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 technological innovation and economic growth. Using panel data on metropolitan areas from 1980 to 2000, this paper estimates the spillover effects of activities of universities and colleges on economic outcomes of individuals in a local economy. Per capita academic R&D, share of science degrees in total bachelors' degrees and stock of college graduates in a metropolitan area are the measures of university activity. The panel structure of the data allows me to include fixed effects for metropolitan areas and time. To further investigate causality, I use deep lags of university activities and presence of land grant universities interacted with a dummy variable for decades, as instrumental variables. Per capita academic R&D and stock of college graduates in a metropolitan area have positive and significant effect on individual wages. The stock of college graduate in a metropolitan area is an important determinant of individual employment. In contrast, the effect of share of science degrees and per capita academic R&D appear to have more important effect on average employment. The results are also empirically important. One standard deviation increase in academic R&D increases wages by .8% and probability of individual employment probability by 0.02%. One standard deviation increase in share of science degrees increases wages by .4% and the probability of individual employment by 0.03%. One standard deviation increase in stock of college grads degrees increases wages by 4% and the probability of individual employment by 1%.

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

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I. Introduction

Endogenous growth theory suggests that technological innovations and a highly skilled workforce fuel economic growth (Romer [1993] and Lucas [1988]). Technological innovations are largely dependent on progress in science. Universities and colleges are important producers of science, conducting scientific research and training graduate and undergraduate students in scientific methods. This puts universities and colleges "at the crossroads of education and innovation" (Pianalto [2006]) supplying both talent and technology to the US industries[1]. R&D and graduates in science and engineering are both believed to be the causes of the economic prosperity of Boston, Silicon Valley[2] and the Research Triangle (Bania and Eberts [1993])[3]. Local universities supplied a lot of this R&D and science graduates. Based on the success stories of these regions, policy makers are increasingly relying on universities and colleges to be the source of economic growth and technological innovations (Cleveland Federal Reserve [2007]). However, this possibility has not been extensively examined by the scholarly literature. This paper fills that gap.

I estimate the spillover effects from universities and colleges to their local economies. A metropolitan area is a standard measure of a local economy. The theoretical insight from Roback [1982] suggests that persistent difference in wages and employment across metropolitan areas may be due to the differences in productive amenities between them. Activities of universities and colleges can be considered as important productive amenities of a metropolitan area. In this paper, panel data on university activities are related to different

[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] The electronics sector earnings in Silicon Valley and Route 128, were approximately 1.4 times larger and per worker earnings were approximately twice as higher than the national averages, (see Hill [2006]).

[3] 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]).

measures of economic outcomes of individuals in a metropolitan area. Because the effects of university activities are estimated after controlling for the individual characteristics like education and experience, this specification yields spillovers from universities and colleges. The economic outcomes of individuals considered in this study are log weekly real earnings, employment status at the individual level and average employment at the level of a metropolitan area.

Because university science is linked to technological change, we focus on university activities which results in the production of science. We use per capita academic R&D as the first measure of university activity, which meets our focus. To capture the role of universities in science training, we construct share of science and engineering degrees in metropolitan areas by dividing total bachelors' degrees in science and engineering by total bachelors' degrees. Universities can also alter the educational distribution in a metropolitan area. This happens through two different sources a) universities can attract highly educated people b) universities produce highly educated people who stay in the region. There is evidence that universities and colleges influence the stock of college graduates (Bound et al [2001]). This motivates us to construct stock of college graduates in a metropolitan area[4] as another measure of university activity.

I collect panel data of universities and college activities for 1980, 1990 and 2000 at the level of individual university. Each university or college is matched to its metropolitan area using its zip code. This allows me to aggregate the measures of university activity to the level of a metropolitan area. Data for stock of college graduates in metropolitan areas come from the

[4] Stock of college graduates is important source of human capital externalities (Rauch [1992], Glaeser [2001], Morretti [2004a, 2004b]).

decennial census. The source of the labor market conditions, i.e. individual wages and employment status were also computed from the 1980, 1990 and 2000 decennial census.

Economic spillovers from science generally transcend the boundaries of local labor markets in form of better technologies or better products. However, this analysis only captures the economic spillovers from universities that accrue to the local economy. Although this is not the central focus of this paper, spillovers can happen in a variety of ways. Universities train students to affect the distribution of human capital of the area, which might lead to adoption of better technologies (Lucas [1988]). University researchers conduct research and often provide expert advice to industries, which may lead to higher innovative activity. In ignoring the direct effects from science and the global effects from science the estimates will present a lower bound to the effect of universities and colleges.

Challenges and Answers

The estimation of spillovers presents some challenges. To begin with, metropolitan areas are different from one another – some are small, while others are big. The university activity variables are measured in per capita terms to account for the size differences of metropolitan areas. This contains the effect of college towns or large metropolitan areas from creating biases in the findings.

To estimate the spillover effects, I begin with OLS. To use the variation of university activities over metropolitan areas as an identification strategy, the variation in university activity need to be exogenous. One concern is that metropolitan areas like New York of Los Angeles may have other amenities in the city, which influences not only university activities but also the economic opportunities available to the individuals. There is a general concern that universities location in underdeveloped regions, might bias the results. The panel aspect of the data is exploited to control the effects of the sources of bias pointed above by including metropolitan area level fixed effects or random effects. The metropolitan area fixed effects eliminate time invariant differences across metropolitan areas including weather, business opportunities, movement in prices and urban amenities, which may be correlated with the university variables. We also control for time trends of different variables by including time fixed effects.

