Investigating Convergence of the U.S. Regions: A Time-Series Analysis

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Abstract: Most economists conclude that the U.S. regions have converged in per capita earnings during a majority of the 20th century, though controversy abounds over the methods employed to test for such convergence. Using time-series techniques, this paper finds evidence that the U.S. regions have conditionally converged in per capita earnings. The findings in this paper differ from cross-sectional studies, which implicitly assume that all regions converge toward the same steady-state and at the same rate. The findings in this paper differ from other time-series studies with its use of recursive parameter estimates.[1]

1. Introduction

Most economists conclude that per capita incomes among the states and regions have converged during a majority of the twentieth century, though controversy abounds over the methods employed to test for such convergence. [2] Barro and Sala-i-Martin find convergence occurring among the states and regions for the years 1880 to 1988 (Barro and Sala-i-Martin 1992). Several economists, such as Garnick (1990) and Sherwood (1996), find convergence continuing up until about 1979. Economists generally agree that

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[1] Recursive estimation involves estimating an equation over successively larger samples, starting from a minimum sub-sample and extending to the full sample. Parameter stability may be tracked by looking at the behaviour of the estimated coefficients, as sample size is increased, to see whether they fluctuate significantly or remain stable (Banerjee et al. 1997).

[2] U.S. regions refer to the eight regions defined by the Bureau of Economic Analysis, U.S. Department of Commerce. See Figure 1 for a map of these regions.

per capita incomes diverged between the years 1979 to 1988, but they dis-
agree over what knowledge can be ascertained from this apparent change in
trend. Sherwood (1996) argues that this period of divergence arose from a
positive shock to the Northeast States. Other economists argue that the
1980's divergence stemmed from falling oil prices. The important question is
whether the 1980's divergence represents a temporary interruption in con-
vergence due to shocks affecting States and regions differently or whether it
signifies the end (or even a reversal) of convergence among the states and
regions.

Standard neoclassical, Solow-type, growth theory suggests that earnings
should converge among closely integrated economies for two main reasons:
decreasing returns and factor mobility. [3] In the presence of decreasing re-
turns, additional factor inputs yield smaller returns in regions with higher
earnings than they do in regions with lower earnings. If technology is ho-
mogeneous across regions, employing factors (i.e. labor) where they are
cheaper will bring a higher return. In the presence of perfect factor mobility,
differences in factor returns diminish over time as labor and capital migrate
to regions where the payoff for their services is highest. Neoclassical theory
does not reject disparities occurring among highly integrated economies due
to shocks to relative earnings, but it does suggest that decreasing returns and
factor mobility will dissipate the effect of such shocks and should make them
less likely to occur as well.

Competing economic growth theories cast doubt on the notion that the
assumptions of decreasing returns holds true for most industries or that fac-
tor mobility will necessarily aid in bringing about convergence. According
to endogenous growth theory, firms' location decisions may create positive
externalities for neighboring firms. For example, firms demanding skilled
labor might benefit by locating close to other firms demanding the same
skilled labor. In such cases, firms will not be choosing to locate with lower
earnings because the returns on labor will be higher in the region with the
existing pool of skilled labor. A perfectly mobile labor force will further in-
crease this clustering of economic activity as skilled workers move to join
these labor pools. Firms may also choose to locate in regions with higher
earnings because those regions offer a higher demand for goods and ser-
vices. This notion has been termed the home-market effect. By locating
within (or near) these wealthier regions, firms can minimize transport costs.
For instance, firms in certain industries, particularly some service-producing
industries, may choose to locate in a higher earnings region in order to gain

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[3] Economic growth and convergence theory is more directly applicable to earnings and not in-
come, as commonly used. Earnings is a component of income. Income includes earnings as well
as interest, dividends, rent, and transfer payments. Carlino and Mill (1996) also focus on earn-
ings.

access to their customers. Again, such movements by firms increase earnings divergence among regions.

Strictly speaking, the above theories apply only to economies with such characteristics. As barriers to trade and factor mobility are reduced and national economies throughout the world push toward further integration, the implications of these models will become more and more relevant. Will poorer nations benefit from joining regional trade arrangements or will wealthier countries' advantages persist? The states and regions are a real-world example of closely integrated economies where labor and capital flow freely. In this way, the states and regions act as a benchmark model for the rest of the world.

2. Methods of Testing For Convergence

There are several competing methods to test for convergence. Barro and Sala-i-Martin find convergence using a cross-sectional test relating the growth rates of state and regional economies during the period of analysis to the initial levels of per capita incomes; an inverse relationship suggests convergence. This type of convergence is referred to as β-convergence, which occurs when economies starting out with below average earnings grow faster than economies starting out with above average earnings. β-convergence implies that poorer economies will converge by growing at a faster rate than wealthier economies. Other economists test for σ-convergence, which occurs when the standard deviation of per capita earnings narrows for the states or regions. σ-convergence implies that per capita earnings for each of the economies become more similar.

Both of the above methods infer dynamic properties on per capita earnings while ignoring problems associated with potential non-stationarities in the data. This oversight is critical because if relative per capita earnings for each state or region are non-stationary, shocks to relative per capita earnings lead to permanent deviations in any tendency toward convergence and estimates of β-term become meaningless. This is because a non-stationary series is permanently affected by shocks whereas a stationary series will, over time, continually revert back to its mean or trend. For a stationary series, deviations from the mean or trend will have a fixed distribution, centered on zero, that does not change over time. Both of the above cross-sectional methods also imply identical steady-state growth paths in earnings for each state or region's economy, making it difficult to distinguish between a break in the overall convergence rate and a scenario where some regions reach their relative steady-states while others continue to converge.

Carlino and Mills examine the convergence characteristics of the U.S. regions using times-series techniques. They argue that two conditions are required for convergence: shocks to relative regional per capita earnings

should be temporary (stochastic convergence) and regions having per capita earnings initially about their compensating differential should exhibit slower growth than those regions having per capita earnings initially below their compensating differential (β-convergence). Carlino and Mills test whether the states and regions are converging conditionally. That is, whether relative per capita earnings are converging toward unity with the national average, plus or minus a compensating differential. This compensating differential may differ for each region; it is a result of a region's unique characteristics, such as amenities, population traits, industry mix, and so forth.[4] Compensating differentials are assumed to be time-invariant.

