Economic Effects of Universities and Colleges

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Abstract

Based on the success of Boston, Silicon Valley and the Research Triangle, policy makers are increasingly looking to universities and colleges as engines of economic growth and technological innovation. This paper estimates the effect of universities and colleges on their local economies using panel data on cities from 1980 to 2000. The panel structure of the data allows me to include fixed effects for metropolitan areas. To further investigate causality I use two sets of instrumental variables (1) historic values of university variables (2) a shift share index of R&D. In contrast to the literature, the estimates show a statistically significant and empirically important relationship between universities and the incomes and employment of individuals in a metropolitan area. A one standard deviation increase in academic R&D, (per capita) Bachelors degrees, and the share of S&E degrees in total Bachelors degrees and the stock of Bachelors degree holders in a city would each increase individual income by 2%-7% and all of them together increases probability of individual employment by 2.2%.

JEL Classification: O18, O31, O32, R11, J01

Key Words: Regional Labor Markets, Academic R&D, Bachelors Degrees in Science and Engineering, Knowledge Spillovers, Universities, Earnings, Employment

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I. Introduction

Endogenous growth theory argues that a highly skilled workforce and technological innovations fuel economic growth (Romer [1993] and Lucas [1988]). Universities and colleges are "at the crossroads of education and innovation" (Pianalto [2006]) supplying both talent and technology to the US industries[1]. Indeed, universities and colleges in Boston, Silicon Valley and the Research Triangle have produced a lot of graduates and R&D, especially in science and engineering (S&E), which are believed to have contributed to the economic prosperity of these regions (Bania and Eberts [1993])[2]. In Silicon Valley and Route 128 the electronics sector earnings were approximately 1.4 times the national average and per worker earnings were approximately twice as much as the national averages (see Hill [2006]). Based on the success stories of these regions, policy makers are increasingly looking to universities and colleges for economic growth and technological innovations (Cleveland Federal Reserve [2007]).

This paper uses the result that in equilibrium with mobile labor and capital, differences in metropolitan area characteristics can lead to differences in wages and employment (Roback [1982]). In this context, I use panel data on universities and colleges aggregated to the metropolitan area level to examine the impact of universities and colleges on their local labor markets. The labor market activities considered in this study are annual earnings and employment status. There are many aspects of universities that can affect labor market conditions. Of them, the flow of Bachelors degrees, the share

[1] After 1980 the US industries have adopted cutting edge technologies across the board (Feldman and Barcovitz [2006]). From mid 1980s the industries relied on scientists who have direct or indirect ties to university research (Marschke et al [2006]).

[2] It is documented that local firms were benefited by the supply of available electronics and computer scientists from Stanford and MIT in the case of Silicon Valley and Route 128 respectively (see Dorfman [1983], Saxenian [1996]).

of Science and Engineering (S&E) in total Bachelors degrees granted and the flow of R&D conducted by universities and colleges are considered in this paper. Several studies report that in a city, universities and colleges influence the stock of Bachelors degree holders (Bound et al [2001]), which is an important source of human capital externalities (Rauch [1992], Glaeser [2001], Morretti [2004a, 2004b]). I collect a variety of data on degrees granted and R&D conducted by universities and colleges for 1980, 1990 and 2000 at the level of individual university and college. Each university or college is matched to its metropolitan areas using its zip codes and is then aggregated to the metropolitan area level. Labor market conditions were estimated from the 1980, 1990 and 2000 Census for each metropolitan area. University variables are measured in per capita terms to control for differences in the size of the cities.

A variety of empirical strategies were used to estimate the effects of universities on their local labor markets, beginning with OLS. The concern with OLS is that it fails to capture unobservable factors that are correlated with the labor market conditions and university activities. For example, city specific factors like urban amenities may attract students, researchers, firms and workers to a city. The panel aspect of the data is used to control this by including metropolitan area fixed effects and time dummy variables. Time dummy variables eliminate any time trends in the university activities. The metropolitan area fixed effects eliminate time invariant differences across metropolitan areas in factors including weather, business opportunities, and urban amenities, which may be correlated with the university variables.

To explore causality, it is also important to control for metropolitan area level unobservable factors that vary across time. For example, shifts in the demand for highly educated workers in the metropolitan areas might increase earnings and lead to growth in universities and colleges. I employ an instrumental variables strategy to control for this.

Historical values of degrees and R&D for each metropolitan area serve as instrumental variables for current degrees and R&D. The historical values of degrees and R&D are related to current degrees and R&D, but do not directly influence current labor market conditions.

A shift-share index is also used as an instrumental variable for R&D. The shift-share considers growth in the variable under consideration decomposed by categories (Bound and Holzer [2000]). This paper uses data for R&D by fields of study and source of funding. The national trends in funding are weighted differently for each city. The intuition for identification in this case is simple. Different regions have universities that are specialized in different fields. Shifts in R&D in a particular field caused by decisions made by federal or state governments impact otherwise similar metropolitan areas differently. For example, Dallas has the most engineering R&D while San Francisco has the most R&D expenditure in life sciences including medicine. An increase in government expenditures in medicine will increase R&D in San Francisco more than in Dallas.

