Determinants of Income Growth in U.S. Metropolitan and Non-metropolitan Labor Markets

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George W. Hammond
Bureau of Business and Economic Research
West Virginia University
Phone: (304) 293-7876
Fax: (304) 293-7061
Email: ghammond@wvu.edu

Eric Thompson
Department of Economics and Bureau of Business Research
University of Nebraska
Phone: (402) 472-3188
Fax: (402) 472-9700
Email: ethompson2@unl.edu

Contact Information:
George W. Hammond
Research Associate Professor
Bureau of Business and Economic Research
College of Business and Economics
West Virginia University
P.O. Box 6025
Morgantown, WV 26506-6025
Phone: (304) 293-7876
Fax: (304) 293-7061
Email: ghammond@wvu.edu

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Abstract

This research analyzes determinants of growth across U.S. labor market regions, using a production function approach based on four inputs: labor, manufacturing investment, human capital investment, and public capital investment. We find significant differences in the relative influence of growth determinants between metropolitan and non-metropolitan regions during the 1969-1999 period. We find little role for public capital investment in either metropolitan or non-metropolitan regions, but that manufacturing investment tended to spur growth in non-metropolitan regions, in contrast to results for metropolitan regions. We find that human capital matters for both metropolitan and non-metropolitan regions, but that increased human capital investment in metropolitan regions may have a larger impact on growth than in non-metropolitan regions. Further, the presence of more colleges and universities, more household amenities, and lower tax rates were all found to encourage human capital accumulation in U.S. labor market areas.

JEL Classification: O40, R11

Key words: metropolitan; non-metropolitan; Constant-Elasticity-of-Substitution; Solow growth model; Income growth
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I. Introduction

Persistent and large differences in the level of income both between countries and within countries have attracted much attention from economists. For example, using data for U.S. states, per capita personal income relative to the national average in 1969 ranged from a low of 62.6% for Mississippi to a high of 126.0% for Connecticut. In other words, per capita personal income in the highest income state was 201.3% above per capita income in the lowest income state. Income differences remained large in 1999, with per capita income in Connecticut 191.2% higher than in Mississippi. Further, income differences are even larger as we disaggregate states into smaller labor market regions. Indeed, using one definition of sub-state labor markets (commuting zone regions for the continental U.S. (Tolbert and Sizer, 1996)), we find that the income difference between the highest income region and the lowest was 279% in 1969 and 335% in 1999.¹

Numerous researchers have examined sources of growth for cities and metropolitan statistical areas using a wide variety of explanatory variables, including human capital, industry mix, amenities, race, and geography, as well as inputs into the production process, like manufacturing and public capital investment. Human capital investment, measured by education attainment, is often found to be highly correlated with strong metropolitan growth, for instance in Glaeser and Saiz (2004), Simon and

¹ In 1969, the commuting zone region with the highest per capita personal income was Nantucket County, Massachusetts ($5,111). The commuting zone region with the lowest income was Maverick County, Texas ($1,349). In 1999, the region with the highest income was the Teton zone (including Teton counties in Idaho and Wyoming) with $47,050. The lowest income region was Maverick County, Texas, with $10,826. Personal income data based on estimates from U.S. Bureau of Economic Analysis, Regional Economic Information System, CD-ROM, May 2001.

The focus on metropolitan regions and cities is natural, given that most U.S. residents live in metropolitan statistical areas. However, the share of residents living in non-metropolitan counties is still significant, at 17% of U.S. population in 2000, which amounts to 49 million residents. Thus, studies that focus exclusively on metropolitan areas or cities may suffer from sample selection bias. To remedy this, Hammond and Thompson (2006), Hammond (2006), Hammond (2004), Rupasingha et al. (2002), Beeson et al. (2001), Nissan and Carter (1999) and Henry (1993), and Carlino and Mills (1987) investigated convergence and growth issues using regional data that encompasses both metropolitan and non-metropolitan regions. Further, with the exception of Beeson et al. (2001), these studies find important growth differences across metropolitan and non-metropolitan regions. Beeson et al. (2001) do not address this issue because their sample, which extends back to 1840, predates the metropolitan/non-metropolitan typology.

However, these past efforts to explore heterogeneity among metropolitan and non-metropolitan regions have not utilized a formal growth model or, with the exception of Hammond and Thompson (2006) and Hammond (2006), sought to pin down possible differences in growth determinants across metropolitan and non-metropolitan areas. Further, Hammond and Thompson (2006) and Hammond (2006) find suggestive evidence that human capital development may play a limited role in non-metropolitan income growth, in contrast to results for metropolitan areas.

The evidence for differences in growth determinants between metropolitan and non-metropolitan regions is thus far only suggestive, because the main thrust of the
empirical work in Hammond and Thompson (2006) and Hammond (2006) was to explore convergence trends across metropolitan and non-metropolitan regions in the U.S. A more structural approach to growth determinants across metropolitan and non-metropolitan regions would provide the opportunity to investigate whether potential heterogeneity occurs due to differences in investment rates across regions, or rather due to differences in structural parameters reflecting differences in technology. This in turn may aid policymakers at the state and local level as they allocate scarce resources to enhance economic development.