In this paper, I test whether conditional convergence takes place among eight U.S. regions. In extend upon earlier work done by Carlino and Mills (1996). Like Carlino and Mills, I first test for stochastic convergence as a necessary (though not sufficient) condition before then testing for β-convergence using time-series techniques. Stochastic convergence implies that shocks to relative earnings for each of the states and regions are temporary. Unit-root tests are run on relative per capita earnings for each of the U.S. regions. If a unit root is found, then shocks to relative per capita earnings lead to permanent deviations in relative regional earnings and convergence cannot take place. Unlike Carlino and Mills, I am able to reflect a unit root for all regions (except New England) without having to establish a trend break around 1946. Testing for β-convergence, I determine whether regions having per capita earnings initially above their compensation differential exhibit slower growth than those regions having per capita earnings initially below their compensating differential. Unlike Carlino and Mills, I use recursive estimates of the trend term (β) and intercept term to interpret the convergence characteristics of each region over time.

Carlino and Mills conclude that U.S. regions are converging if we allow for a trend break in 1946. Carlino and Mills find that U.S. regions are converging up until around 1946. After 1946, they find that U.S. regions are converging at a much slower rate (if at all for some regions). Using recursive estimates of the trend (β) and intercept term, I find evidence that all eight regions continue to converge significantly after 1946. The Great Lakes, Plains, and Far West Regions continue to converge through 1998 (the latest year of data). The New England and Rocky Mountain Regions reach their relative steady-states in the mid-1950's, while the Mideast and Southeast Regions converge until the late 1970's and late 1980's respectively. The Southwest Region converges into the early 1960's. The apparent divergence of the 1980's is due mainly to positive shocks to the New England Region and due partly to a negative shock to the Great Lakes Region.

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[4] The term "conditional convergence" is used by Mankiw, Romer, and Weil (1992), who argue that the Solow model predicts convergence among countries only after controlling for the determinants of each country's steady state.

Testing whether regions conditionally converge instead of converging absolutely allows for differing steady-state determinants such as industry mix and labor force characteristics (i.e. labor force participation) among the regions. Constructing a vector autoregression (VAR) model for relative per capita earnings in each region that incorporates current and lagged values for industry mix and relative per capita employment used as a proxy for labor force participation rates and unemployment rates, I find that these steady-state determinants do help explain relative per capita earnings in each region.

3. Modeling Relative Regional Per Capita Earnings

Conditional Convergence Hypothesis

The convergence hypothesis most often used in the literature is one of absolute convergence. Absolute convergence states that relative regional earnings will converge toward unity (or zero when the data used are in logged form). The conditional convergence hypothesis states that relative regional earnings will not converge toward unity, but towards a stable differential. This 'compensating differential', which is assumed to be time-invariant, is due to unique characteristics (i.e. amenities, industry mix, population traits, etc.) in each region.

Borrowing from Carlino and Mills (1996), I employ a simple model of a regional per capita earnings to explain the notion of a conditional convergence equilibrium. The equilibrium nominal wage in each region (i) is a function of prices (P), capital in the region (K), and amenities in the region (S):

$$W_i = P_i * h(K_i, S_i) \qquad (1)$$

where P_i is a regional price index.

Regional Earnings (Y) is a product of nominal wages and number of workers in the region (N).

$$Y_i = W_i * N_i \qquad (2)$$
$$N_i = (1-u_i)\lambda_l * POP_i \qquad (3)$$

where POP_i is population, u_i is unemployment, and λ_l is the labor force participation rate.

Substituting equation (1) into equation (2) and (3) gives regional per capita earnings (y).

$$y_i = Y_i / POP_i = P_i * g(K_i, S_i, u_i, \lambda_i) \qquad (4)$$

   Therefore, the log of regional per capita earnings relative to the nation (in equilibrium) is:

$$RI_i^e = \log(y_i / Y_n) = \log[P_i * g(K_i, S_i, u_i, \lambda_i)] - \log[P_n * g(K_n, S_n, u_n \lambda_n)] \qquad (5)$$

where subscript *n* refers to a national average.

   Equation (5) shows that the log of a relative regional per capita earnings, RI_i^e, may differ from zero in equilibrium due to differences in prices, capital (industry mix), amenities, unemployment, and population traits affecting the labor force participation rate.

   The times-series properties of relative regional per capita earnings, RI_i, consists of two parts: the equilibrium level, or compensating differential, RI_i^e, and the deviation, or stochastic term, u_t.

$$RI_{it} = RI_i^e + u_t \qquad (6)$$

Allowing for conditional convergence, $RI_i^e \neq 0$. The error term is modeled with a deterministic linear trend and a stochastic term:

$$u_t = v_o + \beta t + v_t \qquad (7)$$

β-convergence requires an inverse relation between v_o and β. v_o is the initial deviation from equilibrium and β is the deterministic rate of convergence. If a region is initially above its compensating differential, $v_o > 0$, then it should grow at a slower rate than the national average, $\beta < 0$. Likewise, if a region is initially below its compensating differential, $v_o < 0$, then it should grow at a faster rate, $\beta > 0$. As Carlino and Mills point out, this time-series approach to βconvergence allows the rate of convergence to differ across regions.

Substituting equation (7) into equation (6) is:

$$RI_{it} = \alpha + \beta t + v_t \qquad (8)$$

where $\alpha = RI_i^e + v_o$.

   Although estimates of α do not separately identify RI_i^e and v_t, α and β should still be inversely related under the notion of beta-convergence.[5] Stochastic convergence requires that the deviations from relative trend growth,

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[5] It is possible for v_o to be large but opposite in sign from RI^e so that α and β are positively related. Carlino and Mills argue that empirical results suggest that this is counterfactual.

v_t, be temporary; that is, v_t must be stationary and have a fixed distribution with a mean of zero.

4. Data Sources

Per capita earnings data for each region is calculated using earnings and population data from the State Personal Income Series: 1929-1998, Bureau of Economic Analysis, U.S. Department of Commerce. Per capita employment data for each region is calculated using employment data from the Regional Economic Information System (REIS) CD: 1969-1998, Bureau of Economic Analysis, U.S. Department of Commerce. Population and earnings data on the REIS CD are consistent with population and earnings data for the State Personal Income Series. REIS employment data is not available prior to 1969. The industry similarity index for each region is calculated using earnings-by-industry data from the State Personal Income Series: 1958-1998, Bureau of Economic Analysis, U.S. Department of Commerce. Earnings-by-industry data are not available prior to 1958.

5. Testing For Stochastic Convergence

Stochastic convergence requires that relative regional earnings be stationary. Shocks to a stationary time series are temporary in that their effects will dissipate and the series will revert back to its long-run mean or trend. If relative earnings are non-stationary for a particular region, then shocks affecting that region's relative earnings have permanent effects and convergence will not occur. In order to determine whether a series is stationary, we must test for unit roots in the auto-regressive terms. If a unit root is present, the series is non-stationary.

