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The Effect of University Host Community Size on State Growth

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Abstract—This study examines the effect of university host community size on state growth. It is argued that if some positive spillovers from universities are localized, needing a host community for capture, or if universities share agglomeration economies with their host communities, and if these effects are large, one may find a significant effect on state growth. Using pooled data from eight U.S. censuses—primarily state-level and university county-level variables—a significant positive effect of university community size is found on state aggregate personal income growth. Weaker effects are found on state employment growth (positive) and state population growth (negative). This suggests that states and perhaps less developed countries could leverage more economic benefits from siting university programs in larger urban areas. A sensitivity analysis reveals no upper bound to the effect on income but a deceleration of the effects on employment growth and population growth when cities become very large. [*JEL* I21] © 1998 Elsevier Science Ltd. All rights reserved

1. INTRODUCTION

MORE so than in most other countries, public universities in the United States may be located in host communities of any size. Large universities can be located next to tiny towns or within huge metropolitan areas. Should the size of a public university's host community matter to policy makers and citizens in the United States and in other countries? Perhaps it might if it could be demonstrated that larger host communities can capture some of the positive spillovers of research knowledge, expertise, educational opportunities, and cultural enrichment that universities produce, while smaller host communities cannot.

2. BACKGROUND

Much empirical evidence has accumulated showing a positive relationship between public investment in higher education and state or regional economic growth. Plaut and Pluta (1983) found larger higher education expenditures related to increased manufacturing employment in a study of 48 states in the late 1960s and early 1970s. Wasylenko and McGuire (1985) found higher education expenditure related to certain industries correlated with increased employment in those industries in a study of 48 states in the 1970s. Helms (1985) found increased personal incomes related to higher education expenditures from 1965 through 1979 for 48 states. Helms' positive effect held up even when the increased tax burden necessitated by those expenditures was controlled in his analysis.

In recent decades, however, two different state economic development strategies regarding higher education have emerged, each of which has shown positive results. In the first strategy, high public investment in higher education attracts knowledge-intensive industries for some states, particularly in the north. In the second strategy, particularly popular in the south, low public investments in higher education, bundled with low taxes, low wages, and low levels of union organization, attract cost-sensitive manufacturing industries. When analyzing the relationship between higher education expenditure and economic growth regionally, Quan and Beck (1987) found a positive relationship in the northeast and a negative relationship in the sunbelt states.

Southern industries still need graduates of higher education institutions to fill managerial, professional, and technical positions, but, to some extent, they can attract northern graduates to move south. Otherwise, they can apply scarce public resources to targeted, specific labor force training, often at vocational/technical colleges, bundled with other economic development incentives used to attract industry.

3. DOES THE SIZE OF THE UNIVERSITY'S HOST COMMUNITY MATTER?

It is often argued that large research universities produce positive "spillovers"—of research-generated

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knowledge, expertise, educational opportunities, and cultural enrichment—that are largely geographically localized. State governments attempt to capture localized positive spillovers from universities explicitly in establishing industry–university consortia in places such as the Research Triangle in North Carolina and the Austin–San Antonio axis in Texas.[1]

Some empirical evidence supports the positive spillovers argument. Herzog and Schlottman (1986, 1991) found that some geographically-migrant job changers prefer new employment in communities with higher education available and cultural amenities. Premus (1982) found that proximity to a university system was a major factor in location decisions made by high tech company executives. Gregorio *et al.* (1982) found that faculty received higher salaries at universities in larger communities, which could make those communities more attractive to higher quality and, perhaps, more entrepreneurial faculty talent.

Noyelle and Stanback (1983) found that communities with high proportions of non-cyclical or counter cyclical businesses, such as universities, tend to experience employment gains in the face of recession and to expand faster than the average during periods of prosperity. Using a data set on the growth of large industries in 170 U.S. cities between 1956 and 1987, Glaeser *et al.* (1992) found evidence supporting the theory (attributed to Jane Jacobs) that, in the aggregate, competition among industries and a variety of industry aid the growth of cities. Moreover, their evidence did not support the theory (attributed to Porter and others) that geographic concentration of a single or a few industries in a city aids city growth. By their nature, universities, even those "specializing" in engineering and agriculture, supply publicly subsidized labor training and research and development for a wide variety of industries and thus promote the Jacobs ideal.

