International Regional Science Review
33(4) 397-420

DOI: 10.1177/0160017610383279
http://irsr.sagepub.com

Divergence and Mobility in College Attainment Across U.S. Labor Market Areas: 1970–2000

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Abstract

Human capital is one factor that significantly influences local economic growth. Our goal in this research is to analyze trends in local human capital dynamics during the past thirty years. The authors find little evidence of convergence in college attainment across metropolitan and nonmetropolitan areas and evidence of divergence across Census regions. The authors also find within-distribution divergence for all labor markets, as well as for metropolitan and nonmetropolitan areas, which is accompanied by lower levels of intra-distributional mobility than we observe for the income distribution. To the extent that human capital accumulation drives growth, these trends are likely to contribute to increasingly different levels of income growth across labor markets in the future. Finally, looking at factors that influence upward mobility within the distribution, the authors find that an increase in the number of four-year colleges and universities per capita increased a labor market's upward rank and quintile mobility in human capital.

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Keywords
human capital, divergence, metropolitan, nonmetropolitan

Introduction

The dynamics of income growth across labor markets continue to command the attention of national, state, and regional policy makers. This interest translates into a vast literature investigating the sources of economic growth across all geographies. Within the United States, there are well-established literatures examining the sources of growth at the state and metropolitan levels. In addition, there is a growing literature examining growth on a more complete (and sometimes more disaggregated) scale, so that nonmetropolitan labor markets (or counties) are included in the analysis as well.

Studies that use a comprehensive set of regions find that a number of factors influence regional economic growth.[1] This list often includes industry mix, race, geography, amenities, taxes, private physical capital investment, and sometimes public capital investment. In addition, human capital often appears as an important source of regional growth and sometimes as the most important driver of growth.

The importance of human capital accumulation for economic growth suggests that policy makers and researchers should understand the dynamics and determinants of human capital accumulation. To date, this has not attracted as much attention. Berry and Glaeser (2005) examine U.S. human capital growth trends and determinants during the 1970–2000 period using data on the share of metropolitan area residents with a bachelor's degree or better. They find that the distribution of human capital diverged during the period and that the concentration of skilled workers is influenced by the tendency of entrepreneurs to employ high-skill workers. Wheeler (2006) also finds evidence of human capital divergence in U.S. metropolitan areas during the 1980–2000 period. This research suggests a role for amenities, industry mix, and the presence of colleges and universities to increase metropolitan human capital accumulation. In contrast, Suedekum (2006, 2008) finds evidence of human capital convergence for Germany during the 1977–2002 period, after controlling for industry mix, market potential, and firm size. Finally, Hammond and Thompson (2008) find that tax rates, the presence of universities, and amenities all influence growth in human capital across 722 metropolitan and nonmetropolitan U.S. labor market areas but do not examine convergence dynamics.

Overall, the importance of human capital for regional growth strongly suggests that additional research into trends, dynamics, and determinants of human capital accumulation would be beneficial. Our aim in this article is to document trends in local human capital accumulation across a comprehensive set of labor markets in the lower forty-eight U.S. states during the 1970–2000 period. We expand on the previous literature in four ways: first, we will analyze data for both metropolitan and nonmetropolitan areas, second, we analyze these trends across Census regions (including breakdowns by metropolitan and nonmetropolitan labor markets), third, we expand the analysis to include an examination of convergence/divergence trends using distribution dynamics concepts popularized by Quah (1993) and finally we explore structural determinants of mobility within the human capital distribution.

Using data from the Census of population for 1970, 1980, 1990, and 2000, we find that the skill upgrading experienced by the U.S. economy during the past thirty years has not been evenly distributed across Census regions or across metropolitan and nonmetropolitan areas. Indeed, we find evidence of divergence across Census regions and no evidence of convergence in college attainment across metropolitan and nonmetropolitan areas. We also find evidence of within-distribution divergence for all labor markets, metropolitan areas, and nonmetropolitan areas. In addition, we find that the regional college attainment distribution shows relatively low levels of intra-distribution mobility, compared to the regional income distribution. For labor markets that do exhibit mobility within the distribution, we find that the concentration of colleges has a significant positive impact on upward mobility. Overall, these results suggest that human capital accumulation may be a force for regional income divergence in the future and that the ability of a labor market to generate human capital is an important part of the process of increasing the concentration of highly educated residents.

This article proceeds as follows. The next section presents the background and literature for our research. Then, we present the data and basic trends in U.S. human capital accumulation and follow that with the results of our analysis of distribution dynamics. We then consider factors that influence mobility within the distribution and then offer concluding comments.

Background and Literature

Economic growth is of critical concern to policy makers at the national, state, and regional levels. This interest has contributed to a large literature on the sources of economic growth at all geographic levels. Various sources of growth have been examined in the literature, including private physical capital investment, public capital investment, and human capital, among other influences (such as amenities, institutions, tax policy, and external economies such as agglomeration economies). One important source of growth that is cited often in the literature is human capital.

For instance, for U.S. metropolitan areas, Shapiro (2006), Drennan (2005), Glaeser and Saiz (2004), Moretti (2004), Simon and Nardinelli (2002), Simon (1998), Glaeser, Scheinkman, and Shleifer (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.

However, a focus on metropolitan areas and cities may yield results that are biased toward convergence, since, by design; the data set excludes nonmetropolitan areas. As noted by Beeson, DeJong, and Troesken (2001), the focus on cities and metropolitan areas may lead to the sort of selection bias noted by DeLong (1988) in his analysis of Baumol's (1986) convergence results for Organisation for Economic Co-operation and Development (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.

While much research has focused on nations, states, and metropolitan areas, there is a growing literature examining growth determinants across all regions within nations, including both metropolitan and nonmetropolitan areas. Studies along these lines include Hammond and Thompson (2008), Hammond and Thompson (2006), Hammond (2006), Higgins, Levy, and Young (2006), Hammond (2004), Henry, Barkley, and Li (2004), Huang, Orazem, and Wohlgemuth (2002), Rupasingha, Goetz, and Freshwater (2002), Beeson, DeJong, and Troesken (2001), Nissan and Carter (1999), and Carlino and Mills (1987), which explore the issue of growth in metropolitan and nonmetropolitan areas, and find a significant role for human capital accumulation as a determinant of regional growth.

