

# **The Methodology Underlying the Measurement of R&D Expenditures: 2000 (data update)**

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## INTRODUCTION

### 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.” Although R&D expenditures have never been more than 3 percent of the United States’ economy, R&D has been widely recognized as a key ingredient for economic growth. Though its precise effects have been difficult to measure, or sometimes even identify, R&D expenditures continue to be studied by scientific and government communities in efforts to understand and improve the patterns of technological change that occur in the economy and society. Along these lines, the National Science Foundation’s Division of the Science Resources Statistics (SRS), acquires and publishes data on R&D statistics through its R&D Statistics Program. In doing so, SRS fulfills the legislative mandate of the National Science Foundation Act to . . . “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”.

**Character of Work.** Total R&D is comprised of basic research, applied research, and development, so defined:

**Basic Research.** Within the Federal, university, and nonprofit sectors, basic research is defined as research directed toward increases in knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific application toward processes or products in mind. For the industry sector, basic research projects are 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.** Within the Federal, university, and nonprofit sectors, applied research is defined as research directed toward gaining ". . . knowledge or understanding necessary for determining the means by which a recognized and specific need may be met." The applied research definition for the industry sector is modified 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 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.

Funds used for R&D refer to current operating costs. These costs consist of both direct and indirect costs. They include not only salaries, but also 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 industry 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.

### **Fields of Science & Engineering.**

By definition, R&D expenditures consist of basic and applied research in the sciences (including medical sciences) and engineering, and 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: (1) the physical sciences, including related engineering and (2) the biological sciences, including medicine but excluding psychology. Industry R&D specifically excludes research in the social sciences.

The exclusion of social science research from industry R&D is done for two reasons. The first reason is simply a matter of feasibility. Such information cannot be easily obtained through surveys of the industrial sector, due to private industry's inexperience with acquiring it. Moreover, even if industrial firms were asked to compile this kind of information for the first time, most of them would not have the incentives or background knowledge to provide consistent data comparable to social science R&D data compiled by organizations in other sectors.

The second reason involves the question of what constitutes new knowledge. In contrast to social science research performed in academic, nonprofit, and governmental settings, social science research performed by industry does not, in general, contribute to a growing body of published literature. Rather, it tends to contribute only briefly to a firm's own internal decision making regarding existing products and processes, and then becomes irrelevant, and is consequently discarded, as new products and processes replace their predecessors. In this sense, unlike social science research conducted in other sectors, such research is fundamentally different from R&D that is commonly associated with the advancement of scientific and engineering knowledge.

### **Sectors of the Economy**

U.S. R&D expenditures are often categorized according to the following concepts. One is the economic sector in which the R&D work is actually *performed*, or the performer for short. A second concept is 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, while the performer is where the money is actually last spent in the process of conducting R&D. Sectors that are intermediate in the process, i.e., that simply move money between sectors, are not counted. For example, if the federal government gives \$1 million dollars to a private company to perform research, but that company contracts-out the research to a university, then the university is the performer of the \$1 million in R&D, and the federal government is the source.

When third parties are involved, as in the above example, information is occasionally (but not often) incorrectly reported, in spite of the specific instructions to the contrary in the survey form and in communications between the survey recipient and the agency managing the survey. In the above example, if the company reports a false R&D performance of \$1 million, then \$1 million would be double-counted in the aggregation of total R&D performance across sectors. If neither the company nor the university report it as performance (each interpreting the other as the true performer), then likewise,

there will be undercounting in the total. Double counting or undercounting can also occur within a single sector, especially the industrial sector, since companies often contract-out their R&D to other companies.

When R&D is conducted by the same sector, or even the same institution, as that which provided the original funds, then that sector is denoted as both the source and performer of the R&D. Another important type of performer is the **Federally Funded Research and Development Center, or FFRDC**. As the name suggests, these are organizations exclusively or substantially financed by the Federal Government to meet a particular requirement or to provide major facilities for research and associated training purposes. Each center is administered either by an industrial firm (called an industry-FFRDC), an individual university, college or university consortium, (university-FFRDC) or a nonprofit institution (nonprofit-FFRDC).

In conclusion, seven different performers are examined in the analysis of U.S. R&D performance: private industry, universities and colleges, the federal intramural, Nonprofits, university-FFRDCs, industry-FFRDCs, and nonprofit FFRDCs. These shares have changed over time. In recent decades the share of industrial R&D performance had increased while federal intramural had declined. R&D performed by state and local governments exists, but it has represented too small a share of the total to be worth tabulating in the R&D statistics.

Five types of organizations provide significant funding: industry, the federal government, universities and colleges, nonprofits, and state and local governments. The source, state and local governments (or nonfederal government), has been measured only to the extent of measuring these funds to universities, especially state-run schools.

The basic sectors covered are:

**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. Performance of FFRDCs administered by industrial firms is obtained from the same industrial R&D survey, although FFRDC breakouts are available and reported separately from R&D totals. Industry's funding of industry R&D includes all funds received from non-federal sources (e.g., from state and local governments).

**Universities and Colleges.** This sector consists of all institutions of higher education, both public and private. Expenditures of FFRDCs administered by universities and colleges are reported separately from totals for this sector. 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 groups: (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, including FFRDCs administered by nonprofit organizations.

As one would expect, the sum of R&D conducted by each performer, or total R&D performed, must add up to the sum of all R&D funded, or total R&D by source. Surveys of R&D performers ask those performers for their sources of funds, and these source data from performers are most often (though not always) used in tabulating R&D by source. For example, the survey of the industrial sector asks participants to separate industrial R&D into company-funded and federally funded components; and the survey of academia ask for data by the sources: federal, nonfederal government, industry, universities and colleges, and nonprofits. Total federal support for R&D is then tabulated as the sum of federal support to industry (according to the industry survey), federal support to academia (according to the academic survey), etc.

A survey of government agencies support for R&D, Federal Funds for Research and Development, is the source of data on federal intramural research, but also provides data on federal extramural research (R&D supported by the government, but not performed by government laboratories). Since data on federal, extramural R&D support is already obtained through surveys of performers, the Federal Funds data on extramural support are not used. The primary rationale behind this choice is simply the belief that performers, themselves, are probably best able to determine the sources of their R&D funding. However, for a variety of reasons, associated primarily with accounting technicalities, federal support to industry according to the Federal Funds survey has been higher than it is according to the industry survey, and vice versa for the academic survey. The first of these discrepancies, being the larger of the two, has been addressed by various investigators, and continues to be investigated.

The R&D statistics compiled by SRS are the Nation's official statistics on R&D levels. These data first appear in NSF reports and data releases, and are then redistributed to other government reports like the *Statistical Abstract of the United States*. They also often appear in press coverage of R&D in the United States, in presentations given by government and non-government officials, etc.

## **How Data on R&D are Obtained and Presented**

Raw data on R&D expenditures derive from four NSF/SRS surveys: *Research and Development in Industry*; *Academic Research and Development Expenditures*; *Federal Funds for Research and Development*; and *Survey of R&D Funding & Performance by Nonprofit Organizations*. These surveys have, associated with them, separate published statistical reports for the sectors they represent and separate Methodology Reports and/or Technical Notes. The reports *National Patterns of R&D Resources*, and *Science and Engineering Indicators* combine these data in order to provide a comprehensive, aggregate picture of total R&D in the United States, as well as R&D categorized by:

<u>Source of Funds:</u>	Federal government, nonfederal government, industry, academia, and nonprofit institutions
<u>R&amp;D performer:</u>	Federal government, industry, academia, nonprofit institutions, and federally-funded research and development centers
<u>Character of work:</u>	Basic research, applied research, and development
<u>Monetary unit:</u>	Current dollars or constant 1996 dollars
<u>Geographic location:</u>	Each of the 50 states and the District of Columbia

The distribution of total R&D, basic research, applied research, and development, by performer and source of funds, is displayed in **Table 1** (page 7).

There is also data available on the distribution of R&D performance by state. These data cover R&D performance by industry, academia, and Federal agencies, along with the federally funded R&D activities of nonprofit institutions. The state data on R&D contains 52 records: the 50 states, the District of Columbia (DC), and "other/unknown" which accounts for R&D in Puerto Rico and other non-state U.S. regions, as well as R&D for which the particular state was not known. Approximately two-thirds of the R&D that could not be associated with a particular state is R&D performed by the nonprofit sector. Consequently, the distribution of R&D by state indicates primarily where R&D is undertaken in federal, industrial, and university facilities. (For example, in 1998, total R&D expenditures in the United States were \$226.9 billion, of which \$214.9 billion could be attributed to expenditures within individual states, with the remainder falling under an undistributed, "other/unknown" category.) The user should take appropriate precaution when using state data as the sampling error for some state data is very large.

An additional method in which R&D expenditures are subdivided, though it is not examined in this report, is by defense-related, space-related, and civilian categories. "Defense R&D" consists of R&D spending by the U.S. Department of Defense and defense-related atomic energy programs of the U.S. Department of Energy. All Defense Department activities are classified as defense, although some activities have secondary objectives (for example, space). "Space R&D" consists of R&D spending by U.S. National Aeronautics and Space Administration. All industry-funded R&D, however, is classified as civilian R&D, including expenditures by aerospace and electronic industries.

<b>Table 1. U.S. R&amp;D expenditures, by performing sector, source of funds, and character of work: 2000</b>							
<b>(millions of U.S. dollars)</b>							
Performers	Total	Sources of funds					Percent distribution, by performer
		Industry	Federal Government	Universities and colleges	State and local government	Other nonprofit institutions	
All R&D: Basic research, applied research and development							
Total.....	264,622	181,040	69,627	5,969	2,197	5,789	100.0
Industry.....	197,280	177,645	19,635	--	--	--	74.6
Industry-administered FFRDCs.....	2,575	--	2,575	--	--	--	1.0
Federal Government.....	19,143	--	19,143	--	--	--	7.2
Universities and colleges.....	30,154	2,310	17,475	5,969	2,197	2,203	11.4
U&C-administered FFRDCs.....	5,801	--	5,801	--	--	--	2.2
Other nonprofit institutions.....	8,750	1,085	4,079	--	--	3,586	3.3
Nonprofit-administered FFRDCs.....	918	--	918	--	--	--	0.3
Percent distribution by sources.....	100.0	68.4	26.3	2.3	0.8	2.2	--
Basic research only							
Total.....	47,903	16,223	23,310	3,672	1,351	3,346	100.0
Industry.....	15,378	14,199	1,179	--	--	--	32.1
Industry-administered FFRDCs.....	704	--	704	--	--	--	1.5
Federal Government.....	3,525	--	3,525	--	--	--	7.4
Universities and colleges.....	20,656	1,421	12,857	3,672	1,351	1,355	43.1
U&C-administered FFRDCs.....	2,809	--	2,809	--	--	--	5.9
Other nonprofit institutions.....	4,492	602	1,898	--	--	1,991	9.4
Nonprofit-administered FFRDCs.....	339	--	339	--	--	--	0.7
Percent distribution by sources.....	100.0	33.9	48.7	7.7	2.8	7.0	--
Applied Research Only							
Total.....	55,041	36,400	14,460	1,884	693	1,604	100.0
Industry.....	37,648	35,396	2,252	--	--	--	68.4
Industry-administered FFRDCs.....	285	--	285	--	--	--	0.5
Federal Government.....	5,826	--	5,826	--	--	--	10.6
Universities and colleges.....	7,260	729	3,259	1,884	693	695	13.2
U&C-administered FFRDCs.....	1,401	--	1,401	--	--	--	2.5
Other nonprofit institutions.....	2,504	275	1,320	--	--	909	4.5
Nonprofit-administered FFRDCs.....	117	--	117	--	--	--	0.2
Percent distribution by sources.....	100.0	66.1	26.3	3.4	1.3	2.9	--
Development Only							
Total.....	161,679	128,417	31,857	413	152	839	100.0
Industry.....	144,254	128,050	16,205	--	--	--	89.2
Industry-administered FFRDCs.....	1,586	--	1,586	--	--	--	1.0
Federal Government.....	9,792	--	9,792	--	--	--	6.1
Universities and colleges.....	2,238	160	1,360	413	152	153	1.4
U&C-administered FFRDCs.....	1,592	--	1,592	--	--	--	1.0
Other nonprofit institutions.....	1,754	208	860	--	--	686	1.1
Nonprofit-administered FFRDCs.....	463	--	463	--	--	--	0.3
Percent distribution by sources.....	100.0	79.4	19.7	0.3	0.1	0.5	--
<b>KEY:</b> FFRDC = Federally funded research and development center; U&C=Universities and colleges							
-- = Not applicable							
<b>SOURCE:</b> National Science Foundation/Division of Science Resources Studies. These data were derived from data collected in four SRS surveys: Survey of Industrial Research and Development, Survey of Research and Development Expenditures at Universities and Colleges, Survey of Federal Funds for Research and Development, and Survey of Research and Development by Nonprofit Organizations.							

## DEVELOPMENT OF THE NATIONAL PATTERNS DATABASE

This section describes the core database that comprises National Patterns R&D expenditure data for the Nation as a whole; data by State will be discussed in a latter section this report. The core database consists of 168 variables, though most of these are simple functions of other variables. Given the number of variables, however, each variable is identified simply in terms of a code number in brackets, i.e., [1], [2], . . . , [168].

The meaning of each variable is displayed in eight tables of R&D data, where each variable is associated with a column of a table, and the headings of the column define the variable. These eight tables (1A, 1B, 2A, ..., 4B) are symmetrically arranged to allow for direct comparisons of R&D data organized in two ways: (1) by performer first and then by source, or (2) by source first and then by performer. The first case effectively asks, "what type of organization performs the R&D, and for that type of performer, from what kinds of organizations does it receive its funding?" The second case effectively asks, "what type of organization provides funding for R&D, and to which kinds of performers does it provide those funds?"