It is not clear whether Bachelors degree holders locate themselves in a city attracted by its high earnings opportunities or that Bachelors degree holders bring about higher earnings opportunities in the metropolitan area. To establish causality, the cities with Land Grant universities and colleges is used as an instrument. Land Grant Act or the Morrill Act of 1875 allocated land randomly to cities within the states to build universities. It is likely that these cities developed a higher stock of Bachelors degree holders because of the presence of the land grant universities, which affects the current share of Bachelors degree holders without having any direct relationship with the current labor market conditions. This instrument is used in the literature by others (see Morretti [2004a, 2004b]).

The estimates show that per capita R&D, the share of science and engineering degrees in total Bachelors degrees, per capita Bachelors degrees and the stock of Bachelors degree holders have a positive effect on earnings and the probability of employment. In the income regressions, per capita R&D, the share of science and engineering Bachelors degrees and the stock of Bachelors degree holders are always statistically significant. A one standard deviation increase in each of the university activity variables increases mean log earnings by 2% - 7%. In the employment regressions, the share of Bachelors degree per capita, the stock of Bachelors degree holders and the share of S&E degrees are always positively and statistically significantly related to employment status of individuals. A one standard deviation increase in all the university variables increases the probability of individual employment by 2.2%. All these results are calculated after controlling for the effects of individual characteristics on their wages and employment like years of education, experience, race, gender and marital status. Over last two decades, the share of the population with a Bachelors degree increased by 14%. Controlling for own education this increase in area education increased employment by 17%.

These results stand in contrast to the existing literature on university effects on local labor markets. Using data from 1980, Beeson and Montgomery [1993] find that total R&D, total degrees and the percentage of science and engineering degrees in a metropolitan area are not statistically significantly related to individual earnings. Goldstein and Renault [2004] found that between 1969 and 1986 the presence of a research university had no effect on an area's relative earnings. However, the effects are significant between 1986 and 1998. Wang [2003] reports weak income spillovers from universities in neighboring counties using a spatial model with data from 1995 and 2000. Desrochers and Feldman [2003] show that although Johns Hopkins University is a large contributor to academic research and well known in academic circles, it has little impact on its local economies. Universities are found to have their largest impact on the middle and small sized metropolitan areas (Goldstein and Drucker [2006]).

There is also a literature on knowledge spillovers in innovation[3].The goal of this work is not to study the mechanisms through which universities operate but it may provide some suggestive evidence. This paper shows the returns to a city from having universities. It also guides university presidents or local governments to policies that would maximize benefits of universities to their local communities.

The remainder of the paper is organized in the following way: Section II discusses the data, variables for the empirical analysis and trends in these variables. Section III reports fixed effects estimates for incomes and employment. Section IV shows instrumental variable estimates. Section V concludes.

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[3] There is ample evidence that academic R&D impacts technological innovations measured by patent citations (Jaffe [1986]). Research shows that academic R&D and university science graduates aid growth of start up companies, new firm openings (Bania, Eberts, and Fogerty [1993], Smith [2006]) and development of industrial research laboratories (MacGarvie and Furman [2005]). Academic scientists who made early contributions to gene sequencing caused to create the US biotechnology industry (Zucker, Darby and Brewer [1998]). Recent work reports that variation in the stock of college graduates in cities, largely influenced by flow of college graduates from universities and colleges (Bound et al [2001]), explains to the wage variation across cities (Morretti [2004a, 2004b], Rauch [1991], Glaeser [2004], Shapiro [2006]).

II Data, Variables and Trends

In the empirical analysis, a variety of local labor market activities are related to local area characteristics, including university variables. I use the Higher Education General Information Survey (HEGIS) data from 1980-81, and the Integrated Postsecondary Education Data System (IPEDS) 1990-91 and 2000-01 to measure total Bachelors degrees and Bachelors degrees in S&E at the level of the universities and colleges[4].

I aggregate the S&E degree data to the metropolitan area level yielding information on degrees for 226 (259, 280) metropolitan areas. Not surprisingly the largest cities like New York, Chicago, Los Angeles, Boston, Philadelphia etc. generate the most degrees in total and in S&E. As indicated before, to account for scale effects, I divide the total Bachelors degrees in a region by the population of that metropolitan area to estimate the importance of Bachelors degrees. I use the share of Bachelors degrees in S&E in total Bachelors Degrees granted in my empirical analysis, which is neutral to the size of a city. On a per capita basis, the cities with the largest number of per capita Bachelors degrees are State College, PA, College Station, TX and Bloomington, IN. The ranking of metropolitan areas with the share of S&E in total Bachelors degrees includes Lafayette, IN, Rochester, NY Palm Bay-Melbourne-Titusville, FL, and Rapid City, SD.

In Figure 1 I show the difference between taking per capita versus aggregate levels of the degree variables in 1980. In each of this graph, the horizontal axis measures per capita Bachelors degrees, and the vertical axis measures logarithm of total Bachelors degrees divided by 10. From these graphs it is clear that college towns such as College Station, Texas, State College, Pennsylvania, Urbana-Champaign, Bloomington-Normal,

[4] The science degrees include Biological sciences, Mathematics, Engineering, Physical Sciences, Computer and Information and Health Professionals

Lafayette, Gainsville Florida, have higher per capita values but moderate on totals while, the New York, CMSA , Boston CMSA have higher aggregate values than per capita values.

