis (2010)

Figure 1. shows β-convergence for per capita personal income for the 50 U.S. states from 1969 to 2005. Figure 1. shows negative correlation (-0.42) of medium magnitude between the average growth rate from 1969 to 2005 and the log of per capita personal income in 1969.

Figure 2. Convergence of Personal Income across the U.S. Regions: 1969 Income and Income Growth from 1969 to 2005

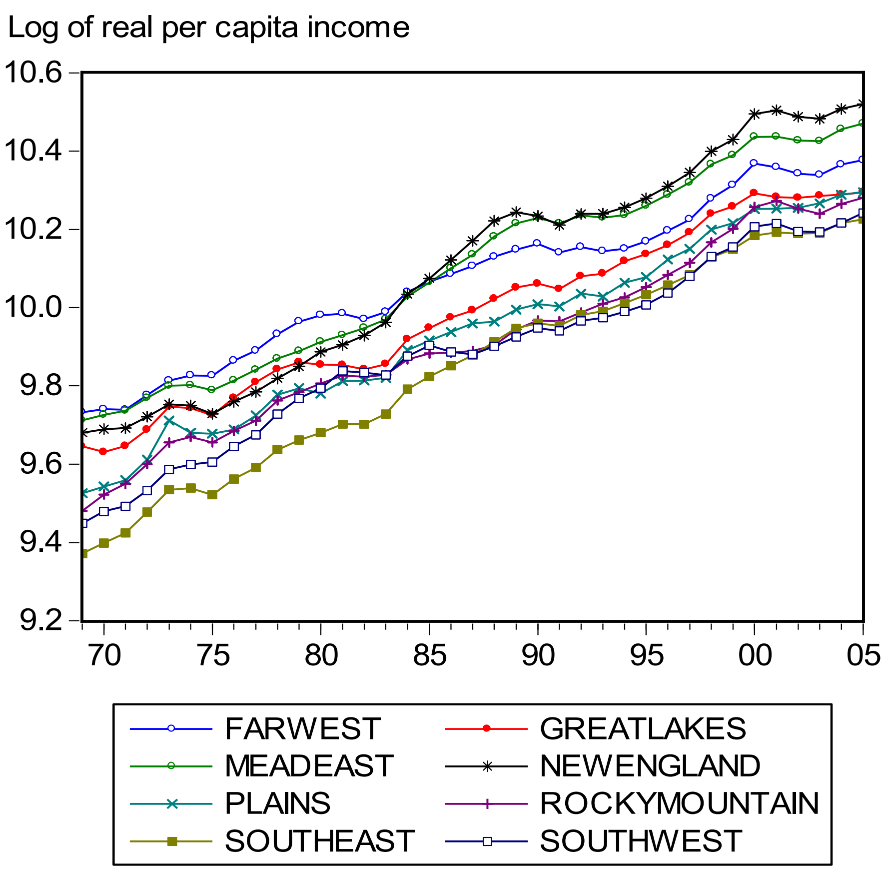


Source: Bureau of Economic Analysis (2010)
The eight data points correspond to the regional means.

Figure 2 shows the southern states, with the lowest per capita personal income in 1969, have some of the highest growth rates among the eight U.S. regions. On the other side, Great

Lakes, Far West and Mideast, which had one of the highest per capita personal incomes in 1969, have relatively low growth rates. New England is an exception with high initial per capita income and high growth rate.

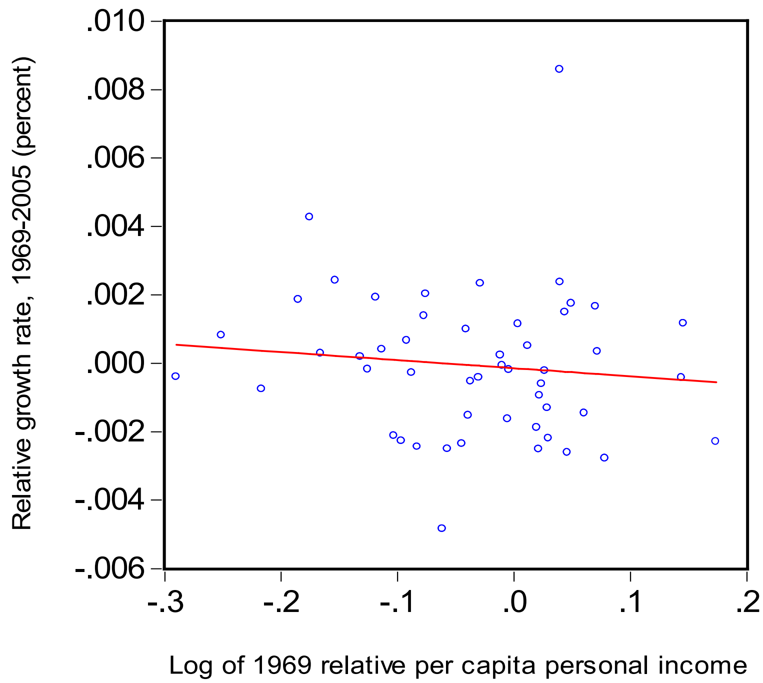
Figure 3. Personal Income of the U.S. Regions, 1969-2005



Source: Bureau of Economic Analysis (2010)

Figure 3. shows the underlying data on average per capita income for the eight regions. This figure shows that the gaps in average incomes across regions have decreased over time but very little.

Figure 4. Convergence of Personal Income, the U.S. States Relative to Regional Means: 1969 Income and Income Growth from 1969 to 2005



Source: Author'sown calculationsbased on BEA 2010 data.

Figure 4. shows the same results with data corrected for heteroskedasticity. It shows more clear the patterns of convergence between states after stripping away the regional patterns of convergence. The $\hat{\beta}$ coefficient is less in this regression, about 0.24% versus 0.7% in the case of total effect (without subtracting the magnitude of regional patterns of convergence).

The strength of β-convergence within and between regions seems to be similar. These empirical results of the β-convergence are consistent with the underlying neoclassical model, which predicts the fact of the convergence.

Conclusion

This paper finds that the U.S. states converge in terms of per capita income at a rate of 0.24% - 0.7% / 1%. These findings compared to those of Barro and Sala-i-Martin (1991) have weaker strength of convergence, but considering the sample difference (I use 1969-2005 vs. 1880-1988), and the fact that much of the convergence already happened before 70s, are part of the same picture, i.e. convergence is real, ongoing economic phenomena, not only outside the U.S. (as the papers discussed in the literature review section suggest) but also within the U.S., between states and regions.

The convergence between states is getting weaker and weaker as states get closer in terms of per capita income, but it is an economic phenomenon that should be taken into account in economic policymaking especially in taxation (particularly in federal streamlined sales tax project). A possible extension for further analysis can be a search for σ -convergence between the U.S. states, a time series analysis using unit-root and cointegration methods which can shed more light on the general fact of convergence.

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