Thus, human capital, usually measured as the share of a labor markets population with a given level of educational attainment, has been identified as an important source of local economic growth. This highlights the importance of understanding the dynamics of regional human capital accumulation and the underlying factors driving these trends. For instance, is human capital concentrating in certain regions (the West?) or types of labor market (metropolitan areas?). If so, then the growth literature suggests that these labor markets will experience a long-run growth advantage as well. An additional important question concerns the distribution of human capital across labor markets. If human capital is becoming more concentrated in certain labor markets, then this may contribute to income divergence in the long run. Furthermore, the importance of human capital raises the issue of policy responses by local authorities, who will want to encourage greater human capital accumulation within their jurisdictions. Thus, an important question will involve determining the fundamental sources of human capital growth over time.

This issue has not received as much attention in the literature to date.[2] Wheeler (2006) finds evidence of human capital divergence in U.S. metropolitan areas during the 1980–2000 period and examines the impact of amenities, detailed industry mix, and the presence of colleges and universities on growth in college attainment. The results suggest that all three factors may play a role. Berry and Glaeser (2005) also find divergence across metropolitan areas in the concentration of residents with a bachelor's degree or better during the 1970–2000 period. They present evidence suggesting that the educational divergence has been driven by the tendency of skilled entrepreneurs to innovate in ways that raise the demand for skilled workers.

As part of an analysis of regional income growth, Hammond and Thompson (2008) examine a number of factors that may influence human capital accumulation across a comprehensive set of labor markets for the lower forty-eight U.S. states, including metropolitan and nonmetropolitan areas. They find that tax rates, the presence of colleges and universities, and amenities all influence human capital growth. In addition, Suedekum (2006, 2008) examined human capital accumulation in both metropolitan and nonmetropolitan areas in Germany but found convergence of the skill composition of across labor markets, in contrast to results for the United States, after controlling for industry mix, market potential, and firm size.

Suedekum (2006, 2008) argues that skilled workers might migrate out of a high-skill labor market in response to lower wages (which are driven down by the abundance of high-skill workers). In this case, there would be convergence in skilled labor between labor markets, with the share of skilled workers growing more slowly in areas with higher initial levels of skilled workers. However, if there is a strong productivity spillover, then wages could rise faster in labor markets with a higher share of skilled workers (Suedekum 2006, 2008). In this case, there would be a divergence in the share of skilled labor across labor markets and the share of skilled labor would grow faster in areas with a higher initial share of skilled workers. Other demand-side factors may play a role as well, including initial industry mix (Suedekum 2008, 2006, Wheeler 2006) and the concentration of entrepreneurs (as identified by Berry and Glaeser 2005).

In addition to these demand-side considerations, supply-side factors would influence the growth in skilled labor among labor markets. In particular, in making migration decisions, skilled workers may be more or less responsive to natural amenities in a location such as climate, topography, or access to water. The number of skilled workers in a labor market could be more responsive to taxes, particularly since higher taxes may discourage unskilled worker from making an investment in education to become skilled workers.

Finally, as noted by Groen (2004) and Bound et al. (2004), areas with more universities and college students may experience higher college attainment rates. For instance, Groen investigates the impact that attending college in a state has on the probability of continuing to work in that state after graduation, for two national samples of undergraduate students. The results suggest that college attendance in a state has a positive and statistically significant impact on in-state work. Bound et al. investigate how state-level production of college graduates affects the stock of college-educated workers in state and find a modest link between state college-graduate production and the stock of bachelor's degree workers.

Overall, the literature has identified divergence in college attainment across U.S. metropolitan areas (but not across German regions) and identified a role for entrepreneurs, amenities, industry mix, tax rates, and the presence of colleges and universities in generating growth in college attainment rates in U.S. metropolitan areas. In this research, we add to the literature by examining growth and convergence trends in college attainment for a comprehensive set of labor markets in the lower forty-eight U.S. states, including both metropolitan and nonmetropolitan areas. We also analyze distribution dynamics more directly by using discrete-time transition matrixes, as well as standard measures of intra-distributional mobility. This provides more information on relative performance during the period by focusing attention on how much labor markets move within the distribution. We then model links between intra-distributional mobility and regional characteristics, such as local amenities, tax rates, entrepreneurship, and the presence of colleges and universities.

Data and Basic Trends in College Attainment Concentration: 1970–2000

We begin by characterizing basic growth and convergence trends in college attainment across local labor market areas (LMAs) in the lower forty-eight U.S. states. Our measure of human capital is college-level educational attainment. While this is just one component of overall human capital accumulation (other indicators might include health, etc.), it is an important and often-used metric in the literature. We take our measures of educational attainment from the U.S. Bureau of the Census, Census of Population, for 1970, 1980, 1990, and 2000. We focus on the share of residents of lower forty-eight U.S. states age 25 and older that report a college level (bachelor's degree or better) of education as their highest level of attainment. It is important to note that the Census of Population has changed the relevant definitions during our period of interest. For the 1970 and 1980 Census surveys, college-level attainment is measured by the share of residents that report four years of college or more as their highest level of attainment. For the 1990 and 2000 Census surveys, college-level attainment is measured by the share of residents that report a bachelor's degree or more as their highest level of attainment.

We gather data from each Census at the county level and then aggregate to LMAs defined by the U.S. Department of Agriculture Economic Research Service (ERS). These mutually exclusive and exhaustive local labor markets were developed by the ERS to capture commuting zones in nonmetropolitan as well as metropolitan areas. There are 722 LMAs in the data set, 256 are metropolitan and 466 are nonmetropolitan. Metropolitan areas include one or more metropolitan statistical areas (MSAs) and nonmetropolitan areas are those which do not contain any counties included in an MSA (Tolbert and Sizer 1996). These LMAs, 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 phenomena that influence local economic growth.[3] 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. For descriptive purposes, we aggregate these LMAs to state and Census regions, based on the state with the largest county (by population) in the labor market.

Growth Trends by Census Region and Metropolitan/Nonmetropolitan Status

The United States has posted huge increases in college-level educational attainment during the past thirty years. Indeed, in 1970, 10.6 percent of residents age 25 and older in the lower forty-eight U.S. states had four years or more of college as their highest level of educational attainment according to the Census of Population. By 1980, that share rose to 16.2 percent, a gain of 52.2 percent in just 10 years. In 1990, 20.3 percent of U.S. residents had a bachelor's degree or better and by 2000 that share rose to 24.4 percent. Thus, the share of the population age 25 and older in the United States with a bachelor's degree or better has risen by 129.1 percent during the past thirty years.

