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An Analysis of Regional Income Variation in the United States: 1969-2013

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Abstract

This paper investigates the variation of per capita personal income among counties within each state from 1969-2013. Department of Commerce BEA data and Department of Labor BLS data for 1969 to 2013 are analyzed. This study follows up on previous analysis of U.S. regional income variation by adjusting time series estimates for serial correction and using random effects models for panel data analysis. In addition, potential short-run disruption of a longer run trend is investigated by including an unemployment rate variable into the model. Results suggest that a general pattern of per capita income divergence has transpired in recent decades, contrary to conventional expectations of convergence.

Keywords

Regional Income Inequality, Kuznet's Inverted-U, Income Convergence, Regional Income Variation

1. Introduction

The spatial distribution of economic activity is a fundamental concern in the study of regional economic analysis. This study dates back at least to the seminal work of Williamson [1], who extended the work of Kuznets [2] from individual income inequality to spatial income inequality, or regional income variation. This concern was also manifested in the growth pole theory developed by Perroux [3] and further discussed by Hansen [4] and Lausen [5]. The presumed pattern of regional income variation during this time frame was one of convergence, with incomes and development more homogeneously distributed across space, matching the convergence of individual income inequality postulated by Kuznets.

However, during the later quarter of the 20th century, evidence began mounting that regional income variation was diverging (Amos [6] [7]). This and subsequent analysis suggested that the divergence of regional incomes commenced in the mid-1970s (Amos [8]); the timing of this divergence coinciding with technological innovations related to the personal computer revolution. This observation led to a systematic investigation into the spatial-temporal patterns of economic development (Amos [9] [10] [11]), combining overarching spatial elements of growth pole theory with long-term temporal cyclical relations reflected in the work of Schumpeter [12] and Kondratieff [13] [14].

One objective of this current study is to update data used to document regional income variation within each of the 50 states in Amos [8] and in the process to employ more sophisticated statistical regression techniques, testing for serial correlation and adjusting where needed. The second objective of this study is to investigate the potential impact that short-run business cycle instability, via the unemployment rate, might have on the longer-run income variation trend. This objective extends previous analysis of this topic (Amos [15] [16]). In particular, this study extends a smaller scale analysis of the relation between regional income variation and unemployment rates for five regions in Oklahoma (Amos and Ireland [17] [18]).

2. Methodology and Expectations

As noted, previous analysis of regional income variation in the United States (Amos [6] [9]) provides evidence of increasing variation, or divergence, beginning in the mid-1970s, in contrast to expectations of continued convergence. Amos [6] employed Bureau of Economic Analysis population and per capita income data for U.S. counties from 1969-1983. Amos [9] updated the data range to 2006. This current study extends the data range to 2013[1].

The foundation of this analysis of regional income variation is a measure (V_w) first presented by Williamson [1], which is used to estimate the population-weighted variation of per capita among counties within each state:

$$V_w = \frac{\sqrt{\Sigma\left(Y_i - Y\right)^2 p_i / p}}{Y}$$

where V_w = the weighted variation of regional income, Y_i = per capita personal income in county i, Y = per capita personal income of the state, p_i = population in county i, and p = total population in the state. This measure is estimated for each state for the period 1969 to 2013. A higher (or increasing) value for V_w indicates greater income inequality (or divergence) and a lower (or decreasing) value indicates lesser inequality (or convergence). And of course, no change in V_w not only indicates a period of stasis but also might suggest a transition from convergence to divergence or divergence to convergence.

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[1] Detailed population and per capita income for counties in the U.S. is released with some time lag. When this research was begun, the most recent year of complete data was 2013. More importantly, the update to 2013 includes the recessionary downturn from 2008 to 2009 and thus provides additional data on the possible short-run impact on the long-run trend.

Previous studies (Amos [6] [9]) estimated for the combined 50 states simple linear and quadratic regression Equations on per capita income to capture the dynamic convergence or divergence of V_w over the course of development.

$$V_w = \alpha + \beta Y \tag{1}$$

$$V_w = \alpha + \beta Y + \gamma Y^2 \tag{2}$$

$$V_w = \alpha + \beta Y + \gamma Y^2 + \varphi CN \tag{3}$$

where: V_w is the variation of per capita personal income among the counties in each state weighted by population of the county, Y = state per capita personal income, and CN = the number of counties in each state. Convergence is indicated if $\beta < 0$ in Equation (1) and/or $\beta < 0$, $\gamma < 0$ in Equation (2). Convergence is also indicated if in Equation (2) $\beta > 0$, $\gamma < 0$, and $\beta < -2\gamma Y$ or if $\beta < 0$, $\gamma > 0$, and $\beta < -2\gamma Y$. Divergence is then indicated if $\beta > 0$ in Equation (1) and/or $\beta > 0$, $\gamma > 0$ in Equation (2). Divergence can also be indicated in Equation (2) if $\beta > 0$, $\gamma < 0$, and $\beta > -2\gamma Y$ or if $\beta < 0$, $\gamma > 0$ and $\beta > -2\gamma Y$. Rather than general statements of divergence/convergence for the entire 1969-2013 time period of analysis, some of these conditions determine divergence/convergence based on specific values of per capital income. The number of counties in each state variable has proven consistently significant in previous panel and cross-section analysis (Amos [9]).

Figure 1 illustrates alternative convergence/divergence possibilities based on parameter values noted in the preceding paragraph. The first four stages, I through IV, are the standard Kuznets inverted-U. The reoccurrence of Stages I and II and beyond then illustrate the onset of an augmented "new" U-pattern hypothesized by Amos [6] as the economy transitions into a new growth pole in the latter stages of development. Stage I (segment a-b) is achieved if $\beta > 0$ and $\gamma > 0$, or if $\beta < 0$, $\gamma > 0$ and $\beta > -2\gamma Y$. Stage II (segment b-c) is indicated if $\beta > 0$,

