Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital

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Abstract

From 1940 to 1990, a 10 percent increase in a metropolitan area's concentration of college-educated residents was associated with a .8 percent increase in subsequent employment growth. Instrumental variables estimates support a causal relationship between college graduates and employment growth, but show no evidence of an effect of high school graduates. Using data on growth in wages, rents and house values, I calibrate a neoclassical city growth model and find that roughly 60 percent of the employment growth effect of college graduates is due to enhanced productivity growth, the rest being caused by growth in the quality of life. This finding contrasts with the common argument that human capital generates employment growth in urban areas solely through changes in productivity.

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From 1940 to 1990, a 10 percent increase in a metropolitan area's concentration of human capital was associated with a .8 percent increase in the area's employment growth. A substantial body of literature confirms this correlation between human capital and local area employment (or population) growth.[1] Little is known, however, about the underlying causes of this relationship.

As I show more formally in the next section, there are essentially three possible explanations for the relationship between human capital and city employment growth. The first is omitted variable bias: some feature or features of an area that are correlated with both human capital and employment growth have been left out of the regression. Although past research has tended to find that including broad sets of controls does not eliminate the positive correlation between population or employment growth and human capital (Glaeser, Scheinkman and Shleifer, 1995; Glaeser and Shapiro, 2003), concerns remain about the causal interpretation of this association.[2]

The next hypothesis is that a highly educated population generates greater local productivity growth, perhaps through knowledge spillovers (Lucas, 1988) or pecuniary externalities arising from job search (Acemoglu, 1996).[3] A number of researchers have adopted this explanation (see, for example, Simon and Nardinelli, 2002), and it has received some support from the work of Rauch (1993) and Moretti (2003), who show that, conditional on observable worker characteristics, wages are higher in high human capital cities. In contrast, however, Acemoglu and Angrist (2000) find, using an instrumental variables approach, that the external effects of human capital at the state level are relatively small.[4]

The final explanation is that areas with more educated populations experience more rapid growth in the quality of life. This might occur because more educated individuals spur the growth of consumption amenities in cities in which they reside,

[1] See, for example, Glaeser, Scheinkman and Shleifer (1995); Simon (1998); Simon and Nardinelli (2002); Simon (2002); and Glaeser and Shapiro (2003).

[2] For example, residents with high human capital may seek out areas in which quality of life is rising, leading to a simultaneity bias. See, e.g., Kahn (2000) and Cullen and Levitt (1999).

[3] Black and Henderson (1999) develop a model of endogenous urban growth that embeds local effects of human capital accumulation.

[4] Lange and Topel (forthcoming) review the existing literature on the social returns to human capital.

or because their influence on the political process leads to desirable outcomes such as reductions in crime and pollution.

In this paper, I attempt to distinguish among these three explanations of the positive relationship between human capital and local area employment growth. To address the omitted variables issue, I instrument for an area's human capital concentration using the presence of land-grant institutions (Moretti, 2004) and compulsory schooling laws (Acemoglu and Angrist, 2000). To separate the remaining explanations, I develop and calibrate a simple neoclassical growth model using data on growth in wages and rents to determine what share of the overall employment growth effect of human capital is due to productivity growth, and what share is due to improvements in the quality of life.

Instrumental variables estimates support the presence of a causal effect of concentrations of college graduates on employment growth, but show no evidence of a similar effect for high school graduates. Though not conclusive, these results serve to lessen concerns about omitted variables and especially reverse causality. To separate the influences of productivity and quality of life, I use Census data from 1940 through 1990 to show that metropolitan areas richer in skilled residents tend to experience faster growth in (hedonically adjusted) wages, rental prices, and house values, with the effect on rents and house values much larger than the effect on wages. A calibration of a simple city growth model based on this evidence suggests that roughly 60 percent of the effect of college graduates on employment growth is due to productivity; the rest comes from the relationship between concentrations of skill and growth in the quality of life. This conclusion is robust to a number of alternative specifications, including direct controls for important determinants of area growth, and allowance for key model parameters to vary with the human capital distribution.

I also test for a connection between human capital and several direct measures of quality of life. Though preliminary, this exercise suggests the effect may be operating through the expansion of consumer amenities such as bars and restaurants (Glaeser, Kolko and Saiz, 2001) rather than through the political process.

The organization of the paper is as follows. Section 1 presents a simple model of city growth and illustrates the three possible explanations for the relationship between human capital and metropolitan area employment growth. Section 2 describes the Census data I use to conduct the estimation, as well as the land-grant and compulsory-schooling instruments. Section 3 presents ordinary least squares and instrumental variables estimates of the relationship between human capital and growth in employment, wages, and housing costs, and provides a calibration of the model in section 1. Section 4 relates human capital to more direct measures of the change in quality of life, and section 5 concludes.

1 Estimating framework

In this section I develop a simple neoclassical model of city growth, and use it to illustrate three hypotheses about the correlation between growth and human capital. The model is based on Roback's (1982) formulation, which has been used extensively to generate city-level rankings of quality of life and to infer the value to consumers and firms of various local public goods or city characteristics.[5] Most studies have exploited the cross-sectional implications of the Roback model; here I will place the model in a more dynamic context.[6]

Before presenting the formal model, it will be helpful to discuss the intuition behind it. Consider a world of identical firms and households choosing among a set of locations. Each location is endowed with a productive amenity (which enters the production function) and a consumption amenity (which enters the utility function). Suppose that households consume only land and a traded good and that firms use only labor as an input. Let us first consider equilibrium in production, which requires that all firms be indifferent between locations. In equilibrium, wages must be higher in more productive locations, because otherwise firms would move into those locations and bid up the price of labor. In order for households to be indifferent between

[5]See, for example, Blomquist, Berger and Hoehn (1988); Gyourko and Tracy (1991); Cragg and Kahn (1997); and Black (1999).

[6]Roback's model's implications for growth have been addressed before. For example, Glaeser, Scheinkman and Shleifer (1995) use a parametric example of the more general model to make inferences about the causes of city growth.

more and less productive locations, land prices must be higher in more productive places because wages will be higher in those locations. Land prices must also capitalize consumption amenities; that is, land will be more expensive in more pleasant locations.

These equilibrium conditions hold equally well in a dynamic context. If a city experiences relative growth in its productivity, then it should experience growth in both wages and land prices; if it experiences growth in quality of life, this will tend to be reflected in land price growth. In a more general model in which firms use land as an input to production, these equilibrium conditions must be modified somewhat, but it remains possible to identify changes in productive and consumption amenities using data on wages and land prices in a set of locations.

To see these results formally, consider an economy with a set of locations $i \in \{1, 2, ..., I\}$, each endowed with location specific productivity and quality of life, denoted A_i and Q_i, respectively. Firms produce a homogeneous good sold on a world market at the numeraire price of 1 using a constant returns to scale production function $Y = AF\left(L, R^f\right)$, where L denotes the quantity of labor and R^f the quantity of land used in production. Input markets are competitive, and firms face a constant per-unit marginal cost given by the function $\frac{C(W_i,P_i)}{A_i}$, where W_i and P_i are the prices of labor and land in location i. Spatial equilibrium requires that this marginal cost be equal to unity at all locations, so that our first equilibrium condition is given by

$$C\left(W_i, P_i\right) = A_i \tag{1}$$

for all i.

