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Patricia Beeson

Edward Montgomery

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ABSTRACTS

Despite the presence of anecdotal evidence linking regional economic growth and the presence of quality universities in such areas as the Silicon Valley in California and Route 128 in Boston, there have been few systematic studies of the relationship between universities and local economies. In this paper we examined the relationship between four measures of the quality or extent of activities of colleges and universities in an area and various measures of the local labor market activity, including employment, income and migration.

We could not reject the hypothesis that there is no relationship between our measures of university activity and the overall employment rate in an SMSA. We did, however, find evidence that colleges and universities affect the composition of employment in an SMSA. The probability of being employed as a scientist or engineer and the probability of being employed in a high-tech industry were both found to increase with the amount of R&D funding at local universities. The probability of being employed in a high-tech industry was also found to be positively related to the number of graduates from local universities. We also found evidence that employment growth rates and earnings are higher in areas with good universities. Finally, the data can not reject the hypothesis that net migration is unrelated to universities.

Patricia Beeson
Department of Economics
University of Pittsburgh
Pittsburgh, PA 15260

Edward Montgomery
Department of Economics
Michigan State University
East Lansing, MI 48824

I. Introduction

Much of the work on the determinants of regional growth has focused on the role of tax incentives and unionism on business location decisions.[1] Perhaps because of the mixed record of success associated with using tax policies and because of the apparent success of areas such as Route 128 near MIT and the Silicon Valley near Stanford, attention has turned to the role of colleges and universities in economic development. Indeed some areas, such as Raleigh-Durham, North Carolina and San Antonio, Texas are attempting to improve local universities, particularly in the areas of science and engineering, in the hopes of duplicating the success of Boston and the Bay Area. This may well be a rational strategy since, as seen in Table 1, many of the areas of the country where rapid growth of high-tech industries has occurred are areas that have top research universities. However, despite the considerable antidotal evidence, there is little systematic evidence documenting a relationship between universities and local economies. This paper attempts to shed some light on this issue by examining the relationship between colleges and universities and local labor market conditions.

We consider two ways in which colleges and universities may affect local labor markets. First, in their role as educators, universities increase the skills of local workers which directly increases the employment and earning opportunities of these university graduates. In addition, by raising the average level of human capital, universities may increase the productivity of all workers in the area if, as suggested by Lucas (1988), the ability to develop and

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[1] See Bartik (1985), Ecker and Syron (1979) and Mulkey and Dillman (1976) for discussions of the impact of taxes and other variables on firm location decisions and regional growth.

implement new technologies depends on the average level of human capital in the economy. This notion that the skill composition of the labor force affects the technology used by firms is supported by Bartel and Lichtenberg (1987) and Woznaik (1984, 1987) who find that skilled and educated workers are better able to implement new technologies. To the extent that university graduates do not migrate, firms in areas with strong universities may then have an advantage in implementing new technologies thereby increasing both worker productivity and labor demand[2]

Colleges and universities may also affect local economies through their research activities. National studies of the effects of public research on the private sector find technological innovation in private industry is related to research conducted at basic research facilities, such as universities (Nelson [1986]). This may be the result of direct university cooperation, as suggested by Cox (1985), O.T.A. (1984), and N.S.F. (1983), or of spillovers from universities to private industry of the type discussed by Bernstein and Nadiri (1988), Kennedy (1986) and Jaffe (1986).

Whether or not research conducted at universities differentially affects the local economy depends on the extent to which a firm's ability to benefit from these technological spillovers depends on proximity. Jaffe (1989), using states, and Bania (1989), using metropolitan areas as the unit of analysis, examine this issue and find rates of innovation, measured by patents, in private industry are positively related to the amount of research conducted at local universities. This relationship between university research and the local economy is further

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[2] Whether graduates remain in the area and attract firms wishing to employ them, or they move to other area where there are firms willing to employ them, depends on the relative mobility of firms and workers across areas. See Muth (1971) for a discussion of this issue.

supported by Bania, Eberts and Fogarty's (1987) finding that new firm openings are positively related to the amount of research conducted at local universities.

