Spatial econometric analysis of regional income convergence: The case of North Carolina and Virginia

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ABSTRACT

The purpose of this study is to determine if and to what extent the states of North Carolina and Virginia display regional income convergence. This study utilizes growth theory as the theoretical foundation to explore this phenomenon. This paper uses OLS (ordinary least squares) as the proposed methodology. The researchers seek to answer the following research questions in this study: (a) Using a county-level of analysis, do the counties of Virginia and North Carolina exhibit regional income convergence? (b) Using a county-level of analysis, do the counties of Virginia and North Carolina exhibit regional sigma convergence? (c) Are there any significant changes in the structure of both of these metrics of convergence over time? (d) Is there evidence of spatial dependence in the county level growth rates in Virginia and North Carolina? (e) Does the additional of the spatial lag of growth rates improve the models of regional income convergence in our two states? Our results indicate that income convergence and spatial dependence found in the North Carolinian counties is more pronounced than those experienced in the Virginian Counties.

Keywords: Virginia, North Carolina, Per Capita Income, Convergence, County-Level Analysis, Spatial Lag Model

INTRODUCTION

Income growth and convergence also known as the catch-up effect has been studied extensively in the literature with most studies citing the works of Salow (1956). The benefits associated with the catch-up effect have been well documented in the literature when viewed through the lens of income convergence. The neo-classical premise behind this catch up effect is associated with the constructs of beta and sigma convergence. Beta convergence simply means that poorer regions will grow faster than richer regions holding all things equal, while sigma convergence is related to a reduction in the disparity of incomes across economies. Despite the many benefits associated with income convergence, there exists an apparent heterogeneity in the literature with some research supporting income convergence (Baumol, 1986; Barro and Sala-i-Martin, 1992), while other research supports income divergence (Mankiw, Romer and Weil, 1992). This study adds to this apparent heterogeneity in the literature.

Studies such as Rey, S. and Montouri, B. (1999), Clinch, J. and O'Neill, E. (2009), Dall'erba, S. and Gallo, J. (2008), and Ertur, C. and Koch, W. (2007) have applied the spatial econometric techniques to explore the dynamic process of regional income convergence to attempt to advance our understanding of the convergence process. The aforementioned papers explore spillover effects, technological diffusion, resource endowments, labor migration, poverty traps, and labor market rigidities in an attempt to explain from a theoretical (i.e. model building) and from a empirical perspective (i.e. examinations of regional spatial relationships) how these spatial relationships influence the convergence process. In addition to adding to the heterogeneity in the literature, in terms of beta and sigma convergence, this paper investigates whether there is evidence of spatial dependence of regional income convergence occurring at a county level of analysis in two neighboring states.

Studies of beta and sigma convergence as well as examinations of spatial dependence typically make generalizations about the underlying individual units of observations and their behavior over the period of investigation. This paper purports to explore the patterns embedded in the beta convergence, sigma convergence, and spatial dependence statistics in an attempt to better understand the dynamic behavior of regional income convergence. It is assumed that by examining trends and patterns over time, researchers will uncover some meaningful implications of the convergence process.

This purpose of this study is to determine if and to what extent North Carolinian and Virginian counties display regional income convergence. This paper seeks to answer the following research questions: (a) Using a county-level of analysis, do the counties of Virginia and North Carolina Counties exhibit regional income convergence? (b) Using a county-level of analysis, do the counties of Virginia and North Carolina exhibit regional sigma convergence? (c) Are there any significant changes in the structure of both of these metrics of convergence over time? (d) Is there evidence of spatial dependence in the process of regional income convergence in the North Carolinian and Virginian Counties?

Our results indicate that the income convergence in the North Carolinian Counties is more pronounced than those experienced in the Virginian Counties. Evidence of this disparity was found to a lesser extent in our analysis of β convergence and to a greater extent in σ convergence. The results from the spatial analysis of regional income convergence carried out in this paper compliments previous results (i.e. the apparent differences in the two states in terms of beta and sigma convergence). This study found statistically significant evidence of spatial dependence occurring in both states at a county level of analysis; however, the spatial lag of

regional income convergence was less significant in our analysis of regional income convergence in the Virginian Counties than it was in the North Carolinian Counties. The researchers question whether this inherent heterogeneity has implications for county and state level policy makers in terms of governance and policy development projects.

The rest of the paper is organized as follows. Section 2 provides a brief review of the literature, while section 3 discusses the data. Section 4 explains the methodology. This is followed by the empirical results in section 5 and finally the researchers conclude in section 6.

