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Abstract

Over the past 30 years, the United States has seen a great transference of wealth from its old manufacturing regions to its regions of comparatively less wealth. This transfer can be explained through Convergence Theory, which predicts exactly that type of movement. However, some locations of initial wealth managed to maintain their position of comparative wealth, suggesting an additional force influencing the locations of investment. The Product Life Cycle (PLC) helps explain those outliers, as it suggests places with high wage, skilled labor will be attractive for the development and production of new products. To test these competing theories, we develop an unconditional convergence model and apply it to the 1980-2010 United States at the county level of aggregation in both Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) specifications. Both models indicate the presence of convergence, though the global OLS fails to account for locations offering early stage PLC benefits. The local GWR significantly improves model fit, and provides evidence of late stage PLC filtering down and convergence through capturing rapid growth of regions of initially low investment, but also evidence of reinvestment in high skilled (wage) locations consistent with the early stages of the PLC.

Keywords: United States, Geographically Weighted Regression, Beta Convergence, Spatial Data Analysis, Product Life Cycle

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Introduction

Convergence theory attempts to explain differences in regional income growth patterns. Couched in neo-classical growth theory, its’ fundamental premise is that given globally fixed capital and resources, investment will flow from regions with relatively high concentrations of wealth to regions with relative smaller concentrations of wealth and capital (Barro and Sala-I-Martin 1991; Baumol 1986). A major reason behind this movement of investment comes from the marginal nature of firms. As each unit of capital or labor is added to the production process in a region, the quality of the input diminishes thereby decreasing returns to investment. Returns to investment eventually diminish to where additional investment generates zero return, removing the incentive for firms to invest in the region, creating a steady state economy. In steady state economies, convergence theory suggests that footloose firms will relocate investment to regions where higher returns to capital or labor can be found (Malizia and Feser 1999). This can take the form of a movement of investment from high wage to low wages regions (Baumol 1986). The end result can be understood as either beta convergence, where regions of initially low incomes experience faster income growth rates than regions of initially higher income levels, or sigma convergence where there is a generalized decrease in the standard deviation of incomes over time (Barro and Sala-I-Martin 1991). Since regions of low capital investment are by definition regions of low wages, firms engaged in this relocation are also addressing a traditional concern in industrial location: minimization of labor costs (Hayter 1997).

While convergence is conceptualized around a regional economic process, it is driven by firm level decisions. These decisions of location and relocation can be understood through the Product Life Cycle (PLC). The PLC describes the profitability of a product over its’ life, and has an inherently spatial dimension (Almor et al. 2006; Hayter 1997; Hirsch 1967; Hirsch 1975). These dimensions, as described by Malecki (1997), explain the role of wages in firm location decisions. In the early stages of product development and production, skilled labor and market proximity are of utmost importance in order to refine design and production (Vernon 1966). These considerations place facilities in regions of high incomes, and patent protection keeps market prices high. When market control of the product is lost due to patent expiration, profits drop as firms lose the ability to set high prices. This drop in revenue is compounded by the fact that no additional costs can be cut on site; standardization has optimized the production process, leaving labor the only cost to cut (Norton and Rees 1979). Thusly, relocation to low wage locations becomes an attractive option, particularly for low skill, labor intensive production (Hirsch 1975). When analyzed in conjunction with convergence theory, the PLC offers a firm level colliery to the region focused relocation explanation. However, the PLC also accounts for growth in regions of high wages or skills, a type of growth outside of convergence theory (Almor et al. 2006). The late stage movement accounted for by the PLC has been cited as a possible reason for income convergence (James 2012b; James and Campbell 2013). When analyzing the movement of investment from region to region, whether through a PLC lens or a convergence lens, a key aspect to note is the consistency in low wages attracting investment.

Derived by Baumol (1986), the formal test for beta convergence is a regression income change serves as the dependent variable against initial incomes levels, and optionally, an additional vector of economic control.
variables. A negative coefficient for initial income levels indicates beta convergence. This model has been widely applied and has provided evidence for income convergence at the international scale (Baumol 1986) down to the intra-national scale, frequently the United States (Barro and Sala-i-Martin 1991; James and Campbell 2013; Rey and Montouri 1999). These studies, however, apply a global regression model. In other words, they provide evidence of the process across regions without being able to identify the role of income on growth in particular locations of high or low initial income levels. Local regression models, notably Geographically Weighted Regression (GWR), allow for that level of analysis (Fotheringham et al. 2002). Applied to convergence and regional growth models, the use of local regression is relatively sparse, though non-stationarity among growth predictors has been found (Ali et al. 2007; Le Gallo et al. 2011; Partridge et al. 2008). This paper adds to the discussion of convergence by applying a GWR convergence model to the 1980-2010 United States, exploring the role of initial income levels on individual county level growth. By doing so, convergence can be examined in a manner that tests the traditional neo-classical forces behind convergence and late stage PLC movement, but also the competing early stage PLC forces. While neo-classical factors and PLC have been compared internationally (Hirsch 1975), this paper is the first to explore these competing factors in a domestic convergence framework. Operating in a time period that already has evidence of convergence (Campbell et al. 2012; James and Campbell 2013), this analysis will attempt to pinpoint the impact income levels have on counties whose incomes converged to the mean from above or below. Results will indicate if differences in income levels attract and repel investment in the manner that convergence theory and PLC suggest it should. The remainder of this paper is organized as follows: the following section provides a review of the literature on convergence, PLC, and GWR; the next section provides specific research questions of this paper and the methods used to answer them; the next section presents and synthesizes results; finally, a conclusion summarizes the paper and provides direction for future research.

The Movement of Investment and How It Is Measured

Convergence
Convergence is a broad theory that suggests that regional differences in income and investment will decrease over time. This theory operates under the neo-classical conceptualization of growth as a function of a regions' bundle of labor, capital investment, savings, and technology (Malizia and Feser 1999; Solow 1956). In this framework, there are assumed diminishing returns to investment, technological change is exogenous and available to all regions, and fixed global capital stocks (Schumpeter 1942; Solow 1956). With diminishing returns, eventually a regional economy will reach a steady state, inducing marginal firms to relocate their investment (Solow 1956). With globally fixed capital, as firms relocate their investment, Schumpetarian (1942) creative destruction occurs over space, reducing differences in regional incomes and output. This process can be understood as either beta convergence, where regions with lower levels of initial income grow faster than region of initial wealth, or sigma convergence where there is a decrease in the standard deviation of incomes over time (Islam 2003). Further, convergence can be unconditional, where regions converge regardless of economic structure, or conditional, where regional incomes converge within the capabilities of their economic structure (Barro and Sala-i-Martin 1991). Beta convergence is the form that is most widely studied (Drennan and Lobo 1999).
Beta convergence is tested by regressing income change against initial levels. Baumol (1986). Beta convergence is present when the beta coefficient for initial income levels is negative and significant. This implies that as incomes levels increase, regional growth slows; that is a large negative correction is needed for the expected growth predicted by the intercept. When this processes is occurring, regions can be understood to be converging “bottom-up”, where their low (towards the bottom) levels of income come up to the global mean as through receiving footloose investment, or “top-down”, where their high levels (towards the top) of income come down towards the same global mean (James 2012b) as a result of losing footloose investment. When unconditional in framework, no other predictor variables are utilized; however in a conditional model additional predictors are used to account for regional differences in economic structure, such as human capital, infrastructure investment, labor specialization, and amenity (Galor 1996; Higgins et al. 2006; Islam 2003). Baumol-inspired models have been applied to regions including the United States (Barro and Sala-I-Martin 1991; Berry and Kaserman 1993; Bishop et al 1992; Higgins et al. 2006; James and Campbell 2013; Johnson and Takeyama 2001; Rey and Montouri 1999; Rupasingha et al. 2002; Santopietro 2002); Canada (Colombe 2000); South America (Magahales et al. 2006); China (Chen and Fleisher 1996; Lau 2010); and Europe (Armstrong 1995; Hofer and Worgetter 1995; Le Gallo et al. 2011; Petrakos and Artelaris 2009). Generally, evidence supports convergence, particularly conditional convergence (Islam 2003), though unconditional convergence evidence can be subject to the effects of spatial aggregation (James and Campbell 2013) and sample (See Baumol 1986 versus Baumol and Wolff 1988).