For example, the upper left-hand corners of 1A and 1B are displayed below, which represents cases 1 and 2, respectively. In table 1A, the column for the Federal Government as a performer, as defined in the first row, is not subdivided because the Federal Government is, by assumption, the only source of funds for Federal intramural research. Industry performance, in contrast, is subdivided by the two main sources of industrial performance: the Federal Government and company and other nonfederal funds (which, by assumption, are classified here as "industry's own funds").

**Table 1A. National expenditures for R&D, by performing sector and sources of funding: 1993-2000<sup>1</sup>**

(See the historical database provided in Table D for the full series of historical data, arranged by the same data columns as defined in this and other tables.)

Performing Sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & Colleges					U&C FFRDCs	
	Total U.S.	Federal Govt.	Total	Federal Govt. <sup>2</sup>	Industry <sup>3</sup>	Federal Govt. <sup>2</sup>	Total	Federal Govt.	Nonfed. Govt. <sup>4</sup>	Industry	U&Cs	Non-Profits	Federal Govt. <sup>5</sup>
Data Column	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
Calendar Year <sup>a</sup>	Millions of current dollars												
1993.....	165,714	16,531	115,435	20,844	94,591	1,965	20,485	12,300	1,556	1,391	3,708	1,530	5,283
1994.....	169,214	16,355	117,392	20,261	97,131	2,202	21,591	12,985	1,621	1,455	3,936	1,594	5,317

In table 1B, on the other hand, the Federal Government as a source defines a column in the first row, which is subdivided into several columns in the second row for the performers that receive those funds, such as the Federal Government itself and industry.

**Table 1B. National expenditures for R&D, from funding sectors to performing sectors: 1993-2000<sup>1</sup>**

(See the historical database provided in Table D for the full series of historical data, arranged by the same data columns as defined in this and other tables.)

Funding Sector:	Total U.S.	Federal Government								Industry			
	Total U.S.	Total	Federal Govt.	Industry <sup>2</sup>	FFRDCs <sup>2</sup>	U&Cs <sup>3</sup>	FFRDCs <sup>3</sup>	Non-profits <sup>2</sup>	FFRDCs <sup>2</sup>	Total	Industry <sup>4</sup>	U&Cs	Non-profits
Data Column	[1]	[3]	[2]	[4]	[6]	[8]	[13]	[15]	[18]	[38]	[5]	[10]	[16]
Calendar Year <sup>a</sup>	Millions of current dollars												
1993.....	165,714	60,515	16,531	20,844	1,965	12,300	5,283	2,843	749	96,549	94,591	1,391	567
1994.....	169,214	60,790	16,355	20,261	2,202	12,985	5,317	2,911	758	99,203	97,131	1,455	617

The third row of each table (labeled “Data Column”) provides the column number for table D (in the National Patterns, “Historical database” included on the SRS web site), containing annual historical data from 1953 to 2000 (where data for 2000 are preliminary). Note, for instance, that, in table 1A, industrial performance that is funded by Federal support is designated as column “[4]” in table D. In table 1B, Federal support that is directed to industry performers is also designated as column “[4]” because these two concepts are identically equal, and thus, they are represented by the same column in table D.

The A and B parts of tables 2, 3, and 4 are structured in exactly the same manner as the A and B parts of table 1, but tables 2, 3, and 4 refer to basic research, applied research, and development, respectively, rather than total R&D (the sum of those three components).

On the following page is a “Guide to the Column Codes Used in the Historical Database”, which serves as a references guide, or cross-walk, that enables people to find a code for the variable they want, or vice versa – find the variable definition that corresponds to a particular code. It displays only the headings of tables 1A, 2A, 3A, and 4A, and only a portion of the headings for tables 1B, 2B, 3B, and 4B – the portion that defines a variable that is not already defined in the matching “A” table. The tables in this guide are the same as those that appear regularly in the NSF report, *National Patterns of R&D Resources*, as well as data updates to the *National Patterns* reports, available at the website: <http://www.nsf.gov/sbe/srs/nprdr/start.htm>.

## Guide to the Column Codes Used in the Historical Database (by first table in which they appear)

Table 1A. National expenditures for R&D, by performing sector and sources of funding: 1991-981

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs	
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.2	Industry3	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Nonprofits	Federal Govt.4	Total	Federal Govt.2	Industry	Nonprofits	Federal Govt.2
Current Dollars	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]

Table 1B. Sources of national expenditures for R&D to performing sectors: 1991-98

Funding sector:	Federal Government	Industry	Nonprofits
Performing sector	Total	Total	Total
Current Dollars	[37]	[38]	[39]
Constant Dollars	[40]	[41]	[42]

Table 2A. National expenditures for basic research, by performing sector and sources of funding: 1991-981

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs	
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.2	Industry3	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Nonprofits	Federal Govt.5	Total	Federal Govt.2	Industry	Nonprofits	Federal Govt.2
Current Dollars	[43]	[44]	[45]	[46]	[47]	[48]	[49]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[58]	[59]	[60]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]

Table 2B. Sources of national expenditures for basic research to performing sectors: 1991-98

Funding sector:	Federal Government	Industry	Nonprofits
Performing sector	Total	Total	Total
Current Dollars	[79]	[80]	[81]
Constant Dollars	[82]	[83]	[84]

Table 3A. National expenditures for applied research, by performing sector and sources of funding: 1991-98

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs	
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.2	Industry3	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Nonprofits	Federal Govt.5	Total	Federal Govt.2	Industry	Nonprofits	Federal Govt.2
Current Dollars	[85]	[86]	[87]	[88]	[89]	[90]	[91]	[92]	[93]	[94]	[95]	[96]	[97]	[98]	[99]	[100]	[101]	[102]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]

Table 3B. Sources of national expenditures for applied research to performing sectors: 1991-98

Funding sector:	Federal Government	Industry	Nonprofits
Performing sector	Total	Total	Total
Current Dollars	[121]	[122]	[123]
Constant Dollars	[124]	[125]	[126]

Table 4A. National expenditures for development, by performing sector and sources of funding: 1991-98

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs	
Performing sector	Total U.S.	Federal Govt.	Total	Federal Govt.2	Industry3	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Nonprofits	Federal Govt.5	Total	Federal Govt.2	Industry	Nonprofits	Federal Govt.2
Current Dollars	[127]	[128]	[129]	[130]	[131]	[132]	[133]	[134]	[135]	[136]	[137]	[138]	[139]	[140]	[141]	[142]	[143]	[144]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]

Table 4B. Sources of national expenditures for development to performing sectors: 1991-98

Funding sector:	Federal Government	Industry	Nonprofits
Performing sector	Total	Total	Total
Current Dollars	[163]	[164]	[165]
Constant Dollars	[166]	[167]	[168]

## EXPANDED GUIDE FOR CHARACTERIZING SECTIONS OF THIS REPORT

Following the “Guide to Column Codes” is a similar, “Expanded Guide”, where all of the codes are the same, though they are displayed more concisely with the table headings appearing only once, and with four sets of rows for: total R&D, basic research, applied research, and development. The reversal of top and bottom headings in terms of “funding sector” and “performing sector” appears in the same header rows, so that the first 18 columns defining codes are “funding sector by performing sector” while the last three columns are “performing sector by funding sector”. This expanded guide is used continually throughout the report at the beginning of sections.

Unlike the previous guide, the expanded guide contains three categories of every variable that is expressed in current dollars. For example, instead of “[10]” for R&D performed by universities and colleges, and funded by private industry, in current dollars, there are “[10 h]”, “[10 r]”, and “[10 f]”. These three categories indicate, respectively:

- h** – **historical data** on this variable, for the earliest years, that are no longer recently-reported but are simply repeated or re-reported whenever the data are compiled,
- r** – data that are **recently reported** (and potentially revised) in each new annual data cycle
- f** – data that are **forecasted** (for, at most, two calendar years or three fiscal years) in the absence of observed survey data.

Since different methodologies apply in making calculations for these three different categories, this notation is utilized in this report to identify more clearly the types of methods that are being used. Such delineation is not necessary in the case of constant-dollar calculations, which are simply carried out by deflating the calculated current-dollar figures.

These codes, therefore, represent the final R&D data that go into the *National Patterns and Science and Engineering Indicators* reports. However, other, similar data are needed from two other sources that are comparable to final data in definition. These data *are not* reported as final data, and in fact, they differ from the final data, but they are used as inputs into the calculation of final data.

Those additional input data are represented by the same codes, only with an additional letter at the end to indicate their origin. “F” indicates data from the *Federal Funds* survey, and “B” data from the most recent *Budget of the United States*. For example, “[92 r]” represents recently reported data on Federal support for applied research at academic institutions, which will be provided in the *National Patterns and Science and Engineering* reports. In contrast “[92 rF]” represents the same concept, but as reported in the Federal Funds survey, which is a different set of numbers. The two variables are different in their values, because [92 r] is based in part on performer-reported information (from the survey of academic R&D), while [92 rF] is based solely on the Federal Funds survey of Federal agencies.

This report is organized sequentially, as a step-by-step explanation of how the R&D Expenditure data are built. At the start of each section of this report, there will be a new expanded guide that will indicate which variables are being discussed in that section, and which variables had been discussed in prior sections. The bottom of the expanded guide shows how this notation works, with blackened cells indicating the variables covered in the section, bold lettering indicating other variable that had been previously covered in earlier sections, and gray-colored lettering indicating which variables have not yet been covered. This notation is also used inside each section to identify the calculations made.



## Notation Used in This Report

Variable Names. The above-mentioned variables in brackets are used algebraically to indicate how they are calculated. For example,

$$[3] = [4] + [5]$$

indicates that [3], total R&D performance by industry (excluding industry FFRDCs), is equal to [4], industry performance funded by the Federal government, plus [5], industry performance funded by industry itself .

Unknown Variables. For the purpose of expressing formulas (like the formula for converting fiscal-year data to calendar-year data, provided shortly) an unknown variable that is a National Patterns data item is expressed as a letter within brackets, e.g.,

$$[X] , [Y], [Z]$$

Subscripts for period. All data are annual, and subscripts are used to indicate a particular year in question, i.e.,

$$[3]_{1953} ; \quad [5]_{2000} ; \quad [4]_t \text{ for some } 1952 < t < 2002$$

for, respectively, total R&D performed by industry in 1953, industry performance funded by industry itself, and industry performance funded by the Federal government in year t (between 1952 and 2002, exclusive).

Superscript for fiscal year. Unless otherwise indicated, the absence of an superscript means that the variable in question is measured on a calendar-year basis. All *National Patterns* variables are on a calendar-year basis in the final reporting of the data, but the raw data associated with many of those variables is initially on a fiscal year basis. For example, R&D performed by the Federal government, [2], originates from fiscal-year data provided in the report, *Federal Funds for Research and Development*. The variable in that report that is equivalent to [2], and is used to calculate [2], but is in fiscal rather than calendar years, is expressed as:

$$[2]^F$$

### Conversion of fiscal years to calendar years.

The following approximations are employed in converting fiscal-year data to calendar-year data.

In the case of federal funds performed by the Federal government, the nonprofit sector, or nonprofit-administered FFRDCs, we have:

$$\begin{aligned} [X]_t &= 0.5 [X]^F_t + 0.5 [X]^F_{t+1} \quad \text{for all } t < 1977 ; \\ [X]_t &= 0.75 [X]^F_t + 0.25 [X]^F_{t+1} \quad \text{for all } t > 1976. \end{aligned}$$

This formula results from a change in the definition of the Federal fiscal year between 1976 and 1977. This formula applies for all  $X = \{2, 15, 18, 44, 57, 60, 86, 99, 102, 128, 141, \text{ and } 144\}$ .

In the case of universities and colleges, and FFRDCs administered by universities and colleges, we have:

$$[X]_t = 0.5 [X]_t^F + 0.5 [X]_{t+1}^F \text{ for all } t.$$

This difference in measurement is due to the fact that most universities begin a new fiscal year in July.

Working Structure to Convert Fiscal Year Data to Calendar Year. In the management of the National Patterns database, especially if it is done in a spreadsheet, it is advisable that a working structure be developed for the easy maintenance and conversion of fiscal year data. This could be done, for instance, by having the first column of a spreadsheet as representing the *calendar years* 1953 to 2000, for the first 49 rows (including the first row for the heading). All of the columns to the right of that first column could then be devoted to the variables [1], [2], etc. or order. Directly below this set of calendar-year data, the first column could contain, as well, a second set of rows for *fiscal years* 1953 to 2001. The fiscal-year data for any given variable (if it originates as fiscal-year data) could be placed in the same column, but directly under, the part of the spreadsheet where calendar-year data for the same variable would be placed. The conversion formula could then be applied within the cells of the calendar-year data. This method is simply a suggestion to anyone who might need to generate the *National Patterns* data from the original data acquired in NSF surveys. (See Figure 1.)

Note on rounding error. For ease of presentation, all of the data presented in this methodology report are rounded to the nearest one million dollars. The data used in producing the *National Patterns* database, however, are often carried out to more significant figures. Consequently, calculations made with the data presented in this report could be subject to rounding error when compared to the final data presented in the *National Patterns* reports.

#### Additional variables for Gross Domestic Product (GDP) and the GDP Implicit Price Deflator.

The following additional variable codes are used in the database:

- [169] = GDP in billions of current dollars (see Section 5)
- [170] = GDP Implicit Price Deflator (1996 = 100 ; see Section 5)
- [171] = GDP in billions of constant 1996 dollars.