LITERATURE REVIEW

This paper is interested in examining whether Virginian and North Carolinian Counties are converging in terms of beta and sigma convergence and if there is evidence of spatial dependence occurring during this convergence process. From a general perspective, when researchers evaluate whether a county exhibits beta convergence, according to Barro, Sala-I-Martin, Blanchard, and Hall (1991), researchers are interested in, "how fast and to what extent the per capita income of a particular economy is likely to catch up to the average per capita income across economies" (p. 112-3) and if they want to examine sigma convergence, according to Barro et al. (1991), researchers need to examine "how the distribution of per capita income across economies has behaved in the past or is likely to behave in the future" (p. 113). When researchers examine spatial dependence they are interested in whether certain geographic associations or distances may offer some explanatory power over how people, according to Ioannides, Y. and Loury, L. (2004), build information networks, establish neighborhoods, or create boundaries that either facilitate or impede information sharing based upon their natural tendency to associate with people that share similar ethnic, occupational, or social ties.

Researchers have paired convergence studies with spatial econometric techniques to explore the dynamic process of regional income convergence. Rey, S. and Dev, B. (2006) and Rey, S. and Montouri, B. (1999) analyzed and found statistically significant levels of spatial dependence and various forms of convergence (i.e. beta and sigma) using a state level of analysis in the United States. Higgins, Levy, and Young (2006) focused explicitly on exploring growth and convergence across the U.S., using a county-level of analysis. The aforementioned studies indicate that spatial relationships influence the convergence process.

Some researchers have explored the process of regional income convergence, whether they focus on country, state, county, or city levels of analysis, to attempt to gain an understanding of the generalized process of convergence and the relationship of spatial dependence in this convergence process. Pede, V., Florax, R., and de Groot, H. (2006) have found that technological growth is explained by a localized human capital effect as well as a technological catch-up effect, which influences the convergence process. Rodriguez-Pose, A. and Ezcurra, R. (2010) relied on a country-level of analysis and questioned whether the centralization of the redistribution of country level GDP or the degree of localized political power influenced regional inequalities, which influences regional development and therefore growth. Kerr, W., and O'Connell (2012) examined whether the degree of industrial agglomeration, in a particular region, could influence that region's growth rate. These research findings seem to indicate that the root causes of regional income convergence, the process driving it, and the spatial dependence embedded in this process is difficult to model and explain.

The goal of the present study is to determine if there is a disparity in terms of regional beta convergence, sigma convergence, and spatial dependence between two states that share a similar

geographic proximity. The researcher's aim is to extend the research of Rey et al. (1999), using a county level of analysis, and focus on exploring beta and sigma convergence as well as the significance of the spatial lag of growth on regional income convergence. This paper will provide a platform from which researchers can analyze the process of regional income convergence.

DATA

This study used county-level per capita income data for Virginian and North Carolinian counties. The data was obtained from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). The specific data set is coded as CA1-3 – personal income summary estimates and the search criteria were 3 Per capita personal incomes. Specifically, for the Virginia data set, the researchers used both traditional county and independent city data in order to provide a comprehensive overview of the structure of regional income convergence.

The time horizon and the number of counties used in this study were limited solely by the data available on the BEA website. According to the BEA there are 71 traditional counties in Virginia and 34 independent cities / non-traditional counties, which are coded as independent cities (non-traditional counties), and 100 counties in North Carolina. All traditional and non-traditional counties had per capita income estimates from 1969 to 2010. In summary, the combined data set yielded approximately 8,405 unique data points.

In both counties annual data was collected and each individual data point was grouped in two ways: (a) based upon county affiliation and (b) the year of observation. Grouping the data this way allowed for the data to be segmented the into cohorts in order explore: (a) Each cohort's beta convergence, (b) The correlation amongst the individual counties' convergence rates with respect to time, and (c) the sigma convergence between the cohorts over time. Therefore, the researchers would classify the data obtained to carry out this analysis as panel data.

METHDOLOGY

This study expands the research conducted by Rey and Montouri (1999), in which they found significant levels of beta and sigma convergence occurring in a state level of analysis. The researchers build on their study by answering the following hypotheses.

Research Question 1: Using a county-level of analysis, do the counties of Virginia and North Carolina exhibit regional beta convergence.

Research Question 2: Using a county-level of analysis, do the counties of Virginia and North Carolina exhibit regional sigma convergence.

Research Question 3: Are there any significant changes in the structure of both of these metrics of convergence over time?

