The Rise of the Skilled City

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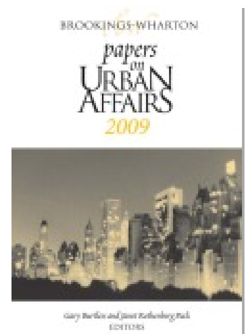

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The Rise of the Skilled City

Between 1980 and 2000, the population of metropolitan areas where less than 10 percent of adults had college degrees in 1980, grew on average by 13 percent. Among metropolitan areas where more than 25 percent of adults had college degrees, the average population growth rate was 45 percent. For more than a century, in both the United States and Great Britain, cities with more educated residents have grown faster than comparable cities with less human capital.[1] There is no consensus, however, on the causes or implications of this relationship.

Why have people increasingly crowded around the most skilled? Why does education seem to be a more and more important ingredient in agglomeration economies? Three disparate, but not incompatible, visions of the modern city offer different answers to these questions. The Consumer City view—cities are increasingly oriented around consumption amenities, not productivity—tells us that skills predict growth because skilled neighbors are an attractive consumption amenity. The Information City view—cities exist to facilitate the flow of ideas—tells us that we should expect cities to be increasingly oriented around the skilled because the skilled specialize in ideas. The Reinvention City view—cities survive only by adapting their economies to new technologies—

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1. Glaeser (1994); Glaeser, Scheinkman, and Shleifer (1995); Simon (1998); Black and Henderson (1999); Nardinelli and Simon (1996, 2002).

tells us that human capital predicts city growth because human capital enables people to adapt well to change.[2] Understanding why skills predict city growth will help us determine if cities thrive because of consumption, information, or reinvention.

We use four approaches to address the possibility that the rise of the skilled city is the result of a spurious correlation between local skills and other urban characteristics. First, we show that controlling for a wide range of other factors makes little difference to the impact of local skills on subsequent city growth and that local human capital is essentially unrelated to many of the most important local amenities such as weather variables. Second, we show that the metropolitan-area human capital effect is robust to including metropolitan-area fixed effects. Third, we examine the connection between the number of colleges per capita in 1940 and growth between 1970 and 2000. The pre–World War II number of colleges seems considerably more exogenous than current skill levels, and it still correlates strongly with growth in the modern era.[3]

Fourth, we examine the timing of skills and growth and test whether skilled workers flock to cities that are growing. Individuals with low education are particularly prone to live in declining cities, but exogenous differences in positive growth rates do not predict changes in the percentage of the population with a college education.[4] Reverse causation from growth to education seems to be present only in a handful of declining metropolitan areas and cannot account for much of the relevant effect. Overall, the evidence supports the view that skills induce growth.

Following Jesse Shapiro, we present a framework for understanding the connection between skills and growth.[5] The framework tells us that production-led growth should increase *nominal* wages and housing prices, while consumption-led growth should cause *real* wages to fall. Rising nominal wages are a sufficient condition for productivity growth, and declining real wages are necessary for the amenity story to be of relevance.

2. For the Consumer City view see, for example, Glaeser, Kolko, and Saiz (2001); for the Information City view see Jacobs (1969); and for the Reinvention City view see Glaeser (2003). For adaptation to change see Shultz (1964); Welch (1970).

3. In this we follow Moretti (forthcoming). Card (1995) uses proximity to college as an instrumental variable for the level of education of an individual.

4. Glaeser and Gyourko (2001).

5. Shapiro (2003).

Our empirical work shows that productivity drives the connection between skills and growth. At the metropolitan level, we find that education *levels* have a positive impact on future wage and housing price growth. With almost any reasonable set of parameter values, the connection between education and population growth is the exclusive result of rising productivity and has less to do with rising amenity levels. Indeed, real wages may be rising in high-education metropolitan areas, which suggests that consumer amenities are declining—in relative terms in high-skill areas.

At the city level, the results are less clear. In small municipalities within metropolitan areas, low levels of human capital predict urban decline and falling housing prices. At the city level (not at the metropolitan-area level), it is the bottom end of the human capital distribution that matters. The prevalence of high school dropouts predicts urban decline. Moreover, this decline seems driven, at least in part, through consumption-related effects. Perhaps, unfortunately, poverty has become perceived as an increasingly negative amenity because of social problems or a higher tax burden.

That skills increase the growth of a metropolitan area through productivity increases is compatible with the Information City and the Reinvention City hypotheses. We try to distinguish between these two interpretations of the connection between growth and skills. To test the Information City hypothesis, we turn to patent data. Previous research shows that areas with more human capital have higher rates of patenting per capita.[6] We find that controlling for patenting rates does not explain any portion of the effect of human capital on growth. This certainly does not disprove the Information City hypothesis, but it does not support it either.

One test of the reinvention hypothesis is to look at the cross effect between skills and factors that have an independent effect on city growth. The Information City view predicts that skills should predict growth among all types of cities. The Reinvention City hypothesis predicts that skills should only matter among those cities that have received negative shocks. We test this implication by looking at the cross effect between skills and the weather, and skills and immigration. Warm weather and immigration have been two of the most important drivers of contempora-

6. Carlino, Chatterjee, and Hunt (2001).

neous metropolitan population growth in the United States. We find that there is a strong negative cross-effect between skills and either warmth or immigration, which means that human capital really only matters in potentially declining places. This supports the reinvention hypothesis.

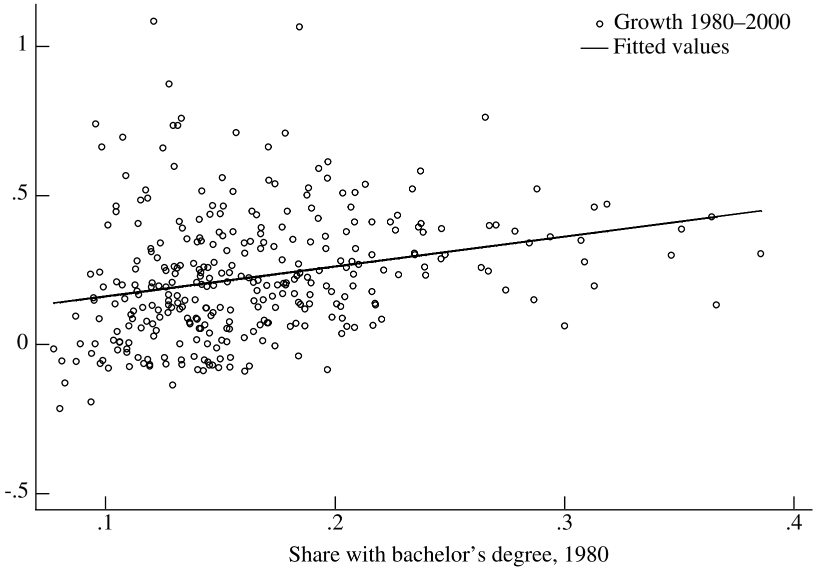
We further test the reinvention hypothesis by seeing whether skilled places shifted out of manufacturing more quickly. In the first part of the twentieth century, urban success generally meant specialization in manufacturing. Declining transport costs and declining importance of manufacturing have meant that at the beginning of the twenty-first century, successful cities have moved from manufacturing into other industries. If the reinvention hypothesis is right, then it should predict the speed at which cities reinvent themselves. Indeed, we find that metropolitan areas with high levels of education and significant manufacturing as of 1940 switched from manufacturing to other industries faster than high-manufacturing areas with less human capital. These results suggest that skills are valuable because they help cities adapt and change their activities in response to negative economic shocks.

Is the Skills-Growth Connection Spurious?

In this section, we confirm the empirical relationship between education and metropolitan statistical area (MSA) growth. We test whether the connection between skills and city growth is spurious, reflecting omitted variables. We use both cities and MSAs as our unit of analysis, because there are advantages and disadvantages to both. The MSAs are more natural labor markets, but cities are smaller and a better unit of analysis for understanding either amenities or real estate prices. We use the 1999 county-based boundaries (New England county metropolitan area [NECMA]) definitions in New England and primary metropolitan statistical area (PMSA) definitions in the rest of the country.[7] Using county-level data, we obtain a complete and consistent panel for 1970, 1980, 1990, and 2000. We select those cities with population over 30,000 in 1970. Table A-1 in appendix A to this chapter details the sources of all variables.

7. Using the most recent boundaries helps us avoid the endogeneity of current definitions to growth.

Figure 1. Growth of Metropolitan Statistical Area (1980–2000) and Human Capital (1980)



Fitted line from the regression: log(pop2000/pop1980) = 0.0611 + 1.001 × share with bachelor's degree in 1980.
(0.036) (0.209)

R squared: 0.067, N: 318.

Figure 1 shows the correlation between the growth of the logarithm of population between 1980 and 2000 and the share of adults in 1980 with college degrees among metropolitan statistical areas. Table 1 (panel a) shows the correlation between metropolitan-area growth and the primary independent variables over the entire 1970–2000 period. Table 1 (panel b) shows similar correlations at the city level. In both cases, there is a significant association between initial education and later growth. The correlation between the share of college graduates and population growth is 18 percent for cities and 30 percent for metropolitan areas. Descriptive statistics on all variables are presented in appendix table A-2.

While we focus primarily on the share of the adult population with college degrees, an alternative measure of human capital, the share of adults who dropped out of high school, is a stronger (that is, more negative) correlate of city growth but a weaker correlate of MSA growth. This suggests that the impact of higher education may be more important at the MSA level (maybe because of a productivity effect), whereas the

Table 1. 1970–2000 Population Growth and 1970 Variables: Correlations

	Log(population 2000) – log(population 1970)
Panel A: Metropolitan statistical areas (MSA)	
Share with bachelor's degree (age 25+) in 1970	0.30
Log population in 1970	–0.13
Log average heating degree days (1961–90)	–0.56
Log average annual precipitation (1961–90)	–0.31
Share of workers in manufacturing in 1970	–0.56
Share of workers in professional services in 1970	0.22
Share of workers in trade in 1970	0.29
Unemployment rate in 1970	0.15
Share of high school dropouts (age 25+) in 1970	–0.18
Log colleges per capita in 1940	0.25
Log family income in 1970	–0.28
Log home value in 1970	0.02
Panel B: Cities	
Share with bachelor's degree (age 25+) in 1970	0.18
Log population in 1970	–0.08
Log average heating degree days (1961–90)	–0.44
Log average annual precipitation (1961–90)	–0.45
Share of workers in manufacturing in 1970	–0.33
Share of workers in professional services in 1970	0.13
Share of workers in trade in 1970	0.21
Unemployment rate in 1970	0.11
Share of high school dropouts (age 25+) in 1970	–0.28
Log colleges per capita in 1940	0.25
Log family income in 1970	–0.08
Log home value in 1970	0.07

impact of low education is more important at the city level (maybe because of localized social interactions). Although these correlations are large, other variables such as heating degree days, annual precipitation, and the share of labor force in manufacturing have stronger correlations with population growth than the human capital variables.

Our baseline regressions use a panel of metropolitan areas (in table 2) and cities (in table 3) over three periods (the 1970s, the 1980s and the 1990s).[8] The dependent variable is the difference in the log of population between census years. We focus on the coefficient on the share of the

8. We have data for four years: 1970, 1980, 1990, and 2000. Since we are using population growth (the first difference in the log of population) we end up with three time periods.

population with a college education.[9] All regressions include decade-specific fixed effects and allow each geographic unit's standard errors to be correlated over time. More precisely, we estimate the coefficients β and γ_j in regressions of the form:

$$(1)\quad \log\left(\frac{\text{Population}_{i,t}}{\text{Population}_{i,t-10}}\right) = \beta \times \frac{\text{College}_{i,t-10}}{\text{Population}_{i,t-10}} + \sum_j \gamma_j Z_{i,j,t-10} + Y_t + \varepsilon_{i,t}$$

where ($\text{College}_{i,t-10}/\text{Population}_{i,t-10}$) is the share of the population with a college degree in the initial year, $Z_{i,j,t-10}$ is the value of independent variable j in the initial year, U_t is a decade-specific fixed effect, and $\varepsilon_{i,t}$ is the city-year error term, which we allow to be correlated across decades.

Regression 1 in tables 2 and 3 shows the raw impact of percent college educated on later growth for MSAs and cities respectively. For the MSA-level regressions, a 1 percentage point increase in the share of the adult population with college degrees increases the decadal growth rate by, approximately, almost one-half of 1 percent. The standard deviation of metropolitan-area growth is approximately .1, and the standard deviation of the college graduation variable is approximately .05: a one-standard-deviation increase in percent college graduates increases the expected growth rate by one-quarter of a standard deviation.

In the city-level regressions reported in table 3, the basic effect of college education is weaker. A 1 percent increase in college graduates increases the expected growth rate by one-fifth of 1 percent. At the city level the standard deviation of the percent college-educated variable is approximately .1, and the standard deviation of decadal growth rates is about .15. This means that a one-standard-deviation increase in the percent college educated at the city level is associated with approximately a one-seventh of a standard deviation increase in the expected growth rate. As suggested by the raw correlations, college education is a more powerful predictor of growth at the MSA level than growth at the city level.

