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Innovation and Technical Change

University research and public/private partnerships
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Outline - 16, 18, 23 Nov
1. Government R&D policy
   - Political economy
2. University science and the public-private interface
   - Public and private R&D
   - Joint ventures
3. R&D joint ventures, antitrust, licensing, and competition policy

Productivity of federal R&D
- generally less than that of private R&D, looking across different countries. Why?
  - much of it is defense spending, which has little private product (gold-plating)
  - another large piece is directed at unmeasured welfare improvements (health, environment, etc.)
  - productivity measures are short term, basic science has long term payoffs
  - Lower short term “productivity” is not a bad thing if spillovers are large
  - politics
Political economy of federal R&D

- Spending on commercial innovation projects by government subject to underperformance and cost overruns. WHY?
  - Elected officials care about "saliency," that is, the few issues that attract voters' interest
  - R&D salient only when it is related to a national priority (e.g., post-Sputnik space research), associated with a scandal, or has a local interest factor (jobs)
  - Saliency more likely if a few people care a lot, or are already organized (a union, an industrial organization)
  - Agencies that implement projects have more information than congress, tend to ally with industry
  - Political asymmetry
    - cheap to start a project
    - hard to cancel if there is a large local job base associated, even if technically shown infeasible or worthless

Political economic implications

- Government more likely to do programs oriented toward a concentrated industry
  - inconsistent with an optimal public goods policy
- Projects sometimes more attractive if they address a salient national issue
- More attractive with a short time horizon, no radical change in the technical base of the industry
  - inconsistent with the market failure arguments for policy
- Net benefits are important early on in the decision, but their importance declines as stakeholders are created by the project
- Programs that can be fragmented are more attractive politically
  - keeps it below the relevant threshold for Congress

Political economy of federal R&D

<table>
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<tr>
<th>Project</th>
<th>Field</th>
<th>Technical Outcome</th>
<th>Political Outcome</th>
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<tbody>
<tr>
<td>SST (Supersonic transport)</td>
<td>aerospace</td>
<td>too costly</td>
<td>killed before a constituency developed</td>
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| Communications satellites      | electronics & aerospace | too much and too infrequent | killed in 1974, became less salient, groups that would benefit were not represented (new industry created)
| Space shuttle                 | aerospace  | too much and too infrequent | Challenger disaster, again this year, still trying along |
| Silk fiber breeder reactor    | nuclear energy | too costly | killed, absorbed a large part of nuclear technology budget, due to local jobs and interests, etc |
| Photovoltaic commercialization| energy     | success, but oil prices moved against it | scaled back for political reasons; benefits very decentralized and nonfocal |
| Synfuels research             | energy     | one success, but misdirected (Eastern coal rather than pricier Western as input) | oil prices moved against it, same as photovoltaic |
Conclusions

- Projects satisfied the market failure criterion for public R&D (except possibly the SST)
- Benefit-cost rationales made 2 mistakes, both due to "technological optimism"
  - Assumed the R&D would achieve objectives
  - Compared the proposed program with a very narrow range of alternatives early on
    - E.g., synfuels project focused only on eastern coal
  - Although using western coal would have been easier
- All were subject to a boom-bust in spending for political reasons (fragile coalitions)
  - Optimal R&D spending is more smooth and grows over time

Public (university) research

- Funding
  - Largerly government but changing
- Incentive systems
  - "Two worlds" view
- Evolution of the university-industry relationship
  - Growth of tech transfer offices
  - Some analysis of univ-ind RJVs

Examples - benefits of public R&D

- Directly valuable additions to the knowledge base, examples:
  - Use of restriction enzymes in gene-splicing techniques
  - Encryption methods
  - Internet communication protocols
  - GPS - global positioning system
- Complementarity between public and private R&D
  - Knowing where not to look
  - Scientific knowledge to guide and inform applied R&D, examples:
    - Einstein and photoelectric devices
    - Genome mapping and biotech
- Research training benefits, not fully captured by R&D employees in their wages
  - Industrial affiliate programs
  - Funding for graduate study
  - Post-doctoral circulation of researchers that embody and transfer tacit knowledge
Trends in university R&D funding in the United States

<table>
<thead>
<tr>
<th>Year</th>
<th>Government</th>
<th>University &amp; Non-profits</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>84.9%</td>
<td>11.3%</td>
<td>3.9%</td>
</tr>
<tr>
<td>1970</td>
<td>84.7%</td>
<td>13.3%</td>
<td>2.0%</td>
</tr>
<tr>
<td>1980</td>
<td>82.5%</td>
<td>14.7%</td>
<td>2.8%</td>
</tr>
<tr>
<td>1990</td>
<td>74.9%</td>
<td>19.8%</td>
<td>5.3%</td>
</tr>
<tr>
<td>2000</td>
<td>71.0%</td>
<td>22.9%</td>
<td>6.1%</td>
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Source of Funds

The “two worlds” of research

<table>
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<tr>
<th>Incentives</th>
<th>“Republic” of science</th>
<th>Private sector (IP-protected)</th>
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<tbody>
<tr>
<td>Dissemination</td>
<td>Early publication encouraged; gives priority</td>
<td>IP requires publication but strategic incentives to conceal some info</td>
</tr>
<tr>
<td>Use of others’ discoveries</td>
<td>At low cost (citation and reciprocity)</td>
<td>Requires payment or cross-licensing agreement</td>
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The “two worlds” of research