In this paper we specify a Solow (1956) growth model with four inputs: labor, public infrastructure, private manufacturing plant and equipment, and human capital. We also employ a constant-elasticity-of-substitution (CES) production function, in contrast to previous studies using U.S. regional data, which have assumed a Cobb-Douglas (CD) production function. The added flexibility of the CES production function allows us to investigate the possible role of the elasticity of substitution in growth. As Klump and Preissler (2000) show analytically, and Masanjala and Papageorgiou (2004), Duffy and Papageorgiou (2000) show empirically using an international dataset, the elasticity of substitution can play an important role in the growth process.

We prefer the production function approach because our goal is to understand the relative importance of human, manufacturing, and public capital development in the regional growth process. We are interested in these inputs because the state and local policy debate frequently revolves around them. With respect to manufacturing capital investment, we would prefer a broader measure that reflected capital expenditures across all industries, but none exists at the sub-state regional level. Nonetheless, we pursue our
analysis with the manufacturing data, because this industry remains of interest to policymakers when designing economic development policies. We also contribute to the literature by examining an important type of parameter heterogeneity: differences across metropolitan and non-metropolitan regions. Finally, we treat all investment rates as endogenous, which as Crihfield and Panggabean (1995) point out, is an important consideration in this context.

In our empirical work, using data for 722 labor market areas in the continental U.S., we find distinct structural differences across metropolitan and non-metropolitan regions. In terms of determinants of income growth, our results suggest that human capital is an important driver of income growth for non-metropolitan regions, as well as for metropolitan areas. However, we note that human capital investment has a larger impact on growth for metropolitan areas than for non-metropolitan regions. We also find that private capital investment in manufacturing has a positive and significant impact on per capita personal income growth in non-metropolitan areas, but no significant impact on growth in metropolitan areas, which is consistent with the more severe decline in manufacturing jobs in metropolitan areas during the period. Further, consistent with the literature, public capital investment has no significant impact on per capita income growth for metropolitan and non-metropolitan regions. Finally, we find only mixed support for the CES production function and the role of the elasticity of substitution in contributing to regional growth during the period.

This paper proceeds as follows: Section II discusses the background literature and introduces the Solow growth model. Section III presents the empirical results, including
the construction of our data, the factor market models, and the growth models. The paper concludes with Section IV.

II. Literature and Theoretical Framework

Issues of regional economic growth and convergence have generated a large and growing body of research, but much of this activity has focused on datasets at the state or even multi-state region level. However, these regional definitions may not make much economic sense, because states are made up of diverse collections of metropolitan and non-metropolitan regions and, in addition, it is common for local labor markets to spill across state lines. Further, as Lucas (1988) argues, cities are a preferable unit of analysis when human capital (and associated externalities) may be an important component of the growth process. In order to avoid the distortions inherent in state-level datasets, many studies have examined growth and related issues at the metropolitan and city level.

For instance, Glaeser and Saiz (2004), Simon and Nardinelli (2002), Simon (1998), Glaeser et al. (1995), Crihfield and Panggabean (1995) and Rauch (1993) examine determinants of growth for metropolitan areas (and cities) and find that human capital has a powerful impact on economic performance, measured by population, employment, and income growth, as well as productivity. These studies also examine a variety of influences on metropolitan growth, including industry mix, amenities, race, and geography, as well as manufacturing and public capital investment.

While the focus on metropolitan areas and cities is a natural extension of the state growth and convergence literature, it ignores important issues. First, the results may be biased toward convergence, since, by design, the data set excludes non-metropolitan

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regions. As noted by Beeson et. al. (2001) the focus on cities and metropolitan areas may to lead to the sort of selection bias noted by DeLong (1988) in his analysis of Baumol’s (1986) convergence results for OECD countries. A more general investigation of convergence and growth should consider all labor markets, not just a subset, even if that subset accounts for a large share of the population.

In addition, the focus on metropolitan regions will ignore possible parameter heterogeneity across U.S. regions. It will naturally tend to focus policy prescriptions on factors which affect metropolitan growth. This advice is likely to be applied by policymakers to all regions, metropolitan or not, even though this literature does not directly present evidence on relevant correlations for non-metropolitan regions.

To address these issues, the literature has begun to investigate convergence and growth in more diverse groups of sub-state economic areas, including both metropolitan and non-metropolitan regions. Hammond and Thompson (2006), Hammond (2006), Hammond (2004), Rupasingha et al. (2002), Beeson et al. (2001), Nissan and Carter (1999) and Henry (1993) and Carlino and Mills (1987) explore the issue of growth in metropolitan and non-metropolitan regions, using a variety of empirical approaches including distribution dynamics, time-series methods, spatial distribution dynamics, cross-section regressions, and trends in cross-section standard deviations.

For instance, Beeson et al. (2001) present evidence that both natural and produced characteristics mattered for U.S. county population growth during the 1840 to 1990 period (for counties delineated in 1840). They find that access to transportation networks (rail and water), topography, climate, and the presence of natural resources help to explain population growth during the period. Even after controlling for these natural
characteristics, they find that produced characteristics, such as the presence of a library and/or college, as well as industry mix, play an important role in county population growth. They conclude that human capital development played a significant role in U.S. county-level population growth during the last 150 years. Beeson et al. (2001) do not attempt a metropolitan/non-metropolitan distinction, presumably because their data predates the concept. They do analyze population growth by county population density and find that counties in the top decile of density (which probably contain large cities) tended to experience relatively fast population growth. However, their focus is more on convergence than on isolating different impacts of growth determinants between more and less densely populated counties.