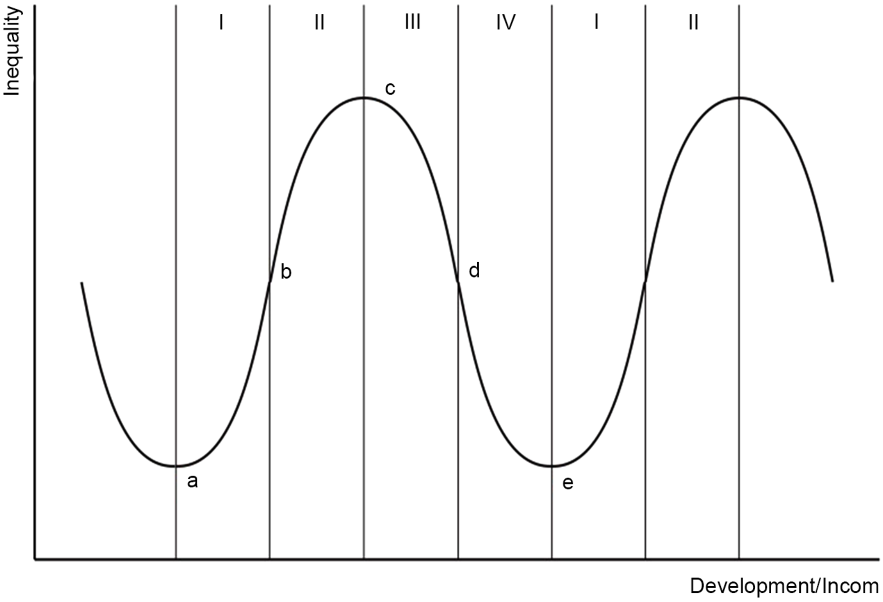

Figure 1. Hypothesized regional income variation.

$\gamma < 0$, and $\beta > -2\gamma Y$. Stage III (segment c-d) results if $\beta < 0$ and $\gamma < 0$, or if $\beta > 0$, $\gamma < 0$, and $\beta < -2\gamma Y$. And stage IV (segment d-e) is consistent with $\beta < 0$, $\gamma > 0$, and $\beta < -2\gamma Y$. It is possible that a given state might be in one stage at the beginning of the time period of analysis, but then move into a different stage before the end of the time period.

While, standard Ordinary Least Squares (OLS) regression techniques were used in the two previous studies (Amos [6] [9]) to analyze prospective convergence or divergence among the states, this study provides special panel estimators and tests for serial correlation and adjusts where needed.

Building on the pilot study analysis of regional income variation within regions in Oklahoma (Amos and Ireland [18]), this study also investigates how short-run business cycle instability, captured by the unemployment rate, might affect regional income variation. The baseline models, Equations (1), (2), and (3) are thus modified to include the unemployment rate.

$$V_w = \alpha + \beta Y + \delta U \tag{4}$$

$$V_w = \alpha + \beta Y + \gamma Y^2 + \delta U \tag{5}$$

$$V_w = \alpha + \beta Y + \gamma Y^2 + \delta U + \varphi CN \tag{6}$$

where: V_w is again the population-weighted variation of per capita personal income among the counties in each state, Y = state per capita personal income, U = state unemployment rate, and CN = the number of counties in each state. As with the baseline analysis, the Equations are initially estimated using OLS and panel estimators, then re-estimated if necessary with a serial correlation adjustment.

The question is whether shorter-run increases in the unemployment rate will counter or reinforce the longer-run development trend. Preliminary analysis of Oklahoma by Amos and Ireland [18] suggests that higher rates of unemployment disrupt the divergence of per capita income. Presumably increases in the unemployment rate have a greater impact on those counties that experience relatively greater increases in per capita income, thus dampening the increase in regional income variation. This is expected if the more urbanized areas in a state grow relatively faster that less urbanized areas, hence triggering the divergence regional income variation, which is consistent with the growth pole cycle (Amos [10]), and thus are also more susceptible to short-run business cycle instability.

3. Results and Analysis: Panel Data

The analysis of regional income variation in the United States from 1969-2013 begins with panel data (pooled cross section-time series) for all 50 states. First, panel data are used to estimate Equations (1), (2), and (3) so as to provide a baseline update of Amos [6] [9] with standard OLS regression techniques as well as special panel estimators assuming either fixed or random effects. Second, an alternative set of estimates of Equations (1), (2), and (3) is undertaken with the panel data for all 50 states after testing for serial correction and adjusting where needed. Third, unemployment rates are included, estimating Equations (4), (5), and (6) for a nation-wide, 50-state test of the possible affect of short-run instability on long-term convergence/divergence suggested in Amos and Ireland [18]. All state and county data concerning per capita income, population, and number of counties within a state was acquired from the Department of Commerce, Bureau of Economic Analysis. The Department of Labor, Bureau of Labor Statistics was the source for all state level unemployment rates.

3.1. Baseline

Table 1 presents results from the baseline analysis of OLS estimates of Equations (1), (2), and (3) using panel (pooled cross section-time series) data for all 50 states from 1969-2013. The simplest model, the regression of V_w on per capita income, presented in Table 1 clearly indicates a general divergence trend with all estimation techniques. The β coefficient of per capita income (0.001374 with OLS and 0.001345 with random effects GLS estimation) is positive and statistically significant[2]. The clear implication is that an increase in per capita income over the 1969-2013 time period results in greater regional income variation, or the divergence of regional incomes. Given that previous analysis suggests that diverging regional incomes began in the mid-1970s, this is the expected result and in line with other analyses.

The quadratic version of the model, Equation (2), estimated when the squared value of per capita income, is added, supports the previous conclusion. The β coefficient is positive and statistically significant and the γ coefficient is negative and not statistically significant with OLS but statistically significant with the random effects model. Previous analysis using the 1969-2006 data range (Amos [9]), shows the γ term as positive and statistically significant. The addition of 7 years of data suggests that the divergence trend might be diminishing in the most recent time period, increasing at a decreasing rate.

As expected, the inclusion of the number of counties variable is positive and statistically significant. Moreover, per capita income remains positive and statistically insignificant, while per capita income squared changes from negative to positive, but statistically significant in the OLS model. In the random effects model per capita income is significantly positive and per capita income squared remains negative and statistically significant. All forms support the divergence pattern[3].

3.2. Serial Correlation Adjustment

Durbin-Watson coefficients presented for the three estimated Equations in Table 1, in the range of 0.09 to 0.11, indicate the presence of serial correlation. Table 2 presents estimates of the three equations after adjusting for serial correlation with a maximum likelihood estimator.

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[2] The random effects estimation form of the pooled panel data proved superior to the fixed effects form and is, therefore, used in all of the discussion and analysis.

[3] Average and ending levels of per capita income (Y) are both considered in all analyses when examining the $\beta > -2\gamma Y$ ($\beta < -2\gamma Y$) condition required for divergence (convergence) when $\beta > 0$ (<0) and $\gamma < 0$ (>0). Per capita income is measured in 000s of dollars.