But, there is a possibility that metropolitan areas with time varying amenities can attract individuals of high income earning potential in a metro that has high university activity. Because fixed effects estimation ceases to be a good estimation strategy under these circumstances, I employ an instrumental variables strategy to control for these biases**.**

Endogenous current R&D is instrumented with time lagged values of per capita federally sponsored academic R&D (from 1973) interacted with a time dummy variable for each decade. The endogenous current share of science degrees is instrumented by share of science degrees (from 1970) interacted with a time dummy variable for each decade. The idea is to take away the effects of the initial distribution of university activities from the current distribution of university activities across metropolitan areas.

For this instrumental variable strategy to be valid, the instruments needs to be related to current university activities and but unrelated to current economic outcomes. Because nature of research in a university and structure of the degree programs are hard to change drastically, the lagged instruments are expected to be correlated to current values. Because the instrumental variables are from an era before the Bayh Dole Act (1980)[5] it is conceivable that the instruments are uncorrelated with current economic activity.

[5] The Bayh-Dole Act (1980) made academic research more commercially focused. It helped universities to set up technology transfer offices so that researchers could get a commercial return on their formulae beyond the academic accolades of publishing in academic journals. As a result universities have become more sensitive to economic conditions of an area post 1980 than pre 1980.

Endogenous stock of college graduates is instrumented with the presence of land grant universities and colleges interacted with a time dummy variable for each decade. Land Grant Act or the Morrill Act of 1862 allocated land randomly to cities within the states to build universities. It is likely that these metropolitan areas developed a higher share of college graduates because of the presence of the land grant universities. This affects the current stock of college graduates without having any direct relationship with the current labor market conditions. This instrument is used in the literature by others (see Morretti [2004a, 2004b]).

Summary of Results

The estimates show that per capita R&D, the share of science and engineering degrees in total bachelors' degrees, and the stock of college graduates have a positive effect on earnings and the probability of employment. In the income regressions, per capita R&D and the stock of college graduates are statistically significant. In the employment status regressions, the stock of college graduates is statistically significant. In the average employment regressions, importance of share of science degrees and academic R&D is reemphasized. The results are in contrast to the literature where insignificant university effects are the norm. Moreover, this paper finds that the empirical significance of university activities is high. One standard deviation increase in academic R&D increases wages by .8% and probability of individual employment probability by 0.02%. One standard deviation increase in share of science degrees increases wages by .4% and the probability of individual employment by 0.03%. One standard deviation increase in stock of college grads degrees increases wages by 4% and the probability of individual employment by 1%. All results are calculated after controlling for the effects of individual characteristics education, experience, race, gender and marital status and metropolitan area level characteristics.

Literature and Contribution

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 bachelors' 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]).

None of the above papers considered the question of endogeneity in a rigorous way. This paper is a break from that tradition. It is more in line with Abel and Deitz [2009], Kantor and Whalley [2009] or Hausman [2010], who takes a variety of approaches to address the question of causality. Abel and Deitz [2009] uses fixed effects model find that academic R&D had a positive and significant effect on both the stock of college graduates as well as on the occupation mix. Katnor and Whalley [2009] use shocks to the endowment of universities as a source of exogenous variation. The estimates indicate that a 10% increase in higher education spending increases local non-education sector labor income by about 0.5%. The estimates from this paper are very close to their estimates. Hausman [2001] uses Bayh Dole Act of 1980 as a natural experiment and finds that universities affect industries that are in close connection to universities and geographical proximity matters. None of these works rely heavily on individual level data. This paper is close to another literature about knowledge spillovers in innovation[6].

The goal of this work is not to study the mechanisms through which universities operate but it may provide some suggestive evidence. This paper suggests that a metropolitan area can get external returns from having universities. It may form a basis for policies at the level of university presidents or local governments to maximize benefits of universities to their local communities. This paper contributes to the literature by the use of individual level data from Census, this is rare in the literature, so we can find out spillover effects on individual outcome variables. It also uses a fixed effects and instrumental variable strategy to account for endogenity.

The remainder of the paper is organized in the following way: Section II discusses the estimation methodology. Section III describes the data, variables for the empirical analysis and trends in these variables. Section IV reports estimates for log weekly real wages and Section V does the same on employment status. Section VI concludes.

II. Estimation

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. We run reduced form cross city regressions:

$$y_{ict} = U_{ct}\beta^{W} + M_{ct}\gamma^{W} + X_{ict}\varphi^{W} + \theta^{W}{}_{c} + \nu^{W}{}_{t} + \varepsilon^{W}{}_{ct} + \xi^{W}_{ict} \qquad (1)$$

[6] 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]).

$$y_{ict} = U_{ct}\beta^{ES} + M_{ct}\gamma^{ES} + X_{ict}\varphi^{ES} + \theta^{ES}{}_{c} + \nu^{ES}{}_{t} + \varepsilon^{ES}{}_{ct} + \xi^{ES}_{ict} \qquad (2)$$

$$\bar{y}_{ct} = U_{ct}\beta^{AE} + M_{ct}\gamma^{AE} + \theta^{AE}{}_{c} + \nu^{AE}{}_{t} + \varepsilon^{AE}{}_{ct} \qquad (3)$$

Where, *i* stand for an individual, *c* stands for city and *t* stands for time. Equation 1 gives the specification for wage regressions, equation 2 gives the specification for employment status regressions and Equation 3 gives the specification for average employment estimations. When y_{ict} represents the logarithm of log real weekly wage of individual *i* in city *c* and time *t*, equation 1 becomes an earnings regression equation. When y_{ict} represents if an individual is employed or not employed, then this becomes an employment status regression. In equation 3, $\bar{y}_{ct}$ represents average employment.

