Perspectives

The End of Research?

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The 1960s are frequently referred to as a "golden age" for science and technology (S&T) because of the tremendous growth in federal funding for research and development (R&D) (1). Few seem to be aware that over the past decade S&T has experienced a second golden age, at least as measured by federal funding, which has increased dramatically in recent years at a pace not seen since the 1960s. But this second golden age is now ending (2) and the consequences for science politics and policies are likely to be profound.

Understanding the implications of slowing growth or even a future decline in federal funding for R&D requires understanding federal funding on science and technology. A number of recent statements by prominent scientists and policy makers suggest confusion about trends in federal support for R&D, and that a primer now makes sense.

Examples of confusion include a July 15, 2004 statement by Shirley Ann Jackson, President of Rensselaer Polytechnic Institute and President of the American Association for the Advancement of Science (AAAS) that "The Federal investment in research, measured as a share of the Gross Domestic Product (GDP), has declined by almost two-thirds since the 1980s." (3) And presidential candidate John Kerry included in a June, 2004 white paper on science and technology an observation that "[G]overnment support for many key disciplines of science and engineering, particularly the physical sciences and engineering, has been declining." (4) The problem with both statements is that they are factually incorrect. Research as a fraction of GDP has not declined by two thirds and most areas of science and engineering are currently receiving more funds than ever before. If science policies are to be informed by on a comprehensive picture of trends in support for R&D, then it makes sense that those trends are well understood and interpreted.

This perspective describes the sources of data on federal funding for R&D, what is measured, what the data show, and some implications for science policy and politics.

Where does the data come from?
Because the United States does not allocate a lump sum for R&D activities of the federal government, Congress mandated that the National Science Foundation (NSF) "provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources and to provide a source of information for policy formulation by other agencies of the Federal Government." In addition, the AAAS (publisher of Science) and the Organization for Economic Cooperation and Development (OECD) also provide related estimates of United States R&D. Understanding federal funding for science and technology requires that budgets be compiled from the various budgets of agencies that support science and technology.

There are currently four different compilations of data: by OECD, AAAS, and two by the NSF Division of Science Resources Statistics. OECD's collection focuses on R&D in the public and private sectors and depends upon official government sources for its U.S. government estimates (5).

One set of NSF data focuses on tallying budget requests from agencies to the Office of Management and Budget (OMB) in the Executive Office of the President, which has responsibility each year for compiling the President's Budget. According to NSF the OMB compilation focuses on 23 agencies that are responsible for 99% of all federal research and development (6). NSF contracts to the AAAS to collect this data. The funding requested by agencies may or may not all be spent in a single year, but instead over several years. Hence, a measure of budget requests will lead to a different total than actual expenditures.

NSF oversees the collection of a second set of research and development funding data by contracting with a consulting firm to collect, via a survey, the research and development expenditures by 29 federal agencies and 73 of their subdivisions. (7) The NSF survey data focuses on the actual expenditure of funds, which may represent Congressional appropriations over more than a single year.

The AAAS compiles its own dataset based on data collected for NSF and focuses on "budget authority." To understand the differences between expenditures and authority, think of budget authority as placing funds into a checking account, while expenditure refers to the withdrawal of funds to make a payment. Finally, to understand trends in research funding over time requires that the data be adjusted for inflation, and economists recommend various adjustments to turn contemporary budget figures into a constant expression. Typically, data are adjusted using implicit price deflators (e.g., as found in table B-3 of the 2004 Economic Report of the President), but other measures are sometimes used (such as the Consumer Price Index).

What to measure?

Measuring R&D requires a definition of R&D activities. The NSF uses the following definition: "Research and Development activities 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 … and includes those funds for personnel, program supervision, and administrative support directly associated with R&D activities." (6) In practice, different agencies may define R&D differently, leading to some inconsistencies across the datasets. It is generally assumed that such errors are insignificant with respect to trends over time.

Of course, any taxonomy implies an underlying structure and the compilation of R&D data is no different. NSF describes research as "basic" or "applied" as follows: "In basic research, the objective of the sponsoring agency is to gain fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind. In applied research, the objective of the sponsoring agency is to gain knowledge or understanding necessary for determining means by which a recognized and specific need may be met." This taxonomy institutionalizes the "linear model" of science where basic research leads into applied research, to development, and then to societal benefits. Even though NSF admits and analysts have frequently demonstrated (e.g., 8) that the basic-applied distinction has little meaning in reality and fails to accurately characterize how research is actually related to societal benefits, it nonetheless continues to use the framework to describe R&D activities.

The basic-applied taxonomy leads to an additional complication in that Congress has granted only NSF and the National Aeronautics and Space Administration (NASA) a legislative mandate that includes conducting research for research sake. For all other agencies, research is an instrumental means for fulfilling the agency mission. Thus, “basic research” in an agency like Interior may be very different than “basic research” in NSF or NASA (9, 10).

