Lecture # 12 – Government Subsidies of R&D

I. Effects of Government Funded R&D

- In today's class, we'll look at direct government support for R&D.
  - Government sponsored R&D
  - R&D tax credits
  - R&D prizes
- The major difference between direct funding and tax credits is that direct funding *goes to a specific purpose*, whereas tax credits give the R&D performers more choice over the projects on which they work.
  - Direct funding allows the government to target areas with greatest perceived social needs.
    - E.g. energy in the 70s, AIDS in the 80s.
  - Types of support
    - Research grants (e.g. NSF funding to universities)
    - Contract work awarded competitively
    - Support to research consortia (e.g. SEMATECH)
- In the United States, most federally-*funded* research is nonetheless *performed* by other sources.
  - 2011: Total federal R&D funding $125.7 billion
    - $31.5 b performed directly by govt.
    - $31.3 b performed by industry
    - $17.9 b performed by FFRDCs
    - $38.7 b performed by universities
    - $6.3 b performed by nonprofits
- Like intellectual property protection, these policies aim to stimulate R&D.
  - Whereas intellectual property rights encourage R&D by making it easier for firms to reap the rewards of their work, government subsidies directly influence the performance of R&D itself.
  - In terms of the firm's decision, intellectual property rights increase the marginal rate of return (MRR).
  - In comparison, tax credits induce R&D by lowering the marginal cost of capital (MCC).
  - As we'll see, government funding of R&D can affect both curves.
- Rationale for government intervention
  - The underinvestment rationale
    - Knowledge is a public good.
    - Positive spillovers lead to underinvestment.
    - This model was initially applied to basic research.
      - Soon found to also be relevant in applied research.
  - Increasing returns in some industries make having few producers optimal. Here, government R&D may be necessary to spur R&D among these groups.
  - Governments may promote R&D to encourage economic growth.
    - In particular, note that local governments are likely more concerned with economic development than the public goods problem.

- Overcoming lock-in of existing technologies
- Key question for government funded R&D: is it a substitute or a complement to private R&D?
    - Recall our model of the R&D process. Firms balance the marginal costs and benefits of doing R&D
    - Government R&D as a complement to private R&D
        - Shifts of the MRR curve:
            - Spillovers from government R&D raise the expected return to R&D. This shifts the MRR return up.
                - For example, scientific knowledge from academic research may increase the productivity of private R&D.
                    - Note the relation to supply-side theories of innovation.
                - Note that it may take a while for some of these shifts to occur.
            - Supplying infrastructure through government R&D may make the firm's R&D more productive.
            - Government R&D may signal future public and private sector demand for products.
                - This lowers the risk of investing, and thus shifts the expected MRR up.
                - Note potential for spillovers here – occurs even to firms not directly funded by the government.
        - Shifts of the MCC curve:
            - Government funding may be used to pay for construction of R&D infrastructure and other fixed costs. This lowers the cost to the firm, and shifts the MCC curve down.
            - R&D funding to a small firm may act as a signal of quality, enabling it to raise capital more easily, shifting the MCC curve down.
    - Government R&D as a substitute for private R&D.
        - The idea here is that government R&D crowds-out privately funded R&D.
        - Two potential sources of crowding out:
            - Limited R&D resources available
                - If there are a relatively fixed amount of R&D resources available, the employment of more resources by the government leads to less being available for private usage.
                    - This raises the MCC curve.
                - Goolsbee (1998) finds that increases in funding for public R&D significantly raise the wages of scientists and engineers.
                    - He suggests that scientists and engineers are the major beneficiaries of government R&D

            support. By raising the cost of S&E to private laboratories, government R&D crowds out private R&D.
        - The government may perform research that the private market would have done anyway. In that case, private firms do less, as government sponsored research competes with privately sponsored research.
            - The expected returns to R&D by non-funded firms may fall, as they now need to compete with a federally-funded company in the market for newly-developed innovations.
            - Govt. R&D on energy in the 1970s may be an example.
            - Here, the MRR curve shifts down, as the government is competing with the private sector.