In 1980 (1990 and 2000) there were 2,874 (3,208 and 3,159) universities and colleges in the sample. I used the zip code of each college and university to match universities to their metropolitan areas. Restricting the sample to universities and colleges in a metropolitan area, leaves a sample of 2,058 (2,396 and 2,401) universities and colleges in 1980 (1990 and 2000) and these institutions awarded 753,025 (864,705 and 1,035,436) Bachelors degrees and 210,619 (215,213 and 267,985) Bachelors degrees in S&E given from all the universities and colleges in the sample.

I obtain National Science Foundation dataset of Academic R&D Expenditures by school, field and source for 1980, 1990 and 2000. In 1980 (1990 and 2000) there were 520 (554 and 614) universities and colleges, of which 413 (440and 511) universities and colleges are in metropolitan areas in for1980 (1990 and 2000). The NSF reports R&D for universities and colleges for a much smaller population than National Center for Education Statistics[5]. Matching these schools to the Carnegie Classification ([2002]), 93% of these universities and colleges are Ph.D. granting research schools, or they are mining and engineering schools. Total R&D from all universities and colleges is 5,422,888 (14,649,223 and 27,902,825) thousand dollars.

The largest total R&D expenditure in all the three years 1980, 1990 and 2000 comes from Johns Hopkins University, with 253,204 (668,915 and 901,156) in thousands of constant dollars, followed by Massachusetts Institute of Technology (MIT), University of Michigan, University of Wisconsin Madison, University of Washington at Seattle, and

[5] I do not use data for the research laboratories given by NSF sample.

University of California, Berkeley, Stanford University, Harvard University. These schools also get the most funding from the federal sources. The large state universities like Texas A&M, the Ohio State University, Louisiana State University, and University of Georgia receive the most state funding. The universities that have the biggest funding from industry are Duke University, MIT, Stanford, Harvard, The Ohio State University, North Carolina State University, and Penn State University.

As before, I aggregate the R&D data back to metropolitan area level obtaining data for 157 (159, 181) metropolitan areas in 1980 (1990 and 2000). As before we find that the largest metropolitan areas that have the most R&D are the big cities like New York, Los Angeles, Boston, Chicago, and San Francisco. On per capita basis R&D is highest in College Station, State College, PA, and Urbana Champaign, IL. Table 1 gives the list of metropolitan areas that have large volumes of R&D in per capita and aggregate levels. I also create a list of universities associated with the cities who lead the nation in greatest amount of R&D.

I use *State and Metropolitan Data Set* 1980, 1990 and 2000 to create a rich set of non-university control variables for metropolitan areas like population, crime rates and public school attendance. I also use utilities mortgages and taxes to measure the difference in standard of living in each metropolitan area from *Places Rated Almanac* of 1972, 1980, 1990 and 2000.

I use the 1% sample of the 1980, 1990 and 2000 Census to estimate individual earnings and employment as the local labor market activity data. There is a larger sample i.e. the 5% Census sample available but it is state specific. Since metropolitan areas often overlap state boundaries, it is not the ideal sample for this work. I restrict the census sample is restricted to people of working age (18-65) who are not institutionalized or in school[6]. Local labor markets are defined by the Consolidated Metropolitan Statistical Area (CMSA), New England County Metropolitan Area (NECMA), or Metropolitan Statistical Area (MSA). People were matched to university data from their metropolitan area of residence.

Data on degrees available for substantially more cities than have reported R&D. Most cities with no reported R&D probably have very low R&D. I delete those observations for which R&D is unknown. The resulting sample has 1,223,224 observations total, with 349,450 (399,751 and 474,023) observations for 1980 (1990 and 2000) which captures 126 (139 and 141) metropolitan areas for the earnings regression. The resulting sample has 462,107 (502,531, 604,635) observations for 1980 (1990 and 2000) which captures 126 (139 and 141) for employment regression.

Table 2 shows the changes in the mean and standard deviations of the earnings and employment of individuals from 1980 to 2000. We find that the mean of log earnings have increased from \$9.17 in 1980 to \$9.78 in 1990 and increased further to \$10.19 in 2000. The mean employment rate has gone up from 68% in 1980 to 73% in 1990 and to 75 % of working age adults in 2000. While the standard deviation of both increase over time, the coefficient of variation for these variables indicate that inequality across city over time has decreased.

Table 2 gives the summary statistics of the regression sample for the earnings and employment regressions. Between 1980 -2000, the mean of Bachelors degrees granted by universities and colleges per capita have increased by over 13%. Interestingly, the

[6] In income regression I drop the observations for which wage information is not available. In the employment regression I drop the observations for which I do not have any employment data. The employment sample is larger than the earnings regression sample.

standard deviations go up as well. The coefficient of variation in this time increased from 72% to 82%, which tells us that inequality in the flow of Bachelors degrees cities increased. The mean of Science and Engineering degrees fell, but this is more a product of adding a few cities to the data set in 1990 and 2000 which lacked in S&E Degrees. The mean of per capita R&D expenditure has risen from $33.30 in 1980 to $ 93.35 in 2000. The coefficient of variation has increased across cities over time- signifying an increase in the dispersion of this variable.

