

APPENDIX A
TECHNICAL NOTES

DEFINITIONS OF R&D AND ITS COMPONENTS

Research and development (R&D is defined as “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” (Organization for Economic Co-operation and Development 2002b, p. 30).

CHARACTER OF WORK

Total R&D comprises *basic research*, *applied research*, and *development*, defined as follows:

- **Basic research.** In the Federal, university, and nonprofit sectors, basic research is defined as research directed toward increases in the knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific application toward processes or products in mind. In the industrial sector, basic research is defined as “original investigations for the advancement of scientific knowledge . . . which do not have specific commercial objectives, although they may be in fields of present or potential interest to the reporting company.”
- **Applied research.** In the Federal, university, and nonprofit sectors, applied research is defined as research directed toward gaining the “knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.” The definition of applied research is modified for the industrial sector to include “research projects which represent investigations directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either products or processes.”
- **Development.** The National Science Foundation (NSF) survey definition of development is “the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes.” It excludes quality control, routine product testing, and production.

FIELDS OF SCIENCE AND ENGINEERING

By definition, *R&D expenditures* consist of basic and applied research in the sciences (including medical sciences) and engineering as well as activities in development. The fields of study that are included depend, in part, on the economic sector that performs the R&D work. In particular, the Federal, university, and nonprofit sectors include data for the broad fields of physical sciences, environmental sciences, mathematical sciences, computer sciences, life sciences, psychology, social sciences, engineering, and an all inclusive “other sciences” category. Industry coverage is limited to the physical sciences, including related engineering and computer science R&D, and the biological sciences, including medicine but excluding psychology. Industrial R&D specifically excludes research in the social sciences.

SECTORS OF THE ECONOMY

Research and development is not limited to one sector of the economy. Presenting a national picture of R&D activity requires analyzing data from several sectors of the economy. The primary sectors analyzed in the *National Patterns of Research and Development Resources 2003* are the following:

- **Federal Government.** This sector consists of the agencies of the Federal Government.
- **Industry.** This sector consists of both manufacturing and nonmanufacturing companies. Manufacturing companies are reported by major industry groupings. Nonmanufacturing companies include those in mining, construction, transportation, communications, and selected service industries such as R&D laboratories and computer and data processing services. Industry’s funding of industrial R&D includes all funds received from non-Federal sources (e.g., state and local governments).
- **Universities and colleges.** This sector consists of all institutions of higher education, both public and private. University funding of university R&D includes restricted or general funds that the institutions themselves have been free to allocate for research. Funds from the Federal Government,

industry, state governments, or other nonprofit institutions, which are supplied in the form of grants or contracts for R&D at a university, are credited to the appropriate source. For example, research contracts from industry are treated as university performance funded by industry. Funds given to the institution by industry for general educational purposes and used by the school—at its discretion—for research are treated as university performance financed with the university's own funds.

- **Other nonprofit institutions.** This sector consists of institutions that fall into two general categories: (1) organizations that are primarily granting in nature (i.e., private philanthropic foundations and voluntary health agencies) and (2) public and private organizations involved in performing R&D, such as research hospitals.
- **Federally funded research and development centers.** As the name suggests, federally funded research and development centers (FFRDCs) are organizations exclusively or substantially financed by the Federal Government to meet a particular R&D need or to provide major facilities for research and associated training purposes. Each center is administered by an industrial firm (industry FFRDC); an individual university or college or a university consortium (university FFRDC); or a nonprofit institution (nonprofit FFRDC).

U.S. R&D expenditures are often categorized according to the following concepts: (1) the economic sector in which the R&D work is actually performed, or the *performer*, for short; and (2) the sector from which funding for R&D originated, or the *source* (of funding), for short. Thus the source is where the money for R&D comes from, whereas the performer is where the money is actually last spent in the process of conducting R&D. Seven R&D-performing sectors are examined in the analysis of U.S. R&D: private industry, universities and colleges, Federal agencies, nonprofit institutions, industry FFRDCs, university FFRDCs, and nonprofit FFRDCs. Five R&D-funding sectors are included in the analysis of U.S. R&D: private industry, the Federal Government, universities and colleges, nonprofit institutions, and state and local governments. Separate data on R&D funding by state and local governments (or non-Federal government) are only available for the R&D performed by universities and colleges. Although state and local governments do perform R&D, the amount

is small relative to the other sectors and has not been consistently tracked over time.