Consumers have preferences given by $U = U\left(Q, X, R^c\right)$, where X is the quantity of goods consumed and R^c is the quantity of land consumed. This utility function implies an indirect utility function $V\left(Q_i, W_i, P_i\right)$ which, in equilibrium, must be constant across locations. Our second condition is therefore

$$V\left(Q_i, W_i, P_i\right) = \overline{U} \tag{2}$$

for all i and some constant $\bar{U}$. To close the model, I will suppose that $P_i = f\left(L_i\right)$, with $f'\left(\cdot\right) > 0$, i.e., that there is an increasing supply price of housing.

Allow A_i and Q_i to change exogenously over time. We can totally differentiate equilibrium conditions (1) and (2) as follows:

$$\begin{aligned} C_W \frac{dW_i}{dt} + C_P \frac{dP_i}{dt} &= \frac{dA_i}{dt} \\ V_Q \frac{dQ_i}{dt} + V_W \frac{dW_i}{dt} + V_P \frac{dP_i}{dt} &= \frac{d\overline{U}}{dt}. \end{aligned} \tag{3}$$

Let k_R and k_L be the shares of land and labor in the firm's cost function, let s_R be the share of land in the household's budget, and let lowercase letters denote natural logarithms of variables. I will normalize $\frac{d\overline{U}}{dt} = 0$. Then we can rearrange the above conditions to yield expressions for the changes in wages and land rents:

$$\begin{aligned} \frac{dp_i}{dt} &= \frac{1}{\frac{k_R}{k_L} + s_R} \left(\frac{V_Q Q}{V_W W} \frac{dq_i}{dt} + \frac{1}{k_L} \frac{da_i}{dt} \right) \\ \frac{dw_i}{dt} &= \frac{1}{k_L} \frac{s_R}{\frac{k_R}{k_L} + s_R} \frac{da_i}{dt} - \frac{\frac{k_R}{k_L}}{\frac{k_R}{k_L} + s_R} \frac{V_Q Q}{V_W W} \frac{dq_i}{dt}. \end{aligned} \tag{4}$$

Additionally, given the assumed supply curve of land, letting σ be the elasticity of land rents with respect to local employment, employment growth can be written as

$$\frac{dl_i}{dt} = \frac{1}{\sigma} \frac{1}{\frac{k_R}{k_L} + s_R} \left(\frac{V_Q Q}{V_W W} \frac{dq_i}{dt} + \frac{1}{k_L} \frac{da_i}{dt} \right). \tag{5}$$

These conditions must hold for all cities i.

Changes in land rents will capitalize growth in productivity and in the quality of life, scaled by the importance of land in the firm and household budgets. Changes in wages will reflect productivity growth, less a correction to compensate firms for changes in land prices. In the limiting case in which firms use no land in the production process, wage growth will directly capitalize productivity growth. The above equations therefore suggest a framework for evaluating the extent to which quality of life and productivity growth are associated with a given correlate of employment growth.

To see this formally, let $H_{i,t}$ denote the concentration of human capital in city i at time t, and let $X_{i,t}$ be a vector of other city characteristics. Suppose that

$$\begin{aligned} \frac{V_Q Q}{V_W W} \Delta q_{i,t+1} &= H_{i,t}\beta^q + X_{i,t}\gamma^q + \epsilon^q_{i,t+1} \\ \Delta a_{i,t+1} &= H_{i,t}\beta^a + X_{i,t}\gamma^a + \epsilon^a_{i,t+1} \end{aligned} \tag{6}$$

where Δ denotes changes.[7] Suppose further that the shocks ϵ^q and ϵ^a are drawn independently of X and H.[8] Then, by equation (5) above, we have

$$\Delta l_{i,t+1} = \frac{1}{\sigma} \frac{1}{\frac{k_R}{k_L} + s_R} \left(H_{i,t} \left(\beta^q + \frac{1}{k_L} \beta^a \right) + X_{i,t} \left(\gamma^q + \frac{1}{k_L} \gamma^a \right) \right) + \varepsilon^l_{i,t+1} \tag{7}$$

where

$$\varepsilon^l_{i,t+1} = \frac{1}{\sigma} \frac{1}{\frac{k_R}{k_L} + s_R} \left(\epsilon^q_{i,t+1} + \frac{1}{k_L} \epsilon^a_{i,t+1} \right). \tag{8}$$

Suppose that a positive correlation is observed between human capital $H_{i,t}$ and subsequent employment growth $\Delta l_{i,t+1}$. Equation (7) illustrates the three possible explanations for such a correlation:

1. *Omitted variables bias.* A positive relationship between $H_{i,t}$ and $\Delta l_{i,t+1}$ could arise if $H_{i,t}$ is correlated with some omitted component of $X_{i,t}$, and that omitted city characteristic is itself a cause of rapid employment growth. For example, if highly-educated individuals tend to concentrate in cities with better weather, and city growth is affected by the weather, a correlation between human capital and employment growth could arise.

2. *Productivity growth.* If high human capital is associated with more rapid productivity growth, that is, if $\beta^a > 0$, then human capital $H_{i,t}$ will be positively correlated with subsequent employment growth $\Delta l_{i,t+1}$.

3. *Growth in the quality of life.* Suppose that cities with higher concentrations of human capital experience faster growth in the quality of life; that is, suppose that $\beta^q > 0$. Then human capital and employment growth will covary positively.

To address hypothesis (1), I employ an instrumental variables approach using both the presence of land-grant colleges and universities (Moretti, 2004) and compulsory

[7] This specification assumes, of course, that the effects of human capital are linear, which need not be the case. In unreported regressions I find no evidence of nonlinearities in the effect of human capital on employment growth, but I do find evidence of convex effects of human capital on the growth of wages and land rents.