Other taxonomies have been proposed, but none has replaced the basic-applied taxonomy. For example, in 1995 a committee of the National Research Council proposed a metric call “Federal Science and Technology” (FS&T) funding which to "generally favor academic institutions because of their flexibility and inherent quality control, and because they directly link research to education and training in science and engineering" (11). Perhaps predictably, scientists in government labs objected to the measure as creating a funding bias against non-university-based research (12).

What do the data show?

With the availability of several datasets, various adjustment methods, and alternative taxonomy, it might be understandable to see periodic confusion about federal funding for science and technology. Using the AAAS dataset for aggregate federal funding for R&D and data from the Congressional Budget Office on general government expenditures, there are several ways to present trends.

First are the aggregate numbers. Figure 1 shows aggregate funding for research and development in current and constant FY 2004 dollars from 1982-2005. The inflation-adjusted data show periods of increases and stasis, but no systematic, significant decreases. The most recent decade saw rapidly accelerating increases to record levels of funding.

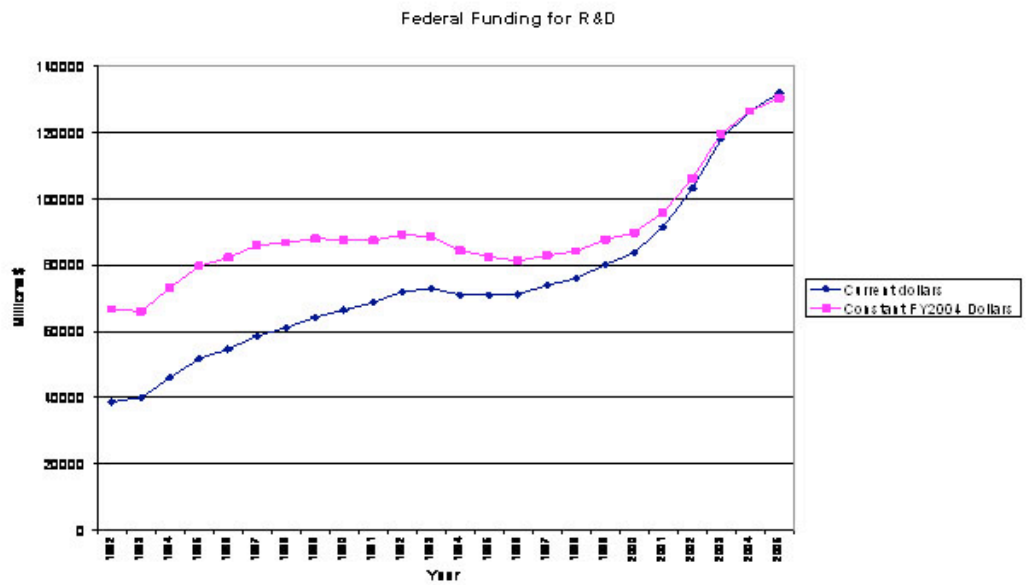

Figure 1. The second golden age: Federal funding for R&D 1982-2005, Source: AAAS, 2005 is an estimate.

Second are comparative measures of funding. For 1982-2005, Figure 2 shows several metrics. (A) Often cited is R&D funding as a percentage of U.S. Gross Domestic Product (13), which shows a decline by slightly more than a third to less than 1% of GDP. But this metric is misleading as GDP is not necessarily related to overall government spending or R&D funding. (B) A second curve shows United States government discretionary spending as a percentage of GDP, and shows a very similar trend.[i] Hence, the relative decline in the ratio of R&D funding to GDP has more to do with trends in GDP (i.e., rapid economic growth in the 1990s) and comparatively smaller increases in overall government expenditures than in any decisions about funding for R&D.