Research Question 4: Is there evidence of county-level spatial dependence in our Virginian and North Carolinian Counties?

Research Question 5: If there is significant spatial dependence, can researchers use this dependence to improve our model of county level growth rate's predictive power?

The following sections document how the regional beta and sigma convergence was calculated. Furthermore, the researchers developed an analytical process to expand the results of the overarching analysis to include more subtle changes in the structural relationships over time.

Beta Convergence

This study applied a basic model to estimate whether a county with a high level of per capita income at the starting period of the analysis (i.e. 1969) converged, in terms of growth rates, with counties that exhibited a lower initial starting level. The dependent variable in this model is the growth rate experienced in county *i* over time period *t*, where the starting observation is time period *t* and the ending period is time period *k*. The formulaic representation of this model is as follows:

$$\left(\frac{\gamma_{i,(t+k)}-\gamma_{i,t}}{\gamma_{i,t}}\right) = \alpha + \beta \ln\left(\gamma_{i,t}\right) + \varepsilon_{i,t} \quad (1)$$

$\gamma_{i,(t+k)}$: The per capita income in county i in time period t plus k units of time.
$\gamma_{i,t}$: The per capita income in county i in time period t.
α: The intercept of the regression equation.
β: The strength and direction of the relationship between the growth rate and the log of per capita income.
$\varepsilon_{i,t}$: The error term for the initial regression

The researchers expect that over a given time horizon (i.e. from 1969 to 2010), the growth rates (i.e. the dependent variable) for the counties with lower starting per capita incomes will be higher than the growth rate of counties with higher starting per capita incomes.

In the second component of this initial analysis, the researchers have segmented the data into yearly cohorts in order to examine whether the relationship between the starting level of per capita income and growth rates is changing over time. Therefore, this portion of the paper analyzed whether, in the aggregate, after grouping counties into state cohorts, the correlations between per capita income and growth rates converge with respect to time. A negative correlation between these two variables would imply that the states counties were converging (i.e. the poorer counties were catching up to the richer counties in that year) and a positive correlation coefficient would imply that the counties in the state were diverging with respect to time (i.e. the richer counties were getting richer and the poorer counties were becoming poorer).

To summarize, the analysis of beta convergence has attempted to use the results of this analysis to make some general conclusions about the governing dynamics of the county level income beta convergence in these two states. In previous studies, researchers have found statistically significant evidence of beta convergence using country, state, and county levels of analysis (see Barro, Sala-I-Martin, Blanchard, & Hall, 1991; Rey and Montouri, 1999; Young, Higgins, & Levy, 2008). However, in this study, the researchers believe that it might be more useful to evaluate how this dynamic process of convergence changes over time and if there is any meaningful information hidden in this convergence process.

Sigma Convergence

According to Barrow, Sala-I-Martin, Blanchard, & Hall (1991), if researchers want to know "how the distribution of per capita income across economies has behaved in the past or is likely to behave in the future" (p. 113), the relevant metric that researchers should explore is sigma convergence.

$$\sigma_t = \sqrt{\frac{1}{n}\sum_{k=t}^{n}(x_{i,k} - \overline{x})^2} \quad (2)$$

To carry this analysis out, the researchers estimated, first, the standard deviation in county level per capita income in period *t* using a cross-section of per capita income in a given state constrained by the year of analysis. The resulting cross-sectional results were then grouped by yearly observations and a time series analysis was conducted to determine if, at the county level of analysis, these two states exhibited significant levels of sigma convergence.

Spatial Dependence

This study will also use the spatially lag model to explain the dependence between our county of interest and its spatial lag. When researchers use a spatially lagged model, they are assuming, according to Ward and Gleditsch (2008) that "they believe that the values of y in one unit i are directly influenced by the values of y found in i's 'neighbors'" (p. 35). Researchers can compare this model with spatial error model, in which, according to Ward et al. (2008), researchers treat the spatial correlation as a nuisance that should be eliminated—this nuisance will lead to estimation problems (p. 65). This study assumes that there is information embedded in 'neighborhood' that will have significant explanatory power over what happens in the county of interest.

EMPIRICAL RESULTS

This section outlines the results of the analysis. The results are segmented into three broad categories: (a) beta convergence, (b) sigma convergence, and (c) spatial dependence. The subsections outline the key findings and expand on the interpretation of these findings when additional analysis seemed necessary. The researchers began by documenting evidence of beta convergence, moved on to evaluating whether sigma convergence has occurred, turned to evaluating whether spatial dependence occurred, and finally summarized the research project's findings.