[8] The shocks are not assumed to be identically distributed, however, nor are they assumed to be drawn independently over time or independently of one another. That is, I will allow for the possibility that ε^q and ε^a are heteroskedastic, serially correlated, and correlated with one another.

schooling laws (Acemoglu and Angrist, 2000) To evaluate the relative importance of hypotheses (2) and (3), I directly estimate β^a and β^q, the parameters relating human capital to growth in productivity and quality of life, respectively. Given data (possibly noisy) on changes in land prices and wages for a panel of cities, by (4) we can write

$$\begin{aligned} \Delta p_{i,t+1} &= \frac{1}{\frac{k_R}{k_L} + s_R} \left(\frac{V_Q Q}{V_W W} \Delta q_{i,t+1} + \frac{1}{k_L} \Delta a_{i,t+1} \right) + \mu^p_{i,t+1} \\ \Delta w_{i,t+1} &= \frac{1}{k_L} \frac{s_R}{\frac{k_R}{k_L} + s_R} \Delta a_{i,t+1} - \frac{\frac{k_R}{k_L}}{\frac{k_R}{k_L} + s_R} \frac{V_Q Q}{V_W W} \Delta q_{i,t+1} + \mu^w_{i,t+1} \end{aligned} \tag{9}$$

where μ^p and μ^w are measurement error in price and wage growth, respectively, and are assumed to be independent of Δa and Δq.[9] Rearranging (9) we have:

$$\begin{aligned} k_L \Delta w_{i,t+1} + k_R \Delta p_{i,t+1} &= H_{i,t}\beta^a + X_{i,t}\gamma^a + \epsilon^a_{i,t+1} + k_L \mu^p_{i,t+1} + k_R \mu^w_{i,t+1} \\ s_R \Delta p_{i,t+1} - \Delta w_{i,t+1} &= H_{i,t}\beta^q + X_{i,t}\gamma^q + \epsilon^q_{i,t+1} + s_R \mu^p_{i,t+1} - \mu^w_{i,t+1}. \end{aligned} \tag{10}$$

Given values of k_L, k_R, s_R, it is thus possible to use data on growth in wages and land prices to estimate β^a and β^q, and thus to determine the relative importance of productivity and quality of life in explaining the relationship between human capital and city employment growth.

The advantage of a reduced-form approach such as the one presented above is that it makes possible the use of price measures to estimate the underlying relationship between human capital and growth in productivity and the quality of life. The disadvantage of this approach, however, is that it necessarily suppresses the mechanism underlying the connection between human capital and growth in productivity and quality of life. For example, the model as formulated does not distinguish meaningfully between technological (Lucas, 1988) and pecuniary (Acemoglu, 1996) externalities from human capital, nor does it identify the channel through which human capital might create consumer amenities. In section 4, I provide evidence on these channels using several direct measures of quality of life.

[9] As with ε^q and ε^a, it will not be necessary to assume that μ^p and μ^w are homoskedastic, independent over time, or drawn independently of one another.

The model also has several more specific limitations. First, in reality households consume locally produced services as well as traded goods, and the prices of these services are determined in part by local labor market conditions. In a simple representative household formulation, each household is neither a net seller nor a net buyer of services, so incorporating services into the framework above would make little difference to my conclusions about the importance of productivity and quality-of-life growth. In a more realistic model with heterogeneity in how much time each household buys and sells in the service market, an increase in productivity could penalize net buyers of services by raising the local wage. The presence of such a force would lead me to overstate the role of productivity in determining the growth effects of human capital, since it would mean that an increase in wages partially represents an increase in the cost of living, and would therefore capitalize quality of life improvements more than is reflected in equations (10).

The model also ignores heterogeneity in labor and housing markets that may be important in determining equilibrium factor prices. For example, if workers come in multiple imperfectly substitutable varieties (e.g., skilled and unskilled), then there will be additional equilibrium conditions that determine the spatial distribution of wages for the two groups, and the estimates from (10) would be interpretable as a weighted average of productivity growth affecting each group. Different groups may also choose different consumption bundles, leading to heterogeneity in the values of the share parameters discussed above. If shares are correlated with human capital, this could introduce bias in estimates that assume homogeneous shares. In section 3.3, I discuss the sensitivity of the results to relaxing the assumption that firm and household budget shares are identical across locations.

2 Data description

2.1 Measuring wages, rents, and human capital

To form the basic panel of metropolitan areas, I extract from the IPUMS database (Ruggles and Sobeck, 1997) all prime-age (25 to 55) white males living in Census-defined metropolitan areas in the years 1940, 1970, 1980, and 1990.[10] My measure of total employment in a given metropolitan area in a given year is a count of the total number of prime-age white males in the sample.[11] I construct an area-level employment growth measure for each time period as the log change in employment. I standardize this to be a ten-year growth rate in the 1940-1970 period.

I construct the wage series as follows. I restrict attention to white prime-age males living in metropolitan areas.[12] To construct a wage estimate, I divide total wage and salary income for each individual by total annual hours worked, imputed from the categorical variables on weeks and hours worked available in the microdata.[13] I then regress the log of the wage for each individual on dummies for each metropolitan area, age and its square, and dummies for veteran status, marital status, educational attainment, industry category and occupational category.[14] All regressions include dummies for missing values of marital and veteran status; observations with missing values of other variables were dropped. I estimate separate regressions for each Census year so as to avoid unnecessary restrictions on the coefficients.

For each year I extract the coefficients on the metropolitan area dummies to be used as estimates of local differences in wages.[15] Naturally, these estimates are

[10]In many cases, the set of counties that make up an area grows larger over time. Since the public-use sample of the Census does not directly identify counties, it is not possible to directly construct county groupings that are consistent over time. In section 3.3, I show that my results are robust to examining only those areas whose definitions did not change over the relevant period.

[11]I have used person-level sample weights wherever appropriate in constructing my measures of employment, human capital, and other metropolitan area characteristics.

[12]Since nearly all prime-age white males are in the labor force, restricting attention to this group helps to limit concerns arising from differences across metropolitan areas in which types of workers choose to participate in the labor market, which could otherwise create a composition bias (Solon, Barsky, and Parker, 1994).

[13]In all cases I used the midpoint of the categorical range as the point estimate.

[14]Further details on the controls used are available in subsection A.1 of the Appendix.

[15]The use of metropolitan area dummies to measure local wage and price differences is related to the approach taken in Gabriel and Rosenthal (2004).

only as good as the controls—sorting on omitted characteristics will introduce bias. However, as Table 1 illustrates, the estimates generally seem sensible. Moreover, for the purposes of studying growth the changes in these price coefficients are more important than their levels—and growth rates in wage residuals will at least be purged of time-invariant differences in the characteristics of local workers.

The Census contains data on the value of owner-occupied housing units as well as on the rental price of renter-occupied units. As it is not clear *a priori* which market is preferable as a means of measuring differences in the implicit price of land, I use both types of data. In contrast to the labor market sample, I do not restrict to units occupied by prime-age white males, on the view that housing prices for different demographic groups will be tied together by market forces. To construct the rental price series, I regress the log of reported monthly contract rents on dummies for metropolitan areas as well as a set of controls for dwelling characteristics.[16] (Data on these characteristics are not available for 1940, but results on rents are robust to excluding the 1940-1970 time period.) I run these regressions separately for each year. The controls for housing characteristics I employ are dummies for commercial use status, acreage of property, availability of kitchen or cooking facilities, number of rooms, type of plumbing, year built, number of units in structure, water source, type of sewage disposal, and number of bedrooms.[17] To construct the house value series, I perform an identical procedure using the log of reported house values for all owner-occupied dwellings.