In this paper we examine whether these technological spillovers and labor force composition effects have translated into measurable improvements in local labor market conditions. In section II we discuss the empirical model and data used. In section III the empirical results are presented and in section IV conclusions are drawn.

II. Empirical Specification and Data

If universities have an important impact on local labor markets, then in the long run we would expect area wages and employment to be related to some measures of university size or quality. Using the Standard Metropolitan Statistical Area (SMSA) as our measure of the local labor market, we explicitly test this proposition by estimating the following reduced form equations in which employment, earnings are expressed as functions of individual area and university characteristics that determine the supply and demand for labor:

$$(1)\quad EMP_{ij} = a_1 + IND_{ij}*B_{I1} + AREA_j*B_{A1} + CU_j*B_{CU1} + REG_j*B_{R1} + u_{1ij}$$

$$(2)\quad LINC_{ij} = a_2 + IND_{ij}*B_{I2} + AREA_j*B_{A2} + CU_j*B_{CU2} + REG_j*B_{R2} + u_{2ij}$$

in which EMP_{ij} is a dummy variable indicating the 1980 employment status of individual i in SMSA j ($EMP_{ij} = 1$ if employed, 0 otherwise); $LINC_{ij}$ is the log of individual i's annual income in 1980. IND_{ij} and $AREA_j$ are vectors of variables reflecting characteristics of the individual and SMSA in which they live; REG_j is a vector of regional dummies where North Central is the omitted region; and

CU_j is a vector of variables on colleges and universities in the SMSA. This choice of empirical specification is similar to that used by Roback (1982), Herzog, Schlottman, and Johnson (1986) and Gyourko and Tracy (1989) in their studies of local labor markets.

Since equilibrium levels in local labor markets may be slow to adjust to university induced demand shocks, we may observe that universities have an impact on various disequilibrium indicators like migration or the rate of growth of employment. To test for this we estimate the following equations:

$$(3) \quad EMPGRO_j = a_3 + AREA2_j * B_{A3} + CU_j * B_{CU3} + REG_j * B_{R3} + u_{3ij}$$

$$(4) \quad NETMIG_j = a_4 + AREA2_j * B_{A4} + CU_j * B_{CU4} + REG_j * B_{R4} + u_{4ij}$$

where $NETMIG_j$ = net migration to SMSA j between 1975 and 1980; and $EMPGRO_j$ is the growth rate of employment in $SMSA_j$ between 1980 and 1988.

Individual and Area Data

Data on individual characteristics, including employment status, earnings and migration, are from the one percent "B" sample of the Public Use Microdata Sample (PUMS) of the 1980 Census of Population and Housing. The advantage of these data is that they are one of the few sources of a large sample of individuals who have migrated across metropolitan areas. Unfortunately the time period covered by the data does not allow us to examine the more recent experiences of regions including the turnaround of New England during the 1980s.

Since part of our analysis involves examining migration patterns, we limit our sample to individuals for whom information concerning location in 1975 is available (approximately fifty percent of the PUMS sample). In addition, the sample was limited to non-institutionalized civilians between the ages of 23 and

65 in 1980, who in both 1975 and 1980 resided in one of the 218 SMSAs for which other data were available. In addition, college professors are omitted to focus on spillovers from colleges and universities to local employment. Since universities may have a stronger impact on high-tech industries than other industries we were also interested in looking at the labor market for high-tech workers. In order to have a sufficient number of high-tech workers, scientist and engineers were over sampled. The resulting data set includes over 7,000 scientists and engineers and 20,000 other workers.

The vector of individual characteristics, IND_{ij} includes: age in 1980, years of schooling, and dummy variables indicating marital status, gender, and race. The vector of area attributes, $AREA_j$, includes: the average number of heating degree days over the period 1950-80, the student-teacher ratio in 1977, and crime rates in 1975. Two measures of local taxes are included: sales and income taxes relative to income, and state business taxes relative to business income in 1977. Population size of the SMSA (entered as a quadratic), annual housing costs based on 1977 housing prices, and the percent of SMSA employment in manufacturing industries, a proxy for area industry mix, are also included.