Recently, increasing attention has been paid to spatial effects in convergence models. Rey and Montouri (1999) pioneered the use of the spatial autoregressive model (SAR) to account for spatial autocorrelation in convergence modeling. Subsequent work has confirmed the importance of spatial effects in convergence models (James and Campbell 2013; Le Gallo et al. 2011). However, spatial dependence is not the only problem that spatial effects can have on data, as non-stationarity of a variable is a risk (Fotheringham et al. 2000). In the case of non-stationarity, the variances among variables are not the same across space, and thusly the relationship between two variables is not uniform across space (Fotheringham et al. 2000; Fotheringham et al. 2002). To deal with non-stationarity, local regressions, particularly GWR offer a remedy (Fotheringham et al. 2002; Charlton and Fotheringham 2009). GWR operates by giving each observation its own regression, diagnostics, and regression coefficients, though the regressions are weighted by a neighborhood (Charlton and Fotheringham 2009). In the case of convergence, non-stationarity is a daunting problem, as the whole premise is conditioned across a rather consistent relationship between variables across space: the lower the income level the faster the income growth. There is evidence the relationship may not always hold, as even a properly calibrated SAR model produces pockets of spatially autocorrelated residuals, in places such as New York and Silicon Valley, where centers of the knowledge economy maintain high wages (James and Campbell 2013). When PLC is added to that framework, the explanation becomes clearer: some regions offering the high-wage, high skill labor needed in early stage products may grow because of that labor concentration (Almor et al. 2006; Hirsch 1975; Malecki 1997). Yet, the reasons for late stage product cycle movement have not changed, thus offering theoretical evidence that a global measure of the relationship between income levels and income change may not be the most
appropriate method of analysis. Further, when local regressions are applied, there is evidence of significant variable drift over space, though most studies are interested in factors other than income and the PLC (Le Gallo et al. 2011; Partidge et al. 2008; Petrakos and Artelaris 2009), which is the focus of this paper. Taken all together, the expected relationship between income and income change may not be uniform across space, as there is theoretical and empirical support for growth as a result of low and high incomes. This is in contrast to the expectations coming out of convergence theory. When PLC is included in the analysis, the picture becomes a bit clearer, though still needing to be empirically explored.

Product Life Cycle
The Product Life Cycle provides an explanation for changes in profitability and cost structure of a product over time (Rink and Swan 1979). Polli and Cook (1969) characterize PLC as the evolution of product attributes and market characteristics across time, and note its use in managerial decisions. The PLC is conceptualized as a segmented bell-shaped curve, representing the sales growth and decline of a given product through time (Schening 1969). Generally, the stages can be classified into four overarching categories: (1) introduction; (2) growth; (3) maturity; and (4) decline (Rink and Swan 1979). Each stage has a unique cost and profit structure, which cause the profitable production locations to change as products cycle through the stages (Almor et al. 2006; Malecki 1997). In its most basic form, the PLC suggests that only skilled and unskilled labor concentrations are of importance in determining regional attractiveness for production of new or mature products. However, a more mild form including regional capital stocks appears to be evident in international investment, as regional labor and capital work together to fit the needs of products, which vary by age and production method (Hirsch 1975). In this mild version, the spatial implication is that while there is a filtering of investment from high to low wage (skill) locations, a complete lack of capital can be a hindrance to development. That is, it is possible to be rural and underdeveloped enough where it is a detriment to investment, regardless of the prevailing wage level.

In the introductory stage unit sales are low, since the product is new to the market place and consumers may not be aware of the new product. Though patent protection does ensure market control, this stage is characterized by high product development and production costs (Rink and Swan 1979), due in part to the skilled labor needed in design, marketing, and a yet to be standardized production process. Market access is also of importance, so any changes in market demand can be quickly addressed. Given that desirable markets tend to have high wages, this increases production costs (Malecki 1997). As a product enters the growth stage, sales increase as the product gains acceptance in the marketplace. Patent protection locks in higher profits as production and development costs are streamlined and standardized. This stage, also referred to as “super profit”, is the stage where most product profits are made, and also recoups the losses associated with development (Malecki 1997). However, when patent protection expires and competitors enter the market unit sales begin to level, followed by a decline in profitability that exemplifies the maturity stage of the PLC. As declining sales begin to intensify, competition couples with limited opportunity for cost savings, and a march toward product decline occurs. With this loss of market control, prices and profits shrink. As production has been streamlined, the only production cost left to cut is labor, which leads to the relocation process
associated with the PLC (Malecki 1997; Park and Wheeler 1983).

In early stage product development, quick and effective communication between management, production, and the market is important, so skilled labor can respond to market changes and refine production processes (Almor et al. 2006). In these early knowledge intensive stages, patent protection keeps market prices high enough to offset the high production costs associated with market proximity and skilled labor (Malecki 1997). Once production becomes fully standardized and patent protection expires, the importance shifts to scale production, where costs can be reduced through less expensive per unit mass output; Caves (1971) refers to this as horizontal investment, where firms will transition mature product lines to low cost locations. This movement is made possible as standardized production reduces the need for skilled labor, the general decline in transport costs, and a reduction in communication intensity from head office to production facility as a product ages (Almor et al 2006; Hayter 1997).

Thompson (1969), echoed by others (Cromley and Leinbach, 1981; Erickson, 1976; Lonsdale, 1969; Thomas, 1974), characterized the changing locational needs of maturing products as a filtering down process. Here, investment is initially centered in high-wage command centers of the economy, and subsequently filters through regions of declining labor costs and capital investment as the product ages. This process is characterized by a decentralization of manufacturing from high-cost metropolitan areas to lower-cost nonmetropolitan areas (Malecki 1997). This urban-rural movement of mature products is well known (Erickson 1976; Park and Wheeler 1983), and is particularly evident in mature industries such as textiles (Wheeler 1998). As investment leaves the high wage region, it is subject to a spatial version of Schumpeterian creative destruction (1942), where given fixed global capital, the disinvestment in the industry leads to regional economic decline unless there is another one to takes its place. In these cases, regions with the innovation infrastructure to continue to be home to the early stage development of new products can continue to grow despite the loss of a particular industry (Almor et al. 2006; Malecki 1997). Regions offering this innovation infrastructure are increasingly at an advantage in the regional growth game, since product cycles are shortening (Malecki and Morrise 2008), and the continued development of new products is key for successful firms, and, in turn, regions.