While the rankings of rental prices shown in Table 1 seem sensible, changes in unmeasured characteristics of the housing stock may cause difficulties in determining the effects of human capital on land prices. As a check on the potential magnitude of such a problem, I obtained the Office of Federal Housing Enterprise Oversight's (OFHEO) House Price Index (HPI) for metropolitan areas for the years 1980-1990 (Calhoun, 1996). This index is based on a repeat sales methodology (Case and Shiller, 1989),

[16] Monthly contract rent includes utilities only if they are a specified part of the rental contract.

[17] Subsection A.2 of the Appendix contains additional details about the controls used. These controls were available for all years (except 1940) and therefore permit me to construct a consistent series. See also the Supplemental Appendix available on my web page.

and thus takes advantage of the fact that the correlation between the growth in house prices and changes in unobservable dwelling characteristics will tend to be smaller when examining multiple transactions at the same address. For the 119 metropolitan areas for which both the growth rate of the HPI and the change in estimated rental price residuals are available, the correlation between these two measures is .83. The correlation between the 1980-1990 growth rate of the HPI and the 1980-1990 change in the estimated house value residual is .92.[18] Such strong correlations across alternative measures reinforce the view that unmeasured housing characteristics do not play a major role in determining the growth rates in my measures of the implicit price of land.

As a measure of the concentration of human capital in a metropolitan area, I calculate the sample share of prime-age white males who have a high school degree only, some college, and a college degree or higher.

2.2 Land-grant colleges and universities

The federal Morrill Act of 1862 granted large parcels of land to each state in the Union (with the size of the parcel proportional to the state's number of Congressional representatives) in order to fund the creation of colleges instructing in agriculture, engineering, and other subjects.[19] Another act in 1890 extended the so-called "land-grant" provision to 16 southern states (Christy, Williamson, and Williamson, 1992). I follow Moretti (2004) in using Nevins' (1962) appendix to code a binary variable indicating whether a metropolitan area contains a land-grant institution.

Consistent with the intention to spread these universities evenly across the states, the geographic distribution of land-grant universities is quite even. For example, among the 251 metropolitan areas in my 1980 sample, 12 percent of Northeastern metropolitan areas, 16 percent of Midwestern metropolitan areas, 15 percent of

[18] Both correlation coefficients are statistically significant at the .01 percent level. The correlation between the change in the rent residual and the change in the house value residual during the 1980-1990 period is .82.

[19] James (1910) argues that, while the bill was introduced by Senator Justin Morrill of Vermont, credit for its passage belongs to Illinois College professor Jonathan B. Turner.

Southern metropolitan areas, and 15 percent of Western metropolitan areas contain a land-grant college or university. (A Pearson's chi-squared test of independence fails to reject the null hypothesis that land-grant colleges and universities are distributed independently of Census region.)

Moretti (2004) reports that the demographic characteristics of metropolitan areas with and without land-grant colleges or universities are similar in most respects. He also reports that the presence of a land-grant institution is associated with higher shares of college graduates, but *lower* shares of individuals with high school degrees and some college. These facts seem consistent with the view that the presence of a land-grant school causes higher rates of college attainment, and not vice versa.

In 1980, 35 percent of prime-age white males in metropolitan areas with a land-grant school were college graduates, versus 25 percent in areas without a land-grant school.[20] A more direct check on the validity of the presence of land-grant schools as an instrument for the current distribution of human capital is to ask whether this correlation existed before land-grant institutions were of significant size. The Census, however, did not begin asking directly about educational attainment until 1940, by which time the land-grant schools were already of significant size (Bowman, 1962).

To circumvent this problem, I have constructed a human capital index based on the distribution of occupations within a metropolitan area. Using Census public-use samples of prime-age white males from 1850 through 1980, I follow Simon and Nardinelli (2002) in assigning to each individual in the sample the percent of individuals in the same occupation in 1950 with a college degree or higher. By averaging this variable by metropolitan area I obtain an occupational human capital measure for each metropolitan area in each year.

Table 2 shows the difference in this human capital index between land-grant and non-land-grant metropolitan areas by year from 1850 through 1980. During the 1850-

[20]This effect is too large to be accounted for solely by the presence of graduates of land-grant institutions themselves. But these schools may well have effects that exceed their size. For example, Bowman (1962) notes that "The comparatively high rate of college attendance in the rural areas of the western states contrasts dramatically with the lag of rural regions in most parts of the world. This lends support to other evidence that the land-grant institutions sold higher education to a public much larger than that represented in their own enrollments." Consistent with this view, I find that the effect of land-grant schools on college graduation rates is largest in the Midwest.

1880 period, when many land-grant institutions had not yet been established, there is essentially no difference in the human capital distributions between the two categories of metropolitan areas. From 1900-1920, when these institutions had been established but rates of college graduation were still relatively low, the differences are moderate. The differences are largest in the sample period of 1940-1980, when rates of college attendance were highest and thus the scope for the impact of land-grant schools greatest. The fact that the correlation between occupational distribution and the presence of a land-grant college or university arose only after these institutions could have played a significant causal role supports the exogeneity of land-grant status with respect to pre-existing differences among metropolitan areas.

2.3 Compulsory schooling laws (CSLs)

Coincident with the rise of high school completion in the first half of the twentieth century was a significant tightening of regulations concerning compulsory school attendance and child labor. Acemoglu and Angrist (2000) have shown that changes in these laws at the state level had a significant impact on the educational attainment of those born in affected states.[21] Since changes in these laws are plausibly exogenous with respect to subsequent labor and housing market conditions, they provide a candidate instrument for concentrations of high school graduates in metropolitan areas from 1940 through 1990.

I have obtained Acemoglu and Angrist's (2000) coding of both compulsory attendance and child labor laws for the 1914-1965 period. Since these laws vary along many dimensions, I follow Acemoglu and Angrist (2000) in adopting two summary measures: the minimum years of schooling required before leaving school (CL), and the minimum years in school required before work is permitted (CA).[22] I then create dummies for four categories of each of these variables: 6 years and under, 7 years, 8

[21] See also Goldin and Katz (2003), who argue that roughly five percent of the increase in high school enrollment from 1910 to 1939 is attributable to CSLs.

[22] CL is defined as "the larger of schooling required before dropping out and the difference between the minimum dropout age and the maximum enrollment age." CA is defined as "the larger of schooling required before receiving a work permit and the difference between the minimum work age and the maximum enrollment age" (Acemoglu and Angrist, 2000).

years, and 9 and over years for CL; 8 years and under, 9 years, 10 years, and 11 and over years for CA. Acemoglu and Angrist (2000) argue that these categorizations efficiently capture the most relevant variation in state laws during this time period.

Given these definitions, I assign each prime-age white male in the 1940-1990 Census public use samples to a CL category and CA category according to the laws prevailing in his state of birth when he was of age 14. I then calculate for each metropolitan area-year the share of prime-age white males in each category. This results in eight variables, two of which are linearly dependent, which measure the variation in the exposure of prime-age white males in each area and year to different CSLs. When metropolitan area fixed effects are included in a specification, these variables capture changes over time in the share of prime-age white males exposed to each type of CSL regime, and thus provide variation useful in identifying the effects of high school graduates on local area growth.