In regression 2 of both tables, we include initial population, the log of heating degree days, the log of average precipitation, the share of labor force in manufacturing, trade and professional services,[10] and controls for

9. This corresponds to individuals with a bachelor's degree.

10. These are the three major occupations in our sample, representing 63 percent of total MSA employment in 1990.

Table 2. MSA Growth and Education

	Δlog(population)					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Share with bachelor's degree (age 25+) at t-10	0.47 (0.096)***	0.582 (0.113)***	0.456 (0.117)***	0.508 (0.215)**	0.414 (0.153)***	
Log of population at t-10		–0.015 (0.004)***	–0.011 (0.005)**	–0.316 (0.030)***	–0.014 (0.004)***	0.003 (0.005)
Log average heating degree days (1961–90)		–0.082 (0.011)***	–0.075 (0.020)***		–0.084 (0.011)***	–0.07 (0.011)***
Log average annual precipitation (1961–90)		–0.026 (0.015)*	–0.001 (0.014)		–0.026 (0.015)*	–0.024 (0.015)
Share of workers in manufacturing at t-10		–0.173 (0.088)*	–0.167 (0.073)**	0.255 (0.125)**	–0.162 (0.085)*	–0.174 (0.084)**
Share of workers in professional services at t-10		–0.328 (0.145)**	–0.166 (0.132)	0.148 (0.203)	–0.238 (0.142)*	0.082 (0.117)
Share of workers in trade at t-10		0.034 (0.260)	0.113 (0.215)	0.229 (0.281)	0.007 (0.279)	–0.129 (0.219)
Unemployment rate at t-10					–0.427 (0.235)*	
Share of high school dropouts (age 25+) at t-10					–0.06 (0.089)	
Log colleges per capita in 1940						0.035 (0.008)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	No	No	Yes	Yes
State fixed effects	No	No	Yes	No	No	No
MSA fixed effects	No	No	No	Yes	No	No
Observations	918	918	918	954	918	816
R squared	0.56	0.51	0.6	0.89	0.51	0.5

Note: Robust standard errors in parentheses
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

Table 3. City Growth and Education

	Δlog(population)					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Share with bachelor's degree (age 25+) at t-10	0.202 (0.044)***	0.217 (0.053)***	0.166 (0.050)***	0.121 (0.086)	0.061 (0.078)	
Log of population at t-10		–0.009 (0.004)**	–0.017 (0.005)***	–0.512 (0.017)***	–0.007 (0.004)	–0.010 (0.004)**
Log average heating degree days (1961–90)		–0.021 (0.009)**	0.000 (0.015)		–0.023 (0.009)***	–0.028 (0.009)***
Log average annual precipitation (1961–90)		–0.097 (0.018)***	–0.071 (0.025)***		–0.097 (0.019)***	–0.087 (0.021)***
Share of workers in manufacturing at t-10		–0.032 (0.060)	–0.023 (0.059)	0.327 (0.091)***	0.014 (0.063)	–0.042 (0.055)
Share of workers in professional services at t-10		–0.113 (0.090)	–0.095 (0.087)	–0.851 (0.144)***	–0.048 (0.102)	0.029 (0.077)
Share of workers in trade at t-10		0.276 (0.151)*	0.122 (0.154)	–0.393 (0.164)**	0.181 (0.154)	0.200 (0.149)
Unemployment rate at t-10					–0.043 (0.200)	
Share of high school dropouts (age 25+) at t-10					–0.163 (0.060)***	
Log colleges per capita in 1940						0.033 (0.007)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	No	No	Yes	Yes
State fixed effects	No	No	Yes	No	No	No
City fixed effects	No	No	No	Yes	No	No
Observations	2160	2160	2160	2169	2160	2070
R squared	0.11	0.26	0.36	0.8	0.27	0.26

Note: Robust standard errors in parentheses
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

the four census regions. Warm and dry weather has been shown to be among the important predictors of population growth in the United States at the end of the twentieth century. Heating degree days is a measure of cold weather severity (roughly proportional to how many days a household would need to use heating to keep warm). Initial population is usually unrelated to later city growth, but it remains a natural control.[11] The employment share variables capture aspects of industrial orientation, and we know from table 1 that specializing in manufacturing is a strong correlate of later decline.

For both cities and metropolitan areas we find that warm, dry places grow much more quickly than cold, wet places. There is a modest amount of mean reversion: bigger cities and metropolitan areas grow somewhat more slowly. Metropolitan areas with substantial manufacturing grow more slowly. Although these correlations are interesting, we do not discuss them further because they have been considered at length elsewhere.[12] Our focus is the extent that controlling for these variables changes the impact of college education on later city growth.

Including these controls has little impact on the coefficient on the college educated. Education does not predict growth because educated metropolitan areas have more employment in the service sector or better weather. In metropolitan areas, including these factors actually causes the coefficient on percent college educated to rise. That controlling for these major potential *omitted* variables causes the impact of college to rise should not surprise us, because skilled workers are less likely to live in warm, dry places. Since more educated people have tended to live in the areas of the country with less desirable climates, controlling for the weather variables makes the impact of education stronger, not weaker.

In specification three, we include state-specific fixed effects. In principle, these fixed effects should capture all time-invariant weather or geographic variables, as well as those state-level policies that change only slowly over time. In tables 2 and 3, controlling for state-specific effects has only a modest impact. For metropolitan areas, the state fixed-effects regressions have almost exactly the same coefficient as the regression with no controls. For cities, the state fixed effects cause the coefficient on

11. Glaeser, Kolko, and Saiz (2001); Glaeser and Shapiro (2003); Glaeser, Scheinkman, and Shleifer (1995); Eaton and Eckstein (1997).

12. Glaeser, Scheinkman and Shleifer (1995); Glaeser and Shapiro (2003).

education to drop 18 percent relative to the no control specification. We generally prefer not to work with state-specific fixed effects, especially for metropolitan-area regressions, since many states have only a small number of metropolitan areas.

In the fourth regression, we include a city or metropolitan-area fixed effect. This control is meant to address the possibility that skilled workers are just proxying for omitted variables that are pushing the area ahead. In this case, all of our identification comes from changes in the share of college educated over time within the city. In other words, during decades in which the city began with more college graduates (relative to its historical mean) did that city have a higher subsequent growth rate? For metropolitan areas, these fixed effects have little impact on the coefficient, although the standard errors rise significantly.[13] For cities, the coefficient drops by 40 percent (relative to the no control benchmark) and becomes statistically insignificant, but the difference between the coefficient in regression 4 and the coefficient in regression 1 is not statistically significant.

Including city-specific fixed effects is asking a great deal of the data, given the extremely high degree of persistence in human capital over time. The correlation coefficient in the share of the college educated in 1980 and 1990 is 97.3 percent across cities and 97.5 percent across metropolitan areas. As the fixed effects eliminate most of the variation in skills across space, we are amazed that we continue to find a positive effect, and we are not troubled that the effect gets somewhat weaker in the city specification.

In the fifth regressions of the two tables, we add two further controls to the specification in regression 2: share of the adult population without high school degree and the unemployment rate. We see both of these variables as added measures of human capital, but these measures capture the lower end of the human capital distribution. While high-frequency changes in the unemployment rate over time generally reflect time-varying labor market conditions, *differences* in the unemployment rate across cities (less so across metropolitan areas) are generally time

13. We understand that we cannot estimate the coefficient on the lagged dependent variable consistently in the fixed-effects specification. However, the results on the other coefficients would not change very much if we omitted the lag of population in the fixed-effects specification.

invariant and reflect characteristics of the labor force and the industry structure in the city.[14] The correlation coefficient between city-level unemployment rates in 1980 and 1990 is .75; the correlation coefficient between MSA-level unemployment rates in 1980 and 1990 is .5.

For metropolitan areas, the effect of the dropout rate is insignificant, and the unemployment rate is marginally significant. Together these variables reduce the coefficient on percent college educated by 15 percent relative to regression 1. In table 3, controlling for these other variables severely reduces the impact of higher education on city growth. The natural interpretation of table 2 and table 3 is that an abundance of college graduates drives the success of a *regional* labor market, but a *local* neighborhood succeeds by avoiding large numbers of low-educated workers. It seems that having high human capital matters most for the metropolitan area, but avoiding low human capital matters more for smaller units of geography.

Finally, in regression 6, we drop our measure of college graduation entirely and follow Moretti, using instead the presence of colleges in the area before 1940.[15] As seen in figure 2, there is a remarkably strong relationship between the number of colleges per capita before World War II and the level of people with higher education in 2000. This variable has the advantage of being predetermined and not a function of recent events that might attract the well educated to a metropolitan area.

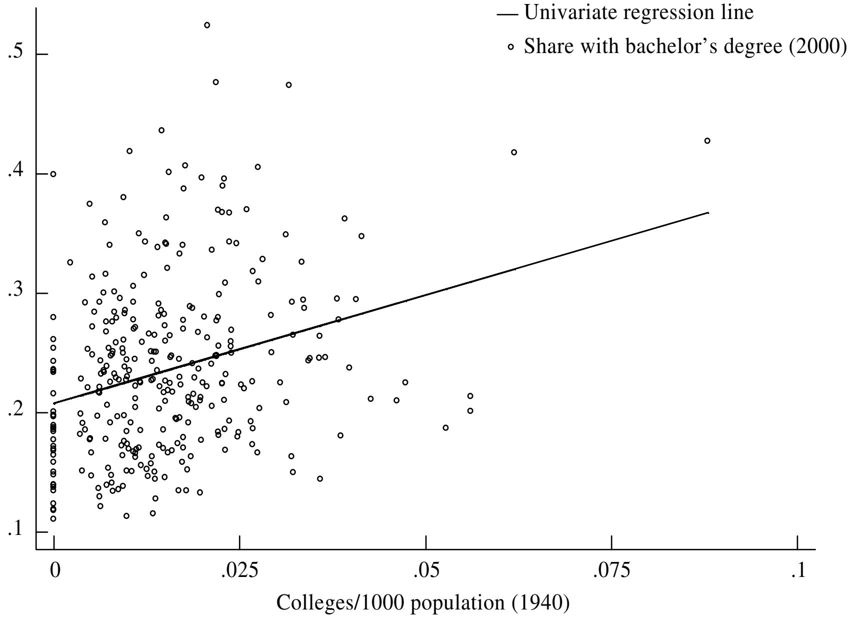
Although we believe that this variable is less likely to reflect reverse causality or omitted factors than our share of college-educated variable, we are not confident that it is completely orthogonal to the error term. As such, using the variable as an instrument (as in Moretti) may give us quite misleading results because in instrumental variables regression, the correlation with the error term is essentially multiplied by the inverse of the first-stage R squared.[16] Instead, we present results by using this variable directly instead of using it to instrument for the share of college graduates. In fact, both as an instrument and as a right-hand-side variable, the variable has a strong, significant impact on population growth.

14. Thus most of the time-series variation in unemployment rates is common to all cities, whereas the relative differentials between cities are quite stable.

15. Moretti (forthcoming).

16. Moretti (forthcoming). Technically, this statement is only true in a univariate regression. Still, the basic point that correlation with the error term explodes in magnitude in instrumental variables regressions holds in all cases.

Figure 2. Colleges in the pre-WWII Era and the Share of College Educated in 2000



Share with bachelor's degree in 2000 = 0.207 + 1.816 × colleges per 1,000 population in 1940.
(0.006) (0.337)

R squared: 0.085, N: 313.

The coefficient in table 2 implies that as the number of colleges per capita doubles, the expected growth rate during the decade rises by roughly 4 percent for both MSAs and cities.[17]

In appendix table A-3 we run similar regressions at the MSA level with a set of controls for other variables that may be correlated with initial high levels of education and find that the impact of education on growth is not driven by these *omitted* variables either.[18]

17. We have also experimented with college enrollment over population in 1970 as an exogenous proxy for human capital with qualitatively similar results (see table A-3, column 1).

18. In table A-3 we control for the possibility that the share of the highly educated may simply be capturing attributes of the age distribution in a city (for example, younger cities will tend to be more educated because of a cohort effect: younger cohorts are attaining higher education levels, or cities with lower education may be cities with elderly retired people). To address that issue we have augmented the MSA regression to control for the initial age distribution of the metropolitan area (variables for the shares of population in the following categories: age 0-21, 22-34, 35-44, 45-54, and 54-65). We also include in

In table 4 we look at reverse causality. In regression 1 we examine the relationship between population growth and the change in the share of the population with bachelor's degrees at the city level. Glaeser and Gyourko argue that durable housing causes unskilled people to move into declining cities for the cheap housing.[19] As such, the relationship between population change and human capital change should be much weaker among growing cities than among declining cities. This asymmetry occurs because durable housing means that housing prices fall sharply in declining cities, and this event attracts the unskilled. We estimate our regression with a spline at zero population growth.

Regression 1 does indeed find a strong relationship between growth and human capital among declining cities and little relationship among growing cities. In regression 4 we repeat this exercise with metropolitan areas and find similar results. Regressions 2 and 5 repeat regressions 1 and 4 with initial population and industry share controls and find little change in the coefficients on growth.

