Chapter 5

Government Decisionmaking

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To be useful to Federal policymakers, quantitative methods for evaluating research and development (R&D) must provide reliable results and fit with existing decisionmaking procedures. As we have seen, neither the economic rate-of-return models nor the noneconomic science indicators can answer all the questions facing policymakers. The economic models do not even meet the needs of industrial private managers, for whom economic payoff is the primary concern. One should not be surprised, therefore, that these models offer little help in making Federal R&D decisions, in which economic payoff is only one of many criteria and often a secondary consideration. In addition, the users of Federal R&D are not captive. Information produced through federally funded R&D is, in most cases, available to anyone who seeks access. Thus, the benefits are dispersed in a way that makes accounting for them nearly impossible.

The goal of federally funded research is not profitability, but a means of achieving social objectives, whether they be health, national security, or the enhancement of knowledge and education. The Federal research infrastructure is designed to provide a stable environment for these goals, despite a changing political environment. This creates an R&D management environment very different from industry, where reorganization is more easily achieved.

In addition, Federal research programs must be responsive to many more groups than industrial research efforts, and this affects the manner by which the research agenda is shaped. The process of obtaining funds from the taxpayer for mission research is complex and quite unlike the R&D decisionmaking apparatus found in industry. The budget process is the first of many hurdles, followed by levels of decisionmaking at the agency level, institute *or* directorate level, program level, and advisory board level. On occasion, Congress has attempted to influence the administration and execution of research programs by using mechanisms such as appropriations riders. Thus, research funding decisions in the Federal Government are subject to levels of review and requirements for accountability unheard of in industry.

To understand the limited utility of quantitative methods for measuring return on Federal R&D, it is important to recognize the complexity of the processes leading to the actual investment decisions. Attempts at evaluating research decisionmaking should be analyzed in the context of the scale and structure of scientific activity in the United States. It is estimated that the Federal Government will be responsible for 49 percent of national R&D expenditures in 1986, up from 46 percent in 1982.[1] The structure of support is pluralistic and decentralized, with 10 agencies responsible for R&D functions. The budgets of each agency differ enormously, as depicted in table 11. Methods for project selection and program evaluation also differ between agencies, reflecting the decentralized and pluralistic nature of the system. These differences are attributable to the age of the agency, the size of the budget, the levels of basic and applied research, agency mission, and the management "traditions" institutionalized over time. In all cases, decisions are made incrementally.

To understand how quantitative methods can be used in Federal decisionmaking, we have to look at the types of decisions that must be made and how these decisions are being made now. Policymakers must establish priorities among all government programs, among the various scientific disciplines, and among projects within a discipline. These priorities are then applied to decisions about research budgets, project selection and termination, and program evaluation. We will look at how these decisions are now made and evaluate the potential for using quantitative methods to assist in the process.

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[1]National Science Foundation, Division of Science Resources Studies, *Science* and *Technology Data Book* (Washington DC. NSF, 1986).

Table 11.- Federal Obligations for Research and Development by Character of Work and R&D Plant: Fiscal Years 1984=85 (thousands of dollars)

Fiscal year and agency	Total R&D and R&D plant	Total R&D	Research: Basic research	Research: Applied research	Development	R&D plant
Fiscal year 1984 (estimated):						
Total, all agencies	*46,554,924*	*44,835,777*	6,981,031	*8,127,270*	29,727,478	1,719,145
Department of Agriculture	*925,364*	*871,942*	386,442	455,594	29,906	53,422
Department of Commerce	*367,252*	*360,021*	20,522	272,644	66,855	7,231
Department of Defense	*27,987,145*	*27,540,045*	816,590	2,168,184	24,555,271	447,1 co
Department of Energy[a]	*5,770,604*	*4,825,576*	841,671	1,231,733	2,752,172	945,028
Department of Health and ‘Human Services[b]	*4,921,924*	*4,864,292*	2,793,052	1,705,911	365,329	57,632
Department of the Interior	*427,558*	*421,825*	124,667	276,330	20,828	5,731
Department of Transportation	*538,429*	*515,929*	600	81,990	433,339	22,500
National Aeronautics and Space Administration	*3,044,400*	*2,888,900*	689,133	1,012,031	1,187,738	155,500
National Science Foundation	1,247,580	*1,238,480*	1,172,466	66,014		9,100
Veterans Administration	*228,100*	*220,900*	15,200	189,700	16,000	7,200
Other agencies	1,096,568	*1,087,867*	120,688	667,139	300,040	8.701
Fiscal year 1985 (estimated):						
Total, all agencies	*54,072,393*	**52,253,607**	7,637,587	8,396,633	36,21 ‘3,387	1,818,786
Department of Agriculture	*926,711*	**898,941**	419,727	449,981	29,233	27,770
Department of Commerce	*282,357*	**270,559**	18,416	201,187	50,956	11,798
Department of Defense	*34,510,984*	**34,142,084**	913,195	2,408,204	30,822.685	368,900
Department of Energy[a]	*6,146,700*	**4,962,272**	944,517	1,268,964	2,748,791	1,184,428
Department of Health and Human Services[b]	*4,967,872*	**4,953,972**	2,925,916	1,679,147	348, ! 09	13,900
Department of the Interior	*369,209*	**368,989**	102,762	248,556	17, [71	220
Department of Transportation	*505,704*	**495,204**	400	79,630	415,174	10,500
National Aeronautics and Space Administration	*3,499,400*	**3,339,400**	826,721	1,088,063	1 ,424,(16	160,000
National Science Foundation	1,426,567	1,414,017	1,335,809	78,208		12,550
Veterans Administration	*207,600*	194,500	15,000	160,000	19,500	13,100
Other Services	1,229,289	1,213,669	135,124	736,693	341,852	15.620