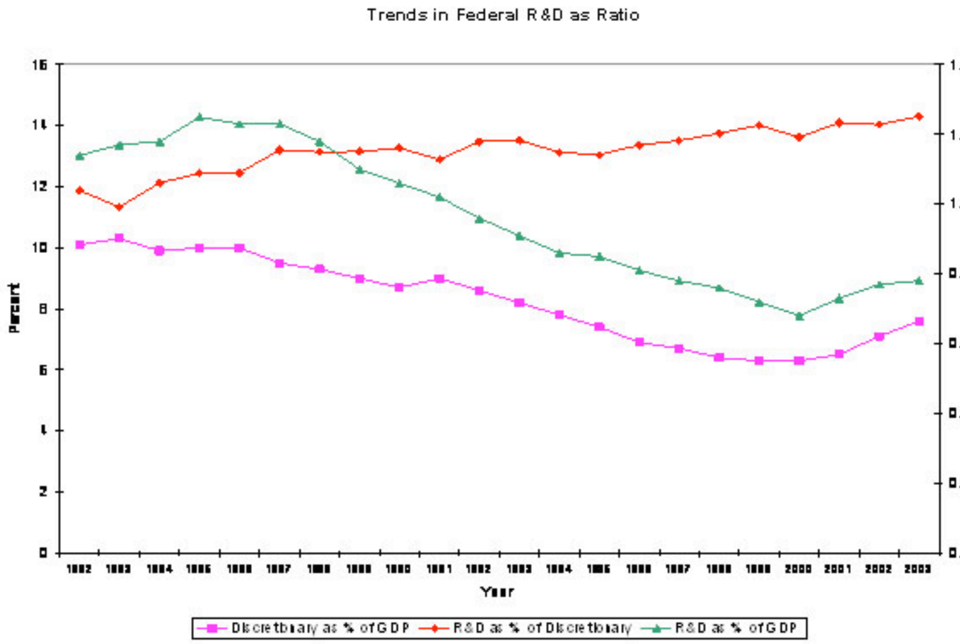

Figure 2. Trends in federal funding in comparison to GDP (right axis) and as portion of discretionary spending (left axis), Source: AAAS. Also shown is discretionary spending in comparison to GDP (left axis), Source: CBO.

A more meaningful metric is shown in the (C) third curve on the graph which shows that R&D funding as a fraction of discretionary spending has increased from 11.3% in 1982 to 14.3% in 2003. Today, R&D is responsible for as large a portion of discretionary expenditures than at any time in the past 22 years.

The data show that over the past decade science and technology have been in a second golden age.[ii] While the first golden age was led by increases in physics and engineering, the second golden age has been led by increases in health and security research. Federal government expenditures for research and development have increased dramatically over this period to record levels, and have represented an ever-growing share of discretionary government expenditures. The second golden age reflects both society's faith in science and technology as a source of societal benefits, but also the prowess of the science and technology community in the annual fray over finite government resources.

Science Politics and Science Policies

Of course, science policy should not be about simply "How much?" but "Why?" (14). However, the S&T community typically focuses narrowly on "how much?" using a three-part strategy to argue for more public sector resources.[iii] It claims crisis, even in times of plenty (15). It calls for balance, to limit intra-disciplinary, intra-agency debates over priorities (10). And it claims that societal benefits are proportional to funds invested; more funds are equated with more benefit (16). Current debate over federal funding for R&D remains far from James Sensennbrener's (R-PA, former Chair of House Science Committee) desire that "[Science and technology] funding should be driven by policy and not the other way around." (17)

A focus on aggregate funding, rather than the marginal benefits of adding or cutting funding for particular programs, may prove problematic as R&D funding all but certainly cannot continue to grow at the pace that it has over the past decade, regardless of who occupies the White House, making tough choices within the scientific community inevitable (2).

Consider the following, perhaps representative situation. In July, 2004 NASA decided to steer a research satellite from earth orbit into the ocean upon completion of its mission. Scientists and some weather forecasters appealed to Congress to overturn NASA's plans for a controlled reentry of the Tropical Rainfall Measurement Mission (TRMM) arguing that the benefits of the satellite's data to weather forecasters far exceed the risks of an uncontrolled reentry resulting from using the mission's remaining fuel to extend TRMM's on-orbit research mission. The decision was important not only because of the risks involved but because the decision has financial consequences for NASA, its TRMM follow on mission, and scientific research related to TRMM.

Ideally, decision makers in NASA and Congress would have had a clear understanding of the costs and benefits associated with its available decision options in order to inform their actions. But as it turned out, information is lacking on costs of TRMM, the benefits of TRMM data, and the risks of reentry (18). The lack of information means that recent decisions about the future of TRMM were based almost completely upon anecdotal information and political sway among participants. TRMM's extension through 2004 was determined via science politics, not science policy.

The TRMM situation reflects the consequences of the S&T community's historical predilection for failing to systematically evaluate the relative costs and benefits of marginal investments in a particular project or area—focusing instead on aggregate measures of federal R&D support (1). However, after a decade of record increases it seems unlikely that claims of crisis, balance, or proportional benefit will avoid intra-S&T conflicts resulting from stagnant budgets. If the extended period of increases in overall funding for S&T is indeed ending (2), then a continued focus on the forests, rather than the trees, does not appear sustainable.

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[i]Data from the Congressional Budget Offfice, http://www.cbo.gov
[ii]For many scientists the recent decade may not *feel* like a golden age, simply because the number of researchers competing for federal funds far exceeds that ratio in the 1960s (14).
[iii]Private sector support for R&D has increased dramatically since the 1960s (1, 5).

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The views expressed in this Perspective are those of the author.

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(4) http://www.johnkerry.com/pdf/pr_2004_0624b.pdf

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