Although these regressions point to a connection between decline and human capital change, the fact that we are regressing change in human capital on contemporaneous population growth is problematic. Obviously, the causal link is hard to determine from this regression. To address this issue, we instrument for growth using the omitted climate variables (heating days and annual precipitation). As already shown,

appendix table A-3 other variables that are generally considered city amenities or disamenities. We control for the murder rate. Higher education levels have been shown to reduce crime (Lochner [1999]; Lochner and Moretti [2001]). Crime is a very salient disamenity. For instance, Berry-Cullen and Levitt (1999) show a causal link between crime and city depopulation. Murder rates are a good indicator of crime, because other crimes are not always reported, and reporting rates for other crimes may vary according to education levels. The number of museums, eating and drinking establishments per capita, health establishments per capita, the number of amusement and recreational service establishments, and the teacher-pupil ratio (a proxy for the quality of primary and secondary education in the metropolitan area) are included as local public goods or amenities that are likely to be provided in high human capital areas. We also include the number of membership organizations as a proxy for social capital. An alternative hypothesis to explain why the presence of highly educated people fosters growth hinges on the propensity of the highly educated to contribute to local social capital by participating in political and civic institutions (Putnam [2000]). Including these amenities, public goods, and controls for social capital does not seem to explain away the role of education on city growth. In fact, the amenity variables are mostly insignificant in this specification, although in line with previous research there is a very strong negative impact of crime on growth.

19. Glaeser and Gyourko (2001).

Table 4. Reverse Causation: Human Capital and Growth

	Δshare bachelor's degree					
	Cities			*Metropolitan statistical area*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Spline growth for declining areas	0.058	0.055	–0.311	0.121	0.087	1.249
	(0.014)***	(0.016)***	(0.203)	(0.024)***	(0.020)***	(1.996)
Spline growth for growing areas	0.011	–0.005	0.057	0.010	0.022	–0.155
	(0.005)**	(0.006)	(0.065)	(0.007)	(0.007)***	(0.103)
Log of population at t-10		0.000	–0.001		0.007	0.006
		(0.001)	(0.001)		(0.001)***	(0.001)***
Share of workers in manufacturing at t-10		–0.048	–0.063		0.023	–0.079
		(0.013)***	(0.017)***		(0.011)**	(0.031)**
Share of workers in professional services at t-10		0.074	0.069		0.138	0.060
		(0.021)***	(0.023)***		(0.016)***	(0.051)
Share of workers in trade at t-10		–0.081	–0.086		0.033	–0.038
		(0.037)**	(0.045)*		(0.034)	(0.054)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
IV for growth (weather instruments)	No	No	Yes	No	No	Yes
Observations	2709	2169	2160	954	954	918
R squared	0.11	0.15		0.22	0.42	

Note: Robust standard errors in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

these variables powerfully predict growth, and we use them as instruments in regressions 3 and 6. Clearly, interpreting the coefficients from the instrumental variables (IV) specification would become problematic if we believed that climate has a direct impact on the skill composition of an area. In regressions 3 and 6 the results are inconclusive, because the standard errors become quite large (especially for the coefficients on decline), but we see little evidence for population growth accompanying skill upgrading among growing cities.

Our interpretation of table 4 is that there is significant potential for reverse causality among those cities that are in decline but little potential for reverse causality among growing cities. We see this as more problematic for the city-level regressions because decline is more common at the city level. To ensure that a tendency for declining metropolitan areas to shed skilled workers is not driving our results in tables 2 and 3, we have run regressions in which we treat all declining cities as having zero population growth. This change has little impact on our estimated coefficient on schooling. We also omitted those areas that are predicted (on the basis of weather) to have population declines. This causes our coefficients to fall but generally remain statistically significant.

Productivity and Amenities: A Theoretical Framework

Tables 2, 3, and 4 suggest that the correlation between human capital and subsequent urban growth is a real phenomenon and not a spurious correlation driven by some obvious omitted variable or reverse causality. We now try to understand this correlation. Following Shapiro, we start with a simple model that helps us to distinguish between consumption and production-led urban growth.[20]

We assume that utility in city j equals $C_j \times U$(Traded Goods, Housing), where C_j represents a city-specific amenity level and housing is a nontraded good. We further assume that output in the city equals: $A_j \times F$(Labor, Capital), where A_j represents a city-specific productivity level, labor is itself a function of skilled and unskilled workers, and capital includes traded and nontraded capital inputs.

Although the details are worked out in appendix B, our key assumptions are that utility ($U(\cdot)$) is Cobb-Douglas in traded goods and housing

20. Shapiro (2003).

and that production ($F(\cdot)$) is Cobb-Douglas in effective labor units, traded capital, and nontraded capital. Effective labor units are themselves produced with a constant elasticity of substitution function of skilled and unskilled labor. In equilibrium, workers are paid the marginal product of labor, and utility levels (within skill categories) are equalized across space.

Our primary focus is on changes in the city-specific productivity level, A_j, and the city-specific consumer amenity level, C_j. These are the only city-specific parameters that we allow to change. We assume that $\log(A_{j,t+1}/A_{j,t})$ = Other Factors + $\delta_A S_{j,t}$ and $\log(C_{j,t+1}/C_{j,t})$ = Other Factors + $\delta_C S_{j,t}$, where S_t is the share of the population that is skilled. These equations can be interpreted as meaning that schooling increases productive innovation or investment in consumer amenities. In these cases, we should think of the previously estimated coefficients as suggesting that schooling has a growth effect. Alternatively, we can think of characteristics as having level effects that change over time. As we show in a companion working paper growth effects and level effects that change over time are empirically indistinguishable in this context.[21]

With these assumptions, in appendix B we show that we can write:

$$(2) \quad \log\left(\frac{\text{Population}_{t+1}}{\text{Population}_t}\right) = (\beta_A + \beta_C) \times S_t + \text{Other Controls} + \text{Error}$$

where β_A equals δ_A times a positive constant and β_C equals δ_C times a positive constant. Our interest is in the ratio $\beta_A/(\beta_A + \beta_C)$, which reflects the share of the growth-skills connection that can be attributed to productivity growth. The appendix also shows that wage and housing growth regressions can be written:

$$(3) \quad \log\left(\frac{\text{Average Wage}_{t+1}}{\text{Average Wage}_t}\right) = (\kappa_A \beta_A - (1-\kappa_C)\beta_C) \times S_t + \text{Other Controls} + \text{Error}$$

and

$$(4) \quad \log\left(\frac{\text{Housing Price}_{t+1}}{\text{Housing Price}_t}\right) = ((1+\kappa_A)\beta_A + \kappa_C \beta_C) \times S_t + \text{Other Controls} + \text{Error}$$

21. Glaeser and Saiz (2003).

where κ_A is a positive constant equal to ratio of spending on housing (nontraded consumer goods) to spending on traded goods, and κ_C is a positive constant equal to the share of producer spending on labor divided by total producer spending on labor plus producer spending on nontraded capital. Comparing equations 2–4 tells us that the coefficients on schooling in the wage and population regressions should add to equal the coefficient on schooling in the housing price regression.

Using calculations in appendix B and the notation $\hat{B}_{Pop}$, $\hat{B}_{Price}$, and $\hat{B}_{Wage}$ to denote the coefficients on schooling in population growth, housing price growth, and wage growth regressions respectively, it follows that:

$$(5) \qquad \frac{\beta_A}{\beta_A+\beta_C} = \frac{\left(\frac{\hat{B}_{Price}}{\hat{B}_{Pop}} - \kappa_C\right)}{1+\kappa_A-\kappa_C} = \frac{\left(\frac{\hat{B}_{Wage}}{\hat{B}_{Pop}} + 1 - \kappa_C\right)}{1+\kappa_A-\kappa_C}$$

$$= \frac{\left(\frac{\hat{B}_{Wage}}{\hat{B}_{Price}-\hat{B}_{Wage}} + 1 - \kappa_C\right)}{1+\kappa_A-\kappa_C}$$

Equation 5 serves as the basis for our subsequent discussion.

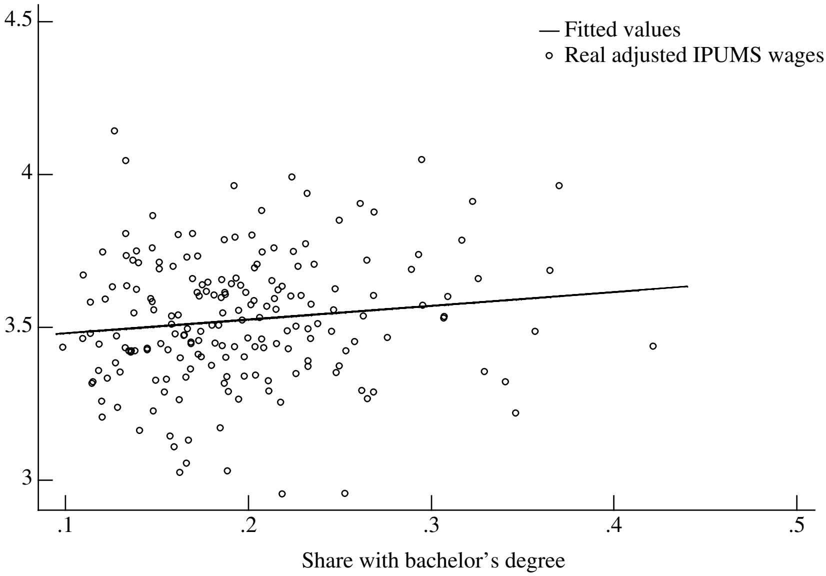
Distinguishing between Productivity and Amenity Effects

We now use the equations in the previous section to measure the extent to which the connection between skill and growth stems from productivity or amenity effects. We know from Rauch's work that, holding one's own skill level constant, wages in a city rise with the skill level of that community.[22] We also know that prices are higher in both cities and metropolitan areas with more skilled workers. Moretti extends Rauch and identifies human capital externalities by using instrumental variables related to human capital but plausibly exogenous to wages.[23] He finds that, after controlling for the private returns to education, a 1 percentage

22. Rauch (1993).

23. Moretti (forthcoming); Rauch (1993). Moretti uses the demographic structure of the city and the presence of "land grant" colleges from the Morrill Act (1862).

Figure 3. MSA IPUMS Adjusted Real Wages and Human Capital, 1990



Real wage 1990 = 3.436 + 0.447 × share with bachelor's degree in 1990.
(0.031) (0.175)
R squared: 0.015, N: 191.

point increase in the share of the college educated in a metropolitan area raises average wages by 0.6 percent to 1.2 percent. Moretti finds more direct evidence of human capital externalities by using plant-level production functions.[24] Of course, since not all individual skills are observed by the researcher, it is arguable if the previous literature succeeds in addressing the problem that selection of more skilled workers into these cities might be driving the correlations.

Figure 3 shows the relationship between wages, adjusted for individual characteristics and local prices, and local human capital across metropolitan areas in 1990. The individual characteristics include age, schooling, and gender, and we use the American Chamber of Commerce Research Analysis data to correct for local price levels. The overall correlation is strong and positive. If we believe these price levels, it seems appropriate to think that in the cross section the primary impact of human capital is to increase productivity, at least at the metropolitan-area level.

24. Moretti (2002).

Our focus is, of course, on changes over time, not on the level effects. So to address these changes we turn first to results from looking at housing price growth at the city and metropolitan-area levels. We are implicitly assuming the relative home quality changes across metropolitan areas are small. The available evidence supports that this assumption is not particularly problematic. Table 5 (panels A and B) reproduces tables 2 and 3 with the change in the logarithm of median housing values as the dependent variable. These are self-reported housing values taken from the census. In these regressions we add the initial housing values as an added control to correct for mean reversion.

Regressions 1 through 6 of panel A in table 5 show the impact that initial human capital has on later housing price appreciation at the metropolitan-area level. The magnitude expands dramatically between regression 1 and regression 2 as the coefficient on percent college educated rises from .18 to 1.17. If we believe the coefficient in regression 1, then a 10 percent increase in the percent college educated at the metropolitan-area level is associated with a 1.8 percent increase in housing prices during the next decade. If we believe the coefficient in regression 2, then a 10 percent increase in the percent college educated increases the expected growth rate of housing prices by almost 12 percent during the next decade.

The difference between the two coefficients is entirely the result of controlling for the initial housing price in each community. There is an extraordinarily large amount of mean reversion in housing prices across metropolitan areas. In general, the high-price areas have also had higher levels of human capital, so controlling for the natural tendency of high-price places to mean revert causes the coefficient on initial share with college degrees to increase.

Regressions 3 through 6 show that at the metropolitan-area level the coefficient on schooling in housing price growth regressions is extraordinarily robust statistically when we control for initial housing price. Even with state or metropolitan-area fixed effects, the t statistic never drops below four. Regression 6 shows that the presence of colleges before 1940 also predicts housing price growth during the past 30 years. Panel A in table 5 certainly seems to make it clear that higher levels of education increase both the population of metropolitan areas and the price that this population is paying for the privilege of living in the area.

In panel B (table 5) we examine housing price growth at the city level, and the results essentially reproduce the findings of panel A. Housing price growth is weakly positively associated with human capital when we fail to control for initial housing prices. When we control for mean reversion, the effect becomes extremely large and extremely robust. The only substantive difference between panel A and B is that in panel B the presence of colleges before 1940 is not a good predictor of housing price growth over the past thirty years. We are certainly struck by the extraordinary power of human capital in predicting housing price growth.

In panels C and D (table 5) we look at the connection between income growth and human capital. Panels C and D essentially reproduce tables 2 and 3 with the log of family income as the dependent variable. These regressions are useful in that they are directly comparable to the previous regressions, but they are flawed by the fact that these results will be biased because of the rise in returns to skill over this time period. Because the compensation for skilled workers has generally risen over the period, we should expect to see incomes rising more quickly in more skilled cities. Average family income, or other aggregate income measures, cannot control for the general change in the skill premium. Nevertheless, for completeness we present these results.