- Somewhat oversimplified view
  - University research output increasingly privatized via patenting and exclusive licensing
  - Some firms in industry, especially in the pharmaceutical industry, encourage journal publication of results in order to encourage interaction between their researchers and the scientific community
- Nevertheless, a useful way to look at the arrangements
The “two worlds” of research

- Either arrangement is an equilibrium
  - Privatized R&D with IP a market equilibrium
  - Republic of science has collective gains from trade (provided the participants value research output highly)
- But...
  - If IP protection available, the first equilibrium is unstable (gains from defection exceed benefits from remaining, at least in some cases)
  - Considerable tension when they come up against each other - as they do when universities partner industry

University-industry research partnering in the United States

- Long history – more than 100 years old, both in agriculture and manufacturing
- Increase in past 10-20 years has restored strong links from the first half of the twentieth century
- Current partnerships have a wide variety of organizational forms
- Still a relatively small fraction of university research funding in the U.S. (~6 to 7 percent)

Variety of partnership types

- Industry support of particular university researchers via grants and consulting
- Large laboratories funded by industry consortia involving 10s to 100s of firms, such as the Stanford Center for Integrated Systems
- Quasi-permanent FFRCs and UIRCs, partially funded by federal government (e.g., LBL)
- Onetime projects that involve a university as a partner
  - Ordinary research joint venture (RJV) with specific goal
  - Government cost-shared RJV, such as funded by ATP comprehensive survey data that includes all types of funding does not exist – studies usually based on one
U.S. Research Joint Ventures

Based on Data from the Federal Register and the CORE Database (Link 2000)

RJVs in the Federal Register (N=741)

JVs with University (%)

|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Share with universities (%)
| 0.0% | 5.0% | 10.0% | 15.0% | 20.0% | 25.0% | 30.0% |

Industrial Distribution of Public Organization Participation in Industry RJVs - United States 1985-2000

Benefits to Industry (Lee 2000)

- Access to new and complementary research
  - also found to be important by Cohen et al. survey (1997)
- Development of new products
- Maintaining a relationship with the university
- Obtaining new patents
- Solving technical problems
- Less important
  - Improving products, recruiting students
  (based on a survey of ~400 R&D managers)
Benefits to Faculty (Lee 2000)

- Funds for research assistance, lab equipment, and one's own research agenda.
- Insights into own research; field test theory and empirical research.
- Less important
  - Practical knowledge useful for teaching
  - Student internships and job placement
  - Patentable inventions and business opportunities
- Variation across research field
  (based on a survey of ~400 university researchers)

Evaluating the benefits

- Henderson and Cockburn (1996) – access to university research enhances sales, R&D productivity, and patenting (pharmaceutical industry)
- Zucker, Darby, and Armstrong (2001) – collaborating (publishing) with "star" university scientists important for firm performance in biotechnology
- Adams, Chiang, and Starkey (2001) – Ind-Univ Cooperative Research Centers, especially those funded by NSF, promote tech transfer and increase patenting rates at industrial labs

Why has partnering increased?

Industry motivation:
- Universities become more important as technical change is closer to "science."
- Declines in direct industry spending on basic research following the wave of corporate restructuring in the 1980s
- Special basic research tax credit introduced in 1981 and strengthened in 1986
  - Currently a tax credit equal to 20% of payments to a "qualified" research organization (university or non-profit) is available to taxpaying firms
Why has partnering increased?

University motivation – changes in government levels of support

- Real growth in federal R&D funding:
  - 16% between 1953 and 1968
  - 1% between 1969 and 1983
  - 5% between 1984 and 2000, but with substantial declines in non-biomedical areas

- As federal funding declined, universities used more of their own funds and more funds from industry

- University administrators increasingly pressure faculty to engage in applied commercial research.

Hall Link & Scott 2000

- How does the performance of RJVs with universities differ from those without?
  - Universities included in research projects involving “new” science
  - => encounter more difficulty in assimilating knowledge and commercialization tends to be delayed
  - Problems with research time and financial resources is technology specific
  - personnel problems in frontier technologies
  - equipment problems fewer in info technology
  - more unproductive time/cost in electronics than in other fields

Barriers that inhibit university-industry partnerships – IP!

- Most significant barrier related to IP, specifically patenting rights
  - From university perspective:
    - want to patent research resulting from the partnering relationship, but found industry extremely difficult to deal with on this issue
    - publication rights and delays were, for the most part, an non-issue from the perspective of the university
  - From firm perspective:
    - IP often a stumbling block for collaborations because many universities want to publish results prior to IP protection, and sometimes will not grant exclusivity on results
    - Universities have an over-inflated view of their intellectual property value, and university licensing officers have an over-inflated view of the value they bring to the project
  - Small companies tend to subcontract with universities rather than include them as a research partner.
    - Higher false start rate with small companies primarily because they seemed less familiar with university bureaucracy. (less tolerant of?)
GO BEARS!