Testing for unit-roots can be difficult for three reasons. First, it is difficult to distinguish a unit-root process from a near unit-root process. Second, the presence of deterministic variables affects the test results. Third, the presence of structural breaks can bias the test results toward a non-rejection of the unit root. These last two difficulties present a particular challenge in this case since, in testing for beta-convergence, we are trying to figure out when and if there are significant deterministic variables and structural breaks in the data-generating process.

Autocorrelation functions (ACF) and partial autocorrelation functions (PACF) suggest either AR(1) or ARMA(1,1) processes for each of the regions. However, it is difficult to differentiate the ACF and PACF of a near unit-root process from those of a unit-root process. Dickey-Fuller tests were applied to relative earnings for each region. [6] For the period 1929-1998, a unit-root

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[6] Augmented Dickey-Fuller tests were used when appropriate for each region.

could not be rejected for any of the regions regardless of whether or not a deterministic trend was included in the regression equation. This suggests that the series are integrated and the regions are not converging. But, using Phillips-Perron tests, the unit root could be rejected for each of the regions during the time period 1929-1998, though evidence is somewhat less convincing for the New England Region. [7] The Phillips-Perron test has a greater power to reject a false null hypothesis of a unit root by allowing for a weaker set of assumptions regarding the error process; the errors can be weakly dependent and heterogeneously distributed (Perron 1989). The Dickey-Fuller test assumes that the errors are statistically independent and with constant variance. Although the Augmented Dickey-Fuller test can deal with correlated errors, the Phillips-Perron test has greater power so long as the true data-generating process is one of positive moving-average terms (Enders 1995). Recursive Least-Squares estimates for each of the regions during the 1929-1998 period indicate an unstable variance term, suggesting a bias in the Dickey-Fuller tests that would be absent from the Phillips-Perron tests.

Trend breaks in a series also bias unit-root tests toward a non-rejection of the unit root. A series with a structural break will be interpreted as a series having permanently persistent shocks instead of a series that is stationary around a structural break (Enders 1995). In order to test for unit roots around a structural break using Dickey-Fuller tests, a test must be run for each of the subperiods occurring before and after the break. But, if the subperiods are not large enough, low degrees of freedom will bias the results toward the non-rejection of a unit root. Phillips-Perron tests can test for unit roots around structural breaks while maintaining the degrees of freedom afforded by the entire sample period. Thus, in the presence of structural breaks, Phillips-Perron tests have a still greater power to reject a false null hypothesis of a unit root than Dickey-Fuller tests. For all regions, Phillips-Perron tests rejected the unit root before taking account of any structural breaks. Taking account of structural breaks did allow the Dickey-Fuller tests to reject the unit root for some regions.

Using Dickey-Fuller tests, Carlino and Mills could also not reject the unit root for any of the regions during the 1929-1990 period. They resorted to parametric and non-parametric methods to examine the amount of persistence (Carlino and Mills 1996) in relative earnings for each region. If there was a unit-root, then persistence would be unending. A near unit-root might show lasting persistence, but it would be "temporary." Carlino and Mills were only able to rule out substantial persistence after they allowed for a structural break in 1946. Allowing for the trend break, Carlino and Mills conclude that the effects of shocks to relative earnings tend to dampen after

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[7] All Phillips-Perron tests were run with a constant term and deterministic trend term.

5-10 years, supporting the notion that relative earnings are, in fact, stationary.[8]

6. Testing for b-Convergence

β-convergence occurs when regions starting out at above-average earnings levels grow slower than regions starting out at below-average earnings levels. Conditional beta-convergence occurs when regions starting out at earnings levels above their compensating differential grow slower than regions starting out at earnings levels below their compensating differential. Conditional β-convergence requires a negative relationship between α and β in equation (7) for each region.

For the period 1929-1998, three regions (Great Lakes, Plains, and Far West) show β-convergence (see Table 1). No significant trend is found for any of the other five regions. However, this does not mean that those five regions are not converging since they may achieve conditional convergence at some earlier point in time. For example, a region that converged to its compensating differential in the mid 1950's and then maintained its compensating differential thereafter may appear to have an insignificant trend for the entire sample period of 1929-1998. Determining when β becomes insignificant, stabilizes, or breaks becomes of paramount concern. It is not enough to search for a time period where the series has a significant trend with the appropriate sign. Concluding that a region has converged at a certain point in time requires not only that the trend be significant and inversely related to α-term up to this point in time, but also that beta becomes (and remains) insignificant after this point in time.

Several cross-sectional studies point to the immediate post-World War II period and the 1980's as points of convergence being achieved or breaks in the trend of convergence. Economists looking at σ-convergence point especially to the 1980's as a period of divergence (Sherwood 1996). Carlino and Mills conclude that regions achieved convergence, for the most part, by 1946 and that the supposed 1980's divergence is merely a result of temporary shocks.

Using recursive estimates of the trend term (β) and intercept term (α), this paper finds that the U.S. regions are conditionally β-converging, but at varying rates and with convergence being achieved by each region at varying points in time (see Table 4). Three regions (Great Lakes, Plains, and Far West) continue to converge through 1998, and may still be converging. The New England and Rocky Mountain Regions converge until the mid-1950s,

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[8] The impulse response functions generated from the vector autoregression (VARS) models (used later in this paper) for the effect on earnings from a positive shock to earnings are similar to Carlino and Mills' parametric tests. However, the VAR is limited to the years 1974-1998 due to data availability.

and then maintain a stable compensating differential. The Mideast and Southeast regions converge until around 1980 and 1989, respectively. The Southwest region converges until around 1962. Graphs of the recursive coefficient estimates for the trend term (β) and intercept term (α) best illustrate these patterns of convergence (see Figures 3-10). The graphs show changing trend and constant terms with appropriate signs during the period of convergence, suggesting a decelerating rate of convergence in most cases. Convergence is achieved once the trend term becomes (and remains) insignificant, which is indicated by the confidence interval including zero. The graphs show the recursive parameter estimates as well as confidence intervals at the five percent significance level.