Table 1. Pooled cross-section time series results, OLS and random effects regional income variation (1969-2013).

Equation	Intercept	Per Capita Personal Income (t-statistic)	Per Capita Personal Income Squared (t-statistic)	Number of Counties (t-statistic)	Adjusted R^2	Durbin-Watson
OLS						
(1)	0.141708 (65.71)*	0.001374 (15.45)*			0.0956	0.0949
(2)	0.139969 (41.30)*	0.001585 (4.81)*	−0.00004 (−0.66)		0.0954	0.0954
(3)	0.112588 (33.02)*	0.001249 (4.10)*	0.000004 (0.80)	0.000468 (20.00)*	0.2319	0.1068
Random Effects						
(1)	0.142310 (20.53)*	0.001345 (33.65)*			0.0956	0.0495
(2)	0.137128 (19.50)*	0.001986 (13.56)*	−0.000013 (−4.54)*		0.0946	0.0500
(3)	0.107370 (10.37)*	0.001972 (13.47)*	−0.000013 (−4.48)*	0.000487 (3.64)*	0.2272	0.0584

$^{+}$Significant at 0.10 level; ^Significant at 0.05 level; *Significant at 0.01 level.

Table 2. Pooled cross-section time series results, serial correlation adjustment regional income variation (1969-2013).

Equation	Intercept	Per Capita Personal Income (t-statistic)	Per Capita Personal Income Squared (t-statistic)	Number of Counties (t-statistic)	Adjusted R^2	Durbin-Watson
(1)	0.154951 (20.30)*	0.000761 (13.52)*			0.9201	2.1128
(2)	0.181857 (21.12)*	−0.002352 (−7.47)*	0.000062 (10.04)*		0.9237	2.0855
(3)	0.153383 (18.98)*	−0.002567 (−8.47)*	0.000066 (11.14)*	0.000497 (13.71)*	0.9296	2.0883

$^{+}$Significant at 0.10 level; ^Significant at 0.05 level; *Significant at 0.01 level.

Estimate of Equation (1) is comparable to that without serial correlation adjustment. The β coefficient for per capita income is positive and statistically significant. Once again this indicates a general divergence trend over the time period of the analysis. Estimate of Equation (2), however, presents a sign reversal and changes in statistical significance. The β and γ coefficients change from positive/negative in the baseline analysis to negative/positive. In addition, the γ coefficient is statistically significant. The adjustment for serial correlation appears to enable the model to capture more of the early period of transformation from convergence to divergence[4].

Once again, including the number of counties in each state has no significant impact on the results. The county variable is statistically significant, as expected, but the signs of the β and γ coefficients remain negative/positive and statistically significant. These findings still indicate divergence.

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[4] As noted in section 2 of this paper, the indication, of convergent or divergent behavior depends not only on the signs of β and γ, but also the relationship between β and $2\gamma Y$. The change in the coefficients of β and γ from positive/negative in the baseline to negative/positive for the serial correlation adjustment can still indicate divergent behavior in the latter case (albeit an earlier stage) if $\beta > -2\gamma Y$. Using both average and ending levels of U.S. per capita income over the period of analysis, this condition is found to be true throughout this analysis and divergence is "indicated".

3.3. Unemployment

Table 3 presents results from OLS, random effects, and serial correlation adjusted estimates in which the unemployment rate is included. As expected the unemployment is negative and statistically significant, with and without inclusion of the number of counties variable. The clear implication is that unemployment associated with short-run cyclical instability disrupts the long-run trend of increased regional income variation. Apparently those counties within each state most affected by unemployment are also the ones leading the divergence of regional income variation.

4. Results and Analysis: State by State

This second analysis is undertaken using time series data for each of the 50 states. While results from pooled models are useful, certain tests (not reported here) indicate that more valuable information may be obtained by examining states separately. Equation (5) is estimated first using standard OLS regression techniques and subsequently adjusting for serial correlation where needed[5].

4.1. Ordinary Least Squares

Table 4 presents OLS regression results for Equation (5) for all 50 states from 1969-2013. Adjusted R^2s range from of low of 0.0219 for Louisiana to a high of 0.9623 for Pennsylvania. In all, 21 of the state regression Equations had R^2s of 0.8 or greater and only 17 states had R^2s of less than 0.5.

Preliminary evidence of possible divergence/convergence can be examined via the signs and significance of the regression coefficients in Equation (5). The coefficients of per capita income (β) and per capita income squared (γ) are positive and negative, respectively, and statistically significant in 35 of the 50 states. Three other states (Alabama, Arkansas, and Nevada) exhibit the same positive/negative set of signs, but no statistically significant coefficients. Rhode Island and South Dakota also exhibit the positive/negative signs, but only the β coefficient for per capita income is statistically significant in each.

The positive/negative coefficients suggests that regional income variation is most likely increasing over the time period of analysis, but beginning to level off, possibly approaching the peak of an inverted-U. Previous analyses in Amos [6] [9] indicate that divergence began around 1980, which would then continue until 2030 or so. The 1969-2013 period of analysis is expected to include a significant amount of divergence, with evidence of approaching the peak.

Of the remaining 10 states, only 5 have statistically significant values for both coefficients. Mississippi, Montana, North Dakota, and Virginia exhibit statistically significant negative/positive values for β and γ. Colorado has statistically significant positive values for both coefficients. Whereas the first four states might capture a notable portion of pre-1980 convergence before the onset of divergence during the time period of analysis, Colorado might be relatively farther

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[5] Focus is placed on Equation (5) instead of Equation (4) in this state analysis due to its more complete form of the relationships and similarity of results.

from the inverted-U peak than those states with a negative γ value.

The final 5 states exhibit a mix of negative and positive values for β and γ, with a mix of statistical significance, as well. Georgia and Utah have statistically significant positive β values, but no significance for the positive γ coefficient. Like Colorado, Tennessee exhibits positive/positive values for the coefficients, but while close, neither achieves the minimum accepted standards for statistical significance. Louisiana and Oklahoma have negative/positive coefficient values, like Mississippi, Montana, North Dakota, and Virginia, but only the β coefficient of per capital income for Oklahoma is statistically significant.

4.2. Ordinary Least Squares: Unemployment

The unemployment rate is also in the OLS regression estimates included in Table 4.

