Lecture # 16 – Government Policy for Technology Transfer/Tech Policy for Local Governments

I. CRADAs (continued)

- Examples of successful CRADAs
  - In the 1960s, scientists demonstrated that paclitaxel, a natural product found in the bark of the Pacific Yew tree, could treat cancerous tumors.
  - Problems hindering development of the drug:
    - Scarcity of paclitaxel
    - Inability to find a company to commercialize the drug
  - Key breakthrough
    - In 1989, Robert Holton, a professor at Florida State University, developed a synthetic process for producing Taxol. He received a patent in 1992.
    - Bristol-Myers Squibb signed a licensing agreement for the right to use this process in 1990.
      - Paid a royalty rate of 4.2%.
  - The technique to make paclitaxel from plant tissue cells came from research done by the Agricultural Research Service (ARS).
    - In 1990, the ARS signed a CRADA with a biotech company, Python, Inc.
    - Python got exclusive license to adopt laboratory-scale procedures to commercial scale procedures for developing Taxol.
    - They then entered into a contract with Bristol-Myers Squibb.
  - A CRADA between Bristol-Myers Squibb and the National Institutes of Health (NIH) addressed these problems.
    - Agreement began in 1991.
      - NIH provided preclinical animal studies, chemical data, research agents, and enough paclitaxel and yew tree bark to continue chemical trials.
      - Bristol-Myers Squibb developed improved procedures to increase the amount of paclitaxel that could be extracted from trees, and supported research on developing of alternative technologies for making paclitaxel.
      - Included a clause allowing NIH to terminate the CRADA if BMS "failed to exercise best effort in the commercialization of Taxol [paclitaxel]."
    - This agreement expired in 1997. BMS and NIH reached a new agreement in 1998.
  - In 1996, NIH and BMS reached a second licensing agreement.
    - BMS pays NIH royalties of 0.5% in return for exclusive license on three additional Taxol-related patents.
    - Through 2002, BMS has paid NIH $35 million in royalties.
  - Economic effects of the CRADAs
    - Research expenses

        - NIH
            - From 1977 to 1997, NIH spent $483 million on paclitaxel research.
            - It spent an additional $301 million from 1998-2002, as part of the second CRADA.
            - NIH also spent $96 million on clinical trials.
        - BMS
            - Paid $16 million to NIH to offset the costs of clinical trials.
            - Spent an additional $1 billion on development of Taxol.
            - Finally, BMS provided NIH with an unlimited supply of synthesized paclitaxel for general research. Estimates of the value of the compound received range from $92 million to $151 million.
    - Drug sales
        - Taxol, BMS's trademark name for synthetically-produced paclitaxel, first reached markets in 1993.
        - Since then, BMS has sold more than $9 billion of Taxol.
    - Including contributions such as the paclitaxel received from BMS by NIH, the total estimated value of the CRADA to NIH is between $143 and $202 million.
- Policy issue: has NIH received a fair return on its investment?
    - NIH says yes.
        - Argues R&D figures include all related R&D done by NIH
        - Agreement requires Taxol be "fairly priced."
            - Key question: what is "fairly priced"?
        - Note that NIH did not hold patent on Taxol. Thus, all they could give BMS was access to data from clinical trials.
            - Someone could have developed another way to produce Taxol.
            - In contrast, FSU got better royalties because could offer exclusive use of their patent for synthesizing the compound.
        - Also, when the agreement was signed, Taxol was only being considered for ovarian cancer.
            - It turned out to be effective for other types of cancers as well.
            - Note importance of uncertainty!
    - Sen. Wyden
        - NIH ignores cost to society of higher drug prices
            - For example, says costs to Medicare must be considered
        - FDA gave BMS five year window of exclusivity once Taxol was approved.

            - Such windows are made available for "unpatentable pharmaceuticals."
- Legal issues:
    - Relaxing antitrust enforcement for research joint ventures.
    - Intellectual property rights
        - Two successful CRADAs through NIH led to valuable property rights being given to private firms. This created political pressure against the CRADAs.
            - AZT, an HIV-drug, was created through a CRADA with NIH and the Burroghs Wellcome Company.
                - As a result of the high price of AZT, Congress passed a "fair pricing" clause for future CRADAs.
                    - To implement it, NIH would have to undertake a broad examination of the economics of pharmaceuticals.
        - As a result of such uncertainties, firms are reluctant to enter into CRADAs with NIH.
    - Exclusive licensing
        - Although the labs are free to partake in numerous CRADAs, in practice, exclusive licensing excludes firms in competitive industries.
            - In some instances, firms have been unwilling to agree to CRADAs unless competitors do not participate.
            - In the Taxol case, Unimed, a small pharmaceutical, also wanted to be involved.
            - Unimed's complaints led to oversight hearings for NIH.
            - The EPA was sued for entering into CRADAs with the competitors of a firm that had been denied a CRADA. The EPA won the case.
    - These examples show CRADAs that can create political problems when they create winners and losers.
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II. The Role of Universities: Academic Enterprise