3 Results

3.1 Baseline specification

Table 3 reports coefficients from ordinary least squares (OLS) regressions of employment, wage, rental price, and house value growth on the log of the percent college graduates for the 1940-1990 panel. Data on wages, rents, and house values come from metropolitan area fixed effects in hedonic regressions of prices on worker or housing unit characteristics as described in the previous section, and are therefore not correlated with observable differences in worker or housing unit quality. Dummies for time period are included in all specifications, and standard errors are adjusted for correlation of the errors within metropolitan areas.

These regressions reveal a number of important facts. First, they confirm the usual finding that cities with greater concentrations of human capital experience more rapid growth in employment. A 10 percent increase in the share of college-educated residents is associated with an increase in the employment growth rate of roughly .8

percent.

A second important pattern is that growth in wages, rents, and house values tends to be higher in cities with greater concentrations of college-educated residents. A 10 percent increase in the share of college-educated residents corresponds to a .2 percent increase in wage growth and a .7 percent increase in the growth of rental prices and house values, all statistically significant. Note also that the effect of human capital on the land price measures is more than three times as large as the effect on growth in wages.

3.2 Calibration of growth model

These reduced-form facts suggest that growth in quality of life may be playing an important role in the relationship between human capital and employment growth, since growth in land prices seems generally to be more sensitive to the share of college-educated residents than growth in wages. For a more quantitative evaluation of the relative importance of quality of life and productivity in explaining the human capital-employment growth relationship, we will need to estimate equations (10). For this we require values for labor's share of output (k_L), land's share of output (k_R), and the share of land in the household budget (s_R).

Existing evidence on factor shares suggests values of $k_L = .75$ and $k_R = .10$.[23] More controversial is the share of land in the household budget (s_R), for which prior studies have traditionally used a value of about .05 (Roback, 1982). This is a good approximation to the literal share of land in the budget, but is likely to be far too small to approximate the concept required by theory. The reason is that the model in section 1 assumes that all goods other than land are traded on a national market and therefore display no local price variation. In a more realistic framework, s_R is not merely the household budget share of land per se but rather the share in the household

[23] Krueger (1999) estimates that labor's total share of output (including the return to human capital) is roughly .75; Poterba (1998) also places it at between 70 and 80 percent of national income. I will therefore use $k_L = .75$. Poterba (1998) reports a corporate capital income share of around 10 percent that, combined with a labor share of about three-fourths, places an upper bound of around .15 on k_R. I will set $k_R = .10$, which is close to the upper bound and, if anything, seems likely to cause me to overstate the productivity effects of human capital.

budget of all goods that are produced using local land as an input. In other words, s_R should capture the importance of all "cost of living" differences between locations, because all of these costs matter in equilibrating utility levels across cities.

In subsection A.3 of the Appendix, I estimate the effect of a one-percent increase in the implicit price of land on the price of a market basket of goods and services, using both cross-sectional data and evidence on price changes over time. These estimates suggest a preferred value of s_R of about .32, with a lower bound of about .22 . I will report results for both values to address the sensitivity of my findings to alternative values of s_R.[24]

As I showed in section 1, regressions of $(k_L \Delta w_{i,t+1} + k_R \Delta p_{i,t+1})$ and $(s_R \Delta p_{i,t+1} - \Delta w_{i,t+1})$ on the log of the share of college graduates will yield estimates of the parameters β^a and β^q. These estimates, denoted $\hat{\beta}^a$ and $\hat{\beta}^q$, capture the effect of human capital on growth in productivity and the quality of life, respectively. Since the total effect of human capital on employment growth is equal to $\beta^q + \frac{1}{k_L}\beta^a$ (see equation (7)), the fraction of the employment growth effect that is due to productivity growth can be estimated as $\frac{\frac{1}{k_L}\hat{\beta}^a}{\hat{\beta}^q + \frac{1}{k_L}\hat{\beta}^a}$.

Table 4 shows the results of this exercise. When s_R is .32, the estimates indicate that roughly 60 percent of the overall employment growth effect of human capital is attributed to productivity growth. This finding is not sensitive to the choice of measure for land price. These findings suggest that while technological or pecuniary externalities may play an important role in the employment growth effects of human capital, consumption amenities are a significant component as well. Even for $s_R = 0.22$, around one-quarter of the total employment growth effect is attributed to growth in local quality of life.[25]

[24] To address concerns about systematic heterogeneity in the s_R parameter, I have re-estimated the models in Appendix A.3 allowing the share of land in the budget to differ depending on whether a metropolitan area has an above-median share of college graduates. The difference in estimated land shares between high- and low-human capital locations is not statistically significant, and the productivity share estimated from specifications (not shown) allowing for heterogeneous land shares is roughly .69. Evidence from 1977 data on manufacturing from the USA Counties 1998 database also shows no systematic relationship between human capital concentrations and proxies for k_L and k_R.

[25] Since I measure wages rather than total compensation, it is possible for my results to understate the productivity effect if growth in nonwage compensation is much more correlated with human cap-

Overall, then, my findings indicate an important role of quality of life in driving the relationship between the share of college-educated residents in a metropolitan area and the area's subsequent employment growth. While prior work has tended to emphasize productive externalities from human capital, this evidence suggests there may be important consumption externalities as well.

3.3 Robustness

In this section, I examine the robustness of my results to a number of alternative specifications. Row (2) of Table 5 repeats the baseline OLS specification controlling for mean January temperature, mean July temperature, and average annual inches of precipitation.[26] Most studies of local area growth in the post-World War II period have found these to be strong and robust predictors of population growth (Rappaport, 2004). Examining the sensitivity of the results to these controls therefore helps identify whether the employment growth-human capital relationship might be arise simply because highly educated residents select growing locations, rather than directly impacting growth. Overall, the results from this specification line up extremely closely with those in the baseline, and the implied productivity share rises only slightly, to .67.

The third row of the table shows results using data from 1970-1990, in which lagged employment growth rates are included as controls. The point estimate of the effect of human capital on employment growth is similar to the baseline, but is much less precisely estimated. This is unsurprising, since employment growth is highly serially correlated, so that including lagged growth rates removes much of the variation in the dependent variable. For wage and rent growth, which display much lower degrees of serial correlation, inclusion of lagged growth rates increases somewhat the estimated

ital levels than growth in wages. Assuming conservatively that nonwage compensation represented 10 percent of total compensation during my sample period (Long and Scott, 1982), I calculate that the growth in nonwage compensation would have to be more than four times as responsive to initial levels of human capital as the growth in wages in order to attribute all of the effect of human capital to productivity growth.

[26] Weather data are from the County and City Data Book 1994. Central cities were matched to metropolitan areas as in Glaeser and Shapiro (2003).

effects of human capital. Because the estimated effect on wage growth increases more than the effect on rent growth, the calculated productivity share rises to about .8. Even this estimate, however, implies an important role for growth in quality of life.