The mean of the share of people with Bachelors degrees increased from 10% in 1980 to 20% of the working population aged 18-65 in 2000. The standard deviation has increased between 1980 and 2000 suggesting increases in regional inequality in distribution of the stock of college educated population in different cities.

III. Fixed Effects Regression Results

The effects of universities are estimated by employing a variety of strategies. The panel structure of my data is used to include city level fixed effects with year dummy variables.

At the individual level, I estimate an equation like:

$$y_{ict} = \alpha + \beta UNIV_{ct} + \gamma Z_{ct} + \phi X_{ict} + \theta_t + v_c + \omega_{ict} \qquad (1)$$

Where, i stands for an individual, c stands for city and t stands for time. When y_{ict} represents the logarithm of annual wage and salary earnings of individual i in city c and time t, equation (1) becomes an earnings regression. When y_{ict} represents the employment status of individual i in city c and time t i.e. this variable takes a value of 0 (1) if the person is unemployed (employed), equation (1) is an employment regression.

A vector of university variables (like per capita Bachelors degrees, per capita R&D, the share of science degrees in total Bachelors degrees and the share of Bachelors degree holders in a city) is denoted by $UNIV_{ct}$ while Z_{ct} represents a vector of city level controls like (population, a dummy variable for year (θ_t) and an interaction between population and the year dummy variable). Both $UNIV_{ct}$ and Z_{ct} vary across cities. X_{ict} is a vector of individual characteristics that vary across individual, time and city including year of schooling, experience, gender and marital status of individuals.

As indicated, to make cities with different size similar, I standardize university data by dividing them by population of that city. To allow for a correlation between observations in a city over time the standard errors are clustered within each city across time.

Results for Annual Earnings

Table 3 reports the effect of universities on the annual earnings of individuals in their local labor markets. The first four columns report the effect of per capita Bachelors degrees, per capita R&D, the share of S&E degrees and the stock of Bachelors degrees on the logarithm of earnings independently. Each variable is positively related to earnings. The share of S&E degrees is statistically significant at the 10% level while per capita R&D and stock of Bachelors degree holders are statistically significant at the 5% level. T-test fails to reject the hypothesis that per capita Bachelors degrees are 0. The stock of Bachelors degrees has the largest independent impact on earnings.

Columns 5-7 report the estimates where the stock of Bachelors degree holders is used along with the other variables, the share of S&E degrees and stock of Bachelors degrees continue to be positively and significantly related to earnings. The coefficients of per capita Bachelors degrees and the share of S&E degrees increase and that of per capita R&D decrease. The levels of significance of S&E degrees increases, while that of per capita R&D falls. Per capita of Bachelors degrees has a positive coefficient but is never statistically significant.

Columns 8-10 show different combinations of per capita Bachelors degrees, the share of S&E degrees and per capita R&D without the stock of Bachelors degrees. Column 9 stands out where both per capita R&D and the share of S&E are significant at the 5% level. The rest of the parameter values and levels of significance match the results presented in columns 1-4. Column 11-13 report results of specification in column 8-10 with the stock of Bachelors degree variable. Not surprisingly the coefficients behave almost like those reported in columns 4-6. In Column 12 all the variables are positive and significant.

The last two columns report the estimates where all the university variables are present with and without the stock of Bachelors degree holders. Per capita R&D, the share of S&E degrees and the stock of Bachelors degree holders all are positively and significantly related to earnings. The joint F-tests of the whole model in each case reject that the university effects are any different from 0. All these results reflect that universities are important determinants of earnings, over and above the direct effect of individual education.

The difference of these results from the literature can be driven home by considering the economic significance of the effects of university activities on individual earnings. Using the standard deviations in Table 2, we get that if the stock of Bachelors degrees per capita R&D and the share of S&E degrees increases by 1 standard deviation, log earnings increase by 7% (1% and 1.6%). From a local government standpoint, it suggests policies that policies that attract Bachelors degree holders in a city, or retain Bachelors degree holders in a city can have large effects on earnings. An increase in the share of S&E degrees or an increase in R&D would also have large positive effects on earnings.

Another way to gauge the importance of the university variables on earnings is to consider that between 1980 and 2000, the share of R&D has increased by 300%. This increase is estimated to have raised the average earnings by 19% to 33% over the last two decades, after controlling for the direct effect of individual education on earnings. These large effects are markedly different from the literature, which often find no effect of universities on earnings (Beeson and Montgomery [1993], Wang [2005], Goldstein and Drucker [2006]).

There are two interesting points about the fixed effects estimation results. First, the flow of Bachelors degree holders is perhaps less important. This variable is dropped from subsequent analysis. Second, including the stock of Bachelors degrees in the regression decreases the value of the coefficient on per capita R&D and increases the coefficients of per capita Bachelors degrees and the share of S&E degrees.