Beta Convergence

Beta convergence, or evidence thereof, implies that counties with lower starting per capita incomes converge towards counties with higher per capita incomes. More succinctly, the growth rates of poor counties dominate the growth rates of rich counties. The beta convergence of the counties in the Virginian and North Carolinian counties are illustrated in Figures 1 and 2.Table 1 illustrates the results obtained from the OLS (Ordinary Least Squares) estimation of the beta convergence obtained in our analysis of Virginian and North Carolinian Counties segmented into state level cohorts from 1969 to 2010.

In both states, at a county-level of analysis, the researchers have identified statistically significant county-level beta convergence. The estimates of regional income convergence are significant using an α of less than .01. Therefore, the reader can be over 99% sure that the counties studied in this paper are exhibiting statistically significant evidence of β convergence.

The Virginian Counties have an interesting structure because they are broken up into two distinct groups: (a) Traditional Counties and (b) Independent Cities. Table 1 illustrates that the Virginian Counties exhibited statistically significant evidence of β convergence over time. To enhance the analysis of the Virginian Counties, the researchers segmented the two distinct cohorts defined in this analysis based upon their affiliation with either: (a) the 'traditional county' or (b) the 'independent county' cohort. Table 2 provides the results of three OLS regression analyses that illustrate the differences between the traditional counties and independent cities. The first regression calculates the β convergence amongst traditional counties—the results of this analysis were similar to those reported on the full sample of Table 1, primarily because the traditional counties dominated the sample, in terms of observations. The next regression presented in Table 2 illustrates how the β convergence deteriorates as the reader looks solely at the independent cities in the analysis; overall, using a county level of analysis, there is statistically significant evidence of regional income convergence.

Similar to Barro, Sala-I-Martin, Blanchard, & Hall (1991), Rey & Montouri (1999), and Young, Higgins, & Levy (2008), this research project finds evidence of beta convergence. To expand this research project, the researchers decided to evaluate whether the structure of the relationship between the starting level of per capita income and growth is changing over time. This analysis was executed by examining the yearly cross-sectional correlation between starting level per capita income and growth rates from 1969 to 2010. Figure 3 displays the results of the correlation analysis on North Carolinian Counties. By reviewing Figure 3 and Table 3 together the reader can see that over time, there does not seem to be a time-trend between the convergence statistics over time in the North Carolinian Counties.

In the initial examination of the changes in the structure of the convergence statistics in the Virginian Counties, see Table 3 – Virginian Counties (1969 to 2010), there appeared to be evidence of a slight structural shift in the convergence statistics (i.e. evidence of a shift of beta convergence to beta divergence).The relationship between starting per capita income and growth is trending towards divergence over time—evidence of this is the positive slope in the plot of correlation over time. The third analysis presented in Table 3 (i.e. Virginian Counties 1969 to 2005) illustrates that if the researchers were to limit our regression analysis to the 1969 to 2005 time period, they would find that the structural changes in correlation between starting per capita income and growth rates is changing over time and that change has been economically and statistically significant.

The data presented in Table 1 and Figures 1 through 4 indicate that from 1969 to 2010 the counties within Virginia and North Carolina exhibited statistically significant β convergence. A more comprehensive analysis of the underlying processes driving this β convergence seems to provide another interesting story. The data presented in Tables 2 and 3 and Figures 3 and 4 seem to indicate that the structure of β convergence experienced in North Carolinian and Virginian Counties are dissimilar. There is no hard evidence of structural changes in the rates of β convergence occurring in this study; however, it seems clear that in Virginia a gradual shift in β convergence has been occurring from 1969 to 2010. It is the researchers' belief that a thorough

analysis of β convergence would include an analysis of the more subtle changes in the convergence process over time.

Sigma Convergence

This section evaluated whether the counties in the state cohorts exhibited signs of σ convergence (i.e. Sigma Convergence). When researchers explore σ convergence over time they are expecting to find that the dispersion between the individual counties per capita income is declining over time. Figure 5 and Table 4 illustrate that the deviation in per capita income, approximated by the standard deviation in per capita income at time *t*, is decreasing over time. This finding supports the expectation that the dispersion of per capita incomes are decreasing over time; however, when the researchers examined the dispersion of per capita income over time in Virginian Counties, they found a different trend or evidence that the dispersion between Virginian Counties per capita income was increasing over time and that this divergence was significant (See Table 4 and Figure 6).