DEFENSE/SPACE/CIVILIAN CLASSIFICATIONS

This report contains data on the estimated percentage distribution of total U.S. R&D performance by national objective and the reported distribution of Federal R&D authority by budget function. The performer-based U.S. shares differ from the Federal budget authority shares for several reasons. The U.S. shares are based on expenditures reported by performers, which often spend Federal R&D funds in a year other than the one in which the Federal Government provided authorization, obligations, or outlays. In addition, the two series are based on different concepts. For example, whereas in the U.S. series all of the National Aeronautics and Space Administration's (NASA's) R&D funds are considered expenditures for space R&D, the budget authority data are distributed according to the functional categories that constitute the Federal budget. Thus, NASA's R&D budget authorizations are distributed between the space research and technology function and the transportation function.

Defense R&D consists of R&D spending by the Department of Defense (DOD), defense-related atomic energy programs of the Department of Energy, and more recently some of the R&D performed under the aegis of Homeland Security. All DOD activities are classified as defense, although some activities have secondary objectives (for example, space). *Space R&D* consists of R&D spending by NASA. All industry-funded R&D, including expenditures by aerospace and electronic industries, is classified as *civilian R&D*.

CURRENT OPERATING COSTS

Funds used for R&D refer to *current operating costs*. These costs consist of both direct and indirect costs. They include salaries as well as fringe benefits, materials, supplies, and overhead. The R&D costs include depreciation, insofar as this information is available to respondents. Capital expenditures are excluded by definition in the surveys of the industrial and academic sectors. Under the accounting practices of some Federal agencies, obligations for capital items may be included.

For universities and colleges, R&D data are for separately budgeted expenditures only. Consequently, these data exclude that portion of salaries for research

time or other research expenses financed by funds not specifically earmarked for R&D from state and local governments and other non-Federal sources, including endowments.

CONTROLLING FOR INFLATION AND FOREIGN CURRENCY

In the tables and figures in this report, the term *current dollars* refers to dollar amounts measured and exchanged in the actual year, or years, in question. In contrast, *constant dollars* refers to dollar amounts normalized for inflation. For example, if the same dollar amount is reported for two different years and expressed in current dollars, then fewer actual goods and services could be purchased with that amount in the most recent year than in the earlier year, because of inflation. If the same amount is expressed in constant dollars, then it would be normalized for inflation in both years and, consequently, the same purchasing power would exist in each of the two years. Terms that are equivalent in meaning to *current* and *constant* dollars are, respectively, *nominal* and *real* dollars. These terms are also used to describe changes in dollar amounts over time. For instance, suppose a particular type of expenditure, when expressed in constant dollars, grew at a rate of 5 percent per year over a 10-year period. Such growth may be described as 5 percent growth *in real terms*, or equivalently, *real growth* of 5 percent, meaning the constant-dollar amounts grew at a 5 percent rate, whereas the current dollar amounts grew at a greater rate due to inflation.

In keeping with U.S. government and international standards, R&D trend data usually are deflated to 1996 constant dollars using the gross domestic product (GDP) implicit price deflator. (See appendix table B-9.) Because GDP deflators are calculated on an economy-wide rather than R&D-specific basis, their use more accurately reflects an “opportunity cost” criterion rather than a measure of cost changes in doing research. That is, the GDP deflator, when applied to R&D expenditure or funding data, reflects the value of R&D in terms of the amount of other goods and services that could have been purchased with the same amount of money. The constant dollar figures reported here thus should be interpreted as real resources forgone in engaging in R&D rather than in other activities such as consumption or physical investment.

Comparisons in this report of U.S. and international R&D expenditure data are based on reported R&D investments converted to U.S. dollars using *purchasing power parity* (PPP) exchange rates. PPP exchange rates are designed to reflect differences in the purchasing power of currencies, based on the quantity of currency needed to purchase equivalent quantities of actual goods and services in the countries in question. See sidebar, “Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data.”