The greatest abundance of research and evidence for the capture of localized positive spillovers from universities concerns network economies in industrial development. In a study of Standard Metropolitan Statistical Areas (SMSAs), Carlton (1983) found that a pool of technical expertise in a region, such as that one might find at and near a university, could attract technologically sophisticated industries. Bania *et al.*, 1987 found a significant relationship between university research spending and openings of new firms in a cross-section sample of SMSAs. With a sample of U.S. states, Jaffe (1989) used time series data on corporate patents to find a significant effect of university research on state-level corporate patent activity. Jaffe found weaker, but still positive, evidence that the spillovers were facilitated by local proximity of universities and corporate research centers, however. Jaffe also cited four case studies that confirm the important roles played by universities in the commercial innovation of Silicon Valley and Route 128.

It may also be true that the universities placed in urban regions themselves benefit from agglomeration economies. Certainly, the marginal cost of attending courses at a university is lower for community residents, so the larger the host community, the more state residents who can benefit. (Students don't have to quit their part-time jobs, move away from home, live in a dormitory at school while they still have a room at home, etc.) In larger cities, universities' purchasing costs may be lower since they face more suppliers willing to bid for their business and lower transportation costs (land costs might be higher, however).

In summary, localized positive spillovers from universities that need a neighboring community of some size in order to be captured could include:

- the hedonic attraction and retention of migrants;
- lower costs for attendance for students from the community;
- recession resistance (i.e. smoothing out business cycles for the community);
- agglomeration economy of professional interaction (a.k.a. network economies);
- agglomeration economy of labor specialization;
- transfer economies (i.e. transport economies); and
- economies of scope from industry competition and variation.

To be complete, it must be mentioned that university towns and neighborhoods can capture localized *negative* spillovers, too. Coming first to mind are those peculiar social behaviors that one commonly finds in geographic concentrations of large numbers of citizens in their late teenage and early adult years.

4. HYPOTHESIS

This study attempts to determine if the size of universities' host communities affects state growth in population, employment, or income. If there are no appreciable net positive spillovers from universities or if the net positive spillovers are diffused statewide, no significant effect will be found. If, however, some net positive spillovers are only localized, needing a host community for capture, and if these effects are large, one should find a significant effect on state growth. Specifically, the size of universities' host communities is measured in two ways: by the proportion of the state population living in the host county or counties; and by the absolute size of the host county or counties. Both measures are standardized by average state county size.

Could the effects be large enough to affect overall state growth? Perhaps they could be. Comparing higher education expenditures to those in other "industries" according to their relative proportions of our country's gross national product, higher education ranks larger (at 2.7%) than the combined category of agriculture, forestry, and fisheries (at 2.4%). Moreover, unlike in agriculture, forestry, or fishing, where the economic activity is widely dispersed, higher education activity is greatly concentrated in certain local areas.[2] (Certainly not all investments in higher education result in localized positive spillovers of proportion equal to the investment. Some investments will produce no localized positive spillovers and others just a few, but still others might leverage spillovers of greater magnitude than the investment that pushed them.)

Nonetheless, some readers might be unhappy with this study's method of measuring the effect of university host community size on state growth. That is because this study does not include actual measures of the local positive spillovers themselves, which would be extremely difficult, if not impossible, to calculate. Rather, this study measures the *potential capacity of states to absorb* the localized positive spillovers from universities.

5. THE DATA SET

The United States provides a good data set for this study. Because of the Morrill Act (which established "land grant" universities) and the Jeffersonian ideal, or "country" ideology in the early decades of the Republic, many state universities were established in rural areas as well as in cities, giving a U.S. data set a more diverse set of university community sizes than one from Europe might have.

This study analyzes data from 38 U.S. states over six decades, from 1930 through 1990. This time period, likewise, produces a good data set for this study. Before 1930, universities were still largely liberal arts colleges that trained teachers and theologians in the classics, languages, and philosophy; so many of the now touted university community synergies, such as technological innovation and incubation, would not have yet existed on a large scale. By the 1990s, much of the public investment in state universities has been diffused to branch campuses or recently created big city universities in an effort to benefit more of the state's citizens.

Universities were chosen that met certain criteria, such as:

- they were established before 1920 (1940 for some newer states out west);
- they were complete research universities, with graduate and professional schools, not simply colleges;
- they were main, not branch, campuses; and
- they were full, public universities, not teachers' colleges, women's colleges, or Negro colleges.

Only these universities possessed *all* the characteristics alleged to produce all the positive spillovers at issue. If a significant effect on economic growth cannot be detected with this sample of universities, it probably cannot be detected at the state level of aggregation.