[a]Data shown for fiscal years 1956.73 and fiscal years 1974-76 represent obligations of the Atomic Energy Commission (A EC) and the Energy Research and Development Administration, respectively.
[b]Data shown for fiscal years 1955-78 represent obligations of the Department of Health, Education, and Welfare.

SOURCE: National Science Foundation.

THE R&D BUDGETARY PROCESS

The process of budgeting is a process of compromising among competing values over how funds should be expended. Since funding is essential for any public policy, the budget process deals directly with how values are allocated in a political system. " It is a political process.[2]

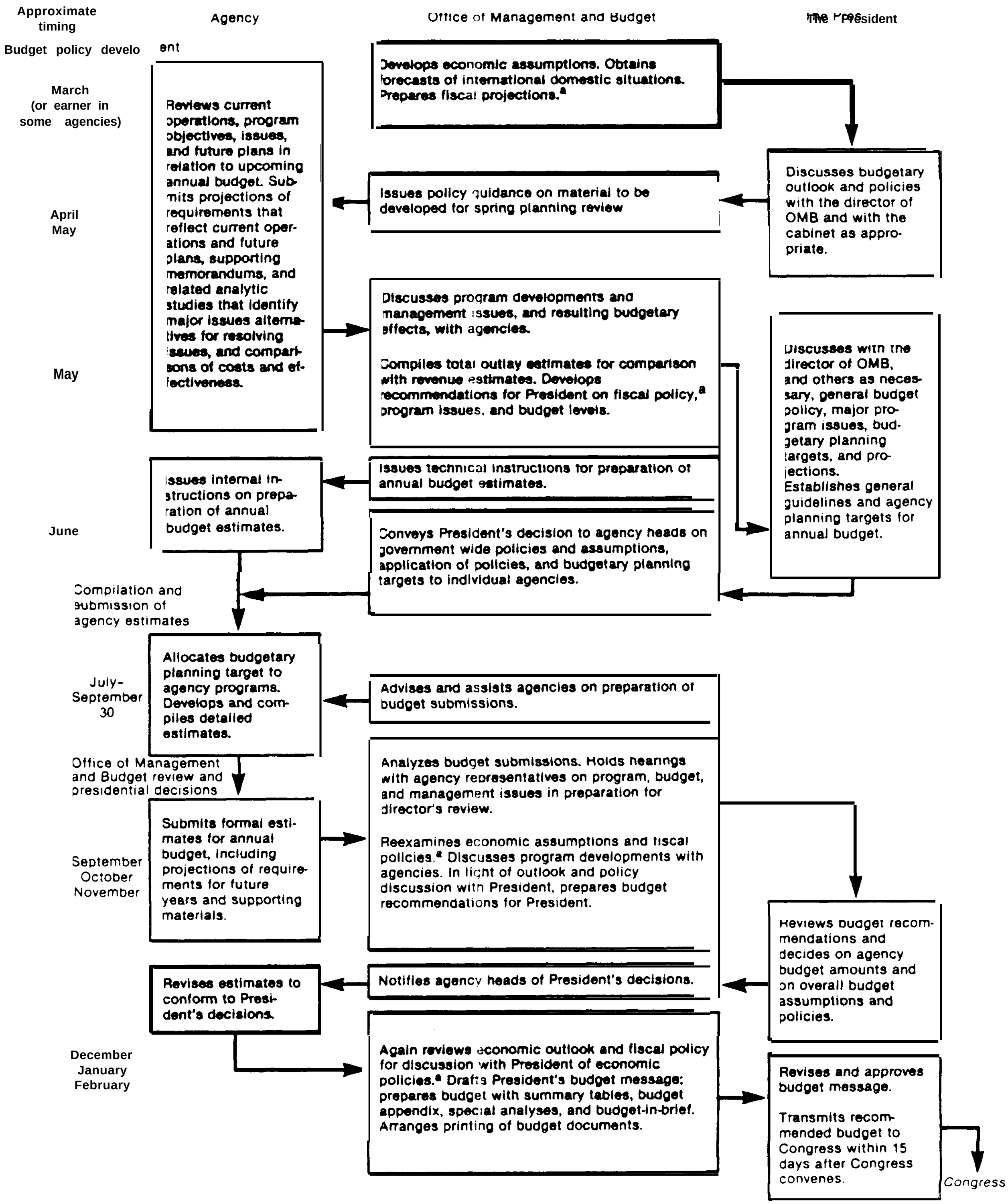
Most descriptions of the Federal budget process include schematic diagrams (see figures 3 and 4) that show the timetable for executive and legislative action. These outlines usually highlight the deadlines for agency budget estimates and the passage of resolutions. The truly significant characteristics of the budgetary process, however, are obscured by the arrows and dotted lines. The process is too complex to be characterized solely by a list of important dates. Outlines and diagrams do not explain how Congress, the Congressional Budget Office (CBO), the President, the Office of Management and Budget (OMB), and the executive agencies formulate recommendations for appropriations and budget outlays. No drawing can adequately represent the influence of the incremental method—the major method for calculating budgets at the Federal level.[3]