Little support is found for a trend break in 1946 that would suggest convergence is achieved. New England shows a significant decrease in its rate of convergence, but the Great Lakes and Far West show an increased rate of convergence after 1946. The remaining regions show no significant change in convergence rates in 1946. Two factors may explain the apparent σ-divergence during the 1980's. First, a positive shock affects New England during the 1980's. The trend in New England's relative earnings (see Figure 7) becomes positive for about eight years before stabilizing again. Evidence suggests a divergent trend continuing for New England only into the early l990's. Researchers commonly point to a surge in defense-related activities (Henderson 1990) and the role of financial services (Browne 1991) as possible explanations for positive shocks to the New England Region. Case (1991) argues that increased construction and real estate activity contributed to New England's boom as well as its subsequent bust. Second, a negative pulse shock affects the Great Lakes Region in the early 1980's, which decreases the compensating differential for the Great Lakes Region and coincides with the beginning of its path of convergence. This negative pulse shock may reflect the recessions of 1980 and 1981-82.

7. Testing Conditional Convergence: A VAR Approach

Testing whether regions conditionally converge instead of converging absolutely allows for the existence of differing steady-state determinants such as industry mix and labor force characteristics among the regions. If conditional convergence holds true, then the time path of any such steady-state determinants should help explain the time path of relative per capita earnings in each region.

A second-order (VAR) model was constructed for each region for the years 1972-1998. A VAR approach allows us to examine the relationships among a set of economic variables without placing restrictions on feedback effects between each of the variables. In this way, we do not have to decide

whether industry mix and relative employment are actually exogenous. Therefore, endogenous growth theories are not ruled out through the modeling process. Along with relative per capita earnings, two variables were included in each VAR to capture unique regional characteristics that would act as steady-state determinants. Each region's relative per capita employment was included as a proxy for labor force participation rates and unemployment rates because neither of these variables are available in the BEA regional accounts. A variable measuring the similarity of the region's industry mix to the national industry mix was included to account for the differences in industrial structure (Bernat and Repice 2000). The variable measuring the similarity of a region's industry mix is based on earnings data for each industry and is calculated using the following formula:

$$SI_r = [1 - (\sum_{i=1}^{n} | S_{i,r} - S_{i,n} |)]$$

Where SI_r is the similarity index for region r; $S_{i,r}$ is industry I's share of earnings in region r: $S_{i,n}$ is industry I's share of earnings in the U.S. [9] The absence of Granger causality among the three variables (including feedback effects) could not be rejected for any of the eight regions, supporting the notion that these variables act as steady-state determinants.

Figures 11-18 show plots of the impulse response functions, which show the behavior of relative per capita earnings over time in response to shocks to itself, relative per capita employment, and industry mix. Of the two regions which converge during the entire 1974-1998 period (Far West Region and Plains Region), both show (see Figures 12 and 18) increasing industry similarity generating a negative response on relative earnings. Since the Far West Region converges from above, the impulse response function suggests that the Far West Region converges (in terms of earnings) as its industry mix becomes less similar to the nation's industry mix. The Southwest Region (see Figure 11), which converges from below until around 1989, shows increasing industry similarity generating a positive response on relative earnings, which suggest that the Southeast Regions converges (in terms of earnings) as its industry mix becomes more similar to the nation's. The Great Lakes Region (see Figure 17), which converges from above from the mid 1970's onward, appears to converge as its industry mix becomes less similar to the nation's.

8. Conclusion

Using time series techniques, this paper finds that the U.S. regions are conditionally converging. Three regions (Great Lakes, Plains, and Far West)

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[9] This index is borrowed from G. Andrew Bernat and Eric Repice (2000). The index is based on an index used by Sukkoo Kim (1995) and Paul Krugman (1991).

continue to converge through 1998, and may still be converging. The New England and Rocky Mountain Regions converge until the mid-1950s, and then maintain a stable compensating differential. The Mideast and Southeast regions converge until around 1980 and 1989. The Southwest region converges until around 1962. Thereafter, each region maintains a stable compensating differential. Using Phillips-Perron tests, unit roots can be rejected for all regions, except perhaps New England.

Several cross-sectional studies note breaks in the trend toward convergence in the mid 1940's and late 1970's. The findings in this paper differ because the methodology does not implicitly assume that each region converges toward the same steady state and at the same rate. Points in time where some regions achieve conditional convergence while others continue to converge are not confused with a change in the trend, or rate, of convergence. The findings in this paper differ from Carlino and Mills, who find convergence virtually ceasing around 1946, because Phillips-Perron tests were used to test for unit roots and because recursive estimates of trend and intercept terms were used to interpret the convergence characteristics of each region over time.

VAR models for relative earnings in each region that incorporate current and lagged of steady-state determinants lend support to the notion that convergence should be viewed as conditional convergence. The relationship between a region's industry mix relative to the nation and its per capita earnings relative to the nation remains unclear. The Southeast and Far West Regions appear to converge as their industry mix becomes less similar to the nation's. However, the Plains and Great Lakes Regions appear to converge as their industry mix becomes more similar to the nation's.

The findings in this paper suggest that, in the absence of barriers to trade and factor mobility, regional economies will converge toward a stable, compensating differential. Using the U.S. regions as an example of closely integrated economies where labor and capital flow freely, these findings suggest that economic integration among national economies will tend to reduce disparities in national per capita earnings over time. However, these findings do not suggest that integration would eliminate disparities in per capita earnings. When economies conditionally converge, they may be converging toward unique steady-states that are very different.

Table 1. Testing for Conditional Beta Convergence for the years 1930-1998.

$RI_t = \alpha + \beta t + \rho RI_{t-1} + u_t : \alpha = (RI^e + v_o)$					
1930-1998	**a**		**b**		**r**
New England	-.0034 (Prob =.5909)		.00016	(Prob = .1879)	.9710	(Prob =.0000)
Mideast	.0140 (Prob = 2680)		-.00011	(Prob =.4875)	.9122	(Prob =.0000)
Great Lakes*	.0324 (Prob =.0150)		-.0005	(Prob =.0181)	.7713	(Prob =.0000)
Plains*	-.0562 (Prob =.0019)		.00068	(Prob = .0216)	.5969	(Prob = .0000)
Southeast	-.0588 (Prob =.0612)		.00068	(Prob =.0923)	.8565	(Prob = .0000)
Southwest	-.0187 (Prob =.2926)		.00027	(Prob=.3491)	.9148	(Prob =.0000)
Rocky Mountain	-.0155 (Prob = 0602)		-.000002	(Prob =.8880)	.7134	(Prob =.0000)
Far West*	.0709 (Prob =.0021)		-.00089	(Prob = .0015)	.7490	(Prob =.0000)

*Region converges for entire period. This requires that the intercept and trend term show an inverse relation and that the trend is significant at 5% level.

Table 2. Testing for Conditional Beta Convergence for the years 1930-1946.

