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Innovation and Technical Change

Government policy towards innovation/R&D
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Outline - 16, 18, 23 Nov
1. Government R&D policy
   ■ Why do we have it?
   ■ How is it done?
   ■ Some facts about US policy
   ■ Politics
2. University science and the public-private interface
3. R&D joint ventures, antitrust, licensing, and competition policy

Why do governments have innovation policies? (1)
- Difficult to evaluate and fund some types of research in the private sector
  ■ obtaining external finance means revealing idea
  ■ benefit diffuse - cannot identify recipients easily, so difficult to collect payment (environment; defense)
  ■ externalities are large, players are small (agriculture)
  ■ risk and size of effort relative to size of market
- should these types of investment be undertaken at all?
  ■ SST, aerospace – but what about orphan drugs?
  ■ investors cannot evaluate projects very well due to extreme uncertainty
- To provide standards, which are public goods
Why do governments have innovation policies? (2)

- To encourage strategic industries
  - important for national security
  - "ripe" for technical advance
  - closely linked to other industries
    - technical advance facilitates progress in other industries
    - Example - the flat panel display initiative
- To provide education and human capital
  - imperfect capital markets imply that private sector will not supply enough finance for higher education

Summary:
- social return to R&D > private return to R&D

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Determining the optimal subsidy

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<tr>
<th>Return or cost of R&amp;D</th>
<th>Social return</th>
<th>S</th>
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<tbody>
<tr>
<td>Optimal subsidy</td>
<td>C</td>
<td>Private return</td>
</tr>
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<tr>
<th>Level of R&amp;D spending</th>
<th>R_C</th>
<th>Optimal competitive level of R</th>
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<tr>
<td>R_S</td>
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<td>Optimal social level of R</td>
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Why the gap between private and social return?

- Knowledge spillovers
  - knowledge created by one agent can be used by another without compensation, or with investment less than the cost of the knowledge creation
- Market (pecuniary) spillovers
  - Some of the benefits of the knowledge creation (new products/processes) flow to purchasers via the operation of market forces, reducing the price
- Network spillovers
  - Value of a new technology strongly dependent on development of related technologies (the hardware/software case)
What’s wrong with this simple graph?

- Magnitude of the spillover gap varies
  - by country
  - by industry
  - by technology type
- Project ordering varies depending on whether you use social or private returns to order

Spillover gap varies by country

- Small open economies like those in Scandinavia, Netherlands, etc.
  - Most R&D benefits there may spill to other countries
- Vs. large semi-open economies like the U.S.
  - Less leakage
- More on this after Thanksgiving

Spillover gap varies by industry

- Consumer electronics or autoparts/metal parts or airframes
  - High appropriability, possibly fewer spillovers
- Vs. pharmaceuticals for life-threatening diseases, environmental and pollution control
  - Conventional as well as R&D externalities
- Vs. telecommunications/electronics/semiconductors/IT
  - Appropriability may be low and there are many small firms
Spillover gap varies by technology type

- Large and diffuse (and possibly nonmarket motivated): "pure" science,
  - Bohr: quantum mechanics; Einstein
  - basic genome mapping
- Smaller (appropriated): goal-oriented applied research
  - Edison: light bulb/phonograph
  - new electric batteries
- Large (not appropriated): scientific discoveries from solving practical problems
  - Pasteur: bacteriology via wine research
  - mathematics for encryption

Project ordering can differ

- according to whether you use social or private returns to rank projects
  - Cures for developing country diseases vs developed country diseases.
  - "me too" drugs
- Targeted government policy that favors one industry or technology over another changes ordering
- => More than one policy is useful, depending on the goal

Standard policy instruments for market failure - summary

1. Internalize the externality
   - R&D joint ventures between firms in the same industry
   - Create a property right in the innovation (the patent system)
2. Subsidize or tax the activity
   - widely used policies
3. Regulation? - not likely or usual
   - Price controls (wage controls on S&E?)
   - Quotas - mandating R&D performance
1. Internalizing the externality

- Exempt R&D joint ventures from antitrust regulation
  - NCRA 1984
  - sometimes with federal support, e.g., Sematech
- Create a property right in the output of the innovative activity (e.g., patent, trademark, copyright, etc.)
  - Allows firms exclusive use of the innovation (monopoly)
  - May allow trading of ideas, promoting spillovers, facilitating cumulative and complex innovation
- Both solutions have costs
  - Deadweight loss (creation of monopoly power)
  - Projects chosen by industry (omits some with high social and low private returns)

2. Subsidize or tax the activity

- Direct government subsidy - where gap is large and beneficiaries uncertain and diffuse
  - science/basic research
  - higher education
  - defense/space/health
- Tax policy - where gap is smaller; industrial R&D
  - R&D is expensed
  - R&D tax credit (federal and state)
  - Returns to foreign R&D repatriated at low tax rates
- The tradeoff between direct and indirect financing:
  - Who chooses projects better?
  - Who performs projects better?
  - Politics and capture?