Panels C and D show a systematic positive relationship between initial human capital levels and later growth in family income at the metropolitan-area and city levels. As in panels A and B, there is a big difference in the coefficients between regressions 1 and 2 (in both panels C and D) where the coefficient on schooling is much bigger in regression 2. Just as for housing prices, there is substantial mean reversion in family incomes, and just as for housing prices, skilled cities look much better once we account for this natural tendency of high income places to become relatively poorer over time.

In panels C and D the baseline impact of having an extra 10 percent of an area's adult population with college degrees is an increase in expected income growth of 2 percent. When we control for mean reversion, that impact increases to more than 10 percent. Given that wages for workers with college degrees expanded (relative to noncollege degree workers) by less than 50 percent over the entire thirty-year period, the pure compositional effect of a 10 percentage point increase in the share of adults

Table 5. Education, Home Value, and Income Growth

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Panel A: Δlog(MSA median house value)						
Share with bachelor's degree (age 25+) at t-10	0.185 (0.083)**	1.166 (0.186)***	2.324 (0.237)***	2.258 (0.518)***	0.902 (0.220)***	
Log median house value at t-10		–0.417 (0.036)***	–0.71 (0.041)***	–1.183 (0.060)***	–0.422 (0.035)***	–0.333 (0.036)***
Unemployment rate at t-10					–0.881 (0.344)**	
Share of high school dropouts (age 25+) at t-10					–0.053 (0.109)	
Log colleges per capita in 1940						0.032 (0.012)***
Panel B: Δlog(city median house value)						
Share with bachelor's degree (age 25+) at t-10	0.226 (0.045)***	1.619 (0.116)***	2.25 (0.118)***	1.869 (0.222)***	1.097 (0.151)***	
Log median house value at t-10		–0.376 (0.024)***	–0.602 (0.029)***	–1.096 (0.026)***	–0.41 (0.025)***	–0.169 (0.017)***
Unemployment rate at t-10					–1.483 (0.279)***	
Share of high school dropouts (age 25+) at t-10					–0.377 (0.083)***	
Log colleges per capita in 1940						–0.002 (0.008)

Panel C: Δlog(average MSA family income)						
Share with bachelor's degree (age 25+) at t-10	0.191	0.761	0.849	1.769	0.59	
	(0.029)***	(0.082)***	(0.090)***	(0.171)***	(0.090)***	
Log average family income at t-10		–0.291	–0.359	–1.155	–0.336	–0.143
		(0.029)***	(0.036)***	(0.043)***	(0.030)***	(0.025)***
Unemployment rate at t-10					–0.307	
					(0.161)*	
Share of high school dropouts (age 25+) at t-10					–0.186	
					(0.054)***	
Log colleges per capita in 1940						0.019
						(0.004)***
Panel D: Δlog(average city family income)						
Share with bachelor's degree (age 25+) at t-10	0.275	0.632	0.671	1.624	0.434	
	(0.020)***	(0.052)***	(0.056)***	(0.094)***	(0.057)***	
Log average family income at t-10		–0.135	–0.167	–1.091	–0.231	0.042
		(0.016)***	(0.020)***	(0.031)***	(0.020)***	(0.009)***
Unemployment rate at t-10					–0.709	
					(0.118)***	
Share of high school dropouts (age 25+) at t-10					–0.313	
					(0.041)***	
Log colleges per capita in 1940						0.015
						(0.003)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	No	No	Yes	Yes
State fixed effects	No	No	Yes	No	No	No
MSA fixed effects	No	No	No	Yes	No	No
Other variables in table 2	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

Table 6. Human Capital and Wage/Value Growth: IPUMS

	Log IPUMS wage	*Log IPUMS house value*
	(1)	*(2)*
Share with bachelor's degree at t-10*1980 dummy	0.527 (0.459)	0.389 (1.550)
Share with bachelor's degree at t-10*1990 dummy	0.738 (0.347)**	2.205 (1.087)**
Share with bachelor's degree at t-10*2000 dummy	0.785 (0.271)***	1.698 (0.855)**
MSA fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	1026867	1222890
R squared	0.33	0.64
Average growth in education effect per decade	0.26	0.57

Note: Robust standard errors clustered by MSA-year in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.
Wage regressions include year and MSA fixed effects, controls for age, age squared, education dummies interacted with year, race, Hispanic ethnicity, marital status, and veteran status. Observations include males over 21 years old with complete observations.
Value regressions include year and MSA fixed effects, controls for number of rooms and bedrooms, quality of plumbing and kitchen facilities, and age of the building. The results use a 50 percent random sample of the IPUMS data for all single units with the relevant information.

with a college degree should be less than 2 percent per decade.[25] Using a back of the envelope estimate, if workers of category *X* have had their wages increase by *Y* percent over a time period, then an upper bound for the purely compositional effect of having an extra 10 percent of a place's labor force in category *X* is $.1*Y$.[26] Thus the large magnitudes of the effects seem incompatible with the view that the only effect is that skilled workers are getting higher wages: workers in skilled cities are getting paid more relative to skilled workers elsewhere.[27]

To show this, in table 6, column 1, we use the Census Individual Public Use Microsample (IPUMS) from 1970 to 2000 to control for individual characteristics in a wage regression that includes MSA education lev-

25. Katz and Murphy (1992).

26. The initial share of the highly educated may also be positively correlated with changes in that share. The microdata regressions will dispel any concerns in that direction.

27. The results cannot be accounted for by the fact that higher-educated people have a higher propensity to be married, and thus (median) higher family incomes: using income per capita at the MSA level we found very similar results.

els as explanatory variables. We look at the wages of males over 21, and we control for schooling, age, and race, and metropolitan-area fixed effects. In these regressions the coefficients on schooling and age were allowed to differ by time period. We also include a control for the schooling in the area. We decided to use the lagged share of the percent of the area with college degrees as our measure of education. The decision to use lagged value is an attempt to make these results more comparable with the growth regressions and an attempt to reduce the causality problems inherent with regressing wages on the population composition of an area. Although this would certainly not eliminate causal issues, our results are essentially unchanged if we use schooling in 1970 as our measure of MSA schooling throughout the time period.

Since we are controlling for metropolitan-area fixed effects, we can only estimate the coefficient on area-level schooling in three decades, and we chose 1970 as the excluded decade. As such, differences in our estimated coefficients on the interaction of schooling and decade should be interpreted as the extent to which the coefficient on average schooling in the area has increased over time. Our results suggest that the coefficient on schooling increased by .58 between 1970 and 1980, and then by .21 between 1980 and 1990. Between 1990 and 2000 the coefficient increased by .047.

On average during the three decades, the coefficient on the share with college degrees increased by .25 per decade, which is comparable to a coefficient in a growth regression of .25. This is comparable to the coefficient in the first regressions of table 5 (panels C and D), not the subsequent regressions, because table 6 does not allow high-wage cities to mean revert and become lower wage over time.

In the second column of table 6 we include housing value regressions that are similar in character to the wage regressions. In this case, we are able to control for housing characteristics and thus to control for any changes in the hedonic value of housing characteristics over time. Just as in the wage regression, we are able to control for metropolitan-area fixed effects, and we identify a tendency of the houses in high-schooling metropolitan areas to increase over time. On average, the coefficient on schooling rises by more than .5 each decade over the thirty years, but all of this increase occurs between 1970 and 1990. Between 1990 and 2000, the coefficient on schooling actually falls.

Interpreting the Coefficients with the Model

We first focus on metropolitan areas and then turn to cities and begin with our estimates of $\hat{B}_{Pop}$, $\hat{B}_{Price}$, and $\hat{B}_{Wage}$. At the metropolitan-area level, the coefficient of schooling in the population growth regressions in table 2 ranges from .42 to .58. This is a fairly narrow band, and not much is gained by focusing on the extremes; as such we will use .5 as value of $\hat{B}_{Pop}$.

The estimates of $\hat{B}_{Price}$ in table 5 range from .2 to 2.4, but the bulk of them are clustered around 1. In table 6 our estimate of $\hat{B}_{Price}$ is .55. We will use .5 and .75 as two estimates of $\hat{B}_{Price}$. Table 5 gives a range of estimates for $\hat{B}_{Wage}$ between .2 and 1.8. In the case of $\hat{B}_{Wage}$, we are inclined to put more weight on table 6's estimate of .25, since this is the only estimate that controls properly for individual characteristics.

To produce a reasonable set of estimates, we rely on the fact that the model implies that $\hat{B}_{Pop} + \hat{B}_{Wage} = \hat{B}_{Price}$, the sum of the coefficients on wages and population, should equal the coefficient on prices. It is not true that this holds perfectly empirically—for table 6's estimates and for the estimates in table 5, the value of $\hat{B}_{Price} - \hat{B}_{Wage}$ ranges from .3 to .5. The two cases where the difference is outside of this range are the case for which there are no controls and the case for which we have state fixed effects. So we calibrate the model with a range of .1 to .5 for $\hat{B}_{Wage}$ and an associated range of .6 to 1 for $\hat{B}_{Price}$, which implies that $\hat{B}_{Price}/\hat{B}_{Pop}$ ranges from 1.2 to 2 or $\hat{B}_{Wage}/\hat{B}_{Pop}$ ranges from .2 to 1.

We must also have an estimate of κ_A—the share of spending on nontraded goods divided by one minus the same share. We can calculate this parameter by using the 2001 Consumer Expenditure Survey to estimate the share of shelter in overall expenditure, which is .19. Shelter is pretty clearly a nontraded good, but as there are other elements of consumption that are nontraded, this estimate qualifies as something of a lower bound.

The second way of estimating κ_A is to use a city-level price index (from the American Chamber of Commerce) and regress the log of this price index on the log of housing prices. If the Cobb-Douglas assumption is correct, and if we assume that the consumption amenity is constant, then the derivative of the logarithm expenditure function (that is, household budget requirements as a function of local prices and constant utility) with respect to the logarithm of local prices equals the share of spending on nontraded goods. Since price indexes are supposed to measure the amount of money needed to provide a fixed level of utility, they are ideally the expenditure function. Therefore we obtain an estimate of κ_A as the extent that local price levels rise with increases in housing prices.

Using the 2000 cross section, we estimate:

$$\text{(6)} \quad \log(\text{Price Level}) = \underset{(18)}{-2.2} + \underset{(.015)}{.29} * \log(\text{Median Housing Price})$$

The R squared is .63, and there are 220 observations. We can also estimate this relationship from a panel with MSA and year dummies:

$$\text{(6}'\text{)} \quad \log(\text{Price Level}) = \text{MSA and Year Dummies} + \underset{(.028)}{.21} * \text{Log(Median Housing Value)}$$

In this case, the R squared is .986, and there are 505 observations. Together, these two methods confirm that a reasonable estimate of the share of spending on nontraded goods lies between .21 and .29, and we use .33[0.25/(1 – 0.25)] as our estimate of κ_A.

The value of κ_C equals the ratio of producer spending on labor divided by producer spending on labor plus producer spending on nontraded capital goods. Although we lack any compelling figures for this ratio, we do not believe that spending on nontraded capital goods can be more than one-third of the wage bill. Thus this parameter is bounded between .75 and 1.

Using the parameter estimates $\kappa_A = .33$, we know that $\beta_A/(\beta_A + \beta_C)$ cannot fall below 1 as long as a $\hat{B}_{Wage}/\hat{B}_{Pop} \geq .33$ regardless of the value of κ_C. This result comes from the fact that if $\hat{B}_{Wage}/\hat{B}_{Pop} \geq \kappa_A$ then real wages are increasing with initial schooling, which can only mean that amenity levels are falling. Even if $\hat{B}_{Wage}/\hat{B}_{Pop} = .2$, then the lowest possible estimate of $\beta_A/(\beta_A + \beta_C)$ is .6. To believe that the majority of the skills effect on growth comes from an amenity effect it must be that $\hat{B}_{Wage}/\hat{B}_{Pop} < .1$ or equivalently $\hat{B}_{Price}/\hat{B}_{Pop} < 1.1$. We do not believe that either of those conditions holds, and as such we are led to the view that the bulk of the skills-growth connection at the metropolitan-area level comes from the fact that skills predict productivity growth.

As final check on this, in table 7 we look at the growth of real wages and the relationship to initial human capital. As argued before, if human capital increases amenities at the metropolitan-area level, then real wages should be falling. We again use the American Chamber of Commerce data for local price levels. We use three different measures of MSA-level wages. First, we use the average wage in the area according to the Bureau of Economic Analysis. Second, we use the average manufacturing wage in the area from the Bureau of Labor Statistics. Third, we use a wage variable that we construct using data from the Individual Public Use Micro-Sample, which corresponds to the MSA fixed effect of a regression of wages on individual characteristics. This can be interpreted as the average wage in the metropolitan area net of the impact of individual characteristics. We present results with and without other controls. In all cases, we find a positive or a zero coefficient on human capital. There is no regression where human capital is associated with declining real wages at the city level. This evidence again pushes us to the conclusion that rising wages at the city level have everything to do with rising productivity and nothing to do with rising amenities.