As table 1 shows, educational attainment levels and growth rates are very different across regions of the country and across metropolitan and nonmetropolitan areas. In 2000, the Northeast had the highest concentration of college-educated residents (with 27.5 percent), followed by the West (with 26.2 percent), the Midwest (22.9 percent), and the South (22.5 percent). Growth in college educational attainment also differed significantly across Census regions. Indeed, the largest increases in college-level attainment were achieved in the Northeast, which generated in increase in the share with a bachelor's degree of 145.6 percent (from 11.2 percent in 1970 to 27.5 percent by 2000). Next fastest was growth in the Midwest, with an increase of 138.0 percent, followed by the South, with 130.7 percent, and the West, with 100.3 percent). These trends suggest geographic divergence of college-educated residents during the period, with the high-attainment Northeast region pulling away, while the low-attainment regions in the South and Midwest making progress catching up to the West. Indeed, the standard deviation of college attainment across these four regions rose from 1.62 in 1970 to 2.47 by 2000, an increase of 52.3 percent during the period.

Table 1 also shows results for metropolitan and nonmetropolitan areas. By 2000, 25.6 percent of residents of metropolitan areas had a bachelor's degree or better, compared to 15.7 percent for nonmetropolitan LMAs. That difference generates a gap of 9.9 percentage points, which means that the college-educated share is 63.1 percent higher in metropolitan areas. The South posted the largest percentage gap between metropolitan and nonmetropolitan attainment (with metropolitan attainment 74.4 percent above nonmetropolitan), followed by the Midwest (54.9 percent), the Northeast (48.8 percent), and the West (33.0 percent). Notice also that the metropolitan/nonmetropolitan gap for the United States has fluctuated during the last thirty years, falling from 58.9 percent in 1970, to 54.9 percent in 1980, then rising to 65.8 percent in 1990, and finally dropping to 62.6 percent by 2000. During the past thirty years, the percentage gap between metropolitan and nonmetropolitan attainment rose most quickly in the Northeast and Midwest, up by 22 percent and 20 percent, respectively. The percentage gap rose modestly in the South, by 5.0 percent, and fell in the West by 14.0 percent. Overall, the data suggest large college education gaps between metropolitan and nonmetropolitan LMAs that have not closed during the past thirty years.

Convergence Trends for College-Level Educational Attainment

We now focus on issues related to convergence trends. The results by Census region and by metropolitan/nonmetropolitan status show large variation over time in

Table 1. College-Level Educational Attainment by Census Region and Metro Status

	Population 25+	Share of Population 25+ With Bachelor's Or Better (%)				Share Percent Change			
	2000	1970	1980	1990	2000	1970–1980	1980–1990	1990–2000	1970–2000
United States	181,029,606	10.6	16.2	20.3	24.4	52.2	25.4	20.0	129.1
Metropolitan	159,621,081	11.2	17.0	21.3	25.6	51.8	25.6	19.7	128.3
Nonmetropolitan	21,408,525	7.0	11.0	12.9	15.7	55.7	17.4	22.1	123.1
Northeast	35,584,275	11.2	17.3	22.9	27.5	54.2	32.4	20.2	145.6
Metropolitan	34,428,878	11.3	17.4	23.1	27.8	54.2	32.7	20.3	146.1
Nonmetropolitan	1,155,397	8.1	12.7	15.7	18.7	57.5	23.5	19.0	131.4
Midwest	39,405,971	9.6	14.7	18.4	22.9	53.0	24.8	24.6	138.0
Metropolitan	32,754,266	10.2	15.6	19.6	24.4	52.6	25.6	24.5	138.8
Nonmetropolitan	6,651,705	7.0	10.9	12.8	15.7	56.0	16.9	23.2	124.8
South	67,342,716	9.8	14.9	18.7	22.5	52.9	25.2	20.4	130.7
Metropolitan	57,262,834	10.6	16.1	20.1	24.1	51.9	24.8	19.9	127.3
Nonmetropolitan	10,079,882	6.2	9.6	11.4	13.8	54.1	19.1	21.2	122.4
West	38,696,644	13.1	19.2	22.6	26.2	46.5	17.9	15.9	100.3
Metropolitan	35,175,103	13.5	19.7	23.2	26.8	45.8	18.2	15.5	99.1
Nonmetropolitan	3,521,541	9.7	15.0	16.6	20.2	54.6	10.7	21.7	108.2

Note: Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT. Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI. South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV. West: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY. Data for Census regions is constructed using labor market areas, which are assigned to the state which accounts for the most residents. Since these labor market areas may cross state borders, population totals differ from Census published counts.

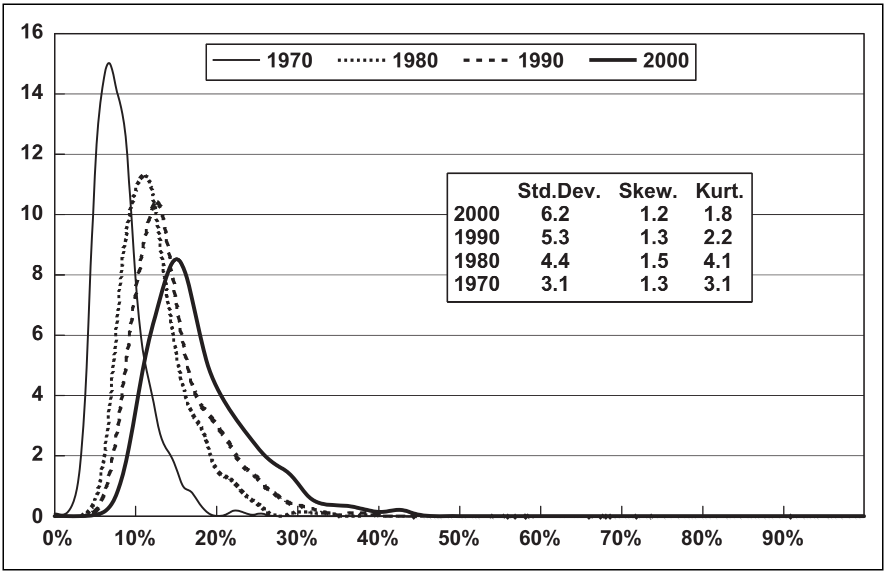

Figure 1. Kernel density estimates of the concentration of college attainment for all LMAs. Share of residents with a bachelor's degree or more. LMAs = local labor market areas.

growth rates. However, these relative growth trends may or may not generate convergence within the regional distribution of educational attainment over time. To investigate convergence trends, we summarize the data in a different way.

