CONVERGENCE OF INCOME ACROSS PENNSYLVANIA COUNTIES

David A. Latzko
Pennsylvania State University, York Campus

The neoclassical growth model predicts convergence. The idea of convergence can be understood in two different ways. The first is in terms of the level of per capita income or per capita output, absolute convergence. Poor regions will grow faster than rich regions so that output per capita across all regions will eventually be the same, even though some may start out way behind. The second is convergence to the steady-state level of income, conditional convergence. Per capita income in a given region converges to the steady-state value determined by that region's characteristics. Regions need not all reach the same level of per capita output.

There is little empirical support for absolute convergence among heterogeneous economies [Romer, 1994]. However, both Dowrick and Nguyen [1989] and Mankiw, Romer, and Weil [1992] find that there has been a significant tendency towards absolute convergence of per capita income among a cross-section of OECD countries, and Barro and Sala-í-Martin [1992; 1995] find evidence of absolute convergence across U.S. states and across Japanese prefectures. Austin and Schmidt [1998] find that per capita income growth of the counties of the Great Plains states is negatively related to initial year income, while Barro [1991] and Mankiw, Romer, and Weil [1992] find evidence of conditional convergence among a cross-section of national economies.

The purpose of this paper is to examine whether output has converged in accordance with the prediction of the neoclassical growth model across a set of even smaller economic units, the 67 counties of the state of Pennsylvania. I find no evidence of absolute convergence. In fact, the gap between the very richest and very poorest counties is widening. This divergence is due to changes in relative county wages. The counties with the lowest incomes per worker have unfavorable wage structures relative to the highest-income county and low wages account for an increasing proportion of low-income counties' income differential. I do find evidence of conditional convergence at a rate of 2 percent a year. The typical Pennsylvania county covers half of the distance between its current and steady-state income levels in 35 years.

TESTING FOR ABSOLUTE CONVERGENCE

A set of counties exhibits absolute convergence if, for all pairs i,j in the set, and at all times t,

$$(1) \qquad \lim_{r\to\infty} \mathrm{E}_t\,(y_{it+r} - y_{jt+r}) = 0,$$

David A. Latzko: Pennsylvania State University at York, 1031 Edgecomb Avenue, York, PA 17403. E-mail: dlatzko@psu.edu.

where y_{it} and y_{jt} are the logarithms of income in countries i and j respectively. I test for absolute convergence of per capita income across the 67 Pennsylvania counties over the period 1969 to 1999. The appropriate income measure, a county-level version of gross domestic product, is not available. Personal income data is available on a county basis, but is not a good measure of county-level economic activity because it includes both unearned income and income earned outside the county. The personal income accounts reported by the Commerce Department's Bureau of Economic Analysis assign income to the county in which the owner of the inputs resides, not to the county in which the income was earned. Because people can work in one county and live in another, and people can own capital in other counties, personal income is not an accurate indicator of county economic output. For instance in 1990, 7,033 residents of Luzerne County worked in Lackawanna County while 5,175 residents of Lackawanna County worked in Luzerne County; nearly 60,000 Delaware County residents worked in Philadelphia County and an even larger number of Philadelphia workers live out of state [Pennsylvania State Data Center web site]. Also, the personal income measure includes transfer payments.

The Bureau of Economic Analysis also tracks "total earnings by place of work". I use this as the measure of county income because it attributes income to the county in which it was earned. Total earnings include wages and salaries, other labor income, contributions for social insurance, and proprietors' income. It excludes dividends, interest, rent, and transfer payments. Total earnings divided by total full- and part-time employment yields total earnings per worker. Data for total earnings and employment are taken from the Regional Economic Information System web page.[1] Total earnings data by county is available for 1969 onward.

Figure 1 plots the compound growth rate of per capita real total earnings from 1969 to 1999 against the log of 1969 real total earnings per capita for all 67 Pennsylvania counties. Absolute convergence implies a negative relationship between the rate of income growth and initial income: poorer counties grow more rapidly than richer counties. The graph reveals no such obvious relationship.

