Lecture # 15 – Technology Transfer

I. Successful Technology Transfer: The Case of the Internet

The Internet is an excellent example of a technology initially developed with government support diffusing to have a broader commercial impact. Our discussion of the Internet revolved around three questions:

1. What was the initial role of the government in the development of the Internet?
   - In 1968, the Defense Advanced Research Projects Agency (DARPA) funded construction of a prototype network.
     - This APRANET is viewed as the early forerunner of the Internet.
     - Goal of the Department of Defense (DOD) was to share scarce computing time at research centers.
   - The DOD supported "generic" research in academics and industry for this purpose.
     - The DOD felt that a viable computer network for defense would require civilian markets.
     - During this time, computer scientists and engineers made many key technological developments.
   - Concerns over having a network that would be less vulnerable to attack than the central switching technology used by phone lines led to the development of packet switching.
     - This minimized the market power of the existing telecommunications industry.
   - Organizational innovations were important
     - The Internet was helped by flexible governance institutions.
     - Requests for Comments (RFC) were used to communicate ideas across the ARPANET community.
     - NSF and DARPA created organizations for standardization
       - TCP/IP developed as the standard backbone.
     - Self-governance was dominant
   - Open-source code was important
     - The French alternative, Minitel was similar to the World Wide Web. However, its source code was proprietary, making development of new applications more difficult.
2. What helped to encourage technology transfer and the commercialization of the Internet?
   - The government's desire to have civilian markets involved was important.
   - Government policy provided support for small companies.
     - Provides competition
     - Avoids "picking winners"
   - In 1983, DARPA split ARPANET into two parallel networks:
     - MILNET: exclusively for military applications
     - ARPANET: for industry, academic, and government research facilities.

            - By 1990, ARPANET users transferred to NSFNET, the network of the National Science Foundation.
    - Prior to 1991, NSF maintained an acceptable use policy (AUP) that prohibited use of NSFNET for commercial purposes.
        - Commercial Internet users were allowed access for research.
        - AUP abandoned in 1991.
        - Control of NSFNET passed to private firms in 1995.
        - In 1995, commercial applications took off.
            - Evidence:
                - 1995: ".com" and ".net" addresses had 1.8 times as many hosts as ".edu"
                - By 2000, these had more than 6 times as many hosts.
        - Note that domain name organization comes from the work of academic computer scientists.
            - Technology transfer is important!
    - Infrastructure growth was important
        - In 1985, NSF required universities receiving federal funding to provide Internet access to all "qualified users."
        - New T1 and T3 networks increased speed.
    - The World Wide Web
        - HTML was developed in 1991
            - Links led to increasing returns to early users.
        - Mosaic, the first browser, was developed in 1993.
            - Made the Internet more accessible.
    - Demand-side influences: the spread of personal computers is important.
3. Why was the U.S. more successful than other countries in developing the Internet?
    - U.S. research was of a larger scale *and* was more diverse.
    - Strong levels of government-sponsored research
        - Computer science funding rose from $190 million in 1976 to $1 billion in 1995 (1996 US dollars)
    - Technology-neutral policy
        - DOD program managers in IT established a broad national research infrastructure in computer science
        - The government invested in many projects, rather than trying to pick winners.
    - Competition in local phone markets led to affordable leased lines for commercial ISPs.
        - Compare to international diffusion: telecommunication monopolies and metered access charges for local telephone usage restricted ISP entry.
    - University-industry partnerships and strong venture capital markets were important for commercialization.
    - Strong anti-trust policy resulted in key innovations of Bell Laboratories being widely licensed.

    - Weak IPR resulted in much public domain software and is one reason for key government research role.
        - IPR became stronger as the Internet became more commercialized.
    - The use of English is widespread, enabling global diffusion of the Internet with English as the primary language.

II. Institutions for Technology Transfer

- By the 1980s, technology developed in the US was being commercialized more rapidly in other nations than by US firms. In addition, by the mid-1980s, Cold War tensions were dying down.
    - Led to a series of initiatives to improve technology transfer:
        - 1980: Bayh-Dole
        - 1980: Stevenson-Wydler Technology Innovation Act: redirected federal labs toward a more commercial focus.
        - 1984: National Cooperative Research Act: relaxed antitrust enforcement for research joint ventures.
        - 1986: Federal Technology Transfer Act: Allowed government-owned labs to enter directly into coo
- Technology transfer can involve firms, government, and universities.
- Research joint ventures (RJV)
    - They are a type of strategic research partnership (SRP).
        - Other types include CRADAs and strategic licensing agreements.
    - Authorized by the 1984 National Cooperative Research Act, which provided protection from antitrust litigation for RJV members.
    - Joint ventures are an example of an *equity alliance*.
        - In an equity alliance, partners share long-term goals.
        - Contrast with contract R&D, which revolves around short term relationships.
            - Contract R&D is growing twice as fast as overall R&D.
            - Contract R&D makes up 5.7% of all R&D.
    - Data 1985-2003:
        - 913 RJVs registered in the NCRA-RJV database.
        - The 1984 NCRA requires registration in the database in order to be protected from antitrust litigation.
        - Number of new entrants falling.
            - New filings peaked in 1995.
            - May be countercyclical: less need for new alliances when the economy is strong.
            - Note that you don't need to say when the RJV ends, so RJVs remain in the database.
    - Types of actors:
        - 88% for-profit firms
        - 9% non-profits (including universities)
        - 3% government