Rupasingha et al. (2002) also examine economic growth for all U.S. counties, using per capita personal income data for the 1990-1997 period. Their primary interest is the impact of social and institutional characteristics on growth. They examine these factors by including measures of income inequality, ethnic inequality, and measures of the importance of two types of social groups: social groups (like religious groups) and rent-seeking groups (like labor and business associations). They include a wide range of control variables, including fiscal measures and educational attainment. They find that the social and institutional characteristics matter for county income growth, as well as an important role for human capital (measured by college-level educational attainment) in raising county income growth. Rupasingha et al. (2002) also find that metropolitan counties tend to grow faster than non-metropolitan counties, and that non-metropolitan counties that are adjacent to metropolitan counties tend to grow faster than non-metropolitan counties that are not, holding other growth influences constant. However,
they do not explore the possibility that the impact of their regressors may differ between metropolitan and non-metropolitan counties.

Carlino and Mills (1987) addressed the issue of U.S. county employment and population growth during the 1970s, and found that several policy variables (like taxes and industrial revenue bonds) had little impact on employment or population growth. They did find a strong influence for climate in driving population growth during the period, as well as a significant positive influence of the presence of the central city of a metropolitan area in the county. They found that counties not including a central city tended to experience slower population growth, whether or not they were adjacent to the county including the central city. Carlino and Mills (1987) also do not attempt to pin down differences in growth determinants across metropolitan and non-metropolitan counties, but they do close with speculation that education may be an important component in county growth.

Hammond and Thompson (2006), Hammond (2006), and Hammond (2004) set out explicitly to address differences in metropolitan and non-metropolitan income growth and convergence during the 1969-2001 period. Their analyses focus on multi-county labor market regions, defined in Tolbert and Sizer (1996), and they generally find significant differences in growth and convergence trends between metropolitan and non-metropolitan areas. They employ a variety of empirical techniques, including analyzing distribution dynamics, time-series properties, and spatial Markov chains. Further, Hammond and Thompson (2006) and Hammond (2006) find some evidence which suggests that human capital investment (measured by college-level educational attainment) may not have a significant positive impact on growth in non-metropolitan
labor market areas, in contrast to metropolitan areas. This points to an interaction between human capital and agglomeration economies, which has troubling implications for economic development efforts aimed at raising the human capital investment in non-metropolitan regions. However, due to the nature of the empirical tools employed, these results are only suggestive.

Thus, to date, there has been no comprehensive effort to examine how the determinants of regional growth may differ across metropolitan and non-metropolitan regions. We follow the general approach of Crihfield and Panggabean (1995) and focus on a formal production process with four inputs: labor, private physical capital, public infrastructure capital, and human capital. We focus on these inputs because the state and local policy debate often revolves around them. Thus, their relative contribution to regional economic growth and differences in those contributions across metropolitan and non-metropolitan regions are important policy considerations.

In order to investigate these issues, we start with a model that describes a one-sector economy and which generates its good using a CES production function. As in Crihfield and Panggabean (1995) we include four inputs in the production function: labor, private physical capital, public infrastructure capital, and human capital. We depart from earlier work by employing a CES production function, which provides added flexibility in the modeling of production technology by allowing the elasticity of substitution to differ from one. CES production functions are becoming increasingly popular in the empirical literature on international growth and convergence (Masanjala and Papageorgiou (2004), Duffy and Papageorgiou (2000)). They are attractive in this
context because they allow us to investigate the role of the elasticity of substitution in the growth process and because they encompass the CD specification.

Following Masanjala and Papageorgiou (2004) we specify a CES production function with labor augmenting technological progress:

\[ Y = \left[ \alpha K^\rho + \beta H^\rho + \gamma Z^\rho + \left( 1 - \alpha - \beta - \gamma \right)(AL)^\rho \right]^{\frac{1}{\rho}} \]  

where A is exogenous technology which grows at rate g, Y is real output, K is the private physical capital stock, Z is the stock of public capital, H is the stock of human capital, and L is the labor force which grows at rate n (we suppress time subscripts). We expand on the work of Masanjala and Papageorgiou (2004) through our inclusion of public capital stock as an input. The parameters \( \alpha, \beta, \gamma \) are distribution parameters. The elasticity of substitution \( (\sigma \geq 0) \) is defined as \( 1/(1-\rho) \). In this four factor case, we focus on the Allen Partial Elasticity of Substitution (Allen, 1938, pp. 503-509), which states that for production functions of the form in Equation [1] the elasticity of substitution \( \sigma = \sigma_{ij} \) where \( i,j=(K, H, Z, AL) \) and \( i \neq j \). Uzawa (1962) contains a full discussion. If \( \rho = 0 \) \( (\sigma = 1) \), the CES production function reduces to the CD case. On the other end of the spectrum, if \( \rho = 1 \) \( (\sigma = \infty) \), we have the perfect substitution case. Finally, if \( \rho = \infty \) \( (\sigma = 0) \) we have the fixed proportions case.