I use ordinary least squares to more rigorously test the absolute convergence prediction of the neoclassical model. Table 1 reports on the estimation of

$$(1/30)(y_{1999} - y_{1969}) = \text{constant} + y_{1969}, \tag{2}$$

where y_t is the natural logarithm of real total earnings per capita in year t. The coefficient on the log of initial per capita income is negative, but both the coefficient and the adjusted R^2 are essentially zero. There is no meaningful tendency for poor Pennsylvania counties to grow faster on average than rich counties.

TESTING FOR CONDITIONAL CONVERGENCE

I test for conditional convergence by estimating

$$g_{nT,0} = \alpha + \beta y_{n0} + \gamma \mathbf{X}_n + e_n, \tag{3}$$

FIGURE 1
Absolute Convergence of per Capita Income Across Pennsylvania Counties

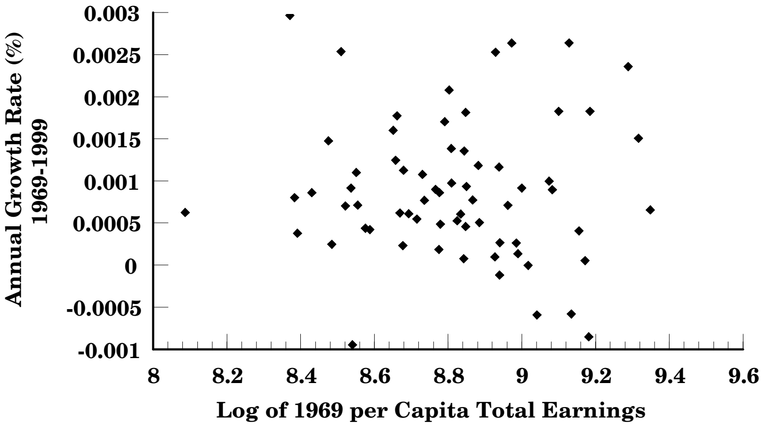

TABLE 1
Testing for Absolute Convergence

Constant	0.002
	(0.50)
Log of total earnings per capita in 1969	-0.000
	(0.25)
Observations	67
Adjusted R^2	-0.01
Standard error of regression	0.00
Durbin-Watson	2.00
Implied speed of convergence	0.2%

The dependent variable is the natural logarithm of the compound growth rate of total earnings per capita, 1969-1999. Absolute values of *t*-statistics are in parentheses.

where $g_{nT,0}$ is the natural logarithm of the compound growth rate of income per capita for economy n between periods 0 and T, y_{n0} is the natural logarithm of income per capita for economy n in period 0, $\mathbf{X}_n$ is a vector of variables that control for cross-economy heterogeneity, α and β are parameters, γ is a vector of parameters, and e_n is an error term. If β is less than zero, economies that are initially poor after controlling for permanent differences associated with their **X**'s and e's grow more quickly than economies that are initially rich controlling for their **X**'s and e's. This is conditional convergence: incomes per capita converge controlling for differences in steady-state income levels.

I utilize five variables in vector **X** to control for differences in county steady-state income levels: the fraction of adults in the county with a college degree, the growth rate of county population, the fraction of voters registered Democratic to control for county government efficiency, and, since Jacobs [1984] stresses that urbanization encourages innovation and growth, the percentage of the county population living in urban areas and the fraction of total earnings from agriculture.[2] The neoclassical model asserts that the steady-state level of income depends on the rates of saving and population growth. The higher the savings rate, the higher the steady-state level of income per capita. The higher the rate of population growth, the lower the level of per capita income in the steady-state. There is no reliable measure of investment in physical capital by county. But Mankiw [1995] emphasizes the importance of broadening the concept of capital to include human capital for understanding growth. The proportion of the county population of persons 25 years and over with a bachelor's degree or higher is used as a proxy for rate of accumulation of human capital.