A vector of university variables (per capita R&D, the share of science degrees in total bachelors' degrees and the stock of college graduates in a metropolitan area) is denoted by U_{ct} while M_{ct} represents a vector of metropolitan are level controls like (population, utilities, mortgages, tax, and interaction between population and the year dummy variable). Both U_{ct} and M_{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. And ν_t, θ_c, ε_{ct} and ξ_{ict} denote time, city, city-time, and individual level effects, which can be treated as fixed or random effects.

As indicated, to make metropolitan areas 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 metropolitan area over time the standard errors are clustered within each metropolitan area across time. The regressions are weighted by sample weights for each individual[7]. Because the covariance of university variables and the error term is non zero, we would introduce metropolitan area fixed effects (θ_c) and time fixed effects (ν_t) in equation 1, 2 and 3. Compared to OLS, we expect the estimated university activities estimate to be lower (higher) if the covariance between university activities and the error terms is positive (negative).

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. Three different instruments are used for three variables: 1) Share of science degrees in 1970 interacted with a dummy variable for decades to instrument for current share of science degrees 2) per capita federal R&D in 1973 interacted with a dummy variable for decade to instrument for current academic R&D 3) metropolitan areas with a land grant institution interacted with dummy variable for years to instrument for share of college graduates.

The First Stage equation is

$$U_{ct} = Z_{ct}\eta^{UW} + M_{ct}\gamma^{UW} + X_{ict}\varphi^{UW} + \theta^{UW}{}_{c} + \nu^{UW}{}_{t} + \varepsilon^{UW}{}_{ic} + \xi^{UW}{}_{ict} \qquad (4)$$

$$U_{ct} = Z_{ct}\eta^{UES} + M_{ct}\gamma^{UES} + X_{ict}\varphi^{UES} + \theta^{UES}{}_{c} + \nu^{UES}{}_{t} + \varepsilon^{UES}{}_{ic} + \xi^{UES}{}_{ict} \qquad (5)$$

$$U_{ct} = Z_{ct}\beta^{UAE} + M_{ct}\gamma^{UAE} + \theta^{UAE}{}_{c} + \nu^{UAE}{}_{t} + \varepsilon^{UAE}{}_{ct} \qquad (6)$$

where Z_{ic} is the vector of the instrumental variables which are used as instruments for the endogenous U_{ic} vector of variables. The predicted values of U_{ic} which is denoted by $\hat{U}_{ic}$ is used as the regressor in the second stage instead of U_{ic} in equation 1, 2 and 3 respectively. For this

[7] Random effects estimation by GLS or MLE estimation is an exception. In STATA 11 GLS/MLE estimation cannot be done with weights and clustering. Since clustering of standard errors are much more important in these regressions we report the results of GLS that controls for clustering but not for weights.

strategy to be successful in establishing causality, two assumptions have to be satisfied simultaneously. First, covariance of Z and U should be non zero and second, the covariance between Z and error term in the second equation should be zero. Because nature of research in a university and structure of the degree programs are hard to change drastically, the lagged instruments are expected to be correlated to current values. Because the instrumental variables are from an era before the Bayh Dole Act (1980) it is conceivable that the instruments are uncorrelated with current economic activity.

III. Data

In the empirical analysis I assume that economic outcomes of individuals are related to individual and local area characteristics. The individual outcomes considered are log weekly real wages and employment status. University activities are a part of the local area characteristics and are measured by the share of science degrees in total bachelors' degrees, per capita academic R&D and stock of college graduates.

Main Independent Variables

Academic R&D

The dataset on Academic R&D Expenditures comes from National Science Foundation by school, field and source for 1980, 1990 and 2000. This data is for sponsored research. The data is available by field and source of funding. In 1980 (1990 and 2000) there were 520 (554 and 614) universities and colleges, of which 413 (440 and 511) universities and colleges are in metropolitan areas in for 1980 (1990 and 2000) for which data was available[8]. NSF reports R&D for universities and colleges for a much smaller population than National

[8] In the data analysis I use total R&D which contains R&D of natural as well as social sciences. I do not include the R&D of research laboratories since they are not academic institutions. R&D is measured in thousands of dollars.

Center for Education Statistics. 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 dollars, followed by Massachusetts Institute of Technology (MIT), University of Michigan, University of Wisconsin Madison, University of Washington at Seattle, and 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. Academic R&D measures the strength of the graduate science programs. Schools that have strong science programs also feature in the "best universities in USA" category. Academic R&D is also a good proxy for the quality of the university[9].

Aggregating the R&D data to the metropolitan area levels 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. There are 157 (159, 181) metropolitan areas in

[9] A limitation of the data is that it does not include information on subcontracts to other organizations or from other organizations. This is only a problem for subcontracts that are to or from organizations that are outside of the lead institution's metropolitan area.