1930-1946	**a**		**b**		**r**
New England*	.1212 (Prob = .0144)		-.0037	(Prob = .0252)	.6760 (Prob = .0001)
Mideast*	.1985 (Prob =.0158)		-.0064	(Prob = .0195)	.3786 (Prob = .1112)
Great Lakes	.0669 (Prob =.0644)		-.0004	(Prob =.7856)	.3993 (Prob = .1152)
Plains*	-.2014 (Prob = .0040)		.0056	(Prob =.0580)	.0677 (Prob =.8027)
Southeast*	-.3675 (Prob = .0252)		.0082	(Prob =.0108)	.4352 (Prob = .0406)
Southwest* -	-.2512 (Prob =.0103)		.0082	(Prob =.0108)	.4352 (Prob = .0406)
Rocky Mountain*	-.1112 (Prob =.0073)		.0045	(Prob =.0455)	.0316 (Prob =.9066)
Far West	.1975 (Prob = .0095)		-.00035	(Prob = .7651)	.2658 (Prob =.3154)

*Region converges for entire period. This requires that the intercept and trend term show an inverse relation and that the trend is significant at 5% level.

Table 3. Testing for Conditional Beta Convergence for the years 1930-1979.

$$RI_t = \alpha + \beta t + \rho\, RI_{t-1} + u_t : \alpha = (RI^e + v_o)$$

1930-1979	a			b			r		
New England	.0129	(Prob	=.3212)	-.00035	(Prob	=.2604)	.9131	(Prob	= .0000)
Mideast*	.0525	(Prob	=.0360)	-.0009	(Prob	=.0317)	.7852	(Prob	= .0000)
Great Lakes*	.0588	(Prob	=.0012)	-.0005	(Prob	=.0402)	.5243	(Prob	= .0001)
Plains*	-.1137	(Prob	=.0001)	.0023	(Prob	=.0005)	.3612	(Prob	= .0101)
Southeast*	-.1802	(Prob	=.0084)	.0027	(Prob	=.0090)	.6603	(Prob	= .0000)
Southwest	-.0621	(Prob	=.0528)	.0013	(Prob	=.0435)	.8128	(Prob	=.6632)
Rocky Mountain	-.0284	(Prob	=.0212)	.00032	(Prob	=.2691)	.5954	(Prob	=.0000)
Far West	.0897	(Prob	=.0038)	-.0012	(Prob	=.0517)	.6888	(Prob	= .0000)

*Region converges for entire period. This requires that the intercept and trend term show an inverse relation and that the trend is significant at 5% level.

Table 4. Unique Convergence Paths for Each Region*

	Converged until approx:	a		b		r	
New England	1955	.0870	(Prob =.0320)	-.0037	(Prob =.0252)	.6760	(Prob =.0001)
Mideast	1979	.0525	(Prob =.0360)	-.0009	(Prob =.0317)	.7852	(Prob = .0000)
Great Lakes	1998	.0324	(Prob =.0150)	-.0005	(Prob =.0181)	.7713	(Prob =.0000)
Plains	1998	-.0562	(Prob =.0019)	.00068	(Prob =.0216)	.5969	(Prob = .0000)
Southeast	1989	-.0933	(Prob =.0433)	.0013	(Prob =.0472)	.8070	(Prob =.0000)
Southwest	1962	-.1540	(Prob =.0192)	.0040	(Prob =.0215)	.6094	(Prob =.0003)
Rocky Mountain	1954	-.1034	(Prob =.0033)	.0040	(Prob =.0126)	.0660	(Prob = .7799)
Far West	1998	.0709	(Prob = .0021)	-.00089	(Prob =.0015)	.7490	(Prob =.0000)

*A regioin's convergence path is estimated using recursive parameter estimates of the deterministic trend and intercept term for its relative per capita earnings. See Figures 3-10.
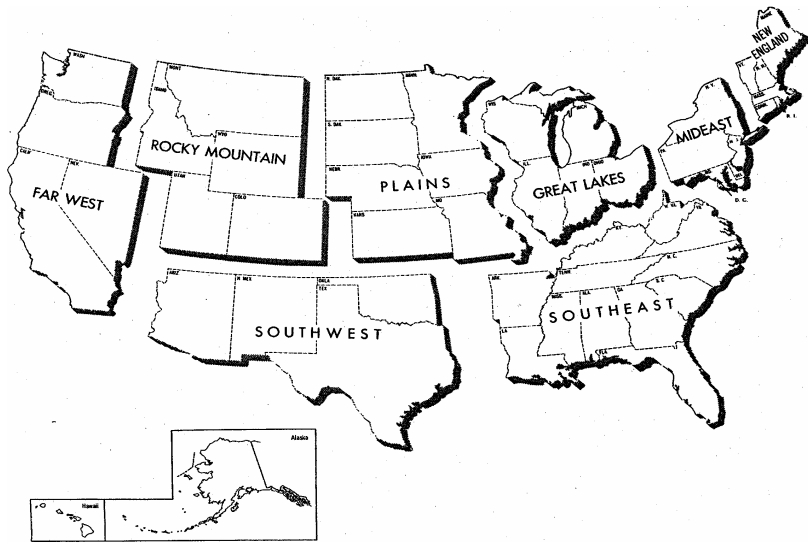
Figure 1. Bureau of Economic Analysis Regions in the United States.

