Evaluating Public Sector R&D Programs: The Advanced Technology Program's Investment in Wavelength References for Optical Fiber Communications

Albert N. Link[1]
John T. Scott[2]

ABSTRACT. Griliches (1958) [*Journal of Political Economy*, 66: 419–431] and Mansfield *et al.* (1977) [*Quarterly Journal of Economics*, 91: 221–240] pioneered the application of fundamental economic insight to the development of measurements of private and social rates of return to innovative investments. This paper illustrates field-based methods for measuring the social rates of return to innovative investments by the public sector. The case study described herein relates to the development of an improved standard reference material for the measurement of the wavelength of light in an optical fiber network.

Key words: social rate of return, benefit-cost analysis, internal rate of return, net present value, program evaluation, innovation

JEL Classification: O33, H54

1. Introduction

Fundamental to an evaluation of any federal program, research program or otherwise, is that the program is accountable to the public. For research programs, such accountability refers to being able to document and evaluate research performance using metrics that are meaningful to the institutions' stakeholders—the public, including the taxpayers.[1] Metrics developed for assessing returns to private investment have been adapted to public investments using case-study techniques that emphasize analysis of public benefits to research users and taxpayers.

With any performance evaluation, it is generally assumed that the government has an economically justifiable role in supporting innovation because of market failures stemming from, among other things, the private sector's inability to appropriate returns to investments, the public-good nature of the research focus, or the riskiness of those investments.[2] Ignoring such an assumption may imply that any evaluation of a public research program is wanting in the sense that the program should initially be scrutinized on first principles as to why it is even undertaking research.

Griliches (1958) and Mansfield *et al.* (1977) pioneered the application of fundamental economic insight to the development of measurements of private and social rates of return to innovative investments. Streams of investment costs generate streams of economic benefits over time. Once identified and measured, these streams of costs and benefits are used to calculate such performance metrics as social rates of return and benefit-to-cost ratios.

For example, for a process innovation adopted in a competitive market, using the traditional framework, the publicly-funded innovation being

[1]*Department of Economics*
University of North Carolina at Greensboro
Greensboro, NC 27412
and Max Planck Institute, Jena, Germany
E-mail:al_link@uncg.edu
[2]*Department of Economics*
Dartmouth College
Hanover, NH 03755
E-mail: john.t.scott@dartmouth.edu

evaluated is thought to lower the cost of producing a product to be sold in a competitive market. As the innovation lowers the unit cost of production, consumers will actually pay less for the product than they paid before the innovation and less than they would have been willing to pay—a gain in consumer surplus. The social benefits from the innovation include the total savings that all consumers and producers receive as a result of producers adopting the cost-reducing innovation. Depending on the extent to which reduced costs are reflected in the price charged to consumers, social benefits are shared by producers who adopt the innovation and consumers of their products. Thus, the evaluation question that can be answered from this traditional approach is: Given the investment costs and the social benefits, what is the social rate of return to the innovation?

This paper, written in honor of Ed Mansfield, illustrates—in the context of a public sector investment—the Griliches/Mansfield pioneering field-based methods for measuring the social rates of return to innovative investments. The case study described herein relates to the development of an improved standard reference material (SRM) for the measurement of the wavelength of light in an optical fiber network. That research, which was conducted at the National Institute of Standards and Technology (NIST), was funded by an intramural grant through NIST's Advanced Technology Program (ATP).

The following Section 2 briefly describes ATP's intramural research program. Section 3 overviews the case study, and relevant social rate of return metrics are presented in Section 4. Section 5 concludes the paper with general observations about the evaluation of public sector R&D.

2. ATP's intramural research program

Since its inception in 1990, ATP has stimulated economic growth through the development of innovative technologies that are high in technical risk and enabling in the sense of having the potential to provide significant, broad-based economic benefits.[3] Industry proposes research projects to ATP in competitions in which proposed projects are selected for funding based upon both their technical and economic or business merits.

The ATP intramural research program provides funding to NIST laboratories to conduct research to advance the U.S. technology infrastructure in order to assist industry in continually improving products and services. Under the statute governing ATP, up to 10% of ATP's budget could be allocated for this research. Since 1997, ATP required that these intramural projects:

- emphasize generic basic research,
- relate to groups of ATP extramural projects, and
- focus on measurement and standards that would facilitate the deployment and diffusion of technologies developed in ATP extramurally-funded projects.

3. Case study of wavelength references for optical fiber communications

The goal of this research project was to develop an improved SRM for the measurement of the wavelength of light in an optical fiber network.

The Optoelectronics Division of the Electronics and Electrical Engineering Laboratory began research on optical communications in the mid-1970s and expanded its research program substantially in the late 1980s. The Optical Fiber and Components Group of the Division began research on SRMs in 1991. The Group's first SRM became available in 1993; with SRM 2520, an optical fiber diameter standard. Since then the Group has produced a number of optoelectronic standards. SRM 2517 was issued in 1997; it was intended for use in calibrating the wavelength scale of wavelength measuring equipment in the spectral region from 1510 to 1540 nm.

In 1998, Dr. Sarah Gilbert in the Optical Fiber and Components Group began a two-year ATP intramural project to develop a more accurate version of SRM 2517. Dr. Gilbert received $145,000 over two years—$70,000 in fiscal year 1998 and $75,000 in fiscal year 1999. The project produced the new SRM for calibration of wavelengths in the spectral region from 1510 to 1540 nm. The references in the 1500 nm region are important to support wavelength division