Results at the City Level

We can distinguish between the impact of human capital on the growth of metropolitan areas and the impact of human capital on the growth of cities (holding metropolitan-area growth constant). The overall growth of cities is driven by factors similar to the ones driving growth in metropolitan areas that surround them. The growth of cities, *holding metropolitan-area growth constant,* enables us to really focus on city-specific factors. There has been little work on this issue, but in many respects it is a natural area for research on amenities. Cities within a metropolitan area have radically different levels of amenities but supposedly are part of the same labor market. After all, metropolitan areas are defined to capture a local labor market. Moreover, many people work outside of their city (within their metropolitan area), but their city still determines their quality of life, thousing prices, and public goods.

If wages are the same across cities within a metropolitan area, then changes in the price of the nontraded good (housing) can only reflect changes in the consumption amenity. The previously discussed framework then implies that:

Table 7. Human Capital and Real Wages: Direct Approach

	Δlog(average wage/ Accra prices)		*Δlog(average manufacturing wage/Accra prices)*		*Δlog(IPUMS adjusted wage/ Accra prices)*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Share with bachelor's degree (age 25+) at t-10	0.78	1.78	–0.003	0.213	0.045	0.057
	(0.217)***	(0.239)***	(0.178)	(0.297)	(0.088)	(0.144)
Log of population at t-10		–0.03		–0.018		–0.018
		(0.011)***		(0.010)*		(0.005)***
Log average heating degree days (1961–90)		–0.033		0.028		0.011
		(0.024)		(0.024)		(0.007)
Log average annual precipitation (1961–90)		–0.03		0.024		0.031
		(0.029)		(0.040)		(0.014)**
Share of workers in manufacturing at t-10		–0.029		0.188		–0.069
		(0.212)		(0.182)		(0.080)
Share of workers in professional services at t-10		–1.362		0.203		–0.08
		(0.318)***		(0.389)		(0.177)
Share of workers in trade at t-10		2.063		0.505		0.262
		(0.505)***		(0.476)		(0.371)
Decade fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	No	No	No	No	No
Observations	238	234	135	135	130	129
R squared	0.11	0.37	0.06	0.22	0.58	0.64

Note: Robust standard errors in parentheses. We use Boston in 1990 as baseline, the evolution of Urban CPI and of relative prices from Accra to calculate prices by MSA and year.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

$$\log\left(\frac{\text{Housing Price}_{t+1}}{\text{Housing Price}_t}\right) = \frac{\kappa_A \tilde{\delta}_C}{1+\kappa_A} \times S_t + \text{MSA Fixed Effect} + \text{Other Controls} + \text{Error} \tag{4'}$$

where $\tilde{\delta}_C$ represents the impact of characteristic k on consumption amenity growth at the local level, which may be slightly different than the impact of the growth of this variable at the MSA level. As shown in Glaeser and Saiz, if the skill level of the city is constant over time, then it also follows that:

$$\log\left(\frac{\text{Population}_{t+1}}{\text{Population}_t}\right) = \frac{\kappa_A \tilde{\delta}_C}{1+\kappa_A} \times S_t + \text{MSA Fixed Effect} + \text{Other Controls} + \text{Error} \tag{2'}$$

Somewhat surprisingly, the Cobb-Douglas utility function implies that the effect of consumption amenity growth on prices and people should be the same.[28] Equations 2′ and 4′ inspire us to run regressions within metropolitan areas controlling for MSA, decade fixed effects. These are shown in table 8, and the regressions should be interpreted as capturing the impact of city-specific human capital controlling for the average growth rate of the metropolitan area over the decade. The first thing that the regressions show is that the impact of human capital on prices and population is not the same, despite the implications of the model. Human capital has a much stronger effect (at least when we control for initial price levels) on price growth than on population growth.

The second implication of the regressions is that human capital powerfully predicts housing price and population growth. Interestingly, the impact of the highly educated capital residents (college graduates shown in regressions 1 and 3) is stronger in the housing price growth regressions. High human capital workers seem to be highly correlated with rising prices. The impact of less educated residents (high school dropouts shown in regressions 2 and 4) is stronger in the population growth regressions. All four regressions can be interpreted to mean that human capital is associated with rising consumer amenity levels at the local level, but the regressions do not tell us a simple story.

28. Glaeser and Saiz (2003).

Table 8. Within MSA Regressions: Minor Civil Divisions within MSA

	$\Delta log(population)$		$\Delta log(median\ value)$	
	(1)	*(2)*	*(3)*	*(4)*
Share with bachelor's degree (age 25+) at t-10	0.179		0.49	
	(0.031)***		(0.035)***	
Share of high school dropouts (age 25+) at t-10		–0.274		–0.079
		(0.028)***		(0.025)***
Log of population at t-10	–0.03	–0.029	–0.019	–0.019
	(0.002)***	(0.002)***	(0.001)***	(0.001)***
Share of workers in manufacturing at t-10	–0.12	–0.068	–0.099	–0.105
	(0.045)***	–0.045	(0.026)***	(0.027)***
Share of workers in professional services at t-10	–0.512	–0.518	–0.264	0.033
	(0.059)***	(0.053)***	(0.041)***	–0.034
Share of workers in trade at t-10	–0.245	–0.363	–0.143	–0.249
	(0.080)***	(0.082)***	(0.049)***	(0.051)***
Log median value at t-10			–0.111	–0.019
			(0.012)***	(0.011)*
Decade fixed effects	Yes	Yes	Yes	Yes
MSA-year fixed effects	Yes	Yes	Yes	Yes
Observations	13752	13752	13645	13645
Minor civil divisions	4584	4584	4584	4584
R squared	0.24	0.25	0.59	0.59

Note: Robust standard errors in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

One possible way to reconcile these regressions is to drop our simple assumptions about housing supply being essentially perfectly elastic (subject to the constraint of the fixed amount of nontraded commodity). Indeed, the impact of housing supply is the most important missing element in understanding city growth. If we assume that there are limits to new construction, such as zoning or land use regulation, and we assume that these were more binding in high-skill, rather than low-skill, cities, then we might expect this pattern. In high-skill cities, supply is relatively inelastic so increasing demand operates mainly by increasing prices. In low-skill cities, supply is more elastic, so increasing demand operates mainly by increasing quantities. This is a possible reconciliation of the four regressions in table 8, but it properly belongs as a subject for future research.

If we accept the assumption that a metropolitan area is a common labor market, with common wages, then table 8 seems to imply that there is a significant impact of skills on consumption amenity growth at the local level. Of course, that assumption may not hold perfectly. Some subareas of a metropolitan region may be much more productive than others, and productivity heterogeneity could explain the results. These findings are best thought of as suggestive evidence supporting the link between skills and amenity growth at the local level.

Understanding the Productivity Effect

The evidence suggests that the skills-growth connection at the metropolitan area is fueled primarily by productivity effects. As suggested earlier, the basic data on wage, price, and population growth cannot distinguish among different stories about the connection between human capital and productivity. However, we use other available evidence to check the validity of two of these stories.

First, we address the hypothesis that an environment dense with the highly educated leads to faster technological innovation and that this explains the connection between metropolitan-area growth and human capital. To test this idea, we turn to the patents data. We are able measure patents by MSA for the period 1990–99, so we focus on growth during the 1990s. We first regress patents per capita on the human capital level, and then see how much of the skills-growth connection is explained by greater patenting activity.

Table 9. Human Capital and Technological Growth

	Log patents per worker	*Δlog(population)*	
	(1)	*(2)*	*(3)*
Share with bachelor's degree (age 25+) at t-10	9.135 (0.903)***		0.781 (0.119)***
Log patents per worker at t-10		0.02 (0.006)***	0.003 (0.006)
Log of population at t-10	0.156 (0.040)***	0.001 (0.005)	–0.011 (0.005)**
Log average heating degree days (1961–90)	–0.208 (0.080)***	–0.026 (0.010)**	–0.037 (0.010)***
Log average annual precipitation (1961–90)	–0.014 (0.107)	–0.038 (0.017)**	–0.05 (0.018)***
Share of workers in manufacturing at t-10	5.894 (0.740)***	–0.226 (0.109)**	–0.047 (0.122)
Share of workers in professional services at t-10	–0.485 (1.341)	–0.213 (0.157)	–0.756 (0.162)***
Share of workers in trade at t-10	1.832 (2.367)	–0.229 (0.287)	0.232 (0.297)
Region fixed effects	Yes	Yes	Yes
Observations	304	304	304
R squared	0.56	0.38	0.46

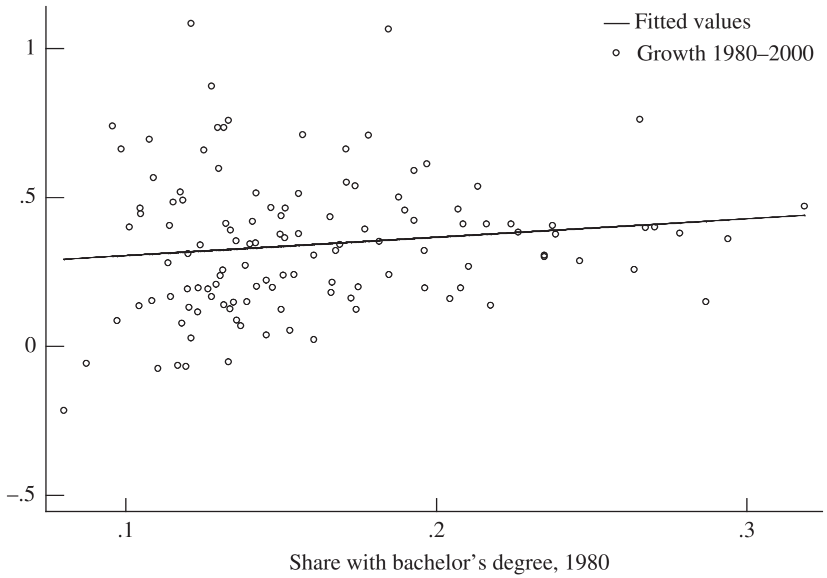
Note: Robust standard errors in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

In table 9, regression 1, we find (like Carlino, Chatterjee, and Hunt) that the share with a bachelor's degree is an important predictor of technological growth.[29] We find that a 10 percent increase in the share of college graduates increases the number of patents by .09 log points (approximately 9 percent). This certainly supports the idea that the better educated are more technologically innovative.

Moreover, in regression 2 we show that there is a connection between patents and growth in regressions where we do not control for human capital. Of course, no causality is posited by these regressions. Patents are as much a sign of a healthy urban environment as a cause. However, the important fact is shown in regression 3. Once we control for human capital, there is no meaningful relationship between patents and urban growth. As such, human capital may matter because it makes people more creative, but the important elements of this creativity must be in areas beyond the formal patenting sector.

29. Carlino, Chatterjee, and Hunt (2001).

Figure 4. MSA Growth, 1980–2000, and Human Capital, Warm MSAs, 1980[a]



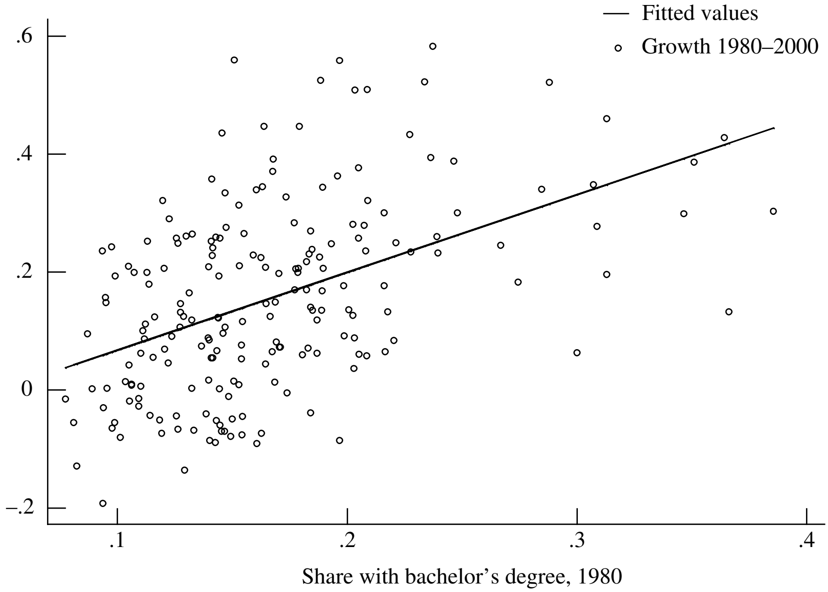
Log(pop2000) – log(pop1980) = 0.615 + 0.242 × share with bachelor's degree in 1980.
(0.429) (0.072)
R squared: 0.0171, N: 120.
a. January temperature over 40 degrees.