1) Mideast Region = LogMEST
2) Far West Region = LogFWST
3) New England Region = LogNENG
4) Great Lakes Region= LogGLAK
5) Rocky Mountain Region= LogRKMT
6) Plains Region= LogPLNS
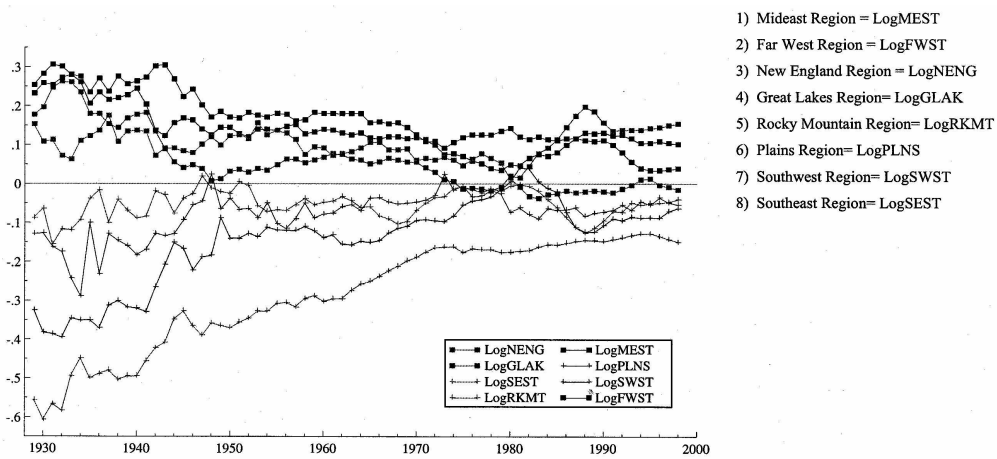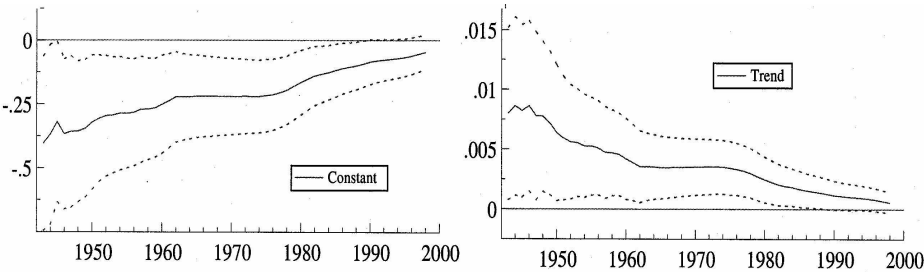7) Southwest Region= LogSWST
8) Southeast Region= LogSEST

Figure 2. Logs of Relative Per Capita Earning: 1929-1998 for U.S. Regions.

Southeast Region

Recursive parameter estimates show Southeast Region converges until late 1980's and Far West Region continues to converge through 1998.
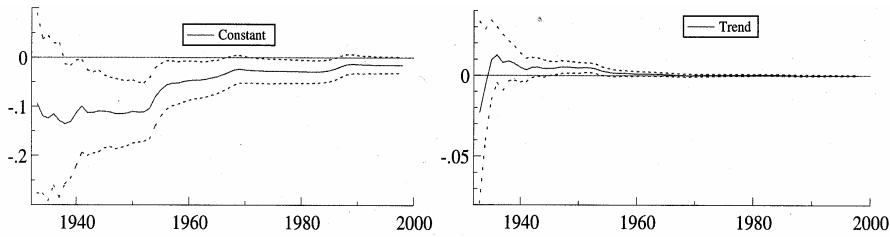
Figure 3. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.

Far West Region
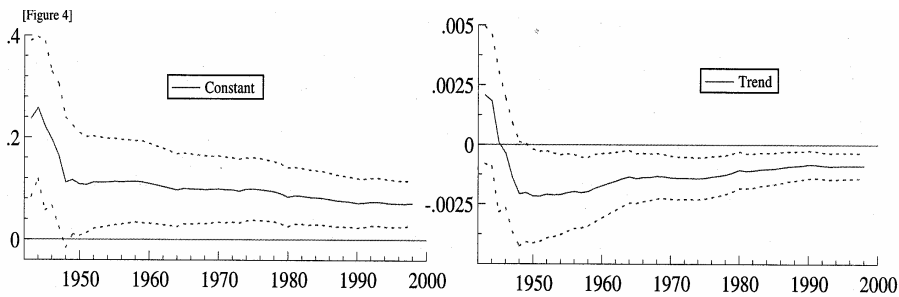
Figure 4. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.
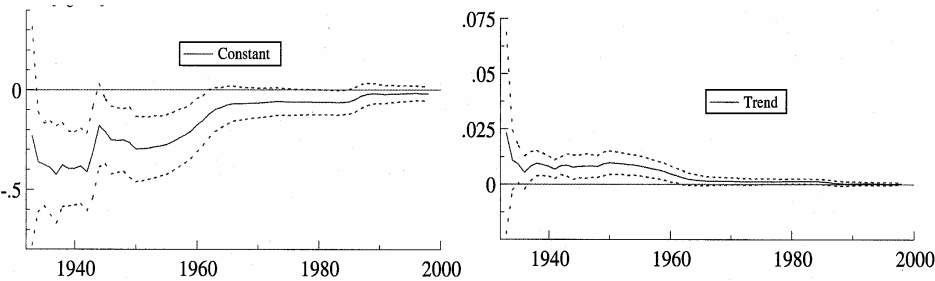
Southwest Region

Recursive parameter estimates show Southwest Region converges until early 1960's and Rocky Mountain Region converges until mid or late 1950's.

Figure 5. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.
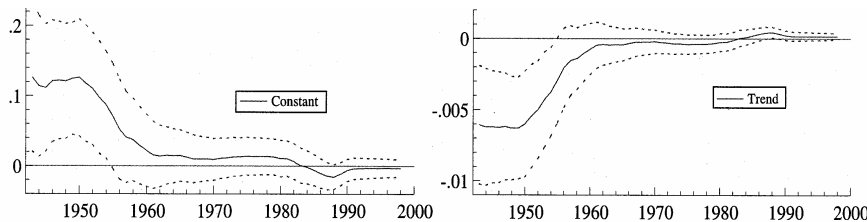
Rocky Mountain Region

Figure 6. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.

New England Region

Recursive parameter estimates show New England Region converges at very unstable rate until mid 1950's. The trend appears to destabilize again during the 1980's.

Recursive parameter estimates show Mideast Region stops (or slows) converging during the 1960's, but then converges again during the 1970's.

Figure 7. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.
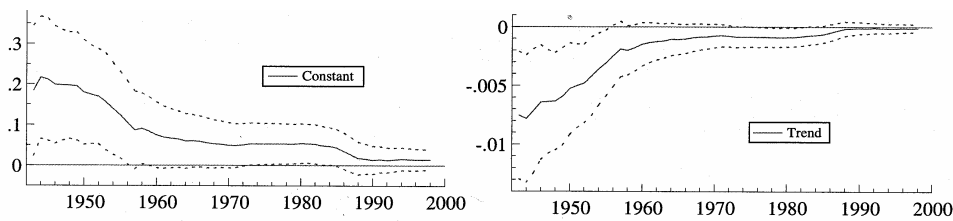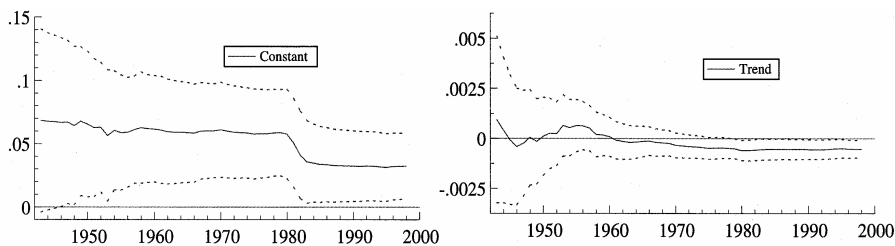
Mideast Region

Figure 8. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.