Given that the two states experienced significant differences in both (a) the general direction of $\boldsymbol{\sigma}$ convergence and (b) the magnitude of sigma convergence, the researchers believed that it might be useful to explore whether the magnitude and tendency of sigma divergence experienced in the Virginian Counties could be due to the structure of the Virginian Counties analyzed in this study. Table 4, line items 3 and 4, document the relative rates of $\boldsymbol{\sigma}$ divergence experienced in traditional and independent cities in Virginian Counties. Divergence is more pronounced in independent cities when compared against traditional counties. However, when the traditional and nontraditional counties are grouped together, the statistical significance attached $\boldsymbol{\sigma}$ divergence deteriorates. The results of this analysis indicate that the dispersion of per capita income in the Virginian counties is increasing and the increase is both economically and statistically significant.

Spatial Dependence

This section of the analysis determines whether there was statistically significant evidence of spatial dependence in our county-level analysis of the two states regional income convergence and if the spatial dependence of growth rates can be used to improve the model of regional income convergence's predictive power. Initially, the researchers were interested in whether the two states, using a county level of analysis, exhibited county level spatial dependence. Table 5 presents the result of the analysis of spatial dependence using a county level analysis. Both states generated statistically significant results in terms of spatial dependence, but the evidence of spatial dependence was more pronounced in North Carolinian Counties. Using the results of this analysis, the researchers evaluated whether the spatial component added any predictive power to our models of regional income convergence.

Table 6 presents the results of our regional income convergence models including the spatial lag of growth rates. After running multivariate regression analyses including the spatial lag of regional income convergence for Virginian and North Carolinian Counties the results for the two states are, again, dissimilar. The final model of regional income convergence for North Carolinian Counties included a spatial lag, whereas the model for Virginian Counties does not include a spatial component and is equivalent to Formula 1.

$$\left(\frac{\gamma_{i,(t+k)}-\gamma_{i,t}}{\gamma_{i,t}}\right) = \alpha + \beta \ln\left(\gamma_{i,t}\right) + \rho W y_i + \varepsilon_{i,t} \qquad (2)$$

$\gamma_{i,(t+k)}$: The per capita income in county i in time period t plus k units of time.
$\gamma_{i,t}$: The per capita income in county i in time period t.
ρWy_i: The spatial lag of growth rates based upon boundary sharing
α: The intercept of the regression equation.
β: The strength and direction of the relationship between the growth rate and the log of per capita income.
$\varepsilon_{i,t}$: The error term for the initial regression

Table 6 presents the restricted and unrestricted models of regional income convergence for both the Virginian and North Carolinian Counties—the spatial lag of growth rates was the variable of interest. Next, an *f* test was conducted to determine if beta coefficient attached to the spatial lag of growth rates was significantly different from zero when the spatial component was included in the multivariate regression analysis of regional income convergence. Again, the process of convergence between the two states is dissimilar: (a) For the North Carolinian Counties, the researchers found statistically significant evidence that the spatial lag of growth adds predictive power to our model and (b) For the Virginian Counties, the researchers could not conclude that the spatial lag of growth added predictive power to our model; therefore, the spatial component was dropped from the final model for Virginia.

CONCLUSION

The goals in this study were to answer five research questions, using a county level of analysis: (a) Do the counties of Virginia and North Carolina exhibit β convergence, (b) Do the counties of Virginia and North Carolina exhibit σ convergence, (c) Are there any structural changes experienced in North Carolinian and Virginian Counties over time, (d) Is there evidence of spatial dependence in the county level growth rates in Virginia and North Carolina, and (e) Does the addition of the spatial lag of growth rates improve the models of regional income convergence in our two states? This paper provides the answers to these research questions using data obtained from the Bureau of Labor Statistic from 1969 to 2010. In the following paragraphs the researchers will provide a summary of the research results obtained as a result of exploring each of the research questions.