The Reinvention Hypothesis

We finally turn to the puzzle created by figures 4 and 5: human capital predicts growth much more sharply for cold places than for hot places. Figure 4 shows the relatively mild (0.13) correlation between skills and growth among those metropolitan areas with January temperatures above 40 degrees on average. Figure 5 shows the 47 percent correlation between the initial share of the population with college degrees and the growth of the logarithm of population between 1980 and 2000 for those metropolitan areas with average January temperatures below 40 degrees. The regression (reported in the figure) suggests that as the share of college educated increases by 1 percent, the growth rate of the period increases by 1.3 percent. Previous literature has pointed to warm weather as an exogenous amenity that has fostered growth in the late twentieth-century United States.[30] Sun, coupled with the availability of air condi-

30. Glaeser, Kolko, and Saiz (2001); Glaeser and Shapiro (2003).

Figure 5. MSA Growth, 1980–2000, and Human Capital, Cold MSAs, 1980[a]



Log(pop2000) – log(pop1980) = –0.064 + 1.317 × share with bachelor's degree in 1980.
(0.031) (0.175)

R squared: 0.222, N: 198.

a. January temperature under 40 degrees.

tioning systems, may have given some areas in the South and West a competitive advantage, but skill appears to be a good substitute.[31]

This fact may be explained by Jacobs's view that cities need to constantly reinvent themselves. Specialization in one area may yield brief success, but eventually the area fades, or the city's comparative advantage in the area decays, and reinvention is necessary. Glaeser details at least four periods in Boston's history when the city reinvented itself.[32] Conversely, in areas with positive exogenous growth shocks, human capital may have less of a role, since reinvention is not necessary.

In table 10 we look at this hypothesis more thoroughly. In regressions 1 through 3 we repeat our benchmark specifications for population, wage

31. Alternatively, the weather variable may be capturing the impact of other variables, though the effect of weather on population growth holds after controlling for state fixed effects. What matters for our argument is not so much the causal impact of weather but the strong predictive power of the part of the signal in this variable that is orthogonal to education.

32. Jacobs (1969); Glaeser (2003).

Table 10. The "Reinvention" Hypothesis

Panel A: All MSA						
	Δ*log (population)* *(1)*	Δ*log(wage)* *(2)*	Δ*log(house value)* *(3)*	Δ*log (population)* *(4)*	Δ*log(wage)* *(5)*	Δ*log(house value)* *(6)*
Share with bachelor's degree (age 25+) at t-10	0.945	2.541	1.264	0.999	2.203	1.046
	(0.138)***	(0.230)***	(0.209)***	(0.135)***	(0.226)***	(0.204)***
Temperature * share with bachelor's degree at t-10	–0.396	–0.284	–0.121			
	(0.112)***	(0.137)**	(0.133)			
Log of population at t-10	–0.013	0.424	0.04	–0.013	0.442	0.038
	(0.004)***	(0.051)***	(0.007)***	(0.004)***	(0.052)***	(0.007)***
Log average heating degree days (1961–90)	–0.143	–0.075	–0.06	–0.093	–0.052	–0.021
	(0.022)***	(0.026)***	(0.023)***	(0.011)***	(0.014)***	(0.014)
Log average annual precipitation (1961–90)	–0.027	–0.015	0.063	–0.026	–0.031	0.078
	(0.015)*	(0.018)	(0.017)***	(0.016)*	(0.019)*	(0.020)***
Share of workers in manufacturing at t-10	–0.128	–0.151	0.138	–0.145	–0.185	0.074
	(0.087)	(0.115)	(0.114)	(0.082)*	(0.109)*	(0.112)
Share of workers in professional services at t-10	–0.295	–1.266	–0.139	–0.456	–1.267	–0.198
	(0.145)**	(0.207)***	(0.178)	(0.143)***	(0.210)***	(0.180)
Share of workers in trade at t-10	–0.004	0.088	0.119	–0.05	0.078	0.103
	(0.257)	(0.336)	(0.307)	(0.252)	(0.333)	(0.304)
Log average wage receipts per worker at t-10		–0.403			–0.417	
		(0.047)***			(0.048)***	
Log median house value at t-10			–0.414			–0.466
			(0.036)***			(0.042)***
Share immigrant at t-10 * share with bachelor's degree t-10				–5.751	2.376	3.433
				(1.201)***	(1.897)	(2.142)
Share immigrant at t-10				0.704	–0.901	–0.031
				(0.268)***	(0.352)**	(0.409)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	918	918	918	918	918	918
R squared	0.52	0.72	0.75	0.54	0.72	0.76

Panel B: 1940–2000			
	Share manufacturing (1940–2000)		*Δlog(population) (1940–2000)*
Share with bachelor's degree in 1940	–0.011 (0.006)*	Share with bachelor's degree in 1940	0.094 (0.017)***
Share in manufacturing in 1940	–0.547 (0.084)***	Log(population) in 1940	–0.139 (0.028)***
January mean temperature	–0.002 (0.0008)**	January mean temperature	0.032 (0.002)***
Share manufacturing 1940 * share with bachelor's degree in 1940	–0.048 (0.018)**	Log average annual precipitation	–0.309 (0.058)***
January mean temperature * share with bachelor's degree in 1940	0.0003 (0.0001)*	Share in manufacturing in 1940	0.046 (0.29)
Log employment in 1940	–0.004 (0.003)	Constant	2.227 (0.371)***
Constant	0.222 (0.050)***		
Observations	293	Observations	293
R squared	0.78	R squared	0.58

Note: Standard errors in parentheses. Panel A: Temperature = 9.27 – log(heating degree days); 9.27 corresponds to the city with max(log heating degree days).
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

growth, and housing price, and we focus on the interaction between initial human capital and warmth. In all three cases, there is a statistically significant negative interaction between warmth and initial skills. The cross effect is strongest in the population regressions, where the regressions imply that a doubling of the number of heating degree days causes the impact of skills to fall by about one-half. The effect on wages is also statistically significant, but smaller in magnitude, at least relative to the benchmark coefficient. The effect on housing prices is the weakest. Although the cross effect is still negative, it is not statistically significant.

One important omitted factor is land use regulations, which seem tighter almost everywhere that there is a high degree of human capital. This would explain why in warm places, skills still matter for housing price growth (because skills are correlated with less elastic housing supply) but not much for population growth. Indeed, if there is a correlation between skills and inelastic housing supply, this would tend to create a perverse negative effect where more skilled places grow less, despite increasing demand for these areas.

In regressions 4 through 6 we look at the share of the population (in the initial time period) that is composed of immigrants. Over this period, immigration was a large source of urban growth, and immigrants tend to settle where other immigrants live.[33] If the reinvention hypothesis is correct, then we should expect to see that human capital does not matter in places with large supplies of immigrants, but it should be important in areas where immigrants are not coming. Indeed, this is exactly what we find in regression 4. Human capital matters much more in predicting population growth in areas without immigrants than areas with immigrants.

One possible explanation for the strikingly different correlation between skills and growth in growing and declining places is that skills allow reinvention. The view that human capital is most valuable because it enables flexibility and the ability to respond to new circumstances was emphasized by Welch.[34] If this view is correct, then we should not be surprised if a high-skill New England city manages to reinvent itself while a low-skill rust belt town does not.

One implication of this hypothesis is that places with high human capital should be better at switching out of declining industries. To test this

33. Altonji and Card (1991); Saiz (2003).
34. Welch (1970).

hypothesis, we gathered data on education and industrial composition in 1940 by metropolitan area (contemporaneously defined). We then tested whether the impact of skills on contributing to the shift away of manufacturing over the next sixty years has been more important in industrial, colder areas of the country (table 10, panel B). The regressions support the view that the skilled rust belt towns were better at reorienting themselves: the importance of education to explain the shift away of manufacturing (the change in the manufacturing share in the lefthand side) in the second half of the twentieth century was stronger in colder areas (interaction between human capital and temperature) and in areas with an initial bigger share of manufacturing (interaction between education and share manufacturing).

Conclusion

Human capital predicts population and productivity growth at the city and metropolitan-area level as surely as it predicts income growth at the country level. High-skill areas have been getting more populous, better paid, and more expensive. Indeed, aside from climate, skill composition may be the most powerful predictor of urban growth. This is a boon to the skilled cities that have done spectacularly during the past two decades and a curse to the cities with less-skilled workers that have suffered an almost unstoppable urban decline.

Why do skilled cities grow more quickly? At the metropolitan area, the available evidence seems to show clearly that skills predict productivity growth and not an increase in amenity levels. The high-skill metropolitan areas are not seeing falling real wages. To the contrary, prices seem not to be rising quickly enough to offset the increases in wages. Standard economic reasoning tells us that this means that high skill levels are associated with decreasing quality of life, perhaps because of increasing population.

Within metropolitan areas, at the very local level, there is some evidence that the prices of skilled places have risen sharply. If the standard assumption that a metropolitan area is a single labor market holds, then the skills-housing price growth connection is best understood as suggesting that skills increase amenities at the very local level, if not at the metropolitan-area level. Thus our results suggest that skills are important because they increase productivity at the metropolitan level and amenities at the local level. On net, the productivity effects appear to be much stronger.

Why are skills so strongly associated with productivity growth at the metropolitan level? Certainly skilled cities are more innovative, but controlling for the rate of innovation does not affect the importance of skills. One clue may be the fact that skills are much more significant in otherwise disadvantaged regions than in exogenously growing regions. This fact might reflect the idea that cities are constantly reinventing themselves—moving from one field of specialization to another. Skills may well be a crucial part of this reinvention as skilled workers react more speedily to painful economic shocks and educated workers find it easier to switch techniques.[35] Although at this point the reinvention hypothesis is only a guess, the fact that skills are so important in the Northeast and almost irrelevant in the West suggests that there is something very significant about the connection between skills and the process of urban decline.

The results in the chapter suggest that city growth can be increased with strategies that increase the level of local human capital. At the regional or metropolitan level, attracting high human capital workers may require provision of basic services, amenities, and quality public schools that will lure the skilled. Conversely, redistributive policies *at the local level* have to be carefully designed to avoid the undesired side effect of repelling the skilled and deterring growth. Generating new technologies *locally* does not seem as important as having the capacity to adapt them. Providing basic quality education (maximizing success rates in high school graduation) may both produce and attract the educated. Since local tax bases are heterogeneous, state and federal funds can help ailing cities to avoid the "low-education" trap.

35. Welch (1970).

Appendix A: Data Appendix

Table A-1. Variables and Sources

Variable	*Source*	*Details*
Share of persons 25 or older with a bachelor's degree	HUD State of the Cities Data System (Census)	
Population	HUD State of the Cities Data System (Census)	
Average heating degree days (1961–90)	County and City Data Books, 1994	We match MSAs to the corresponding major city
Average precipitation (1961–90)	County and City Data Books, 1994	We match MSAs to the corresponding major city
Share of workers in manufacturing	HUD State of the Cities Data System (Census)	Employment in manufacturing over total employment
Share of workers in professional services	HUD State of the Cities Data System (Census)	Employment in professional services over total employment
Share of workers in trade	HUD State of the Cities Data System (Census)	Employment in trade over total employment
Unemployment rate	HUD State of the Cities Data System (Census)	Unemployment over labor force
Share of persons 25 or older with less than high school degree	HUD State of the Cities Data System (Census)	
Colleges per capita in 1940	*Peterson's College Guide* (and Census)	*Peterson's* provides foundation dates for all colleges in the United States. We use the foundation date to ascertain if a college was founded before 1940. We match the college zip code with the pertinent county, and then assign counties to MSA using 1999 MSA/NECMA definitions. We have used the Department of Education IPEDS dataset for 1969–99 and confirmed that attrition bias is not an issue: colleges do not seem to disappear from the IPEDS sample at a faster rate in stagnating metro areas.

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Table A-1. Variables and Sources (continued)

Variable	*Source*	*Details*
Family income	HUD State of the Cities Data System (Census)	
Median house value	HUD State of the Cities Data System (Census)	
Wages	Bureau of Economic Analysis	Average wage and salary disbursements per worker
Manufacturing wages	Bureau of Labor Statistics	Average hourly earnings in the manufacturing industry
IPUMS wages	IPUMS (Census)	
IPUMS house values	IPUMS (Census)	
Adjusted IPUMS wages	IPUMS (Census)	Obtained as the MSA fixed effects of independent cross-sectional regressions where we control for age, age squared, education dummies, sex, race, Hispanic ethnicity, marital status, and veteran status
ACCRA Price index	American Chamber of Commerce Research Analysis Data	A cross section of relative prices for 1970, 1980 (about 36 observations) and 1990 and 2000 (about 210 observations)
CPI-U	Bureau of Labor Statistics	Consumer Price Index - Urban
College enrollment in 1970	IPED/HEGIS database (NCES)	HEGIS/IPEDS offers enrollment for each institution of higher education. We match zip code to counties and add up enrollments for all institutions in a metro area.
Murders per 1,000 population	National Archive of Criminal Justice Data	Originally from FBI. By county, we generate data by MSA.
Teacher/pupil ratio	NCES Common Core of Data	The data are for 1990. We locate the county of each school and aggregate the number of pupils and teachers by county. Then we aggregate the county data to MSA.
Museums	County Business Patterns (1980, 1990)	

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Table A-1. Variables and Sources (continued)

Variable	*Source*	*Details*
Eating and drinking establishments per capita	County Business Patterns (1980, 1990)	
Motion picture establishments per capita	County Business Patterns (1980, 1990)	
Health establishments per capita	County Business Patterns (1980, 1990)	
Amusement and recreational service establishments	County Business Patterns (1980, 1990)	
Membership organizations	County Business Patterns (1980, 1990)	
Patents per worker	U.S. Patent and Trademark Office	Data on patents by county were generously provided by Robert Hunt. We aggregated at MSA level.

Note*:* MSA data are for metropolitan areas as defined by the Office of Management and Budget in 1999. We use the county MSA/NECMA definition. In most cases we need to aggregate data by county to obtain the appropriate MSA data. City data are from the Department of Housing and Urban Development State of the Cities Data System. We select those cities with population greater than 30,000 in 1970, the initial year for which the data are available.