States were also chosen according to certain criteria:

- private colleges accounted for less than one-third of the higher education student enrollment, as a large presence of private universities in a state would confuse the policy implications of the results of this study (this criterion eliminated all the New England states, except Maine, and Maryland, New York, Pennsylvania, and Utah);[3]
- the state maintained only a "single-tiered" university system, as double-tiered systems might have served to diffuse higher education investments and university spillovers (this criterion eliminated California and New York); and
- the state existed (as a state) in all of the decades covered by the study (this criterion eliminated Alaska and Hawaii).

Decades were included if data for the key variables could be found for them. As a reliable series on state personal income is available only back to the late 1920s, the first full decade available for this study became the 1930s. With the 1980s being the last full decade available for this study, six decades could be included.

The data set consists, then, of 38 states across six decades, or 228 observations. The six decades' data were pooled.

5.1. Key Variables

To construct the measures of university community size, population densities were extracted for the host county (or counties in the case of some universities) or MSA of each university for each decennial census involved. First, the universities were selected, according to the criteria listed above, by perusing the lists of universities in contemporary editions of the World Almanac (multiple years) dating back to the earlier decades of this century. Then, the universities' precise geographic locations were identified on maps that incorporated county boundaries. Finally, the county-level population data were tediously transcribed from hard copy state census volumes for six decennial censes, 1930–1980 (that is, 228 separate census publications).

If a university straddled county lines, the populations of the two counties were summed. If a state had more than one university that met the criteria for university inclusion (most states did), then more than one county's, or pair of counties', population was counted.

Because counties come in many shapes and sizes, with some small states having many small counties and some larger states having not so many very large counties, for example, an adjustment for county size was thought to be in order. Without it, any university town size effect would be artificially high in states with large counties and artificially small in states with small counties.

The variation in county sizes from state to state can be very large. For example, the state of Maryland contains more than three times the population of Nebraska (almost 5 million to about 1.6 million), but

Maryland has only 23 counties compared to Nebraska's 100. Maryland's average county population is 217,000 persons compared to Nebraska's 16,000.

The adjustment consists of standardizing the two measures of university host community size by the county mean in the state, and then dividing by the number of campuses in the states.[4] Specifically, for the measure of the proportion of the state population living in university communities:

$$U_p = H_p/C_p/N,$$

where:
H_p = proportion of state population in university host counties,
C_p = proportion of state population in mean county, and
N = number of public university campuses in state.

The result, U_p, is the proportion of the state population residing in the mean university community, measured in mean county units.

For the measure of the absolute size of university communities:

$$U_s = H_s/C_s/N,$$

where:
H_s = sum of the populations of university host counties,
C_s = population size of mean county, and
N = number of public university campuses in state.

The result, U_s, is the size of the population residing in the mean university community, measured in mean county units.

Some readers may note that these constructions produce measures that represent the *average* university town proportion or size in states with more than one university campus rather than, strictly speaking, a variable that represents the size of every separate host community for every university included in the data set.

State population density and employment density were obtained from readily available census compilations of seven decennial censes, 1930–1990. State aggregate personal income was obtained from the Commerce Department's Bureau of Economic Analysis (Bureau of Economic Analysis, U.S. Department of Commerce, 1929–1995, 1948–1995). It is a consistent series, using the same definitions for all years. The income variables were adjusted using the Bureau of Labor Statistics' CPI-U series (Bureau of Labor Statistics, U.S. Department of Labor, April, 1996), the only consistent series dating back to before 1930.

6. ANALYTIC MODEL

A general equilibrium model of regional population and employment growth is borrowed from Carlino and Mills (1987) (who attribute some of its development to Steinnes and Fischer). The Carlino and Mills model was designed to integrate within one model the variety of different interregional movements of jobs and people, such as: from metropolitan central cities to suburbs; from metropolitan to non-metropolitan areas; and from the frostbelt to the sunbelt. Further, unlike in most earlier studies which assumed that employment growth is exogenous and a determinant of population growth, they posed a simultaneous determination of population and employment growth, in a general equilibrium model in which both households and firms are assumed to be geographically mobile.

Carlino and Mills (1987) first used the model to analyze the effects of economic, demographic, climatic, and policy-related variables on the growth of population and employment during the 1970s, using a data set consisting of about 3000 U.S. counties. The general form of the Carlino and Mills growth model is:

$$P_{t+1} = f(P_t, E_{t+1}, C_t, A_t)$$

$$E_{t+1} = g(E_t, P_{t+1}, C_t, B_t).$$

I expand the model in the most logical way in order to explicitly incorporate personal income as an outcome variable. Since I have no preexisting rationale for excluding it from any one of the three equations, I place the test variable, either university community proportion of the state population or the absolute size of the university community, in each of the three equations.