Incrementalism informs all aspects of decisionmaking in normal budget years. Last year’s budget is the single most important factor in determining this year’s budget, which is the single most important factor in determining this year’s author-

[2]William L. Morrow, *Public Administration: Politics, Policy and the Political System* (New York: Random House, 1980), p. 309.

[3]Aaron Wildavsky, *The Politics of the Budgetary Process* (Boston, MA: Little, Brown & Co,, 1984), p 13

Figure 3.—Formulation of the Pesident's Budget



[a]In cooperation with the Treasury Department and the Council of Economic Advisers.

SOURCE William L Morrow, *Public Administration: Politics, Policy and the Political system* (New York Random House. 1980), pp 27-28

Figure 4.—The Congressional Budget Process

Phase	Month	Actions	Related activities
Congressional action on spending bills	June		
	July	To extent practicable, CBO cost analyses and 5-year projections will accompany all reported public bills, except appropriation bills [sec. 403] Reports on new budget authority and tax expenditure bills must contain comparisons with first concurrent resolution and 5-year projections [sec. 308(a)] If a committee reports new entitlement legislation that exceeds appropriate allocation in latest concurrent resolution, it shall be referred to the appropriations committee with instructions to report its recommendations within 15 days [sec. 401(b)(2)]	CBO issues periodic scorekeeping reports comparing congressional action with first concurrent resolution [sec. 308(b)]
	August		Budget committees prepare second concurrent resolution and report
Adoption of second concurrent resolution and reconciliation	September	Seventh day after Labor Day: Congress completes action on all budget and spending authority bills [sec. 309] 15: Congress completes action on second concurrent resolution [sec. 301(a), (b)] *Thereafter, neither house may consider any bill, amendment, or conference report that would result in an increase over budget outlay or authority figures or a reduction in revenue level adopted in second concurrent resolution* [sec. 311(a)] 25: Congress completes action on reconciliation bill or resolution [sec. 310(c)–(e)] *Congress may not adjourn until it completes action on second concurrent resolution—and reconciliation, if any* [sec. 310(f)]	
	October	Fiscal year begins	

SOURCE; William L. Morrow, *Public Administration: Politics, Policy and the Political System* (New York: Random House, 1980), pp 40, 43

Phase	Month	Actions	Related activities
Information gathering, analysis, and preparation of first concurrent resolution	October	1: Fiscal year begins [sec. 501]	
	November	10: President submits current services budget [sec. 605(a)]	CBO five-year projections (as soon as possible after October 1) [sec. 308(c)]
	December	31: Joint Economic Committee reports analysis of current services budget to budget committees [sec. 605(b)]	
	January	Approximately last week of month: President submits budget (15 days after Congress convenes) [sec. 601]	
	February		
	March	15: All committees and joint committees submit estimates and views to budget committees [sec. 301(c)] Legislation providing contract or borrowing authority must be made subject to amounts provided in appropriation acts [sec. 401(a)]	Budget committees hold hearings; begin work on first concurrent resolution [sec. 301(d)]
Adoption of first concurrent resolution	April	1: CBO report to budget committees [sec. 202(f)] 1-15: Budget committees report first concurrent resolution (on or before April 15) [sec. 301(d)]	House and Senate consider first concurrent resolution [sec. 305] Conference action and adoption of conference report [sec. 305] Conference report accompanied by joint explanatory statement, which allocates total levels of budget authority and outlays among committees [sec. 302(b)] Before adoption of concurrent resolution, neither house may consider new budget authority or spending authority bills, revenue changes, or debt limit changes (some exceptions, and waiver procedure) [sec. 303(a)-(c)] Before reporting first regular appropriation bill, House Appropriations Committee, to extent practicable, marks up all regular appropriation bills and submits to House summary report comparing proposed outlays and budget authority levels with first concurrent resolution [sec. 307] After adoption of first concurrent resolution, each committee subdivides its allocation among its subcommittees, and promptly reports such subdivisions to its house [sec. 302(b)]
	May	Congress—until seventh day after Labor Day—enacts appropriations and spending bills 15: Congress completes action on first concurrent resolution [sec. 301(a)] 15: Deadline for committees to report authorization bills (some exceptions, and waiver procedure) [sec. 402(a)–(e)]	