In addition to the aforementioned area characteristics, $AREA2_j$, which is used to estimate the migration and employment growth equations, includes: SMSA unemployment rate in 1975; per capita income in 1974; and to capture labor force composition effects, the percent of the 1975 population that are scientists and engineers. The migration equation also includes a measure of employment growth from 1970-75. A further description of the data sources for these variables is contained in the Data Appendix.

College and University Data

We hypothesize that universities may affect local labor markets through their research activities and through their education and training of workers. In our empirical model we use total R&D funding as a proxy for research conducted at universities in the SMSA. This variable is entered as a quadratic to capture nonlinearities of the type discussed by Bania, Eberts and Fogarty (1987). We also include the number of bachelor's degrees awarded and the percent of bachelor's degrees awarded in science and engineering at universities in the SMSA as measures of education and training conducted at local universities. Finally, we include the number of science and engineering programs rated as one of the top 20 in the country as a proxy for the quality of science and engineering programs at local universities. All of these variables reflect 1980 values.

III. Empirical Results

Logit parameter estimates of the effect of our measures of colleges and universities on employment probabilities are presented in Table 2 column 1. As found in other studies, the probability of a worker is employed rises with age and years of schooling and is higher for whites and males (see Appendix Table A1). In addition to individual characteristics, the probability of employment depends to some extent on characteristics of the area in which an individual lives. The probability of being employed is found to be significantly higher in SMSAs with cold climates, low crime rates, low student-teacher ratios, high housing costs, and low sales and income tax rates. Finally, the probability of employment is found to increase, at a decreasing rate, with city size, and increase with the percent of total employment in an SMSA that is in manufacturing.

None of our measures of university quality have a significant effect on the probability an individual worker is employed. These weak results may partially reflect collinearity between our measures of university quality. Not surprisingly, the simple correlations between R&D spending, program rating and total bachelor's degrees are high.[3] Nonetheless, a likelihood ratio test indicates that the hypothesis that the probability of being employed is unrelated to the college and university variables as a group can not be rejected at the 10 percent level of confidence (likelihood ration = 2.2).

Before concluding that our university variables are of limited importance it is necessary to look at the point estimates to determine whether the economic significance of these variables is as limited as their statistical significance. As a first cut we calculate the elasticity of the probability of employment with respect to the college and university variables. As seen in Table 2, these elasticities all appear to be quite small.

Perhaps a more informative way to look at the economic significance of these variables is to calculate the probability of employment for a base case individual. To do this we evaluated all of the continuous variables in our employment equation at their respective sample means and the dummy variables are set equal to zero. The probability of employment for this individual, who is a single 40 year old white male living in the North Central region of the country is .922. If we consider an SMSA in which R&D spending is one standard deviation above its mean value, the probability of employment for our base case worker changes by less than .1 of one percent. Similarly, a standard deviation increase in the mean value of university program ratings or total bachelor's degrees

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[3] The correlation between R&D spending and program rating is .83 while the correlation between it and total bachelor's degrees is .79.

awarded changes the probability of employment by at most .2 of one percent. Degrees awarded in science and engineering as a percent of total degrees has the largest effect of any of the university variables, but this has a smaller impact than that of our tax variables which most previous research have found to be of limited importance.[4]

Even if we look at the difference in probability of employment for our base case worker in the SMSA where the university variables have their highest and lowest values we find only small differences. For instance, the probability of employment would still be .923 regardless of whether our base case worker resided in Boston, Mass., the SMSA where R&D spending was highest, or in one of the SMSAs where there was no R&D spending at local universities. The effects of program rating and total bachelor's degrees are only slightly larger but in neither case does the probability of employment change by more than .006. The percent of degrees awarded in science and engineering again has the largest effect changing the probability of employment by a little more than 2 percent, again approximately the same size effect as taxes.[5]

As a check on the robustness of our conclusion that universities have only a limited impact on area employment we tried a number of other empirical specifications. First, since the SMSA is an arbitrary geographic definition and universities generally educate students from a broader geographic area, state wide totals of the university measures were also considered. The results,

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[4] A standard deviation increase in either of the tax measure decreases the probability of employment by about .4 percent while a similar increase in the percent of graduates in science and engineering decreases the probability of employment by .3 percent.