1980 (1990 and 2000) for which R&D data is available[10]. Table 1 gives the list of metropolitan areas that have large volumes of R&D in per capita and aggregate levels across 1980, 1990 and 2000. It shows that when the larger metropolitan areas are at the top of R&D spending, in per capita terms the smaller metropolitan areas and college towns dominate the rankings. Figure 1 shows the relationship between using per capita versus aggregate levels of academic R&D variables in 1980. In this graph, the horizontal axis measures per capita Academic R&D, and the vertical axis measures logarithm of R&D levels. From these graphs it is clear that college towns such as College Station, Texas, State College, Pennsylvania, Urbana-Champaign, Bloomington-Normal, Lafayette, Gainesville 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.

Share of Science Degrees

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 science and engineering at the level of the universities and colleges[11]. Because of our belief that spillover effects come from science affecting technology, we worry about the bachelors' degrees in science. As programs differ in size it is important to divide share of science degrees by the total bachelors' degrees. This is how we construct the share of bachelors' degrees in science, which is a measure of the strength of

[10] Metropolitan areas without academic R&D for any institution were imputed to be at the 5th percentile of the distribution of academic R&D per capita.

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

undergraduate programs in science in a university. Since Academic R&D data already takes the strength of graduate programs into account, we do not use masters or doctorate degrees[12].

Aggregating the degree data to the metropolitan area level yields 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, total bachelors' degrees in a region is divided by the population of that metropolitan area to estimate the importance of bachelors' degrees. In the analysis the share of bachelors' degrees in S&E in total bachelors' degrees granted is used, which is neutral to the size of a city[13]. 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 1980 (1990 and 2000) there were 2,874 (3,208 and 3,159) universities and colleges in the sample. Using the zip code of each college and university I 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.

[12] Masters or Doctoral students in science fields are generally funded through grant monies, which would be a part of R&D expenditure.

[13] Because we have the universe of university and colleges, if a metropolitan area has missing value for science degrees, it must be because the amount of science degrees in that area was very low. We imputed these metros with a 0 value for science.

Stock of College Graduates

The stock of college graduates was calculated from the Census. It is the weighted sum of all individuals with at least a college degree (or 16 years of education) divided by the total number of observations per metro in a year. There is a large variation between metropolitan areas of stock of college graduates. While the college towns have more college graduates, large metropolitan areas like Boston, San Francisco, Tallahassee and Washington DC have higher shares of stocks of college graduates.

Outcome Variables: Census

We measure labor market activities, including earnings and individual employment status. Individuals are considered employed if they have a job and they can either be at their work or not at their work using Census data from the Integrated Public Use Microdata Series (IPUMS; see Ruggles; Alexander; Genadek; Goeken; Schroeder; and Sobek [2010]). We use the 1980 1% unweighted metro sample, the 1990 1% weighted sample, and the 2000 1% unweighted sample from IPUMS. These samples were chosen to maximize identification of metropolitan areas. These data contain a range of individual characteristics including education, gender, race, ethnicity, marital status as well as city of residence, earnings, weeks worked and the industry and occupation of employment.

The sample is limited to non-institutionalized civilians not currently enrolled in school living in metropolitan areas between age 18 and 65. Earnings are measured in log of real weekly wages (deflated to 1982-1984=100 dollars). Individuals whose real weekly wages were below 40 dollars and above 4000 are excluded from the sample. Lastly, to ensure that our estimates capture spillover of academic R&D on the local economy, we discard people who are post-secondary teachers or who work in universities or colleges. Our wage sample includes 411,432 individuals in 1980, 454,196 individuals in 1990, and 485,217 individuals in 2000. Our employment sample includes 469,484 individuals in 1980, 513756 individuals in 1990, and 564,359 individuals in 2000. Average employment is calculated from metro data. There are 653 metros in the average employment sample.

Metropolitan Area Controls

A rich set of non-university control variables for metropolitan areas like population, crime rates and public school attendance is taken from *State and Metropolitan Data Set* for the years 1980, 1990 and 2000. In the same vein I also use data of 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. The pooled sample has 1,350,845 observations for wage sample and 1,547,599 observations for the employment sample. We do not include these variables in the estimates we report here because they are likely to be endogenous, but our results are robust to including these variables as controls.

Aggregation

Metropolitan areas are aggregated to Consolidated Metropolitan Statistical Areas (CMSA), New England Consolidated Metropolitan Areas, (NECMA) and Metropolitan Statistical Areas (MSA). The constituent metropolitan areas in CMSAs and NECMAs change from year to year. For consistency, we use the CMSA, NECMA and MSA classification in the State and Metropolitan Area Data Book 1997-1998 (U.S. Bureau of Census [1998]).

Descriptive Statistics

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 real weekly earnings have increased from $5.809 in 1980 to $5.827 in 1990 and increased further to $5.904 in 2000. The variable employment status takes the value 1 if the individual has a job. The mean employment rate has gone up from 83% in 1980 to 85% in 1990 and to 86% of working age adults in 2000. While the standard deviation of both increase over time, the coefficient of variation for log weekly wages indicate that inequality of wages across city over time has increased but the inequality of employment across metropolitan areas have decreased. Average employment across metropolitan have a mean of 73% on an average – the standard errors associated with this variable are low.

Table 2 gives the summary statistics of the regression sample for the earnings and employment regressions. The mean of real R&D per capita was $54 per capita with a standard deviation of 8%. The mean of real per capita R&D expenditure, have risen by 54% between 1980 and 1990 and then increased by 24% between 1990 and 2000. This shows that post 1980 there was a boom in sponsored research from universities. Since 1980, R&D expenditure has nearly doubled (growth of 92%). The coefficient of variation increased between 1980 and 1990 but decreased between 1990 and 2000. This suggests that there are cities who took the lead in academic R&D production and the rest of the country caught up to them in the 1990.