The vast majority of the states, 36, have statistically significant negative δ coefficients for unemployment. This reinforces preceding panel data analysis that higher unemployment disrupts the longer-run divergence trend. Of the

Table 3. Pooled cross-section time series results, OLS, random effects, and serial correlation adjustment regional income variation (1969-2013).

Equation	Intercept	Per Capita Personal Income (t-statistic)	Per Capita Personal Income Squared (t-statistic)	Unemployment Rate (t-statistic)	Number of Counties (t-statistic)	Adjusted R^2	Durbin-Watson
OLS							
(4)	0.147326 (38.43)*	0.001376 (15.48)*		−0.000962 (−1.77)$^{+}$		0.0965	0.0929
(5)	0.145674 (31.00)*	0.001569 (4.76)*	−0.000004 (−0.60)	−0.000952 (−1.75)$^{+}$		0.0962	0.0933
(6)	0.117476 (25.79)*	0.001236 (4.06)*	0.000005 (0.85)	−0.000810 (−1.61)	0.000467 (19.99)*	0.2324	0.1046
Random Effects							
(4)	0.159801 (22.38)*	0.001358 (34.92)*		−0.003022 (−11.24)*		0.0911	0.0489
(5)	0.155054 (21.39)*	0.001892 (13.24)*	−0.000011 (−3.88)*	−0.002949 (−10.98)*		0.0906	0.0491
(6)	0.126891 (12.02)*	0.001880 (13.16)*	−0.000011 (−3.83)*	−0.002927 (−10.90)*	0.000458 (3.42)*	0.2226	0.0573
Serial Correlation							
(4)	0.163627 (21.10)*	0.000879 (15.01)*		−0.001901 (−6.60)*		0.9216	2.1415
(5)	0.185917 (21.71)*	−0.001979 (−6.15)*	0.000056 (9.03)*	−0.001429 (−4.97)*		0.9245	2.1108
(6)	0.157345 (19.55)*	−0.002251 (−7.25)*	0.000061 (10.19)*	−0.001194 (−4.31)*	0.000487 (13.47)*	0.9301	2.1113

$^{+}$Significant at 0.10 level; $^{\wedge}$Significant at 0.05 level; *Significant at 0.01 level.

Table 4. State OLS results for Equation (5) regional income variation (1969-2013).

State	Intercept (t-statistic)	Per Capita Personal Income (t-statistic)	Per Capita Personal Income Squared (t-statistic)	Unemployment Rate (t-statistic)	Adjusted R^2	Durbin-Watson
Alabama	0.177422 (30.58)*	0.000693 (1.25)	−0.000003 (−0.24)	−0.00335 (−5.69)*	0.5589	0.6627
Alaska	0.035933 (0.93)	0.006568 (5.36)*	−0.000107 (−5.24)*	0.002376 (0.74)	0.4145	1.3673
Arizona	0.105727 (15.84)*	0.005981 (9.82)*	−0.000128 (−8.68)*	−0.002184 (−2.85)*	0.7211	0.5599
Arkansas	0.169081 (20.87)*	0.000874 (1.37)	−0.000012 (−0.77)	−0.001406 (−1.37)	0.1256	1.0907
California	0.091784 (7.92)*	0.006758 (8.91)*	−0.000049 (−3.37)*	−0.003857 (−3.18)*	0.9308	0.5547
Colorado	0.173971 (54.39)*	0.001141 (4.54)*	0.000010 (2.08)^	−0.001408 (−3.02)*	0.9508	1.4929
Connecticut	0.129428 (8.81)*	0.003845 (5.60)*	−0.000023 (−2.15)^	−0.005143 (−3.19)*	0.8836	0.5500
Delaware	0.119873 (12.19)*	0.002558 (3.83)*	−0.000050 (−3.61)*	0.000082 (0.07)	0.2379	0.7359
Florida	0.146590 (24.12)*	0.005101 (9.26)*	−0.000079 (−6.60)*	−0.002941 (−4.11)*	0.8122	0.7275
Georgia	0.237884 (27.80)*	0.001589 (2.11)^	0.000021 (1.18)	−0.006503 (−5.99)*	0.8280	0.8424
Hawaii	0.052149 (3.59)*	0.003005 (3.26)*	−0.000036 (−1.95)+	0.001514 (0.84)	0.4633	1.1239
Idaho	0.140431 (15.56)*	0.009620 (12.47)*	−0.000175 (−8.74)*	−0.007951 (−6.81)*	0.9137	1.0014
Illinois	0.107333 (15.79)*	0.007402 (13.80)*	−0.000118 (−11.10)*	−0.004847 (−6.43)*	0.8723	0.8557
Indiana	0.090604 (28.34)*	0.004208 (14.24)*	−0.000059 (−8.32)*	−0.001743 (−5.71)*	0.9533	1.2914
Iowa	0.085548 (13.26)*	0.002448 (4.75)*	−0.000040 (−3.65)*	0.000072 (0.07)	0.4482	1.9602
Kansas	0.161759 (19.39)*	0.008342 (15.04)*	−0.000140 (−11.83)*	−0.008267 (−4.95)*	0.8805	1.1456
Kentucky	0.219737 (23.99)*	0.003726 (4.25)*	−0.000109 (−4.80)*	−0.003852 (−3.65)*	0.4767	0.4881
Louisiana	0.185270 (15.70)*	−0.001491 (−1.54)	0.000026 (1.19)	−0.000460 (−0.34)	0.0219	0.7805
Maine	0.108041 (9.68)*	0.003501 (5.22)*	−0.000055 (−3.60)*	−0.003271 (−2.67)^	0.7302	0.8379
Maryland	0.192568 (33.14)*	0.002811 (9.20)*	−0.000034 (−6.39)*	−0.002861 (−3.46)*	0.8307	0.9233
Massachusetts	0.088486 (12.01)*	0.003458 (9.61)*	−0.000033 (−5.52)*	−0.001398 (−1.70)+	0.9089	0.3866
Michigan	0.149406 (22.25)*	0.007135 (12.47)*	−0.000122 (−9.03)*	−0.004112 (−8.66)*	0.9224	0.6201
Minnesota	0.184067 (21.24)*	0.003176 (6.06)*	−0.000057 (−5.54)*	−0.001842 (−1.46)	0.4955	0.9940
Mississippi	0.192912 (31.75)*	−0.001708 (−2.55)^	0.000047 (2.53)^	−0.002062 (−3.09)*	0.2765	1.1501
Missouri	0.228659 (27.36)*	0.003959 (6.10)*	−0.000081 (−5.44)*	−0.005116 (−4.82)*	0.5893	1.1995
Montana	0.160189 (11.04)*	−0.002330 (−2.90)*	0.000046 (2.47)^	−0.002373 (−1.27)	0.1409	1.2194
Nebraska	0.101962 (7.33)*	0.0040186 (4.58)*	−0.000073 (−4.02)*	−0.001609 (−0.52)	0.3268	1.2351
Nevada	0.089984 (14.11)*	0.000546 (1.01)	−0.000003 (−0.30)	−0.000406 (−0.75)	0.1766	0.6785
New Hampshire	0.073901 (11.51)*	0.002350 (5.78)*	−0.000027 (−3.46)*	−0.002666 (−2.67)^	0.7325	0.4095
New Jersey	0.116207 (17.56)*	0.005313 (16.62)*	−0.000059 (−11.03)*	−0.003578 (−5.35)*	0.9597	0.6276
New Mexico	0.162952 (13.26)*	0.010421 (11.64)*	−0.000274 (−11.75)*	−0.005329 (−3.39)*	0.7573	0.4595
New York	0.272531 (13.47)*	0.011008 (11.02)*	−0.000111 (−6.37)*	−0.010541 (−4.43)*	0.9146	0.5252
North Carolina	0.171237 (30.25)*	0.002546 (4.91)*	−0.000052 (−4.07)*	−0.002406 (−3.41)*	0.4754	0.8457