Figure 1 gives a more detailed view of the evolution of the distribution for all regions, using kernel density estimates. The distribution drifts to the right, which depicts the advancing educational attainment on average across all LMAs. Note as well that the kernel density estimates reflect a large increase in dispersion across LMAs during the past thirty years. Indeed, the standard deviation doubles from 1970 to 2000, rising from 3.1 to 6.2. Furthermore, the distribution is skewed to the right, which indicates relatively high rates of college attainment at large levels, although the skewness does not change much over time. The distribution also gradually becomes less peaked over time, relative to the normal distribution, as kurtosis falls from 3.1 in 1970 to 1.8 by 2000. This indicates a higher probability of values away from the mean in 2000 than in 1970. Overall, the data for all ERS LMAs indicate that the distribution diverged during the period. Thus, college educational attainment rates have become less similar across LMAs over time.

Figure 2 depicts the evolution of the college attainment distribution across metropolitan and nonmetropolitan LMAs during the 1970–2000 period, again using kernel density estimates. The figure makes clear that college attainment rates have been rising on average for metropolitan LMAs, because the distribution drifts to the right

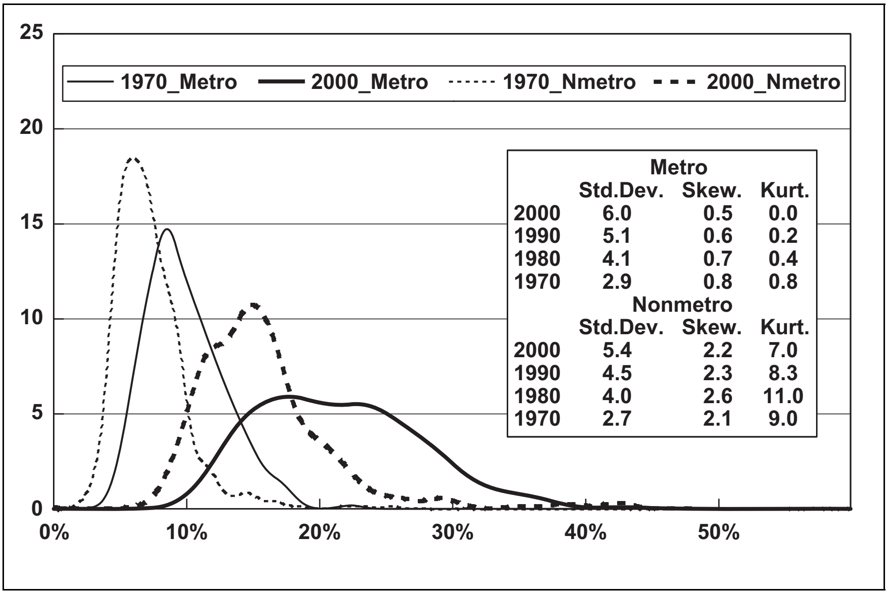

Figure 2. Kernel density estimates of the concentration of college attainment for metropolitan and nonmetropolitan LMAs. Share of residents with a bachelor's degree or more. LMAs = local labor market areas.

over time. In addition, we note a large increase in the standard deviation during the past thirty years, from 2.9 in 1970 to 6.0 by 2000. The metropolitan distribution also displays relatively low levels of right skewness and skewness declines during the past thirty years. The metropolitan distribution also shows relatively low levels of kurtosis, which falls from 0.8 in 1970 to 0.0 in 2000. The metropolitan distribution shows a strong trend toward divergence during the past thirty years, as noted by Berry and Glaeser (2005).

As Figure 2 also shows, we find evidence of strong increases in the dispersion of college attainment across nonmetropolitan LMAs, with the standard deviation of the distribution doubling from 2.7 to 5.4. The nonmetropolitan distribution is more right skewed than the metropolitan distribution and the degree of skewness is similar in 1970 and 2000. The nonmetropolitan distribution also displays more kurtosis than does the metropolitan distribution and kurtosis falls from 9.0 in 1970 to 7.0 by 2000.

Overall, our analysis of the basic trends in college attainment during the past thirty years indicates large differences in the evolution of the distributions over time. We find evidence of large increases in average college educational attainment for both metropolitan and nonmetropolitan LMAs during the period but that growth was fastest for metropolitan LMAs. We also find evidence of divergence in the college attainment distribution for all LMAs, as well as for both for metropolitan and nonmetropolitan LMAs. Indeed, the standard deviation of each distribution roughly doubles during the thirty-year period, while kurtosis declines.

Analysis of Distribution Dynamics

Our analysis of trends in the concentration of human capital so far indicates divergence within the college attainment distribution for all LMAs (and for metropolitan as well as nonmetropolitan LMAs). However, these basic trends obscure more detailed information on mobility within the distribution over time. For instance, a distribution that is diverging over time may do so with little or no intra-distribution mobility. In this case, the rank ordering within the distribution tends to be preserved and high attainment areas pull away while low attainment areas fall behind. However, overall trends toward divergence may be accompanied by a great deal of distributional mobility, in which case there is a large amount of leap-frogging. This implies that low attainment areas catch-up while high attainment areas fall back.

We explore these issues by calculating transition matrixes for the 1970–2000 period for all LMAs and both LMA types. We wish to focus attention on the within-distribution dynamics during the period, so we work with the mean-adjusted log college attainment share relative to the nation. We calculate the college attainment share relative to the nation as follows:

$$\text{Relative College Attainment Share}_i = \frac{\text{Share of Population with BA+}_i}{\text{Share of Population with BA+}_{\text{US}}},$$

where i indexes LMAs. Thus, we remove trend growth in college attainment over time.

Transition matrixes are one way to summarize the evolution of the overall distribution (see Hammond and Thompson 2006, Fingleton 1997, 1999, and Quah 1993). We choose to work with five classes of educational attainment. For instance, we sort the data for college attainment by LMA for 1970 from lowest to highest and assign the lowest 20 percent to quintile 1, the next lowest 20 percent to quintile 2, and so on. We then track the movement of these LMAs across quintiles over time.

Mathematically, we represent our transition matrix as:

$$P_{t,t+S} = \begin{pmatrix} p_{11} & \cdot & \cdot & \cdot & p_{15} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ p_{51} & \cdot & \cdot & \cdot & p_{55} \end{pmatrix},$$

where the p_{ij} are the estimated probabilities of transition from class i to class j during the span of time S. These p_{ij} are defined so that

$$F_{(x,t+S)} = F_{(x,t)} * P_{t,t+S},$$

where $F_{(x)}$ is a (1×5) vector containing the income class distribution.

We use the transition matrixes to extract information regarding mobility and modality in the distribution. We use the Shorrocks (1978) index to summarize mobility across class. This index is computed as follows:

$$\text{Shorrocks index} = \frac{\#\ \text{states} - \text{trace}(P_{t,t+S})}{\#\ \text{states} - 1},$$

where #states is the number of fractiles under consideration (in this case five). The value of the index ranges between 0 and 1.25, with higher values indicating more mobility across class.[4] We also present the rank correlation coefficient as an additional measure of mobility.