The general model becomes:

$$P_{t+1} = f(P_t, E_{t+1}, Y_{t+1}, U_t, \mathbf{C}_t, A_t)$$

$$E_{t+1} = g(E_t, P_{t+1}, Y_{t+1}, U_t, \mathbf{C}_t, B_t)$$

$$Y_{t+1} = h(Y_t, P_{t+1}, E_{t+1}, U_t, \mathbf{C}_t, D_t),$$

where:
P and E are state population and employment densities (log),
Y is aggregate state personal income (log),
U is the test variable, either proportion of the state population living in the average university community or absolute size of the average university community (log),
C is a vector of common control variables, which include the percent of the state population living in urban areas, the number of public university students per capita, state government revenues per capita (i.e. taxation), and state and decade dummy variables, and
A, B, and D are unique variables that serve to identify the model—rate of property crime, proportion of the state population that is elderly, and proportion of the state population that is black.

Even aside from the expansion of the model to include state aggregate personal income as an explicit endogenous variable, the empirical model used for this study needed to vary from that used by Carlino and Mills in other ways. For one thing, Carlino and Mills' unit of analysis was a county, not a state. Some data that make sense for county-level analysis make less sense for state-level analysis, and vice versa. Likewise, some data available at the county level are not available at the state level, and vice versa.

Furthermore, they were studying events in the 1970s and 1980s. Some data available for the 1970s and 1980s are not available for the 1930s (e.g. industrial development bonds, interstate highway miles).

Nonetheless, the model used here bears more similarity to the Carlino and Mills model than difference, even in its cast of variables. I tried to include the same endogenous variables, plus personal income, and control variables for crime (both against persons and against property), state government revenue per capita (i.e. taxation), percent unionization, percent of the population that is black, and percent illiterate (i.e. percent non-graduates). I use state dummies where they used regional dummies. As Carlino and Mills didn't, I include control variables for the percent of state population that is elderly—it represents, along with the great black migration northward in the middle decades of the century, one of most important demographic migrations of the century. For blacks, the route was from the south to the north; for the elderly it has been from the midwest and northeast to the south.

The variables for illiteracy (i.e. level of education), violent crimes (i.e. those against persons), and percent of the state workforce that is unionized proved to be unusable because they were too highly correlated with too many other variables.

I also include the percent of state population that is urban as a control variable. Given the structure of the test variables—university host community state population proportion or absolute size—they would tend to take on larger values in more urbanized states and smaller values in rural states, whether they affected state growth or not. The value of university host community state population proportion will, other factors being equal, be larger in states where the population of the state is more concentrated (i.e. more urbanized). If the level of urbanization itself contributes to state growth, leaving it out of the model could allocate some of its influence on state growth by default to the university variable, making it a statistically significant predictor of state growth when it really is not.

Likewise, the value of the other test variable—absolute size of university communities—will tend to be larger in states where the population of the state is more urbanized. So, the state's level of urbanization needs to be controlled.

Similarly, because empirical studies have shown that greater state expenditures on higher education are associated with faster state growth, everything else being equal, I have included a control variable for the level of state investment in higher education—the number of students per capita attending public state universities. (While I would have preferred to use higher education expenditures as most studies have, I found through trial and error that I could not obtain a reliable series dating back to 1930.) The exogenous factor of higher education's absolute size in a state can affect the test variables. Other things being equal, university host community size will be larger the larger the university and the larger the public investment in the university. So, the absolute size of each state's investment in higher education needs to be controlled.

Because I cannot account for all the other pertinent characteristics of the states through specific control variables, I also incorporate state dummy variables in each equation of the model for all the included states (with Kansas as the base case).

Since I cannot account for all the other pertinent characteristics of the various time periods included in the span of time from 1930 through 1990, I also incorporate decade dummy variables in each equation of the model for each included decade (with the 1940s as the base case).

7. RESULTS

Tables 1 and 2 contain the results of two-stage least squares regressions run on the revised Carlino and Mills model using the university host community state population proportion test variable. The null hypothesis is that the proportion of the state population residing in university communities has no effect on state growth, measured either with population, employment, or personal income. This hypothesis leads us to focus on the size of the coefficient for the test variable. The null hypothesis proposes that the coefficient is zero; the alternative hypothesis that the coefficient is greater than zero.

Table 1 displays the results of F-tests and t-tests conducted on the coefficient of the test variable, proportion of state population residing in university communities, in the three equations of the model. The coefficient in the income equation appears to be greater then zero (F-test or t-test, one- or two-tailed). The coefficient in the employment equation is statistically significant only at a level of 0.10. That for the population equation is, indeed, negative.