In the first section of this analysis the researchers analyzed whether Virginian and North Carolinian counties exhibited evidence of β convergence. The results of this analysis support the expectation—both states exhibit statistically and economically significant evidence of β convergence; however, in terms of economic significance the β convergence experienced in the North Carolinian counties was more significant. Due to the unique county structure found in Virginia Counties, the researchers believed that it would be useful to examine the difference in the rates of β convergence experienced in traditional and independent city counties. The researchers found that the difference between the two cohort's β convergences was significant; however, the dissimilarities between the independent and traditional county's β convergence had a minimal effect on the results of our analysis of β convergence in the Virginia Counties because the traditional counties dominated our independent cities in terms of observational units.
To provide a more comprehensive analysis of β convergence the researchers thought that it would be worthwhile to segment the convergence statistics by year and evaluate how the cross-sectional statistics change over time. In North Carolina the cross-sectional β convergence

coefficients did not display economically or statistically significant variation over time; however, in our analysis of Virginian Counties, the variation of cross-sectional β convergence did change over time and if the model is constrained to the following time horizon, from 1969 to 2005, the change in the Virginian Counties was economically and statistically significant. The researchers provided evidence that seems to suggest that the Virginian Counties are experiencing an economically and statistically significant shift in β convergence over time or, more succinctly, that the convergence rates experienced between the rich and the poor counties seem to be trending towards divergence over time.

The analysis of σ convergence of North Carolinian and Virginian Counties supports the findings previously documented in this analysis. The per capita income in North Carolinian Counties identified in this analysis seem to be converging over time or the dispersion of per capita incomes seem to be decreasing over time in the North Carolinian cohort. The results of the findings of Virginian County's σ convergence seem to, again, diverge from theoretical expectations. The Virginian Counties seem to be exhibiting economically and statistically significant divergence in terms of σ convergence. The structural relationship of the Virginian Counties does not seem to create this divergence, because if the individual county-level σ convergence is evaluated grouped based upon traditional and independent city cohorts, the researchers find that the significance levels of σ divergence increases over time.

The analysis of spatial dependence occurring at a county level of analysis in these two states, again finds a divergence in terms of results. This study finds statistically significant evidence of spatial dependence of growth rates in both Virginian and North Carolinian Counties. However, when the researchers questioned whether the spatial component of growth rates should be included in the final model of regional income convergence in the North Carolinian and Virginian Counties, the researchers found statistically significant evidence that the coefficient for the spatial lag of growth was significantly different from zero. In terms of the Virginian Counties, the researchers could not conclude that the addition of the spatial lag of growth added enough predictive power to our model to include; therefore, the spatial lag of growths rates was removed from the final model of growth for the Virginian Counties.

The researchers believe that the results of this study motivate a prescriptive study from a policy setting standpoint using states like Virginia and North Carolina that share a geographic boundary, whose beta and sigma convergence, as well as spatial dependence, are dissimilar. Future research should provide some clues in regards to why this divergence is occurring, potential public policy prescriptions that could be implemented to change this divergence, and hint at structural changes to governance that might either speed up or slow down the potential rate of convergence using a county level of analysis. For example, researchers could use the results found in Rodriguez-Pose, A. and Ezcurra, R. (2010) and question whether these two states differ in terms of the degree of (de)centralization of their redistribution of state level GDP or whether the political bargaining capacity of the various counties within these two states are significantly different. From another perspective, researchers could take the work of Ghani, E., Kerr, W., and O'Connell (2012) and examine whether the industrial structure of a county may cause localized agglomeration of counties within the state that may in turn influence the structure of the work force and entrepreneurial activity within these counties, which have been shown to effect regional growth rates (see Fritsch, M., 2008).

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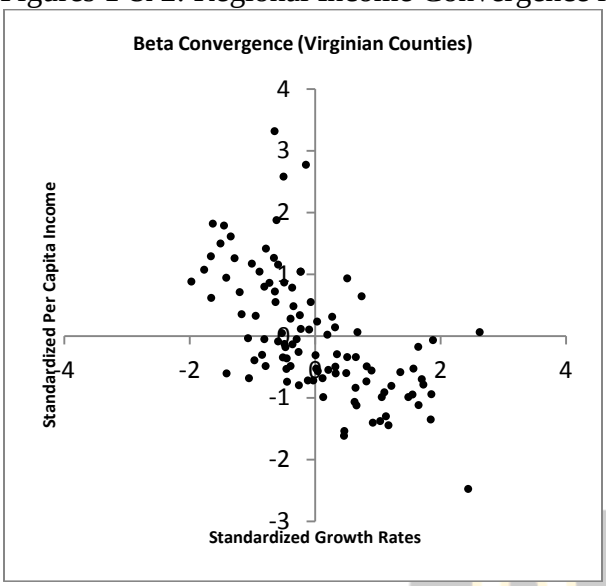
TABLES & FIGURES

Figures 1 & 2: Regional Income Convergence in Virginian and North Carolinian Counties