Table 2 presents the transition matrixes for college attainment from 1970 to 2000 for all LMAs, as well as metropolitan and nonmetropolitan LMAs. Each row shows the mobility for a given 1970 educational attainment class over time. For instance, for all LMAs, 63.2 percent of LMAs that were in quintile 1 (the lowest class) in 1970 were still in that quintile in 2000. However, 27.8 percent of LMAs that began in quintile 1 moved up to quintile 2 during the period, while 8.3 percent moved up to quintile 3, and 0.7 percent rose to quintile 4. No LMA transitioned from quintile 1 to quintile 5. Thus, the transition matrix provides information about the intra-distribution mobility during the period.

Note from the transition matrix that quintile 1 and quintile 5 show the least mobility overall, with quintile 1 retaining 63.2 percent of LMAs and quintile 5 retaining 77.2 percent. We find more mobility in the middle quintiles, as they retain between 46.5 percent and 38.6 percent of LMAs during the period. The Shorrocks index for this distribution is 0.585, suggesting that the distribution overall displays a modest level of mobility. The rank correlation is 0.845 during the period, which is significantly different from zero at the 1 percent significance level. For comparison purposes, Hammond and Thompson (2006) calculate these mobility measures using per capita personal income data for the 1969–1999 period and find a Shorrocks index value of 0.729 and a rank correlation of 0.719. Overall, the all-LMA college attainment distribution shows less intra-distribution mobility during the thirty-year period than does the income distribution.

In addition, the share of LMAs in each class is similar in 2000 to the initial 1970 distribution. Overall, the evolution of the distribution (described using these discrete classes) shows little tendency to converge over time, which is consistent with the kernel density estimates and other summary measures presented earlier.

The results for metropolitan and nonmetropolitan LMAs (also shown in table 2) suggest greater mobility within the nonmetropolitan distribution than within the metropolitan distribution.[5] Indeed, the Shorrocks index for nonmetropolitan LMAs is 0.644, which is 14.3 percent higher than the metropolitan value of 0.558.

Table 2. Transition Matrixes for College Attainment, Mean-Adjusted Log Relative Share (Percent)

	All Regions				
Quintile (Q) Range[a]	Q1-2000 0.0–0.739	Q2-2000 0.740–0.917	Q3-2000 0.918–1.098	Q4-2000 1.099–1.335	Q5-2000 1.335–∞
Q1-1970	63.2	27.8	8.3	0.7	0.0
Q2-1970	20.1	46.5	29.2	4.2	0.0
Q3-1970	8.3	31.3	40.3	17.4	2.8
Q4-1970	1.4	12.4	32.4	38.6	15.2
Q5-1970	0.0	1.4	2.8	18.6	77.2
Percent of Regions 1970	20	20	20	20	20
Percent of Regions 2000	19	24	23	16	19
Shorrocks index: 0.585; rank correlation: 0.845					
	Metropolitan Regions				
Quintile (Q) Range[a]	Q1-2000 0.0–0.772	Q2-2000 0.773–0.914	Q3-2000 0.915–1.075	Q4-2000 1.076–1.282	Q5-2000 1.283–∞
Q1-1970	80.4	15.7	3.9	0.0	0.0
Q2-1970	19.6	43.1	31.4	5.9	0.0
Q3-1970	3.9	25.5	29.4	37.3	3.9
Q4-1970	0.0	2.0	19.6	49.0	29.4
Q5-1970	0.0	1.9	3.8	19.2	75.0
Percent of Regions 1970	20	20	20	20	20
Percent of Regions 2000	21	18	18	22	22
Shorrocks index: 0.558; rank correlation: 0.873					
	Nonmetropolitan Regions				
Quintile (Q) Range[a]	Q1-2000 0.0–0.757	Q2-2000 0.758–0.922	Q3-2000 0.923–1.080	Q4-2000 1.081–1.305	Q5-2000 1.306–∞
Q1-1970	51.6	28.0	18.3	2.2	0.0
Q2-1970	18.3	44.1	28.0	9.7	0.0
Q3-1970	7.5	23.7	46.2	19.4	3.2
Q4-1970	2.2	9.7	38.7	37.6	11.8
Q5-1970	0.0	6.4	9.6	21.3	62.8
Percent of Regions 1970	20	20	20	20	20
Percent of Regions 2000	16	22	28	18	16
Shorrocks index: 0.644; rank correlation: 0.748					

[a] Range reflects the mean-adjusted distribution, with conversion from natural log.

In addition, rank correlation in nonmetropolitan areas is 0.748, which is 13.8 percent lower than the metropolitan level of 0.873.[6] Overall, we find that the distribution dynamics differ across metropolitan and nonmetropolitan LMAs.

Factors Influencing Regional Human Capital Dynamics

The distribution dynamics analyzed so far have identified evidence of human capital divergence, accompanied by less intra-distributional mobility than we observe for the per capita personal income distribution. However, there remains a significant amount of intra-distribution mobility to be explained. For instance, for the all LMA distribution, 53.2 percent of LMAs remained in the same quintile from 1970 to 2000. During the same period, we find that 25.8 percent moved downward within the distribution, while 21.1 percent moved upward within the distribution. We also find similar levels of mobility within both the metropolitan (61.3 percent remaining in the same quintile while 38.7 percent moved either up or down) and nonmetropolitan distributions (48.7 percent remaining in the same quintile, while 51.3 percent either moved up or down).

There is previous research that has addressed specific factors that influence human capital accumulation among LMAs (Hammond and Thompson 2008; Suedekum 2006, 2008; Wheeler 2006; and Berry and Glaeser 2005). However, previous research does not directly analyze the determinants of rank or quintile mobility within the distribution and does not investigate differences across metropolitan and nonmetropolitan LMAs. Another key question is whether a different set of factors influence quintile and rank mobility among LMAs with lower initial human capital than LMAs with higher initial human capital. The key factors influencing human capital growth could differ greatly among LMAs with low, high, or average initial human capital.

We examine rank and quintile mobility among both metropolitan and nonmetropolitan LMAs. We begin with a model for rank mobility. From 1970 to 2000, an increase in college attainment relative to other LMAs is defined as a positive change in rank.[7] Following Hammond and Thompson (2008) and Wheeler (2006), we include measures of amenities, industry mix, colleges and universities, and tax rates as explanatory variables. We also include a measure of local entrepreneurship, to reflect issues raised by Berry and Glaeser (2005). Explanatory variables were gathered for counties and then aggregated into the 722 multicounty LMAs. Table 3 contains descriptive statistics for our right-hand side variables and we provide a brief explanation of each now.