About 25% of bachelors' degrees were in science and engineering fields on an average, with a standard deviation of 6%. The mean of per capita science and engineering degrees decreased between 1980 and 1990 by 10% but increased by 3% between 1990 and 2000. The coefficient of variation decreased over time indicating catch up effect of different metropolitan areas. About 27% percentage of population on an average had college graduate degrees with a standard deviation of 7%. The mean of the stock of college graduates went up by 26% between 1980 and 1990 while the same share increased by 24% between 1990 and 2000. The standard deviation increased between 1980 and 2000 suggesting that regional inequality in distribution of the stock of college educated population have increased within the metropolitan areas.

It is also worth noting that the innovation and aggregate education variables are relatively weakly correlated with each other. The main exception is academic R&D and the college graduate population share, which frequently have correlations in the range of .25-.4. By contrast the other correlations are beneath .1, frequently considerably lower.

We have also explored the extent to which academic R&D and science degree shares explain stock of college graduates. Our estimates are reported in Appendix Table1 and show that there is a tendency for college graduate stock to be higher in metropolitan areas with higher academic R&D and share of science degrees. Thus, both academic R&D and high share of science degrees are related to high stock of college degrees. This is the reason why we want to think of stock of college graduates to be a university activity variable.

IV. Wage Regression Results

OLS

Table 3 reports the cross sectional estimates (OLS) results by year. Column 1 –Column 3 has the individual effects of per capita academic R&D, share of science degrees and per capita stock of bachelors' degrees. Column 4 presents estimates when all the variables are included. We find that the estimates for college graduates and R&D increased from 1980 both in magnitude and statistical significance. The negative sign on R&D in column 4 can be explained by correlation between R&D and stock of college graduates. The share of college graduates became the dominant variable in the 2000.In contrast, the share of science degrees became small and statistically insignificant in the later years. The negative sign suggests that the labor supply effect may have dominated in the later years depressing the wages. Although these estimates are imprecise, still it appears that some university activities become more important with time.

Random Effects and Fixed Effects

Because OLS is inadequate if we are not sure about the exogeneity of the university activities, we employ a random effects model. Here, we pool all observations from different years and employ a GLS estimation model. The primary source of identification in these estimates comes from variation across metropolitan areas, with additional identification from changes over time within metropolitan areas. Table 4 reports results of GLS. It shows that when the stock of college graduates' has a positive and significant relationship with wages, the share of S&E degrees and per capita academic R&D do not have positive but insignificant relationship with wages. The stock of college graduates also has the largest independent impact on earnings. We think that in the joint regressions R&D becomes negative largely because of the correlation with stock of college degree holders. Science degrees have a negative coefficient because of the labor supply effect.

Table 5 reports fixed effects estimates. Each variable is positively and significantly related to earnings. Each of the estimates is considerably larger than the random effects estimates. It suggests that the covariance between the time invariant components of error term is negatively correlated to university activities. In other words, the university activities may be correlated with fewer productive amenities or higher consumption amenities – this is possible if labor takes more time to adjust to the increase in the wages. The reversal of sign of share of science degrees suggests that once we account for the time invariant factors by which metropolitan areas differ, the supply effect on degrees goes away. Using these estimates, one standard deviation increase in academic R&D increases wages by 1.4% one standard deviation increase in share of science degrees increases wages by .01% and stock of college degrees increases wages by 5%.

Instrumental Variables

We directly address causality by introducing instrumental variable estimates. Appendix Table 2 shows the first stage results. We see that per capita federal R&D in 1970 (interacted with a dummy variable for decades) is strongly related to R&D in current years, share of science degrees in 1970 (interacted with a dummy variables) is strongly related to share of current share of science degrees and presence of land grant universities (interacted with a dummy variable) explains current stock of college graduates powerfully. The partial R Squares and F statistics from the first stage regressions are reported for each instrument independently.

Table 6 reports the 2SLS instrumental variable results for the second stage. We find that the coefficients of both academic R&D and stock of college graduates are positive and significant at the 1% level. The coefficients of both these variables are between the GLS and Fixed Effects Estimates. The coefficient of share of science degrees is positive but insignificant. It is noticeable that this coefficient increases quite a bit above the fixed effects estimates. The table reports Hansen's J test statistic and the associated p values. Because the null hypothesis is that the instruments are exogenous, the p value needs to be high enough for us to fail to reject the null. In each case, the p values are large enough to fail to reject the null hypothesis at the 5% level. The results are also empirically important. A one standard deviation increase in academic R&D, and share of science and engineering degrees in total bachelors' degrees and the stock of college degree holders in a metropolitan area would each increase log real weekly wages by 0.8%, 0.4% and 4% respectively.

Shape of Relationships

It is important to understand the nature of relationship between university activities and wages in different metropolitan areas when we consider higher order terms. To answer this question we include higher order terms in the regression specification. Table 7 shows the fixed effects regression results with higher order terms of the university variables. The sign on the squared term of per capita R&D is negative suggesting that diminishing returns happen in the relationship between wages and academic R&D. It also indicates that cities having lowest R&D expenditure has an opportunity to grow, while cities with high per capita R&D will have a tendency to slow down. Interestingly, the sign of the square terms of share of science and stock of college graduates are positive. This indicates that stock of college graduates and share of science degrees have a convex relationship with wages suggesting the educated and cities with higher science degrees would be better equipped to reap benefits from having university activities. These relationships continue to hold even when we remove college towns from our sample. Although, not in the scope of this paper this result suggests some of the mechanisms through which university spillovers happen.