For the absolute size of university host community test variable, the test variables' coefficients were lower in all but one equation, but still statistically significant in the income equation (F-test or t-test, one- or two-tailed). Table 2 displays the results.

Table 3 displays comprehensive results from the two-stage least squares regression using the revised Carlino and Mills model, with the proportion of the state population living in the mean university community as the test variable.

Table 1. Tests on coefficient for state population proportion in mean university host community

Dependent variable	F-ratio on coefficient for state population proportion in mean university host community	t-ratio on coefficient for state population proportion in mean university host community
State population at end of decade (log)	1.5570	−1.248
State employment at end of decade (log)	2.2745	1.508
State aggregate personal income at end of decade (log)	4.8747*	2.208*

*Significant at $p = 0.05$ (one- and two-tailed).

Table 2. Tests on coefficient for absolute size of mean university host community

Dependent variable	F-ratio on coefficient for absolute size of mean university host community	t-ratio on coefficient for absolute size of mean university host community
State population at end of decade (log)	0.5294	−0.728
State employment at end of decade (log)	1.2300	1.109
State aggregate personal income at end of decade (log)	4.3151*	2.077*

*Significant at $p = 0.05$ (one- and two-tailed).

The model obviously fits the data quite well. F-values ascend into the thousands for two of the three equations, and exceed 700 for the other. Adjusted R^2s well exceed 0.99 in all three equations, even though each contains over 50 variables.

7.1. Sensitivity Analysis in Search of Optimal Host Community Size

Results of the aforementioned regressions that employed the second of the test variables—absolute size of mean university community—suggest that the larger the university host community, the faster aggregate state personal income and employment will grow. Is the relationship really strictly linear? That is, do the data suggest to us that the larger the host community size is, the better...without limit? Or, perhaps, does larger host community size induce faster income and employment growth just up to some threshold level, where diseconomies of scale kick in (congestion and pollution are frequent candidates) and ever larger host community size no longer correlates with state income and employment growth?

In order to test these speculations, I converted the absolute community size variable into dummy variables with four values based on size (small, medium, large, very large). I ran the revised Carlino and Mills model under various permutations of dummy variable coverage of the range of sizes. That is, I varied the range of host community sizes represented by each dummy value. In some regression runs, the medium category might include host communities of 25,000–50,000 population, while in others it might include host communities of 40,000–100,000 population, and so on. Then, I looked at the pattern of the coefficients across the test variable dummy variables.

State aggregate personal income seems to grow without limit as university communities get larger. That is, there does not seem to be an upper threshold size of university communities where agglomeration diseconomies balance out economies. Indeed, the advantage to state aggregate personal income growth appears to accelerate as university communities get larger.

State employment growth, however, does seem to have a threshold level or and optimal mean university community size, at about 300,000–400,000 persons.

Whereas employment growth over mean university community size appears to manifest itself in a concave function, population growth over mean university size would appear to form a convex function. State population growth appears to decelerate as mean university community sizes grow to about 100,000 persons but, above mean university community sizes of 200,000, state population growth appears to accelerate.

7.2. Analysis

I experimented with the model in other ways, too, including trying different sets of variables and fitting the model to a non-linear regression procedure. The pattern of the test variables across the three equations remains consistent. The mean state population proportion living in university communities has its strongest weight in the income equation, sometimes as a statistically significant positive predictor of state aggregate income growth. It is weaker in the employment equation, statistically (positively) significant only in the model with a reduced set of right-hand-side variables (which is still probably a valid model, given the presence of adequate proxies). State population proportion living in university communities also has a weak, but negative, presence in the population equation.

The pattern across the three model equations is

Table 3. Structural equations for state population, employment, and income, with host communities' state population proportion, U.S., 1930–1990; coefficient (t-value)