SOURCE: House Budget Committee Section numbers are from the Congressional Budget and Impoundment Control Act of 1974

The number of actors involved in the setting of an agency budget is enormous. The three tracks of the budgetary process—authorization, appropriation, and reconciliation-each focus on different dimensions of the agency budget, and each yields its own version. Disparity may occur between the three versions within one Chamber of Congress, as well as between the House and Senate versions. Throughout the congressional budget process, industrial research organizations, scientists, and scientific and professional societies, whose members benefit from research funds, lobby Congress to support increased funding for those programs.

The Federal budget process, while susceptible to confusion and manipulation, is a legitimate attempt to foster some kind of consensus between legislative and administrative budget actors and between competing national policies. In addition, the budget process has become a multi-purpose vehicle for political and policy statements that are not necessarily related to the agency's mission directly. The process is a cobweb of interaction rather than a linear progression from investment to output.

PROJECT SELECTION

Once an agency receives its budget, project selection procedures and styles differ between agencies. In National Science Foundation (NSF) and National Institutes of Health (NIH) investigator-initiated basic research grant programs, the ideas for new projects come largely from the scientific community through the grant application process, consensus conferences, and workshops. The National Science Board and the study sections of NSF, along with the Advisory Councils of the 11 National Institutes of Health, provide additional overall guidance on agency and program direction. There is a high degree of confidence in the peer review process at these agencies and in the scientific community. Questions about the perils of peer review persist but there have been no proposals for change convincing enough to overhaul the system. Until a reliable replacement is found, qualitative, judgmental approaches will dominate in the selection of basic research approaches.

This qualitative approach to project selection has been standard in many agencies since Vannevar Bush recommended it in his 1945 report, The *Endless Frontier.* [7] The first R&D agency to truly implement the concept of peer review as the method for investing in basic research was the Office of Naval Research (ONR), a research agency of the Department of Defense (DOD). ONR uses a peer review process that relies on both in-house and external review, The old ONR model of separating the mission of basic science from the practical mission of the agency provided the model for peer review at NSF.

In comparison, mission-oriented programs in agencies such as DOD, the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), the U.S. Department of Agricultural, EPA, and agencies with a relatively smaller R&D function, such as the Department of the Interior, the Department of Commerce, the Nuclear Regulatory Commission (NRC), and the Veterans Administration, contract for applied research in support of their technology development or industry support activities, They tend to receive ideas for new projects from a wide variety of sources: industry, Congress, their own program staffs, the national laboratories, and the scientific community. Regardless of the source of a new idea, agency staff will usually conduct a feasibility study to determine whether the new concept is likely to meet cost, performance, and user-acceptability criteria. If the results of the study are promising, the program manager will propose the project as a line item in the new fiscal year budget. The administrative officer in charge of the program area (often an assistant secretary), the head of the agency, the examiners at OMB, and (if it represents a sizable fraction of the program

"Vannevar Bush, *Science–The Endless Frontier* a report to the President on a Program for Postwar Scientific Research (Washington, DC: National Science Foundation, 19801 (reprinted from Office of Scientific Research and Development, 1945).

izations and appropriations. Many items in the budget are simply reenacted every year unless there is a special reason to challenge them. In addition, long-range commitments have often been made and the current year's share for previous commitments must be taken out of the total and included as part of the annual budget.[4] These commitments preclude comprehensive assessments of any agency's budget. Thus, actors in the budget process are concerned with relatively small increments to an existing base. Their attention is focused on a small number of often politically controversial items over which the budget battle is fought. Understanding the nature of these battles is crucial to comprehending the entire process.