Thanks to Kelly and Yang for leading a very successful discussion today. Below are my notes on the role of universities.

- Academic enterprise: "systematic efforts to strengthen the short-term commercial value of their research, and to facilitate or pursue the commercialization of their inventions" (Larsen, p. 6)
- University patents pre-Bayh-Dole
    - Although most universities avoided patenting, some did patent
    - A UC Berkeley chemist, Frederick Garnder Cottrell, proposed patenting his inventions as early as 1912
        - Royalties could be used to support research

        - Because this was controversial, instead UC Berkeley started a Research Corporation to administer the patents
    - MIT singed first agreement with the corporation in 1937
    - By 1980, about 75% of universities had such agreements
        - Most prominent was Wisconsin Alumni Research Foundation (WARF), founded in 1924
    - Until late 1960s, most university patents came from research financed using institutional funds, not university funds
    - Federal policy gained attention in 1968, when two studies criticized Dept. of Health, Education, and Welfare for policies preventing firms screening compounds developed using NIH funding from obtaining patents on the research
        - The reports said firms stopped using these compounds for testing
        - In response, HEW established Institutional Patent Agreements giving universities the right to retain patents
            - HEW approved 90% of petitions for IPAs between 1969-1974
    - Prior to Bayh-Dole, patenting was allowed by various agencies, such as the Department of Defense, Department of Health, Education, and Welfare (now Health and Human Services), and the National Science Foundation.
        - However, for DHEW and NSF, patents and licenses were negotated individually under Institutional Patent Agreements (IPAs).
        - Some universities, such as the University of California system, patented before Bayh-Dole. Others didn't bother.
            - For UC system, medical innovations from rDNA led to many patents in the 1970s.
- Passed in 1980
- Took effect on July 1, 1981
- Allowed patenting of research resulting from federal funding
    - Prior to this, patenting was allowed by various agencies, such as the Department of Defense, Department of Health, Education, and Welfare (now Health and Human Services), and the National Science Foundation.
    - However, for DHEW and NSF, patents and licenses were negotiated individually under Institutional Patent Agreements (IPAs).
- Some universities, such as the University of California system, patented before Bayh-Dole. Others didn't bother.
    - For UC system, medical innovations from rDNA led to many patents in the 1970s.
- The Bayh-Dole Act made patenting easier. Special permission was no longer needed.
- Also, it gave a "Congressional stamp of approval" for patenting of federally-funded research.
- Motivation:
    - The goal was to encourage commercialization of university research.

    - Congress felt that exclusive licenses between university patent holders and universities would encourage commercialization.
- Did it work?
    - Pro:
        - Universities did patent more.
            - Number of university patents (by year of issue):
                - 1969: 188
                - 1974: 249
                - 1979: 264
                - 1984: 551
                - 1989: 1228
                - 1994: 1780
                - 1997: 2436
                - 2005: 2577
                - 2012: 8700
                    - 25% of these patents are in biotech
            - However, other factors also helped:
                - 1980 court decision allowing patenting of biotechnology.
                    - The growth in patenting was dominated by biomedical patents. Would this have happened even without Bayh-Dole?
                    - Note that the number of universities with at least one patent rose from 36 in 1970 to 86 in 1980. This growth occurred before Bayh-Dole
                    - Other policies, such as the Court of Appeals for the Federal Circuit, that strengthened patent protection in general.
        - Universities increased licensing efforts
            - Number of universities with technology licensing and transfer offices rose from 25 in 1980 to 200 in 1990.
            - Licensing revenues rose from $222 million in FY 1991 to $698 million in FY 1997 to $1.6 billion in 2005.
            - By 2011, 33,000 active licenses with a total of $1.5 billion in royalties
            - Universities make about 4,000 licensing agreements per year
                - Big patents, can bring in over $1 billion
                - However, most patents raise little or no money
            - Mowery and Zedonis (*Research Policy* 2002) find that the patents granted to universities with little or no patenting experience were of lower quality than other patents (measured by citations). However, this was not true of patents from experienced universities.
                - It may be that it is patenting behavior, not research, that is changing.