We re-write [1] in intensive form:

\[ y = \left[ \alpha k^\rho + \beta h^\rho + \gamma z^\rho + \left( 1 - \alpha - \beta - \gamma \right)(AL)^\rho \right]^{\frac{1}{\rho}} \]  

where lower case variables are expressed per unit of effective labor. The stocks of the three forms of capital evolve over time according to the following relationships:

\[ \dot{K} = S_k - \delta K \]  

[3]
\[ \dot{H} = S_h - \delta H \]  
\[ \dot{Z} = S_z - \delta Z \]

where \( S_k, S_h, \) and \( S_z \) are shares of output invested in each form of capital. We make the standard assumption that all forms of capital depreciate at the same rate (\( \delta \)). We use these equations in the standard way to solve for steady-state output:

\[
y^* = \left\{ \frac{1}{(1 - \alpha - \beta - \gamma)} \right\} \left\{ \frac{\alpha}{\delta + n + g} S_k \right\}^\rho - \frac{\beta}{(1 - \alpha - \beta - \gamma)} \left\{ \frac{\gamma}{\delta + n + g} S_h \right\}^\rho - \frac{\gamma}{(1 - \alpha - \beta - \gamma)} \left\{ \frac{S_z}{\delta + n + g} \right\}^\rho \]  

To facilitate estimation, we follow Masanjala and Papageorgiou (2004) and Kmenta (1967) by computing a linearized version of the steady-state solution via a second-order Taylor series expansion of [6] around \( \rho = 0 \). This linearization yields:

\[
\ln \left( \frac{Y}{L} \right)_t = \ln A(0) + g \rho + \frac{\alpha}{1 - \alpha - \beta - \gamma} \ln \left( \frac{S_k}{\delta + n + g} \right) + \frac{\beta}{1 - \alpha - \beta - \gamma} \ln \left( \frac{S_h}{\delta + n + g} \right) + \frac{\gamma}{1 - \alpha - \beta - \gamma} \ln \left( \frac{S_z}{\delta + n + g} \right) + \frac{\rho^2}{2 (1 - \alpha - \beta - \gamma)^2} \left[ \frac{\alpha^2}{\ln (S_h/S_k)^2} - \frac{\beta^2}{\ln (S_k/S_h)^2} - \frac{\gamma^2}{\ln (S_h/S_z)^2} - \frac{\alpha \beta}{\ln \left( \frac{S_k}{S_h} \right)^2} - \frac{\beta \gamma}{\ln \left( \frac{S_h}{S_z} \right)^2} - \frac{\alpha \gamma}{\ln \left( \frac{S_k}{S_z} \right)^2} \right] \]  

Note that if \( \rho = 0 \) (\( \sigma = 1 \)) Equation [7] reverts to the CD solution. This will facilitate a test for mis-specification in research that has assumed a CD production function. That is, if \( \rho = 0 \) the squared terms on the second line of Equation [7] will be jointly insignificantly different from zero.

Since regional economies may not be at their steady-states at all times, we follow Crihfield and Panggabean (1995) and account for the adjustment to steady state, using:

\[
\ln \left( \frac{Y}{L} \right)_t - \ln \left( \frac{Y}{L} \right)_0 = (1 - \pi) \left[ \ln \left( \frac{Y}{L} \right)_t - \ln \left( \frac{Y}{L} \right)_0 \right] \]  

Substituting Equation [7] into Equation [8] we have:
\[
\ln \left( \frac{Y}{L} \right) _t - \ln \left( \frac{Y}{L} \right) _0 = (1 - \pi) A(0) + (1 - \pi) g t - \frac{(1 - \pi)(\alpha + \beta + \gamma)}{1 - \alpha - \beta - \gamma} \ln(\delta + n + g) + \frac{(1 - \pi)\alpha}{1 - \alpha - \beta - \gamma} \ln(S_k) \\
+ \frac{(1 - \pi)\beta}{1 - \alpha - \beta - \gamma} \ln(S_h) + \frac{(1 - \pi)\gamma}{1 - \alpha - \beta - \gamma} \ln(S_z) \\
+ \frac{\rho}{2} \frac{(1 - \pi)}{(1 - \alpha - \beta - \gamma)^2} \left[ a \ln \left( \frac{S_k}{\delta + n + g} \right) + \beta \ln \left( \frac{S_h}{\delta + n + g} \right) + \gamma \ln \left( \frac{S_z}{\delta + n + g} \right) \right] \\
- \frac{\alpha}{2} \ln \left( \frac{S_k}{S_h} \right)^2 - \beta \ln \left( \frac{S_h}{S_z} \right)^2 - \gamma \ln \left( \frac{S_z}{S_k} \right)^2 \\
- (1 - \pi) \ln \left( \frac{Y}{L} \right) _0
\]

This is the form of the equation which we estimate in the following section, after converting to annual rates. It allows us to test for the relative influence of each form of investment on growth and to identify possible asymmetries in the impact of investment (manufacturing plant and equipment, human capital, and public capital) and the elasticity of substitution across metropolitan and non-metropolitan regions.

III. Empirical Results

We test the model using data from 722 local labor market areas (LMAs) in the continental United States. These mutually exclusive and exhaustive local labor markets were developed by the U.S. Department of Agriculture’s Economic Research Service to capture commuting zones in non-metropolitan as well as metropolitan areas. These ERS commuting zones are aggregations of counties, and, of the 722 LMAs in the data set, 256 are metropolitan and 466 are non-metropolitan. Metropolitan areas include one or more metropolitan statistical areas (MSAs) and non-metropolitan areas are those which do not contain any counties included in an MSA (Tolbert and Sizer(1996)). These labor market areas, which county-to-county commuting data from the 1990 Census reveal to be integrated labor markets, are an appropriate aggregation of counties for the study of variables influenced by the labor market, such as per capita personal income growth. We
also prefer aggregating county data to the LMA level because this should reduce the influence of spatial spillovers on our results, particularly when compared to county data.