[5] The range is .923 to .918 for program rating; .920 to .926 for total bachelor's degrees awarded; .928 to .906 for %degrees in science and engineering; .930 to .909 for business taxes; and .931 to .913 for sales and income taxes.

however, are similar to those using only the SMSA totals. Second, the percent of total university R&D funded by private industry was included as a proxy for the strength of the ties between universities and local industry, but it was found to be insignificant. Finally, since Federally Funded Research and Development Centers, such as Oak Ridge, are arguably different from universities a dummy variable was included to indicate the presence of such a Center. Again, the inclusion of this measure again did not qualitatively change our results.

While colleges and universities do not appear to affect the probability of employment, they may affect its composition. To test for this we examined the impact of universities on the probability that an individual is employed in a high-tech job or in a high-tech industry, conditional on being employed, by estimating the following:

$$(5)\quad SE_{ij} = a_5 + IND_{ij}*B_{I5} + AREA_j*B_{A5} + CU_j*B_{CU5} + REG_j*B_{R5} + u_{5ij}$$

$$(6)\quad HT_{ij} = a_6 + IND_{ij}*B_{I6} + AREA_j*B_{A6} + CU_j*B_{CU6} + REG_j*B_{R6} + u_{6ij}$$

in which SE_{ij} is a dummy variable indicating employment in a high-tech job (SE_{ij} = 1 if employed in science or engineering occupation), and HT_{ij} indicates employment in a high technology industry (HT_{ij} = 1 if employed in a high-tech industry). For the purpose of this study we define scientist and engineer as individuals whose primary occupation is in occupation codes 44-83. Following Herzog, Schlottman, and Johnson (1986) we use SIC codes 283, 348, 357, 36, 372, and 381 as our definition of high-tech industries.

Logit parameter estimates of the effect of colleges and universities on the probability that an individual is employed as a scientist or engineer, equation (5), are presented in column 3 of Table 2, (other parameter estimates are presented in Appendix Table A1). Three of the five university variables are significant at the 5 percent level. The probability that an individual is employed as a scientist or engineer is found to increase, at a decreasing rate, with the amount of R&D funding at local colleges and universities, and, surprisingly, is found to decrease with the number of top rated science and engineering programs at local universities. The latter finding may reflect the fact that universities with top rated programs produce scientists and engineers for the national rather local labor markets and hence tend to retain fewer of them for local employment. In any case, the joint hypothesis of no relationship between the probability of being a scientist or engineer and our university variables is rejected at the 1 percent level (likelihood ratio = 18.0).

In addition to having statistically significant impact on the composition of employment, the point estimates of the individual coefficients suggest that the effects of colleges and universities on labor force composition are fairly important. For our base case worker the probability of being employed in a high-tech job is .286. A standard deviation increase in R&D spending increases this probability by about 6 percent to .302. Similarly, a standard deviation increase in the number of degrees awarded in an area increases the likelihood of being employed in a high-tech job about 3 percent to .294. Further, the difference in the probability of being employed in a high-tech job for our base case worker if he lived in Boston, where the number of top rated science and engineering programs is highest, versus living in the SMSA where there are no top rated programs is about 4.8 percentage points or about 19 percent.[6]

[6] Other things equal, the probability of being employed in a high-tech job in an SMSA with the same number of top rated programs as Boston is .250 while it is .298 in a similar SMSA with no top rated programs.

The college and university variables are also found to have an important effect on the probability of being employed in a high-tech industry (column 5 of Table 2). The probability of being employed in a high-tech industry is found to increase with R&D funding at local universities. A positive and significant relationship is also found between the probability of being employed in a high-tech industry and the number of bachelor's degrees awarded at local universities. Further, the joint hypothesis of no relationship between the university variables and the probability of being employed in a high-tech industry is again rejected at the one percent level (likelihood ratio = 43.4).