Table A-2. Descriptive Statistics for the Main Variables

	1970		*1980*		*1990*		*2000*	
	Mean	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*
Metropolitan statistical area (N = 318)								
Log population – log population at t-10	n.a	n.a	0.17	0.15	0.10	0.13	0.12	0.10
Share with bachelor's degree (age 25+)	0.11	0.04	0.16	0.05	0.20	0.06	0.24	0.07
Population	504,782	970,639	560,354	981,159	626,707	1,073,780	712,948	1,197,389
Average heating degree days (1961–90)	4,453.08	2,192.30	4,453.08	2,192.30	4,453.08	2,192.30	4,453.08	2,192.30
Average annual precipitation (1961–90)	36.67	13.89	36.67	13.89	36.67	13.89	36.67	13.89
Share of workers in manufacturing	0.23	0.11	0.21	0.09	0.17	0.07	0.14	0.07
Share of workers in professional services	0.19	0.06	0.21	0.05	0.24	0.05	n.a	n.a
Share of workers in trade	0.21	0.03	0.21	0.02	0.22	0.02	0.16	0.02
Unemployment rate	0.04	0.01	0.06	0.02	0.06	0.02	0.06	0.02
Share of high school dropouts (age 25+)	0.46	0.09	0.32	0.08	0.24	0.07	0.18	0.06
Colleges per 1,000 people in 1940	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
Home value	16,022	4,189	47,255	15,616	79,504	45,484	115,785	53,119
Median family income	9,170	1,480	19,585	2,807	34,153	6,101	48,929	8,360
Cities (N = 723)								
Log population – log population at t-10	n.a	n.a	0.03	0.19	0.05	0.14	0.06	0.13
Share with bachelor's degree (age 25+)	0.13	0.08	0.18	0.10	0.22	0.12	0.26	0.14
Population	118,794	363,363	119,624	334,524	127,120	348,124	138,225	378,873
Average heating degree days (1961–90)	4,460.59	2,123.92	4,460.59	2,123.92	4,460.59	2,123.92	4,460.59	2,123.92
Average annual precipitation (1961–90)	35.00	12.80	35.00	12.80	35.00	12.80	35.00	12.80
Share of workers in manufacturing	0.26	0.12	0.23	0.10	0.17	0.08	0.14	0.07
Share of workers in professional services	0.19	0.07	0.22	0.07	0.25	0.07	n.a	n.a
Share of workers in trade	0.21	0.04	0.21	0.03	0.22	0.03	0.15	0.02
Unemployment rate	0.04	0.02	0.06	0.03	0.07	0.03	0.07	0.03
Share of high school dropouts (age 25+)	0.43	0.13	0.31	0.12	0.24	0.10	0.20	0.10
Colleges per 1,000 people in 1940	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Home value	19,569	7,008	54,847	26,139	113,982	81,750	146,108	103,341
Median family income	10,529	2,299	20,964	4,954	37,382	11,299	50,909	16,288

n.a. Not available.

Table A-3. Further Robustness Tests

	Δlog(population)		
	(1)	*(2)*	*(3)*
Share with bachelor's degree (age 25+) at t-10		0.686 (0.134)***	0.505 (0.166)***
Log of population at t-10	–0.003 –0.004	–0.019 (0.004)***	–0.014 (0.008)*
Log average heating degree days (1961–90)	–0.078 (0.011)***	–0.09 (0.011)***	–0.123 (0.013)***
Log average annual precipitation (1961–90)	–0.02 –0.015	–0.033 (0.015)**	–0.056 (0.016)***
Share of workers in manufacturing at t-10	–0.31 (0.086)***	–0.11 –0.09	–0.349 (0.103)***
Share of workers in professional services at t-10	–0.433 (0.196)**	–0.442 (0.144)***	–0.299 (0.185)
Share of workers in trade at t-10	–0.187 –0.237	–0.005 –0.257	–0.428 (0.302)
College enrollment/population in 1970	0.477 (0.126)***		
Museums			0.000 (0.001)
Eating and drinking establishments per capita			–1.316 (18.143)
Motion picture establishments per capita			64.137 (187.538)
Health establishments per capita			–9.404 (16.920)
Membership organizations			0.000 (0.000)
Amusement and recreational service establishments			0.000 (0.000)
Teacher/pupil ratio			–0.504 (0.298)*
Murders per 100 inhabitants			–3.822 (1.064)***
Year fixed effects	Yes	Yes	Yes
Lagged age distribution	No	Yes	No
Observations	909	915	550
R squared	0.51	0.6	0.57

Note: Robust standard errors in parentheses.
*Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

Appendix B: The Framework

We assume that there are a large number of cities, and we consider the equilibrium of a single city, denoted "*j*." There are two types of workers, high skill and low skill, who receive different wages in the city denoted W_j^H and W_j^L. Utility is Cobb-Douglas over a traded good, a nontraded good, and over a place-specific commodity, and as such consumers choose the consumption of the non-traded good (denoted Q) to maximize $C_j(W_j^i - P_j^Q Q)^{1-\gamma} Q^{\gamma}$, where P_j^Q is the price of that good in city j, and C_j is a city-specific consumer amenity level. Optimization yields $P_j^Q Q = \gamma W_j$. We assume a fixed supply of the nontraded good in city "*j*," which is denoted $\bar{Q}_j$. If we let N_j denote total city population and $\hat{W}_j$ denote the average wage, then total utility for each person equals $(1 - \gamma)^{1-\gamma} C_j W_j^i (\bar{Q}_j / N_j \hat{W}_j)^{\gamma}$, which must equal $\underline{U}_i$, the reservation utility for each group H and L. This implies that the ratio of wages in every city equals the ratio of reservation utilities, or $W_j^H / W_j^L = \underline{U}_H / \underline{U}_L$.

We assume a Cobb-Douglas production function that uses capital (denoted K), effective labor units (denoted L and defined later), and a city-specific production input (which is meant to represent commercial land or access to waterways and is denoted F). Total output is $A_j K^{\alpha} L^{\beta} F^{1-\alpha-\beta}$, where A_j is a city-specific productivity factor. Capital is available at a national price of r, but there is only a fixed amount, F_j, of the city-specific input. To allow for multiple skill categories, we assume that a unit of effective labor is produced through a constant elasticity of substitution technology that uses both high- and low-skilled workers, i.e. $L = (\theta_j^{1-\sigma} L_H^{\sigma} + L_L^{\sigma})^{1/\sigma}$, where θ_j is a city-specific parameter increasing the relative returns to skilled workers, and L_H, L_L reflect the number of high- and low-skilled workers respectively. Cost minimization implies

$$\frac{L_H}{L_L} = \theta_j \left(\frac{W_j^L}{W_j^H} \right)^{\frac{1}{1-\sigma}} = \theta_j \phi^{\frac{-1}{1-\sigma}},$$

where $\phi = \underline{U}_H / \underline{U}_L$ so the skill composition of the city is determined by the parameter θ_j. Manipulation of the first-order conditions and using the notation $\eta = 1 - \alpha - \beta + \gamma\beta$ implies:

$$\text{(A1)} \qquad N_j = A_j^{\frac{1-\gamma}{\eta}} F_j^{\frac{(\eta-\gamma\beta)(1-\gamma)}{\eta}} C_j^{\frac{1-\alpha}{\eta}} \bar{Q}_j^{\frac{\gamma(1-\alpha)}{\eta}} \Theta_j^N \Omega_N ,$$

$$\text{(A2)} \qquad \hat{W}_j = A_j^{\frac{\gamma}{\eta}} F_j^{\frac{(\eta-\gamma\beta)\gamma}{\eta}} C_j^{\frac{\alpha+\beta-1}{\eta}} \overline{Q}_j^{\frac{-\gamma(1-\alpha-\beta)}{\eta}} \Theta_j^W \Omega_W ,$$

and

$$\text{(A3)} \qquad P_j^Q = A_j^{\frac{1}{\eta}} F_j^{\frac{1-\alpha-\beta}{\eta}} C_j^{\frac{\beta}{\eta}} \overline{Q}_j^{\frac{-(1-\alpha-\beta)}{\eta}} \Theta_j^Q \Omega_Q ,$$

where Θ_j^i for $i = N, W, Q$ refers to city-specific terms that are only a function of θ_j and ϕ, and where Ω_i for $i = N, W, Q$ refers to terms that are common across cities, including the reservation utilities, rent level, and the parameters α, β, γ and σ. The values of Θ_N^i and Ω_N are

$$\Theta_j^N = \left(\phi^{\frac{1}{1-\sigma}} + \theta_j\right)\left(\phi^{\frac{\sigma}{1-\sigma}} + \theta_j\right)^{\frac{-\sigma(1-\alpha)+\beta(1-\gamma)}{\sigma\eta}}$$

and

$$\Omega_N = \left(\underline{U}_H^{\alpha-1}\left((1-\gamma)\beta\right)^{(1-\gamma)(1-\alpha)}\left(\frac{\alpha}{r}\right)^{\alpha(1-\gamma)}\right)^{\frac{1}{\eta}} .$$

To manipulate these equations, we will assume that, within a city, the production and consumption amenities are changing over time, that all other city-specific factors are fixed, and that while reservation utilities are changing, the ratio $\underline{U}_H/\underline{U}_L$ is fixed. If we assume that $\log(A_{j,t+1}/A_{j,t}) = \Sigma_k \delta_A^k X_{j,t}^k + \varepsilon_{j,t}^A$ and $\log(C_{j,t+1}/C_{j,t}) = \Sigma_k \delta_C^k X_{j,t}^k + \varepsilon_{j,t}^C$, where $X_{j,t}^k$ are city-specific characteristics as of time t, which include the skill composition of the city, then it follows that:

$$\text{(A1}'\text{)} \qquad Log\left(\frac{N_{j,t+1}}{N_{j,t}}\right) = I^N + \sum_k \left(\delta_A^k \frac{1-\gamma}{\eta} + \delta_C^k \frac{1-\alpha}{\eta}\right) X_{j,t}^k + \mu_{j,t}^N$$

$$\text{(A2}'\text{)} \qquad Log\left(\frac{\hat{W}_{j,t+1}}{\hat{W}_{j,t}}\right) = I^W + \sum_k \left(\delta_A^k \frac{\gamma}{\eta} - \delta_C^k \frac{1-\alpha-\beta}{\eta}\right) X_{j,t}^k + \mu_{j,t}^W$$

$$\text{(A3}'\text{)} \qquad Log\left(\frac{P^{Q}_{j,t+1}}{P^{Q}_{j,t}}\right) = I^{Q} + \sum_{k}\left(\delta^{k}_{A}\frac{1}{\eta} + \delta^{k}_{C}\frac{\beta}{\eta}\right)X^{k}_{j,t} + \mu^{Q}_{j,t},$$

where I^i for $i = N, W, Q$ is an intercept term that is constant across cities, and $\mu^i_{j,t}$ again for $i = N, W, Q$ is an error term, which has a zero mean and is orthogonal to the X terms as long as the underlying error terms, $\mu^i_{j,t}$, are mean zero and orthogonal to the X terms.

As such, $\beta_A = \delta^k_A[(1 - \gamma)/\eta]$, $\beta_C = \delta^k_C[(1 - \alpha)/\eta]$, $\kappa_A = [\gamma/(1 - \gamma)]$ and $\kappa_C = [\beta/(1 - \alpha)]$.

Comments

Gary Burtless: Edward Glaeser and Albert Saiz have written a lucid, stimulating, and convincing paper. Readers like me who know little about the correlates of metropolitan-area growth will learn a great deal about this fascinating subject. Clearly, my ignorance of the broader literature places me at a disadvantage in assessing how many of the empirical findings represent new knowledge to specialists in the field. But my guess is that many economists who are not specialists in regional economics will be intrigued and largely persuaded by the results.

In looking at U.S. metropolitan area growth during the past three decades, Glaeser and Saiz find that areas with large initial concentrations of college-educated adults have experienced above-average population growth, outsized increases in home prices, and exceptional growth in family incomes.

When they examine population growth more closely, they find that the beneficial impact of college graduates is not uniform across the country. Instead, it is concentrated in parts of the United States with cold winters. In other words, the benefits of college graduates seem to be focused on regions in relative decline. This follows from the fact that the U.S. population is gravitating toward places with warm winters and limited rainfall. In those parts of the country with comfortable winters and low rainfall, heavy concentrations of college-educated workers provide less of an advantage for population growth.

The authors are persuaded that their finding of a beneficial overall impact of college-degree holders on growth is truly causal. They find that metropolitan areas grew faster in the past thirty years if they had a high concentration of colleges as far back as 1940, a year that long predates the era they are studying. Since a concentration of colleges in the prewar era is a good predictor of a concentration of college-degree-holding adults in the more recent period, it seems likely that college concentrations predict growth rather than vice versa.

Glaeser and Saiz pose a question about their basic findings. Do the beneficial impacts of college-degree holders on growth spring from the fact that such concentrations boost average productivity growth? Or are they because such concentrations improve metropolitan-area amenities and hence make certain areas more attractive destinations for migration? The authors argue that the beneficial impacts are from effects on productivity rather than improved amenities, at least at the metropolitan-area level. In view of their evidence, this conclusion seems reasonable.