**Figure 1. Working Structure to Convert Fiscal Year Data to Calendar Year**

Calendar Year	[1]	[2]	[3]					
1953		1,015	$\frac{1}{2} = 0.5 \times 1,010 + 0.5 \times 1,020$					
1954		963	50 percent of that year and					{Could be directly below Calendar data}
1955		973	50 percent of the next year					
1956		1,130						
1957		1,297						
1958		1,507						
1959		1,681			Fiscal Year	[1]	[2]	[3]
1960		1,801			1953		1,010	
1961		1,987			1954		1,020	
1962		2,188			1955		905	
1963		2,558			1956		1,041	
1964		2,965			1957		1,220	
1965		3,156			1958		1,374	
1966		3,308			1959		1,639	
1967		3,444			1960		1,723	
1968		3,497			1961		1,878	
1969		3,790			1962		2,096	
1970		4,154			1963		2,279	
1971		4,409			1964		2,838	
1972		4,676			1965		3,093	
1973		4,837			1966		3,220	
1974		5,132			1967		3,396	
1975		5,561			1968		3,493	
1976		5,890			1969		3,501	
1977		6,211	$\frac{1}{2} = 0.75 \times 6,012 + 0.25 \times 6,810$		1970		4,079	
1978		6,962	75 percent of that year and		1971		4,228	
1979		7,471	25 percent of the next year		1972		4,589	
1980		7,831			1973		4,762	
1981		8,605			1974		4,911	
1982		9,501			1975		5,354	
1983		10,830			1976		5,769	
1984		11,916			1977		6,012	
1985		13,093			1978		6,810	
1986		13,504			1979		7,418	
1987		13,588			1980		7,632	
1988		14,342			1981		8,426	
					1982		9,141	
					1983		10,582	
					1984		11,572	
					1985		12,945	
					1986		13,535	
					1987		13,413	
					1988		14,115	
					1989		15,025	

## METHODOLOGY. Summary of Sections

The table below provides a summary of the *sections of this report* that address the variables indicated by the headers and rows of the table. (Compare this table to Table A above, to identify the precise variable numbers covered in each section.)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits	
	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	12	1	4	4	4	1	7	7	7	7	7	7	7	12	1	1	1	1		12	12	12
Recently Reported	12	2	4	4	4	4	8	7	7	7	7	7	7	12	2	11	11	2		12	12	12
Forecast Last Years	12	3	6	6	6	6	8	8	8	8	8	8	10	12	3	11	11	3		12	12	12
Constant Dollars	12	12	12	6	6	6	12	12	12	12	12	12	12	12	12	12	12	12		12	12	12
<b>Basic Research</b>																						
Historical	12	1	4	4	4	1	7	1	1	1	1	1	1	12	1	1	1	1		12	12	12
Recently Reported	12	2	4	4	4	4	7	7	9	9	9	9	7	12	2	11	11	2		12	12	12
Forecast Last Years	12	3	6	6	6	6	8	8	9	9	9	9	10	12	3	11	11	3		12	12	12
Constant Dollars	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12		12	12	12
<b>Applied Research</b>																						
Historical	12	1	4	4	4	1	12	1	1	1	1	1	1	12	1	1	1	1		12	12	12
Recently Reported	12	2	4	4	4	4	12	9	9	9	9	9	10	12	2	11	11	2		12	12	12
Forecast Last Years	12	3	6	6	6	6	12	9	9	9	9	9	10	12	3	11	11	3		12	12	12
Constant Dollars	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12		12	12	12
<b>Development</b>																						
Historical	12	1	4	4	4	4	12	1	1	1	1	1	1	12	1	1	1	1		12	12	12
Recently Reported	12	2	4	4	4	4	12	9	9	9	9	9	10	12	2	11	11	2		12	12	12
Forecast Last Years	12	3	6	6	6	6	12	9	9	9	9	9	10	12	3	11	11	3		12	12	12
Constant Dollars	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12		12	12	12
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																						
<b>R&amp;D / revision</b>			2			2																
/ forecast																	3					
<b>Applied / revision</b>							2						2									
/ forecast							3						3					3				
<b>Develop. / revision</b>							2						2									
/ forecast							3						3					3				

## Section 1. Historical Data that are Inherited by a New Report

The highlighted black cells with white lettering denote data that are inherited from earlier National Patterns reports and are reused in every report. When a new National Patterns database is being developed, if current sources of data drop a year of coverage from what had been reported earlier, then the historical data are expanded accordingly. In other words, there is often no predetermined "cut-off year" for the historical data, but a general rule: *When a year is no longer covered (and thus no longer recently-reported) by the most-current survey report, then the data for that year enter into the set of historical data, which includes the most recent data available from a previous report.* In this sense, Tables 1 and 2 below best reflect "potential historical data", i.e., data that would be used in the absence of more recently-reported revisions. Though 1989 and 1987, respectively, were used in these tables as the last year in the "historical data", these years are somewhat arbitrary, because, for some survey reports, more current data are provided in these years (and, perhaps, earlier years). As indicated by "NA" (for "not available") some of the historical data for some of the variables are missing, and will probably continue to be missing in future reports. Several of these historical data had not been directly observed by a survey, but had been imputed on the basis of other survey data acquired in other years. Appendix A of this report provides background information on the original survey data used to impute the other historical data.

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	F S.	Federal Govt.	Industry	Non-profits	
	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	P. S.	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																			<b>From Budget of the United States</b>			
<b>R&amp;D / revision</b>			[4 rf]		[6 rf]																	
/ forecast																						
<b>Applied / revision</b>									[92 rf]						[97 rf]						[79 fb]	
/ forecast									[92 ff]						[97 ff]						[121 fb]	
<b>Develop. / revision</b>									[134 rf]						[139 rf]							
/ forecast									[134 ff]						[139 ff]							[163 fb]

**Table 1. Fiscal-year historical data not Recently Reported**

Fiscal Year	[2 h]	[15 h]	[18 h]	[44 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[57 h]	[60 h]	[86 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[99 h]	[102 h]	[128 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[141 h]	[144 h]
1953	1,010	54	NA	101	73	5	12	5	15	33	25	NA	345	57	29	6	28	10	44	13	NA	564	8	3	1	2	1	44	16	NA
1954	1,020	61	NA	102	90	8	14	7	17	39	29	NA	349	61	31	7	28	10	51	15	NA	569	9	3	1	3	1	51	17	NA
1955	905	60	8	90	103	11	16	10	19	49	33	NA	310	58	32	8	28	10	65	17	NA	505	8	4	1	3	1	66	18	NA
1956	1,041	68	9	105	130	17	18	13	22	51	39	NA	356	68	33	9	26	11	71	19	NA	580	15	4	2	3	1	72	19	NA
1957	1,220	73	13	122	155	21	21	18	25	65	44	NA	417	62	34	11	27	11	86	22	NA	681	12	5	2	4	2	89	20	NA
1958	1,374	84	15	126	178	28	24	22	29	78	53	NA	474	64	34	12	27	11	102	25	NA	774	12	6	3	4	2	113	21	NA
1959	1,639	106	21	172	226	34	24	26	33	92	64	NA	558	67	36	12	28	12	119	35	NA	909	13	6	3	4	2	127	28	NA
1960	1,723	143	23	157	299	41	24	31	38	97	80	NA	595	88	38	13	28	12	122	50	NA	971	18	6	3	5	2	141	36	NA
1961	1,878	153	73	210	382	49	25	36	44	115	90	NA	634	98	40	13	29	12	135	75	NA	1,034	20	6	2	5	2	160	61	NA
1962	2,096	185	110	249	481	58	25	44	51	136	120	NA	702	109	40	13	30	13	155	90	NA	1,145	23	7	2	6	2	179	85	NA
1963	2,279	215	150	255	610	69	25	52	58	159	140	NA	715	128	41	14	31	13	170	105	NA	1,309	22	8	2	6	2	201	120	NA
1964	2,838	253	180	314	768	81	24	63	67	191	160	NA	903	127	43	14	34	14	202	125	NA	1,621	22	8	2	6	2	236	148	NA
1965	3,093	247	230	364	879	88	26	76	69	208	172	NA	990	157	47	13	41	21	204	135	NA	1,739	37	8	2	7	3	217	170	NA
1966	3,220	325	200	385	1,008	101	27	96	71	227	185	NA	997	194	46	13	43	32	207	145	NA	1,838	59	9	2	9	5	196	195	NA
1967	3,396	332	220	435	1,124	106	31	117	79	250	190	NA	1,027	222	48	15	54	35	219	160	NA	1,934	63	10	2	10	5	204	202	NA
1968	3,493	352	230	432	1,251	122	36	154	87	276	197	NA	1,110	253	43	16	54	37	231	172	NA	1,952	68	7	3	10	8	212	213	NA
1969	3,501	376	240	532	1,279	140	39	158	95	275	195	NA	1,113	246	49	16	56	40	210	200	NA	1,856	75	8	5	9	10	240	221	NA
1970	4,079	399	250	558	1,296	166	40	184	110	269	189	NA	1,345	267	47	16	52	45	216	220	NA	2,175	84	6	5	7	10	252	240	NA
1971	4,228	420	210	565	1,349	193	46	207	119	260	200	NA	1,322	292	55	19	60	48	210	230	NA	2,340	83	7	5	7	10	246	200	NA
1972	4,589	433	220	597	1,420	194	53	221	134	244	214	NA	1,387	320	66	18	74	46	221	251	NA	2,605	55	9	3	10	7	288	188	NA
1973	4,762	510	180	608	1,454	196	57	212	134	296	218	NA	1,480	461	83	23	89	57	227	234	NA	2,674	70	16	4	17	11	294	238	NA
1974	4,911	622	200	696	1,523	196	60	235	139	390	245	NA	1,574	438	92	29	111	66	178	280	NA	2,641	71	19	6	23	14	297	297	NA
1975	5,354	655	220	734	1,695	211	72	266	166	439	245	NA	1,730	515	100	34	125	77	203	300	NA	2,890	78	21	7	26	16	345	330	NA
1976	5,769	695	230	786	1,841	213	71	262	162	512	265	NA	2,093	584	127	43	156	107	235	330	NA	2,890	87	23	9	29	16	400	330	NA
1977	6,012	727	260	914	2,007	222	79	305	187	600	290	NA	2,044	607	128	46	175	111	290	345	NA	3,054	112	24	14	34	16	494	352	NA
1978	6,810	780	320	1,029	2,221	242	99	363	208	867	335	NA	2,192	644	141	56	213	130	319	385	NA	3,590	194	31	15	47	21	531	380	NA
1979	7,418	980	370	1,089	2,577	278	114	433	217	1,022	400	NA	2,392	707	161	65	251	125	339	480	NA	3,936	314	33	14	51	26	574	470	NA
1980	7,632	1,000	450	1,182							450	NA	2,484							480	NA	3,966							520	NA
1981	8,426	1,000	550	1,302							495	NA	2,732							515	NA	4,392							540	NA
1982	9,141	1,150	500	1,466							535	NA	2,729							540	NA	4,947							575	NA
1983	10,582	1,250	600	1,690							600	NA	3,020							580	NA	5,872							670	NA
1984	11,572	1,500	600	1,861							650	NA	2,904							600	NA	6,808							850	NA
1985	12,945	1,700	700	1,923							675	NA	3,133							575	NA	7,889							1,150	NA
1986	13,535	1,700	550	2,019							700	NA	3,141							600	NA	8,375							950	NA
1987	13,413	1,700	500	2,046							700	NA	3,392							600	NA	7,975							900	NA
1988	14,115	1,683	506	2,050							729	17.7	3,288							571	65	8,776							383	423
1989	15,025	2,000	522	2,313							839	42.2	3,584							681	67	9,128							480	412

**Table 2. Calendar-year historical data not Recently Reported**

Calendar Year	[6 h]	[16 h]	[17 h]	[48 h]	[58 h]	[59 h]	[90 h]	[100 h]	[101 h]	[142 h]	[143 h]
1953	NA	26	28	NA	9	12	NA	11	10	6	6
1954	NA	31	31	NA	11	13	NA	13	11	7	7
1955	123	35	32	NA	13	14	NA	14	11	8	7
1956	333	37	38	NA	15	17	NA	14	14	8	7
1957	407	37	51	NA	15	23	NA	14	20	8	8
1958	323	38	62	NA	16	28	NA	14	25	8	9
1959	418	42	67	NA	18	30	NA	15	27	9	10
1960	477	48	68	NA	21	30	NA	17	28	10	10
1961	555	49	86	NA	22	37	NA	17	35	10	14
1962	426	54	109	NA	24	46	NA	19	45	11	18
1963	414	55	119	NA	25	50	NA	19	49	11	20
1964	463	55	112	42	25	47	62	19	47	11	18
1965	373	62	124	29	29	52	46	21	52	12	20
1966	355	70	138	31	32	58	53	24	57	14	23
1967	419	74	145	34	34	61	83	25	60	15	24
1968	415	81	151	35	37	63	87	28	62	16	26
1969	464	93	161	37	43	67	95	32	66	18	28
1970	473	95	172	36	44	72	97	33	70	18	30
1971	491	98	184	33	45	77	67	34	74	19	33
1972	548	101	198	39	47	84	107	35	79	19	35
1973	545	105	211	36	49	90	110	36	83	20	38
1974	648			49			120				
1975	727			53			139				
1976	890			69			167				
1977	962			75			212				
1978	1,082			94			235				
1979	1,164			104			250				
1980	1,277			120			275				
1981	1,385			137			298				
1982	1,484			128			367				
1983	1,585			117			414				
1984	1,739			136			547				
1985	1,863			131			630				
1986	1,891			117			629				
1987	1,995			142			623				

## Section 2. Federal Funds Data Used in Producing the Report

Recently-reported Federal funds data are acquired from the most recent *Federal Funds* report, at <http://nsf.gov/sbe/srs/fedfunds/start.htm>. To obtain these data, one must find, in the detailed statistical tables, the data item that matches the definition of the one in question. The actual numbers are provided here for guidance and confirmation. These numbers are in fiscal year-data, which need to be converted to calendar-year estimates. However, in order to have a 2000 calendar-year estimate, forecasts for 2001 are needed. (See the conversion formula presented above.) The forecasts of these variables for 2001 are presented in Section 3. The data for the variables highlighted are presented in Table 3.