The tax variable is the effective tax rate defined as total state and local tax revenue in the LMA in 1972 divided by area income in 1972. The tax data are from the 1972 Census of Government, *Compendium of Government Finance*, while the income data were from the Bureau of Economic Analysis' *Regional Economic Information System*. The amenity variables are January and July temperature, a measure of topography, and a variable for the percent of a LMA's surface area covered by water. This amenity data were compiled by the Economic Research Services of the U.S. Department of Agriculture (McGranahan 1999). A variable for the number of four-year colleges and universities per capita also is included given findings by Bound et al. (2004) and Groen (2004) that states with more college students have

Table 3. Summary Statistics for Independent Variables

	Metro		Nonmetro	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Four-Year Colleges and Universities Per Capita 1980 (X1,000)	0.010	0.007	0.009	0.016
Effective State and Local Tax Rate 1972 (percent)	10.3	1.5	10.5	1.7
Ruggedness (1 = Plains, 21 = High Mountains)	8.6	6.1	9.7	6.1
January Temperature	35.7	12.5	29.6	12.2
July Temperature	76.2	5.2	74.9	5.8
Percent Water	6.4	9.5	3.5	10.0
Entrepreneur Share 1970	12.1	2.9	18.9	5.8
Major Metropolitan Area 1990 (=1, Otherwise zero)	0.2	0.4	0.0	0.0
Employment Share 1970 (percent)				
Farm	6.2	4.8	18.8	10.9
Agricultural Services	0.7	0.8	1.1	1.0
Mining	1.1	2.3	2.5	4.7
Construction	5.1	1.2	4.6	2.5
Manufacturing	20.2	10.3	13.6	10.7
Transportation, Comm., Utilities	4.9	1.5	4.2	1.8
Wholesale Trade	3.8	1.5	2.4	1.0
Retail Trade	15.1	1.9	15.3	2.8
Finance, Ins., and Real Estate	5.8	1.8	4.4	1.4
Services	17.8	3.6	15.4	3.6

higher levels of college graduates among the adult population, as well as findings by Hammond and Thompson (2008) and Wheeler (2006) that the LMAs with more four-year colleges and universities have faster growth in human capital. The number of four-year colleges and universities in counties in 1980 was obtained from the National Center for Education Statistics of the U.S. Department of Education. An entrepreneurship variable is included defined as the ratio of nonfarm proprietor employment in a LMA in 1970 divided by total employment in that year. A set of industrial structure variables shows the share of total employment in each industry in 1970. The *Regional Economic Information System* was the source for this data. The industries included were the major industries in the Standard Industrial Classification system that prevailed during the 1970–2000 period. Government employment is the omitted variable.

Finally, a variable is included for rank in the share of college graduates in each LMA in 1970. This is a necessary control if LMAs with lower initial rank for the share of population with a college degree tend to be either more or less likely to have an upward movement in rank, which could happen if, for example, there is a

Table 4. Educational Attainment Rank Mobility Regression

	Metro LMAs	Nonmetro LMAs
Intercept	96.21*	19.92
Rank Pct. College Graduates in 1970	−0.27***	−0.38***
Four-Year Colleges Per Capita	1,647.10***	980.28***
Effective State and Local Tax Rate 1972	−157.25	62.05
Ruggedness	0.230	0.87
January Temperature	−0.54*	−2.39***
July Temperature	−0.43	0.17
Percent Water	0.66***	0.20
Entreprenuership 1970	−183.64	352.18***
Major Metropolitan Area (Cat 6)	17.97***	
Share Farm Employment	−23.32	−128.39
Share Agricultural Services	−419.67	76.42
Share Mining	−407.50***	−403.62***
Share Construction	463.05***	624.83***
Share Manufacturing	−18.68	−80.89
Share Trans., Comm., and P.U.	55.92	−235.84
Share Wholesale Trade	189.00	130.60
Share Retail Trade	−195.18	−89.35
Share Fin., Ins., and R.E.	478.10***	135.67
Share Services	−92.81	433.72***
N	256	466
Adjusted R^2	0.484	0.382

*** Statistically significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

tendency for more upward rank mobility in the lower portion of the distribution. When interpreting the coefficient on the initial rank variable, it is important to remember that the LMA with the lowest initial share of college graduates has a rank of 1. Therefore, a negative coefficient on the rank variable would indicate that LMAs with a lower initial share college graduates had a tendency for more upward rank mobility.

Regression results are summarized in table 4. Results are presented for the 256 metropolitan LMAs and 466 nonmetropolitan LMAs. In other words, the metropolitan results were based on each metropolitan LMA's rank among the 256 metropolitan LMAs, while nonmetropolitan results were based on rank among the 466 nonmetropolitan LMAs.

Results in table 4 indicate that regional entrepreneurship, amenities, university presence, and industry structure all influence movements within the human capital distribution in terms of rank mobility. Broadly speaking, the determinants of rank mobility were similar for metropolitan and nonmetropolitan LMAs.

LMAs with more universities per capita exhibited upward rank mobility. The coefficient on universities per capita was positive and statistically significant for both metropolitan and nonmetropolitan LMAs. The magnitude of the coefficient was twice as large for metropolitan LMAs suggesting a larger effect for metropolitan areas.

The coefficient on taxes was not statistically significant in either of the equations. Among natural amenity variables, the coefficient on the January temperature variables was negative and statistically significant in both regressions in table 4, indicating that warmer winter temperatures encouraged downward mobility. This finding could indicate that less educated households are attracted more to this amenity. For example, one possibility is that, older residents, who on average are less likely to have a college degree, may be more attracted to warm weather.

We found no evidence in the results in table 4 that the ruggedness or July temperature amenity variables had an influence on rank mobility. However, metropolitan LMAs with more surface water were found to have greater upward mobility.

Among nonmetropolitan LMAs, higher levels of initial entrepreneurship were associated with upward mobility. More entrepreneurial nonmetropolitan areas were able to attract or grow more college graduates.

By contrast, greater levels of initial entrepreneurship were not associated with mobility in metropolitan areas. This result is inconsistent with the results of Berry and Glaeser (2005) who argued that entrepreneurs in metropolitan LMAs demanded workers with higher levels of human capital, causing faster growth in the share of college graduates in larger metropolitan areas. However, major metropolitan areas with more than one million persons also had upward rank mobility, consistent with the findings of Berry and Glaeser.