Ordinary least squares estimations of equation (3) produce consistent estimates only if the variables in vector **X** account for all of the permanent cross-county variation in income growth rates. Otherwise, omission of the individual effect biases estimates of β and the γ's towards zero and, therefore, understates the rate of convergence [Caselli, Esquivel, and Lefort 1996; Evans, 1997b]. A solution is a panel data approach because it allows for the control of unobservable, omitted individual effects that are constant over time.

The panel approach divides the 30-year study period into several shorter time spans. One issue is choosing the appropriate length of these time spans. Long time spans decrease the value of the time series nature of panel data while short-term disturbances may dominate short time spans. So, I opt to estimate the model separately for six different time spans: one year, two years, three years, four years, five years, and ten years. Values of the independent variables are taken from the beginning of each interval. All but the four-year interval estimates are over the 1969-1999 period. The four-year interval estimates are for 1970-1998.

A second issue is the appropriate panel estimation technique. The fixed effects estimator takes deviations from individual means to eliminate the individual effects and assumes that each county has its own intercept. The fixed effects regression leads to consistent estimates only if all of the explanatory variables are exogenous, but it is unlikely that county population growth, for instance, is unaffected by county income growth. Caselli, Esquivel, and Lefort [1996] advocate use of a generalized method of moments estimator to simultaneously address the problems of correlated individual effects and endogeneity. Their estimator takes all variables as deviations from period means. Taking deviations from period means reduces any bias generated by the business cycle. The growth model is first differenced to remove the individual effects, and then all of the past values of the explanatory variables are used as instruments to alleviate the endogeneity bias. A Hausman test comparing the GMM estimates to those obtained by adding the current and future values of the explanatory variables to the set of instruments is used to test the null hypothesis that the two estimates are not significantly different. Rejection of the null hypothesis is strong evidence of the endogeneity of the explanatory variables and suggests that GMM is the appropriate method of estimation. However, I am unable to reject the null hypothesis, which indicates that the fixed effects estimates are consistent. A third estimation issue is that shocks may be correlated across counties. If so, standard errors but not the coefficients themselves are inconsistently estimated, leading to wide confidence intervals for the estimated coefficients.

Table 2 presents the results from fixed effects regressions of equation (4) for the different time spans:

$$g_{nt+1,t} = \alpha_n + \beta y_{nt} + \gamma \mathbf{X}_{nt} + e_{nt}. \tag{4}$$

The coefficients of the log of initial income are similar and significantly negative for all time spans. The implied speed of convergence, derived from that coefficient, is between 0.01 and 0.02. The typical Pennsylvania county covers 1 to 2 percent of the distance between its current and steady-state income levels in one year.

DISCUSSION

The 67 Pennsylvania counties constitute a set of small open economies with similar political and social institutions and access to identical technology. Barro, Mankiw, and Sala-í-Martin [1995] demonstrate that if human capital cannot be completely financed by outside borrowing, an open economy will have a rapid but finite convergence rate. However, there is no evidence that poorer Pennsylvania counties have grown faster than rich counties and, thus, no evidence of absolute convergence across Pennsylvania counties.

The failure of absolute income convergence is due to a widening gap between the highest income and lowest income counties. Total earnings per worker in the poorest Pennsylvania county in 1999, Sullivan, were 46 percent of total earnings per worker in the richest county, Montgomery. In 1969, total earnings per worker in the poorest county, still Sullivan, had been 61 percent that of Montgomery County. Workers in Sullivan and other low-income counties are being paid increasingly lower average wages relative to workers in Montgomery and other high-income counties. Is this because they are paid less for the same jobs or because they are employed in lower paying jobs? I investigate this question by utilizing a procedure developed by Hanna [1951] to separate income differences into employment mix and wage components. The procedure involves constructing two hypothetical county incomes and comparing them with actual county income. The first assumes that all counties have identical industry mixes and identical industry wages, with the industry mix and industry incomes set equal to that of the richest county, Montgomery. The second hypothetical income is constructed two different ways. The first, the industry mix decomposition, assumes that counties have different industry mixes but identical wages at the industry level set equal to industry incomes in Montgomery County. The second, the wages decomposition, assumes that counties have different per worker wage rates and identical industry mixes, with the industry mix for all counties set equal to the industry mix in Montgomery County.