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits		
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total	
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																							
<b>Total R&amp;D</b>																							
Historical	[1 h]	<b>[2 h]</b>	[3 h]	[4 h]	[5 h]	<b>[6 h]</b>	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	<b>[15 h]</b>	<b>[16 h]</b>	<b>[17 h]</b>	<b>[18 h]</b>			[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	<b>[2 r]</b>	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	<b>[15 r]</b>	[16 r]	[17 r]	<b>[18 r]</b>			[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]			[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]			[40]	[41]	[42]
<b>Basic Research</b>																							
Historical	[43 h]	<b>[44 h]</b>	[45 h]	[46 h]	[47 h]	<b>[48 h]</b>	[49 h]	<b>[50 h]</b>	<b>[51 h]</b>	<b>[52 h]</b>	<b>[53 h]</b>	<b>[54 h]</b>	<b>[55 h]</b>	[56 h]	<b>[57 h]</b>	<b>[58 h]</b>	<b>[59 h]</b>	<b>[60 h]</b>			[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	<b>[44 r]</b>	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	<b>[57 r]</b>	[58 r]	[59 r]	<b>[60 r]</b>			[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]			[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]			[82]	[83]	[84]
<b>Applied Research</b>																							
Historical	[85 h]	<b>[86 h]</b>	[87 h]	[88 h]	[89 h]	<b>[90 h]</b>	[91 h]	<b>[92 h]</b>	<b>[93 h]</b>	<b>[94 h]</b>	<b>[95 h]</b>	<b>[96 h]</b>	<b>[97 h]</b>	[98 h]	<b>[99 h]</b>	<b>[100 h]</b>	<b>[101 h]</b>	<b>[102 h]</b>			[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	<b>[86 r]</b>	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	<b>[99 r]</b>	[100 r]	[101 r]	<b>[102 r]</b>			[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]			[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]			[124]	[125]	[126]
<b>Development</b>																							
Historical	[127 h]	<b>[128 h]</b>	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	<b>[134 h]</b>	<b>[135 h]</b>	<b>[136 h]</b>	<b>[137 h]</b>	<b>[138 h]</b>	<b>[139 h]</b>	[140 h]	<b>[141 h]</b>	<b>[142 h]</b>	<b>[143 h]</b>	<b>[144 h]</b>			[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	<b>[128 r]</b>	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	<b>[141 r]</b>	[142 r]	[143 r]	<b>[144 r]</b>			[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]			[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]			[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>			
R&D / revision / forecast			<b>[4 rf]</b>			<b>[6 rf]</b>																[79 fB]	
Applied / revision / forecast								<b>[92 rF]</b>							<b>[97 rF]</b>							[121 fB]	
Develop. / revision / forecast								<b>[134 rF]</b>							<b>[139 rF]</b>							[163 fB]	

**Table 3. Recently-reported Federal Funds data: Fiscal Years 1990-2000.**

**Data used directly in the *National Patterns* database**

Fiscal Year	[2 r]	[15 r]	[18 r]	[44 r]	[57 r]	[60 r]	[86 r]	[99 r]	[102 r]	[128 r]	[141 r]	[144 r]
1990	15,849	2,248	622	2,295	924	59	3,515	736	78	10,039	588	484
1991	15,138	2,637	679	2,392	1,016	81	4,063	910	90	8,684	712	509
1992	15,583	2,804	746	2,338	1,097	66	4,186	953	75	9,060	754	606
1993	16,663	2,812	753	2,662	1,165	71	4,790	876	102	9,212	771	580
1994	16,132	2,937	736	2,498	1,133	74	4,983	969	104	8,651	835	558
1995	17,025	2,834	825	2,694	1,148	75	4,991	930	132	9,340	755	618
1996	16,540	2,887	755	2,677	1,235	76	4,837	944	119	9,027	708	560
1997	16,718	2,962	821	2,688	1,290	88	4,979	1,005	129	9,051	667	603
1998	17,122	3,171	820	2,919	1,398	166	5,051	1,028	126	9,152	746	528
1999	18,085	3,609	913	3,255	1,650	355	5,431	1,157	115	9,399	802	444
2000	19,073	4,047	898	3,483	1,871	338	5,721	1,307	113	9,869	869	448
2001	19,352	4,176	978	3,651	1,980	340	6,142	1,360	130	9,560	835	508

**Data that are not used directly, but used as input into the analysis**

Fiscal Year	[4 rF]	[6 rF]	Fiscal Year	[4 rF]	[6 rF]	[92 rF]	[97 rF]	[134 rF]	[139 rF]
1955	636	135	1978	11,400	1,242				
1956	1,246	333	1979	12,172	1,318				
1957	1,838	407	1980	12,969	1,408				
1958	2,283	324	1981	14,868	1,414				
1959	3,833	418	1982	17,192	1,506				
1960	4,357	477	1983	17,020	1,501				
1961	5,435	455	1984	18,610	1,608				
1962	6,136	426	1985	21,705	1,791				
1963	7,877	414	1986	24,201	1,697				
1964	8,693	443	1987	26,768	1,860				
1965	8,657	401	1988	26,719	1,911				
1966	9,027	359	1989	28,548	2,056				
1967	9,878	385	1990	29,370	2,327	2,588	564	1,001	1,658
1968	9,047	414	1991	26,421	2,168	2,803	855	1,301	1,443
1969	8,703	427	1992	29,745	2,117	2,729	958	1,211	1,504
1970	7,770	431	1993	30,219	1,451	3,059	897	1,316	1,315
1971	7,588	480	1994	30,455	1,293	3,299	845	1,505	1,112
1972	7,716	530	1995	30,236	1,202	3,410	795	1,574	1,328
1973	7,731	582	1996	30,374	1,137	3,263	864	1,271	1,062
1974	7,752	593	1997	31,419	1,128	3,477	999	1,386	1,102
1975	8,423	704	1998	31,999	1,189	3,787	1,101	1,642	1,147
1976	9,340	814	1999	31,902	1,328	4,097	989	1,755	1,342
1977	10,717	1,113	2000	32,815	1,336	4,655	1,053	1,913	1,319
			2001	33,026	1,386	4,790	1,201	2,028	1,241

### Section 3. Forecasting Federal Funds Data to the Next Year Forward

When National Patterns data are prepared to calendar year Y, data on fiscal year components are required for fiscal year Y+1 in order to make the fiscal-to-calendar-year conversion for calendar-year Y. In the most recent, 2000 Update, Federal Funds estimates for 2001 were directly available from the Federal Funds survey. However, in earlier cases, when fiscal year Y+1 data from the Federal Funds survey are not yet available, estimates of these data are made based on percent increases in [79 fB], [121 fB], and [163 fB] as reported in the Budget of the United States. (For example, in an earlier data analysis data were acquired from page 99, Table 5-2, of the Budget of the United States 2001). These proportional increases, for earlier National Patterns data, were applied as shown in the following equations.

$$\begin{aligned}
 [X]^F_{2001} &= [X]^F_{2000} \left( [79 \text{ fB}]^F_{2001} / [79 \text{ fB}]^F_{2000} \right) \text{ for all } X = \{44, 57, 60\} \\
 [X]^F_{2001} &= [X]^F_{2000} \left( [121 \text{ fB}]^F_{2001} / [121 \text{ fB}]^F_{2000} \right) \text{ for all } X = \{86, 92 \text{ rF}, 97 \text{ rF}, 99, 102\} \\
 [X]^F_{2001} &= [X]^F_{2000} \left( [163 \text{ fB}]^F_{2001} / [163 \text{ fB}]^F_{2000} \right) \text{ for all } X = \{128, 134 \text{ rF}, 139 \text{ rF}, 141, 144\} \\
 [2]^F_{2001} &= [44]^F_{2001} + [86]^F_{2001} + [182]^F_{2001} \quad ; \quad [15]^F_{2001} = [57]^F_{2001} + [99]^F_{2001} + [141]^F_{2001} \\
 [18]^F_{2001} &= [60]^F_{2001} + [102]^F_{2001} + [144]^F_{2001}
 \end{aligned}$$

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits	
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the National Patterns and Science and Engineering Indicators reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the National Patterns Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision / forecast				[4 rf]		[6 rf]																[79 fB]
Applied / revision / forecast								[92 rF]							[97 rF]							[121 fB]
Develop. / revision / forecast								[134 rF]							[139 rF]							[163 fB]
								[134 fF]							[139 fF]							

## Section 4. Recently-reported Industrial R&D Data

Recently-reported industry R&D data are acquired from the most recent *R&D in Industry* report, at <http://www.nsf.gov/sbe/srs/indus/start.htm>. As with the Federal Funds data, to obtain these data, one must work with the detailed statistical tables contained in the report. The actual numbers are provided here for guidance and confirmation. One important difference between the data presented in the *R&D in Industry* report and the data presented in the *National Patterns* report is that, in the former, the column for Federal support for industrial R&D includes R&D in industry-administered FFRDCs, where as the latter do not. In other words, *R&D in Industry* does not provide [4] directly, but instead provides a column equal to [4] + [6], which we will denote as “[4+6]”. The reason for this is that the Industry report is then able to subdivide [4+6] into industrial categories, which it would not be able to do to [4] and [6] individually because of information disclosure issues. The Industry report also provides, a separate column for [6], which is not subdivided by industrial category.

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits	
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision			[4 rf]		[6 rf]																[79 fB]	
Applied / revision								[92 rF]					[97 rF]									
/ forecast								[92 fF]					[97 fF]									[121 fB]
Develop. / revision								[134 rF]					[139 rF]									
/ forecast								[134 fF]					[139 fF]									[163 fB]

Another minor issue is that the data provided in the *Industry R&D* report for [5] and for [4+6] include the full historical series, from 1953 to 1998, but the data on [6] alone begins in 1988. For this reason, data on [6] for years earlier than 1988 were inherited from earlier *Industry R&D and National Patterns* reports. Accordingly, data on [6] prior to 1988 were included in Section 1 above on historical data, though data on [4] and [5] were not. Thus, the distinction between [4 r] and [4 h] is ambiguous, in that:

$$\begin{aligned} [4] &= [4+6 \text{ r}] - [6 \text{ h}] \quad \text{for all } t < 1988 \\ [4] &= [4+6 \text{ r}] - [6 \text{ r}] \quad \text{for all } t > 1987. \end{aligned}$$

In any case, because this section will provide data on [4+6] and on [5] that will go as far back as 1953 (when the series begins), subsequent guide tables after this section will indicate [4 h], [4 r], [5 h], [5 r], and [6 r] as having been completed.

The situation that exists for the character components of industry R&D are precisely symmetric to the situation described above for total R&D. That is:

$$\begin{aligned} [46] &= [46+48 \text{ r}] - [48 \text{ h}] \quad \text{for all } t < 1988 \\ [46] &= [46+48 \text{ r}] - [48 \text{ r}] \quad \text{for all } t > 1987 \\ [88] &= [88+90 \text{ r}] - [90 \text{ h}] \quad \text{for all } t < 1988 \\ [88] &= [88+90 \text{ r}] - [90 \text{ r}] \quad \text{for all } t > 1987 \end{aligned}$$

New data (not already listed in Section 1) for all of these variables, and for [5], [47], and [89] are provided in table 4.

The components of development by industry and industry-FFRDCs – [130], [131], and [132] – are simply calculated as the difference between total R&D and basic and applied research, i.e.,

$$\begin{aligned} [130] &= [4] - [46] - [88] \\ [131] &= [5] - [47] - [89] \\ [132] &= [6] - [48] - [90] \end{aligned}$$

Likewise, the totals for all industry performance – [3], [45], [87], and [129] – are taken as the sum of their Federal-support and industry-support components, i.e.,

$$\begin{aligned} [3] &= [4] + [5] \\ [45] &= [46] + [47] \\ [87] &= [88] + [89] \\ [129] &= [130] + [131] \end{aligned}$$

Since the values for all of these variables follow from the data provided thus far in this section, and in Section 1, subsequent guide tables beyond this point will indicate their completion.

In the most recent National Patterns database, [6]<sub>1999</sub> and [48]<sub>1999</sub> were not available at the time the data were compiled, though [4+6]<sub>1999</sub>, [46+48]<sub>1999</sub> and [90]<sub>1999</sub> were. Consequently, [6]<sub>1999</sub> and [48]<sub>1999</sub> were forecasted for 1999 (see below), and [4]<sub>1999</sub> and [46]<sub>1999</sub> were derived on the basis of those forecasts and the above equations.

NOTE: Historical data are reported for industry-administered basic research [48], applied research [90], and development [132] for the years 1964 to the present. The data for the years 1964-1988 were obtained from analyses conducted by the Bureau of Economic Analyses when they were preparing an R&D Satellite Account, in July 1992. Revised actual year survey data were reported for most years, with the following exceptions: The character-of-work distribution for 1970, 1976, and 1985 were based on preliminary estimations that apparently were NOT subsequently updated. The character-of-work distribution for 1978, 1980, and 1982 are BEA estimates since either NSF did not survey for these data in those years or the data were not included in published reports.