	State population at end of decade (log)	State employment at end of decade (log)	State aggregate personal income at end of decade (log)
Intercept	−2.186(−1.372)	3.889(2.884)**	11.981(8.578)***
State population (log)	0.220(2.283)*		
State employment (log)		0.088(1.080)	
State aggregate personal income (log)			0.247(2.641)**
State population at end of decade (log)		1.036(9.038)***	1.552(2.766)**
State employment at end of decade (log)	0.694(6.062)***		−1.025(−1.875)*
State aggregate personal income at end of decade (log)	0.158(1.727)*	−0.257(−3.235)***	
Percent of state population in university host communities	**−1.944 × 10^5 (−1.248)**	**3.200 × 10^5 (1.508)**	**9.009 × 10^5 (2.208)***
Public univ. students/capita	−0.429(−0.430)	1.488(1.210)	−0.882(−0.359)
Percent urban of state population	−0.002(−2.216)*	0.005(4.519)***	0.009(3.598)***
State revenue/capita (taxation)	4.10 × 10^7 (1.907)*	−7.23 × 10^7 (−2.575)**	−0.137 × 10^5 (−2.529)**
Percent black of state population	−0.001(−0.668)		
Percent elderly of state pop.			2.407(2.989)**
Crimes against property (per 100,000 inhabitants)		0.819 × 10^5 (0.326)	
1930s	0.141(2.804)**	−0.254(−5.739)***	−0.570(−8.329)***
1950s	−0.025(−1.433)	0.037(1.867)*	0.009(0.169)
1960s	−0.111(−2.645)**	0.141(3.193)***	0.267(3.073)**
1970s	−0.226(−3.546)***	0.321(4.538)***	0.540(3.107)***
1980s	−0.345(−4.034)***	0.465(4.340)***	0.781(3.057)**
Alabama	0.115(2.383)**	−0.072(−2.040)*	−0.082(−1.064)
Arizona	0.204(9.249)***	−0.190(−3.665)***	−0.140(−0.966)
Arkansas	0.133(4.720)***	−0.129(−3.230)***	−0.240(−2.648)**
Colorado	0.064(3.093)***	−0.052(−1.622)	0.019(0.265)
Delaware	0.091(2.053)*	−0.116(−1.998)*	−0.060(−0.534)
Florida	0.092(1.526)	0.038(0.994)	0.106(1.572)
Georgia	0.075(1.298)	0.004(0.081)	0.002(0.019)
Idaho	0.131(3.908)***	−0.176(−3.788)***	−0.220(−1.915)*
Illinois	−0.102(−1.991)*	0.184(3.282)***	0.374(3.361)***
Indiana	−0.033(−1.135)	0.080(2.289)*	0.177(2.651)**
Iowa	−0.061(−2.713)**	0.086(2.762)**	0.115(1.660)*
Kentucky	0.077(3.524)***	−0.061(−1.706)*	−0.077(−1.025)
Louisiana	0.161(2.720)**	−0.121(−3.272)***	−0.120(−1.231)
Maine	0.080(2.599)**	−0.119(−3.242)***	−0.219(−2.707)**
Michigan	−0.043(−0.946)	0.117(2.603)**	0.311(3.859)***
Minnesota	0.006(0.108)	0.001(0.004)	−0.094(−0.647)
Mississippi	0.167(2.737)**	−0.126(−2.934)**	−0.220(−2.363)**
Missouri	−0.025(−0.921)	0.064(1.952)*	0.093(1.402)
Montana	0.076(2.328)**	−0.129(−3.148)***	−0.144(−1.540)*
Nebraska	0.012(0.447)	−0.036(−1.134)	−0.110(−1.816)*
Nevada	0.121(3.245)***	−0.096(−1.291)	0.045(0.343)
New Jersey	−0.062(−1.484)	0.116(2.705)**	0.278(3.181)***
New Mexico	0.252(7.323)***	−0.312(−5.330)***	−0.344(−1.784)*
North Carolina	−0.012(−0.208)	0.142(3.235)***	0.276(3.136)***
North Dakota	0.084(2.052)*	−0.153(−3.615)***	−0.230(−2.296)*
Ohio	−0.057(−1.347)	0.125(2.457)**	0.254(2.774)**
Oklahoma	0.074(3.661)***	−0.085(−2.953)**	−0.099(−1.357)
Oregon	0.011(0.470)	0.023(0.760)	0.089(1.638)
South Carolina	0.100(1.708)*	−0.021(−0.604)	0.020(0.287)
South Dakota	0.054(1.361)	−0.104(−2.577)**	−0.194(−2.425)**
Tennessee	0.074(2.350)**	−0.033(−0.792)	−0.064(−0.816)
Texas	−0.002(−0.048)	0.114(2.338)**	0.277(3.300)***
Virginia	0.009(0.156)	0.102(2.747)	0.271(4.063)***
Washington	0.017(0.631)	0.023(0.723)	0.136(2.269)*
Wisconsin	−0.060(−2.227)*	0.108(3.007)**	0.191(2.606)**
West Virginia	0.131(5.499)***	−0.159(−4.353)***	−0.194(−1.751)*
Wyoming	0.092(2.437)**	−0.141(−2.473)**	−0.094(−0.757)
F-ratio	3878, $\alpha = 0.0001$	2084, $\alpha = 0.0001$	738, $\alpha = 0.0001$
R^2 (adjusted)	0.9988	0.9978	0.9939
Degrees of freedom	227	227	227

Significant at: $*p = 0.05$ (one-tailed); $**p = 0.01$; $***p = 0.001$.

much the same for the other test variable—mean absolute size of university communities—only the coefficients are weaker.