The point estimates on the university variables suggest that the relationship between universities and labor force composition are economically as well as statistically important. A standard deviation increase in university R&D spending, for instance, increases the likelihood that our base case worker will be employed in a high-tech industry by over 50 percent.[7] A standard deviation increase in bachelor's degrees awarded by universities in an SMSA increases the likelihood of our base case worker being employed in a high-tech industry by about 17 percent and our base case worker would be about three times more likely to be employed in a high-tech industry if he resided in New York City, which awarded the most bachelor's degrees, than if he resided one of the twelve SMSAs in our sample which do no have any four year colleges or universities.[8] Thus, we find that there are strong effects of universities on the industry and

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[7] The base case probability of being employed in a high-tech industry is .101 while it is .156 for a worker in an SMSA with one standard deviation above the means value of university R&D spending.

[8] Other things equal, the probability of being employed in the SMSA where total bachelor's degrees awarded is highest is .237 while it is .071 in SMSA with no degrees awarded.

occupational composition of employment in an area even if the effects on overall employment probabilities are limited.

As discussed earlier, universities may have a greater impact on the rate of growth in employment than its level. As a check on this, OLS parameter estimates of the effects of colleges and universities on local employment growth over the period 1980-88, equation (3), are presented in column 1 of Table 3. Employment growth is found to be negatively and significantly related to the square of R&D funding and positively and significantly related to the number of degrees awarded. Further, the joint hypothesis of no relationship between employment growth and the university variables can be rejected at the ten percent level ($F = 1.7077$).

The point estimates indicate that the economic importance of these university measures is fairly large, particularly with respect to the number of graduates, where a standard deviation increase in the number of graduates from local universities increases the employment growth rate by 4.6 percentage points or by about 25 percent above its mean.[9] Further, if an area could increase its position from that of awarding the fewest bachelor's degrees to being the SMSA that awards the highest number, its employment growth rate would be about five times higher, ceteris paribus.[10] To put this effect in perspective changing our tax variables from their highest to lowest values would change the predicted employment growth rate by about fifty percent ceteris paribus. Thus, while we do not find any relationship between universities and employment probabilities,

[9] The predicted employment growth for this period is .181 for an SMSA with average characteristics while it is .227 if they have a standard deviation above the means value for degrees awarded.

[10] The growth rate predicted by our equation if total degrees is set at it maximum is .448 while it is .0796 at the minimum.

we do find some evidence that universities affect employment composition and subsequent employment growth.

We now turn to our examination of the relationship between colleges and universities and earnings. As found in previous research, earnings depend to a large extent on individual characteristics although we do find that they are affected by local amenities (see Appendix Table A2 column 4).

Estimates of the effects of universities on earnings, equation (3), are presented in column 3 of Table 3. An F-test rejects the joint hypothesis that earnings are unrelated to the college and university variables at the 10 percent level ($F = 2.067$). Earnings are found to be positively and significantly related to research and development funding and, surprisingly, negatively related to the number of top rated science and engineering programs at local universities. Other things equal, a standard deviation increase in university R&D increases our base case worker's earnings by 1.8 percent while a similar increase in the number of top rated science and engineering programs decreases this worker's earnings by two percent. Thus, we find evidence of important effects of universities on earnings of workers in an area.

Finally, we looked at the effects of universities on net migration to an SMSA. OLS parameter estimates of equation (4), are presented in column 5 of Table 3.[11] In general our results are consistent with the results of previous studies in terms of the impact on migration of area amenities, income and our other control variables. Interestingly, we found that net migration over the period 1975-80 was significantly lower into areas that had high concentrations of scientists and engineers in 1975.

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[11] Parameter estimates of the effects of other variables on migration are presented in Appendix table A2.