**Table 4. Data taken directly from the report, *R&D in Industry: 1999***

Calendar Year	[4+6]	[5]	[6 r]	[46+48]	[47]	[48 r]	[88+90]	[89]	[90 r]
1953	1,430	2,200		19	132		288	438	
1954	1,750	2,320		23	143		322	492	
1955	2,180	2,460		27	162		368	560	
1956	3,328	3,277		37	216		474	794	
1957	4,335	3,396		41	230		678	992	
1958	4,759	3,630		43	252		774	1,137	
1959	5,635	3,630		72	248		813	1,178	
1960	6,081	4,428		79	297		833	1,196	
1961	6,240	4,668		81	314		812	1,165	
1962	6,434	5,029		143	345		1,011	1,438	
1963	7,270	5,360		147	375		1,007	1,450	
1964	7,720	5,792		165	384		1,040	1,560	
1965	7,740	6,445		186	406		1,038	1,620	
1966	8,332	7,216		173	451		1,039	1,804	
1967	8,365	8,020		202	427		1,066	1,849	
1968	8,560	8,869		180	462		1,043	2,081	
1969	8,451	9,857		160	458		1,015	2,272	
1970	7,779	10,288		158	444		1,049	2,378	
1971	7,666	10,654		134	456		974	2,441	
1972	8,017	11,535		130	463		952	2,562	
1973	8,145	13,104		132	499		993	2,832	
1974	8,220	14,667		163	536		1,025	3,263	
1975	8,605	15,582		157	573		1,130	3,440	
1976	9,561	17,436		185	634		1,200	3,912	
1977	10,485	19,340		210	701		1,325	4,311	
1978	11,189	22,115		250	785		1,430	4,870	
1979	12,518	25,708		265	893		1,555	5,670	
1980	14,029	30,476		290	1,035		1,900	6,550	
1981	16,382	35,428		301	1,313		2,340	8,359	
1982	18,545	40,105		381	1,523		2,960	9,363	
1983	20,680	44,588		463	1,760		3,641	10,286	
1984	23,396	51,404		476	2,132		4,224	11,541	
1985	27,196	57,043		489	2,373		5,347	12,908	
1986	27,891	59,932		551	3,496		4,678	15,082	
1987	30,752	61,403		740	3,583		4,660	15,153	
1988	30,343	66,672	2,122	993	3,507	337	4,217	16,531	371
1989	28,554	73,501	2,195	1,384	3,832	398	4,698	17,993	374
1990	28,125	81,602	2,323	1,368	3,760	499	6,353	18,432	386
1991	26,372	90,580	2,277	1,712	6,125	461	6,021	21,425	433
1992	24,722	94,388	2,353	1,186	5,816	474	4,983	21,184	507
1993	22,809	94,591	1,965	958	5,961	492	4,730	19,956	435
1994	22,463	97,131	2,202	939	6,078	503	4,119	19,372	503
1995	23,451	108,652	2,273	720	5,379	530	3,699	23,755	535
1996	23,653	121,015	2,297	1,358	6,848	708	3,871	25,370	231
1997	23,928	133,611	2,130	1,654	8,766	625	2,861	29,782	213
1998	24,164	145,016	2,078	1,894	11,701	568	2,763	27,808	230
1999	22,535	160,288		2,641	12,813		3,714	31,927	274

## Section 5. GDP and GDP Implicit Price Deflator

Data on the Gross Domestic Product (GDP) and the GDP Implicit Price Deflator are prepared every year around February or March, for use in various NSF statistical reports. These data are not prepared more frequently than once per year, in order to minimize any inconsistency in the data and analysis among NSF reports that are released at different times during the year.

Fiscal year GDP and deflators for 1953-2000 are from the Office of Management and Budget, FY 2002 *Budget of the United States*. Calendar year GDP and deflators for 1953-2000 are from the Bureau of Economic Analysis. All projected values were provided by the Office of Management and Budget, based on economic assumptions in the 2001 Bush Administration's report, "A Blueprint for New Beginnings", February 2001.

**Table 5. Gross Domestic Product (GDP) and GDP Deflator**

Year	Calendar-Year GDP (billions of current dollars)	Calendar-Year GDP Deflator (1996 = 100)	Fiscal-Year GDP Deflator (1996 = 100)	Year	Calendar-Year GDP (billions of current dollars)	Calendar-Year GDP Deflator (1996 = 100)	Fiscal-Year GDP Deflator (1996 = 100)
1953	379.7	19.25	19.23	1977	2,031.4	45.02	44.51
1954	381.3	19.44	19.46	1978	2,295.9	48.23	47.56
1955	415.1	19.78	19.62	1979	2,566.4	52.25	51.42
1956	438.0	20.45	20.14	1980	2,795.6	57.04	55.99
1957	461.0	21.13	20.89	1981	3,131.3	62.37	61.42
1958	467.3	21.64	21.52	1982	3,259.2	66.25	65.72
1959	507.4	21.88	21.87	1983	3,534.9	68.88	68.61
1960	527.4	22.19	22.12	1984	3,932.7	71.44	71.14
1961	545.7	22.44	22.43	1985	4,213.0	73.69	73.49
1962	586.5	22.74	22.68	1986	4,452.9	75.31	75.26
1963	618.7	23.00	22.98	1987	4,742.5	77.58	77.33
1964	664.4	23.34	23.25	1988	5,108.3	80.21	79.86
1965	720.1	23.78	23.66	1989	5,489.1	83.27	82.93
1966	789.3	24.46	24.17	1990	5,803.2	86.51	86.05
1967	834.1	25.21	24.94	1991	5,986.2	89.66	89.40
1968	911.5	26.30	25.84	1992	6,318.9	91.84	91.74
1969	985.3	27.59	27.01	1993	6,642.3	94.05	93.93
1970	1,039.7	29.06	28.49	1994	7,054.3	96.01	95.96
1971	1,128.6	30.52	29.92	1995	7,400.5	98.10	98.04
1972	1,240.4	31.82	31.32	1996	7,813.2	100.00	100.00
1973	1,385.5	33.60	32.71	1997	8,300.8	101.95	101.95
1974	1,501.0	36.62	35.04	1998	8,759.9	103.22	103.40
1975	1,635.2	40.03	38.67	1999	9,254.6	104.77	104.85
1976	1,823.9	42.30	41.40	2000	9,708.1	106.91	106.87
				2001 estimate			109.11

## Section 6. Forecasting Industrial R&D

The National Patterns series produced in each year Y usually contains projections for calendar year Y and year Y-1, while the observed data from the Industry R&D Survey contain data only up to year Y-2. In the most recent database, however, where Y = 2000, R&D data on industry R&D were available for 1999 (or Y-1), and therefore needed to be forecasted out for only one year to 2000. However, as mentioned in Section 4 above, [6]<sub>1999</sub> and [48]<sub>1999</sub> were forecasted, and [4]<sub>1999</sub> and [46]<sub>1999</sub> were derived on the basis of those forecasts, since data were available on [4+6]<sub>1999</sub> and [46+48]<sub>1999</sub>.

The projection of industry R&D for the two last years of a National Patterns series has not been carried out the same way each year, due to changes in the availability of information, shifts in observed patterns, and the consideration of improved forecasting methods. For the most recent report, forecasts were done on constant-dollar industry-R&D levels. Forecasted nominal values were then calculated by inflating the constant-dollar forecasted estimates. (This was done because the constant-dollar levels appeared to follow better-behaved patterns over time, thus making their values more appropriate to forecast.) The deflator used was the GDP Implicit price deflator, which was displayed in the previous section.

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>		
<b>R&amp;D / revision</b>			[4 rf]		[6 rf]																	
/ forecast																						[79 fB]
<b>Applied / revision</b>									[92 rF]						[97 rF]							
/ forecast									[92 fF]						[97 fF]							[121 fB]
<b>Develop. / revision</b>									[134 rF]						[139 rF]							
/ forecast									[134 fF]						[139 fF]							[163 fB]

## Forecasting Aggregate Constant Dollar Components: [22], [23], and [24]

Generally preliminary survey data on **company-budgeted R&D** is obtained from the Bureau of the Census during the summer. Due to time constraints as a result of the NAICS conversion process, these data were NOT compiled this year (but they will be available in future years). Instead, forecasts were carried as follows:

- (1) A value of  $[23]_{2000}$  was forecasted, which can be inflated to its nominal-dollar equivalent, [5].
- (2) Forecasts were then made of  $[24]_{1999}$  and  $[24]_{2000}$  which relied upon the forecasted value of  $[23]_{2000}$ . Those forecasts could then be inflated to their nominal-dollar equivalents,  $[6]_{1999}$  and  $[6]_{2000}$ .
- (3) A forecast was then made of  $[22]_{2000}$ . (As mentioned earlier, a value of  $[22+24]_{1999}$ , or its inflated equivalent  $[4+6]_{1999}$ , was already available, implying that  $[22]_{1999}$  could be calculated directly as the difference between  $[22+24]_{1999}$  and the forecast of  $[24]_{1999}$ .)

The econometric analysis was conducted using the software package “Forecast Pro”. Various models were considered, which included various possibilities for leading indicators of the dependent variables. The final choice of a model was based on how well the models fitted the data, under the constraint that all models were reasonable explanations from an economic perspective. These models are presented below for each of the variables [22], [23] and [24] respectively.

**Forecast of [23].** The variable [23] is R&D performed by industrial firms, paid for by nonfederal sources and analytically treated as being financed by industrial firms themselves, by calendar year, in constant 1996 dollars. One leading indicator was found: the component of the Gross Domestic Product called “gross domestic investment in equipment” which is reported in the National Income and Product Accounts provided by the U.S. Bureau of Economic Analysis (BEA). Let GDI\_EQUP denote this variable in constant 1996 dollars, based on the calendar-year nominal values provided by BEA, converted to constant dollars using the deflator provided in Section 5 above. The final data series for GPI\_EQUP in constant 1996 dollars (after deflation) is provided below in Table 7. The forecast model for [23] is provided in Table 8.

**Forecast of [24].** The variable [24] is R&D performed by industry-administered FFRDCs, by calendar year, in constant 1996 dollars. The best model available for forecasting [24] had, as explanatory variables,  $[24]_{-1}$ ,  $[23]$ ,  $[24 \text{ rF}]^F$  and  $[24 \text{ rF}]^F_{-1}$ , as shown in Table 9.

**Forecast of [22].** In this case, modeling the log of [22] appeared to be more efficient for forecasting. The model employed had log [22] as the dependent variable, and its first and second lags as explanatory variables (Table 10).

For Forecast Pro output, see the following terms below:

ARIMA(p,d,q) = Autoregressive Integrated Moving Average model, for which there are p autoregressive terms and q moving average terms, where the data have been differenced d times.

MAPE = Mean absolute percentage error.

MAD = Mean absolute deviation

BIC = Bayes information criterion

RMSE = Root mean square error

**Note:** For background on these and other terms that appear in this output see: Eric A. Stellwagen and Robert L. Goodrich, *Forecast Pro for Windows*, Business Forecast Systems, Inc., Belmont, MA, 1997.

**Table 7. Gross Domestic Investment in Equipment,  
In millions of 1996 dollars**

Year	GDI EQUIP	Year	GDI EQUIP
1955	120.829	1978	388.140
1956	128.606	1979	414.737
1957	135.353	1980	397.966
1958	115.065	1981	406.926
1959	129.799	1982	377.811
1960	134.295	1983	384.292
1961	129.679	1984	439.950
1962	142.040	1985	453.657
1963	151.304	1986	460.497
1964	167.952	1987	457.205
1965	195.542	1988	482.234
1966	220.769	1989	504.383
1967	217.771	1990	494.509
1968	227.757	1991	474.459
1969	242.842	1992	494.229
1970	236.407	1993	534.609
1971	234.273	1994	584.418
1972	256.757	1995	632.518
1973	292.560	1996	674.400
1974	295.467	1997	729.377
1975	280.789	1998	798.586
1976	298.818	1999	875.632
1977	342.292	2000	970.723

After numerous tests of possible models, the model finally chosen to forecast [23] was:

$$[23] = b_0 + b_1 [23]_{-1} + b_2 [23]_{-2} + b_3 [23]_{-3} + b_4 \text{GDI\_EQUIP}$$

The regression results are as follows:

Forecast Model for [23] as the Dependent Variable  
Regression(5 regressors, 0 lagged errors)

Term	Coefficient	Std. Error	t-Statistic	Significance
Constant	-1551.422174	699.376850	-2.218292	0.967247
[23] <sub>-1</sub>	1.618714	0.149229	10.847212	1.000000
[23] <sub>-2</sub>	-1.067541	0.244129	-4.372862	0.999904
[23] <sub>-3</sub>	0.389594	0.143315	2.718438	0.990076
GDI_EQUIP	19.561968	6.531246	2.995136	0.995128

Within-Sample Statistics

-----

Sample size 42	Number of parameters 5
Mean 6.14e+004	Standard deviation 3.694e+004
R-square 0.9979	Adjusted R-square 0.9977
Durbin-Watson 1.75	Ljung-Box(18)=19.67 P=0.6486
Forecast error 1774	BIC 2080
MAPE 0.02826	RMSE 1665
MAD 1379	

As already mentioned, the observations on [23] were from 1955 to 1999; the derivation of an estimate for 2000, based on the above regression results, are displayed below in Table 8.

**Table 8. Calculation of Forecasted Values of [23] and [5].**

(GDI\_EQUP in millions of 1996 dollars)

	[23]	_Const	[23] <sub>-1</sub>	[23] <sub>-2</sub>	[23] <sub>-3</sub>	GDI_EQUP	Estimated
<b>Coefficient</b>		-1551.422174	1.618714	-1.067541	0.389594	19.561968	[23]
<b>Calendar Year</b>							
1997	131,055	1	121,015	110,756	101,168	729.377	129,783
1998	140,492	1	131,055	121,015	110,756	798.586	140,173
1999	152,990	1	140,492	131,055	121,015	875.632	150,234
2000 estimate	<b>166,163</b>	1	152,990	140,492	131,055	970.723	166,163
<b>Calendar Year</b>	<b>Final [23]</b>	<b>Final [5]</b>					
1997	131,055	133,611					
1998	140,492	145,016					
1999	152,990	160,288					
2000 estimate	<b>166,163</b>	<b>177,645</b>					

**Forecast of [24].** The model chosen for forecasting [24]<sub>1999</sub> and [24]<sub>2000</sub> was:

$$[24] = b_0 + b_1 [24]_{-1} + b_2 [23] + b_3 [24 F]^F + b_4 [24 F]_{-1}^F$$

The regression results are as follows:

Forecast Model for I24

Regression(5 regressors, 0 lagged errors)

Term	Coefficient	Std. Error	t-Statistic	Significance
Constant	392.680142	138.777770	2.829561	0.992595
[24] <sub>-1</sub>	0.422442	0.143659	2.940594	0.994450
[23]	0.004031	0.001225	3.290167	0.997834
[24 F] <sup>F</sup>	0.624757	0.100259	6.231434	1.000000
[24 F] <sup>F</sup> <sub>-1</sub>	-0.320743	0.138640	-2.313500	0.973798

Within-Sample Statistics

Sample size 43	Number of parameters 5
Mean 2076	Standard deviation 364.5
R-square 0.8498	Adjusted R-square 0.834
Durbin-Watson 1.852	Ljung-Box(18)=12.36 P=0.1718
Forecast error 148.5	BIC 173.7
MAPE 0.05227	RMSE 139.6
MAD 104.7	

The derivation of forecasts for [24]<sub>1999</sub> and [24]<sub>2000</sub> were then calculated as shown in Table 9.