Any thoughts I can contribute to explain why larger university host communities seem to contribute to state income and employment and detract from population should certainly be considered speculative.

One constructive way to frame the issue may be to think about what happens to newly trained university graduates. If they attend a university in the middle of nowhere, they are unlikely to stay there after graduation. They will find a job, which may be in their state or not. If they are attending a university in the middle of a metropolitan area, however, they might well remain. Indeed, they may have already built up some relationship, personal or professional, in the community that they continue after graduation.

A similar relationship portends with professors who want to collaborate with others outside the university or with non-faculty scientists or engineers who might like to collaborate with those inside the university. Such relationships are more possible if the university lies in a community with its own vitality and reason for being. Note that all the people involved in these two examples—university graduates, professors, scientists and engineers—receive relatively high incomes.

It's no leap of logic to theorize that larger university host communities have a greater potential to attract and retain high income earners and, thus, help accelerate state income growth.

It less clear why large university host communities should induce higher levels of state employment growth. Perhaps, university–industry collaboration helps to create more employment and, perhaps, more types of employment than would otherwise exist in the state.

As for why large university host communities should detract from state population growth, perhaps the relatively low fertility of their high income residents (and their students) contrasted with the relatively high fertility of the low income residents of the other states offers some explanation.

7.3. Regression Diagnostics—Autocorrelation and Heteroskedasticity

Durbin-Watson *d*-statistics were calculated on all equations to test for (spatial or temporal) autocorrelation. The *d*-statistic exceeds 2.0, with first-order autocorrelation coefficients remaining under 0.15, in all three equations. Thus, autocorrelation, and the damage it can do to meaningful interpretation of coefficients, does not appear to be a problem.

Examination of residual plots reveals little problem with heteroskedasticity as well. Some relatively unimportant variables—proportion of the state population that is black and the number of property crimes committed per 100,000 inhabitants—seem to have heteroskedastic errors and distributions censored at zero. (Think of states in the Rocky Mountains, Plains, or upper New England that have few black residents or little property crime.)

7.4. Regression Diagnostics—Multicollinearity

The empirical model used in this study employs three equations, each containing either a beginning-of-decade or end-of-decade measure of state population, employment, and aggregate personal income. As one might well imagine, these three variables are highly correlated in each equation.

The high level of multicollinearity in and of itself is not necessarily a problem. The model still has lots of predictive power. For example, one finds end-of-decade state population and state employment resting harmoniously on the right side of the state aggregate income equation, each, as it were, with something different to say. Population and employment are correlated with each other at 0.99 (Pearson r). But in the income equation they are each statistically significant (at $\alpha = 0.05$) and of opposite sign.

One has to believe, however, that the high degree of multicollinearity reduces the significance of the coefficients for all variables, including the test variables. This provides support for an argument that the coefficients of the test variables are *underestimated* in the adapted Carlino and Mills model. For more details on the model's multicollinearity, see Appendix A.

8. POLICY IMPLICATIONS

This research is significant for higher education facility planning. Policy makers may wish to situate universities or university facilities in larger population centers in a deliberate attempt to induce greater regional income growth. If a state currently has an urban university and a small town university, it can bias its investment decisions toward the urban school. New faculty hires, new programs, and new capital investment can be directed to the urban campus.

If a state has universities only in small towns, it is forced to open a branch campus or a new university in the city in order to benefit. Again, new faculty hires, new programs, and new capital investment can be directed to the urban campus. If the state has two small town universities, it could play them against each other by offering expanded programs and facilities to the one willing to move programs to the city campus.

The implications are greater for developing countries where siting decisions for public institutions are still being made.

This research also has implications for organizing the implementation and dissemination of the knowledge that universities produce. In the United States, many are concerned that despite the creative talent, expertise, and prolific output of our academic centers, academic ideas are only slowly disseminated outside or put into practical use. Part of the problem may be proximate. If, for example, a state treasurer relies on the advice of an economics professor at the state university, she can call her on the phone or send her an e-mail anywhere in the state. But if the professor works nearby, they can see each other more often and work together more closely.

Is university expertise exploited more efficiently if the exploiters are located nearby? If it is, state governments may wish to encourage the proximate location of university experts and those who can use the expertise. The latter may be industry research and development labs, corporate headquarters, non-profit social action agencies, arts ensembles, or even state governments.