Synthesis and Deficiency
Convergence theory and the PLC both offer explanations for regional growth and the movement of investment. Convergence theory comes from the neo-classical explanation of growth, and presents a relatively deterministic relationship between labor costs, capital investment, and growth; locations with large endowments of both will grow more slowly than those that do not. This relationship is supported by a portion of the PLC, where regional growth can be attributed to a concentration of low skilled, low wages workers and a filtering of investment as footloose firms seek to maximize returns to investment. While both theories agree that low wages can be a cause for growth, they differ in their explanation of growth in locations well-endowed in wealth and capital; convergence predicts slow or negative growth, while the PLC allows for sustained growth in these locations. While the latter stages of the PLC have been used to help explain the regional filtering of investment in convergence (James 2012b; James and Campbell 2013), and non-convergence models support the impact of both neo-classical and PLC factors (Hirsch 1975), these theories have yet to be fully
synthesized in to one convergence model. This lack of synthesis is understandable, as the competing effects of wage levels cannot be captured by a global convergence model, thus requiring local regression techniques not available until recently. This deficiency in the literature is addressed here, as this paper is the first to examine convergence with a model that accounts for both the traditional neo-classical convergence theory and late stage PLC movement, but also the contradictory effects of early PLC stage investment. The implications for theory deal with the strictness of the theorized relationships between actors influencing growth. If results indeed reflect both positive and negative effects from high wages, then the model would present a more moderate convergence process, where wealth flows from locations of high concentrations to low concentrations, but recognizing that the movement is not an absolute. This more moderate model also has a natural extension for policy. If the movement is not absolute, then policy makers should have a definite need to understand how these variable factors influence growth, and how certain regions can retain investment. Following the model provided here, attention would need to be shifted away from traditional neo-classically influenced polices, such as wage minimization and industrial subsidization, to more nuanced, less traditional policies more closely aligned to this localized understanding of regional growth.

**Research Questions and Methods**

As noted previously, there is an expectation that low levels of wages will serve as a mechanism for attracting growth. This concept is supported by both convergence and PLC theories. However, evidence from convergence studies (James and Campbell 2013) and the PLC (Hirsch 1975) suggest the expected negative relationship between income levels and income growth may not be uniform. For example, some regions (i.e. Silicon Valley) grew because of (or at least in spite of) their high wages and levels of labor skill, which is in contrast to the expected growth trajectory coming from convergence theory. With concentrations of highly skilled labor in a few pockets of urban focused Research and Development (R&D) clusters and the need for firms to maintain investment in these sectors, PLC also provides theoretical support that some regions may grow because of their high wages, a process not captured in a global convergence model. By using a local regression model, this paper accounts for this competing relationship, and allows for an examination of how it manifests spatially in a convergence framework. Specifically, it addresses the following three questions: (1) What is the role of income levels in predicting income growth, and is it uniform across space?: (2) Do regions with high levels of initial incomes have a large negative beta coefficient?: and (3) Do regions of initial poverty have positive (or at least less negative) beta coefficients?

To answer these questions, a GWR unconditional convergence model is developed for the United States 1980-2010 at the county level of spatial aggregation. Different from OLS, GWR is a local regression, designed to address spatial non-stationarity (Fotheringham et al. 2002). With spatial non-stationarity, the relationship (significance, magnitude, or even direction), between two variables is not uniform, and there is a marked regional pattern to varying relationship (Fotheringham et al. 2002). Here, by fully incorporating the PLC in to a convergence framework, a spatially non-stationary relationship between income levels and income is the expected result, thereby necessitating a local regression in order to capture those effects. Local regressions, such as GWR, produce individual regressions for each observation, weighted by a defined
neighborhood (Fotheringham et al. 2002). The advantage of this approach is that it allows researchers to explore how variables are related at the observation level, and thus able to identify general trends, regional deviations from theory, neighborhoods of similar processes, and test competing theories, as is the case in this paper.

Central to GWR is the specification of the kernel and bandwidth, which are responsible for the neighborhood weights. The kernel is the weighting scheme, and the bandwidth, which is a part of the kernel, defines which observations are to be included as neighbors (Fotheringham et al. 2002). As bandwidth increases and the number of observations included in the neighborhood approaches total observations, local variations decrease eventually turning the local model into a global one (Charlton and Fotheringham 2009). A kernel can be fixed, where all observations within a fixed distance bandwidth are included in neighbors, or adaptive where the bandwidth includes the nearest k-observations as neighbors (Charlton and Fotheringham 2009). Fixed kernels are appropriate when spacing is relatively uniform, and adaptive is preferred otherwise (Charlton and Fotheringham 2009). A more computationally detailed presentation of GWR can be found in Fotheringham et al. (2002).

The time period and level of spatial aggregation offers several advantages. First, it is a time period and study area where beta convergence has already been detected with an urban-rural movement of investment reflecting PLC influence (Campbell et al. 2012, James and Campbell 2013). The large number of observations offered by county-level analysis allows for a GWR to be constructed. Formally, Per Capita Personal Income (PCPI) growth rate serves as the dependent variable against 1980 PCPI level. Data comes from the Bureau of Economic Analysis Regional Economic Information System (BEA REIS) and was joined to a 1980 county shapefile from the National Historic GIS (NHGIS). The measure of PCPI that is used is PCPI as a percent of U.S. PCPI. This measure offers the advantage of providing the data in an already base lined measure. So, instead of testing for convergence in terms of dollars, this model will test for convergence of comparative wealth. PCPI growth is calculated as:

$$\Delta \text{PCPI} = \left( \frac{\text{PCPI}_{2010}}{\text{PCPI}_{USA2010}} \right) \div \left( \frac{\text{PCPI}_{1980}}{\text{PCPI}_{USA1980}} \right)$$