Continued

North Dakota	0.162583 (4.41)*	−0.005003 (−3.62)*	0.000123 (5.05)*	0.001341 (0.19)	0.4621	1.2623
Ohio	0.112965 (33.66)*	0.002378 (7.63)*	−0.000026 (−3.66)*	−0.001057 (−3.01)*	0.8864	0.8486
Oklahoma	0.239868 (28.60)*	−0.001410 (−2.03)*	0.000009 (0.62)	−0.003759 (−2.77)*	0.4972	0.9007
Oregon	0.121124 (16.57)*	0.002681 (4.79)*	−0.000041 (−3.15)*	−0.002274 (−3.07)*	0.6344	0.7244
Pennsylvania	0.138445 (27.61)*	0.006237 (18.07)*	−0.000080 (−11.27)*	−0.004243 (−7.60)*	0.9623	0.7083
Rhode Island	0.040790 (4.98)*	0.002818 (5.37)*	−0.000004 (−0.41)	−0.003395 (−4.17)*	0.9192	0.5591
South Carolina	0.133546 (25.75)*	0.002085 (4.38)*	−0.000033 (−2.65)^	−0.002189 (−3.66)*	0.5976	0.7102
South Dakota	0.125080 (12.02)*	0.001003 (1.71)+	−0.000005 (−0.47)	0.006514 (2.79)*	0.4306	1.7036
Tennessee	0.179807 (39.26)*	0.000639 (1.55)	0.000015 (1.50)	−0.001541 (−2.99)*	0.7922	0.7501
Texas	0.198903 (36.58)*	0.004958 (8.87)*	−0.000093 (−7.93)*	−0.005089 (−5.09)*	0.6614	0.9626
Utah	0.115188 (20.70)*	0.002398 (5.42)*	0.000010 (0.96)	0.000958 (1.37)	0.9488	0.6311
Vermont	0.062206 (11.73)*	0.004564 (15.35)*	−0.000091 (−14.79)*	−0.000861 (−1.29)	0.8828	1.0817
Virginia	0.193958 (52.29)*	−0.001757 (−6.86)*	−0.000037 (7.58)*	−0.002384 (−3.81)*	0.6169	0.7586
Washington	0.116885 (8.13)*	0.007892 (10.61)*	−0.000103 (−7.20)*	−0.004484 (−3.47)*	0.9114	0.7774
West Virginia	0.180538 (52.31)*	0.000768 (2.09)^	−0.000030 (−3.08)*	−0.001738 (−5.72)*	0.4627	0.9677
Wisconsin	0.141757 (28.28)*	0.001996 (5.27)*	−0.000022 (−2.73)*	−0.003118 (−5.27)*	0.7930	0.7887
Wyoming	0.163662 (11.31)*	0.009984 (9.11)*	−0.000119 (−6.07)*	−0.018123 (−7.49)*	0.8562	0.7163

+Significant at 0.10 level. ^Significant at 0.05 level. *Significant at 0.01 level.

remaining 14 states without statistically significant negative δ coefficients, only one, South Dakota, has a statistically significant positive δ coefficient value. Arkansas, Minnesota, Montana and Vermont have the expected negative δ coefficient values and are close to statistical significance, but fall short of the accepted threshold. In contrast, Utah is also close to statistical significance, while falling short of the accepted threshold, but like South Dakota has a positive unemployment rate coefficient. The remaining 8 states have either positive or negative coefficient values, but are nowhere close to statistical significance.

4.3. Serial Correlation Adjustment

Table 5 presents regression results for Equation (5) from 1969-2013 for the 47 states requiring adjustment for serial correlation using a maximum likelihood estimator (excluding Iowa, South Dakota, and Colorado). R^2s range from of low of 0.2408 for Montana to a high of 0.9786 for New Jersey. In all, 26 of the state regression Equations had R^2s of 0.8 or greater and only 6 states had R^2s of less than 0.5.

Adjusting for serial correlation reduces the total number of states that exhibit statistically significant positive/negative values for both β and γ from 35 to 25. This continues to suggest evidence for the possible divergence of regional incomes during the time period of analysis. A dozen additional states also exhibit

Table 5. State serial correlation results for Equation (5) regional income variation (1969-2013).