The inherently incremental nature of the budgetary process precludes in-depth, systematic reviews of programs and agencies. In the past 20 years, two major attempts have been made to infuse some "rationality" into the process, to "change the rules of the game." In 1965, President Johnson announced the implementation of the Planning, Programming, and Budgeting System (PPB) at the Federal level. PPB provided decisionmakers with data from systems analysis, cost-benefit analysis, program budgeting, and cost-effectiveness studies to support decisions about alternative courses of action. However, all of the data generated did not enable policymakers to establish priorities in a more systematic fashion; the program failed to account for the political nature of the budgeting process:

> PPB . . . could determine, within a reasonable margin of error, what the results would be if money was spent for x instead of y. It could also project how much of x and how much of y could be purchased or developed for a specified amount of money. What it could not do was to determine whether it was best to allocate funds for either program x or y.[5]

PPB failed because it set out to tackle an impossible task: the goal of its supporters was to "objectively determine what is inherently ideal, rational, and moral in public policy."[6]

In 1974, Congress enacted the Congressional Budget and Impoundment Act of 1974 (Public Law 93-344) to provide more focus on the "big picture" of the Federal budget. The two standing budget committee and CBO determine the appropriate levels of revenues and public debt for each fiscal year and the subsequent level of total budget outlays and authority. This attempt at budget reconciliation has not affected the incremental nature of preparing separate agency budgets or appropriations bills.

President Carter offered another plan to free the budgetary process from the constraints of incrementalism. He introduced the concept of zero-based budgeting (ZBB). Although its application is a complicated process, its basic purposes and procedures are relatively simple to comprehend. Agencies are directed to bracket their programs into "decision units." Each of these units is assigned a priority status— i.e., the degree to which it is essential to each agency's operations. A minimum expenditure base is supposed to be established by the agencies to represent "essential" program obligations that, therefore, are safe from budget cuts. Theoretically, this is the zero base, with all unnecessary expenditures eliminated. In practice, the base was often much higher than zero. Agencies had a vested interest in protecting certain programs. By increasing the level of the base, the agencies effectively decreased ZBBs effectiveness in evaluating programs. This new, arbitrarily established base only served to increase the budget officials' dependence on the incremental method. Less than 2 years after it was introduced, ZBB was abandoned by all Federal agencies, with the exception of the Environmental Protection Agency (EPA), which still employs this method today.

Incrementalism in the budgetary process is only one difficulty encountered in attempting systematic review of research agency programs. Comprehensive review of Federal R&D efforts is further complicated by the fact that the Federal Government does not have a separate R&D budget. Federal funding for R&D is the sum of those program requests submitted by individual agencies to OMB, subsequently by the President to Congress, and approved, rejected, or altered during the budget review and appropriation process.

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[4] Ibid.
[5] Morrow, op. cit., p. 309
[6] Ibid., p. 310.

budget) the staffs of the authorizing and appropriating committees in Congress will review the proposal. The project selection process is complete only after a project has been formally included in a congressionally approved budget.

Within DOD, the Defense Advanced Research Projects Agency (DARPA) uses no formal system of peer review for project selection, but relies on the management of contractors by DARPA program managers. Occasionally, the Defense Science Board examines an area of research supported by DARPA in order to make recommendations for future action.[8]

DOE supports R&D carried out through its own laboratories and by contracting with universities and industry. Research is evaluated for funding through the use of peer review, programmatic technical review, and programmatic management review.

NASA relies heavily on internal and external advisory committees for planning future missions, assigning priorities among them, and selecting specific experiments. The NASA Office of Aeronautics and Space Technology research programs select projects by collaborative-review by a network of both researchers and users of research results.[9]

Whether project selection is conducted by peers or agency management, the traditional criteria for selection are based on qualitative judgments. Like industry, government seldom uses quantitative project selection models. A 1974 review of the use of quantitative methods for project selection in government agencies revealed that they were used very little except in a few decisions involving large development projects. Recent surveys reveal no evidence that the patterns and extent of use of quantitative techniques to evaluate proposed research in the Federal Government are undergoing any significant change. *O Recent DOE surveys reached similar conclusions.[11]

J. David Roessner's[12] limited study of the use of R&D project selection models in DOE offers insight into the different ways models can be used in Federal agencies and reveals some of their limitations. He reports that the most extensive use of such models took place in DOE's energy conservation programs. Program managers at the Energy Research and Development Administration and later at DOE were under unusual pressure to justify public expenditures for energy conservation. At the same time, the conservation program was confronted with mountains of proposals that had to be screened and acted on in some systematic, defensible fashion. The models helped screen projects and select those most likely to pay off. They were also used to justify the program to Congress, where models received considerable attention. Congress cared less about the project-by-Project scores *than about the* aggregate benefit . scores *achieved by all projects funded by a program*. Quantitative estimates of oil displacement and energy savings generated by the models proved extremely useful in defending expenditures for R&D programs. One successful model compared cost-benefit ratios at the program level based on oil savings with and without Federal expenditures. These models evolved gradually and were applied over several years to project screening and budget decisions. DOE usually used the models with applied research programs, in which the links to commercial applications were apparent.[13]

The Department of Energy's use of cost-benefit analysis for its conservation program is not representative, The connection between technical improvements and economic benefits in energy equipment is much more straightforward than for other technological advances, making a predictive model somewhat useful. Also, economic benefits were the primary goal of the program. Such conditions are rare in Federal research programs, and it is instructive that even DOE has limited its use to a few applied research programs.