- Empirical analysis of the effects of government R&D
    - The biggest challenge is that, since both the MRR and MCC curves are shifting simultaneously, we need to control for endogeneity.
    - Examples of endogeneity problems in R&D:
        - Selection bias in awarding grants
            - Presumably the best firms will win grants. Is their success due to the grant, or because of greater ability (e.g. what can we say about a researcher from Harvard who gets a grant?)
        - Both private and public R&D respond to the same signals
            - E.g. both private and public energy R&D spending increased in the 1970s.
    - The typical regression is of the form:
        - Private R&D = a + b*Public R&D + cX + e.
            - The sign of b tells us whether public funds are a complement or substitute to private funds.
        - Grants vs. contracts
            - Contracts most often given to for-profit firms
                - For a specific purpose
                - Government will often purchase resulting product
            - Grants usually competitive, and have no purchase commitment
                - Scope of research broader
                - More likely given to non-profits or universities
            - Most of the studies below apply to contract R&D
        - David *et al*. present results for five types of studies. I've summarized each below. Most important is the summary of all results at the end.
        - Results I: Micro cross studies at the firm or industry level
            - Here, controlling for firm characteristics is important.
            - Find public R&D is either a complement or find no significant effect (Table 1)

            - Effect is small (highest is 0.336)
        - Results II: Firm-level studies, often using panel data
            - The use of panel data controls for time-invariant differences across firms.
            - Mixed results
        - Results III: Industry level studies
            - Only a few done, since the data is too aggregated
            - These studies tend to find complementary effects
            - Includes results of some case studies
        - Results IV: Aggregate studies
            - Look at macro level private R&D vs. public R&D.
            - Important to control for other macroeconomic influences.
            - Example: Levy and Terleckyj (1983):
                - Government contract R&D is a complement
                - Other government R&D has little effect in the short run, but acts as a complement in the long run (lag of 3-9 years).
            - Cross-country comparison:
                - Levy (1990) finds government R&D is a complement in 5 countries, and a substitute in two.
                - Most of these studies find positive effects
                - However, recall that Goolsbee found public R&D led to higher salaries for S&E.
                    - These higher prices raise the price of R&D, but are included in R&D spending.
                    - Thus, these studies may overestimate the positive effect.
        - Results V: studies of nonprofits.
            - Adams (1990) surveyed 208 industrial laboratories.
                - He found that publicly supported academic research does not stimulate industrial learning R&D.
            - Toole (1999) found that public R&D did stimulate private R&D in the pharmaceutical industry.
                - Typical lag is 6-8 years
        - Summary (see table 5, p. 526)
            - One-third of papers find public R&D is a substitute
                - Occurs most often at firm and line-of-business level
            - Most studies finding substitution (9 of the 11) are done on US data.
- Example of government supported research for industry
    - Small Business Innovation Research (SBIR)
    - Established in 1982 with the goal of stimulating innovation in small, high-tech firms.
    - All federal agencies spending more than $100 million/yr on external research were to set aside 2.5% of these funds to award to small businesses.

- Three phases to SBIR research
  - In phase I, firms can get grants up to $150,000 for 6 months to investigate feasibility of proposed idea
  - In phase II, ideas with potential can receive grants up to $1,00,000 for two years
  - In phase III, the product must be brought to market with private funds.
    - SBIR does not provide funding for phase III.
    - However, some agencies may provide non-SBIR R&D funds, production contracts, or bridge funds
- In FY 2011, $1.9 b awarded to 5,396projects
  - 43% of awards come from DOD, 32% form HHS.
- Motivation: Smaller firms may have a more difficult time raising research capital.
- SBIR recipients must be:
  - Independently owned
  - For-profit firms
  - Less than 500 employees
  - Majority of shares must be owned by US citizens
- Results:
  - Lerner (1998): SBIR firms grew faster than non-supported firms
  - Question: is this because of SBIR, or does SBIR "target winners"?
    - Lerner checks this by comparing results in low-tech and high-tech industries.
    - He argues it should be harder to pick winners in high-tech.
    - Nonetheless, the results hold in high-tech.
    - Furthermore, the first award to a firm plays a big role, and the marginal value of subsequent awards declines sharply.