Where:

$$\Delta \text{PCPI} = \text{PCPI growth in area i}$$

$$\text{PCPI}_{2010} = 2010 \text{ PCPI in area i}$$

$$\text{PCPI}_{1980} = 1980 \text{ PCPI in area i}$$

Prior to the GWR, an Ordinary Least Squares (OLS) model is run to baseline results. This global baseline gives a frame of reference for model fit, beta direction and a standard error around the beta for 1980 PCPI that can be compared to the range of betas in the GWR to address the question of spatial drift in the beta. The OLS is specified as follows:

$$\Delta \text{PCPI} = \beta_0 + \beta_1 \text{PCPI}_{1980} + \varepsilon$$

Where:

$$\Delta \text{PCPI} = \text{PCPI growth in area i}$$

$$\text{PCPI}_{1980} = 1980 \text{ PCPI in area i}$$

$$\varepsilon = \text{Error assumed i.i.d.}$$

When applied to a GWR, this unconditional model is constructed as follows, beginning with the kernel function:

$$w_i(u) = \left(1 - \frac{(d_i(u))/h}{^2}\right)^2$$

Where:

$$w_i(u) = \text{Weight of the ith observation relative to location u}$$

$$d_i(u) = \text{Distance between the ith observation and location u}$$

$$h = \text{Bandwidth}$$
With the above kernel defining the neighborhood for the weighting of the parameters, the following local regression is applied:

$$\Delta \left[ PCPI \right] _i (U) = \beta_{0i} (U) + \beta_{1i} (U) \left[ PCPI \right] _i^{1980} + \epsilon$$

Where:

- $$\Delta \left[ PCPI \right] _i (U)$$ = PCPI growth in location U
- $$\beta_{0i} (U)$$ = Constant at location U
- $$\beta_{1i} (U) \left[ PCPI \right] _i^{1980}$$ = Parameter estimate for 1980 PCPI at location U
- $$\epsilon$$ = error assumed i.i.d.

Once specified, the GWR is run in ESRI ArcGIS 10.1. Since counties are not uniformly spaced, an adaptive kernel is applied, with the corrected Akaike Information Criterion (AICc) (Hurvich et al. 1998) bandwidth selection option. The AICc bandwidth selection minimizes the AICc, thereby selecting the neighborhood that maximizes model fit (Charlton and Fotheringham 2009).

With both models complete, answers to the research questions come from the output of both regressions. The OLS offers a baseline of results for GWR comparison. Model fit, convergence evidence, diagnostics, and residual autocorrelation are presented and discussed. Model fit is discussed in terms of R-Squared, which can be understood here as how much of the variation in income change is explained by the model. The Jarque-Bera test is used to test for residual normality. When residuals are not normally distributed, confidence intervals around beta coefficients can be skewed, compromising significance calculations. (Affifi et al. 2003). This operates in conjunction with the Koenker Bruesch-Pagan test, which tests for constant residual variance in geographic and data space, where failure of this test indicates appropriateness for a GWR (Charleton and Fotheringham 2009). Convergence evidence is with a negative and significant beta coefficient for 1980 PCPI, reflecting the magnitude, direction, and significance of its influence on $$\Delta$$ PCPI. The intercept term reflects the expected national growth rate. These baselines from the global model establish the direction and strength of the relationship between initial income levels and income growth rates, answering the first research question. But, more importantly, the outliers identify regions where the model failed to capture the relationship, which in conjunction with the Koenker Bruesch-Pagan provides the first evidence of the non-stationary.

In the GWR, local versions of these diagnostics allow for the explanatory power of the model, the variable relationship, and expected growth to be examined at each observation. With the GWR analysis, a comparison of model fit diagnostics address if explanatory power improves by allowing for locally varying relationships. Mapping the R-Squared, intercept, and beta coefficients will identify the locations where the model worked well and the locations where it did not, while helping to explain the nature of the relationship between income growth and income levels in those locations (providing answers to the second and third research questions). Finally, a comparison of the minimum and maximum beta and intercept values against the OLS values and standard errors will allow for a determination of the intercept and beta coefficients that exhibit spatial drift in the GWR.

Results

Preliminary Conditions

To help contextualize the results, $$\Delta$$PCPI and 1980 PCPI are mapped in Figures 1 and 2, respectively. In converging economies, the conditions driving convergence (i.e. high income levels and slow growth rates) can be detected visually when mapped, and these maps can be used to identify the regions
subject to top down and bottom up convergence (James 2010). Locations of top down convergence can be identified as observations with high level of initial incomes and low growth rates, while bottom up converging regions can be identified with the opposite (James 2010). In Figure 1, the regions of expected convergence are noticeable. Beginning in the southeast, there is a large band of low incomes comprising the majority of West Virginia, Kentucky, the Carolinas, Georgia, Alabama, Mississippi, Louisiana, Missouri, Virginia, Tennessee, and Arkansas. There is also a secondary region located in the Dakotas stretching through eastern Nebraska, and portions of Montana, Idaho, and Minnesota, and a third clustering of low values in Texas, Arizona, New Mexico, and southern Colorado. In general, these locations tend to be largely rural. For locations of higher incomes, they tend to be more urban in location. These locations include a narrow band along the eastern seaboard stretching from New York City to Washington, D.C.: most of California and stretching northward to include Seattle, Portland, and their surrounding areas; and an area along the Great Lakes in Ohio, Indiana, Illinois, and Michigan, and Wisconsin that includes Cleveland, Detroit, Chicago, Milwaukee, Cincinnati, Indianapolis, and Columbus.

The growth rates, mapped in Figure 2, largely coincide with the expectation of rapid
growth for locations of lower incomes, and slower growth for locations of initially higher incomes. A few exceptions worth noting and further exploration in model results are moderate instead of slow growth in high income cluster in the New York to Washington, D.C. cluster along the eastern seaboard; moderate growth instead of slow growth in the urban centers of the west coast (notably San Diego, San Francisco, Seattle); and slow growth in the area of low initial incomes in southern West Virginia, western Virginia, piedmont North Carolina, western South Carolina, and northern Georgia. This mapping of income levels is consistent with the findings of James (2010) and the theoretical discussion of industrial transition in Hayter (1997), where investment left the urban areas surrounding the Great Lakes, and relocated to locations of lower incomes in the southern and western United States that largely coincide with those noted here. As such, this preliminary exercise has already set the expectation for convergence, but also established a few locations that appeared to operate outside of the model, notably key urban areas that would be subject to the growth associated with early stage PLC reinvestment.

**OLS**

In the OLS, Δ PCPI serves as the dependent variable against 1980 PCPI. The global regression model provides the test for
convergence evidence and a baseline for comparison to the GWR results. Results are displayed in Table 1.

On the surface, these results offer a few interesting findings. First, the model explains 16% of variation in PCPI growth. Though not the strongest R-Squared, for a bivariate model with over 3,000 observations, it is not unreasonable. The intercept predicts growth rates to be roughly 152%, a reflection of overall national growth. This predicted growth is then negatively "corrected" by the beta coefficient of 1980 PCPI, indicating beta convergence. Thus, while there is an aggregate prediction of growth, that prediction is tempered by initial levels of income. The negative beta reflects that the average county had its growth tempered, however the magnitude of the scaling back would be increased as 1980 income levels increased. Thus, the constant over predicted all, but was even more imprecise where base income levels were high.