'J.M. Logsdon and C.B. Rubin, ***Federal Research Evacuation Activities*** **(Cambridge,** MA: **Abt Associates,** 1985), p. ***14.***

'Ibid., p. 17.

[10]H. Lambright and H. Sterling, ***National Laboratories and Research Evaluation*** (Cambridge, MA: Abt Associates, 1985).

"K. G. Feller, *A* Review *of* Methods *for Evacuating R&D* (Livermore, CA. Lawrence Livermore Laboratory, **1980); and J. David** Roessner, *R&D Project Selection Models in the U.S. Department of Energy* (Atlanta, GA: Georgia Institute of Technology, 1981),

''Roessner, op. cit.

'Ibid., pp. IV-1, 2; V-2.

RESEARCH PROGRAM EVALUATION

Quantitative methods are only occasionally used in evaluating the productivity and relevance of existing programs. A number of agencies are experimenting with quantitative techniques, but few have adopted them for use in systematic evaluation of research programs. Several recent surveys of research managers in the agencies and national laboratories found little evidence of quantitative techniques in research evaluation.

NIH is the only agency consistently using quantitative evaluation methods for accountability and program planning. Its bibliometrics analysis effort is described in chapter 3. The Alcohol, Drug Abuse, and Mental Health Administration is planning to use bibliometric approaches in evaluating research programs in the future. For other agencies and other techniques, we find a history of disappointment.

The National Bureau of Standards (NBS), for example, made an abortive attempt to measure the economic impact of individual projects in the Semiconductor Technology Program. NBS asked firms that subscribed to a program publication to estimate the benefits of each project to the firm and the costs of implementing technical information received from NBS. Agency analysts then compared the social costs with the estimated social benefits. They also used a production function to measure the productivity of the entire program. The objective was to estimate the changes in a firm's productivity attributable to changes in the stock of R&D capital generated by NBS. NBS staff reports that these studies were discontinued because of serious theoretical and methodological problems. [14] NASA's macroeconomic and macroeconomic approaches to measuring the effects of its R&D programs (see ch. 2) also met with serious criticism, and NASA discontinued its efforts. [15]

The Department of Energy employed an elaborate, quantitative evaluation scheme based on peer review to evaluate its Basic Energy Science Program in the early 1980s. Forty small review panels used a formal rating sheet to evaluate 129 randomly selected projects on publications produced, personnel achievements, and project summary descriptions. Panel members rated projects for researcher quality, scientific merit, scientific approach, and productivity. The evaluators compared the results with the scores of comparably funded, nonlaboratory projects also rated by the panels. DOE has not applied this expensive and time-consuming evaluation method to other programs, but the ONR has adopted some aspects of the technique. [16]

In 1982, a National Academy of Sciences panel conducted a study for NSF of approaches to evaluating basic research. They concluded that, beyond peer review, "any additional evaluation procedures should be introduced only if they clearly enhance rather than constrict the environment in which the research proceeds, and that formal techniques cannot usefully replace informed technical judgment." [17] A 1984 survey of 41 research managers in 11 Federal agencies found that nonquantitative methods dominated evaluation:

> Some form of peer review was used by almost every Federal agency, both for selecting individual or team research projects and for exercising managerial control over them. Peer review is also the major way that agencies build a case to demonstrate the value of research they support. [18]

No Federal agency "has in place a research evaluation system which appears to move substantially beyond the organized use of "informed technical judgment." [19]

A review of national laboratory evaluation techniques uncovers a similar picture. [20] Most evaluations of laboratory research are relatively unstructured and do not assume major importance among laboratory activities. [21] The complexity of

[14] Logsdon and Rubin, op. cit., p. 34.

[15] Ibid., p. 15; and Henry R. Hertzfeld, "Measuring the Economic Impact of Federal Research and Development Investments in Civilian Space Activities," paper presented to the National Academy of Science Workshop on "the Federal Roie in Research and Development," Nov. 21-22, 1985, pp. 9-12 and 16-21,

[16] Logsdon and Rubin, op. cit., pp. 26-28: and Lambright and Stirling, op. cit., p. 28.

[17] Logsdon and Rubin, op. cit., p, 38,

[18] Ibid., p. 25.

[19] Ibid., p. 38.

[20] Lambright and Stirling, op. cit.