II. R&D Tax Credits

- Compared to government R&D, tax credits are a more market-oriented approach than R&D subsidies, as they let firms choose the research projects they will do.
- The disadvantage of this freedom is that R&D tax credits can be taken for any project.
  - Ideally, government aid should target projects with the highest social rate of return, or the highest divergence between private and social rates.
  - Given the credit, firms will still choose to do projects with the highest private rates of return.
    - However, the credit may allow them to do more research.
- Tax credits in practice
  - In general, there is lots of policy variation both across countries and across time.
  - This makes it difficult for firms.
  - Variations include (see Table 1, pp 452-3):
    - Definitions of R&D

        - Most countries follow the definitions in the Frascati manual. This manual was first developed in 1963 by a team of international scientists and statisticians from over 60 OECD countries to create an international definition of R&D. The manual is continually updated.
        - Most recent update was in 2002. It can be seen here.
        - Basic definition: "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."
    - R&D depreciation rates
    - R&D capital depreciation rates
    - Tax credit rates
    - Base at which credit begins
        - In general, the goal is to only give credit for R&D induced by the credit, not all R&D performed.
    - Special treatments for small firms
    - Treatment of R&D done abroad by domestic firms
    - Treatment of R&D done at home by foreign firms
    - Is the credit itself taxable income?
- US policy:
  - Definition excludes contract R&D and reverse engineering.
  - R&D above a base determined by the average of 84-88 R&D is eligible.
    - Adjustments are made for new firms.
  - R&D depreciated at 100% (the quantity is expensed)
  - The credit is taxable
  - Foreign R&D is not eligible
  - The credit rate is 20%.
  - In addition, many states (at least 32) have their own programs
    - More than ½ of these mimic the federal program (incremental credit with fixed base)
    - A recent paper found that state tax credits do increase R&D, but that it may come at the expense of neighboring states.
- Japan's policy
  - Software is included in the definition of R&D
  - 20% tax credit rate
  - Base R&D is the maximum R&D since 1966
  - Foreign R&D is eligible.
- Changes over time
  - Reforms tend to lower statutory rates and broaden the tax base.
  - Canada has treated R&D most favorably.
  - Germany has been the least generous
    - Close to neutral
  - In each country in figure 1, tax treatment has become more favorable since 1980s.

- Heterogeneous effects among firms
    - Historically, different firms have been treated differently by the tax credit, which can lead to perverse incentives.
    - Examples:
        - Unless the tax credit is fully refundable, firms with smaller tax burdens (such as startups) cannot take advantage of the full credit.
        - There are usually caps on the maximum credit.
        - The definition of the base affects firms differently.
            - Moving bases may affect the timing of R&D.
- Effectiveness of the tax credit
    - Typically, studies compare the amount of R&D induced by the tax credit to the loss of tax revenue.
        - A ratio less than one suggests direct subsidies would be more effective.
        - A ratio greater than one suggests tax credits are more effective than subsidies.
        - Note that this doesn't address which research projects get done, or how successful they are.
    - Issues:
        - The cost of the credit
            - Traditionally, this is measured as the total credit claimed.
                - In the US, $7.8 billion claimed in 2009, $8.3 billion in 2008
                - Claims typically represent 3-3.5% of firm R&D since 2001
            - 80% of claims generated by five industries:
                - Computer and electronic products
                - Chemicals (includes pharmaceuticals)
                - Transportation equipment
                - Information, including software
                - Professional, scientific, and technical services, including computer services and R&D services
            - Administrative costs are typically ignored.
        - Measuring the R&D induced
            - The trick is we want to know how much R&D the firm would have done without the tax credit. Since we cannot observe this, the following techniques are used:
                - Event and case studies
                - Natural experiments: what happens after policy shifts
                - Price elasticity estimation: user cost of R&D used as an explanatory variable.