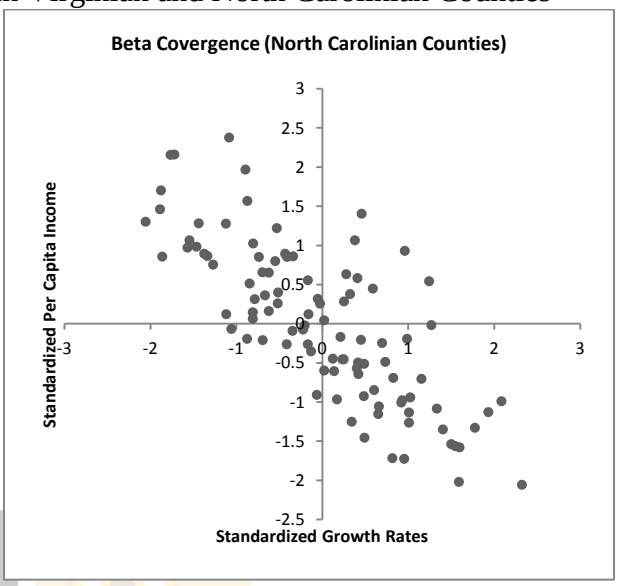


Table 1: Comparison of Virginian and North Carolinian Regional Income Convergence

Comparison of Virginian and North Carolinian Regional Income Convergence			
	$\hat{\beta}$	Standard Error	R-Squared
Virginian	-0.072	0.009	0.379
p value	(.000)		
North Carolinian	-0.100	0.008	0.612
p value	(.000)		

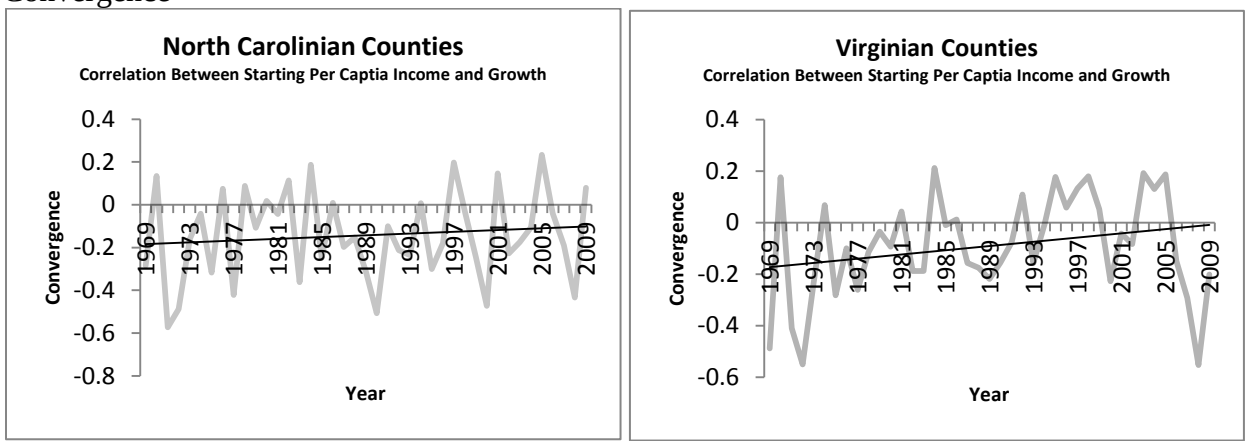
Notes: B-Hat is the estimated regional income convergence statistic estimated based upon the convergence experienced in the Virginian and North Carolinian Counties from 1969 through 2010.

Table 2: Virginian Counties (Traditional & Independent City)

Virginian Counties (Traditional & Independent City)			
	$\hat{\beta}$	Standard Error	R-Squared
Traditional Counties	-0.075	0.012	.352
p value	(.000)		
Independent Cities	-0.042	0.016	.187
p value	(.011)		

Notes: B-Hat is the estimated regional income convergence statistic estimated based upon the convergence experienced in the Virginian Counties from 1969 through 2010.