NOTES ON DATA SOURCES

FEDERAL GOVERNMENT

Federal agency R&D obligations for *intramural performance* are treated as the equivalent of R&D expenditures in the *National Patterns* series. Intramural R&D performance by Federal agencies refers to work carried out directly by agency personnel. Federal obligations reported in this category are for activities performed by the reporting agency itself or represent funds that the agency transfers to another Federal agency for performance of work, as long as the ultimate performer is that agency or any other Federal agency.

As detailed in the *Federal Funds for Research and Development* series (hereafter, *Federal Funds*), R&D obligations for *intramural activities* cover costs associated not only with actual intramural R&D performance but also with the planning and administration by Federal personnel of intramural and extramural R&D programs [see NSF, Division of Science Resources Statistics (2002a)]. Intramural activities also include the costs of supplies and equipment that are procured for use in intramural R&D. For example, the purchase of saline solution that is used for intramural performance of R&D is reported as a part of the cost of intramural R&D.

In general, the universe of Federal agencies with R&D programs has been surveyed annually since 1953 for R&D performance and since 1963 for the distribution of R&D by character of work on the Survey of Federal Funds for Research and Development.

INDUSTRY

In general, the industrial sector has been surveyed annually since 1953 for its total R&D performance and since 1956 for the distribution by character of work. The

U.S. Bureau of the Census conducts the Survey of Research and Development in Industry for NSF. The target population of the survey is companies, whether U.S. or foreign-owned, that perform R&D in the United States and have more than five employees.

For the 2001 industrial R&D data (the most recent data incorporated into this report), the sample frame constructed for the survey included approximately 2 million companies. Of these, 3,010 known R&D-performing companies were surveyed and 21,956 other companies were selected for the sample.

Nonmanufacturing R&D. The enormous growth in nonmanufacturing industries is common knowledge. It should be noted, however, that some of this growth is the result of the methodology used to classify companies into industries as opposed to actual increases in nonmanufacturing R&D activity. (See the discussion of nonmanufacturing R&D in the main text and the sidebar, “Redistributing Trade R&D.”)

Character-of-Work Revisions. Recent data quality reviews revealed that some companies were misreporting their R&D as 100 percent basic research. Followup calls confirmed that these cases were almost entirely the result of respondent error. To correct the aggregate character-of-work estimates, the R&D expenditures reported by these companies were reallocated for years 1998 through 2001. This resulted in a decrease in industrial R&D characterized as basic research for 1998 and subsequent years.

UNIVERSITIES AND COLLEGES

R&D data for the academic sector are derived from NSF’s Survey of Research and Development Expenditures at Universities and Colleges. For the fiscal year (FY) 2002 survey cycle (the latest data included in this report), a total of 626 institutions were included in this survey. These institutions have doctoral programs in science and engineering (S&E), are historically black colleges or universities that expend any amount of separately budgeted R&D in S&E, or are master’s or bachelor’s degree-granting institutions that expend at least \$150,000 in separately budgeted R&D in S&E.

Recently, corrections from large respondents and a revised imputation procedure for academic basic research have resulted in a break in the data series beginning in FY 1998. The corrections and the revised imputation

procedure resulted in a net increase for academic R&D classified as basic research.⁴⁴

OTHER NONPROFIT INSTITUTIONS

The R&D activities of other nonprofit institutions have not been surveyed with the same frequency as other sectors. The most recent data used in this report are from NSF’s Survey of Research and Development Funding and Performance by Nonprofit Organizations, Fiscal Years 1996 and 1997. Organizations covered by the survey included research institutes; university-affiliated hospitals; other voluntary nonprofit hospitals; professional and technical societies and academies of science and engineering; private foundations; science exhibitors; and trade associations, industrial consortia, and academic consortia.

Prior to this survey, the last R&D survey of nonprofit organizations collected data for 1973. Because of the paucity of data for the nonprofit sector, many of the figures for this sector presented in this report are NSF estimates.