Diagnostic tests in Table 1 reflect a few problems with the model. First, the Breusch-Pagan indicates heteroskedastic residuals, providing the first evidence of a non-stationary, i.e. the relationship between 1980 PCPI and ΔPCPI is not uniform, thereby suggesting this relationship to be a candidate for a GWR. Further, given the non-stationary relationship, there is a suggestion that more than one theoretical factor influences this relationship, adding some credence to the competing effects between convergence and the PLC. The Jarque-Bera test indicates non-normal residuals, though with over 3,000 observations a failed normality check is not a critical failure. Finally, a global Moran’s I, with an inverse distance squared weight matrix, applied to the residuals indicates there to be spatial autocorrelation in the residuals. This narrowly defined neighborhood will be able to detect spatial autocorrelation outside of the expected existing regionalization of income and income change, and thus aiding in the detection of the strongest of outliers. When taken together, these results reflect a few issues in the OLS. The heteroskedastic and spatially autocorrelated residuals suggest an additional factor influencing results. It may be an omitted variable or the failure could arise from a non-stationarity of the

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<th>Table 1: OLS Results</th>
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<td><strong>R-Squared</strong></td>
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<td>Konker (Breusch-Pagan)</td>
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* Significant at 0.05 level
variables. Anselin’s Local Indicators of Spatial Association (LISA) (Anselin 1995) clusters of the OLS residuals (Figure 3) helps shed some light on the potential cause.

A distinct spatial pattern in the LISA cluster map is visible. First, there is a large concentration of large residual values (a high-high cluster) in a band along the east coast from southern New Hampshire to northern Virginia. Though relatively narrow, usually only two –to-four counties wide, this band holds some of the largest and most complex economies in the country, including Boston, New York, Philadelphia, Baltimore, and Washington, D.C., as well as portions of the urbanized areas connecting them. This area, the Megalopolis region of the United States, is a region that has historically been a unique economy and driver of the larger United States economy (Gottmann 1957). In 1980, the region had comparatively high incomes, which according to convergence theory should have led to slower growth as the negative beta associated with income would drastically reduce the growth expected from the intercept. When that predicted value is subtracted from observed, the difference is large enough to create a statistically significant cluster; a result implying that the region grew in spite of the high levels of initial income. This is not entirely surprising, as it is the central place in the United States’ economy and center of high knowledge activity (whether it be the Tech Corridor in Boston or the massive urbanization and localization benefits and large potential market in New York) (Malecki 1997; Chinitz 1961; Gottmann 1957). The advantages offered by these places are exactly the types location factors that early stage products will need. These advantages can be explained by the PLC, as it accounts for regional economies that grow not just in spite of, but because of their high wage labor. There is a secondary high-high cluster centered in the Dakotas and eastern Nebraska. While the energy economy may be able to explain some of the growth in this cluster, a comparative lack of capital in 1980 would cause any growth to be a large growth rate. Thus, this region serves as an example of both the theorized convergence process, but also of a regional advantage in a growing sector influencing growth.

A large low-low cluster begins in central Michigan, continuing through northeast Indiana/northwest Ohio, and continues south through Appalachian portions of eastern Ohio, western West Virginia, eastern Kentucky, western Virginia, western North Carolina and terminates in eastern Georgia, largely between I-75 and I-77. This is an interesting case. Appalachia is a region that has historically been poverty stricken, but also filling a peripheral role in the national economy (James 2012a; Moore 1994). Even though Appalachia offered the low wages attractive to firms, an additional factor appears to have stunted growth. Appalachia’s historic role as a peripheral region supplying United States’ core may have placed Appalachia outside of the neo-classical framework that drove the convergence of the rest of the United States, thereby marginalizing the ability of low wages to positively influence growth. Additionally, the Indiana-Ohio-Michigan locations are Rust Belt regional economies that focused heavily on semi-skilled Fordist production. The Detroit economy offers insight in to this region, as its economic structure was so focused on Fordist-style mass production in terms of manufacturing support, labor, and firm relations that it lost competitive advantage when the dominant manufacturing paradigm changed for its’ dominant industry (Klier and Rubenstein 2008).

OLS results offer some insight into economic growth in the study period. There is evidence of convergence, with one notable rapidly converging region centered on the
Dakotas. However, model diagnostics and outliers suggest the processes were not as clear cut as the unconditional framework would suggest. While a standard response would be to add more variables to the regression, there is also evidence that the forces driving regional growth may not be constant across space. In particular, the repulsive effect of high wages on growth seemed to hold true only in particular places. If that is the case, places identified as outliers (notably the Megalopolis and Silicon Valley), may have grown in spite of high wages, due to early PLC stage benefits. In order to capture these opposing effects, a local regression needs to be applied.

**Geographically Weighted Regression Results**

To address the OLS diagnostic problems and test for differing effects of income levels on growth, a Geographically Weighted Regression is run using the same variables as the OLS. The results will address the primary research questions of this paper: identify the role and effect of income levels on growth rates; if regions of initial wealth had the expected large negative beta for income; and if regions of initial poverty had smaller betas for income.

GWR are displayed in Table 2. The local regression improves model fit with an increase in R-Squared values from .15 to .66,
and a lower AICc. This dramatic increase in model fit by accounting for local variation suggests that the relationship between initial income levels and growth rates may be the result of local, not globally constant relationships, providing evidence to both the filtering process associated with convergence and late stage PLC movement and the reinvestment of early PLC stages. Thusly, this GWR model provides a method for capturing the convergence process captured in the OLS model, while also accounting for a competing process unable to be captured in the global model.

In Figure 4, the local R-Squared values are mapped, and yield a few interesting results. First, there is a distinct negative relationship between model fit and urbanization. The best R-Squared values are located in three notably rural regions: in the plain states of North Dakota, eastern South Dakota, eastern Nebraska, and northern Kansas; the Texas panhandle; and central Appalachia in eastern Kentucky, Western Virginia and eastern Tennessee. Conversely, the lowest R-Squared values are found through the old manufacturing region stretching from western New York, through Pennsylvania, Ohio, Indiana, and connecting to western Illinois and Wisconsin; a band of urban southern locations stretching from Nashville through Jacksonville passing through Birmingham and Atlanta; and western locations centered in California and Seattle—of which the latter two are regional and national hubs of production and urban activities. Urban-rural fringe counties buffer these regions, and contain mid-level R-Squared values. Notable exceptions to this pattern are the Rocky Mountain locations covering the majority of Colorado, Utah, and portions of Idaho and Wyoming (poor model fit, yet rural) and New York City (good model fit, yet urban). These economies are somewhat unique due to Rocky Mountain tourism and New York’s massive agglomerations, and may operate with slightly different drivers than convergence or the PLC address.