Industrial structure also influenced human capital. LMAs with a larger share of employment in farming or mining (rather than government) in 1970 experienced downward rank mobility while LMAs with a larger share of employment in finance and services exhibited upward rank mobility. This is consistent with the findings of Wheeler (2006), who argued that industries such as services and finance use relatively more college graduates while some goods producing industries such as agriculture or mining use fewer.

LMAs with a larger share of employment in construction also experience more upward mobility. Construction typically accounts for a larger share of employment in growing labor markets. Growing labor markets may attract more college graduates, since younger people are more likely to migrate and more likely to be college graduates.

Finally, in table 4, we find a negative correlation between initial rank and rank mobility for both metropolitan and nonmetropolitan areas. Therefore, LMAs at the lower end of the education attainment distribution tend to show more upward rank mobility than LMAs at the top.

In table 5, we examine factors that influence quintile mobility for LMAs. We start with the same data used for the LMA transition matrixes in table 2, which breaks the distribution of relative college attainment shares into quintiles in 1970 and then tracks movement across quintiles during the thirty-year period. Quintiles are created separately for metropolitan LMAs and nonmetropolitan LMAs.

Table 5. Marginal Effects on the Upward Quintile Mobility of Educational Attainment

	Metro LMA Quintile in 1970					Nonmetro LMA Quintile in 1970				
	Lowest	Second	Third	Fourth	Highest	Lowest	Second	Third	Fourth	Highest
Four-Year Colleges Per Capita	8.174	−7.081	74.750**	11.659	−1.470	22.005	1.968	14.084***	0.176	0.988
Effective S&L Tax Rate 1972	8.646	−5.476	11.022	−9.595	−2.281	25.115**	3.782	−0.758	−1.300	−0.209
Ruggedness	−0.014	0.040	0.020	0.006	0.003	0.005	0.029**	−0.0003	0.0002	−0.001
January Temperature	−0.004	−0.026	−0.034	−0.028*	−0.001	−0.037	−0.029**	−0.011	0.002	0.002
July Temperature	0.019	0.059	0.003	0.025	−0.012	−0.041	0.031	0.001	−0.009*	−0.005
Percent Water	0.003	0.014	0.002	0.001	0.017	−0.010	0.037*	−0.0002	0.005	0.022
Entreprenuership 1970	3.063	0.102	12.699	−3.936	−2.830	9.081**	0.552	1.230	−0.310	0.466
Major Metropolitan Area (Cat 6)			−0.112	0.472**	0.338					
Share Farm Employment	−3.038	−0.769	−19.254**	−2.785	2.277	10.927***	1.246	0.109	0.288	−0.284
Share Agricultural Services	−10.675	−25.390	−2.445	33.475*	−31.329	54.053***	15.442	2.255	−4.807*	−0.151
Share Mining	−8.065	−4.282	−17.907*	−2.980	−3.507	13.860**	2.413	0.537	0.031	−0.931
Share Construction	4.003	1.910	30.577*	−8.056	6.305	21.927***	9.958**	0.684	1.704	1.560
Share Manufacturing	−0.911	−0.135	−2.730*	−0.689	−0.858	16.527***	0.931	−0.184	−0.363	−0.593
Share Trans., Comm., and P.U.	−2.481	−7.583	−8.513	−1.141	−2.873	−16.440*	−1.784	1.096	−0.163	−1.368
Share Wholesale Trade	5.410	6.936	22.004*	−2.458	−4.043	39.611***	−2.245	1.707	1.067	−0.716
Share Retail Trade	−3.118	5.498	−18.683	−0.783	3.721	17.661***	2.466	1.998	0.114	−0.731
Share Fin., Ins., and R.E.	−7.917	−3.587	7.138	10.814*	4.642	42.493***	−2.854	−2.186	3.353*	1.430
Share Services	0.570	−3.803	6.777*	4.271*	−1.481	25.902***	3.162	2.060	0.756	1.229
N	51	51	51	51	52	93	93	93	93	94
Psuedo R^2	0.375	0.688	0.582	0.571	0.607	0.576	0.330	0.179	0.298	0.394
Limit Point 1	13.710	36.194	−4.434	2.015	−19.968	38.450	9.416	2.203	−5.517	−3.870
Limit Point 2		40.707	−2.149	5.537			11.376	3.780	−3.644	

***Statistically significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

For each starting quintile, we create a dependent variable that measures quintile mobility. For the lowest quintile in 1970, the dependent variable is a binary variable equal to 1 if an LMA moved into a higher quintile by 2000 and equal to 0, if an LMA remained in the lowest quintile. We estimate the model for this lowest quintile using a probit model. For the highest quintile in 1970, the dependent variable was a binary variable equal to 1 if an LMA remained in the highest quintile in 2000 and equal to 0 if it fell into a lower quintile by 2000. We estimate the model for this highest quintile using a probit model. For LMAs in the second, third, and fourth quintiles in 1970, the dependent variable was a measure of quintile mobility with a value of 2 if an LMA moved into a higher quintile in 2000 than it was in during 1970, a value of 1 if an LMA remained in the same quintile, and a value of 0 if an LMA fell into a lower quintile. We assumed a normally distributed latent dependent variable and estimated an ordered probit model. Limit points were reported for the underlying distribution.

We use the same independent variables included in the rank mobility regressions. Table 5 reports the marginal effect of a one unit increase in the independent variable on the probability of an upward quintile movement. Specifically, we report the marginal effect on the probability of moving to a higher quintile for LMAs that began in the first, second, third, or fourth quintile in 1970, and the marginal effect of remaining in the highest quintile for LMAs that begin in the fifth quintile in 1970. In the interest of brevity, we do not report the marginal effects of independent variables on the probability of downward quintile movements. Finally, the variable for large metropolitan areas with population at or above one million is only included for quintile regressions for the third, fourth, and fifth quintiles. This is because Berry and Glaeser (2005) found that it was large metropolitan areas with higher initial education that exhibited the fastest increases in education attainment.

Estimates from the probit and ordered probit models are provided in table 5. Note that we have fifty-one observations for each metropolitan quintile and ninety-three observations for each nonmetropolitan quintile. Due to these relatively small sample sizes, we see these results as exploratory and they should be interpreted with caution. However, a number of results should be noted. In particular, as seen in table 5, many of the factors that influenced rank mobility (in table 4) also influence quintile mobility, but the impact from these variables, such as four-year colleges or climate, was less consistent. The inconsistent findings may result from our smaller sample sizes. However, the results could indicate that factors that lead to marginal improvements in rank mobility may not lead to the types of large improvements often required for quintile mobility. The results also may indicate that the influence of these factors may only hold for certain portions of the distribution.