To address the issue of changes in the composition of metropolitan areas over time, in the fourth row I present results for the sub-sample of metropolitan area-year pairs in which the definition of the metropolitan area does not change during the time period. While the smaller sample size leads to larger standard errors (and a smaller point estimate) for the employment growth effect, the wage and rent growth coefficients are similar to the baseline specification, and lead to an implied productivity share only slightly higher than in the baseline. Controlling directly for the growth in the number of counties composing the metropolitan area also yields results similar to those of the baseline (regression not shown).[27]

3.4 Instrumental variables estimates

The previous subsections present correlational evidence on the connection between human capital and local area growth. The evidence confirms the finding of prior studies that human capital is positively related to employment growth, and provides further indication that much of this effect operates through increases in the quality of life, rather than productivity. Although these facts seem robust to a number of controls and alternative specifications, concerns may still remain about the causal interpretation of my estimates. Of primary concern is the possibility that skilled residents seek out growing or soon-to-be growing areas, which would lead to a reverse-causality confound in my estimates. In this section I examine instrumental variables (IV) estimates of the growth effects of human capital, instrumenting with the presence of land-grant institutions as in Moretti (2004) and compulsory schooling laws as in Acemoglu and Angrist (2000).

[27] In additional specifications reported in the Supplemental Appendix (available on my web page), I show that the implied productivity share is similar for metropolitan areas with and without significant supply restrictions on housing. I also show that both the employment growth effect and the productivity share are higher for manufacturing-intensive areas, possibly due to pecuniary externalities of the sort discussed in Acemoglu (1996).

Row (5) of Table 5 presents results from a 2SLS estimation in which land-grant status is used to instrument for the log of the share college-educated. As I argue in section 2.2 above, land-grant institutions seem to be distributed evenly over different regions of the United States and do not appear to have been placed in relation to pre-existing differences in human capital levels across metropolitan areas.[28] Relative to the baseline OLS results, the 2SLS results tend to show larger (although less precisely estimated) growth effects of human capital. For example, a 10 percent increase in the share of residents who are college-educated is now estimated to increase employment growth by about 1.7 percent, as against .8 percent in the baseline OLS specification. The estimated effects of human capital on wage and rent growth are larger in similar proportion, so that the implied productivity share of the growth effect remains similar to the baseline estimate.

Although I have argued that land-grant institutions have a causal impact on the skill distribution in an area, it is of course possible that their effects on local labor and housing markets occur through other, more direct channels, and not exclusively through their effect on the concentration of human capital. For example, universities purchase land and labor, therefore making them direct (and sometimes large) participants in these markets. The fact that I examine growth rates, rather than levels, of employment, wages, and rents, should help to reduce the impact of these other channels, as long as they are relatively fixed over time. Additionally, since land-grant institutions were placed well in advance of the time period under study, the 2SLS strategy should at least serve to alleviate concerns about simultaneity bias arising from skilled residents' desire to live in places that will grow in the future. On the whole, then, it seems reassuring that the 2SLS estimates suggest a productivity share very similar to that obtained using the OLS specifications discussed above.

In Table 6 I estimate the growth impact of those with a high school degree or more,

[28] The first-stage estimates from this specification show a large and statistically strong effect of land-grant institutions on the share of residents who are college-educated. In a regression of log(share college-educated) on the land grant status dummy, the land-grant coefficient is 0.3105 with a standard error of 0.0522. An F-test of the null hypothesis that land-grant status has no effect on log(share college-educated) rejects with $p < 0.001$, and an F-statistic of 34.61. This F-statistic is sufficient to rule out any significant weak-instruments bias (Stock and Yogo, 2002).

instrumenting with compulsory schooling laws as coded by Acemoglu and Angrist (2000). These specifications include metropolitan area fixed effects, so identification comes from changes over time in the exposure of prime-age white males to CSLs. As column (1) shows, the first stage estimates generally confirm that these laws affect the human capital distribution, although the coefficients are less monotonic and precise than those reported in Acemoglu and Angrist (2000). This non-monotonicity, coupled with a small F-statistic, suggests caution is needed in the interpretation of these estimates.[29]

The 2SLS estimates show no statistically significant effect of high school graduates on growth in employment, wages, or rents, consistent with the prior literature's emphasis on college graduates as a determinant of urban growth in the post-World War II period.[30] Though the confidence intervals on the growth effects of human capital are large, the point estimates are largely negative, and thus provide no evidence for significant productivity (or quality of life) externalities from high school graduates, consistent with the findings of Acemoglu and Angrist (2000).

4 Direct indicators of the quality of life

The results presented in the previous section provide preliminary support for a causal interpretation of the relationship between the concentration of college graduates in a metropolitan area and subsequent growth in quality of life in the area. In this section, I conduct a preliminary investigation of two candidate explanations for this relationship.

First, concentrations of skilled residents may encourage the growth of consumer services, such as the restaurants and bars, which then make an area more attractive to potential migrants. In line with this hypothesis, Glaeser, Kolko and Saiz (2001) show evidence that cities with superior markets for goods and services experience

[29] Given the small F-statistic, it is not possible to reject the presence of a weak-instruments bias (Stock and Yogo, 2002).

[30] Although the human capital measure includes those with a college degree, existing evidence and unreported specifications indicate that the effect of CSLs is predominantly to move individuals from the "no high school" category to the "high school" category.

more rapid population growth.[31]

Second, highly-educated households may act, through the political system or privately, to improve local quality of life. Moreover, better educated households are more likely to be homeowners, and some evidence exists to suggest that homeowners make greater investments in their local communities (Glaeser and Shapiro, 2003).

To distinguish between these hypotheses, I have collected data on direct measures of quality of life from several sources. First, from the USA Counties 1998 database, I have obtained data for 222 of the metropolitan areas in my 1980 sample on the number of restaurants per capita in 1977 and 1992, and the number of FBI-defined serious crimes per capita in 1980 and 1990.[32] Second, using the public-use sample of the Census, I have computed the share of individuals ages 16 to 19 in 1980 and 1990 who are neither high school graduates nor currently in school. I will treat this variable as a proxy for the share of high school dropouts in an area and hence as a loose measure of the quality of public schools. Finally, I have obtained for 74 of the metropolitan areas in my sample a count of the number of days in 1980 and 1990 that the Environmental Protection Agency's Air Quality Index exceeded 100, indicating poor air quality.[33]

In Table 7, I compare mean 1980-1990 growth rates in these variables between land-grant and non-land-grant metropolitan areas. As row (1) shows, land-grant metropolitan areas experienced more rapid growth in the number of restaurants per capita than non-land-grant areas. This difference is both statistically and economically large, suggesting that consumer amenities may play a role in the effects of human capital on quality of life.