Finally, the authors offer a conjecture that areas with heavy concentrations of college graduates are more successful than other areas in responding to economic challenges that can lead to urban decline. Perhaps the local availability of workers with advanced skills allows areas faced with decline to attract or develop new industries or reorient old ones so the area can continue to prosper.

To someone unfamiliar with the subject, one of the biggest surprises in the paper is almost independent of its main message about the importance of human capital. I was struck by the importance of winter temperatures and annual rainfall in accounting for recent trends in urban rise and decline. Although the authors treat these findings as though they are well known to readers, I was not aware climate amenities are so critical to regional population growth, home prices, and average incomes. Like any other casual empiricist I recognize that American cities in the Northeast and Midwest have grown more slowly or shrunk in comparison with cities in the South and Southwest. But many differences besides winter temperatures and rainfall might account for the variation in growth rates.

My impression is that cities in the Northeast and Midwest are located in high-tax, high-regulation jurisdictions. Labor laws in those states are more likely to allow unions to compel workers to pay union dues and contribute to union strike funds. Obviously this strengthens union negotiating power compared with the situation in southeastern and western states, where right-to-work laws mean unions cannot force workers to contribute to union operations.

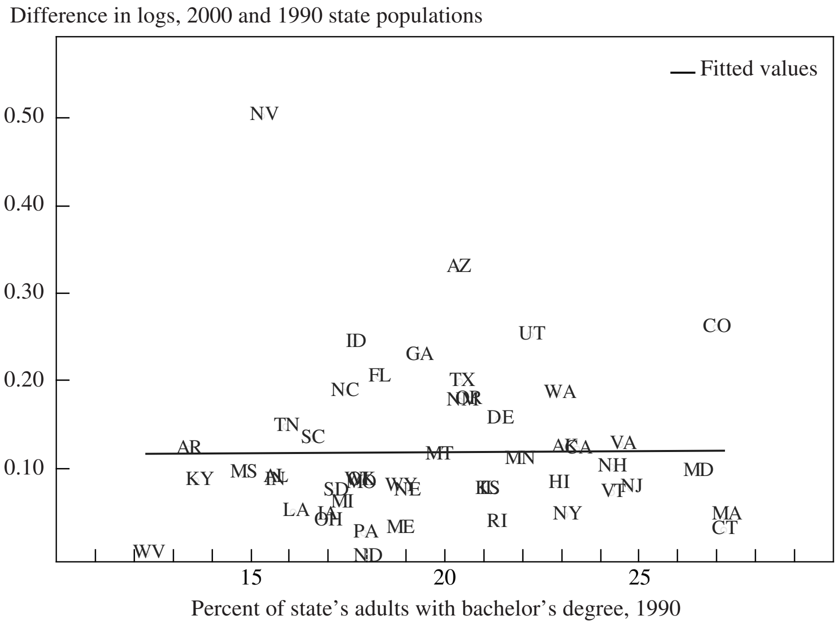
Labor economists probably do not understand all the determinants of plant location, but many of them have the impression that the tax laws and labor regulation in the northeastern and midwestern states are less attractive to firms than regimes in the South and West, which often impose light tax and regulatory burdens on employers. To be sure, state regulatory and tax regimes have some relationship with winter temperatures and annual rainfall. But it seems doubtful that high summer temperatures cause legislators to vote for low taxes, limited regulation, poor unemployment benefits, paltry worker compensation, and modest minimum wages. The association seems statistical rather than causal.

Here is another surprise. Glaeser and Saiz consistently find that high concentrations of college graduates are beneficial for growth of metropolitan areas, increases in home prices, and growth of family income. But they do not find this same consistent pattern for the effects of warm winter temperatures and low rainfall. Warm winters have a significantly positive impact on population growth and house prices but essentially no impact on income growth. Low rainfall tends to boost population growth, but it depresses house prices and growth of family income.

This seems odd. If warm winters and low rainfall are amenities that attract Americans from places with cold winters, why is it that these two amenities have opposite effects on house prices and very different effects on family income growth? Some readers may wonder whether a model placing such heavy emphasis on the influence of climate amenities on population growth might have some limitations. If low rainfall boosts house prices, it seems logical to predict warm winter temperatures do the same thing. Both amenities attract people to a region, but the findings in this paper imply they do not have the same effect on house prices.

These reflections on the impact of temperature and rainfall on metropolitan-area growth make me wonder whether the authors' findings would be duplicated if we examine growth across larger jurisdictions than metropolitan areas. Can we find the same effect of college-degree holders on state population growth as for metropolitan-area growth? At least during the period from 1990 through 2000 the answer is no. Figure 6 shows the simple correlation between states' 1990-2000 population growth and concentrations of college graduates in 1990. States with high concentrations of college graduates grew no faster than states with low concentrations of graduates.

Figure 6. State Population Growth and Human Capital, 1990–2000



Note: Fitted line from the regression: log(pop2000/pop1990) = 0.12556 + 0.00002 × share with bachelor's degree in 1990. R squared: 0.00000, N: 51.

This pattern is broadly repeated in geographical areas larger than states. The Census Bureau divides the United States into four main geographic regions. In 1990 the Northeast had the highest regional concentration of college graduates, but it also had the slowest regional population growth in the ensuing ten years. This pattern is not new. The Northeast also had the slowest regional population growth in the forty years after 1960. In contrast, during the 1990–2000 decade the South grew three times faster than the college-graduate-rich Northeast, and it grew more than four times faster in the forty years after 1960. This is pretty good performance for the geographical region that has the smallest endowment of highly educated, human-capital-rich workers.

Results in this paper suggest that population growth has been fastest in the areas *within* states and regions that are richest in human capital. These results depend, however, on statistically controlling for the influence of region, mean winter temperature, and annual rainfall when determining the impact of college-degree holders on metropolitan growth. The statistical estimates imply that warm winter temperature and low rainfall are external amenities that are attractive to folks in all educational groups—amenities that irresistibly draw populations toward the South and West.

Another interpretation is that voters in the Northeast and Midwest have devised tax, government transfer, and regulatory policies that increase employer costs and push employers toward places where burdens are lighter. As it happens, those destinations also have warmer winters or less rainfall. But whether it is the government institutions that are pushing firms and workers out of the Northeast and Midwest or warm sunny skies that are drawing folks to the South and West—well, that is a question not settled in this paper.

It may be hard for readers to understand why the beneficial impacts of college graduates at the metropolitan level do not translate into similar benefits at the state and regional level. Why don't concentrations of college graduates in a state or region confer the same benefits that flow to metropolitan areas? One reason may be that concentrations at the urban level matter more than concentrations at the state or regional level. But it is not a straightforward case. The Northeast is the region with the most abundant supply of highly educated workers. It is also the region that has seen the smallest rise in population during the past ten years and forty years.

We are left with the puzzle that the region of the country with the highest concentration of college graduates has grown slowly while a region with an exceptionally small concentration of educated workers has grown much faster. "Holding constant" winter temperatures and rainfall, the puzzle may disappear. But can we really be sure that winter temperature and rainfall are reliable indicators of desirable urban amenities? Or is it possible these variables are proxies for other aspects of the social and legal environment that help create attractive business locations for employers? If the second explanation rather than the first is correct, then we should rethink the ways that endowments of human capital contribute to metropolitan growth. After all, that endowment also influences the social and policy environment in a way that makes some locations attractive and others unattractive to employers.

William C. Strange: The chapter by Edward L. Glaeser and Albert Saiz addresses a fundamental issue in urban economics: the role of human capital in the urban growth process. Several interesting conclusions are reached. First, the chapter shows that there is a large and robust correlation between population growth in metropolitan statistical areas (MSA) and human capital. This result has been obtained elsewhere, so IT is not the chapter's primary contribution.[36] Second, the chapter shows that there is a larger positive effect of skills on wages than on housing prices. This result is new. It is important because it suggests that at the metropolitan level the skills-growth relationship captures productivity effects rather than amenities. Third, the chapter establishes that a somewhat different pattern exists at the city level (rather than MSA), with low-skill workers having the most pronounced effect on growth. This effect is negative, which means that at the microlevel, the absence of local human capital is a disamenity. These results all speak to the way that cities are now about brains rather than brawn and about human capital rather than factories.

The chapter reaches a fourth conclusion, that declining metropolitan areas drive the MSA effects. This result appears first in a spline regression showing that the marginal effect of human capital on growth is larger in MSAs that are losing population than in those that are growing. The result reappears in a model that uses heating degree days to proxy for decline. As is well known, cold cities have declined since World War II, relatively at least, while warm cities have thrived. Glaeser and Saiz find that in cold cities, the effect of human capital is larger at the margin than in warm cities. This result helps us understand why some cold cities have fared better than others during this period. I focus my discussion on this point.

As Glaeser and Saiz observe, the increase in the importance of human capital in declining cities is consistent with Jacobs's analysis of how successful cities reinvent themselves.[37] This is different than the idea that cities are more innovative. Glaeser and Saiz test this "Information City" idea by looking at the determinants of patenting. As might be expected, they find patenting to be correlated with human capital. However, they do not find that controlling for patenting explains the relationship between human capital and growth. Thus the evidence is consistent with

36. Rauch (1993).
37. Jacobs (1969).

reinvention of the sort that Glaeser finds in looking at the history of Boston.[38]

In considering this reinvention, it is best to begin by letting Jacobs speak for herself:

> The process by which one sort of work leads to another must have happened millions of times in the whole history of human development. Every newspaper reports it. From only a few days gleanings in the women's pages, one learns that a cleaner of suede clothing is now starting to bottle and sell her cleaning fluid for people who want to clean their own suede; a chest and wardrobe manufacturer is starting, for a fee, to analyze what is wrong with one's household or office storage arrangements; a playground designer is starting to make and sell equipment for playgrounds and nursery schools; a sculptor is starting a line of costume jewelry; a designer of theater costumes is launching himself as a couturier; a couturier is starting a boutique; an importer of Italian marble is starting to manufacture marble-top tables; a clothing store is starting classes in teen-age grooming and dieting.[39]

This analysis has several key elements. The first is urban reinvention, the idea that successful cities are those where new products and processes are created from established production processes. Jacobs calls this "new work." The second key element is that there are many pieces to the new-work dynamic. These include both endowments and attitudes. Among the most obvious endowments required to create an environment that is friendly to new work is the presence of venture capital. The availability of specialized labor is also implicit in these stories. In regard to attitudes, clearly Jacobs recognizes the importance of an entrepreneurial mindset. The final element in her analysis is one that plays a central role in all of her writings: diversity.

It is interesting to consider how Jacobs's verbal analysis and the systematic econometric work of Glaeser and Saiz might be captured in a simple economic model. One way would be to use a matching model (adapted from Helsley and Strange).[40] Suppose that a city has resources, denoted by addresses $x_i \in [0,1]$, the unit circle. Suppose also that opportunities present themselves, also denoted by addresses $y_j \in [0,1]$, again the unit circle. An opportunity is realized only if it is in some sense "close" to the city's resources: $|x_i - y_j| < d^*$. In this simple model, a city's

38. Glaeser (2003).
39. Jacobs (1969, pp. 53–54).
40. Helsley and Strange (2002).

ability to reinvent itself depends on whether it can realize the opportunities that present themselves.

What are the implications of this simple model for estimating the human capital–urban growth relationship? As just stated, the realization of an opportunity depends on whether there exist resources within some distance on the unit circle (as in Helsley-Strange). This is more likely the more spread out are the resources. This captures the importance of diversity, but diversity is not the only part of the story. This critical "realization distance" d^* might also depend on the amount of an MSA's resources of a particular kind, a different sort of effect. The human capital results obtained by Glaeser and Saiz seem to be in this spirit. Smart cities allow opportunities to be realized that would be missed elsewhere. The realization distance might also depend on the entrepreneurial nature of the local business environment or the nature of the local venture capital sector.

This suggests possible extensions of the chapter's intriguing treatment of the human capital–urban growth relationship. The first of these concerns diversity. There is already strong evidence of a diversity-growth relationship.[41] The IPUMs data used in the chapter are amenable to considering the impact on growth of the allocation of skilled workers across sectors. For instance, one might look at the correlation between the Herfindahl-Hirschman index across industries of skilled labor and growth.

The second possible extension concerns entrepreneurship and the local business environment. There are many aspects of the MSA environment that influence the creation of new work. Some of these surely relate to specific kinds of human capital. I discuss one with which I am familiar (and with which I must in honesty admit an interest): management education. There is evidence that this kind of human capital has a different effect than does human capital in general.[42] The U.S.-Canadian productivity gap is large, roughly 25 percent. Among all types of education, the largest difference is in management education, where the U.S. investment is roughly twice as large. Glaeser and Saiz suggest a way that this relationship could be explored further, by looking at relationships between specific kinds of education and growth.

41. Glaeser and others (1992); Rosenthal and Strange (2003a).
42. Institute for Competitiveness and Prosperity (2002).

The third possible extension concerns attitudes. The idea that some cities are more creative than others is present in the work of many authors, including Jacobs. This chapter's finding that cold cities have more reinvention parallels work on European history concerned with why the industrial revolution took place earlier in the colder North. One famous explanation is that the work ethic was different in the North.[43] It is not farfetched to think that there might be differences in attitudes toward work between the warmer and colder parts of the United States. It may be that these attitudes are complementary to human capital, a finding consistent with work on urban labor supply by Rosenthal and Strange.[44]

43. Weber (1958).
44. Rosenthal and Strange (2003b).

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