Results for Employment Status

Table 4 reports the results of the employment regressions. Employment is a discrete variable, which takes the value 1 if the person is employed, and it takes the value 0 if an individual is not employed. I fit a linear probability model to facilitate comparison with instrumental variables estimates in the next section. The specifications in Table 4 are organized in the same way as those in Table 3. The first four columns report the individual effects of per capita Bachelors degree, the share of S&E degrees and the stock of Bachelors Degree holders, all of which are positively related to individual employment status. The coefficient for per capita R&D is close to 0 and is not statistically significant. Only the stock of Bachelors degree holders and the share of S&E degrees are statistically significant at the 5% and 10% levels respectively.

Columns 5-7 report specifications that include the stock of Bachelors degree holders. The coefficients increase for S&E degrees and per capita Bachelors degrees but the sign of per capita R&D variable reverses and the coefficient becomes smaller in magnitude. Per capita Bachelors degrees and the share of S&E degrees become significant at the 10% level. Columns 8-10 present combinations of the university variables without the stock of Bachelors degrees, which are similar. Columns 11-13 show the change in the estimates from column 8-10 when the stock of Bachelors degree holders is introduced. The coefficients of the share of S&E degrees and per capita Bachelors degrees increase, but that of per capita R&D change signs but stays insignificant, its value being close to 0.

The last two columns report the estimates where all the university variables are all included together with and without the stock of Bachelors degree holders in a city. The share of S&E degrees and stock of Bachelors degrees continue to be positively and significantly related to employment.

The coefficient on per capita R&D is close to zero and insignificant. Thus, while R&D has a large impact on income, its effect on employment status is insignificant. On the other hand, a one standard deviation in increase in the stock of Bachelors degrees; per capita Bachelors degrees; and the share of S&E degrees increases the probability of employment by 1.4% .05% and 0.03%. Together, their influence would increase the probability of individual employment by 2.2%. It is noteworthy that the variables that are related to employment are degree variables for the local economy and that these estimates control for individual education.

Another way to gauge the importance of the university variables on employment is to consider the impact of recent increases. Between 1980 and 2000, the share of the workforce with Bachelors degrees increased by 15%. This increase is estimated to have raised the average probability of employment by 18% over the last two decades (again controlling for the direct effect of education on employment). These large effects are consistent with the literature which often finds greater effects on employment than on earnings (Beeson and Montgomery [1993], Wang [2005], Goldstein and Drucker [2006]).

Robustness

I have used a variety of other specifications to check the robustness of the results. Polynomials of the variables already used were included. A common concern is R&D takes time to impact local labor markets. Similar concerns surround degrees – spillovers from degree recipients may increase over time. To allow for gestation periods, values of university variables were measured at a 5 year lag. Lastly, R&D expenditures at federal laboratories were included in the already existing R&D measure and aggregate science and engineering Bachelors degrees were used instead of per capita values. None of these robustness checks, the results of which are available upon request, changed the results qualitatively.

IV. Instrumental Variable Regression Results

City fixed effects account for time-invariant unobserved determinants of labor market conditions that are related to universities, but they do not control for time-varying unobserved factors. To deal with this issue, I use instrumental variables. Two different sets of instruments were used: 1) Historical values of Bachelors degrees, the share of degrees in science and R&D interacted with year dummy variables and 2) a shift share index for R&D. The historical values of the degrees are from 1969-1970 and the historical values of R&D are from 1973. The First Stage equation is

$$UNIV_{ict} = \varphi + \sum_{t} \delta_t HistoricUNIV_{ic1970} + \mu Z_{ct} + \tau X_{ict} + \theta_t + \nu_c + \varepsilon_{ict} \qquad (2)$$

The Second Stage Equation is

$$y_{ict} = \alpha + \beta UNIV_{ct} + \gamma Z_{ct} + \phi X_{ict} + \theta_t + \nu_c + \omega_{ict} \qquad (3)$$

The historical variables are expected to be related to current university variables, but not directly to current labor market conditions. Table 5 shows the partial R^2 for the excluded instruments. The partial R^2 of the historical values of Bachelors degrees was 5%, that of the share of science and engineering was 23% and the partial R squared for R&D is 62%. Similarly, I find out the F statistics for the excluded instruments, which are also reported in Table 5. For example, the value of the F statistic for the historic value of per capita Bachelors degrees is 26897.83 for the earnings and 32687.90 for the employment sample. This indicates that the strength of the instruments is not 0.

I use a second set of IV for R&D – a shift share index of R&D. Total R&D is broken down into 14 categories based on field of and source. The fields are life science, physical science, psychology, social science, geology, math and computer science, engineering and other sciences. The sources are total, federal and non federal. The instruments are constructed finding the average share of R&D in each city in an initial year, which in my case is 1973. The weights vary across cities. The share shift index for each city is then calculated by constructing weighted averages of aggregate trends in spending in each of the 14 categories, where the weights vary across cities as a function of the initial specialization. Formally the instrument is

$$S_{cf73}{}^{j} = \frac{E^{j}_{cf73}}{\sum_{f_j} E^{j}_{cf73}} \qquad (4)$$

$$IVRD^{j}{}_{ct} = \sum S_{cf73}{}^{j} * \bar{E}_{cft}{}^{j} \qquad (5)$$

Here S_{cf73} denotes the initial weights (for 1973 in this case) field *f* in city *c* for R&D source *j*. Equation (4) gives the share of expenditure on say medicine among total expenditure in all other fields in 1973. $\bar{E}_{cft}$ is the weight of expenditures in field *f* in city *c* in time *t* for R&D source *j*. In this case, $\bar{E}^{j}{}_{f}$ represents the average expenditure in a certain type of R&D in field f over three decades. E^{j}_{cft} is the R&D from the source *j* in city *c* in field *f* and in time *t*.