- Results:
  - US studies
    - Early studies show little effect
    - More recent studies show price elasticities near 1.
      - For each dollar decrease in the cost of R&D (and thus each dollar of tax revenue lost, since the credit lowers costs by lowering tax bills) an additional dollar of R&D is performed.
    - Hall argues that this is because it took time for firms to adjust to its presence.
  - Non-US studies
    - Canada
      - Elasticities below 1 (note that the results I gave in class were in error).
    - Australia
      - Elasticity 0.6-1.0
    - France
      - Small elasticity (0.26)
    - Cross-country study
      - Short-run effect small (0.16)
      - Long-run effect near 1.
        - Note similarity to differences in early and late US studies
        - Strong long run effects may mean that multinational firms locate R&D where tax treatment is most favorable.
  - Explaining differences
    - Japan and France have a moving base: this seems to lower the effect of the tax credit.
  - An OECD study found that, in Europe, R&D tax credits were not effective at encouraging non-R&D performing firms to perform R&D.

III. Research Prizes

- Alternative funding options: research prizes
  - Most R&D funding programs provide support up front.
    - This may be important, as it helps pay for expensive equipment and staff.
  - However, paying up front does not guarantee performance.
  - An alternative that does guarantee performance is a research prize.
    - With a prize, a specific goal is set, and a monetary reward offered to the first research team to meet the goal. Examples:
      - Netflix offering a prize for a program matching movie tastes that makes predictions 10% better than its current program.
      - Longitude Prize

      - Offered by British government in 1714 for developing a method to measure longitude
    - NASA's Centennial Challenges
      - Multiple challenges, in areas such as robotics and spacecraft, began in 2005
    - TopCoder programing competitions
      - On-line computer programming challenges
    - X Prize created in 1996 offered $10 million for first private manned flight into space.
    - Defense Advanced Research Projects Agency's "Grand Challenge" awarded for the development of driverless vehicles that would reduce battlefield casualties of U.S. troops.
  - Unlike traditional R&D funding, no payments are made unless the goal is met.
    - Thus firms, rather than government, bear the risk of failure.
      - If a project is risky, a large prize will be needed to make firms willing to compete.
  - Winning firm unknown ahead of time.
    - Avoids potential of politics influencing who gets an award.
  - Fewer bureaucratic hurdles may make it easier for smaller entities.
    - But, do they have needed money to support their effort? Particularly an issue if large up-front costs are needed.

- Example: Netflix's $1 million prize
  - In 2006, Netflix announced a $1 million prize for the first research team for the first team that could improve its movie recommendation system
    - Competing teams needed to use Netflix's data to predict which movies consumers would prefer
    - The winning team needed to predict a consumer's preferences 10% better than Netflix's existing system
  - Access to data was valuable for researchers
    - Netflix has rich consumer data, with over 100 million movie ratings, but not the researchers to work on it
      - Being able to analyze and model such data has multiple applications in business, science, and politics
    - Indeed, the team that came in second place has earned $10 million from what it learned in the research
      - Had met Netflix's goal, but were the second team meeting the goal to submit their solution
      - They were able to develop improved statistical analysis and modeling techniques that its firm uses with other marketing clients
        - Would this work in a setting with fewer commercial applications (e.g. a new spaceship)?