Comparisons

The effects we find in this paper 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]). It is line with the findings of Abel and Deitz [2009], Whalley and Kantor [2010] who shows a 10% increase in university activities will lead to an increase in wages by 0.5%. Our estimate of one standard deviation increase is large but not as large as in Morretti [2004a].

Robustness

I have used a variety of other specifications to check the robustness of the results. 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. We find that 5 year lag variables are not significant. We estimated the fixed effects model at the metropolitan area level as well. The results were similar. As metro level regressions do not include individual characteristics, we cannot easily capture individual heterogeneities. To circumvent this problem, I used metro specific fixed effects at the individual level and then estimated these wage dummies on the university variables. This two step procedure which might lead to biases in standard errors.

V. Employment Regression Results

Employment Status

To find out the impact of university activities on individual employment status, we relate university activities across metropolitan areas to a dummy variable which takes the value 1 if the individual has a job or 0 if the individual does not have a job. Because the dependent variable is a binary variable, we fit a linear probability model as a first cut. Table 8 gives the random effects, fixed effects and instrumental variable results. It is striking to see that while in random effects model R&D have strong relationship with employment status, in fixed effects or instrumental variable model this relationship becomes weak and insignificant. The share of science degrees has positive coefficients in all three estimation methods, and is significant at the fixed effects regression. The stock of college graduates has a positive and significant relationship with the 2SLS regressions and random effects but shows no relationship at the fixed effects regressions.

Taking the 2SLS coefficients of these variables we find that one standard deviation increase in R&D will lead to increase in probability of employment by .02%, one standard deviation increase in science degrees will lead to an increase in probability of employment by .03% and an one standard deviation increase in stock of college graduates will lead to increase in employment by 1%. The economic effects are smaller than the wage estimates. This is possibly because the elasticities of the underlying demand and supply of labor. It is conceivable that the supply elasticity is on average is small in cities where university activity is the strongest, leading to larger impact on wages than on employment.

Average Employment

Although individual level results are weak, there is no reason to believe that university activities have no impact on metro level average employment. Table 9 gives the OLS results when we relate average employment to university activities by year. Surprisingly, in all the years, 1980, 1990 and 2000, the estimates of university activities are strongly related to average employment of a metropolitan area. The strength of the relationship decreased between 1980 and 1990 but it increased between 1990 and 2000. Relative to the wage estimates, the coefficient on the share of science degrees is always positive and it is statistically significant in 1980 and 2000. The stock of college graduates still has the highest coefficient.

Table10 gives the random effects estimates in the top panel. The coefficients of all the variables decrease relative to the OLS estimates, but the relationship between the university activity variables and the average employment stay positive and significant. It is interesting to note that the share of science degrees start having a higher coefficient than that of academic

R&D. The middle panel of Table 10 gives the fixed effects estimates. The surprising result here is that the significance of both academic R&D and share of science degrees fall, although the coefficients are positive. The coefficient on college graduates is positive and significant and it has the strongest relationship to average employment. The bottom panel of Table 10 reports the instrumental variable results. Here the coefficients increase again and get close to the 2000 OLS estimates reported in Table 9. Surprisingly, stock of college graduates does not have a significant relationship, but R&D and share of science degrees are both important.

Because the results vary between alternative models, it is hard to use them meaningfully to predict employment. However, there is one strong trend in the average employment regressions. Academic R&D and particularly the science degrees are at least as important as the stock of college graduates. It indicates the role of universities as trainees of educated students both at the graduate and undergraduate level is useful in increasing average employment. These results resonate with recent work by Carlino and Hunt [2009] and Abel and Deitz [2009] on the effect of academic R&D on employment in metropolitan areas.

3.5 Conclusion

This paper estimates the economic effects of universities on their local economies. It extends and enriches the existing empirical work, which does not always deal with causality rigorously. I use panel data at the level of universities and colleges. Using metropolitan area level fixed effects and different instrumental variables we 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, individual employment and average employment significantly. The results are also empirically important. One standard deviation increase in academic R&D increases wages by .8% and probability of individual employment probability by

0.02%. One standard deviation increase in share of science degrees increases wages by .4% and the probability of individual employment by 0.03%. One standard deviation increase in stock of college grads degrees increases wages by 4% and the probability of individual employment by 1%. 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 Francisco, CMSA	Iowa City, IA	San Francisco, CMSA	Urbana Champaign	San Francisco, 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	Gainesville FL
9	Detroit, CMSA	Gainesville, FL	Detroit, CMSA	Lafayette	Detroit, CMSA	Madison
10	San Diego	Bloomington, IN	Philadelphia, CMSA	Gainesville, FL	Philadelphia, CMSA	Lafayette

Table 2. Descriptive Statistics.