The intuition is the following. Different universities in USA specialize in one or more of these fields. For example, San Francisco and Baltimore are two of the top places in USA for expenditure in life sciences (including medical sciences). The federal government is a large part of such expenditures. Through the decades, there have been variations in the federal government budget expenditure to universities in life sciences. These changes in life sciences expenditure provide a source of exogenous variation in R&D in San Francisco and Baltimore relative to places that are less specialized in life sciences. The shift share index is a weighted average of spending trends, where the weights vary across cities according to initial shares in each category, this exogenous variation gives us identification. The partial R^2 for the shift share index is 5% - so there is a strong relationship between the shift share index instrument and per capita R&D variable.

There is a concern that the stock of Bachelors degrees in a city may be endogenous – affected by the current demand and supply shocks which also affect current incomes. To address this, I use an interaction term between the presence of a land grant university and year. Land grant schools were developed under the Morrill Act of 1875. Given that they were founded a century before the labor market conditions we measured, they should have no influence on current conditions beyond their effect on current university variables. The presence of a land grant institution has been used by others as the instrument for the share of college graduates in the population (see Morretti [2004a, 2004b]).

The instruments are missing for some individual observations and city-year pairs. Deleting these observations yields a data set with individual observations and 373 city-pairs. The means and standard deviation for this sample is similar to the full sample descriptive statistics as reported in Table 2. The fixed effects results for this sample are similar to those reported above.

Results for Annual Income

These results are given in Table 6. In column 1, column 2 and column 3, I instrument for R&D by the historic R&D variable, the shift share index with total R&D and by both historic R&D and the shift share index. The specification with historic instruments, and the specification with historic and the shift share instruments together leave the second stage estimator positive and significant. The specification where only the shift share instrument is used, the coefficient is positive but not significant. So the shift share instruments are not strong, they produce insignificant results. Similar pattern is seen when we insert the stock of Bachelors degree holders are included in the estimation. Column 4 and column 6 shows that per capita R&D is significant at the 10% level, but it is not in column 5 where only the shift share index was used as the instrumental variable.

The share of S&E degrees are instrumented by the historic values of S&E variable. This is reported in column 7. The share of science and engineering degrees is not significant but positive. Also the value goes down by almost 40%. It suggests that S&E degrees are not as important as the fixed effects regression would suggest, but R&D increases earnings significantly. In all these specifications the stock of Bachelors degree holders is still positive and significant and the value of its coefficient is the same as in the fixed effects regression.

Column 8-10 has the instrumental variable results for specification 9 from the fixed effects model. Once again, for R&D, three different sets of instruments are tried, while for the share of S&E degrees I only use the historical value of the variable. The share of S&E degrees is not significant, as they were in the fixed effects regression. Column 11-13 shows the result of the instrumental variables for per capita R&D and the share of S&E degrees controlling for the effects of stock of Bachelors degrees in a city. We find that R&D is significant at 10% instead of being significant at 5%. Since the point estimates are close to the fixed effects numbers, the economic impact of these variables is going to be the same as before.

In all these regressions, the first stage results are as expected. For example, the historical R&D variable positively influences per capita R&D, and the shift share index positively influences R&D as well. The level of significance is positive of all the instruments. In the same vein, the first stage signs for the share of S&E degrees indicate that they positively influence the current S&E degrees. As before, the results suggest that the universities are important determinants of annual earnings of the people living in metropolitan areas with R&D being one the main factors.

Results for Employment

From Table 4 from the fixed effects section, it is evident that R&D does not play a large role in determining employment. The indication was that per capita Bachelors degree or the share of S&E degrees can have a large role to play apart from the stock of Bachelors degrees. It was also noticed that employment effects of the university variables was significant in the presence of stock of Bachelors degrees. The instrumental variable results are summarized in Table 7. The columns report the second stage estimates of the regressors.

In column 1 I report the instrumental variable estimates of per capita Bachelors degrees. I use the historic values of per capita Bachelors degrees as instruments along with the land grant year dummy as another instrument. The coefficient for per capita Bachelors degrees increases nearly twice as much as in Specification 5 of Table 4 and the significance increases as well. The results for the share of science and engineering degrees in column 2, shows that it is not significant and the coefficient has the unexpected sign. In column 3 I instrument for both per capita Bachelors degrees and the share of S&E degrees with their historical values and land grant. In the end, only per capita Bachelors degrees have a positive sign. The stock of Bachelors degree holders keep on being positive and significant in all three columns regressions. The main lesson learnt is that only Bachelors degrees, either the stock or the flow have the real power in affecting employment status of individuals.