Descriptive statistics for all investment and growth variables are provided in the top panel of Table 1 and the Data Appendix details data sources. In most cases we acquire county-level data and aggregate to labor market regions. We use real per capita personal income as our measure of regional income growth. This is a broad measure of income, including earnings from work, asset income, and transfer receipts. The average annual growth rate of real per capita income (deflated using the U.S. CPI-U for all items, all cities) for all areas was 1.62% per year during the 1969-99 period. Growth was faster in metropolitan areas (at 1.67% per year) than in non-metropolitan areas (1.59%). The top-three fastest growing metropolitan LMAs during the period included Austin-San Marcos, Texas; Raleigh-Durham-Chapel Hill, North Carolina; and the Tallahassee, Florida region. Of the non-metropolitan LMAs, the three fastest growing included Demopolis City-Marengo County, Alabama; Eufaula City-Barbour County, Alabama; and the Gonzales City-Gonzales County, Texas region. Real per capita personal income was also significantly higher in metropolitan areas ($15,300 in 1982-84 dollars on average in 1999) than in non-metropolitan areas ($12,715).

We use data on new capital expenditures in the manufacturing sector as our measure of private capital investment. We would prefer a broader measure that reflected capital expenditures across all industries, but none exists at the sub-state regional level. Nonetheless, we pursue our analysis with the manufacturing data, because this industry

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3 This data set abstracts from issues of cost-of-living differences. It is common in the literature on convergence and growth to do so, because these costs are notoriously difficult to measure. However, as Deller et al. (1996), among others, argue, cost-of-living differences may influence the results.
remains of interest to policymakers when designing economic development policies. As Table 1 shows, new manufacturing capital expenditures for all LMAs, relative to region income, average 2.50% during the period, with investment rates in metropolitan areas (at 3.15%) well above rates in non-metropolitan areas (2.14%).

Public capital outlays, again relative to region income, average 1.37% for all LMAs, with generally smaller rates of investment for metropolitan regions than for non-metropolitan regions. This measure of local government spending will reflect local spending for infrastructure development (transportation, water and sewer), as well as government structures. For both manufacturing and public-sector investment, our measures are the same concepts employed in Crihfield and Panggabean (1995).

Finally, we find differences in human capital investment between metropolitan and non-metropolitan regions during the period. Using decennial Census data, we estimated the average annual increase in years of schooling per worker age 25 or older. Average years of schooling grew by 0.044 annually for all LMAs from 1970 to 2000, with slightly faster growth (0.045) in metropolitan areas than in non-metropolitan areas (0.043). This measure focuses on the change in the stock of human capital during the period, which better reflects the investment concept, in contrast to the average level of educational attainment used in Crihfield and Panggabean (1995) and the beginning-period educational attainment (or median years of schooling) used in Glaeser et al. (1995). The coverage of our measure is similar to Crihfield and Panggabean (1995) and Glaeser et al. (1995) in the sense that it reflects both high school and college level attainment. Human capital measures employed in Hammond and Thompson (2006), and
Hammond (2006), and Rupasingha et al. (2002) focused on college or better levels of educational attainment.

A. Factor Market Model

As in Crihfield and Panggabean (1995), we consider the potential endogeneity of the factors of production in the Solow growth model. This possible endogeneity comes about because we consider small open economies, with free flows of capital and labor among regions. Thus, in contrast to international studies, investment rates and population growth will influence, and be influenced by, income growth. We implement a two-stage model where investment rates are modeled in the first stage and then predicted values are utilized in estimating the growth model.

The bottom panel of Table 1 shows descriptive statistics for variables used in reduced form equations for each of the factors of production. We include tax and utility rate variables, along the lines of Crihfield and Panggabean (1995), as well as the level of unionization. These cost variables are expected to reduce private sector factor growth (private physical and human capital investment, and population growth), but in the case of taxation encourage growth in public sector investment.

We also included a number of other variables expected to influence the rate of investment and population growth in labor market areas. The presence of more four-year colleges and universities per person is expected to encourage growth in education attainment, along the lines of Beeson et al. (2001) and Glaeser and Saiz (2004). We include the mean temperatures for January and July to reflect the local climate and a measure of the percent of the region covered by water to reflect proximity to the coast, lakes, and/or rivers. As noted by many others, we expect higher January temperatures,
lower July temperatures, and greater access to coasts, lakes, and/or rivers to encourage faster population growth.

In contrast to previous research, we include an indicator of the regional topography developed in McGranahan (1999). This topography scale (1 through 21) runs from 1 (plains) to 21 (high mountains). We expect this measure to reflect higher costs for building public and private physical capital in rougher terrain and to reflect recreation amenities that encourage population growth.

Finally, we expect the death rate to influence the natural rate of population growth, as well as the level of public sector physical capital investment, and we include a set of state dummy variables in each factor market regression.

We use these variables to estimate a reduced form equation for the three types of investment and for population growth. Hausman tests based on these factor market equations reject the exogeneity of public capital (at the 1% confidence level), human capital (at 1%), and population growth (at 10%), though not the private manufacturing investment variable.