[21] Ibid.

lab roles, which include research performance, research management, and entrepreneurship, precludes most formal, quantitative evaluation techniques.[22] some laboratories occasionally use structured peer review and bibliometric techniques, often performed by outside contractors, but lab managers view these as "supplements to the less structured evaluations, rather than substitutions."[23]

Although economic models for R&D performance came into use in the 1950s, government research managers have not adopted them for program evaluation. This reflects the nature of research manager concerns as well as the accuracy of the models. Research managers are responsible primarily for the quality of research in their programs, and economic payoff does not necessarily reflect the quality of research. A breakthrough in basic or applied government research does not guarantee an economic benefit. No economic effect will occur unless a private company decides to incorporate the breakthrough in a product, and the success of that product depends on such factors as the availability of capital, effective product development, consumer interest, marketing skill, tax and regulatory environment, and competition. Research managers have no say in these other factors and no control over the commercial uses of the research they manage. They therefore limit their attention to what they can control—the quality of research.

Bibliometric methods offer a quantitative measure of research quality, but one not reliable enough to serve as the sole basis of research evaluation. These methods are, however, a useful supplement to informed technical judgment and the peer review process.

‘Ibid., p. 9.
‘Ibid., p. 10.

FORECASTING AND STRATEGIC PLANNING

The extent of agency use of strategic planning to identify promising future directions for civilian research is not known. DOE's Energy Research Advisory Board, NSF's National Science Board, and NIH's scientific advisory councils provide guidance that might pass for strategic planning. The NRC and its constituent bodies,—the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine—carry out numerous reviews of research programs and research fields for the executive and legislative branches. The most comprehensive of these are the *Research Briefings* and *Five Year Outlooks* prepared by the Committee on Science, Engineering and Public Policy. Since all NRC reports are prepared by committees of scientists, they represent, to some degree, the informed, consensus-based peer judgments of the scientific community on the state of the research enterprise. None of these, however, can be said to constitute true strategic planning or forecasting. For examples of more systematic forecasting and planning activities related to science and technology, one can look to Japan.

Planning for Innovation in Japan

The Japanese Science and Technology Agency (STA), established *by* the Japanese Government in 1956, has relied on strategic planning for its success in identifying technological innovations. In 1969, STA's responsibilities expanded to include funding research as well as coordinating research activities among the various government ministries and agencies. In addition, STA began to make technological forecasts. After the results of the first study were obtained, the agency realized these forecasts would be vital to the creation of rational, long-term research policies and made them a regular part of its operating procedures.

The forecast effort begins by identifying economic and social needs. Forecasters then survey research areas to identify potential scientific and technological developments that can meet these needs. They then establish priorities for various R&D plans. Each forecast is presented in two ways: one that is "exploratoy or predicative, relating to individuals' expectations of change given their accumulated knowledge and experience and another that is normative—that involves setting an objective and a time-scale within which it is to be achieved. "[24] The forecast is based on a survey of over 2,000 people from government, academia, and industry with a broad knowledge of several scientific and technological research areas, who not only answer questions but who also comment on their colleagues remarks.

Industrialists, academics, and government officials have cited four benefits from the survey process:

1. The studies provide a mechanism to ensure that researchers in all sectors, along with policymakers in government and industry, are periodically forced to think systematically about the long-term future.
2. The forecasts yield a general summary of what is happening, or likely to happen, across the entire range of R&D activities. They therefore permit more "holistic" vision-making, enabling the potential longer term cross-impacts of developments in ons research field on another to be identified at an early stage.
3. By surveying comprehensively the intentions and visions (and thus indirectly the current strategic R&D activity) of the industrial research community, the surveys provide a useful mechanism for synthesizing major research trends across science-based sectors. . . . It is the existence of such surveys that is in part responsible for the strong agreement among Japanese firms as to what are likely to be the critical future developments in their sector.
4. The STA forecasts provide a useful mechanism for helping government establish national priorities in allocating resources. Requirements for infrastructural support can be identified from the "bottom-up" by industry, rather than being imposed by state planners who may not always be in touch with industrial problems. Although such forecasts do not, in themselves, lead directly to policy decisions, the systematic information which they generate helps narrow down the range of different views that can be held on a particular R&D related issue, bringing eventual consensus that much closer. [25]

In addition to the STA, the Ministry of international Trade and Industry (MITI) and the Agency for Industrial Science and Technology (AIST) are responsible for providing funding and long-term guidance for applied research and development. Each MITI division, representing a major industrial sector, establishes a long-term plan, which is revised every 3 to 5 years. Officials from both the ministry and the agency try to incorporate these plans into MITI's vision of the future of Japanese industry. This vision serves as the basis for MITI and AIST's long-term R&D plan, which is also revised every 3 to 5 years. This plan enables the ministry to spot research trends early and *to* predict how new technologies might develop. These predictions, in turn, form the basis for an R&D policy that concentrates on initiating research programs in areas of strategic importance. Like STA's forecasts, MITI's visions are based on suggestions that come from the bottom up. Irvine and Martin stress that the myth of "Japan, Inc. " has arisen because foreign commentators have often overlooked this point:

> The process involved here is not one of centralized "top down" planning by MITI, which then imposes its objectives on industry and others (who do not question them), Instead, most influence tends to flow in precisely the opposite direction, with MITI's role largely confined to "tapping into" the views and firms where consensus lies. Only as a last resort are priorities imposed—for example, to give *one* industrial sector's agreed program precedence over another's.[26]

Before the government introduces a new policy members of an informal working group, which represents a major trade association, meet to discuss common long-range goals. These member: are employees of firms that continuously monitor R&D developments throughout the world They also have access to the company's interna forecasts of technological innovations. The in formed comments of these members are used by consulting groups when they design surveys of in

"John Irvine and Benjamin R. Martin, ***Foresight m Science: Picking the Winners*** (London: Frances Pinter, 1984), p. 108.