Another potential factor driving the disparities in R-Squared values may come from the heterogeneity of the dependent and independent variables. R-Squared values can be aided by homogeneous data; if there is little variation in the data then there are few points that will stray from the best-fit line. To test for this effect, the categories from Figure 4 representing the highest and lowest R-Squared groupings using the Jenks methodology are more closely examined, with results in Table 3. In the high R-Squared locations, 1980 PCPI has a mean of 75.90 with a variance of 442.86, and ΔPCPI has a mean of 136.41 with a variance of 33.66. Meanwhile, in the low R-Squared locations, 1980 PCPI has a mean of 86.80 and a variance of 320.36, and ΔPCPI has a mean of 98.99 and a variance of 188.48. This

<table>
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<th>Table 2: GWR Results</th>
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<tr>
<td>R-Squared</td>
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<td>AICc</td>
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<td>Neighbors</td>
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<td>Intercept Min</td>
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<td>Intercept Mean</td>
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<td>Intercept Max</td>
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<tr>
<td>1980 Income Beta Min</td>
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<td>1980 Income Beta Mean</td>
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<tr>
<td>1980 Income Beta Max</td>
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<td>Sigma</td>
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result is somewhat surprising, with the low R-Squared locations containing the larger variances. However, tying these results and locations to the theories and data used to construct the model may help shed some light on this. While it is a bit counter-

**Figure 4:** GWR Local R-Squared

**Table 3:** Variable Variance and Model Fit

<table>
<thead>
<tr>
<th>Variable</th>
<th>High R-Squared Locations</th>
<th>Low R-Squared Locations</th>
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<tr>
<td>1980 PCPI Mean</td>
<td>75.90</td>
<td>86.80</td>
</tr>
<tr>
<td>1980 PCPI Variance</td>
<td>442.86</td>
<td>320.36</td>
</tr>
<tr>
<td>Δ PCPI Mean</td>
<td>136.41</td>
<td>98.99</td>
</tr>
<tr>
<td>Δ PCPI Variance</td>
<td>33.66</td>
<td>188.48</td>
</tr>
<tr>
<td>β 1980 PCPI Mean</td>
<td>-1.88</td>
<td>-0.10</td>
</tr>
<tr>
<td>β 1980 PCPI Variance</td>
<td>1.32</td>
<td>0.02</td>
</tr>
<tr>
<td>1980 PCPI/ΔPCPI Covariance</td>
<td>-633.55</td>
<td>-39.34</td>
</tr>
</tbody>
</table>
intuitive that the higher R-Squared areas contain larger variances, the variables also have a larger covariance than in the low R-Squared locations, indicating a strong relationship between the two variables even though they are not tightly clustered around the mean. This large variation may be attributable to the inclusion of the New York City area and its comparative initial wealth with other rural, initially poor locations. This is an important result: it suggests that in places of expected neo-classically driven, bottom up convergence, but also the epitome of high skill, high wage early stage PLC growth locations, wages can do a very good job in explaining growth. In other words, there is evidence of both theorized effects. On the other end, in the low R-Squared locations, their locations tend to overlap with high wage, top-down converging locations. Tying this back to theory, it suggests in in the locations subject to bottom down convergence, that is the locations of high wealth that were not able to take advantage of early stage PLC growth and thus subject to the filtering of wealth, income levels only tell part of the story. Rather, the factors that influenced their growth rates fell outside the scope of this study, perhaps suggesting a more conditional convergence to explain their growth processes. So, even with the small variation, the relationship simply was not a particularly strong one. The differences in the beta coefficients in these locations tend to support these conclusions. Though the distribution of large positive and negative values will be discussed in the following paragraphs, it is worth noting the variance of the betas here. Here, there is also a larger variance in the betas of the high R-Squared verses the low R-Squared locations. This may add further evidence to the suggestions that the high R-Squared locations were subject to a wider range of effects form initial income levels, as there were both strongly positive and strongly negative effects, while in the low R-Squared locations the effects were more tightly clustered around the mean, which itself was closer to zero.

The functionality of the model is examined in Figures 5 and 6, mapping the intercept and beta coefficients respectively. When taken together, these results are a departure from expected convergence results. If the Baumol-inspired framework holds true, in regions of wealth the regression equations should have a constant representing the expected moderate regional growth rate, with a large negative tempering coming from the beta for 1980 PCPI. Even with a local regression, the Baumol framework should predict an increasingly negative effect on growth as 1980 PCPI increases, given that the theorized relationship between income levels and income growth has not changed. In regions of comparative low wages, the constant should be relatively large, larger than the global intercept, with initial income providing a small negative correction for local conditions. Results generally confirm the spatial drift of the intercept and beta values, though depart a bit from the theorized Baumol framework. In Figure 5, there is a noticeable spatial drift of intercept values, confirmed by Table 2 which shows tails of intercepts falling outside of the standard errors of the OLS intercept. In regions of expected top down convergence, notably along the west coast from Washington to California, the east coast along the previously defined Megalopolis area, and the old manufacturing regions of Pennsylvania, Ohio, Indiana, Michigan, and Illinois, this relationship is made rather clear, as intercept values less than 100 predict a loss of relative wealth in these locations. This represents a small departure from the traditional convergence test, as the loss of ground by regions of large incomes is captured in the intercept rather than the beta coefficient. While still true to beta convergence in end result (regions of wealth coming down to the mean), this does cast some doubt on the universality of the

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traditional convergence test when applied with a local regression. If the intercept accounts for the loss of ground, then the regression no longer captures the theorized effect as strongly (i.e. the strong negative relationship between income levels and income growth rates as the driving force behind growth rate dissipates). In bottom up regions (notably in a plains cluster originating in North Dakota and stretching to Kansas and a southern pocket in western Mississippi, eastern Arkansas, and northeastern Louisiana), the intercepts captured the expected rapid growth, which also is consistent with convergence theory in end result. However, if the growth is reflected in the intercept the role of income levels is uncertain. If growth was a result of the lower income levels, the effect may be a positive (or at least less negative) beta coefficient holding intercepts constant. But, with rapid growth predicted by the local intercept, theory does not give a concrete idea of the role of income levels in this relationship, given this intercept.

Figure 6 displays beta coefficients for 1980 PCPI. In the top down regions identified previously the impact of initial income levels on change is not as elegant as in the OLS, where it uniformly slowed growth. Here, coefficients are either slightly negative or
even positive. These coefficients suggest two processes at play. In locations with slight negative coefficients, the loss of ground was largely captured with the intercept; little “income correction” was needed. This reinforces what was first noted with the intercept, that the growth in these locations is consistent with convergence, though it is captured in a manner outside of the expected test results. For the counties with a positive beta, the explanation departs from convergence theory. These counties represent command-control locations of the old, Fordist economy (Chicago-Milwaukee, east coast Megalopolis, Columbus-Cleveland, northern Indianapolis), as well as other unique, skill-driven economies such as California or Miami. The comparative loss of ground predicted by the intercept is to be expected by convergence theory. However, factors captured by their high wages helped shield them from a portion of the top down convergence process. Their locations help explain the processes: these are large urban economies, home to many corporate headquarters, and large agglomeration effects. By virtue of their size and role in the economy, wages and skill levels are expected to be high. Thus, while some of the factors inducing a movement of investment (marginal returns to labor and mature product filtering) are evident, there is also
evidence that their skilled (and high) wage labor force tempered some of that loss, and even provided a spark for growth. This is not inconsistent with Hirsch (1975) and Almor et al. (2006), who note that regions with a comparative advantage of labor skills of high knowledge activity (and in turn high wages) will remain attractive for investment. Here, evidence of the importance of skilled labor in early stage product development is reflected with the positive impact of wages in these economies. Since new product introduction is the key to long term profitability, and life cycles are shrinking (Malecki and Moriset 2008), firms will need to continually reinvest in the regions that can offer the R&D, market proximity, and skilled labor needed to innovate new products. Those locations are going to be urban locations, with existing skilled labor forces, such as those identified here. Since, according to PLC, it is the skill levels that are important in these locations, that can help explain the low R-Squared; wages can be correlated with labor skills, but are a proxy. Therefore, the growth process occurring in these locations is a complex one, of which labor needs and costs play a role, but remain only a part of the picture.