2. Example – government subsidy

- NIST (National Institute of Science and Technology)/ATP (Advanced Technology Program)
  - Example - Joint venture of NCMS (ATT, TI, Dec, United Tech) to research aspects of printed wiring board interconnection systems
  - $28.5 M for 5 years (ATP share $13.8M)
- Only half of 62 projects studied would have been started without ATP funding
- See next slide for more examples
Selected ATP projects

- Ultra-High Density Magnetic Recording Heads
- Engineering Design with Injection-Molded Thermoplastics
- Enhanced Molecular Dynamics Simulation Technology for Biotechnology Applications
- Computer-Integrated Revision Total Hip Replacement Surgery
- Film Technologies to Replace Paint on Aircraft
- Low-Cost Advanced Composite Process for Light Transit Vehicle Manufacturing
- Low Cost Manufacturing and Design/Sensor Technologies for Seismic Upgrade of Bridge Columns
- Integrated Microfabricated DNA Analysis Device for Diagnosis of Complex Genetic Disorders
- Automated DNA Amplification and Fragment Size Analysis

2. R&D tax credit

- Alternative to R&D subsidies
- Lowers cost of doing R&D for firms
- Firm does project selection rather than the government
  - Advantage: firms may be better at choosing projects
  - Disadvantage: firms maximize private rather than social returns
  - \[ \Rightarrow \text{project ranking may differ using these two different criteria}\]

2. Who uses R&D tax credits?

- United States:
  - temporary R&D tax credit since 1981
  - renewed on and off to 1998
  - made semi-permanent (5 years) in the November 1999
- Other countries:
  - Yes: Canada, France, Japan, Australia, Korea, Netherlands,
  - No: Switzerland, Singapore, Taiwan
  - New: Norway (beg 2003), UK (small firms in 1998; all firms beg 2003)
- Tax subsidy to research equipment:
  - Germany, Italy, UK, Belgium, Denmark, Mexico, Spain, Sweden
2. Why incremental?

- Firm will do some R&D anyway
  - credit cheaper for the government if firm receives credit only on spending in excess of what they would have done anyway
  - Problem: how to determine that figure?
    - Often use a moving average of past spending rates, which can have perverse effects on the effective tax credit rate (because what you do this year affects the base next year)

- Empirical research on effectiveness:
  - Do tax credits have an impact? Usually yes, dollar for dollar.
  - Do they cost more in tax revenue than the amount of increased R&D? probably not.

Federal Support for R&D

- Composition of federal support for R&D:
  - fundamental and basic scientific research of all types (NSF, NIH, energy, and space science)
  - research for military and space applications (NASA, Dept. of Defense)
  - research in applied technology areas perceived to be of national importance in health, energy, and agriculture (EPA, Dept. of Agriculture/ERS).
  - commercialization and adoption programs/demonstration programs like the clean coal demonstration (SBIR, ATP, CRADA)
  - cost-sharing private R&D in commercial areas (Sematech and the flat panel display project ATP)

See graph on next slide

Composition of Federal R&D Spending 1953-2003

- Defense related
- Space related
- Civilian related
Productivity of federal R&D

- generally less than that of private R&D, looking across different countries. Why?
  - politics
  - 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

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)
  - Congress impatient and risk averse
  - 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>
<thead>
<tr>
<th>Federal R&amp;D Projects Studied by Cohen and Noll (1990)</th>
<th>Rent</th>
<th>Political Outcome</th>
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<tbody>
<tr>
<td>SST (Supersonic transport)</td>
<td>aerospace</td>
<td>too costly</td>
</tr>
<tr>
<td>Communications satellites</td>
<td>aerospace</td>
<td>killed in 1974, became less salient, groups that would benefit were not represented</td>
</tr>
<tr>
<td>Space shuttle</td>
<td>aerospace</td>
<td>killed in 1974, too much weight, too slow, constituency developed</td>
</tr>
<tr>
<td>Clinch River breeder reactor</td>
<td>nuclear</td>
<td>killed in 1974, absorbed a large part of nuclear technology budget, local jobs</td>
</tr>
<tr>
<td>Photovoltaic commercialization</td>
<td>energy</td>
<td>scaled back for political reasons, benefits very decentralized and nonfocal</td>
</tr>
<tr>
<td>Synfuels research</td>
<td>energy</td>
<td>one success, but misdirected (Eastern coal rather than cleaner Western as input)</td>
</tr>
</tbody>
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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