"lb[d., pp. 110-111.

"Ibid., p. 118.

dividual industrial sectors .27 The working groups' suggestions and the sectorwide surveys provide an essential link between STA's and MITI's macroforecasts and firms' internal forecasts for specific products .28 According to Martin and Irvine:

> From the point of view of industry, the sector forecasts, because they are much more specific than the macroforecasts, are much more valuable for planning corporate R&D strategy. Equally, the sector studies, based as they are on a synthesis of industrial views, constitute a key input into discussions within MITI and STA.[29]

MITI's role is to construct the broad framework within which a consensus on long-range R&D goals can be established; to catalyze the formation of consensus by sorting and publicizing the results within the relevant sectors; and to try to build a consensus among the various industrial sectors as to long-term R&D priorities.

Several lessons can be learned from MITI's consensus-generating approach to strategic research forecasting. First, forecasts that successfully identify research areas of long-term strategic importance are based on up-to-date background information on research trends gathered from industry, academic, and government reports from around the world. Second, the forecasts incorporate "technology-push" and "market-pull" perspectives because scientific and technological advances must be coupled with changing market demands for technological innovations to be successful. Third, there are a number of advantages that can be gained from adopting a bottom-up approach to forecasting rather than a centralized, "top-down" approach.

> Apart from being dependent on a narrow range of information inputs, "top-down" forecasts and the resultant research policies are more likely to antagonize not only the basic science community (which may feel that it has been inadequately consulted in the forecast process), but also industry (which naturally tends to feel that it is in the best position to judge the commercial prospects for strategic research). 'o

"Ibid,, p 301
'® Ibid., p 129
'Ibid., p. 128
'Ibid., p. 143

The last and perhaps most important lesson to be gained from the STA and MITI forecasts is that the process of generating the forecasts is much more important than the product—the specific results they yield. The process unites people from different groups and different professions within those groups and provides a framework within which they can "communicate directly or indirectly (through a Delphi-style forecast) with each other. "[31] Policymakers, professional forecasters, scientific analysts, and academic and industrial researchers are periodically forced to think about long-term R&D activities by the process. This enables them to coordinate research plans and to form a consensus on priorities for future strategic research. Furthermore, the process generates a feeling of commitment to the outcomes of the forecasting studies. Thus, the predictions become self-fulfilling prophecies. The Japanese contend that these five C's—communication, *concentration on the future, coordination, creation of consensus, and commitment—have* benefited their strategic planning efforts tremendously. Until now, these benefits have outweighed such disadvantages as forecasts' tendency to encourage conservativism and breed excessive competition. Martin and Irvine warn that this balance might be upset in the future "as the Japanese place increasing emphasis on more basic research (where creativity and unconventional approaches are clearly at a premium)."[32]

While other students of Japan warn against placing too much faith in the apparent tidiness and completeness of the framework building process, the importance of wide participation in goal-setting is apparent.

The centrally coordinated Japanese R&D system has served Japan well in applying basic research findings. Yet, pluralism in the U.S. R&D system encompasses several attributes. In testimony before the Task Force on Science Policy, Rodney Nichols of Rockefeller University states that the pluralism of the system "hedges against

'Ibid., p. 144.
"Ibid.

fluctuations in the fashions and policies influencing any lines of R&D support. ”[33]

A full-blown pluralistic system depends upon a high level of sustained R&D. It runs the risks of some redundancy when sponsors overlap their support—surely at the research end of the spectrum, where there are many, small projects underway through many sponsors. By doing so, it gains the long-run advantages of giving all missions a window on research.

Pluralism also protects against the inherent frailty, even occasional ignorance, of decisions by research managers. It aims, in principle, to strengthen the broad swath of R&D by being aware of how unpredictable are the origins of great ideas: and how unpredictable are the consequences of results that first seem mere curiosities. Thus, some funds go to all good ideas in order to ensure that the few seen later to be the best have had a chance.[34]

“Rodney W. Nichols, testimony presented before the U.S. House of Representatives, Committee on Science and Technology, Task Force on Science Policy, Oct. 23, 1985.

“Ibid, pp. 10-11.

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