    - However, more RJVs have *some* participation from government or universities.
        - 15% of RJVs have a university member
            - Varies by industry: from 1985-2001, 30% of RJVs in electronics had at least one university member.
        - 12% of RJVs have a government laboratory member.
    - 2/3 of participants only participated in one RJV
    - Two-thirds of partnerships in electric equipment, computers, chemicals, or transportation.
    - Size of RJVs:
        - Largest: Oil and gas RJVs had a median of 8 members.
        - Chemicals: median of 5
        - Electronics: median of 6
    - Motivation:
        - Alleviate the spillover problem by internalizing leakage of R&D
        - Improve coordination of R&D efforts to avoid wasteful duplication
        - Spread the risks associated with large-scale projects
        - Assure access to complementary knowledge
        - Take advantage of scale economies
    - However, unintended transfer of technologies is a concern of industry
    - When are they likely to be effective?
        - When spillovers are only moderately high
            - If spillovers are too high, there is no incentive to join. Being a free rider makes more sense.
            - If they are too low, there is no reason to internalize them.
        - When overall IP protection is weak.
            - If IP protection is strong, the costs of sharing information are greater (you give up more of your private benefits by sharing).
- Industry-university collaborations
    - Motivation
        - Support for industry objectives
        - Industry can hire graduates
    - Engineering Research Centers
        - Program created in 1984
        - Centers are funded by NSF
        - Designed to foster university-industry R&D collaboration
            - To get an award, a university must show support from private industry.
            - To help develop future graduates prepared to work in industry, centers should have an educational component.
        - Goal: to develop fundamental knowledge in areas critical to competitiveness in world markets
        - Compared to other government institutions, ERCs spend more resources (52.2%) on basic research
        - 18 ERCs were operating by 1994.

        - Why do firms participate?
            - To gain access to upstream knowledge
        - Impacts:
            - Lead to more licensing of university patents and more co-authorship between university and industry members.
    - Science parks
        - Real estate developments involving technology transfer.
            - Often affiliated with a university or government agency.
        - Began in 1950s:
            - Stanford Research Park (1951)
            - Research Triangle Institute (1957)
        - The number of science parks grew in the 1980s.
            - However, not all have been successful.
        - Haven't been studied much
    - Land grant Universities
        - The 1862 Morrill Land Grant Act authorized a land grant university in each state.
        - State tuition subsidies provide an important contribution of states to research and development.
        - State support for diffusion initially organized through agricultural experiment stations and extension services within the land-grant schools.
        - University presence can lead to business development (e.g. Route 128, Research Triangle, Silicon Valley).
- Government institutions for technology transfer
    - The federal agency with the greatest experience in technology transfer is the Advanced Research Projects Agency (ARPA).
        - Began in 1958 as the Defense Advanced Research Projects Agency (DARPA)
        - DARPA funds were given to project managers to create mission-oriented research projects.
            - The goal was to ensure that technologies created entered the appropriate forces and the supporting industrial base.
        - In 1991, the Carnegie Commission recommended that DARPA be transformed into a general agency focused on more than defense. Thus, the new name, ARPA.
    - Advanced Technology Program (ATP)
        - Part of the National Institute of Standards and Technology (NIST).
        - ATP provides multiyear funding for projects involving cost sharing with individual companies or industry-led joint ventures to pursue high-risk R&D.
        - Universities, non-profits, and government labs can participate in these joint ventures.
        - Rationale: Industry decides which projects to pursue.
        - Project proposals are peer-reviewed.
        - Funding has fallen over time

    - FY 2004: $177 million
    - FY 2006: $76 million
    - FY 2007: $40 million
  - Replaced in August 2007 by the Technology Innovation Program (TIP).
    - Still run by NIST.
- Small Business Technology Transfer Program (STTR)
  - Created in 1992
  - Similar to SBIR, which provides research funding.
  - Agencies with over $1 billion R&D programs must set aside 0.3% for STTR
  - Pairs eligible small businesses with non-profits or FFRDCs for joint research projects.
  - Participating businesses perform at least 40% of the work and are in overall control of the project.
  - In 2011, awarded $234 million
    - Most funding from DOD and HHS
    - Mostly paired with universities
- Government laboratories
  - Laboratory research supporting commercial activities of firms is considered technology transfer.
  - Private participants receive the property rights.
- Cooperative Research and Development Agreements (CRADAs)
  - Authorized by the 1986 Federal Technology Transfer Act.
  - Agreements between government labs and the private sector.
  - The lab and the collaborator can share personnel, services, and property from the collaborator.
  - For jointly developed technology, the private firm has the right of first refusal for an exclusive license for a defined field of use.