Table 2 shows the results of the factor market model regressions. Results overall indicate that higher taxes and the presence of business dis-amenities like a rough terrain (a higher value for the topography variable) discourage manufacturing investment. Taxes on the other hand encourage public physical capital investment. Further, a rough terrain does not discourage public capital investment, indicating that the public sector is less sensitive to investment costs than the private sector. A higher death rate, characteristic of an older population, also discouraged public capital investment, perhaps due to a shorter time horizon to benefit from these investments.
Higher taxes discouraged population growth, but household amenities such as rougher terrain, mild temperatures, and proximity to coasts, lakes, and/or rivers encouraged it. A higher death rate discouraged population increase, as would be expected. The presence of more colleges and universities per capita encouraged increases in human capital investment. Amenities also encouraged growth in human capital, presumably by encouraging net immigration. Younger workers are both more likely to migrate and have higher education levels.

B. Solow Growth Model with a CES Production Function

We now use data for all LMAs to estimate unrestricted and restricted versions of Equation [9], making use of predicted values derived from our first stage regressions. Table 3 contains unrestricted estimations and Table 4 contains the restricted estimations, obtained via non-linear least squares. Starting with results for pooled metropolitan and non-metropolitan regions, we reject the null hypothesis that the squared terms in the unrestricted regression are jointly equal to zero at the 10% level. This provides some support for the CES model over a Cobb-Douglas specification. The restricted estimates, in Table 4, suggest that manufacturing and human capital investment are significantly and positively correlated with income growth. Results for public capital investment suggest a significant negative correlation, which is consistent with the results of Crihfield and Panggabean (1995) and Glaeser et al. (1995). The estimate of the elasticity of substitution ($\rho$) is positive but not significantly different from zero at the 10% level.

A key consideration in this paper is the validity of pooling the metropolitan and non-metropolitan data. We test this hypothesis and find that pooling of the data for
metropolitan and non-metropolitan labor market areas is rejected (at the 1% level). This provides evidence that the relative influence of investment rates differs between metropolitan and non-metropolitan regions. We provide separate results metropolitan and non-metropolitan LMAs in Tables 3 and 4.

[TABLE 3 ABOUT HERE]

[TABLE 4 ABOUT HERE]

We find some interesting differences in the impact of investment rates on growth across metropolitan and non-metropolitan areas, as Table 4 shows. For instance, private capital investment in manufacturing has a positive and significant impact on per capita personal income growth in non-metropolitan areas, but a negative (although not significant) impact on growth in metropolitan areas. For metropolitan areas, this is similar to results obtained by Crihfield and Panggabean (1995), who found a negative but insignificant correlation between manufacturing investment and income growth during the 1960-1977 period. This is also consistent with results reported in Glaeser et al. (1960), who find a strong negative correlation between the manufacturing employment share in 1960 and growth during the 1960-1990 period for SMSAs in their sample. It also reflects the relative employment trends across metropolitan and non-metropolitan regions. Using employment data from the U.S. Bureau of Economic Analysis, the manufacturing share of jobs in metropolitan areas has fallen from 23% in 1969 to 11% by 1999. The share relative decline has been less severe in non-metropolitan regions, falling from 20.6% in 1969 to 15.7% by 1999.4

While we found that public capital investment had a significant negative impact on growth for the full sample of LMAs, we find that the coefficient on public capital investment

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4 Manufacturing employment defined using the Standard Industrial Classification.
investment was negative but insignificant after disaggregating across metropolitan and non-metropolitan regions. For metropolitan areas, these results are similar to Crihfield and Panggabean (1995), Dalenberg and Partridge (1995), and Glaeser et al. (1995) and for non-metropolitan regions the results are consistent with evidence reported by Chandra and Thompson (2000) for highways. Overall, this suggests that infrastructure development at the margin did not contribute significantly to growth in U.S. sub-state areas during the 1969-1999 period.

A consistent result across metropolitan and non-metropolitan regions is the positive and significant coefficient on human capital investment, which highlights again the importance of education in growth. There were, however, differences in the impact of education. To examine this, we computed a simulation of the effects of human capital investment on growth using our restricted CES results. We examine the impact of a 10% increase in human capital investment in both metropolitan and non-metropolitan labor market areas. Such an increase leads to a 0.032 percentage point increase in annual per capita income growth in metropolitan areas, and a 0.021 percentage point increase in annual per capita income growth in non-metropolitan areas. The contribution of human capital investment to income growth is approximately 50% greater in metropolitan areas than in non-metropolitan areas.

The greater impact of human capital investment in metropolitan than non-metropolitan regions is generally consistent with Hammond and Thompson (2006) and Hammond (2006). However, the parametric approach in this research shows that education has a significant positive impact on income growth in non-metropolitan regions as well. Further, since the measure of human capital employed in this research reflects
both high school and college-or-better educational attainment it suggests that local
economic development officials should focus on raising human capital levels across a
broad range of attainment levels, and not solely concentrate on the highest levels of
educational attainment.