                - That is, patents are of lower quality because universities are patenting things that they wouldn't have bothered to patent before.
                - However, if the goal is technology transfer, perhaps this is sufficient.

- Did Bayh-Dole enhance technology transfer?
    - Technology transfer activities appear to increase
    - In 25 years, more than 4,500 firms spun out of non-profit research activities.
        - Many of these advances are in medicine.
    - The key questions is whether they would have occurred anyway
        - For example, Cohen-Boyer rDNA was used by industry before UC and Stanford began to license
        - Licensing revenue is thus a boon to the university, but an extra cost to firms and eventually consumers
    - Might Bayh-Dole slows technology transfer
        - 2002 *Madey v. Duke*
            - Supreme Court said universities are no different than businesses because compete for resources and make money from patents.
            - Thus, the research exemption is not automatic.
        - The *Myriad* case
            - The University of Utah licensed the patent for breast cancer testing to Myriad, creating Myriad's monopoly
            - Moreover, the firm sued universities that used the technology in follow-up research
            - Note that the breadth of the research exception is important here.

        - More generally, a 2003 study found:
            - 1/4 of all licenses allow the business partner to delete information from research papers
            - 1/2 of all licenses say that publication can be delayed by the business partner.
            - Less sharing of research (e.g. using patents for research purposes)
- Should exclusive licenses be limited?
    - Sampat argues should only be used when necessary to encourage technology transfer
    - He is critical that universities have the power to decide licenses
        - Make decisions for their own self-interest, not those of consumers (e.g. principal agent problem)
    - Possible solutions:
        - Better monitoring
        - Agencies can make it clear that broad dissemination is desirable

        - Agencies can revoke patents from publicly funded research in exceptional circumstances
            - Rarely used, but should it be made easier?
- Does focus on short-term commercial value of academic research have unintended long-term effects?
    - Two questions:
        - Does academic enterprise occur at the expense of production and dissemination of scientific knowledge (e.g. fewer publications)?
        - Does academic enterprise force scientists to do more applied research?
    - Establishing causal relationships challenging
        - Other factors, such as the personal characteristics of the researcher, matter?
- Why has academic enterprise activity been increasing?
    - Dissatisfaction with returns to basic science=> "quest for greater relevance"
        - Results in pressure for academics to engage industry more directly
    - Increasing research costs and decreasing government funding => search for new funding sources
        - Foundations support research strategically
        - Private sector supports research with short-term relevance
    - Successful patenting shows universities potential of licensing income
        - Often encouraged by policy makers
    - Academic enterprise activities increase visibility in industry, potentially leading to even more funding
- Studies or relationship between academic enterprise and production of scientific knowledge
    - What is scientific performance?
        - Scientific productivity, e.g. number of publications
        - Scientific impact, e.g. citations
    - Does academic enterprise hurt scientific performance?
        - How might it hurt?
            - Researchers have limited time
            - Changes disclosure incentives
                - Industry supporters may want to keep results secret longer
                    - Blumenthal et al (1996) found life scientists receiving industry funding were more likely to restrict communication with colleagues
                - Data may be confidential – makes replication difficult
                    - Studies find scientists receiving industry funding more likely to withhold data or restrict research materials
                - Restrictions on downstream use of new materials may impede research
        - How might it help?

        - Are both patents and publications a sign of higher individual productivity?
            - E.g. research in Pasteur's quadrant
        - Even if patent, still need to publish to advance an academic career
        - Collaboration and contact with industry may lead to new questions
- Empirical evidence
    - Do scientists receiving industry funding publish more?
        - Most studies find a positive relationship
            - But, is this because better scientists receive funding?
        - Research collaboration between industry and academic scientists also found to lead to more publications
    - Do scientists receiving industry funding have a higher impact?
        - Evidence is mixed
        - Hicks and Hamilton (1999): co-authored papers with industry and academics more likely to be cited
    - All studies looking at links between scientific performance and patenting find a positive relationship
    - Lowe and Gonzalez-Brambila (2007) find that scientific productivity does not decline even after beginning a start up company.
        - In fact, publishing increased for engineers!
    - Studies such as these do suggest that a complementary relationship is field specific
        - Most often noted in biomedicine and life sciences
    - Are there diminishing returns?
        - While Blumenthal et al (1996) find that scientists receiving industry funding are more productive than those that don't, scientists receiving a large portion of industry funding are less productive than those receiving a small proportion.
        - Fabrizio and Di Minin (2008) find a similar diminishing returns relationship between patents and publications
            - Those with many patents less productive than those with just a few patents.
        - Similarly, early studies found that universities patent more after Bayh-Dole, but quality is lower
            - Fewer citations
            - A small number of patents account for most licensing revenue
    - What about the timing?
        - Calderini and Franzoni (2004) study Italian researchers
            - Some evidence of publication delays because of patenting
            - However, publications of researchers who patent are higher both before and after patenting