**Table 9. Forecast Model for [24]**

	<b>[24] = Constant</b>		<b>[24]<sub>-1</sub></b>	<b>[23]</b>	<b>FFFY24</b>	<b>FFFY24[-1]</b>
	Coefficient					
	392.6801		0.422442	0.004031	0.624757	-0.320743
1997	2,089	1	2,297	131,055	1,109	1,137
1998	2,013	1	2,089	140,492	1,154	1,109
1999	<b>2,265</b>	1	2,013	152,990	1,240	1,154
2000	<b>2,409</b>	1	<b>2,265</b>	166,163	1,261	1,240
<hr/>						
	<b>Inflated [6]</b>					
1997	<b>2,130</b>					
1998	<b>2,078</b>					
1999	<b>2,373</b>					
2000	<b>2,575</b>					

From these estimates of [6] for 1999, [4] for 1999 was estimated as the difference between [4+6] and [6]  
 Which is equal to: **20,162**                      **Implying [22]<sub>1999</sub> = 19,244**

**Table 10. Forecast of [22].** The model chosen to forecast log [22]<sub>2000</sub> was:

	<b>Log [22] =</b>	<b>Constant</b>	<b>Log [22]<sub>-1</sub></b>	<b>Log [22]<sub>-2</sub></b>
	Coefficient			
		0.754991	1.520107	-0.594979
1997	9.9703	1	9.9691	9.9799
1998	9.9710	1	9.9703	9.9691
1999	9.8650	1	9.9710	9.9703
2000	9.8183	1	9.8650	9.9710

**Taking antilogs and deflating led to the series:**

	<b>[22]</b>	<b>[4]</b>
1997	21,381	21,798
1998	21,397	22,086
1999	19,244	20,162
2000	18,366	19,635

## Forecasting the Character Components of Industry R&D

Statistical analyses were done of the time trends in the percentages of R&D that were basic research and applied research for the industry R&D variables. More precisely, time-series analyses were done on the ratios:

- [46]/[4] (basic research as a percent of R&D in federally-financed industry-performed R&D);
- [47]/[5] (basic research as a percent of R&D in industry-financed industry-performed R&D);
- [48]/[6] (basic research as a percent of R&D in industry-administered FFRDCs);
- [88]/[4] (applied research as a percent of R&D in federally-financed industry-performed R&D);
- [89]/[5] (applied research as a percent of R&D in industry-financed industry-performed R&D);
- [90]/[6] (applied research as a percent of R&D in industry-administered FFRDCs);

With regard to these character of work components, the industry survey provided 1999 data only for components of [5], i.e., [47] and [89], and for [90] (a component of [6]) but not for the components of [4] or for other components of [6]. Consequently, the [47] and [89] character components of [5] needed to be forecast to 2000 only, while the other components needed both a 1999 and 2000 forecast.

Each of these ratios displayed a random walk process over time from 1964 to 1998 (or 1999 for [47]/[5] and [89]/[5] and [90]/[6]). Consequently, the ratios predicted for forecasted years were simply taken as the most currently observed ratios for the previous year. Below are the statistical analyses performed in Forecast Pro leading up to the estimated ratios used:

### Expert data exploration of dependent variable Percent [88]/[4]

---

Length 35 Minimum 11.313 Maximum 23.192  
Mean 14.545 Standard deviation 3.303

Classical decomposition (nonseasonal)  
Trend-cycle: 82.79% Irregular: 17.21%

Log transform recommended for Box-Jenkins.  
Series is too short to consider Box-Jenkins.  
Series is trended and nonseasonal.  
Recommended model: Exponential Smoothing

Forecast Model  
Simple exponential smoothing: No trend, No seasonality  
Confidence limits proportional to level

Component	Smoothing Weight	Final Value
Level	1.00000	11.469

---

### Within-Sample Statistics

---

Sample size 35	Number of parameters 1
Mean 14.54	Standard deviation 3.351

R-square 0.6396                      Adjusted R-square 0.6396  
 Durbin-Watson 1.797                Ljung-Box(18)=10.13 P=0.07256  
 Forecast error 2.012                BIC 2.086  
 MAPE 0.08651                        RMSE 1.983  
 MAD 1.332

Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
1999	11.469	14.362	2.893
2000	11.469	15.560	6.469

**Expert data exploration of dependent variable Percent [46]/[4]**

Length 35 Minimum 0.897 Maximum 6.004  
 Mean 2.127 Standard deviation 1.173

Classical decomposition (nonseasonal)  
 Trend-cycle: 67.28% Irregular: 32.72%

Log transform recommended for Box-Jenkins.  
 Series is too short to consider Box-Jenkins.  
 Series is trended and nonseasonal.  
 Recommended model: Exponential Smoothing

Forecast Model  
 Simple exponential smoothing: No trend, No seasonality  
 Confidence limits proportional to level

Component	Smoothing Weight	Final Value
Level	1.00000	6.0038

Within-Sample Statistics

Sample size 35                        Number of parameters 1  
 Mean 2.127                            Standard deviation 1.19  
 R-square 0.5304                        Adjusted R-square 0.5304  
 Durbin-Watson 1.888                Ljung-Box(18)=13.92 P=0.2657  
 Forecast error 0.8154                BIC 0.8455  
 MAPE 0.2273                            RMSE 0.8036

## Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
1999	6.004	10.211	4.207
2000	6.004	11.954	9.408

## Expert data exploration of dependent variable Percent [90]/[6]

Length 35 Minimum 10.000 Maximum 33.816  
Mean 20.354 Standard deviation 5.860

Classical decomposition (nonseasonal)  
Trend-cycle: 61.00% Irregular: 39.00%

Series is too short to consider Box-Jenkins.  
Series is stationary and nonseasonal.  
Recommended model: Exponential Smoothing

## Forecast Model

Simple exponential smoothing: No trend, No seasonality

Component	Smoothing Weight	Final Value
Level	1.00000	11.068

## Within-Sample Statistics

Sample size 35	Number of parameters 1
Mean 20.35	Standard deviation 5.946
R-square 0.5292	Adjusted R-square 0.5292
Durbin-Watson 1.888	Ljung-Box(18)=18.36 P=0.5679
Forecast error 4.08	BIC 4.23
MAPE 0.1388	RMSE 4.021
MAD 2.319	

## Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	11.068	22.794	18.540

## Expert data exploration of dependent variable [48]/[6]

---

Length 35 Minimum 6.187 Maximum 30.823  
Mean 12.692 Standard deviation 7.538

Classical decomposition (nonseasonal)  
Trend-cycle: 95.94% Irregular: 4.06%

Log transform recommended for Box-Jenkins.

Series is too short to consider Box-Jenkins.

Series is trended and nonseasonal.  
Recommended model: Exponential Smoothing

Forecast Model  
Simple exponential smoothing: No trend, No seasonality  
Confidence limits proportional to level

Component	Smoothing Weight	Final Value
Level	1.00000	27.334

### Within-Sample Statistics

---

Sample size 35	Number of parameters 1
Mean 12.69	Standard deviation 7.648
R-square 0.9	Adjusted R-square 0.9
Durbin-Watson 1.859	Ljung-Box(18)=7.888 P=0.01974
Forecast error 2.418	BIC 2.508
MAPE 0.1014	RMSE 2.384
MAD 1.412	

### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
1999	27.334	35.196	7.862
2000	27.334	38.452	17.579

## Expert data exploration of dependent variable [47]/[5]

---

Length 36 Minimum 3.396 Maximum 8.069  
Mean 5.028 Standard deviation 1.293

Classical decomposition (nonseasonal)

Trend-cycle: 88.18% Irregular: 11.82%

Log transform recommended for Box-Jenkins.

Choice is narrowed down to Box-Jenkins or exponential smoothing.

Exponential smoothing outperforms Box-Jenkins by 1.356 to 1.365 out-of-sample

Mean Absolute Deviation. I tried 21 forecasts up to a maximum horizon 6.

For Box-Jenkins, I used a log transform.

Series is trended and nonseasonal.

Recommended model: Exponential Smoothing

Simple exponential smoothing: No trend, No seasonality

Confidence limits proportional to level

Component	Smoothing Weight	Final Value
Level	0.94375	7.9930

### Within-Sample Statistics

---

Sample size 36	Number of parameters 1
Mean 5.028	Standard deviation 1.311
R-square 0.7423	Adjusted R-square 0.7423
Durbin-Watson 2.012	Ljung-Box(18)=17.7 P=0.5242
Forecast error 0.6655	BIC 0.6896
MAPE 0.07353	RMSE 0.6561
MAD 0.4029	

### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	7.993	9.817	1.824

## Expert data exploration of dependent variable [89]/[5]

---

Length 36 Minimum 19.176 Maximum 26.934  
Mean 22.757 Standard deviation 1.571

Classical decomposition (nonseasonal)  
Trend-cycle: 68.34% Irregular: 31.66%

Choice is narrowed down to Box-Jenkins or exponential smoothing.

Exponential smoothing outperforms Box-Jenkins by 1.326 to 1.370 out-of-sample Mean Absolute Deviation. I tried 21 forecasts up to a maximum horizon 6. Series is trended and nonseasonal.  
Recommended model: Exponential Smoothing

Forecast Model  
Simple exponential smoothing: No trend, No seasonality

Component	Smoothing Weight	Final Value
Level	0.72500	19.925

---

### Within-Sample Statistics

---

Sample size 36	Number of parameters 1
Mean 22.76	Standard deviation 1.593
R-square 0.5147	Adjusted R-square 0.5147
Durbin-Watson 2.057	Ljung-Box(18)=10.13 P=0.07237
Forecast error 1.11	BIC 1.15
MAPE 0.03497	RMSE 1.094
MAD 0.7834	

### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	19.925	22.179	2.254

## Final Analysis of Character-of-Work Components

These ratios were then applied to the forecasted total R&D expenditure variables – [4],[5], and [6] – to get estimates of their character-of-work components. That is:

$$[46 f]_{1999} = [4 f]_{1999} \{[46]/[4]\}_{1999}, \dots, [90 f]_{2000} = [6]_{2000} \{[90]/[6]\}_{2000}$$

Given these forecasts of [46], [47], [48], [88], [89], and [90], forecasts of the development components of industrial R&D performance were taken as simply the difference between the R&D figures and the sum of the basic research and applied research components. In other words:

$$\begin{aligned} [130]_t &= [4]_t - [46]_t - [88]_t \\ [131]_t &= [5]_t - [47]_t - [89]_t \\ [132]_t &= [6]_t - [48]_t - [90]_t . \end{aligned}$$

## Section 7. Recently-reported Academic R&D and Academic Basic Research

Annually recently-reported and updated data on R&D at universities and colleges, and at university and college administered FFRDCs, by fiscal year, are taken from the *Survey of Academic Research and Development Expenditures*, at <http://nsf.gov/sbe/srs/rdexp/start.htm>. However, as shown below, the survey, and its corresponding report, provides only observations on total R&D performance by academia and by financial source ([8 r]<sup>F</sup>, [9 r]<sup>F</sup>, . . . , [13 r]<sup>F</sup>), and observations on basic research from all sources ([49]<sup>F</sup>) and basic research supported by the Federal government ([50]<sup>F</sup>, [55]<sup>F</sup>). All of the other character-of-work components of academic R&D, by source, are estimated, as detailed below in Section 8. Table 11 displays the data that are obtainable directly from the report *Academic Research and Development Expenditures*. One exception, noted in Table 11, is that there are some missing data in the *Academic R&D* report for the year 1978, which had to be inherited from previous reports. (Though there is no other “inherited” academic data, the “h” cells for academic R&D that were not previously highlighted are done so now, to indicate completeness.)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the National Patterns and Science and Engineering Indicators reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the National Patterns Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision / forecast			[4 rF]			[6 rF]															[79 fB]	
Applied / revision / forecast								[92 rF]					[97 rF]									[121 fB]
Develop. / revision / forecast								[134 rF]					[139 rF]									[163 fB]
								[134 fF]					[139 fF]									

