Lecture # 14 – Evaluating Public R&D/Technology Transfer

I. Example: Prospective Analysis of Energy R&D

- The previous studies evaluate programs that already exist (<u>retrospective analysis</u>)
    - However, we also want to know about might happen in the future
        - That is, should we make an investment? What are the likely outcomes if we do?
    - This is <u>prospective analysis</u>.
        - The DOE framework provides an example.
- Background on Department of Energy (DOE) study
    - In 2000, Congress requested that the National Academy of Sciences (NAS) evaluate the benefits and costs of DOE's R&D programs for fossil fuel and energy efficiency
    - In 2001, NAS reported that, in the aggregate, benefits exceeded costs
        - However, the DOE portfolio included both successes and failures
        - Noted methodology used by DOE to assess programs varied
    - As a result, Congress gave funds to develop prospective benefits of DOE programs
        - Phase one, which is this report, began in 2003
        - Tasks were to review existing methodologies and propose a conceptual framework for prospective evaluation
        - Teams would use the framework to study the effectiveness of three technology programs:
            - Advanced lighting
            - Fuel cells
            - Carbon sequestration
        - Evaluation would lead to recommendations for Phase Two
- Note the consideration of resources and the needs of stakeholders
    - Committee was guided by three criteria**:**
        - Simplicity and flexibility
            - Methods needed to be rigorous, but practical so that they could be applied to a wide variety of programs
    - Transparency
        - Decision makers must be able to understand
    - Consistency
        - To facilitate comparisons across programs, definitions and assumptions should be the same
- Paper begins by reviewing methods for retrospective analysis
    - There, NAS created a benefits matrix, where there were three types of benefits:
        - Economic, environmental, and energy security

    - Three possible realizations:
        - Options benefits and costs represent benefits that may be realized in the future if circumstances change (e.g. higher energy prices)
        - Knowledge benefits represent spillovers
    - While this isn’t a logic model, note that it is similar.
- To adapt to prospective analysis, must consider the role of uncertainty.
    - What is uncertain?
        - Technological outcome
            - Project could be complete, partially, or not at all successful
        - Market acceptance
            - Note that behavior matters
            - Consumers must be willing to use a new technology
            - The article raises the possibility that competing products may also improve
                - It misses that there is more here: consumers may not care about the targeted need
            - Resistance by special interests
                - Will those adversely affected lobby against the technology?
                - Will they be successful?
        - Future states of the world
            - Future energy prices or policies
        - Complementary and prerequisite technology
            - Is adoption dependent on other technologies also being available?
                - If so, are these technologies also being developed?
        - Should benefits be attributed to the DOE program, or will they come from other sources
            - Private investment or support from other governments and/or programs
    - Leads to a revised matrix
        - Columns changed because results not yet realized
            - Columns instead focus on three possible market scenarios
                - Reference case: based on EIA projections
                    - Assumes a world oil price of $24 in 2020, $27 in 2025!
                - High oil and gas price
                    - $33.41 in 2012!
                - Carbon constrained prices
                    - Assumes a 18% reduction in greenhouse gas intensity
            - These are presented as representative outcomes, but there is no attempt to assign probabilities to each
            - Knowledge benefits (e.g. spillover) not considered because they are not an intended goal of DOE programs
                - Note how benefits used relate to program goals