        - Azoulay *et al*. (2006, 2007) find evidence that patenting supports research. They help to address issues of causality
            - Use a panel data of 3862 life scientists at universities and non-profits
            - The stock and flow of researcher's patents positively related to subsequent publications.
                - Citations also remain high
            - Publishing and patenting appears to arise from increased scientific opportunities
                - Patents often come after a burst of publication in the year before the patent
        - To address causality, Breschi *et al*. match scientists on patents to similar scientists without patents
            - Find positive relationship between patents and publishing
            - Patents were "discrete events associated with productivity increases for individual scientists"
            - Scientists on patents were more productive both around the patent event and before the patent event.
                - Suggests that, at least in part, those patenting are better scientists
                - Also suggests a resource effect
                    - Industry funding opens up new areas
            - Generally find higher citations as well
                - However, decrease in citations for biologists who patent in year 2000 and afterwards
    - Caveats to empirical work
        - Most studies use patenting as indicator of industrial activity, because it is widely available
            - Would a complementary relationship hold up using other measures
        - Differences across fields suggest need to study other fields more
            - Patents important for life sciences
            - Are they a distraction elsewhere?
- Has academic enterprise changed the nature of research?
    - For example, does pressure to do commercial research lead to less basic research?
    - If academics don't do basic research, who will?
    - Larsen suggests a distinction between "basic" vs. "applied" content and "academic" vs. "commercial" content
        - Commercial research need not be applied
    - Key question: what is the mission of a university?
        - How does patenting fit in a university culture?
        - Do faculty want to "invent"?
            - Should they invent? Universities shape future workers and provide stable environments for invention.

        - Universities can provide new outlets for creativity.
    - If patenting is important, tenure standards need to be adjusted.
  - Theory
    - Thursby *et al*. (2007) argue that additional applied research can come at the expense of leisure time, rather than basic research
  - Empirical evidence
    - Fewer studies address this question
    - Results are mixed
      - Four studies find no negative impact
        - Three look at research activity at Catholic University of Leuven in Belgium
        - Classify research as basic or applied based on the journal in which it was published
      - Five find a potential negative impact
        - Blumenthal et al. (1996) survey found life science researchers receiving industry funding were more likely to take commercial considerations into account when choosing research topics
        - Other survey work finds similar results
          - Researchers often asked to classify their own research as basic or applied
          - In one survey, about 1/3 did not answer this question, suggesting it is a difficult distinction to make.
        - Fabrizio and Di Minin (2008) argue that lower citation rates among those that patent most suggest the publications they get are less basic
    - Do universities patent more basic science?
      - To examine this, Sampat looks at the number of non-patent references on US patents between 1976-1996
      - Asks whether the share of such citations increases for university patents after 1980
      - Figure 6 of his paper shows that they have
      - However, Sampat notes alternative explanations are possible
- Policies in other countries
  - Countries such as Japan and Germany have now adopted similar policies.
  - Financial cuts from European governments lead universities to look for more money from industry.
  - This changes the status of faculty.
  - For example, French professors are now allowed to do some work for industry.