In contrast, bottom up converging regions have the largest negative beta values. These locations are largely concentrated in a band starting in the Dakotas that stretches south through eastern Nebraska, Kansas and the Texas panhandle; a Southern band originating in eastern Missouri and Arkansas, then stretching through northern Louisiana, central Mississippi, Alabama, and Georgia; and an Appalachian pocket in Eastern Kentucky, eastern Tennessee, and western Virginia. This is different from the expected result from the global beta convergence model as low income levels should not have a negative effect on growth rates. The most negative beta coefficients are energy boom locations in the Dakotas, where the amazing growth predicted from the intercept required some tempering. However, in general, the bottom-up regions are home to negative beta values. This is interesting for several reasons. First, it suggests that the growth predicted by the intercept in these regions actually overshoot true growth, and needed the tempering of what little levels of income these regions had. This does hold with the convergence expectation of fast growth in regions of low initial income levels, though not captured in the expected manner. There is a strong relationship between the size of the intercept, and the magnitude of the correction needed. This tempering should be kept in perspective as the low levels of initial income levels require a large beta for much of any change at all.

An interesting regional case is located in the Northern Utah-Idaho-Wyoming-Colorado area. Here is an area of mixed overall wealth in 1980, with healthy urban places such as Denver in addition to very rural location in the mountains. However, this region reflected low overall growth through the intercept and a positive beta for income. Given the diversity of the initial income levels, this result may fall outside of either theory driving the research in this paper. It does, however, present an interesting location for a case study in the future focused on tourism as well as rural growth.

Additionally, the standard errors around the beta coefficients are mapped in Figure 7. Here, there is a unique pattern. There are small standard errors around the beta coefficients in the Megalopolis region identified previously, the Appalachian outliers identified previously, and westward from central Nebraska, South Dakota, and Oklahoma, reflecting a relative strong confidence that the predicted beta for 1980 PCPI is close to the “true” beta. In contrast, the locations that fill up gaps between those locations have larger standard errors, and
the confidence that the betas in these locations are close to "true" is less strong. A notable example in this is located in a band around the Great Lakes starting western New York, and moving westward to include portions of northwestern Pennsylvania, northern Ohio, southern Michigan, and large portions of Indiana and Illinois. This band includes many of manufacturing cities, such as Buffalo, Cleveland, Toledo, Columbus, and Indianapolis, whose economies can be rather complex. The large standard errors in these locations can be understood by contextualizing the performance and construction of the model: the R-Squared values in these locations were rather low, and this model does not account for factor conditions or firms strategy, which as noted by Porter (1990) can influence the competitive advantage of a region. When applied to the Michigan, Ohio, Indiana, and Illinois region, for example, these factors may do a better job of explaining the regional economic decline, as a change in the production strategies of the industries and firms historically clustered in the region operating in conjunction with the inability of the region to supply the necessary factor conditions to be competitive in this new production system that slowed the growth in

Figure 7: GWR Local Beta Coefficient Standard Errors
this region (Klier and Rubenstein 2008). Given the bivariate nature of the regression, the intercept and 1980 PCPI were the only places to assign the change in variation. Thus, since 1980 PCPI is acting as a proxy for others factors of growth, the standard errors around the coefficients would be quite large, since it is working to capture multiple processes instead of capture the “true” coefficient.

Taken together, the results of the GWR offer an interesting insight to the research questions of this paper. First, while income is a significant predictor globally, its role as a predictor at the local level is a bit more complex than simple convergence theory suggests as the relationship is not uniform across space. Secondly, in regions of top down convergence, the slow growth was not captured by the initial income beta, rather it was captured in the constant. In fact, some counties in these locations exhibited a positive coefficient. To explain this departure, it is necessary to extend the theoretical discussion beyond beta convergence. In these locations, while there is the expected slower growth, some locations were able to exhibit growth as a result of their high income levels fitting with the spatial implications of the PLC. For these expected top down locations income change may be a result of both theoretical processes. For the third research question, in regions of bottom up convergence, initial income is used to temper rather exuberant growth from large intercepts, thus taking negative values.

Conclusion

Convergence theory suggests that regional differences in income will dissipate over time (Barro and Sala-I-Martin 1991). There are a variety of frameworks for this process, but one constant across these processes is the fact that there is a movement of investment from regions of comparative wealth to comparative poverty. This movement is influenced by the marginal nature of firms and the natural movement of regional economies towards steady state equilibrium. As continued investment in a region pushes it to the steady state equilibrium, footloose firms tend to relocate to locations where returns to investment can be maximized. Formally, this can be tested by regressing income change against initial income levels, where a negative beta coefficient for income indicates convergence. In general, there is evidence supporting this proposition (Barro and Sala-I-Martin 1991; Baumol 1986; James and Campbell 2013). This movement is also consistent with the filtering down of investment associated with the Product Life Cycle (James 2012b). However, the spatial implications of the PLC also suggest regions with skilled labor, innovation infrastructure, and agglomeration economies will continue to grow as they offer the necessary location factors for early PLC stage production (Malecki 1997). With these two theories combined, there is a suggestion that regions of low wages should grow, but also regions of high wages should grow as well. This paper explores this dichotomy through examining county level economic growth in the United States 1980-2010 using an unconditional convergence model applied in an OLS and GWR framework. These tests allow for the following research questions to be addressed:

(1) What is the role of income levels in predicting income growth, and is it uniform across space?
(2) Do regions with high levels of initial incomes have the expected large negative beta coefficient?
(3) Do regions of initial poverty have positive (or at least less negative) beta coefficients?

OLS results offer global evidence of beta convergence, although model fit is comparatively weak. Here, higher income levels negatively impact growth, though the
overall explanatory power of the model suggests that income growth may be more complicated process than the bivariate OLS captures. The GWR substantially improves model fit, explaining 66% of variation. Income levels are strongly related to regional growth rates, though not in a spatially uniform fashion. When mapped, the intercept and coefficient values offer evidence that growth could be associated with low or high income levels. Rural regions, notably through the Dakotas and extending south, tended to reflect bottom up convergence associated with rural, low wage regions attracting investment. However, that growth was captured in the intercept, with a slight negative correction from the beta coefficient for income. To answer a research question of the paper, regions of initially low income levels did grow rapidly, however it was not reflected in the coefficient for initial income levels. Locations that were not command-control centers of the economy in the old manufacturing belt (i.e. major cities with large urbanization and localization benefits) tended to be subject to top-down convergence, however, their growth was largely captured through a small intercept. To directly answer the research question, these locations did not see the expected large, negative beta coefficient. Finally, a set of counties emerged where high income levels positively influenced growth. These were concentrated in the urban command and control centers of the manufacturing belt (i.e. New York, Chicago, Columbus, etc.) whose agglomeration and skilled labor force were able to retain some investment as the unskilled manufacturing in the region migrated South. This ability may lie in the spatial dimensions of the PLC, where locations that offer the skilled labor, market access, and innovation infrastructure will continue to see reinvestment as firms develop new products. In general, the following trends can be gleaned from this research: (1) initial income levels do play a role in influencing regional growth, however that role can be positive or negative given the local economic structure; (2) locations with higher initial incomes tended to grow more slowly, however that growth was captured in the intercept and in a subset of these locations high income levels had a positive effect on growth; and (3) locations with lower levels of initial incomes experienced faster growth rates, however that growth was reflected in the intercept.