FFRDCs

Beginning with FY 2001, R&D data for all 36 FFRDCs are collected as part of the Survey of Academic Research and Development Expenditures. Prior to FY 2001, R&D data for industry-administered FFRDCs were derived from the *R&D in Industry* report and data reported in the *Federal Funds* series were used for nonprofit-administered FFRDCs.

DATA ANALYSIS

PRELIMINARY DATA AND PROJECTION

PROCEDURES FOR 2002 AND 2003

Preliminary R&D performance totals in *National Patterns* are calculated for each sector, by character of work and by source of funds from surveys and time-series extrapolation techniques, as follows:

- **Federal Government.** Projections for 2002 and 2003 are based on changes in intramural R&D obligations reported in *Federal Funds*. Data for 2003 are projections based in part on changes in intramural R&D represented in administration 2004 budget proposals.

⁴⁴For more information, see M. Machen and B. Shackelford, *Academic R&D Spending Maintains Growth From All Major Sources in FY 2001*, NSF InfoBrief (Arlington, VA, 2003).

- **Industry.** Preliminary data for company-funded 2002 and 2003 performance are based on partial responses to the 2002 Survey of Industrial Research and Development and time-series forecasting methods.
- **Universities and colleges.** Preliminary data for 2002 and 2003 are based on university responses to the FY 2002 Academic R&D Survey and time-series forecasting models.
- **Other nonprofit institutions.** Preliminary tabulations for 2002 and 2003 are based on (1) Federal obligations reported in *Federal Funds* and (2) time-series-modeled extrapolations of recent trends in R&D performance and funding within the industrial and university sectors. (The method of estimation for these levels is provided in a forthcoming methodology report.)
- **FFRDCs.** Preliminary data for 2002 and 2003 are based on FFRDC responses to the FY 2002 Academic R&D Survey and expected Federal funding of FFRDC R&D reported in *Federal Funds* and the Bush administration's FY 2004 budget.

USE OF TIME-SERIES DATA

Data presented in trend tables are assembled from the most recently completed survey cycles. Data for prior years are reviewed for consistency with the current year's responses and, when necessary, revised in consultation with survey respondents. In addition, changes in sample design or imputation methodologies can result in revisions to previously published data. For trend comparisons, the historical data contained in this report should be used rather than the data published in previous *National Patterns* volumes.

GEOGRAPHIC DISTRIBUTION

This report contains information on the state distribution of R&D performance for 2001 (appendix table B-17). These data cover R&D performance by industry, academia, Federal agencies, and FFRDCs as well as the federally funded R&D activities of nonprofit institutions. These state-distributed data are meant to be indicative of general R&D patterns; they are not necessarily precise.

SUPPORTING DATA SOURCES ON R&D EXPENDITURES

National Science Foundation, Division of Science Resources Statistics. 2002. *Federal R&D Funding by Budget Function: Fiscal Years 2001–2003*. NSF 02-330. Arlington, VA.

Provides information on Federal R&D budget authority by Federal budget function as proposed in the administration's 2003 budget.

National Science Foundation, Division of Science Resources Statistics. Forthcoming. *Academic Research and Development Expenditures: Fiscal Year 2002*.

Detailed statistical tables cover academic R&D performance as reported in a survey of U.S. universities and all FFRDCs. Data include distribution by source of funds, performing institution, character of work, field of science, and geographic location.

National Science Foundation, Division of Science Resources Statistics. Forthcoming. *Federal Funds for Research and Development: Fiscal Years 2001, 2002, and 2003*.

Detailed statistical tables cover R&D (and R&D plant) funding levels for FY 2001–2003 as reported by all Federal agencies with R&D programs. Includes data by agency, performer, character of work, geographic distribution, and S&E field.

National Science Foundation, Division of Science Resources Statistics. Forthcoming. *Research and Development in Industry: 2001*.

Detailed statistical tables cover industrial R&D performance as reported in a sample survey of companies. Data include distribution by source of funds, industry classification, character of work, product field, geographic location, and company size as well as other tabulations.

Office of Management and Budget. 2003. *The Budget of the United States Government, Fiscal Year 2004*. Washington, DC.

Provides quantitative and qualitative information on R&D funding as proposed in the administration's 2004 budget.