Of the five university variables only the percent of total degrees awarded in science and engineering has a significant impact on net migration. The predicted net migration rate for an SMSA with the highest values for the percent of degrees going to scientists and engineers is .053 while the predicted net migration rate using the lowest value of this variable is -.040.[12] Thus, the composition of university graduates may have potentially important effects on an areas ability to attract and retain workers. Despite this, it should be noted that the joint hypothesis that net migration is not related to the university variables cannot be rejected even at the ten percent level (F = .9648). Thus, there does not appear to be much evidence to support the notion that high quality universities serve as a magnet in attracting workers to an area.[13]

IV. Conclusions

In this paper we examined the relationship between four measures of university activity including R&D funding, and the number and composition of graduates, and various measures of the local labor market activity, including employment, income and migration. Regarding employment, we could not reject the hypothesis that there is no relationship between our measures of university activity and the overall employment rate in an SMSA. We did, however, find evidence that colleges and universities affect the composition of employment in an SMSA. The probability of being employed as a scientist or engineer and the

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[12] All other variables are evaluated at their sample means in this calculation. When all variables were evaluated at their sample means the predicted net migration rate is -.0151.

[13] The effect of our university variables on the probability that a worker was an in or out-migrant from an area are available from the authors upon request.

probability of being employed in a high-tech industry were both found to increase at a decreasing rate with the amount of R&D funding at local universities. The probability of being employed in a high-tech industry was also found to be positively related to the number of graduates from local universities. It may be the case that by increasing the share of employment in high-tech jobs or industries universities help local areas by shifting the mix of jobs away from the declining sectors of the economy and toward the faster growing service and high-tech industries.

In fact, we find evidence that employment growth rates are higher in areas with good universities. We also found that colleges and university R&D spending has a positive impact on earnings in an SMSA. Finally, the data can not reject the hypothesis that net migration is unrelated to universities.

Based on this analysis it does not seem that there is a strong link between the quality of local universities and several measures of local labor market success. The failure to find that universities are the proverbial golden goose may be due to our crude measures of university quality or because these spillover effects take more subtle or indirect routes than our data have been able to uncover. Alternately, it may simply be the case local policy makers will have only limited success in stimulating local labor markets through efforts to enhance universities. Nonetheless, it should be emphasized that we do find evidence for an important link between universities and earnings and employment growth that seems to warrant further research.

Table 1

Top Ranking Metropolitan Areas for Colleges and Universities

Bachelor's Awarded Rank University	R&D Funding	Top Ranking Science and Engineering Programs	Number of Bachelor's Degrees Awarded	Bachelor's Degrees in Science and Engineering
1	Boston	Boston	New York	New York
2	New York	New York	Los Angeles	Boston
3	Baltimore	Los Angeles	Boston	Los Angeles
4	Los Angeles	San Francisco	Philadelphia	Chicago
5	San Francisco	Chicago	Chicago	Philadelphia
6	Chicago	San Jose	Washington, DC	Washington, DC
7	Madison	New Haven	San Francisco	San Francisco
8	Philadelphia	Philadelphia	Austin	Raleigh-Durham
9	San Diego	Madison	Dallas-Ft. Worth	Atlanta
10	Raleigh-Durham	Ann Arbor	Nassau-Suffolk	Pittsburgh
11	Minneapolis	Champaign-Urbana	Minneapolis	Lafayette
12	San Jose	Raleigh-Durham	Raleigh-Durham	Ann Arbor

Table 2

Employment and Employment Composition

	Employed		Employed as a Scientist or Engineer		Employed in a High-tech Industry	
	Parameter Estimates	Elasticity at Means	Parameter Estimates	Elasticity at Means	Parameter Estimates	Elasticity at Means
	(1)	(2)	(3)	(4)	(5)	(6)
University R&D	-0.0371 (0.1235)	-.0027	0.2778* (0.0976)	.1702	0.5193* (0.1312)	.3800
University R&D Squared	0.0108 (0.0332)	.0015	-0.0488*** (0.0258)	-.0560	-0.1527* (0.0338)	-.2077
Program rating (#top 20)	-0.1612 (0.5184)	-.0016	-0.5184*** (0.2828)	-.0431	-0.3095 (0.3744)	-.0307
Bachelor's Degrees Awarded	0.0263 (0.1176)	.0022	0.0910 (0.0938)	.0624	0.4226* (0.1366)	.3461
% Degrees Science & Engineering	-0.3383 (0.2824)	-.0081	0.2729 (0.2435)	.0541	0.1992 (0.3452)	.0472
R^2	.0936[a]		.2191[a]		.0829[a]	
no. of obs	27409		24235		24235	