I calculate each county's industry mix based on employment in 11 industries: farming, forestry and fishing, mining, construction, manufacturing, transportation, wholesale trade, retail trade, finance, services, and government. The industry mix is each industry's share of total county employment. Industry earnings per worker are

TABLE 2
Testing for Conditional Convergence

	Time Intervals					
	1 year	2 years	3 years	4 years	5 years	10 years
Log of initial year income	−0.013	−0.020	−0.016	−0.019	−0.015	−0.010
	(10.67)	(13.65)	(11.32)	(13.48)	(12.72)	(9.31)
Fraction of adults with a college degree	0.019	0.035	0.035	0.037	0.030	0.021
	(4.43)	(6.99)	(7.52)	(7.11)	(6.79)	(5.53)
Population growth rate	−0.072	−0.001	−0.009	0.047	0.053	0.049
	(6.36)	(0.03)	(0.50)	(2.08)	(2.53)	(2.12)
Farm income as a fraction of total earnings	−0.036	−0.035	−0.011	−0.011	−0.023	−0.011
	(6.62)	(5.38)	(1.93)	(1.74)	(4.03)	(2.32)
Fraction of voters registered Democratic	−0.019	−0.017	-0.010	−0.013	−0.006	0.005
	(5.12)	(3.90)	(2.77)	(3.10)	(1.62)	(1.85)
Percent urban population	0.013	0.014	0.012	0.016	0.013	0.008
	(2.85)	(2.59)	(2.51)	(2.91)	(2.90)	(2.55)
Observations	2,010	1,005	670	469	402	201
Adjusted R^2 standard error of	0.09	0.15	0.16	0.26	0.29	0.44
regression	0.00	0.00	0.00	0.00	0.00	0.00
Durbin-Watson	1.36	1.86	1.95	1.85	1.87	1.66
p-value of F-test for absence of panel effects	0.000	0.000	0.000	0.000	0.000	0.000
p-value of Hausman test for exogeneity of explanatory variables	–	–	1.000	0.980	0.501	0.541
Implied speed of convergence	1.3%	2.0%	1.6%	2.0%	1.6%	1.1%

The dependent variable is the natural logarithm of the compound growth rate of total earnings per capita. Growth rates are over 1, 2, 3, 5, and 10-year intervals over the period 1969-1999 and over 4-year intervals over the period 1970-1998. Values of the explanatory variables are for the beginning of each interval. Absolute values of *t*-statistics are in parentheses.

calculated by dividing total earnings in the industry by total employment in the industry. Under the industry mix decomposition, the percentage difference between county income per capita and the income per capita of the highest-income county attributable to county industry mix is calculated by taking the difference between the log of the hypothetical industry mix income per worker and the log of income per worker in Montgomery County. The percentage difference attributable to wages is found by taking the difference in logs between actual county income per worker and the hypothetical industry-mix income per worker. Using the wages decomposition, the percentage difference between county income per capita and the income in the richest county attributable to industry mix is found by taking the difference in logs between actual county income per worker and the hypothetical wages income per worker. The percentage difference attributable to wages equals the difference between the log of the hypothetical wages income per worker and the log of income per worker in Montgomery County.