	All years	1980	1990	2000	Units / Measurement
Academic R&D Per Capita	0.054	0.036	0.055	0.069	Thousands of Current Dollars per person.
	(0.081)	(0.053)	(0.086)	(0.092)	
Share of Science Degrees	0.252	0.268	0.242	0.250	Science degrees per bachelors' degrees.
	(0.067)	(0.073)	(0.063)	(0.063)	
Stock of College Graduates	0.274	0.211	0.267	0.333	
	(0.077)	(0.044)	(0.059)	(0.070)	
Log(Wage)	5.849	5.809	5.827	5.904	Current Dollars
	(0.727)	(0.695)	(0.728)	(0.747)	
Individuals	1,350,845	411,432	454,196	485,217	
Employment Status	0.855	0.838	0.856	0.869	Have a job at work and not at work
	(0.352)	(0.368)	(0.351)	(0.338)	
Individuals	1,547,599	469,484	513,756	564,359	
Average Employment	.732	0.698	.745	.7506	
	(0.048)	(0.041)	(.042)	(.0425)	
Metros	653	213	222	218	

Note. Table reports means and standard deviations in parentheses.

Table 3. Relationship between University Activities and Wages, By Year.

Dep. Var: Log Wages	(1)	(2)	(3)	(4)
			1980	
Academic R&D Per capita	-0.069			-0.164+
	(0.071)			(0.092)
Share of Science Degrees		0.231*		0.265*
		(0.095)		(0.105)
Stock of College Graduates			-0.041	0.011
			(0.227)	(0.260)
			1990	
Academic R&D Per capita	0.047			-0.046
	(0.041)			(0.032)
Share of Science Degrees		-0.064		-0.081
		(0.066)		(0.066)
Stock of College Graduates			0.371***	0.422***
			(0.101)	(0.116)
			2000	
Academic R&D Per capita	0.073+			-0.040
	(0.042)			(0.031)
Share of Science Degrees		-0.024		-0.120*
		(0.064)		(0.061)
Stock of College Graduates			0.439***	0.502***
			(0.115)	(0.129)

Note. Sample includes 44,432 observations in 213 metropolitan areas in 1980, 454,196 observations in 222 metropolitan areas in 1990, and 485,217 observations in 218 metros in 2000. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Estimates weighted by population weights. Standard errors, clustered at the metropolitan area level, are reported in parentheses. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table 4. Relationship between University Activities and Wages, Random Effects.

Dep. Var: Log Wages	(1)	(2)	(3)	(4)
Academic R&D Per capita	0.037			-0.040
	(0.037)			(0.030)
Share of Science Degrees		-0.035		-0.049
		(0.064)		(0.061)
Stock of College Graduates			0.548***	0.572***
			(0.149)	(0.152)

Note. Data pool 1980, 1990, and 2000. Sample includes 1,350,845 observations in 229 metropolitan areas. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Estimates weighted by population weights. Significance given by: *** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

Table 5. Relationship between University Activities and Wages, Fixed Effects.

Dep. Var: Log Wages	(1)	(2)	(3)	(4)
Academic R&D Per Capita	0.182			0.095
	(0.118)			(0.101)
Share of Science Degrees		0.010		0.033
		(0.090)		(0.086)
Stock of College Graduates			0.738***	0.723***
			(0.194)	(0.190)

Note. Data pool 1980, 1990, and 2000. Sample includes 1,350,845 observations in 229 metropolitan areas. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Estimates weighted by population weights. Standard errors, clustered at the metropolitan area level, are reported in parentheses. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table 6. Relationship between University Activities and Wages, Two-Stage Least Squares With and Without Fixed Effects

Dep. Var: Log Wages	(1)	(2)	(3)	(4)
Academic R&D Per Capita	0.104*			-0.114
	(0.047)			(0.103)
Share of Science Degrees		0.068		-0.119
		(0.097)		(0.079)
Stock of College Graduates			0.639***	0.794**
			(0.171)	(0.267)
J Statistic	1.944	0.055	0.046	1.214
(p value)	(0.163)	(0.815)	(0.830)	(0.750)

Note. Data pool 1980, 1990, and 2000. Sample includes 1,350,845 observations in 229 metropolitan areas. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Instruments are (1) per capita federal R&D in 1970; (2) share of science degrees in 1970; and (3) presence of land grant universities. Each instrument is interacted with dummy variables for 1990 and 2000. First Stage Regressions are reported in Appendix Table 2. Standard errors, clustered at the metropolitan area level, are reported in parentheses. Estimates weighted by population weights. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table 7. Curvature of the Relationship between Innovation and Aggregate Education and Wages, Fixed Effects.

Dep. Var: Log Wages	(1)	(2)	(3)	(4)
Academic R&D Per Capita	0.359			0.022
	(0.264)			(0.213)
Squared	-0.125			
	(0.113)			
Share of Science Degrees		-0.206		-0.191
		(0.258)		(0.249)
Squared		0.398		0.363
		(0.549)		(0.520)
Stock of College Graduates			-0.939*	-0.947*
			(0.369)	(0.366)
Squared			2.429***	2.432***
			(0.574)	(0.570)

Note. Data pool 1980, 1990, and 2000. Sample includes 1,350,845 observations in 229 metropolitan areas. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Estimates weighted by population weights. Standard errors, clustered at the metropolitan area level, are reported in parentheses. Significance given by: *** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

Table 8. Relationship between University Activity and Employment Status. –Individual Level