V. Conclusion

This paper estimates the economic effects of universities on their local markets. It extends and enriches the existing empirical work, which answer if the universities have important impact on local economies. I use panel data at the level of universities and colleges. City fixed effects and two different instrumental variables are included to find that universities and colleges have significant impact on their local economies. In contrast to the literature, universities and colleges are found to affect individual incomes and employment significantly. A one standard deviation of the share of Bachelors degrees in science and engineering, R&D and the stock of Bachelors degrees individually can increase the mean earnings in a city by 2%-7%. The university activities together increase the probability of employment by 2.2%. The instrumental variables show that R&D still positively and significantly affects earnings and the stock of Bachelors degrees always affects earnings and probability of employment positively. The other implication of the study is while R&D and the share of S&E degrees are important for earnings, while per capita Bachelors degrees are important for employment. It implies the importance of academic science in general and suggests policies for university presidents to make universities have larger effects on their communities.

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Table 1: Comparison of leading cities in Total Versus Per Capita R&D

	1980	1980	1990	1990	2000	2000
	Total R&D	Per Capita R&D	Total R&D	Per Capita R&D	Total R&D	Per Capita R&D
1	New York, CMSA	Bryan College Station	New York, CMSA	Bryan College Station	New York, CMSA	State College
2	DC, CMSA	State College	DC, CMSA	State College	DC, CMSA	Bryan College Station
3	San Fransisco, CMSA	Iowa City, IA	San Fransisco, CMSA	Urbana Champaign	San Fransisco, CMSA	Iowa City, IA
4	Boston, NECMA	Lafayette	Boston, NECMA	Athens	Boston, NECMA	Urbana Champaign
5	Los Angeles, CMSA	Urbana Champaign	Los Angeles, CMSA	Iowa City, IA	Los Angeles, CMSA	Bloomington, IN
6	Chicago, CMSA	Athens	Houston	Madison	Raleigh Durham	Athens
7	Philadelphia, CMSA	Madison	Raleigh Durham	Bloomington,IN	Houston	Lawrence,KS
8	Madison, WI	Columbia,MO	Chicago, CMSA	Columbia,MO	Chicago, CMSA	Gainsville, FL
9	Detroit, CMSA	Gainsville, FL	Detroit, CMSA	Lafayette	Detroit, CMSA	Madison
10	San Diego	Bloomington,IN	Philadelphia, CMSA	Gainsville, FL	Philadelphia, CMSA	Lafayette

Table 2: Descriptive Statistics of Labor Market and Universities Activities

	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
	1980	**1980**	**1990**	**1990**	**2000**	**2000**	**Panel**	**Panel**
Log Wages	9.1726	1.0440	9.7876	1.0227	10.1964	0.9890	9.7707	1.0977
Bachelors Degree Per Capita	0.0044	0.0033	0.0047	0.0041	0.0050	0.0041	0.0047	0.0039
Share of S&E Degrees	0.2830	0.0622	0.2515	0.0509	0.2582	0.0445	0.2631	0.0537
R&D per Capita	0.0342	0.0432	0.0869	0.1313	0.1470	0.2073	0.0952	0.1580
Stock of Bachelors Degree Holders	0.1102	0.0197	0.1667	0.0310	0.2053	0.0368	0.1656	0.0494
Observations (earnings sample)	352385	352385	401704	401704	479167	479167	1233256	1233256
Employment status	0.68	0.46	0.73	0.44	0.75	0.43	0.72	0.44
Observations (employment sample)	462107	462107	502531	502531	604635	604635	1569273	1569273

Note: The descriptive statistics for the earnings and employment samples are very similar for all other variables.

Table 3: Earnings Regressions Fixed Effects Estimates

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Bachelors Degree Per Capita	1.78				3.7			1.96		2.92	4.15		4.19	3.18	4.64
	(3.80)				(3.28)			(3.79)		(3.62)	(3.24)		(3.22)	(3.60)	(3.19)
Share of S&E Degrees		.20 *				.31**		.205*	.22*		.32**	0.31**		.222*	0.32**
		(.12)				(.12)		(.124)	(.126)		(.12)	(.12)		(.13)	(.12)
R&D per Capita			.12**				.06 *		.12**	.127**		0.06**	0.06*	0.13**	0.06**
			(.04)				(.03)		(.04)	(.039)		(.03)	(.03)	(.039)	(.03)
Stock of Bachelors Degree Holders				1.46**	1.47**	1.53**	1.39**				1.58**	1.49**	1.40**		1.50**
				(.280)	(.28)	(.27)	(.277)				(.27)	(.25)	(.29)		(.27)
R Squared	.3610	.3611	.3611	.3612	.3612	.3612	.3612	.3611	.3611	.3611	.3612	.3612	.3612	.3611	.3612

Note: *Observations:* 1233256 *Clusters:* 421: * - Significance at 10% and **- Significance at 5% The individual controls include years of education, experience, experience squared, experience cubed, experience raised to the power of four, interaction between gender and marriage and race. The city controls include logarithm of population, population squared, total crime rate, mortgage payment with taxes, utilities and public school enrollment in K-12 system in a city. Include time dummy variables and city level fixed effects.