Table 3 summarizes the results of both decomposition procedures for 1997-99 and 1969-71 for the four highest-income and 12 lowest-income counties as of 1997-99. A three-year average of the data is utilized to mitigate the effects of the business cycle. All dollar amounts are in 2001 dollars. Column (1) provides each county's actual total earnings per worker. Counties are ordered by actual per worker earnings. The county industry mix income in column (2) is calculated by assuming all counties earn identical earnings equal to the Montgomery County industry earnings. So, while actual earnings per worker in Sullivan County in 1997-99 were $21,695, county income would have been $42,783 if its industry earnings structure had been the same as Montgomery County's. The wages income in column (5) is calculated assuming all counties have an employment mix identical to that of Montgomery County. The result measures earnings per worker if the county industry mix had been identical to the Montgomery County mix, given the county wage structure. This hypothetical income was $21,411 for Sullivan County in 1997-99. Columns (3) and (4) and (6) and (7) provide the results of the two decomposition procedures. The figures are the percentage difference between actual county earnings per worker and the per worker earnings in the wealthiest county attributable to the county employment mix and to its wage structure. According to the industry mix decomposition 5.9 percentage points of the difference between Sullivan County's actual income and per capita income in Montgomery County is due to the Sullivan County's industry mix; 66.7 percentage points is due to its wages. Under this decomposition, high wages account for 92 percent [-66.7/(−5.9 − 66.7)] of the difference between Sullivan County's and Montgomery County's incomes per worker.

The two decomposition procedures differ slightly on the details but offer the same conclusions. First, the counties with the lowest incomes per worker have unfavorable wage structures relative to the highest-income county. Workers in these low-income counties earn less for the same job than do workers in the high-income counties. For both the 1997-99 and 1969-71 periods, each of the 12 lowest-income counties had an unfavorable wage structure relative to Montgomery County. Second, low wages account for an increasing proportion of these low-income counties' income differential. The unfavorable wage gap for the typical low-income county has grown from 34 percentage points in 1969-71 to 68 percentage points in 1996-98. According to the wages decomposition, low wages account for 105 percent [−67.8/(3.1 − 67.8)] of the difference between earnings per worker in the average low-income county and Montgomery County in 1997-99 compared to 91 percent [−33.8/(−3.4 − 33.8)] for 1969-71.

The 2 percent per year conditional convergence rate detected in this paper, while similar to the convergence rate of about 2 percent a year typically found across various samples [Mankiw, 1995, 285], is inconsistent with rates found in other panel data studies: 10 percent [Caselli, Esquivel, and Lefort, 1996] to 30 percent [Lee, Pesaran, and Smith, 1997] for a broad sample of countries and 15.5 percent for a sample of U.S. states [Evans, 1997a]. The slow rate of conditional convergence implies that Pennsylvania county economies can be away from their long-run equilibria for very long periods of time. This means that income differences may persist for a very long time in the absence of policies designed to encourage growth in low-income counties. Low wages, not a concentration of low-paying jobs, is the problem facing low-income Penn-

TABLE 3
Decomposition of Income Differences

	1997–99						
	(1) Actual Earnings per Worker ($/yr)	(2) Industry Mix Earnings per Worker ($/yr)	(3) % Attributable Industry	(4) Difference to: Wages	(5) Wages Earnings per Worker ($/yr)	(6) % Attributable	(7) Difference to:
Montgomery	45,367						
Chester	44,572	44,205	−2.6	0.8	45,961	−3.1	1.3
Philadelphia	44,254	43,740	−3.7	1.2	43,890	0.8	−3.3
Allegheny	40,979	43,504	−4.2	−6.0	43,879	−6.8	−3.3
Fayette	25,780	42,318	−7.0	−49.6	25,349	1.7	−58.2
Adams	25,538	44,083	−2.9	−54.6	24,539	4.0	−61.5
Bedford	24,513	42,983	−5.4	−56.2	22,998	6.4	−67.9
Carbon	24,204	45,277	−0.2	−62.6	23,097	4.7	−67.5
Wayne	24,195	40,771	−10.7	−52.2	24,217	−0.1	−62.8
Tioga	24,187	44,079	−2.9	−60.0	22,688	6.4	−69.3
Forest	24,158	44,543	−1.8	−61.2	20,356	17.1	−80.1
Susquehanna	23,120	41,860	−8.0	−59.4	22,044	4.8	−72.2
Juniata	23,026	44,325	−2.3	−65.5	21,646	6.2	−74.0
Pike	22,387	40,257	−12.0	−58.7	26,708	−17.7	−53.0
Perry	22,336	39,867	−12.9	−57.9	22,032	1.4	−72.3
Sullivan	21,965	42,783	−5.9	−66.7	21,411	2.6	−75.1