State	Intercept (t-statistic)	Per Capita Personal Income (t-statistic)	Per Capita Personal Income Squared (t-statistic)	Unemployment Rate (t-statistic)	Adjusted R^2	Durbin-Watson
Alabama	0.178864 (17.24)*	0.000289 (0.23)	0.0000006 (0.02)	−0.002690 (−3.28)*	0.7178	2.2015
Alaska	0.080329 (1.66)	0.005529 (3.38)*	−0.000093 (3.40)*	−0.001173 (−0.29)	0.4596	2.0058
Arizona	0.111346 (8.62)*	0.004231 (2.36)*	−0.000084 (−1.91)+	−0.001202 (−1.69)+	0.8708	1.6126
Arkansas	0.174505 (15.74)*	0.000656 (0.70)	−0.000008 (−0.35)	−0.001951 (−1.45)	0.2749	2.0559
California	0.086875 (5.11)*	0.006254 (4.28)*	−0.000042 (−1.59)	−0.002259 (−1.76)+	0.9662	1.4796
Connecticut	0.123213 (5.78)*	0.002747 (1.47)	−0.000005 (−0.20)	−0.002387 (−1.63)	0.9471	1.8740
Delaware	0.128007 (9.51)*	0.002095 (1.91)+	−0.000040 (−1.81)+	−0.000695 (−0.52)	0.5318	1.7738
Florida	0.144608 (3.19)*	0.000102 (−0.04)	0.000061 (1.50)	−0.001586 (−2.02)^	0.9023	1.4540
Georgia	0.217441 (13.99)*	0.002260 (1.29)	−0.000006 (−0.14)	−0.002930 (−1.97)+	0.8922	1.8031
Hawaii	0.044553 (2.40)^	0.002794 (2.01)+	−0.000032 (−1.18)	0.003736 (1.59)	0.5482	2.2550
Idaho	0.129047 (9.62)*	0.009675 (7.64)*	−0.000177 (−5.50)*	−0.006124 (−3.44)*	0.9336	1.9186
Illinois	0.109519 (10.36)*	0.006834 (6.87)*	−0.000108 (−5.72)*	−0.004188 (−4.05)*	0.9097	1.8619
Indiana	0.090037 (22.43)*	0.004161 (10.68)*	−0.000058 (−6.26)*	−0.001576 (−4.06)*	0.9583	1.9888
Kansas	0.161228 (16.64)*	0.008098 (10.17)*	−0.000136 (−8.22)*	−0.007528 (−4.30)*	0.8985	2.1490
Kentucky	0.240158 (10.27)*	−0.000033 (−0.01)	−0.000026 (−0.38)	−0.002082 (−1.67)	0.7627	1.8986
Louisiana	0.206829 (10.33)*	−0.001770 (−0.98)	0.000028 (0.71)	−0.003013 (−1.62)	0.3781	1.4699
Maine	0.099483 (7.26)*	0.003252 (2.63)^	−0.000052 (−1.88)+	−0.001227 (−0.88)	0.8080	2.0286
Maryland	0.190364 (25.70)*	0.002883 (6.09)*	−0.000035 (−4.38)*	−0.002600 (−2.72)*	0.8742	1.7470
Massachusetts	0.083472 (8.84)*	0.003414 (4.97)*	−0.000032 (−2.95)*	−0.000643 (−0.99)	0.9679	1.4935
Michigan	0.148116 (14.88)*	0.006902 (6.55)*	−0.000116 (−4.73)*	−0.003849 (−6.80)*	0.9580	1.9893
Minnesota	0.185937 (17.15)*	0.002802 (3.35)*	−0.000051 (−3.17)*	−0.001395 (−0.95)	0.6036	1.9489
Mississippi	0.193744 (22.69)*	−0.002204 (−2.08)^	0.000057 (2.02)^	−0.001559 (−1.58)	0.3305	1.9595
Missouri	0.230277 (22.07)*	0.003624 (3.91)*	−0.000075 (−3.59)*	−0.004790 (−3.73)*	0.6281	1.9297
Montana	0.147627 (7.07)*	−0.002076 (−1.89)+	0.000043 (1.69)+	−0.000796 (−0.32)	0.2408	2.0692
Nebraska	0.104663 (6.26)*	0.003651 (3.08)*	−0.000066 (−2.73)*	−0.001426 (−0.39)	0.4096	1.9343
Nevada	0.095164 (10.01)*	0.000054 (0.05)	0.000008 (0.42)	−0.000648 (−1.02)	0.5258	1.4937
New Hampshire	0.0666231 (7.07)*	0.002461 (3.19)*	−0.000028 (−2.08)^	−0.001459 (−1.90)+	0.9046	1.7087
New Jersey	0.116808 (13.20)*	0.004821 (6.18)*	−0.000050 (−3.71)*	−0.003141 (−4.39)*	0.9786	1.8212
New Mexico	0.160577 (7.14)*	0.005349 (1.92)+	−0.000137 (−2.01)+	−0.000676 (−0.58)	0.9281	1.1618
New York	0.255746 (9.51)*	0.011075 (5.76)*	−0.000114 (−3.58)*	−0.008054 (−3.44)*	0.9604	1.7906
North Carolina	0.170688 (20.49)*	0.002124 (2.23)^	−0.000045 (−2.02)^	−0.001496 (−1.74)+	0.6415	2.0013
North Dakota	0.137720 (2.94)*	−0.005176 (−2.85)*	0.000133 (4.14)*	0.006905 (0.76)	0.5089	1.8541

Continued

Ohio	0.116242 (22.08)*	0.002076 (3.82)*	−0.000019 (−1.61)	−0.00147 (−2.55)^	0.9197	2.0354
Oklahoma	0.234242 (4.49)*	−0.005425 (−1.84)+	0.000136 (2.83)*	−0.003816 (−2.63)*	0.6880	2.0681
Oregon	0.120405 (12.44)*	0.002713 (2.88)*	−0.000042 (−1.98)+	−0.002208 (−2.69)*	0.7762	1.6174
Pennsylvania	0.138254 (13.82)*	0.005404 (5.23)*	−0.000066 (−3.39)*	−0.002738 (−3.24)*	0.9756	1.9218
Rhode Island	0.029192 (2.60)^	0.003257 (3.38)*	−0.000017 (−0.92)	−0.001808 (−2.23)^	0.9632	1.4764
South Carolina	0.137700 (12.81)*	0.000728 (0.46)	−0.000003 (−0.08)	−0.001052 (−1.58)	0.7456	1.6017
Tennessee	0.179970 (26.45)*	0.000391 (0.54)	0.000019 (1.17)	−0.001210 (−1.85)+	0.8693	2.0811
Texas	0.213632 (6.80)*	0.000166 (0.08)	0.000026 (0.64)	−0.004126 (−3.57)*	0.7830	1.8866
Utah	0.113720 (15.80)*	0.002828 (3.57)*	−0.0000006 (−0.03)	0.000605 (0.89)	0.9715	1.7463
Vermont	0.067992 (10.72)*	0.004168 (9.04)*	−0.000082 (−8.42)*	−0.001400 (−1.93)+	0.9053	2.0014
Virginia	0.184526 (19.42)*	−0.001315 (−1.62)	−0.000022 (1.51)*	0.000202 (0.31)*	0.7981	1.4725
Washington	0.113308 (7.13)*	0.007750 (6.74)*	−0.000101 (−4.56)*	−0.003784 (−2.93)*	0.9423	1.7692
West Virginia	0.184733 (29.93)*	0.000227 (0.31)	−0.000018 (−0.97)*	−0.001679 (−3.73)*	0.5135	1.8867
Wisconsin	0.138937 (17.74)*	0.001859 (2.46)^	−0.000023 (−1.46)	−0.002025 (−2.61)^	0.8589	1.7162
Wyoming	0.155309 (5.52)*	0.007356 (2.91)*	−0.000076 (−1.80)+	−0.011150 (−3.50)*	0.9186	1.4629