The contribution of the independent variables to quintile mobility was particularly weak for LMAs that begin in either the lowest or highest quintile in 1970. In particular, for both metropolitan and nonmetropolitan LMAs in the highest quintile in 1970, none of the marginal effects reported in table 5 were statistically significant. The same was found for metropolitan LMAs that begin in the lowest quintile in 1970.

Several significant marginal effects were identified for nonmetropolitan LMAs that began in the lowest quintile in 1970. Nonmetropolitan LMAs with a higher degree of initial entrepreneurship, as measured by the share of proprietor employment in 1970, were more likely to transition to a higher quintile for human capital in the year 2000. A higher effective tax rate also was found to increase the likelihood of transition to a higher quintile, suggesting a positive role for tax policy. Transitions to a higher quintile also were more likely in LMAs with a larger share of the regional employment in private industries rather than in government (the omitted category).

Among LMAs that fell in one of the middle quintiles in 1970, there were several consistent findings regarding the factors that influenced the probability of upward quintile mobility. For LMAs in the third quintile in 1970, there was a positive and statistically significant marginal effect from increasing the number of four-year colleges or universities in a LMA. The marginal effect was greatest in metropolitan areas. In a metropolitan LMA that began in quintile 3, adding one college per capita would yield a 74 percentage point increase in the probably of transitioning to a higher quintile. In a nonmetropolitan LMA that began in quintile 3, adding a one college per capita would yield a 14 percentage point increase in the chances of an upward transition. The marginal effect of adding another four-year college was not statistically significant for LMAs that were in the second or fourth quintile in 1970, in either metropolitan or nonmetropolitan LMAs.

In several cases, we also found that warmer average January temperatures decreased the probability of a transition to a higher quintile. For metropolitan LMAs that begin in the fourth quintile in 1970, a one degree increase in average January temperature decreased the probability of jumping to a higher quintile by just under 3 percentage points. A similar size marginal effect was identified for nonmetropolitan LMAs that begin in the second quintile in 1970. The calculated marginal effect also was negative for most other quintiles but was not statistically significant.

Among industry share variables, positive and statistically significant marginal effects were identified in several cases for the LMAs that had a higher initial share of employment in the construction, finance, and services industries in 1970s. This result held for both metropolitan and nonmetropolitan LMAs and also is consistent with the findings for rank mobility in table 4.

Conclusion

Human capital is one factor that significantly influences local economic growth. Our goal in this research is to analyze trends in human capital dynamics during the past thirty years. Our results suggest a rich variety of trends and dynamics across Census regions and across metropolitan and nonmetropolitan LMAs. These varied dynamics are likely to contribute to vastly different growth outcomes across LMAs during the next thirty years.

Overall, our results suggest that the U.S. economy has experienced a significant amount of skill upgrading during the past thirty years. There is now a significantly larger share of the population with a bachelor's degree or better as the highest level of attainment. However, this skill upgrading has not been shared evenly across LMAs. Indeed, we find the college attainment gap between metropolitan and nonmetropolitan regions remains large. In addition, we find a large increase of within-distribution dispersion for all LMAs, as well as for metropolitan and nonmetropolitan LMAs, and even Census regions.

Furthermore, as human capital accumulation is highly varied, and potentially diverging, among LMAs, we also examined factors that influence distributional dynamics among LMAs. We found that an increase in the number of four-year colleges and universities per capita increased an LMAs upward rank mobility in terms of human capital. Furthermore, for select quintiles, we also found that raising the number of four-year colleges and universities increased the probability of upward quintile mobility. In all these results, the influence of education institutions on rank and quintile mobility was estimated to be larger in metropolitan than in nonmetropolitan LMAs.

A warmer climate was found to encourage downward rank mobility, and for select quintiles, to decrease the probability of upward quintile mobility. These findings, which held for both metropolitan and nonmetropolitan LMAs, suggest that college graduates are less responsive to this climate amenity than those without a college degree. This could occur because older residents, who on average are less likely to have a college degree, may be more attracted to warm weather. Industry structure was found to influence both rank and quintile mobility in metropolitan and nonmetropolitan LMAs. In particular, LMAs with a higher share of initial employment in construction, finance, and services exhibited greater upward rank mobility, and for select quintiles, an increased the probability of transitioning to a higher quintile. Finally, entrepreneurship, as measured by proprietor's share of employment, was associated with greater upward mobility among nonmetropolitan LMAs, particularly among LMAs with lower levels of initial education.

Notes

1. Examples include Hammond and Thompson (2008), Hammond and Thompson (2006), Hammond (2006), Higgins, et al. (2006), Hammond (2004), Henry, Barkley, and Li (2004), Huang, Orazem, and Wohlgemuth (2002), Rupasingha, Goetz, and Freshwater (2002), Beeson, DeJong, and Troesken (2001), Nissan and Carter (1999), and Carlino and Mills (1987).
2. Literature examining the growth of human capital in regions generally has focused on aggregate growth, whether the source of growth was net migration of high human capital workers, or human capital accumulation among a region's indigenous population. The relative importance of migration versus indigenous human capital accumulation is an important topic for future research. Recent research, however, finds that the two effects are reinforcing within regions (Beckstead, Brown, and Newbold, 2008), suggesting that analysis of aggregate human capital growth rates will not mask any conflicting patterns among these two sources of human capital formation.

3. The basic trends are similar for county data classified by metropolitan/nonmetropolitan status in 1973.
4. As Geweke, Marshall, and Zarkin (1986) and Quah (1996) point out, there are many ways to summarize mobility within a distribution. We use the Shorrocks index because it is simple and intuitive. Quah (1996) finds significant similarities across various measures of mobility.
5. We test for differences across transition matrixes both across region type and decade using the loglinear modeling approach implemented by Fingleton (1997, 1999) (see also Hammond and Thompson 2006) for additional details). Loglinear models describe relationships between categorical variables. In our case, the main categorical variables will be beginning and ending year college attainment rates, which are categorized into five classes. We reject the null that the metropolitan transition matrix is equal to the nonmetropolitan matrix at the 1% level.
6. Both are significantly different from zero at the 1% level.
7. The region with the highest college attainment is assigned rank 256 and the region with the lowest college attainment is assigned rank 1. For example, if a region was ranked 200 out of 256 in metropolitan LMAs in 1970, and then rose to be ranked 225 in 2000, the change in rank would be +25. If instead, the region fell to a rank of 175 in 2000, then the change in rank would be -25.

Declaration of Conflicting Interests

The author(s) declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research and/or authorship of this article.

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