As rows (2) through (4) indicate, the evidence on more policy-dependent measures of quality of life—namely crime rates, air quality, and school quality—is much less impressive. In no case is there a statistically significant difference between land-grant and non-land-grant metropolitan areas. Only in the case of crime does the point

[31] See also George and Waldfogel (2003), who show evidence of economies of scale in catering to consumers' varying tastes.

[32] Counties were matched to metropolitan areas as in Glaeser and Shapiro (2003).

[33] Data are from http://www.epa.gov/airtrends/factbook.html.

estimate suggest an economically large benefit from human capital, but this effect is too imprecisely estimated to be statistically distinguishable from zero.

Clearly a more structured investigation would be required to fully separate alternative theories of the relationship between human capital and growth in quality of life. Nevertheless, the findings reported in this section seem more consistent with a consumer amenities mechanism than with a mechanism in which improvements are made via the political system.

5 Conclusions

Several key findings emerge from the analysis in this paper. First, instrumental variables estimates are consistent with a causal effect of concentrations of college graduates on local area employment growth. Second, there is no evidence to indicate a growth effect of high school graduates. Third, evidence from wages and rents implies that, while the majority of the employment growth effect of college graduates operates through changes in productivity, roughly one-third of the effect seems to come from more rapid improvement in the quality of life. Finally, a preliminary investigation of several direct measures of quality of life indicates that the effect of college graduates may operate through "consumer city" amenities such as bars and restaurants, rather than from more politically mediated area attributes such as crime, schools, and pollution.

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Table 1 *Highest and lowest wage and rental price fixed effects, 1990*

A. Wage fixed effects

Highest	Stamford, CT	0.60
	Norwalk, CT	0.55
	Danbury, CT	0.41
	New York-Northeastern NJ	0.39
	Bridgeport, CT	0.38
Lowest	Alexandria, LA	-0.11
	Laredo, TX	-0.12
	Bryan-College Station, TX	-0.13
	McAllen-Edinburg-Pharr-Mission, TX	-0.18
	Brownsville - Harlingen-San Benito, TX	-0.22

B. Rental price fixed effects

Highest	San Jose, CA	0.77
	Stamford, CT	0.73
	Santa Cruz, CA	0.69
	Ventura-Oxnard-Simi Valley, CA	0.66
	Norwalk, CT	0.66
Lowest	Dothan, AL	-0.58
	Florence, SC	-0.60
	Danville, VA	-0.64
	Anniston, AL	-0.66
	Johnstown, PA	-0.66

Notes: Wage fixed effects reflect coefficients from metropolitan area dummies in a regression of log(wage) on these dummies and controls for observable worker characteristics. Rental price fixed effects reflect coefficients from metropolitan area dummies in a regression of log(monthly contract rent) on these dummies and controls for observable housing characteristics. See section 2 of text for details.

Table 2 *Land-grant institutions and metropolitan area human capital*

Year	Occupational human capital index			Wilcoxon
	No land-grant	Land-grant	Difference	rank-sum p-value
1850	0.0579	0.0612	0.0034	0.7697
(N)	(7)	(2)		
1860	0.0599	0.0600	0.0001	0.9025
	(10)	(5)		
1870	0.0630	0.0633	0.0003	0.8763
	(15)	(6)		
1880	0.0687	0.0713	0.0026	0.9559
	(20)	(7)		
1900	0.0712	0.0821	0.0109	0.5730
	(48)	(13)		
1910	0.0749	0.0844	0.0096	0.1173
	(70)	(13)		
1920	0.0740	0.0783	0.0043	0.3414
	(89)	(17)		
1940	0.0844	0.1010	0.0166	0.0006
	(112)	(20)		
1950	0.0942	0.1176	0.0234	0.0000
	(122)	(22)		
1970	0.1355	0.1616	0.0261	0.0000
	(96)	(21)		
1980	0.1455	0.1862	0.0432	0.0000
	(235)	(37)		

Notes: Number of observations in cell in parentheses. Land-grant classification based on Nevins (1962). Occupational human capital index is constructed by matching each prime-age white male in the Census public-use file with the share of prime-age white males in 1950 in the individual's occupation with a college degree or higher, and then averaging by metropolitan area and year.

Table 3 *Human capital and growth*

	Dependent variable is growth in...			
	Employment	Wage	Rental price	House value
log(share college educated)	0.0786 (0.0247)	0.0160 (0.0081)	0.0664 (0.0126)	0.0714 (0.0176)
Initial level of:				
Employment	-0.0345 (0.0097)			
Wage		-0.2347 (0.0274)		
Rental price			-0.0382 (0.0242)	
House value				0.0244 (0.0401)
R^2	0.0581	0.2333	0.2306	0.0888
N	495	495	495	495

Notes: Table shows coefficient in regression of dependent variable on the log of the percent of prime-age white males with a college degree in the metropolitan area. Wage, rent, and house value growth are measured as the growth in metropolitan area fixed effects from hedonic regressions as described in section 2 of the text. Regressions include time period dummies. Standard errors have been adjusted for serial correlation within metropolitan areas.

Table 4 *Human capital and growth in productivity and the quality of life*

Share of land in budget s_R	Measure of land prices	Effect of human capital on growth in Productivity $\hat{\beta}^a$	Quality of life $\hat{\beta}^q$	Productivity share of growth effect $\frac{\frac{1}{k_L}\hat{\beta}^a}{\hat{\beta}^q+\frac{1}{k_L}\hat{\beta}^a}$
.32	Rents	0.0209	0.0172	0.62
		(0.0069)	(0.0061)	
.22	Rents	0.0209	0.0070	0.80
		(0.0069)	(0.0065)	
.32	House values	0.0229	0.0214	0.59
		(0.0072)	(0.0061)	
.22	House values	0.0229	0.0116	0.72
		(0.0072)	(0.0060)	

Notes: Table shows coefficients in regression of $(k_L \Delta w_{i,t+1} + k_R \Delta p_{i,t+1})$ and $(s_R \Delta p_{i,t+1} - \Delta w_{i,t+1})$ on the log of the share of prime-age white males in the metropolitan area with a college degree. All calculations use $k_L = .75$ and $k_R = .10$. I measure $\Delta w_{i,t+1}$ as the change in a metropolitan area i's log(wage) fixed effect from time t to $t+1$, as described in section 2; $\Delta p_{i,t+1}$ is measured similarly using data on rents and house values. All regressions include time period dummies. All standard errors have been adjusted for serial correlation within metropolitan areas.