With respect to the elasticity of substitution, our results remain mixed once we
disaggregate metropolitan and non-metropolitan regions. In the unrestricted estimation,
F-tests on the joint significance of CES-coefficients (squared terms in brackets in
Equation [9]) reject the null hypothesis in the case of non-metropolitan labor market
areas. This suggests that the data may be consistent with the CES specification. However,
as shown in Table 4, the estimated value of $\rho$ is statistically significant at the 17% level in
the case of non-metropolitan areas. For metropolitan areas, the squared terms are not
jointly significantly different from zero in the unrestricted estimation and the point
estimate of $\rho$ is also not significantly different from zero.

Finally, with respect to the coefficient on initial income, which is commonly
referred to in the literature as the conditional convergence coefficient, Quah (1993) has
forcefully argued that it must be interpreted carefully. In particular, Quah (1993) shows
that a significant negative coefficient on initial income in a cross-section growth
regression does not imply that income levels are becoming more similar during the
estimation period. We do not place the convergence interpretation on the coefficient of
initial income. Rather we view it as indicating that initially lower income regions have
tended to grow faster than initially higher income regions, after accounting for steady-
state determinants, which is what we observe. See Hammond and Thompson (2006),
Hammond (2006), and Hammond (2004) for analyses of convergence in this dataset using valid empirical techniques.5

IV. Conclusions

This study utilized data from 722 labor market regions in the U.S. to estimate a Solow growth model for the 1969 to 1999 period. Factor market models are used to address the potential endogeneity of regional factor market investments, including human capital, manufacturing capital, and public capital. We test for parameter heterogeneity between metropolitan and non-metropolitan regions with respect to these inputs. We also utilize a CES production function, which allows the elasticity of substitution to vary from one.

We find significant differences in determinants of growth between metropolitan and non-metropolitan labor market areas, which result from structural differences across regions. This is a new result in the regional growth literature and it suggests that policymakers should take this into account when designing policies to enhance economic development.

One common theme across metropolitan and non-metropolitan regions is the importance of human capital for growth. This suggests that state and local economic development officials in both metropolitan and non-metropolitan regions should focus

5 However, in order to compare our results with previous research (that has placed the convergence interpretation on the coefficient of initial income) we momentarily adopt their use of the term. Under this interpretation, our results from Table 4 suggest that all regions converge to their steady states at a rate of 1.1% per year. This is similar to the speed of per capita personal income convergence across U.S. states reported by Barro and Sala-i-Martin (1999) for the 1970-1990 period, at 0.9%. Our results suggest a somewhat slower rate of convergence for all metropolitan areas (0.8% per year) than we do for non-metropolitan regions (1.5% per year). Our results for metropolitan regions differ markedly from those reported by Crihfield and Panggabean (1995), who find a much faster rate of convergence (between 5.5%-6.6% per year). This may be related to their sample period (1960-1977), because Barro and Sala-i-Martin (1999) report substantially faster rates of convergence across states for the 1960-1970 period than they do for either of the two following decades.
their efforts on encouraging education and retaining and attracting better-educated residents. However, we find that human capital investment has a stronger impact on income growth in metropolitan areas than in non-metropolitan regions, which is broadly consistent with the results of Hammond and Thompson (2006) and Hammond (2006). Further, our factor model results suggest that the presence of more colleges and universities, more household amenities, and lower tax rates tended to encourage human capital accumulation in labor market areas.

In contrast to the large positive impact of human capital investment on growth, we find little correlation between public capital outlays and income growth. Indeed, the coefficients on this input are negative, but not significant at the 10% level, for both metropolitan and non-metropolitan regions. This mirrors the results reported in the literature for both metropolitan and non-metropolitan areas and suggests that this type of investment should not be targeted by state and local officials in order to spur economic development.

Finally, we find that private physical capital investment in the manufacturing sector encouraged per capita income growth in non-metropolitan areas but not in metropolitan regions. This likely reflects the relative decline in manufacturing in metropolitan areas during the period and the resiliency of manufacturing activity in non-metropolitan regions.
Data Appendix

Real Per Capita Personal Income Growth

Personal income and population data come from the U.S. Bureau of Economic Analysis, Regional Economic Analysis System CD-Rom, May 2001. Personal income includes earnings from work, asset income, and transfer payments. Population estimates reflect residents in the county on July 1 of the year. The growth rate is the compound average annualized rate of growth.

Manufacturing Capital Investment and Depreciation

Private manufacturing new capital expenditures by county come from the Census of Manufacturers, Geographic Area Series, for 1972, 1977, 1982, 1987, and 1992. Data from 1977-1992 come from the USA Counties CD-ROM. Data for 1972 was compiled by hand by the authors. The investment rate is computed by summing county-level new capital expenditures to labor market areas and then dividing by personal income less transfers. In those cases in which no counties reported data, due to disclosure requirements, we substitute the state value.

Depreciation data are available only for states for 1977, 1982, 1987, and 1992. State depreciation rates are assigned to labor market areas based on the state containing the largest county within the region. Annual investment and depreciation rates for local labor market areas are then averaged across years.

Public Capital Investment

Local government capital outlay data were hand-compiled by the authors from the Census of Government, Compendium of Government Finances, for 1972, 1977, 1982,
1987, and 1992. The investment rate is computed by summing county-level public capital outlays to local labor market areas and then dividing by personal income. Annual investment rates are then averaged across years.