Table 4: Employment Status Regressions Fixed Effects Estimates

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bachelors Degree Per Capita	.99 (.91)				1.28 (.87)			1.04 (.94)		1.04 (.92)	1.36 (.900)		1.240 (.870)	1.09 (.941)	1.33 (.900)
Share of S&E Degrees		.051 (.038)				.068* (.03)		.05 (.04)	.05 (.04)		.069* (.037)	.0681* (.037)		.052 (.037)	.069* (.0375)
R&D per Capita			.0048 (.010)				-.006 (.011)		.006 (.009)	.006 (.0097)		-.005 (.011)	-.005 (.0112)	.007 (.009)	-.0045 (.010)
Stock of Bachelors Degree Holders				.22** (.07)	.22** (.073)	.241** (.074)	.226** (.078)				.246** (.0746)	.248** (.079)	.229** (.079)		.252** (.079)
R Squared	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439	0.1439

Note: *Observations:* 1569273 *Clusters:* 421: * - Significance at 10% and **- Significance at 5% The individual controls include years of education, experience, experience squared, experience cubed, experience raised to the power of four, interaction between gender and marriage and race. The city controls include logarithm of population, population squared, total crime rate, mortgage payment with taxes, utilities and public school enrollment in K-12 system in a city. Include time dummy variables and city level fixed effects.

Table 5: The Partial R Squares from Residuals and [F statistics] for: Earnings (Employment) Instrumental Variables Regressions

	Residual of Bachelors per capita in 1970 1	Residual of Bachelors share in S&E in 1970 2	Residual of per capita R&D in 1973 3	Residual of Per capita R&D federal in 1973 4	Shift Share1 5	Shift Share2 6	Shift Share3 7	Residual of Land Grant 8
Residual of Per Capita Bachelors	0.0625 (0.0599) [26897.83 (32687.90)]							
Residual of share of S&E degrees		0.1618 (0.1651) [77846.53 (.)]						
Residual of per capita R&D			0.7551 (0.7517) [.(.)]	0.7222 (0.7152) [.(.)]	0.0105 (0.0104) [12869.68 (16250.20)]	0.0095 (0.0094) [11592.51 (14587.57)]	0.0061 (0.0060) [7480.67 (9269.83)]	
Residual of stock of Bachelors								0.0438 (0.0456) [27711.85 (36764.77)]
Observations	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)	1209570 (1538754)

Note: F statistics are noted in []. For the cells where F values are reported missing, STATA reports Prob >F=0.000

Table 6: Earnings Regression: Instrumental Variables

	1	2	3	4	5	6	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Share of S&E Degrees							.0936 (.229)	.0075 (.2237)	.1298 (.3456)	.008 (.223)	.1970 (.212)	.243 (.326)	.1976 (.212)
Per Capita R&D	.1501** (.0540)	.260 (.344)	.150** (.0537)	.0803* (.0418)	.1486 (.377)	.0806* (.041)		.1512** (.053)	.2062 (.1588)	.1517** (.0533)	.078* (.041)	.0998 (.156)	.078* (.041)
Stock of Bachelors Degree Holders				1.426** (.2781)	1.354** (.522)	1.425** (.278)	1.542** (.307)				1.49** (.2950)	1.487** (.3175)	1.494** (.295)
R Squared	0.3625	0.3625	0.3625	0.3626	0.3626	0.3626	0.3626	0.3625	0.3625	0.3625	0.3627	0.3627	0.3627
IV Used	Historic R&D	Share Shift Index	Historic R&D and Share Shift	Historic R&D	Share Shift Index	Historic R&D and Share Shift	Historic Share of S&E degrees	Historic S&E degrees and R&D	Historic S&E degrees, and Share Shift	Historic S&E degrees, R&D and Share Shift	Historic S&E degrees and R&D	Historic S&E degrees, and Share Shift	Historic S&E degrees, R&D and Share Shift

Note: *Observations*: 1209570 *Clusters*: 373* - Significance at 10% and **- Significance at 5% The individual controls include years of education, experience, experience squared, experience cubed, experience raised to the power of four, interaction between gender and marriage and race. The city controls include logarithm of population, population squared, total crime rate, mortgage payment with taxes, utilities and public school enrollment in K-12 system in a city. Include time dummy variables and city level fixed effects. The estimates reported are second stage estimates.

Table 7: Employment Regression: Instrumental Variables

	1	2	3
Per Capita Bachelors Degree	4.654 (3.95)		2.29 (4.00)
Share of S&E Degrees		-.057 (.080)	-.11 (.072)
Stock of Bachelors Degree Holders	.2590** (.0850)	.2140** (.09327)	.207** (.103)
R Squared	0.1445	0.1445	0.1445
IV Used	Historic Value of per capita Bachelors Degrees and Land Grant	Historic Values of S&E degrees	Historic Value of per capita Bachelors Degrees and S&E degrees and Land Grant

Note 1: * - Significance at 10% and **- Significance at 5% *Observations*: 1538754 *Clusters*: 373
Note 2: The individual controls include years of education, experience, experience squared, experience cubed, experience raised to the power of four, interaction between gender and marriage and race. The city controls include logarithm of population, population squared, total crime rate, mortgage payment with taxes, utilities and public school enrollment in K-12 system in a city. Include time dummy variables and city level fixed effects.

Figure 1: Per Capita Vs. Aggregate R&D for 1980