Coefficient estimates for individual characteristics and other area characteristics included in regressions are reported in Appendix table 2A.

Standard errors are in parenthesis. North Central is the omitted region.

*, **, *** indicate 1, 5 or 10 percent levels of significance, respectively.

a. McFadden R^2 adjusted for degrees of freedom (see Hensher and Johnson (1981)).

Table 3

Employment Growth, Income and Migration

	Employment Growth 1980-1988		Income		Net Migration	
	Parameter Estimates	Elasticity at Means	Parameter Estimates	Elasticity at Means	Parameter Estimates	Elasticity at Means
	(1)	(2)	(3)	(4)	(5)	(6)
University R&D	0.0819 (0.0673)	.0958	0.0494*** (0.0293)	.0394	0.0198 (0.0509)	.9828
University R&D Squared	-0.0384** (0.0194)	-.0568	-0.0050 (0.0078)	-.0074	0.0013 (0.1735)	.0809
Program Rating (# top 20)	-0.0025 (0.0022)	-.0338	-0.2583* (0.0847)	-.0279	-0.0083 (0.1623)	-.0478
Bachelor's Degrees Awarded	0.1108*** (0.0631)	.1741	0.009 (0.0278)	.0008	-0.0395 (0.0484)	-2.628
% Degrees Science & Engineering	-0.0429 (0.0762)	-.0538	-0.0332 (0.0703)	-.0086	0.1075*** (0.0599)	5.358
R^2	.4145		.3038		.6195	
no. of obs	218		23096		218	

see notes table 2.

Data Appendix

The source for all variables reflecting individual characteristics, and scientists and engineers as a percent of 1975 population, is the PUMS sample B data file discussed above. The average number of heating degree days over the period 1950-80, crime rates and per capita income in 1974 are from the City and County Data Book. Unemployment rate in 1975 is from the State and Metropolitan Area Data Book (1979) and all employment growth rates are based on employment data from the National Planning Association's State Economic Forecast Data. The student-teacher ratio in 1977 is reported in Local Government in Metropolitan Areas (1980). Sales and income taxes relative to income, and annual housing costs based on 1977 housing prices are from Boyer and Savingeau (1981). State business tax relative to business income in 1977 are from Bania and Caukins (1988).

All data on colleges and universities are aggregated to the SMSA level and are based on information on individual colleges and universities from the following sources: data on university R&D are from the National Science Foundation's Surveys of Academic Science and Engineering, 1987; ratings of science and engineering programs are from An Assessment of Research-Doctorate Programs in the United States; and the number and composition of bachelor's degrees awarded at four year colleges and universities are from the U.S. Department of Education's Higher Education General Information Survey.

Appendix

Table A1

Determinants of Employment, Employment Composition, and Income.