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NOTES

1. Localized positive spillovers from universities are also identified in the calculation of quality of life ratings of cities in publications like the *Places—Rated Almanac* and at least five regular circulation popular magazines —*Money, Fortune, Forbes, Inc.* and *U.S. News and World Report*—which rank U.S. cities for their "livability." Explicitly and implicitly, many of the factors used to calculate cities' ratings put university communities at an advantage in the comparisons. Some examples: "recession resistance," "low crime rate," "close to colleges," "high civic involvement," "low unemployment rate," "museums nearby," "proximity to major sports events," "local symphony orchestras," "plentiful doctors," "many hospitals," and "affordable medical care" (Readers' poll, 1994). These hedonic advantages can, obviously, be captured by more people if there are more people there to capture them, as there would be in larger towns or cities. *Money* magazine sums up the quality of life advantages for university "towns" in a sidebar: "What makes these towns such terrific places to live? They start off with nearly recession-proof economies, says John Kasarda, business professor at the University of North Carolina–Chapel Hill. College towns also benefit from 'urbanicity without urban problems'—recreation, culture and athletics generally without much crime, pollution...." Translate "town" into "neighborhood" for universities in big cities.
2. This does not suggest that all higher education expenditures produce equally high localized positive spillovers. Some higher education expenditures may, indeed, leverage equally high or higher localized positive spillovers but, probably, most do not.
3. While it is true that private universities may provide many of the same benefits as public universities, and without taxation, not all the possible benefits are present. The public may not have the same access to the cultural, intellectual, and athletic amenities at a private university as they do at a public university. The private university's faculty and staff may not be as well-connected in professional networks with state officials as public university faculty and staff can be with their fellow state employees. A private university may have very selective entry requirements, cater to students of particular religious denominations, and demand relatively high tuition, thus not offering the same ease of access to local students that a public university can. Data on private universities might not offer this study much explanatory power either. Outside the Ivy League and Notre Dame, almost all large, private research universities seem to be located in large cities, thus providing little variation. Finally, information from private universities would be less policy relevant since public officials have little say over strategic decisions at private universities.
4. Adjustments were made in calculating the mean county size if single universities straddled county lines. For example, in a state with just one university included in the data set, a university that straddled county lines, the university host community size was represented by the sum of the two county populations. Then, mean county population size for the state was calculated by dividing the state population by the number of counties in the state times two, thus adjusting for the fact that the university community includes two counties.

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APPENDIX A.

I ran several iterations of the model with different combinations of variables deleted in order to determine the effect on the coefficients of reducing multicollinearity. The most logical iteration subtracted one variable of the trio of population, employment, or income from the right side of each of the three equations. The weakest (as measured by t-ratio) of the three was subtracted in each case: end-of-decade state aggregate income was taken out of the population equation; beginning-of-decade employment was taken out of the employment equation; and end-of-decade employment was deleted from the income equation.

Superficially, this action deleted just three variables from a system of three equations that contained over 150 variables. But these three were gargantuan contributors to the equations' multicollinearity, producing almost half of it. Their deletion diminished the condition numbers for each of the three equations by 40% from over 4000 (to about 2300) but seemed not to improve the model's predictive power very much.

Our first test variable—state population proportion in the mean county—in the employment equation, for example, enlarges its coefficient (see Table 4) to become statistically significant (at $\alpha = 0.05$, one-tailed test). But, the coefficients in the other two equations become weaker after the attempt to reduce multicollinearity.

Deleting just one variable from each equation of the model for the purpose of reducing multicollinearity probably does little damage to the model's validity. For example, end-of-decade state employment was removed from the income equation, leaving behind end-of-decade state population, not at all a bad proxy for employment. Again, end-of-decade state employment and population share a Pearson r of 0.99. Deleting any more variables from each equation, however, would increase the risk to the model's validity and for left-out-variable bias.

Besides, it doesn't seem to help reduce multicollinearity much anyway. I tried running the model with two of the three variables—population, employment, and income—deleted from the right-hand side of each equation. The condition number for each equation remains well into the hundreds, as related state dummy variables (usually neighboring states) start to clump together.

Table 4. Tests on coefficient for state population proportion in mean university host community with reduced set of variables

Dependent variable	t-ratio on coefficient for state population proportion in mean university community
State population at end of decade (log)	−0.87
State employment at end of decade (log)	1.68*
State aggregate personal income at end of decade (log)	1.98*

Significant at $*p = 0.05$.