- Policy background
  - 2011 America COMPETES Reauthorization Act gives federal agencies authority to offer innovation prizes
    - While some agencies, such as NASA, had done so before, offered a simplified path for agencies to do so
  - Including government, private, and non-profit sector prizes, McKinsey (2009) estimates that the "prize sector" in the U.S. is between $1-$2 billion
    - However, growing rapidly
    - Most growth has come from philanthropic sector
- Goals of research prizes
  - Provide incentives to create a desired technology
    - Choosing and refining prize targets
      - Often, detailed technical specifications must be met
        - Requires consultation with experts, affected parties, and potential participants
    - But, if inventors have ideas that no one has thought of, prizes with detailed specifications will not help
      - Does this make prizes less useful for basic research?
    - Thinking about price targets is also important
      - If there is one winner, they will have monopoly power
      - Setting price guidelines such as the AMC example described below, avoids abuse of market power
  - Orienting research towards designing a project capable of being used at scale by consumers
    - What event should trigger the prize: meeting technology goals or market penetration (e.g. ex post use)
    - Examples promoting market penetration:
      - Super Efficient Refrigerator Program (SERP)
        - $30 million prize offered by a group of electric utilities in 1992
        - Goal: to spur development of an energy efficient refrigerator meeting certain energy efficiency and environmental standards
          - Whirlpool won the prize in 1993
          - However, to win the full award, had to sell at least 250,000 by 1997
            - Sales were lower than expected, due to higher prices of the refrigerators
            - Thus, Whirlpool did not receive the prize
          - The market test thus ensured that the winning technology be desirable to consumers
      - Advance Market Commitment (AMC)
        - Legal contract to pay a guaranteed price for a predefined number of vaccines
        - Conditions:
          - Vaccine must meet technical specifications

                - Poor countries express demand, such as by contributing a small price to the purchase
            - Subsidized price induces research, but long-run price will be low once initial quantity purchased at the subsidized price
                - Note how this avoids the monopoly pricing distortion of patents
                    - The subsidy provides the incentive for development
                    - Once developed, developing countries pay a price similar to marginal cost
        - In contrast to demonstration projects
            - The Ansari X Prize is an example of a demonstration project
                - Prize offered to the first team to "build and launch a spacecraft capable of carrying three people to 100 kilometers above the earth's surface, twice within two weeks."
                - Goal was to show it is possible, not to develop the technology for consumers
    - Placing technology in the public domain to incentivize subsequent research
        - In 1839, France bought the patent for Daguerreotype photography and placed it in the public domain
        - Thus, it is important to consider what happens after the prize has been won
            - Some prize sponsors want to control intellectual property
                - Particularly true when businesses are the sponsor
            - Others let winners keep IP
        - If innovation is cumulative, important that the winner not be able to hinder future research on the topic
        - Patent buyouts can ensure technology remains in public domain
            - Auctions could be used to determine the commercial value of a patent
- What issues should be considered when setting the size of a prize?
    - Needs to be high enough to encourage firms to do research
    - However, government does not want to overpay
        - Analogous to patent races
            - Too many competitors may enter a race for a large prize
        - Complexity matters here
            - If the goal is difficult to reach, different teams using different methods to try to reach the goal may be useful
        - Note that the tradeoff is between duplicating research versus having enough different entrants to ensure success
    - Larger prizes may generate results more quickly
    - Looking at evidence is difficult

        - If a prize hasn't been awarded, is it because the prize was too small or simply because the goal has yet to be met?
    - Other markets may provide information
        - Advance market commitments for vaccines try to set a price comparable to what pharmaceutical companies could get for a product made for high income markets
- Evaluating prizes
    - Key questions:
        - Would the technology have been developed without the prize?
        - Would the technology have been developed more quickly with a different prize structure?
    - Evaluation challenge: What is the appropriate baseline?
        - That is, what would firms have done if the prize had not been offered?
            - For example, the Archon X Prize for Genomics offered a $10 million price of a method of sequencing the human genome
            - However, firms were already working on this question before the prize
        - Given the small number of prizes, hard to evaluate
            - All but a few of the 200 prizes complied by McKinsey (2009) have been awarded
        - Cannot observe a world both with and without the prize
    - Because of these challenges, most existing research uses case studies
        - Suggests past prizes have been successful
    - Williams argues that field experiments would be a promising alternative
        - E.g. having groups randomly assigned to compete for a cash or not cash prize