	Employed	Employed as a Scientist or Engineer	Employed in a High-tech Industry	Log Income
Constant	-5.9034*	-8.3023*	-4.7789*	6.3901*
	(0.4367)	(.3849)	(0.5149)	(0.1100)
Age	0.3370*	0.0308*	0.0508*	0.0751*
	(0.0125)	(0.0118)	(0.0158)	(0.0034)
Age squared	-0.0041*	-0.0003**	-0.0005**	-0.0759*
	(0.0001)	(0.0001)	(0.0002)	(0.0040)
Years of Schooling	0.1280*	0.3344*	0.0826*	0.0704*
	(0.0084)	(0.0065)	(0.0081)	(0.0018)
Married (=1)	0.0279	0.1195*	-0.0218	0.0715*
	(0.0440)	(0.0399)	(0.0527)	(0.0111)
Sex (Female=1)	-0.7133*	-1.7483*	-0.9127*	-0.7136*
	(0.0406)	(0.0451)	(0.0581)	(0.0105)
Race (White=1)	0.3610*	0.3035*	0.1797**	0.1515*
	(0.0548)	(0.0545)	(0.0731)	(0.0146)
Population 1980	0.0953**	0.0754**	-0.0291	0.0507*
	(0.0462)	(0.0374)	(0.0536)	(0.0110)
Population Squared	-0.0092**	-0.0150*	-0.0181*	-0.0039*
	(0.0044)	(0.0036)	(0.0051)	(0.0010)
Heating Degree Days	0.4157***	0.5435*	-1.1019*	0.1146**
	(0.2214)	(0.1833)	(0.2412)	(0.0539)
Crime Rate	-0.1626	-0.1116	0.5183**	-0.0020
	(0.1955)	(0.1664)	(0.2322)	(0.0480)
Student-Teacher Ratio	-0.0339*	-0.0039	-0.0543*	0.0055***
	(0.0127)	(0.0107)	(0.0140)	(0.0031)
Housing Costs	0.4672*	0.4362*	0.5949*	0.0965**
	(0.1629)	(0.1326)	(0.1681)	(0.0390)
Business Taxes	-4.2669	2.0066	-18.0630*	1.4273**
	(2.6764)	(2.2246)	(3.2115)	(0.6497)
Sales and Income Taxes	-1.8313***	-1.0781	-4.0133*	-0.3007
	(0.9870)	(0.8032)	(1.0770)	(0.2351)
% Manufacturing	0.5025	1.3438*	5.3346*	0.1418***
	(0.3072)	(0.2570)	(0.3489)	(0.0746)
Northeast	-0.0331	-0.1885**	0.3715*	-0.0615**
	(0.1093)	(0.0914)	(0.1286)	(0.0266)
South	0.1600	0.2595*	-0.5557*	0.0121
	(0.1037)	(0.0861)	(0.1182)	(0.0251)
West	0.0050	0.2159*	0.6119*	-0.0182
	(0.1000)	(0.0811)	(0.1050)	(0.0240)

Standard errors are in parenthesis. North Central is the omitted region.
*, **, *** indicate coefficient different from zero at 1, 5 or 10 percent levels of significance, respectively.

Table A2

Employment Growth and Migration

	Employment Growth 1980-88	Net Migration
Constant	0.1359	-0.1179
	(0.1337)	(0.1067)
% Scientists & Engineers	0.2919**	-.0440*
	(0.1172)	(0.0740)
Employment Growth 1970-75		0.2946*
		(0.1035)
Average SMSA Income	0.0015	0.0073*
	(0.0024)	(0.0017)
Unemployment Rate	0.0126*	0.0078
	(0.0040)	(0.0031)
Population 1975	-0.0402	-0.0462**
	(0.0280)	(0.0234)
Population Squared	0.0001	0.0046***
	(0.0033)	(0.0025)
Heating Degree Days	-0.1457**	-0.1164***
	(0.0799)	(0.0604)
Crime Rate	0.0668	-0.0614
	(0.0711)	(0.0541)
Student Teacher Ratio	-0.0054	0.0021
	(0.0047)	(0.0036)
Housing Costs	0.1940**	0.0308
	(0.0775)	(0.0595)
Business Taxes	-2.1132**	-0.9939
	(0.9474)	(0.7134)
Sales and Income Taxes	0.5994***	-0.5611**
	(0.3547)	(0.2673)
% Manufacturing	-0.4417	-0.1026
	(0.1069)	(0.0829)
Northeast	0.0460	0.0083
	(0.0378)	(0.0289)
South	0.0113	-0.0022
	(0.0374)	(0.0285)
West	0.0030	0.0579**
	(0.0380)	(0.0293)

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