Great Lakes Region

Recursive parameter estimates show Great Lakes Region converges from the late 1970's through 1998. A negative shock to the intercept term occurs in the early 1980's.
Recursive parameter estimates show Plains Region continues to converge through 1998.

Figure 9. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.
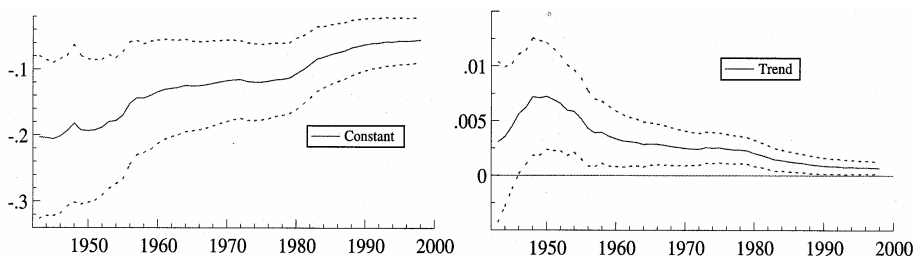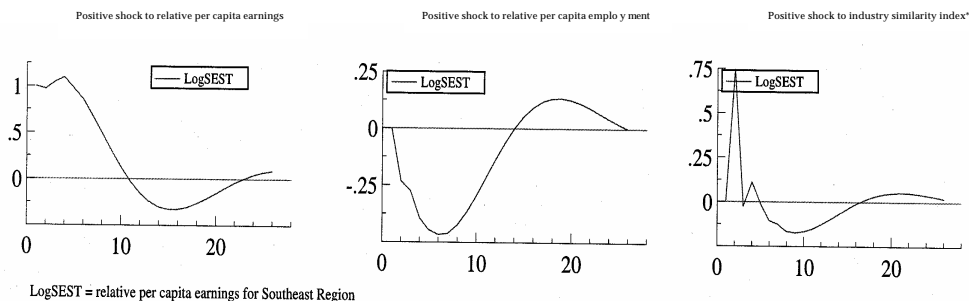
Plains Region

Figure 10. Recursive Parameter Estimates of Deterministic Trend and Intercept Term for Relative Per Capita Earnings for Each Region.

Impulse Response Functions: Years of data: 1972-1998
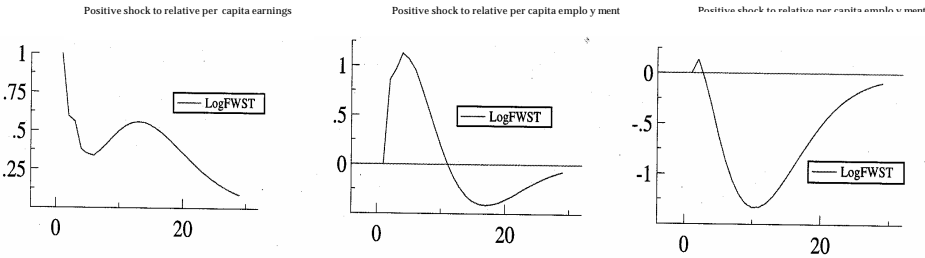
Southeast Region

Positive shock to relative per capita earnings   Positive shock to relative per capita employ ment   Positive shock to industry similarity index*

LogSEST = relative per capita earnings for Southeast Region

Figure 11. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

Impulse Response Functions: Years of data: 1972-1998

Far West Region

Positive shock to relative per capita earnings   Positive shock to relative per capita employment   Positive shock to relative per capita employment
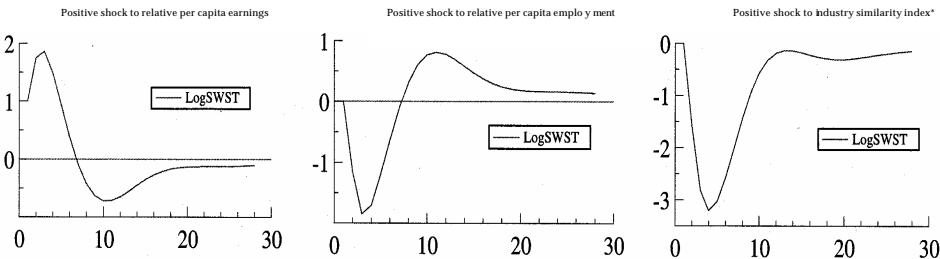
LogFWST

LogFWST

LogFWST

LogFWST = relative per capita earnings for Far West Region

* A postive shock to industry similarity index means region's industry mix becomes more similar to national industry mix

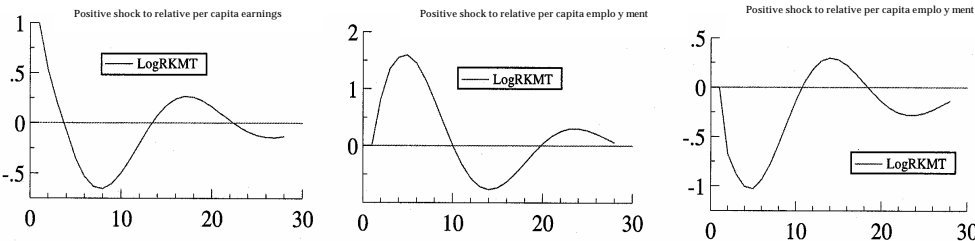**Figure 12.** Impulse Response Functions of Relative Per Capita Earnings for Each Region.