Table 5 *Alternative specifications*

Independent variable: log(share college-educated)

Specification		Productivity share	Dependent variable is growth in... Employment	Wage	Rental price	N
(1)	Baseline	0.62	0.0786	0.0160	0.0664	495
			(0.0247)	(0.0081)	(0.0126)	
(2)	Weather controls	0.67	0.0500	0.0163	0.0561	495
			(0.0226)	(0.0084)	(0.0120)	
(3)	Lag growth controls	0.83	0.0639	0.0329	0.1270	247
			(0.0606)	(0.0155)	(0.0293)	
(4)	No change in area definition	0.69	0.0307	0.0260	0.0748	297
			(0.0274)	(0.0128)	(0.0196)	
(5)	IV with land grant status	0.55	0.1708	0.0237	0.1184	495
			(0.0964)	(0.0219)	(0.0501)	

Notes: Table shows coefficient in regression of dependent variable on the log of the percentage of prime-age white males with a college degree in the metropolitan area. Wage, rent, and house value growth are measured as the growth in metropolitan area fixed effects from hedonic regressions as described in section 2 of the text. Regressions include time period dummies. Standard errors have been adjusted for serial correlation within metropolitan areas. All calculations use $k_L = .75$, $k_R = .10$, and $s_R = .32$. Data on weather taken from the County and City Data Book 1994. Land-grant classification based on Nevins (1962).

Table 6 *Instrumental variables estimates*

	log(share with HS or more)	Employment growth	Wage growth	Rental price growth	House value growth
log(share with HS or more)		-0.3939 (0.4341)	-0.1317 (0.0687)	-0.1950 (0.1347)	-0.2404 (0.2237)
Minimum years of schooling required before leaving school (CL):					
9	-0.2366 (0.1311)				
10	0.4642 (0.2143)				
11	0.2149 (0.1621)				
Minimum years in school required before work is permitted (CA):					
7	-0.0524 (0.1367)				
8	0.1204 (0.1692)				
9	-0.0384 (0.1949)				
$F-statistic$	3.87	—	—	—	—
N	495	495	495	495	495

Notes: Wage, rent, and house value growth are measured as the growth in metropolitan area fixed effects from hedonic regressions as described in section 2 of the text. Compulsory schooling laws coded as in Acemoglu and Angrist (2000). F-statistic is test statistic from a test of the null hypothesis that the coefficients on the CL and CA dummies are jointly significant. Regressions include time period dummies and metropolitan area dummies. Growth regressions include initial levels of employment, wages, rents, and house values, respectively, as controls. Standard errors have been adjusted for serial correlation within metropolitan areas.

Table 7 *Sources of the effect of human capital on quality of life*

	1980-1990 change in:	No land-grant	Land-grant	Difference	N
(1)	log(restaurants per capita)	0.2682 (0.0085)	0.3275 (0.0187)	0.0594 (0.0212)	222
(2)	log(serious crimes per capita)	-0.0363 (0.0150)	-0.0913 (0.0335)	0.0549 (0.0377)	222
(3)	High school dropout rate	-0.0404 (0.0032)	-0.0396 (0.0077)	-0.0008 (0.0029)	252
(4)	log(no. days air quality index > 100)	-0.3616 (0.1755)	-0.1929 (0.2973)	0.1687 (0.3795)	74

Notes: Change in log(restaurants per capita) is from 1977 to 1992. Data on restaurants per capita and the number of FBI-defined serious crimes per capita are from the USA Counties 1998 database, with counties matched to metropolitan areas as in Glaeser and Shapiro (2003). High-school dropout rate is the share of individuals ages 16 to 19 in 1980 and 1990 who are neither high school graduates nor in school, calculated from Census public-use samples. Data on air quality is a count of the number of days in 1980 and 1990 that the Environmental Protection Agency's Air Quality Index exceeded 100, taken from http://www.epa.gov/airtrends/factbook.html.

A Appendix

A.1 Measuring Local Area Wages

In order to measure relative wage levels in metropolitan areas at time t, I regress the log wage of all prime-age males in the sample at time t on dummies for metropolitan areas and a set of controls. These controls are age in years, the square of age in years, and dummies for categories of the following worker characteristics (additional details in Supplemental Appendix available on author's web page):

- Veteran status: not applicable; no service; yes; not ascertained.
- Marital status: married, spouse present; married, spouse absent; separated; divorced; widowed; never married, single, or not applicable.
- Educational attainment: none or preschool; grade 1, 2, 3, or 4; grade 5, 6, 7, or 8; grade 9; grade 10; grade 11; grade 12; 1, 2, or 3 years of college; 4+ years of college.
- Occupation category (1950 classification): professional and technical; farmers; managers, officials, and proprietors; clerical and kindred; sales workers; craftsmen; operatives; service; farm laborers; laborers.
- Industry category (1950 industrial classification): agriculture, forestry, and fishing; mining; construction; durable goods manufacturing; nondurable goods manufacturing; transportation; telecommunications; utilities and sanitary services; wholesale trade; retail trade; finance, insurance, and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; and public administration.

Observations with missing data on education attainment, occupation, or industry were dropped from the regression.

A.2 Measuring Local Area Rents and House Values

My housing dataset consists of all households not residing in group quarters. In order to measure relative rental prices in metropolitan areas in 1970, 1980, and 1990, I regress the log of the reported monthly contract rent of all renter-occupied dwellings in the sample in each year on dummies for metropolitan areas and a set of controls. For 1940, the controls are not available, so the regression includes only the metropolitan area dummies. To measure relative house values, I repeated the above procedure using the log of the reported value of all owner-occupied dwellings in the sample. The controls used in the 1970, 1980, and 1990 samples are dummies for the following housing characteristics (additional details in Supplemental Appendix available on author's web page): commercial use status; acreage of property; availability of kitchen or cooking facilities; number of rooms; type of plumbing; year built; number of units in structure; water source; type of sewage disposal; number of bedrooms.

A.3 Calibrating the Household Share of Land (s_R)

The share of land in the budget, s_R, ought to capture the share of household expenditures that go to non-traded goods. Put differently, it should reflect the elasticity of the household's expenditure function with respect to the price of land. It is this elasticity that determines the utility consequences of a one-percent increase in the price of land. In this subsection, I attempt to infer this elasticity by estimating the effect of an increase in the price of land on the price of a representative basket of goods. (Additional details and regression tables are in a Supplemental Appendix available on the author's web page.)

My first set of estimates comes from ACCRA's cost of living index for U.S. cities for the first quarter of 2000. This index is constructed by obtaining prices for a basket of goods, and aggregating these to form a composite score for each city. I am able to match 64 metropolitan areas in my 1990 sample to ACCRA cities, and will use these 64 areas to study the relationship between land prices and the price of a representative basket of goods and services. Using this dataset, I find that a one percent increase in the price of land increases the overall price of goods and services by .32 percent after adjusting for measurement error in the independent variable, with an unadjusted elasticity of about .28.

My second set of estimates of s_R comes from the Consumer Price Index (CPI). The CPI is calculated at the metropolitan area level for 24 of the areas in my sample, and for some of these is measured repeatedly throughout the sample period. Regressions of the growth in the CPI on the growth in measured land prices yield an elasticity of .32 after accounting for measurement error, and an estimate of .22 if measurement error is not taken into account. (It is necessary to use growth rates rather than levels because the CPI is only comparable within an area over time, not across different areas within a given time period.) Overall, then, the evidence from several different approaches seems consistent with a value of s_R of about .32, and probably not lower than .22. In section 3, I report results for both of these values.