sylvania counties. Making the industry mix of these counties comparable to the mix in the highest-income county will raise county per capita income only slightly, 5.9 percent for Sullivan County. To achieve sizeable relative income gains, wages for all jobs in the low-income counties need to be improved. While extending tax breaks to encourage investment in distressed areas may increase physical capital per worker, human capital accumulation is more strongly correlated with per capita income. Education is in the domain of policymakers. There are 19 community colleges in Pennsylvania, none of which are in the 23 lowest-income counties.

TABLE 3 (Cont.)
Decomposition of Income Differences

	1969–71						
	(1) Actual Earnings per Worker ($/yr)	(2) Industry Mix Earnings per Worker ($/yr)	(3) % Attributable Industry Mix	(4) Difference to: Wages	(5) Wages Earnings per Worker ($/yr)	(6) % Attributable Industry Mix	(7) Difference to: Wages
Montgomery	33,401						
Chester	31,792	32,398	−3.0	−1.9	31,922	−0.4	−4.5
Philadelphia	34,554	32,539	−2.6	6.0	34,642	−0.3	3.6
Allegheny	34,548	32,779	−1.9	5.3	35,356	−2.3	5.7
Fayette	27,075	32,360	−3.2	−17.8	26,481	2.2	−23.2
Adams	23,177	31,665	−5.3	−32.2	24,354	−5.0	−31.6
Bedford	23,623	30,737	−8.3	−26.3	24,604	−4.1	−30.6
Carbon	22,810	34,556	3.4	−41.5	22,831	−0.1	−38.0
Wayne	22,456	30,412	−9.4	−30.3	23,636	−5.1	−34.6
Tioga	25,417	30,343	−9.6	−17.7	26,554	−4.4	−22.9
Forest	24,139	33,475	0.2	−32.7	24,026	4.7	−32.9
Susquehanna	21,650	30,370	−9.5	−33.8	23,657	−8.9	−34.5
Juniata	20,789	30,779	−8.2	−39.2	21,420	−3.0	−44.4
Pike	23,291	30,175	−10.2	−25.9	25,070	−7.4	−28.7
Perry	21,398	29,351	−12.9	−31.6	22,484	−5.0	−39.6
Sullivan	20,306	30,979	−7.5	−42.2	21,270	−5.1	−44.7

Dollar amounts are in 2001 dollars. The hypothetical county industry mix income in column (2) is calculated by assuming all counties earn identical earnings equal to that of Montgomery County. The percentage difference between county income per capita and Montgomery County income per capita attributable to county industry mix in column (3) equals the difference between the log of the hypothetical industry mix income per worker and the log of Montgomery County income per worker. The percentage difference attributable to wages reported in column (4) is found by taking the difference in logs between actual county income per worker and the hypothetical industry mix income per worker. The hypothetical county wages income in column (5) is calculated assuming all counties have an employment mix identical to the Montgomery County industry mix. The percentage difference between county income per capita and the Montgomery County income per capita attributable to industry mix reported in column (6) is found by taking the difference in logs between actual county income per worker and the hypothetical wages income per worker. The percentage difference attributable to wages given in column (7) equals the difference between the log of the hypothetical wages income per worker and the log of Montgomery County income per worker. The source for county earnings and employment by industry is the Regional Economic Information System web page.

NOTES

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1. <http://fisher.lib.virginia.edu/reis>. The Bureau of Economic Analysis produces the REIS database. I am indebted to participants at the 1998 Pennsylvania Economic Association conference for pointing me towards this web site.
2. Latzko [2001] found that these five variables were robustly correlated with Pennsylvania county income growth. The inclusion or exclusion of these control variables has little effect on the estimated convergence rates. Failing to include all of these control variables lowers the estimated convergence rate to around 1 percent.

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