*Human Capital Investment*

Human capital investment is the increase in average years of schooling from 1970 to 2000. Years of schooling in a county in each year is calculated based on high school and college attainment rates from the Census of Population. In particular, years of schooling is computed by multiplying the share of the population (age 25 and older) with a given level of educational attainment by the assigned years of schooling. College graduates or higher are assigned 17 years of schooling, while high school graduates who did not complete college were assigned 13 years of schooling, and persons who did not complete high school were 10 years of schooling. These weighted years of schooling are then summed for the region. High school and college attainment data for 1970 was collected by hand by the authors and data for 2000 was extracted from the U.S. Bureau of the Census website.

*Tax Variables*


*Energy Price Variables*

Electricity and natural gas rates for industrial customers are based on average annual data from the U.S. Department of Energy, Energy Information Administration,
Unionization Rates

Data on the share of the workforce which is unionized are based on state-level annual averages from the years 1970, 1972, 1978, 1980, 1982, 1983, 1994, which are taken from the *Statistical Abstract of the United States*. State data is assigned to labor market regions based on the state containing the largest county within the region. Labor market data are averaged across years.

Topography

The topography scale is from McGranahan (1999), who mapped topographic information from *The National Atlas of the United States of America 1970* to U.S. counties. The land surface code scale (1 through 21) runs from 1 (plains) to 21 (high mountains).

Death Rate


University Count

The number of four-year colleges or universities in 1980 for counties in each labor market area was downloaded from the National Center for Education Statistics website ([http://nces.ed.gov/ipedspas/](http://nces.ed.gov/ipedspas/)). Institutions are initially geo-located by ZIP codes, which
are then assigned to counties using a ZIP-to-county correspondence purchased from zipinfo.com.

Temperature and Water Surface Area

The mean January temperature, mean July temperature, and water access variables in each labor market area were developed by the U.S. Department of Agriculture, Economic Research Services, see McGranahan (1999) for a complete description of the data. County data were aggregated into labor market area based on surface area. Temperature data were annual averages for 1941 through 1970.
References


### Table 1
#### Summary Statistics

<table>
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<tr>
<th></th>
<th>All LMAs Mean</th>
<th>All LMAs Standard Deviation</th>
<th>Metropolitan LMAs Mean</th>
<th>Metropolitan LMAs Standard Deviation</th>
<th>Non-Metropolitan LMAs Mean</th>
<th>Non-Metropolitan LMAs Standard Deviation</th>
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<td>$\ln(Y/L)<em>{1999}$/$\ln(Y/L)</em>{1989}$</td>
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<td>10.24%</td>
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### Table 2
Results of Factor Market Models

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<td>Coefficient</td>
<td>Std Error</td>
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<td>Std Error</td>
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<td></td>
<td>0.006947 *</td>
<td>0.003875</td>
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<td>0.009282 **</td>
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* Statistical significant at 10% confidence.
** Statistically significant at 5% confidence.

Regressions are corrected for heteroskedasticity using White (1980).
Table 3
Results for CES Model: Unrestricted Estimation of Equation 9
Dependent Variable: $\ln(Y/L)_{1999}$-$\ln(Y/L)_{1969}$

<table>
<thead>
<tr>
<th></th>
<th>All LMAs</th>
<th>Metropolitan LMAs</th>
<th>Non-Metropolitan LMAs</th>
</tr>
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<tr>
<td></td>
<td>Coefficient</td>
<td>Std Error</td>
<td>Coefficient</td>
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<td>Intercept</td>
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<td>0.090339 **</td>
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<td>0.006368</td>
<td>0.02625 **</td>
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<tr>
<td>$\ln(S_z)$</td>
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<td>-0.0036</td>
</tr>
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<td>0.005526</td>
<td>-0.003265</td>
</tr>
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<td>$\ln(Y/L)_{1969}$</td>
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<td>-0.004862 **</td>
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<td>$[\ln(S_v/(\delta + g + n))]^2$</td>
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<td>0.00122</td>
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* Statistical significant at 10% confidence.
** Statistically significant at 5% confidence.
Regression results are computed from unrestricted estimation using two stage least squares.
Regressions are corrected for heteroskedasticity using White (1980).
Table 4
Results for CES Model: Restricted Estimation of Equation 9

Dependent Variable: ln(Y/L)_{1999} - ln(Y/L)_{1969}

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<td>Coefficient</td>
<td>Std Error</td>
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<td>π</td>
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<td>0.992299  ** 0.001217</td>
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<td>0.984541  ** 0.001029</td>
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<td>65.26356  ** 21.38229</td>
<td></td>
<td>21.3159  ** 2.276452</td>
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<tr>
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<td>0.085565  ** 0.029438</td>
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<tr>
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<td>0.28118  * 0.158827</td>
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<td>0.120756  ** 0.044013</td>
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</tr>
<tr>
<td>γ</td>
<td>-0.23799  ** 0.092727</td>
<td></td>
<td>-0.039331</td>
<td>0.046723</td>
<td>-0.068486</td>
<td>0.057134</td>
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<tr>
<td>ρ</td>
<td>0.01008  0.182863</td>
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<td>-3.543852</td>
<td>3.940999</td>
<td>0.125992</td>
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<tr>
<td>Adj R²</td>
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<tr>
<td>Obs.</td>
<td>722</td>
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<td>256</td>
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</tr>
</tbody>
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* Statistical significant at 10% confidence.
** Statistically significant at 5% confidence
Regression results are computed from restricted estimation using non-linear two stage least squares.