Dep. Var: Employment Status	(1)	(2)	(3)	(4)
			Random Effects	
Academic R&D Per capita	0.014+			0.002
	(0.007)			(0.010)
Share of Science Degrees		0.064**		0.060**
		(0.021)		(0.021)
			0.053	0.044
			(0.037)	(0.039)
Stock of College Graduates				
			Fixed Effects	
Academic R&D Per capita	-0.035			-0.019
	(0.028)			(0.029)
Share of Science Degrees		0.071*		0.067*
		(0.033)		(0.034)
Stock of College Graduates			-0.045	-0.029
			(0.059)	(0.061)
			2SLS	
Academic R&D Per capita	0.023			-0.024
	(0.014)			(0.027)
Share of Science Degrees		0.041		-0.014
		(0.033)		(0.028)
			0.133**	0.156*
			(0.050)	(0.070)
Stock of College Graduates				

Note. Data pool 1980, 1990, and 2000. Regressions also include population and its square, and year dummy variables. Standard errors reported in parentheses. Estimates weighted by the square root of population. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table 9 Relationship between University Activity and Employment Status. –Metro Level – By Year

Dep. Var: Employment Status	(1)	(2)	(3)	(4)
			1980	
Academic R&D Per capita	0.193*** (0.049)			-0.042 (0.053)
Share of Science Degrees		0.117* (0.055)		0.035 (0.046)
Stock of College Graduates			0.646*** (0.093)	0.653*** (0.120)
			1990	
Academic R&D Per capita	0.110** (0.040)			-0.007 (0.029)
Share of Science Degrees		0.078 (0.055)		-0.005 (0.049)
Stock of College Graduates			0.466*** (0.074)	0.471*** (0.092)
			2000	
Academic R&D Per capita	0.092** (0.035)			-0.003 (0.034)
Share of Science Degrees		0.168** (0.055)		0.087 (0.054)
Stock of College Graduates			0.300*** (0.078)	0.279** (0.095)

Note. Data pool 1980, 1990, and 2000. Regressions also include year dummy variables. Standard errors reported in parentheses. Estimates weighted by the square root of population. Significance given by: *** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

Table 10. Relationship between University Activity and Employment Status. –Metro Level

Dep. Var: Employment Status	(1)	(2)	(3)	(4)
			Random Effects	
Academic R&D Per capita	0.032+			-0.021
	(0.016)			(0.009)
Share of Science Degrees		0.061***		0.042**
		(0.023)		(0.020)
Stock of College Graduates			0.437***	0.445***
			(0.037)	(0.040)
			Fixed Effects	
Academic R&D Per capita	0.029			-0.008
	(0.048)			(0.042)
Share of Science Degrees		0.088		0.109*
		(0.056)		(0.055)
Stock of College Graduates			0.252***	0.274*
			(0.0106)	(0.111)
			2SLS	
Academic R&D Per capita	0.124***			0.38
	(0.034)			(0.070)
Share of Science Degrees		0.190*		0.058
		(0.081)		(0.062)
Stock of College Graduates			0.260	0.225
			(0.160)	(0.202)

Note. Data pool 1980, 1990, and 2000. There are 653 metropolitan areas in the sample. Regressions also include year dummy variables. Standard errors reported in parentheses. Estimates weighted by the square root of population. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Appendix Table 1. Relationship between Stock of College Graduates and Other University Activities

Dep. Var: Employment Status	(1)	(2)	(3)
		Random Effects	
Academic R&D Per capita	0.121***		0.119***
	(0.026)		(0.026)
Share of Science Degrees		0.044*	0.033+
		(0.021)	(0.020)
		Fixed Effects	
Academic R&D Per capita	0.194**		0.185**
	(0.067)		(0.066)
Share of Science Degrees		-0.079+	-0.065
		(0.044)	(0.044)
		2SLS	
Academic R&D Per capita	0.328***		0.279***
	(0.076)		(0.078)
Share of Science Degrees		0.446**	0.266*
		(0.149)	(0.122)

Note. Data pool 1980, 1990, and 2000. Regressions also include population and its square, and year dummy variables. Standard errors reported in parentheses. Estimates weighted by the square root of population. Significance given by: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Appendix Table 2. First Stage Regressions,Without Fixed Effects.

Depvar:	(1) Academic R&D Per Capita	(2) Share of Science Degrees	(3) Stock of College Graduates	(4) Academic R&D Per Capita	(5) Share of Science Degrees	(6) Stock of College Graduates
1973 Federal R&D*1990	2.153***			1.693***	0.089	0.379***
	(0.187)			(0.168)	(0.123)	(0.104)
1973 Federal R&D*2000	2.111***			1.655***	0.090	0.320**
	(0.185)			(0.167)	(0.094)	(0.118)
1970 Share of Science Degrees * 1990		0.486***		0.050+	0.486***	0.042
		(0.057)		(0.028)	(0.063)	(0.031)
1970 Share of Science Degrees * 2000		0.516***		0.050+	0.501***	0.071
		(0.050)		(0.029)	(0.057)	(0.047)
Land Grant *1990			0.057***	0.013	-0.021*	0.045***
			(0.012)	(0.008)	(0.008)	(0.013)
Land Grant * 2000			0.064***	0.020*	-0.001	0.049**
			(0.015)	(0.009)	(0.007)	(0.015)
First Stage Diagnostics						
Partial R Squared	0.675	0.2677	0.2288			
F Stat	69.02	64.52	10.51			

Note.. Individual-level controls include education, a quartic in potential experience, race (dummies for black and other race), Hispanic background, citizenship, and marital status. Regressions also include the log of population in the metropolitan area and its square interacted with year dummy variables. Estimates weighted by population weights. Standard errors, clustered at the metropolitan area level, are reported in parentheses. Significance given by: *** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

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