III. Examples of Local Technology Policy

- Because of strong correlations between small enterprises and local economic development, local officials often emphasize attracting clusters of innovative firms.
  - o Goal is to be the “next Silicon Valley”
  - o Supporting clusters allows policy to affect many entrepreneurs simultaneously
  - o Consider Seattle and Detroit
    - ▪ Both lost large employers (Boeing, auto plants)
    - ▪ Seattle attracted local entrepreneurs and rebounded. Detroit did not.
- Example: Cities Race to Bet on Biotech
  - o Examples of attempts to attract biotech
    - ▪ Kannapolis, NC spent $500 million building the North Carolina Research Campus
    - ▪ State of Florida and Palm Beach County spent $510 to build a research institute
    - ▪ New York City spent over $45 million on bioscience infrastructure
    - ▪ Kentucky matches federal grants dollar per dollar
    - ▪ Shreveport, LA built the InterTech Science Park
      - The biotech manufacturing center in the park had only one tenant, for just six months in 2001
      - The park director says the building remains an asset, and people have expressed interest in buying it
  - o Key questions:
    - ▪ Traditional centers are Boston, San Diego, and San Francisco
      - Will biotech investors want to locate in places such as Kannapolis, NC?
    - ▪ Even if a small biotech company develops a drug, unlikely to be tested and produced in the same community
      - For example, a potential anti-leukemia drug was developed at Oregon Health Sciences University in Portland, OR.
      - However, rights to manufacture and market owned by Novartis, so not produced in Portland.
    - ▪ *Times* article notes that biotech companies are small and create few jobs
      - However, the NBER paper supports that small companies are likely to grow
- Policies for encouraging clusters in specific regions
  - o Policies to increase local supply of entrepreneurs
    - ▪ Motivated by the finding that most entrepreneurship activity is local
    - ▪ Education programs
      - Federal government supports entrepreneurship education through the Small Business Administration (SBA)
      - STEM training at local universities
    - ▪ Immigration for high-skilled workers

            - *Note that many of these policies are out of local government control*
        - Direct subsidies and targeted tax breaks
            - R&D funds
                - A study in Michigan found start-ups receiving R&D funds from the state were 15-25% more likely to survive after three years
            - State venture capital funds
                - Lerner (2009) suggests such programs often fail
                    - Lead to reduced flexibility for investors and adverse selection for managers
                    - Taxpayers face mostly downside risk
            - Investment tax credits
                - Can be targeted for investment in a particular location
                - Few studies of their effectiveness exist
            - Supporting business incubators
        - Regional clusters policies to promote entrepreneurship
            - Note that main clusters were not necessarily planned
                - Silicon Valley and Route 128 benefited from federal research funds, but there was no comprehensive vision to develop the area
                - In contrast, the Research Triangle Park in NC resulted from state planning
            - Local policies begin by identifying the geographic and industrial target
                - Common follow-up policies then include establishing connections between a local university and start-ups
                    - E.g. research funds, seed funding for university spinoffs
                    - Thus, *the focus is often on knowledge transfer*.
        - Federal policies to promote entrepreneurship clusters
            - More emphasis from federal government since 2009
                - As of April 2012, Obama administration spent $225 million on regional cluster projects
            - Dept. of Energy Regional Innovation Clusters are an example
            - 2011 JOBS Act included rules reducing financial reporting for small firms and facilitating crowd funding
- Figure 2 highlights range of policy choices
    - Specificity of location
        - National policy vs. local policy
            - Some national policies may focus on a region
                - Appalachian Regional Commission is an example
                - In these programs, redistribution is an explicit goal
            - Physical constraints may also force governments to choose which regions to support
                - E.g. cannot provide transportation infrastructure everywhere

- Specificity of aid
  - Broad focus, or focus on specific sectors or firms
    - It is not unusual to focus on specific sectors
      - In some cases, there may be local comparative advantages
      - In others, may want to promote promising new technologies
        - Is this picking winners?
        - Supporting green technologies often justified by externalities
          - Loan support for Solyndra an example
          - But do the benefits of environmental protection go to the local area?
  - Focus on new or existing firms?
    - Differences can be subtle
      - Taxing profits, rather than labor, benefits start-ups that are less likely to generate profits right away
- Cluster policies fall in at bottom of table, focusing on specific areas
  - May be general or focus on specific sectors
  - Rarely firm-specific, since start-ups are too small to justify dealing with on a one-on-one basis
    - Thus, may be "picking winners" for an industry, but not for specific firms

IV. Theory: Arguments for Industrial Clusters

- Justifications for market intervention to promote industrial clusters
  - Note that industrial policy may be motivated by market failures, or may just "reflect a public desire to appear to be doing something to engineer economic growth from the top down" (p. 3).
  - Three common classes of justification
    - Externalities
      - Up front subsidy (e.g. tax breaks for construction) can be seen as compensating the plant for future tax payments (*doesn't seem like an externality to me*)
      - Subsidizing the import of technical knowledge, which can then spread through the region
      - To help build local human capital
      - Presence of clusters suggests externalities flow across firms
        - But, are these externalities or simply a response to unobserved geographic advantages or reduced transport costs
    - Redistribution
      - Encourage business in impoverished areas
        - E.g. "Empowerment Zones" in U.S
    - Credit constraints