**Table 11. Data taken directly from the report, *Academic Research and Development Expenditures: 1999\****

Fiscal Year	[8 r] <sup>F</sup>	[9 r] <sup>F</sup>	[10 r] <sup>F</sup>	[11 r] <sup>F</sup>	[12 r] <sup>F</sup>	[13 r] <sup>F</sup>	[49 r] <sup>F*</sup>	[50 r] <sup>F*</sup>	[55 r] <sup>F*</sup>
1953	138	37	19	35	26	121	110		33
1954	160	42	22	38	28	141	136		39
1955	169	47	25	41	30	180	159		49
1956	213	53	29	43	34	194	200		51
1957	229	60	34	49	38	240	240		65
1958	254	68	39	53	42	293	281		78
1959	306	76	39	58	47	338	343		92
1960	405	85	40	64	52	360	433		97
1961	500	95	40	70	58	410	536		115
1962	613	106	40	79	66	470	659		136
1963	760	118	41	89	73	530	814		159
1964	917	132	40	103	83	629	1,003		191
1965	1,073	143	41	124	93	629	1,138		208
1966	1,261	156	42	148	108	630	1,303		227
1967	1,409	164	48	181	119	673	1,457		250
1968	1,572	172	55	218	132	719	1,650		276
1969	1,600	197	60	223	145	725	1,711		275
1970	1,647	219	61	243	165	737	1,796		269
1971	1,724	255	70	274	177	716	1,914		260
1972	1,795	269	74	305	187	753	2,022	1,420	244
1973	1,985	295	84	318	202	817	2,053	1,454	296
1974	2,032	308	95	368	219	865	2,153	1,523	390
1975	2,288	332	113	417	259	987	2,410	1,695	439
1976	2,512	364	123	446	285	1,147	2,549	1,841	512
1977	2,726	374	139	514	314	1,384	2,800	2,007	600
1978	3,059	414	170	623	359	1,717	3,133	2,221	867
1979	3,598	472	193	735	368	1,935	3,619	2,577	1,022
1980	4,098	491	236	835	403	2,246	4,036	2,861	1,132
1981	4,571	546	291	1,004	435	2,486	4,594	3,260	1,270
1982	4,768	616	337	1,111	491	2,479	4,879	3,402	1,327
1983	4,989	626	389	1,302	576	2,737	5,303	3,547	1,484
1984	5,431	690	475	1,411	613	3,150	5,733	3,830	1,690
1985	6,064	752	560	1,617	694	3,523	6,556	4,343	1,765
1986	6,712	915	700	1,869	732	3,895	7,493	4,868	1,876
1987	7,343	1,023	790	2,168	828	4,206	8,393	5,375	2,033
1988	8,193	1,106	872	2,356	935	4,531	8,894	5,678	2,245
1989	8,991	1,224	994	2,698	1,071	4,730	9,792	6,195	2,352
1990	9,638	1,324	1,127	3,006	1,191	4,832	10,643	6,648	2,428
1991	10,234	1,474	1,204	3,367	1,307	5,078	11,606	7,127	2,595
1992	11,092	1,491	1,279	3,547	1,409	5,247	12,516	7,718	2,843
1993	11,956	1,559	1,360	3,589	1,486	5,295	13,303	8,398	2,938
1994	12,644	1,553	1,422	3,826	1,574	5,271	13,981	8,874	2,998
1995	13,326	1,689	1,488	4,046	1,613	5,363	14,802	9,394	2,742
1996	13,833	1,810	1,605	4,169	1,618	5,380	15,471	9,862	2,580
1997	14,300	1,906	1,729	4,691	1,711	5,440	16,587	10,308	2,683
1998	15,131	1,946	1,894	5,000	1,868	5,531	17,442	10,908	2,636
1999	16,047	2,028	2,048	5,366	2,000	5,646	18,844	11,808	2,734

\*In the case of [49], [50] and [55], data for FY 1978 were not provided. These three figures, provided in this table, were taken from earlier *National Patterns* reports.

## Section 8. Forecasting Academic R&D, and Basic Research as a Percent of R&D, for FY 1999-2001

### Forecasts of [8], [9], [10], [11], and [12] --What had been done historically, for future reference

In the previous round of generating National Patterns data, as opposed to the one currently being documented, in addition to the data directly available from the academic survey, which went up to 1998, a partial sample of comparable data was available for the year 1999. This partial sample became available to NSF after the 1998 survey data were complete, but before the 1999 survey data were complete. In the sample, various institutions reported their R&D expenditure levels for both 1998 and 1999, allowing for an estimate of the proportional increase in R&D (in nominal terms) by all academic institutions between the two years. Data from the sample are provided in Table 12. As the table indicates, Federally supported, academic R&D appears to increase by a factor of 1.060 between 1998 and 1999, and nonfederally supported, academic R&D by a factor of 1.067. Therefore, the following estimates were made for 1999 figures:  $[8 f]_{1999}^F = 1.060 [8 f]_{1998}^F$ ; and  $[X f]_{1999}^F = 1.067 [X f]_{1998}^F$  for all  $X = 9, 10, 11,$  and  $12$ .

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits	
	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																						
<b>R&amp;D / revision</b>			[4 rf]			[6 rf]																
/ forecast																					[79 fB]	
<b>Applied / revision</b>									[92 rF]						[97 rF]							
/ forecast									[92 fF]						[97 fF]						[121 fB]	
<b>Develop. / revision</b>									[134 rF]						[139 rF]							
/ forecast									[134 fF]						[139 fF]						[163 fB]	

**Table 12. Previous Round Imputation of Percent Increase in Academic R&D from 1998 to 1999**

	FY 1998	FY 1999
<b>Total R&amp;D in thousands of dollars from partial, matched sample:</b>		
Public Doctorate-granting Academic Institutions	16,442,537	17,535,238
Private Doctorate-granting Academic Institutions	8,139,212	8,647,954
Public Masters-granting Academic Institutions	210,493	210,194
Private Masters-granting Academic Institutions	56,130	30,091
Public Other degree-granting Academic Institutions	33,651	30,992
Private Other degree-granting Academic Institutions	24,146	23,237
<b>Total</b>	24,906,169	26,477,706
<b>Federal Support</b>		
Public Doctorate-granting Academic Institutions	8,527,877	9,126,751
Private Doctorate-granting Academic Institutions	5,925,896	6,241,988
Public Masters-granting Academic Institutions	129,291	124,346
Private Masters-granting Academic Institutions	39,486	19,895
Public Other degree-granting Academic Institutions	30,225	28,080
Private Other degree-granting Academic Institutions	15,059	13,219
<b>Total</b>	14,667,834	15,554,279
<b>Factor of Increase</b>		<b>1.060</b>
<b>Non-Federal Support</b>		
<b>Total</b>	10,238,335	10,923,427
<b>Factor of Increase</b>		<b>1.067</b>

A separate time-trend analysis was then done on the each of the variables [8], [9], [10], [11] and [12] using the available fiscal year data from 1953 to 1998 and the 1999 imputation estimate described above.

**Most Recent Round:**

In the most recent round of Academic data, however, actual observed values for FY 1999 (for the above-mentioned variables) were available, but no partial data were available for FY 2000 (given that the most recent calculations were made in March 2001).

The software package used to perform these analyses was Forecast Pro. Displayed below is the output of the Forecast Pro program, which provides forecasts for each of these variables. Forecasts were taken up to, and including, fiscal year 2001, which, as in the case with Federal funds, was needed in order to convert the data to a calendar-year basis up to calendar year 2000.

As indicated in the table, the software’s “expert data exploration” recommended an autoregressive integrated moving average (ARIMA) model (also known as a “Box-Jenkins” model.) for forecasting each variable, though the optimal ARIMA parameters (the number of autoregressive terms, the number of moving average terms, and the number of the differences taken before the analysis) differed between the variables. In these estimations, these variables were seen as independent enough to warrant their own time-trend behavior, given that each represented funding of academic research from a different type of source (or type of institution), and such differences in sources could warrant general differences in behavior. Table 13, below,

presents the final outcome of these forecasts. These numbers were conveniently provided by Forecast Pro based on the ARIMA models that were fitted.

### Output from Forecast Pro Analysis of [8]<sup>F</sup>, [9]<sup>F</sup>, [10]<sup>F</sup>, [11]<sup>F</sup> and [12]<sup>F</sup>

#### Expert data exploration of dependent variable [8]<sup>F</sup>

---

Length 47 Minimum 138.000 Maximum 16047.000  
Mean 4772.468 Standard deviation 4797.879

Classical decomposition (nonseasonal)  
Trend-cycle: 99.86% Irregular: 0.14%

Square root transform recommended for Box-Jenkins.  
Very low irregularity suggests Box-Jenkins.  
Series is trended and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for F8  
ARIMA(0,2,0) with square root transform

#### Within-Sample Statistics

---

Sample size 47	Number of parameters 0
Mean 116.9	Standard deviation 71.06
R-square 0.9993	Adjusted R-square 0.9993
Durbin-Watson 2.338	Ljung-Box(18)=18.65 P=0.5861
Forecast error 1.815	BIC 87.2
MAPE 0.03326	RMSE 122.4
MAD 84.95	

#### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	16989.918	17467.174	477.256
2001	17959.754	19065.895	1536.676

#### Expert data exploration of dependent variable [9]<sup>F</sup>

---

Length 47 Minimum 37.000 Maximum 2028.000  
Mean 634.511 Standard deviation 619.752

Classical decomposition (nonseasonal)  
Trend-cycle: 99.85% Irregular: 0.15%

Log transform recommended for Box-Jenkins.

Very low irregularity suggests Box-Jenkins.

Series is trended and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for F9

ARIMA(0,2,1) with log transform

Term	Coefficient	Std. Error	t-Statistic	Significance
b[1]	0.8183	0.0930	8.7992	1.0000

Within-Sample Statistics

Sample size 47	Number of parameters 1
Mean 5.851	Standard deviation 1.21
R-square 0.999	Adjusted R-square 0.999
Durbin-Watson 2.013	Ljung-Box(18)=12.98 P=0.2074
Forecast error 0.03847	BIC 13.78
MAPE 0.02765	RMSE 37.58
MAD 20.7	

Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	2138.415	2307.822	169.407
2001	2254.842	2537.304	420.882

### Expert data exploration of dependent variable [10]<sup>F</sup>

Length 47 Minimum 19.000 Maximum 2048.000  
Mean 480.340 Standard deviation 600.031

Classical decomposition (nonseasonal)

Trend-cycle: 99.84% Irregular: 0.16%

Log transform recommended for Box-Jenkins.

Very low irregularity suggests Box-Jenkins.

Series is trended and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for F10

ARIMA(0,2,1) with log transform

Term	Coefficient	Std. Error	t-Statistic	Significance
b[1]	0.4405	0.1314	3.3530	0.9983

### Within-Sample Statistics

-----  
Sample size 47                      Number of parameters 1  
Mean 5.176                           Standard deviation 1.52  
R-square 0.999                       Adjusted R-square 0.999  
Durbin-Watson 2.027                Ljung-Box(18)=15.37 P=0.3638  
Forecast error 0.04857              BIC 8.857  
MAPE 0.03748                       RMSE 21.9  
MAD 13

### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	2218.044	2442.136	224.092
2001	2402.206	2871.095	653.222

### Expert data exploration of dependent variable [11]<sup>F</sup>

-----  
Length 47    Minimum 35.000    Maximum 5366.000  
Mean 1336.957    Standard deviation 1587.996

Classical decomposition (nonseasonal)  
Trend-cycle: 99.93%    Irregular: 0.07%

Log transform recommended for Box-Jenkins.

Very low irregularity suggests Box-Jenkins.

Series is trended and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for F11  
ARIMA(0,2,1) with log transform

Term	Coefficient	Std. Error	t-Statistic	Significance
b[1]	0.6366	0.1173	5.4250	1.0000

### Within-Sample Statistics

-----  
Sample size 47                      Number of parameters 1  
Mean 6.181                           Standard deviation 1.634  
R-square 0.9993                       Adjusted R-square 0.9993  
Durbin-Watson 1.961                Ljung-Box(18)=9.825 P=0.06252  
Forecast error 0.04459              BIC 22.21  
MAPE 0.03284                       RMSE 81.73  
MAD 40.47

## Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	5758.613	6290.576	531.962
2001	6179.953	7175.735	1433.213

## Expert data exploration of dependent variable [12]<sup>F</sup>

Length 47 Minimum 26.000 Maximum 2000.000  
Mean 558.809 Standard deviation 593.947

Classical decomposition (nonseasonal)  
Trend-cycle: 99.91% Irregular: 0.09%

Log transform recommended for Box-Jenkins.

Very low irregularity suggests Box-Jenkins.

Series is trended and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for F12  
ARIMA(0,2,1) with log transform

Term	Coefficient	Std. Error	t-Statistic	Significance
b[1]	0.7918	0.0939	8.4333	1.0000

## Within-Sample Statistics

Sample size 47	Number of parameters 1
Mean 5.59	Standard deviation 1.353
R-square 0.9994	Adjusted R-square 0.9994
Durbin-Watson 1.907	Ljung-Box(18)=12.54 P=0.1816
Forecast error 0.03374	BIC 9.307
MAPE 0.02588	RMSE 30.68
MAD 17.23	

## Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	2132.698	2280.164	147.466
2001	2274.200	2525.629	371.993

<b>Fiscal Year</b>	<b>Basis of Forecast</b>	<b>[8]</b>	<b>[9]</b>	<b>[10]</b>	<b>[11]</b>	<b>[12]</b>
1999	Most Recent observed data	16,047	2,028	2,048	5,366	2,000
2000	ARIMA (using Forecast Pro)	<b>16,990</b>	<b>2,138</b>	<b>2,218</b>	<b>5,759</b>	<b>2,133</b>
2001	ARIMA (using Forecast Pro)	<b>17,960</b>	<b>2,255</b>	<b>2,402</b>	<b>6,180</b>	<b>2,274</b>

### Basic-Research to R&D Ratios for Federally-supported and Nonfederally-supported R&D

Additional forecasts were done on two ratios:

$B^F$  = the ratio of federally-supported basic research performed by academia to all federally-supported R&D by academia =  $[50]/[8]$ .

$B^{NF}$  = the ratio of nonfederally-supported basic research performed by academia to all nonfederally supported R&D by academia  $\{[49]-[50]\}/\{[7]-[8]\}$

The output displays the results from Forecast Pro on these ratios, for which Forecast Pro, again, prescribed ARIMA models. These forecasts were based on the data series for  $B^F$  and  $B^{NF}$  from 1953 to 1999, generated from the historical data and updated Academic Survey data. The entire series for  $B^F$  and  $B^{NF}$  are provided below in Table 15.

**Table 14. Output from Forecast Pro Analysis of  $B^F$  and  $B^{NF}$**

**Expert data exploration of dependent variable  $B^F$**

-----

Length 47 Minimum 52.899 Maximum 83.751  
Mean 72.423 Standard deviation 6.013

Classical decomposition (nonseasonal)  
Trend-cycle: 91.07% Irregular: 8.93%

Choice is narrowed down to Box-Jenkins or exponential smoothing.

Box-Jenkins outperforms exponential smoothing by 0.894 to 1.133 out-of-sample Mean Absolute Deviation. I tried 21 forecasts up to a maximum horizon 6.

Series is stationary and nonseasonal.