+Significant at 0.10 level; ^Significant at 0.05 level. *Significant at 0.01 level.

the positive/negative coefficient values but lack statistical significance in one or both. Seven of those 12 states, however, have statistically significant β coefficient values. And in three of those 7 states the coefficient of the quadratic term falls just below the accepted level of statistical significance.

Four other states, Alabama, Nevada, Tennessee and Texas, also have a positive/positive coefficient sequence, but none are statistically significant. The remaining 8 states have negative β coefficient values. For Mississippi Montana, North Dakota, and Oklahoma the β coefficient is statistically significant as is the positive γ coefficient value, suggesting that they exhibit a notable amount of convergence in the time period of analysis before possibly undertaking divergence. For the other four states, Florida, Kentucky, Louisiana, and Virginia, neither β nor γ is statistically significant.

4.4. Serial Correlation Adjustment: Unemployment

Results presented in Table 5 also include estimates of the δ coefficient for the unemployment rate. After adjusting for serial correlation, 30 of the 50 states have statistically significant δ coefficient values. Of those only one state, South Dakota, has a positive value. The other 29 have the expected negative value. The 20 states lacking statistical significance for δ have a mix of positive and negative values. However, six states with negative coefficient values (Arkansas, Connecticut, Kentucky, Louisiana, Mississippi, and South Carolina) fall just below the threshold of statistical significance. Only one state with a positive δ coefficient (Hawaii) is close to statistical significance. The remaining 13 states exhibit no discernible relationship between the unemployment rate and regional income variation.

4.5. Analysis of Stages

Estimated results of Equation (5) of all 50 states using standard OLS, and then after adjusting for serial correlation where needed, are used to determine which stage each state is in based on a comparison of signs for β, γ and the relationship between β and $-2\gamma Y$. Three separate calculations are made: 1) based on per capita income at the beginning of the time period (1969), 2) using an average per capita income for the all years, and 3) then using per capita income at the end of the time period (2013). These results are presented in Table 6.

Using per capita income at the beginning of the time period (1969), the vast majority of states, 43, exhibit unquestionable divergence with the new inverted U (Stages I or II) using both OLS and serial correlation estimations. Only six states have evidence of convergence (Stages III or IV) at the beginning of the study period (Louisiana, Mississippi, Montana, North Dakota, Oklahoma, and Virginia). One state, Kentucky, provides mixed results with divergence indicated by OLS and convergence with serial correlation estimates.

Similar results are obtained using average per capita income for the 45 years of data. In this case 42 states exhibit unquestionable divergence into the new inverted U using both OLS and serial correlation estimations. North Dakota has evidence of convergence for OLS and divergence for serial correlation estimates. The remaining 7 states exhibit convergence using both OLS and serial correlation. Kentucky (only in the OLS form) and West Virginia are two states diverging using 1969 per capital income that converge using average per capital income. This provides overwhelming evidence that regional income variation increased for the majority of states during the time period of analysis.

Using per capita income for the final year of the study period (2013) provides interesting and unexpected results. Of the 42 states exhibiting divergence using average per capita income, 26 exhibit convergence using 2013 per capita income, again for both OLS and serial correlation estimates. Five additional states (Arkansas, Florida, South Carolina, Texas, and Wisconsin) show signs of convergence after divergence for at least one of the estimation procedures. These results suggest that several states may have passed through a Stage II and are entering a "new" Stage III, which is surprising because the onset of a new Stage III is not expected until on or around 2030.

The onset of a new Stage III is a tentative conclusion at best. It is possible that the observed convergence is but a short-run "blip" in the long-run divergence trend. Although inclusion of the unemployment rate is intended to capture short-run disruption of the long-run regional income variation trend, other forces might be at play. Given that much of the convergence occurs after the post-2007 housing market collapse, subsequent recession, and historic anemic recovery, the unemployment rate alone may not be sufficient to capture the overwhelming severity of this disruption. More study is clearly needed.

Table 6. Evaluation of state convergence and divergence[a].

State	1969	Average 1969-2013	2013
Alabama	Diverging	Diverging	Diverging
Alaska	Diverging	Diverging	Converging
Arizona	Diverging	Diverging	Converging
Arkansas	Diverging	Diverging	Diverging
California	Diverging	Diverging	Diverging
Colorado	Diverging	Diverging	Diverging
Connecticut	Diverging	Diverging	Diverging
Delaware	Diverging	Diverging	Converging
Florida	Diverging	Diverging	Diverging
Georgia	Diverging	Diverging	Diverging
Hawaii	Diverging	Diverging	Converging
Idaho	Diverging	Diverging	Converging
Illinois	Diverging	Diverging	Converging
Indiana	Diverging	Diverging	Converging
Iowa	Diverging	Diverging	Converging
Kansas	Diverging	Diverging	Converging
Kentucky	Converging	Converging	Converging
Louisiana	Converging	Converging	Diverging
Maine	Diverging	Diverging	Converging
Maryland	Diverging	Diverging	Converging
Massachusetts	Diverging	Diverging	Converging
Michigan	Diverging	Diverging	Converging
Minnesota	Diverging	Diverging	Converging
Mississippi	Converging	Converging	Diverging
Missouri	Diverging	Diverging	Converging
Montana	Converging	Converging	Diverging
Nebraska	Diverging	Diverging	Converging
Nevada	Diverging	Diverging	Diverging
New Hampshire	Diverging	Diverging	Converging
New Jersey	Diverging	Diverging	Converging
New Mexico	Diverging	Diverging	Converging
New York	Diverging	Diverging	Converging
North Carolina	Diverging	Diverging	Converging
North Dakota	Converging	Diverging	Diverging

Continued

Ohio	Diverging	Diverging	Diverging
Oklahoma	Converging	Converging	Diverging
Oregon	Diverging	Diverging	Converging
Pennsylvania	Diverging	Diverging	Converging
Rhode Island	Diverging	Diverging	Diverging
South Carolina	Diverging	Diverging	Diverging
South Dakota	Diverging	Diverging	Diverging
Tennessee	Diverging	Diverging	Diverging
Texas	Diverging	Diverging	Diverging
Utah	Diverging	Diverging	Diverging
Vermont	Diverging	Diverging	Converging
Virginia	Converging	Converging	Diverging
Washington	Diverging	Diverging	Converging
West Virginia	Diverging	Converging	Converging
Wisconsin	Diverging	Diverging	Converging
Wyoming	Diverging	Diverging	Converging

[a] Based on serial correlation adjustment results except for Colorado, Iowa, and South Dakota which do not require it.