            - Not meant to be comprehensive (p. 16)
    - Note that the revised matrix provides room for descriptive summaries, but numerical calculations will be done using the decision tree.
    - Also note that benefits may not occur in all scenarios
        - For example, carbon sequestration only useful if carbon emissions are regulated
- Decision tree analysis
    - Used to address multiple sources of uncertainty
        - Examples of uncertainty
            - Policy environment
            - Future prices
            - Success of research outcomes
    - Figure above includes three uncertainties
        - Does the government fund the technology?
        - Is the research successful?
            - Note that there could be success even without government funding
        - Is the product accepted in the market?
    - Each path represents a possible outcome
        - Need to establish a probability for each point of the path
            - No probability needed for the first node: does government fund, as that yes/no choice is what we are evaluating
        - Funding can change the probability of a successful outcome, however, as shown in figure 3-3.
        - Product of probabilities along each path is the probability that path occurs
            - Tables 3.2 & 3.3 provide an example of expected benefits
                - Expected value here is $25,000
            - Note that very unlikely outcomes have little impact unless they are large. The table below adds a spectacular success:
                - Expected value here is $25,500
            - Now, change spectacular outcome to $2,000,000
                - Expected value now $44,000
    - How to determine the probabilities
        - Only consider important features – can't include everything
        - NAS used expert panels to determine what was important and develop probabilities
            - NAS provided experts with guidelines for assessing probabilities
                - Each panel member asked to specify probabilities for key uncertainties in a questionnaire
                    - Gives the respondent time to think
                - Can decline to answer if not sure
                    - E.g. may a scientist might only address questions related to his or her discipline

            - Thus, committee should include a range of disciplines
        - Follow up with a second meeting where the panel reviews individual assessments and discusses rationales for them
            - Allows for debate about differences
            - After discussion, committee is given opportunity to revise chosen probabilities
    - Must consider a range of goals
        - If only consider the DOE's highest goal, will underestimate benefits by ignoring intermediate outcomes
- For now, we'll take benefits as a given and demonstrate calculation of expected benefits.
    - We will then discuss estimating benefits in greater detail.
- This hypothetical example looks at advanced lighting technology.
    - There are three possible outcomes of lighting efficacy
        - 150 lumens per watt (lpw)
        - 100 lpw
        - No change
    - Note that DOE investment increases the likelihood of success by 10% for the best outcome, and increases the medium outcome by 20 percentage points
        - Thus, DOE investment doesn't guarantee success, but makes it more likely
        - Also, some success is possible even without DOE involvement
    - The example also considers whether other nations will come up with the technology
        - 150 lpw
            - Assume 0 probability of other nations coming up with 150 lpw without DOE investment
            - Increases to 5% if DOE invests
        - 100 lpw
            - 50% probability other nations will do with or without DOE investment
    - The products show the probability of the US and other nations developing a specific level of efficiency
        - E.g. with DOE investment: 0.005 probability that both come up with 150 lpw (= 0.1*0.05)
        - 0.05 probability US gets 150 lpw and other countries achieve 100 lpw (= 0.1 * 0.5)
    - Dollar values are assigned to the potential benefit of each outcome
    - The expected benefit is the probability times the benefit of that outcome
    - Difference between expected value with and without DOE investment is the net benefit of the R&D funding

- Calculating the benefits
    - Estimated benefits are needed for each path
    - Background
        - The NEMS modeled mentioned is a large computer model that simulates the US energy market
    - Benefits of energy efficiency
        - Reduces costs
        - May change energy usage
        - To calculate benefits, calculate reduction in quantity of input needed to produce same energy service and value at marginal cost
            - These inputs are now free to be used elsewhere
        - What if MC and price are not the same?
            - For example, if average cost pricing used for electricity?
            - Retail prices cannot be used to estimate MC
            - In that case, need data on costs of production
                - Total cost savings is now total cost of supplying electricity, not cost paid by consumer, as show in figure 3.5.
                - Top lines represent original and reduced MC as seen by user (e.g. the price they pay)
                - Lower solid and dashed lines are actual costs of energy service
            - The key here is that the MC to the consumer is greater than the MC of producing and distributing energy
                - Area B is larger because add both additional CS and PS from using more electricity and producer surplus
                - Compare to figure 3.4, where there is only additional CS, because P = MC
    - Benefits of new energy resources
        - Increase the amount available at a given cost
        - Calculate value by valuing additional supply as difference between marginal benefit and marginal cost
            - Figure assumes there is a resource constraint, so that initial output is not where MB = MC
                - Remainder is imported. For example:
                    - MC of production in US = $25
                    - Price of imports = $40
                    - Increasing production by 100,000 barrels per day leads to 36.5 million barrels per year, with a value of $15 each, for a total benefit of $547 billion
                - Assuming no change in world price
            - If prices change, need a general equilibrium model
    - Note that there may also be benefits that are not monetized, such as environmental benefits or energy security benefits
        - Security benefits difficult to calculate and likely low (p. 16)