Southwest Region

Positive shock to relative per capita earnings   Positive shock to relative per capita employment   Positive shock to industry similarity index*

LogSWST

LogSWST

LogSWST

LogSWST = relative per capita earnings for Southwest Region

Figure 13. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

Rocky Mountain

Positive shock to relative per capita earnings   Positive shock to relative per capita employment   Positive shock to relative per capita employment

LogRKMT

LogRKMT

LogRKMT

LogRKMT = relative earnings per capita for Rocky Mountain Region

* A postive shock to industry similarity index means a region's industry mix becomes more similar to the national industry mix

Figure 14. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

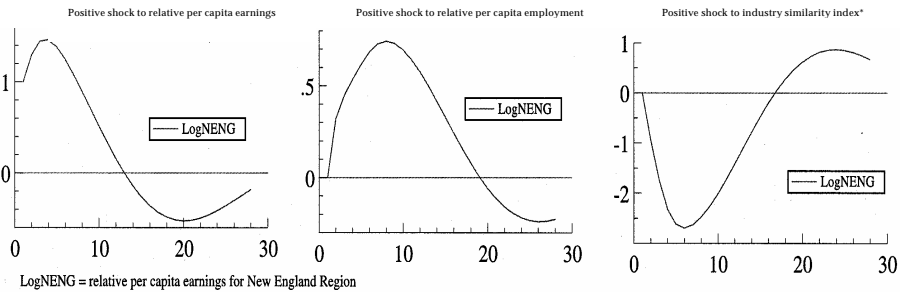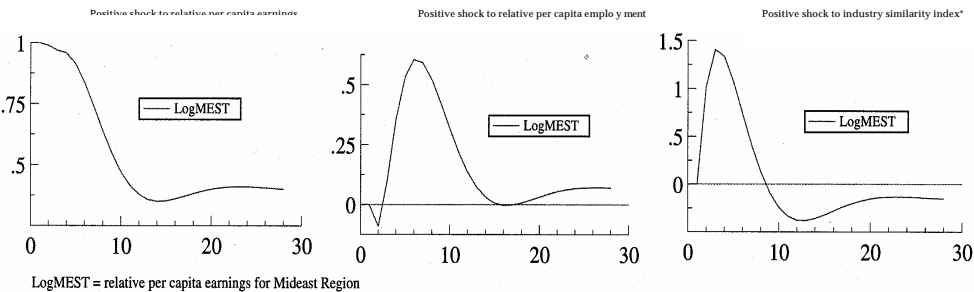Impulse Response Functions: Years of data: 1972-1998

New England Region

Positive shock to relative per capita earnings   Positive shock to relative per capita employment   Positive shock to industry similarity index*

LogNENG = relative per capita earnings for New England Region

Figure 15. Impulse R esponse Functions of Relative Per Capita Earnings for Each Region.

Mideast Region

Positive shock to relative per capita earnings   Positive shock to relative per capita emplo y ment   Positive shock to industry similarity index*

LogMEST = relative per capita earnings for Mideast Region

* A positive shock to industry similarity index means a region's industry mix becomes more similar to national industry mix

Figure 16. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

Impulse Response Functions: Years of data: 1972-1998
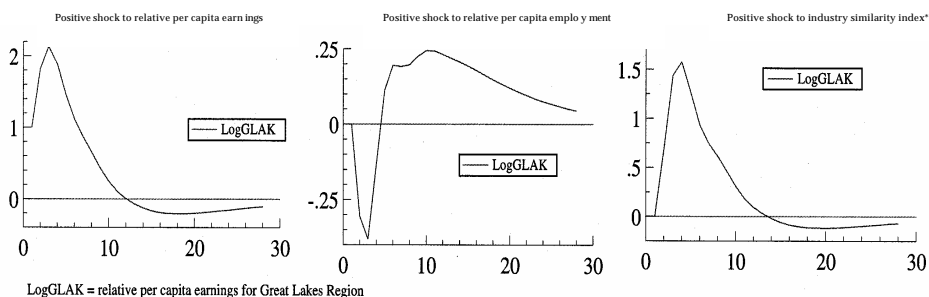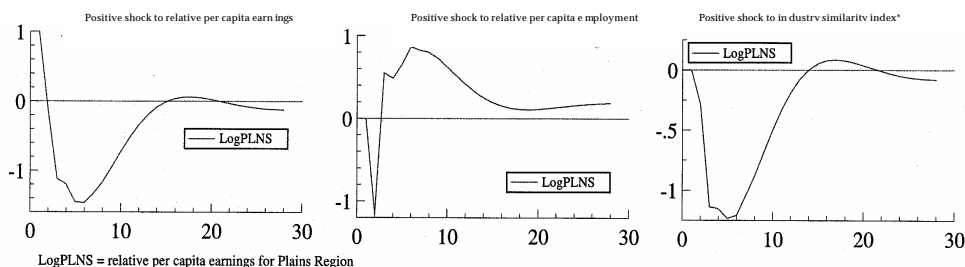
Great Lakes Region

Figure 17. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

Plains Region

Figure 18. Impulse Response Functions of Relative Per Capita Earnings for Each Region.

References

Barro, Robert and Xavier Sala-I-Martin. 1992. Convergence, *Journal of Political Economy,* 100(2):223-251.

Banerjee, Anindya, Juan Dolado, John W. Galbraith, and David F. Hendry. 1997. *Co-integration, Error-correction. and the Econometric Analysis of Non-Stationarv Data*. Oxford UniversityPress.

Bernat Jr., G. Andrew and Eric Repice.2000. Industrial Composition of State Earnings in 1958-1990, *Survey of Current Business,* 80(2):70-78.

Browne, Lynn. 1991. The Role of Services in New England's Rise and Fall: Engine of Growth or Along for the Ride?, *New England Economic Review,* (Jul./Aug.):27-44.

Carlino, Gerald and Leonard Mills. 1996. Convergence and the U.S. States, *Journal of Regional Science,* 36(4):597-616.

Cass, Karl. 1991. The Real Estate Cycle and the Economy: Consequences of the Massachusetts Boom of 1984-87, *New England Economic Review,* (Sept./Oct.):37-46.

Ender, Walter. 1995. Applied Econometric Time Series, *Wiley Series in Probability and Mathematical Statistics,* New York: John Wiley & Sons, Inc.

Garnick, Daniel. 1990. Accounting for Regional Differences in Per Capita Personal Income Growth: An Update and Extension, *Survey of Current Business,* 70(1):29-40.

Henderson, Yolanda. 1990. Defense Cutbacks and the New England Economy, *New England Economic Review,* (Jul./Aug.):3-24.

Krugman, Paul. l991. Geography and Trade, Cambridge, MA: MIT Press.

Mankiw, N.G., D. Romer, and D.N. Weil. 1992. A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics,* CVII(429):407-437.

Perron, Pierre. 1989. The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis, *Econometrica,* 57:l361-1401.

Sherwood-Call, Carolyn. 1996. The 1980's Divergence in State Per Capita Incomes: What Does It Tell Us? *Economic Review: Federal Reserve Bank of San Francisco,* l:14-25.

Sukkoo, Kim. 1995. Expansion of Markets and the Geographic Distribution of Economic Activities: The Trends in U.S. Manufacturing Structure, 1860-1987, *The Quarterly Journal of Economics,* 110:881-908.