Figures 3 & 4: Correlation Analysis of North Carolinian and Virginian Counties – β Convergence

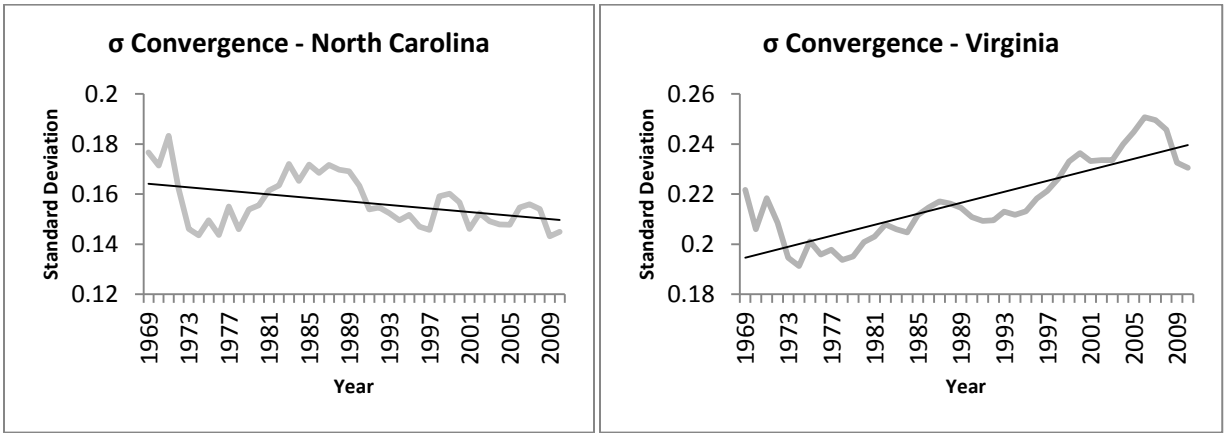


Notes: The correlation between Growth and Per Capita Income was calculated using the following formula $\frac{E[(X_i-\mu_x)(Y_i-\mu_Y)}{\sigma_x\sigma_Y}$. The yearly cross-sectional correlation coefficients were plotted on the Y axis and the year of observation was plotted on the X axis.

Table 3: Virginian Counties (Traditional & Independent City)

Virginian Counties (Traditional & Independent City)			
	$\hat{\beta}$	Standard Error	*R* Squared
North Carolinian Counties	0.002	0.003	0.014
p value	(.464)		
Virginian Counties (1969 to 2010)	0.004	0.003	0.059
p value	(.124)		
Virginian Counties (1969 to 2005)	0.009	0.002	0.252
p value	(.001)		
Notes: B-Hat is the beta coefficient that describes the evolution of the relationship between the correlation of starting per capita income and growth rates over time.			

Figures 5 & 6: Regional σ Convergence in North Carolinian and Virginian Counties from 1969 to 2010.



Notes: ***σ*** convergence identified in time *t* using a cross-section of log per capita income was calculated using the following formula: $\sigma_t = \sqrt{\frac{1}{n}\sum_{k=t}^{n}(x_{i,k} - \overline{x})^2}$

Table 4: σ Convergence

σ Convergence			
	$\hat{\beta}$	Standard Error	R-Squared
North Carolina	-0.00035	0.00012	.17623
p value	(.00565)		
Virginia (Traditional / Independent Cities)	.00110	.00010	.68800
p value	(.00010)		
Virginia (Traditional Counties)	.00120	.00010	.71620
p value	(.00000)		
Virginia (Independent Cities)	.00150	.00010	.85270
p value	(.00000)		

Notes: B-Hat is the estimated regional income sigma convergence statistic estimated based upon the convergence experienced in the Virginian and North Carolinian Counties from 1969 through 2010.

Table 5: County Level Spatial Dependence (Virginia and North Carolina)

Spatial Regression Results		
Statistics	Virginia	North Carolina
Intercept	0.0000	0.0000
St Error	0.0929	0.0857
p value	0.0008	0.0000
Beta	-0.3210	-0.5220
St Error	0.0933	0.0862
p value	0.0008	0.0000
R2	0.1031	0.2725
p value	0.0008	0.0000

Table 6: Regression Analysis of Virginian and North Carolinian Counties

Statistics	NC (Unrestricted)	NC (Restricted)	VA (Unrestricted)	VA (Restricted)
Intercept	0.8514	1.1039	0.8004	0.8927
St Error	0.0893	0.0636	0.1025	0.0725
p value	0.0000	0.0000	0.0000	0.0000
Beta (Per Capita Income)	-0.0828	-0.1004	-0.0685	-0.0724
St Error	0.0089	0.0081	0.0096	0.0091
p value	0.0000	0.0000	0.0000	0.0000
Beta (Spatial Lag)	0.3633		0.1930	
St Error	0.0956		0.1518	
p value	0.0003		0.0000	
R2	0.6619	0.6115	0.3892	0.3735
p value	0.0000	0.0000	0.0000	0.0000
F test - *p* value	0.0003		0.2063	