II. Technology Transfer: Theory

- Types of technology transfer:
    - Cooperative research and development
    - Licensing or sale of intellectual property
        - Either across firms or to a startup spin-off firm
    - Technical assistance
    - Public exchange of information
        - E.g. conferences, publications, networking
- What is technology transfer?
    - Bozeman notes that there is no standard definition
    - He offers the following: "the movement of know-how, technical knowledge, or technology from one organizational setting to another."
        - Note that technology transfer is more than just the diffusion of a final product.
        - It is about flows of knowledge and ideas as well.
    - The technology itself may be clearly defined, or it may evolve over time
- Three competing paradigms for government support
    - Market failure
        - The government intervenes to correct market failures.
            - Examples used by Bozeman include externalities, high transactions costs, and imperfect information.
            - However, as we discussed in class, transactions costs need not be a market failure. Transactions costs are legitimate costs paid by individuals.
            - However, the government can still take advantage of opportunities to lower transactions costs.
        - Evolution of universities as the source of basic research after WWII follows from this.
        - Examples of policies:
            - Intellectual property rights
            - R&D subsidies
            - R&D tax credits

- Mission technology paradigm
    - Government should perform R&D in service of well-specified missions for the national interest that aren't well-served by private R&D.
        - Has been used to justify agricultural research for a long time.
        - More prominent after WWII, in areas such as defense, energy, and health.
    - In some ways, this is related to market failure, as that may be why private R&D doesn't serve the need.
    - Other times, private R&D won't serve the need because there is no market -- it is the government who is purchasing the good.
- Cooperative technology paradigm
    - Government plays an active role in technology transfer

        - Has received more attention recently.
- Evaluating government labs: how do we identify successful technology transfer?
    - Note that different actors may have different goals.
    - “Out the door”: has another organization received the technology provided by the first.
        - Commonly used in practice, although not a very useful evaluation measure.
        - Easy to quantify.
        - Evaluation criteria are under laboratories control.
        - Assumes that the role of the lab or university is to create technology, but that it is industry’s job to make it work.
        - Also, doesn't ask whether the technology transferred was beneficial.
    - Market Impact/Economic Development
        - Has the product had an impact on the firm and/or on the economy?
        - Little direct evidence of successes here.
        - May be difficult to identify, as we want to know the *marginal* effect of government involvement:
            - If a project is successful, we need to ask if it would have been successful *without* government involvement.
            - Similarly, if a project fails, is it because of bad technology transfer, or because the project was a bad idea?
        - Example: patent citations from government labs
            - Jaffe, Banks, and Fogerty (1998) look at patent citations received by NASA patents.
            - NASA patents are more general (that is, cited by patents in more patent classes) and more important (that is, cited more often) than other patents.
                - Other federal labs are also general, but are cited less often than non-government patents.
            - They also did case work at one lab to find out how knowledge flows from NASA labs.
                - Of patents examined only 4 of 26 (15%) involved known contact, but over half appear to be legitimate spillovers.
                - Thus, most spillovers appear to come from indirect means, such as reading papers or patent documents.
        - Political reward
            - Labs often view technology transfer as a way to win political support.
            - Can ask if agency benefited politically.
            - Bozeman notes this may be realistic, but doesn’t provide systematic evaluation.
        - Opportunity cost
            - What are the other impacts of the mission of the transfer agent?

        - Taking on new missions reduces capabilities to work on old projects.
            - Example: universities' concerns over more private funding.
- Scientific and Technical Human Capital
    - Does technology transfer lead to enhanced skills at the recipient company?