In answering the research questions, this paper finds evidence that regional growth exhibits aspects of neo-classically driven convergence, but also the spatial dimensions of the PLC. The answers to the research questions help address some of the deficiencies noted in the literature review, with notable contributions to both theory and the practice of economic development. For theory, results provide evidence of the more mild convergence process discussed in the literature review. This process combines the spatial dimensions of both early and late stage PLC investment with the natural movement of predicted by the neo-classical factors of convergence to suggest that while there is a broad movement of investment from regions of wealth to regions of comparative poverty, that movement is not an absolute. And further, locations with the ability to offer the locational advantages for high skilled (and high wage) production characteristic of early stage PLC production may have the ability to somewhat sidestep that convergence process. Even with this implication, in many high wage, urban locations, the model performed somewhat poorly, further suggesting that in these complex economies growth is driven by processes additional to PLC and neo-classical factors. Porter (1990), for example, notes that it is not just a skilled labor force, but a labor force that is particularly skilled in the production of the products in demand. For policy, the implications are rather straightforward. First, the tempering of the strict interpretation of the relationship
between labor costs and investment offers some hope to regions whose growth prospects would be bleak under the neo-classical framework. In the old framework, regions with high labor costs, regardless of skill level, would see their attractiveness decline. In order to fight that, the foci of policy has been on cost minimization, and tend towards subsidization of firms and industries. In this new framework, the recognition of the value firms place on skilled labor gives governments a new option for inducing growth, namely polices focused on the creation and continued training of a skilled workforce. This workforce driven approach would also mark a departure in implementation from the old neo-classically driven policies. According to Porter (1990), skilled labor and the innovation process needs constant attention and retraining to remain at peak competitiveness. As such, instead of simple subsidization, these policies are more ongoing in nature. But, with this ongoing nature, it also changes the recipient of the policy benefits and presents a more long term solution. By making the labor more competitive, these polices are investing in the competitiveness of the regions, as opposed to a simple change in the cost structure for a firm.

An additional policy implication comes from the regional effects identified in the results; that is, that forces causing economic growth are not uniform across space, and a county tends to grow similarly to its neighbors. While the change in policy approach noted previously is inherently a local level approach, the presence of these regional effects lends support to the case for Regionalism as noted by Foster (2001). Here, Foster (2001) notes that cooperation in growth policy through the development and exploitation of regional assets can produce growth for component counties that is larger than could be achieved had they functioned independently. The reason behind this capacity lies in the nature of the regions in the global economy. While Swanstrom (2001) notes that labor markets, capital markets, and consumption markets are regional and not necessarily bound by political boundaries, Pierce et al. (1993) adds depth to the argument by noting that in the global economy, the most successful competitive regions are those whose component entities work together to supply capital and labor as one unit. Tying this concept to the results of this study is fairly simple; the regionalization of the growth process depicted by the varying role of wages (and, in turn role of labor) is exactly the kind of regional economy noted by Swanstrom (2001). In other words, at the broad regional scale, cities and surrounding areas operate as one unique unit in the global economy; a concept identified by Pierce et al. (1993). Pierce et al. (1993) further note, that the most competitive of these regional economies are the ones whose component parts act regionally, that is they recognize that they “are all in this together” (Foster 2001), and act accordingly. For the counties located in the broad regions of similar growth process indicated by this study, growth policy should extend beyond the bounds of the individual counties, and incorporate the other locations in the regions, since that is the market which is competing globally. To do so would require a shift in the nature of governance, as some of these regional economies extend across state bounds and would thus require a level of governance more akin to a Metropolitan Planning Organization (MPO), where counties and cities would “grant up” governing authority, and states would “grant down” certain decision making. This reorganization is not dissimilar to the call from Higgins and Savoie (1997), who argue that decisions should be made at the smallest reasonable level of aggregation, which given the regional characteristic of growth and competitiveness identified here, is at the regional level.
This introduces directions for future research. First, drawing from the GWR results, while it is clear that the convergence process of faster growth by regions of initially lower income levels is occurring, the growth is captured in the intercept, suggesting aspects other than their comparative lack of wealth drove growth. Rather, it appears that income simply is a structural variable that has a somewhat weak correlation to the true drivers of growth, reflected in both the importance of the intercepts and the weak R-Squared in the OLS. To find those drivers, a conditional GWR model should be applied, which includes structural variables to account for the PLC evidence, such as high skill employment specialization, corporate headquarter concentration, as well as other variables including capital investment, agglomeration benefits, and available capital. Additionally, growth processes can be unique to scale, and a worthwhile endeavor would expand this analysis to other levels of spatial aggregation to determine if the same drivers of growth and PLC evidence is of similar importance in other scales of aggregation. Practically speaking, the application of this model at other scales is a simple one; the variables and expected relationships from convergence and the PLC should not change. However, the key in application at different scales comes in the interpretation of results, and in the selection of study areas. While a state-level analysis may be very appealing given the development and policy power at the state level of government, the ability of the model to capture regional the localized regional growth process is suspect, as GWR operates best when the number of observations is large (Fortheringham et al. 2002). A better scale of application may be found in the metropolitan (Metropolitan Statistical Area or Bureau of Economic Analysis Economic Areas) or international levels of aggregation, where sample sizes would minimally approach 200. The metropolitan level of aggregation, this would extend the analysis to identify how larger city-systems operate in these regional economies, and how larger cities either conformed to neo-classical convergence or sidestepped predicted losses by filling roles early stage PLC demands. At the international scale, the application gets a bit more interesting. Here, there already has been analysis testing for these competing factors, and exploring the role of the PLC in international development (Hirsh 1975; Almor et al. 2006). While these studies identified the presence of these competing effects, they were not encapsulated in traditional growth model framework. Applying this model at the international scale would do so. Further, the local diagnostics would provide the ability to identify the strength in which these relationships explained growth, thereby providing a mechanism for testing if the degree to which international growth can be explained by these popular theories, and most importantly identifying locations which operate outside of these theories as candidates for development polices from derived from alternative theories.

References


James, A.C. 2012.a *Economic Change and Regional Overlap: Did Being Appalachian Influence County Level Economic Change During the Rust Belt-Sun Belt Transition?* Master of Arts Thesis in Geography. University of North Carolina at Charlotte: Charlotte, NC.


Magalhaes, A. Hewings,G., & Azzeni, C. 2006. Spatial Dependence and Regional