5. Summary and Conclusions

This study sought to provide an updated and statistically improved investigation into regional income variation among the 50 states. Previous studies suggest that regional income variation began to increase in the mid-1970s, contrary to conventional wisdom that regional income converged in the latter stages of development.

With data updated from 2006 to 2013 and using improved statistical estimation techniques to adjust for serial correlation, the results are overwhelmingly indicative of regional income divergence over the past several decades. These results are consistent using standard OLS regression analysis and after adjusting for serial correlation and reinforce previous analyses that also indicate regional income divergence.

This study also sought to test for the impact of short-run stability, using the unemployment rate, on the long-run divergence trend. Results from a study of Oklahoma suggest that higher unemployment rates negatively impact regional income variation. This initial expectation is clearly confirmed with this analysis.

An unexpected implication from this study is that several states appear to be entering a new period of convergence after an extended period of divergence. While this pattern is consistent with the Growth Pole Cycle theory, the onset of convergence is at least a decade earlier than expected. The convergence onset is clearly a preliminary conclusion and needs additional years of data to determine if this is a short-run aberration or an actual change in the long-run trend. Suspicions of a short-run aberration are supported given that the new convergence coincided with 2007 housing market collapse, subsequent recession, and prolonged recovery. Including the unemployment rate might not have sufficiently captured the short-run impact caused by this disruption.

Evidence of regional income divergence and subsequently support of the Growth Pole Cycle theory has significant implications for social-economic activity in the coming decades. In particular, the Growth Pole Theory suggests that a significant economic and financial collapse is likely 100 years after, and comparable to, the 1930s Great Depression. It further suggests that a period of structural and institutional change is possible as the economy transitions from increasing income inequality (both regional and individual) that corresponds with the emergence of a technology-based industrial pole that benefits small segments of the economy to decreasing income inequality that results from the dispersion of this technology across the rest of the economy. Evidence of increasing regional income inequality is compelling enough that other implications of the Growth Pole Cycle theory should be carefully considered and evaluated.

References

[1] Williamson, J.G. (1965) Regional Inequality and the Process of National Development: A Description of Patterns. *Economic Development and Cultural Change*, **13**, 3-47. https://doi.org/10.1086/450136

[2] Kuznets, S. (1955) Economic Growth and Income Inequality. *American Economic Review*, **45**, 1-28.

[3] Perroux, F. (1970) Note sur la Notion de Pôle de Croissance. *Economic Appliquée*, 307-320. [Note on the Concept of Growth Poles. In: McKee, D., Dean, R. and Leahy, W., Eds., *Regional Economics*: *Theory and Practice*, The Free Press, New York, 93-104.]

[4] Hansen, N.M. (1967) Development Pole Theory in a Regional Context. *Kyklos*, **20**, 709-725. https://doi.org/10.1111/j.1467-6435.1967.tb00871.x

[5] Lasuen, J.R. (1969) On Growth Poles. *Urban Studies*, **6**, 137-161. https://doi.org/10.1080/00420986920080231

[6] Amos, O.M. (1988) Unbalanced Regional Growth and Regional Income Inequality in the Latter Stages of Development. *Regional Science and Urban Economics*, **18**, 549-566. https://doi.org/10.1016/0166-0462(88)90026-9

[7] Amos, O.M. (1989) An Inquiry into the Causes of Increasing Regional Income Inequality in the United States. *Review of Regional Studies*, **19**, 1-12.

[8] Amos, O.M. (1989) A Re-Evaluation of Long Cycle Theories: Development as the Satisfaction of Hierarchial Needs. *Social Science Quarterly*, **70**, 341-355.

[9] Amos, O.M. (2014) Evidence of Increasing Regional Income Variation: 1969-2006. *Modern Economy*, **5**, 520-532. https://doi.org/10.4236/me.2014.55049

[10] Amos, O.M. (1990) Growth Pole Cycles: A Synthesis of Growth Pole and Long Wave Theories. *Review of Regional Studies*, **20**, 37-48.

[11] Amos, O.M. (1995) Secular Seasons: Long Run Trends in Socio-Economic Behavior. *Papers in Regional Science*: *The Journal of the RSAI*, **74**, 187-204.

https://doi.org/10.1111/j.1435-5597.1995.tb00636.x

[12] Schumpeter, J.A. (1939) Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalistic Process, 2 Volumes. McGraw-Hill, New York.

[13] Kondratieff, N. (1935) Long Swings in Economic Life. *Review of Economics and Statistics*, **17**, 105-115. https://doi.org/10.2307/1928486

[14] Kondratieff, N. (1984) The Long Wave Cycle. Daniels, G., Trans., Richardson and Snyder, New York.

[15] Amos, O.M. (1983) The Sensitivity of Regional Income Variation to Cyclical Economic Fluctuations. *Review of Regional Studies*, **13**, 4-11.

[16] Amos, O.M. (2012) An Examination of Short-Run and Long-Run Factors Affecting Regional Income Inequality in the United States. 2012 *Conference Proceedings, Mid-Continent Regional Science Association*, 6-8 June 2012.

[17] Amos O.M. and Ireland, T.C. (2010) Oklahoma per Capita Personal Income: Converging or Diverging Trends? Missouri Valley Economic Association, St. Louis, MO.

[18] Amos O.M. and Ireland, T.C. (2015) An Analysis of Regional Income Variation among the Five Regions of Oklahoma. *Modern Economy*, **6**, 134-144. https://doi.org/10.4236/me.2015.62011