            - Government can address with:
                - Loan guarantees
                - Direct lending
            - Is there a market failure?
                - Government's risk tolerance may be higher
                - Government may have a longer time horizon
            - Key question: is government in a better position to judge potential than venture capital markets?
    - Does clustering matter?
        - Entrepreneurs may benefit neighbors, but there may be diminishing returns to externalities
            - First entrepreneurs in an area important to get it started, but adding 100 more not crucial
        - If so, suggests spreading benefits to multiple areas justified

V. Evidence

- Because many of these local policies are small, good evaluation is rare
    - Establishing plausible counterfactuals is rare
    - Should that be considered in developing new policies
    - Authors suggest experimentation necessary
- Is innovation and entrepreneurship good for a local area?
    - Hard to interpret evidence, because of endogeneity
        - Does entrepreneurship lead to growth, or do entrepreneurs pick prosperous locations?
    - Differences in entrepreneurial culture
        - Pittsburgh (steel industry) vs. New York in 1950s
        - Boston and Silicon Valley
    - Empirical evidence
        - First causal evidence looked at venture capital financing
            - Easier to identify exogenous shocks in financing
        - Samila and Sorenson (2011) find that doubling VC in a typical city increases jobs by 1%
            - Would be high-skilled jobs
            - However, this number seems like a small gain
                - Overall, VC accounts for just 10% of differences in economic growth across US cities
            - Does this justify credit-related policies?
                - While VC has been successful, would government have a similar track record?
                - Even if policy just supported VC itself (e.g. with tax breaks), need to consider the opportunity cost of those tax breaks
        - Glaeser *et al*. (2012) look at industries in which growth occurred

            - In cities with strong foundations in entrepreneurship, much employment growth came from small firms that became large employers
                - Suggests dynamics are important – it isn't just enough to assume small firms are better
    - What about innovation?
        - Duranton (2007) proposes a theory where location of industries depends on past breakthrough innovations
        - To assess the model, Kerr *et al*. (2010) look at spatial patents of top 1% of new patents
            - Cities with the highest concentration of these patents experienced more subsequent patents
                - Suggests possible externalities (e.g. via knowledge spillovers)
        - In earlier work, Jaffe *et al*. (1993) find that patent citations are geographically localized
            - Citing patents are more likely to come from the same area
            - This effect fades over time
                - Later citations more likely to come from longer distances
        - Hausman (2012) finds faster employment growth in industries related to universities pre-existing strengths after Bayh-Dole Act
- Do spillovers cluster?
    - Policies to enhance clustering only make sense if there are strong local spillovers
        - The challenge is figuring out whether existing clusters result from positive externalities, or from other factors such as uneven distribution of resources
        - Does natural clustering suggest that policy should support even more clustering?
    - Spatial determinants of clusters
        - General traits of cities that influence innovation and entrepreneurship
            - General education of workforce
                - May be sector specific – appears less important for industrial clusters
            - Age structure of local area
                - For startups, workers near age 40 most important
            - Local supply of entrepreneurs
                - Most businesses founded in the entrepreneur's region of birth
            - Less is known about the importance of physical infrastructure
        - Industry-level clustering
            - Most powerful predictor is presence and strength of incumbent firms

        - For manufacturing, existing business landscape explains 80% of spatial variation in new entry rates
        - Why important?
            - Many entrepreneurs leave an incumbent firm to start their own business (e.g. spin-off business)
            - Entrepreneurs know that needed resources are available for their industry if there are incumbent firms
                - Access to customers and suppliers
                - Access to labor inputs
                - Access to ideas
        - Immigrants also important
            - Most apparent in locations such as Silicon Valley

- Discussion: Can investing in local universities lead to regional economic development?
    - Goals
        - Research leads to start ups
        - Graduates supply entrepreneurs and employers
    - Concerns
        - Faculty and students can move
            - Students leave after graduation
            - Example: Marc Andreessen invented a web browser at University of Illinois, but moved to Silicon Valley to found Netscape
        - Ideas can also move
            - Supporting research doesn't mean that the research will benefit local companies
        - Star scientists are associated with more start ups
            - But, star scientists are in short supply
            - Competition for star scientists leads to higher salaries