III. Government Laboratories

- Of the $125.6 billion government funded R&D in 2007, $31.5 billion was performed by the government.
- Types of intramural research done at government laboratories
  1. Research in support of agency activities. This contributes to technologies purchased by the government.
  2. Data collection (e.g. Department of Commerce, BLS, NSF)
  3. Basic and applied science in areas with a public interest, such as:
     - Biomedical research at NIH
     - Basic physics research at DOE
     - Meteorology research at NIST
     - Agricultural research at Agricultural Research Stations
  4. Supporting the commercial activities of firms
     - Unlike the above three (“mission research”), this type of research focuses on technology transfer.

        - Much of this is done in Federally Funded Research and Development Centers (FFRDC)
            - First established during WWII
            - Designed to help meet long-term research goals that cannot be done in-house or through contracts
- Rationales for Federal Laboratories and FFRDCs
    - Scale – some research projects rely on large capital expenditures (e.g. medical institutes, large telescopes)
    - Security – some projects require direct government supervision
        - DOD performs the most intramural R&D.
    - Mission and regulatory requirements – agencies such as FDA are required to perform a certain amount of R&D
    - Knowledge management – Long-term R&D kept in house to preserve control of projects and keep close connections with sponsors
  - Intellectual property rights are an issue
    - The government generally tries to diffuse the results of mission research as widely as possible.
        - When technology is licensed, it is typically to more than one company.
    - However, for cooperative agreements, licensing agreements allocate the property rights to private companies.
    - Such arrangements are usually exclusive licensing, or, if the research was collaborative, direct assignment of the patent to the collaborating firm.
- Differences between universities and labs
    - Survey from late 1990s:
        - Is technology transfer an important mission?
            - University labs: 23%
            - Government labs: 51%
        - Is basic research a major mission?
            - University labs: 70%
            - Government labs: 42%
            - Industry labs: 11%
        - Are you involved in technology transfer?
            - University labs: 40%
            - Government labs: 52%
        - Activities devoted to publishing scientific research:
            - University labs: 44%
            - Government labs: 36%
        - Activities devoted to production of patents and licenses:
            - University labs: 2%
            - Government labs: 2%
        - Government labs more likely to be managed hierarchically.
    - Comparative advantages of government labs:
            - Interdisciplinary research

            - Surveys of firms find that this is one of the reasons firms choose to work with government labs rather than universities.
        - Have expensive equipment
    - Comparative advantages:
        - Government labs:
            - Interdisciplinary research
                - Ham/Mowrey survey firms that use CRADAs. This is one of the reasons firms choose to work with government labs rather than universities.
            - Have expensive equipment
        - Universities:
            - Graduate students
                - Not only do they become trained to be the next generation of researchers, but they also participate in the research process as students.
                - As they get jobs, students serve as a means of tech transfer.
- Similarities between university and government labs
    - In each, the dominant technical disciplines are medicine and engineering.
    - The reward system is largely based on scientific publications.
    - Ph.D. required for top positions.
        - Both have stepped up commercial activities since the early 1980s.

IV. Cooperative Research and Development Agreements (CRADAs)

- Authorized by the 1986 Federal Technology Transfer Act.
- Agreements between government labs and the private sector.
    - Negotiations can be long, and firms find delays costly.
- Research performed under a CRADA must be consistent with the government laboratory's mission.
    - Case studies suggest that the partnerships are most successful when the research is close to the government lab's traditional mission.
- The lab and the collaborator can share personnel, services, and property from the collaborator.
    - In addition, the lab can accept funding from the private collaborator.
    - The lab can cover overhead costs of the collaborator, but cannot provide direct funding.
- What happens to the inventions?
    - Inventions made solely by government scientists remain federal property.
        - They can be licensed to the private sector.
    - For jointly developed technology, the private firm has the right of first refusal for an exclusive license for a defined field of use.
- Data:
    - 8,525 active in 2010

        - 4,768 defined as “traditional” CRADAs, which include collaborative R&D between a government lab and one or more nonfederal organizations
            - Of these, 2,516 with Department of Defense
- Rationale for CRADAs:
    - The contribution of laboratories to commercial technologies has been substantial. CRADAs are a means of increasing the transfer of these technologies.
    - Labs and private firms can bring different areas of expertise to the research project. Thus, complementarities are possible.
- What types of companies are most likely to want to work with federal labs?
    - Interest increases as internal R&D support decreases.
    - Larger companies motivated by access to unique technical resources available at labs.
    - Firms surveyed said the greatest benefits received from the lab were generic. That is, overall lab skill, rather than specific skills related to the project.