Recommended model: Box-Jenkins

Forecast Model for BAS\_F8  
ARIMA(1,0,0)

Term	Coefficient	Std. Error	t-Statistic	Significance
a[1]	0.9930	0.0108	92.0691	1.0000
_CONST	0.5076			

#### Within-Sample Statistics

Sample size	47	Number of parameters	1
Mean	72.42	Standard deviation	6.078
R-square	0.883	Adjusted R-square	0.883
Durbin-Watson	1.634	* Ljung-Box(18)=34.57	P=0.9893
Forecast error	2.079	BIC	2.143
MAPE	0.01942	RMSE	2.057
MAD	1.386		

#### Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	73.576	77.607	4.031
2001	73.568	79.249	8.989

#### Expert data exploration of dependent variable B<sup>NF</sup>

Length 47 Minimum 31.624 Maximum 72.809  
Mean 59.602 Standard deviation 8.366

Classical decomposition (nonseasonal)  
Trend-cycle: 93.06% Irregular: 6.94%

Choice is narrowed down to Box-Jenkins or exponential smoothing.

Exponential smoothing outperforms Box-Jenkins by 0.730 to 0.898 out-of-sample Mean Absolute Deviation. I tried 21 forecasts up to a maximum horizon 6.

Series is stationary and nonseasonal.

Recommended model: Exponential Smoothing

Forecast Model for BAS\_FN8  
Holt exponential smoothing: Linear trend, No seasonality

Component	Smoothing Weight	Final Value
Level	0.96378	61.474
Trend	0.27460	0.027457

Within-Sample Statistics

-----  
 Sample size 47                      Number of parameters 2  
 Mean 59.6                              Standard deviation 8.457  
 R-square 0.9441                      Adjusted R-square 0.9428  
 Durbin-Watson 1.954                Ljung-Box(18)=8.755 P=0.03485  
 Forecast error 2.022                BIC 2.147  
 MAPE 0.0263                         RMSE 1.978  
 MAD 1.527

Forecasted Values

Date    Forecast    97.5 Upper    97.5 Safety  
 -----  
 2000    61.502    65.710    4.208  
 2001    61.529    68.195    10.279

**Table 15. Time Series of  $B^F = [50]/[8]$  , and  $B^{NF} = \{[49]-[50]\}/\{[7]-[8]\}$**   
 (in percentages)

<b>Fiscal Year</b>	<b><math>B^F</math></b>	<b><math>B^{NF}</math></b>		<b>Fiscal Year</b>	<b><math>B^F</math></b>	<b><math>B^{NF}</math></b>
1953	52.899	31.624		1978	72.605	58.238
1954	56.250	35.385		1979	71.623	58.937
1955	60.947	39.161		1980	69.815	59.796
1956	61.033	44.025		1981	71.319	58.612
1957	67.686	46.961		1982	71.351	57.808
1958	70.079	50.990		1983	71.096	60.698
1959	73.856	53.182		1984	70.521	59.674
1960	73.827	55.602		1985	71.619	61.082
1961	76.400	58.555		1986	72.527	62.263
1962	78.467	61.168		1987	73.199	62.757
1963	80.263	63.551		1988	69.303	61.036
1964	83.751	65.642		1989	68.902	60.080
1965	81.920	64.589		1990	68.977	60.093
1966	79.937	64.978		1991	69.640	60.922
1967	79.773	65.039		1992	69.582	62.102
1968	79.580	69.151		1993	70.241	61.359
1969	79.938	69.120		1994	70.183	60.979
1970	78.689	72.674		1995	70.494	61.204
1971	78.248	72.809		1996	71.293	60.954
1972	79.109	72.096		1997	72.084	62.559
1973	73.249	66.630		1998	72.090	61.020
1974	74.951	63.636	<b>Forecast</b>	1999	73.584	61.493
1975	74.082	63.782	<b>Forecast</b>	2000	<b>73.576</b>	<b>61.502</b>
1976	73.288	58.128	<b>Forecast</b>	2001	<b>73.568</b>	<b>61.529</b>
1977	73.624	59.135				

The forecasts of  $B^F$  were used to estimate  $[50]^F$  for fiscal years 1999-2001, i.e.,

$$[50]^F_t = B^F_t [8]^F_t / 100 \quad \{\text{if } B^F \text{ is expressed as a percentage}\}$$

for  $t = 1999, 2000, \text{ and } 2001$ .

Likewise,

$$[49]^F_t = [50]^F_t + \{[49]-[50]\} = [50]^F_t + B^{NF}_t \{[7]^F_t - [8]^F_t\}$$

for  $t = 1999, 2000, \text{ and } 2001$ .

The variable [7], total academic R&D (excluding academically-administered FFRDCs), was simply calculated as the sum of its source-components: [8], [9], [10], [11], and [12].

## Section 9. Estimating and Forecasting the Character-of-Work Components of Academic R&D

### Nonfederal, Basic-research Components

The nonfederal components of academic basic research – [51], [52], [53] and [54] – were based on historical, inherited data up to 1979 (as shown in Section 1, Table 1). For 1980 and later years, they were estimated based on the simplifying assumption that all nonfederal, academic, basic research {[49]<sup>F</sup>-[50]<sup>F</sup>} is divided in the same proportions by nonfederal source as total R&D is divided by nonfederal source. For example, the fraction of nonfederal academic R&D supported by “nonfederal government”, by fiscal year, would be given by  $9^F / ([7]^F - [8]^F)$ . This same fraction was assumed to be the fraction of nonfederal basic research {[49]<sup>F</sup>-[50]<sup>F</sup>} attributable to nonfederal government. That is:

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision			[4 rf]			[6 rf]																
/ forecast																						[79 fB]
Applied / revision							[92 rF]						[97 rF]									
/ forecast							[92 fF]						[97 fF]									[121 fB]
Develop. / revision							[134 rF]						[139 rF]									
/ forecast							[134 fF]						[139 fF]									[163 fB]

$$[51]^F = \{[9]^F / ([7]^F - [8]^F)\} \{[49]^F - [50]^F\}$$

For instance, in 1980, approximately 25 percent of all nonfederally-supported R&D performed by academia (excluding academically-administered FFRDCs) were supported by nonfederal government. Therefore, it was assumed that 25 percent of all nonfederally-supported basic research performed by academia was supported by nonfederal government.

The same simplifying assumptions, but for the other nonfederal sources of academic basic research, were used as follows for all academic fiscal years beginning in 1980:

$$[52]^F = \{[10]^F / ([7]^F - [8]^F)\} ([49]^F - [50]^F)$$

$$[53]^F = \{[11]^F / ([7]^F - [8]^F)\} ([49]^F - [50]^F)$$

$$[54]^F = \{[12]^F / ([7]^F - [8]^F)\} ([49]^F - [50]^F).$$

### **Federal, “nonbasic” components**

The *Survey of Academic Research and Development Expenditures* does not provide splits for applied research and development – only for basic research versus nonbasic research – due partially to academic institutions being unaccustomed to distinguishing between applied research and development. Consequently, the survey only provides numbers for federally-supported “nonbasic R&D”, i.e.,  $\{[8]^F - [50]^F\}$ , or equivalently,  $\{[92]^F + [134]^F\}$ , and numbers for nonfederally-supported “nonbasic R&D”, i.e.,  $\{[7]^F - [8]^F\} - \{[49]^F - [50]^F\}$ , or equivalently,  $\{[91]^F - [92]^F\} + \{[133]^F - [134]^F\}$ .

In the case of federally-supported, nonbasic research, comparable data from the Federal Funds survey –  $[92 \text{ rF}]^F$  and  $[134 \text{ rF}]^F$  – was used as the source of the proportional split between applied research and development. (The variables  $[92 \text{ rF}]^F$  and  $[134 \text{ rF}]^F$  were first mentioned in Section 2.). Therefore, the following estimations were made for  $[92]^F$  and  $[134]^F$  for all fiscal years beginning in 1980:

$$[92]^F = \{[8]^F - [50]^F\} \{ [92 \text{ rF}]^F / \{ [92 \text{ rF}]^F + [134 \text{ rF}]^F \} \}$$

$$[134]^F = \{[8]^F - [50]^F\} \{ [134 \text{ rF}]^F / \{ [92 \text{ rF}]^F + [134 \text{ rF}]^F \} \}.$$

### **Nonfederal, nonbasic components**

Once all nonfederal components (by source) of academic R&D and academic basic research have been estimated, as described above, the source components of academic applied research *plus* academic development were known as well, since they make up the difference between R&D and basic research for each source. On the basis of survey information acquired by NSF, the estimation was made that applied research accounts for 82 percent

of each one of these source components, and thus development accounts for the other 18 percent. Hence, the following estimations were made for each fiscal year starting in 1980:

$$\begin{array}{ll} [93]^F = 0.82*([9]^F - [51]^F) & [135]^F = 0.18*([9]^F - [51]^F) \\ [94]^F = 0.82*([10]^F - [52]^F) & [136]^F = 0.18*([10]^F - [52]^F) \\ [95]^F = 0.82*([11]^F - [53]^F) & [137]^F = 0.18*([11]^F - [53]^F) \\ [96]^F = 0.82*([12]^F - [54]^F) & [138]^F = 0.18*([12]^F - [54]^F). \end{array}$$

Of course, all fiscal year estimates were converted to calendar year estimates, as described at the beginning of this report.

## Section 10. Completing the Estimates on University and College – Administered FFRDCs

### Total R&D and Basic Research

As indicated earlier, direct fiscal-year observations were obtainable from the *Survey of Academic Research and Development Expenditures* with regard to R&D performance and basic research performance at academically administered FFRDCs (variables [13] and [55] respectively). However, these observations ended in fiscal year 1999, and therefore, needed to be forecast to fiscal year 2001, in order to have calendar-year estimates ending in calendar year 2000. Symmetric with other analyses of R&D components, forecasting was done on the variable [13]<sup>F</sup>, and on [55]<sup>F</sup> as a percent of [13]<sup>F</sup>, i.e.,  $\{100[55]^F/[13]^F\}$ . Various statistical and econometric tests were run on these variables, again using the software package Forecast Pro. According to Forecast Pro diagnostics, the most-preferred forecasting model for each variable was an “exponential smoothing model”, as indicated in the Forecast Pro output displayed below. At the end of each of these output runs are the forecasted values for fiscal years 2000 to 2001. With regard to [55]<sup>F</sup> as a percent of [13]<sup>F</sup>, these estimates were then applied to [13]<sup>F</sup> in order to obtain estimates of [55]<sup>F</sup>, followed by conversion of the data to calendar years.

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision			[4 rF]			[6 rF]																
/ forecast																						[79 fB]
Applied / revision									[92 rF]				[97 rF]									
/ forecast									[92 fF]				[97 fF]									[121 fB]
Develop. / revision									[134 rF]				[139 rF]									
/ forecast									[134 fF]				[139 fF]									[163 fB]

**Output from Forecast Pro Regarding the Time-Trend Analysis of [13]**

Holt exponential smoothing: Linear trend, No seasonality  
 Confidence limits proportional to level

Component	Smoothing Weight	Final Value
Level	1.00000	5646.0
Trend	0.68746	103.63

Within-Sample Statistics

Sample size 47	Number of parameters 2
Mean 2243	Standard deviation 2014
R-square 0.9983	Adjusted R-square 0.9983
Durbin-Watson 1.862	Ljung-Box(18)=18.54 P=0.5796
Forecast error 83.17	BIC 88.32
MAPE 0.04626	RMSE 81.38
MAD 58.61	

Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	5749.634	6494.541	744.906
2001	5853.269	7314.411	2136.005

**Output from Forecast Pro Regarding the Time-Trend Analysis of {100[55]<sup>F</sup>/[13]<sup>F</sup>}**

Length 47 Minimum 26.289 Maximum 56.877  
 Mean 41.695 Standard deviation 10.087

Classical decomposition (nonseasonal)  
 Trend-cycle: 98.30% Irregular: 1.70%

Choice is narrowed down to Box-Jenkins or exponential smoothing.

Exponential smoothing outperforms Box-Jenkins by 4.326 to 4.326 out-of-sample Mean Absolute Deviation. I tried 21 forecasts up to a maximum horizon 6.

Series is trended and nonseasonal.

Recommended model: Exponential Smoothing

Forecast Model for F55pct

Simple exponential smoothing: No trend, No seasonality

Component	Smoothing Weight	Final Value
Level	1.00000	5646.0
Trend	0.68746	103.63

Level 1.00000 48.424

Within-Sample Statistics

-----  
 Sample size 47                      Number of parameters 1  
 Mean 41.7                              Standard deviation 10.2  
 R-square 0.94                         Adjusted R-square 0.94  
 Durbin-Watson 1.635                 Ljung-Box(18)=18.5 P=0.5771  
 Forecast error 2.498                 BIC 2.575  
 MAPE 0.03961                         RMSE 2.472  
 MAD 1.686

Forecasted Values

Date	Forecast	97.5 Upper	97.5 Safety
2000	48.424	53.471	5.047
2001	48.424	55.561	11.286

**Applied Research [97] and Development [139]**

The estimation of [97]<sup>F</sup> and [139]<sup>F</sup> involved a method symmetric to that of the estimation of [92]<sup>F</sup> and [134]<sup>F</sup> in Section 9. That is, the sum of these components were first derived as the difference between total R&D and basic research, i.e., {[13]<sup>F</sup>-[55]<sup>F</sup>}. This sum was then split according to the same proportions as the analogs of [97]<sup>F</sup> and [139]<sup>F</sup> in the Federal Funds Survey: [97 rF]<sup>F</sup> and [139 rF]<sup>F</sup>:

$$[97]^F = \{[13]^F - [55]^F\} \{[97 \text{ rF}]^F / \{[97 \text{ rF}]^F + [139 \text{ rF}]^F\}\}$$

$$[139]^F = \{[13]^F - [55]^F\} \{[139 \text{ rF}]^F / \{[97 \text{ rF}]^F + [139 \text{ rF}]^F\}\}$$

As for other fiscal year variables, estimates were made for 2000 to 2001, allowing for calendar estimates to 2000.

## Section 11. Estimating R&D in the Nonprofit Sector

The greater a sector's involvement in National R&D performance, in terms of amount of money spent, the more resources were devoted to surveying that sector, in an effort to capture the most accurate information about National R&D, given the available survey resources. Along these lines, because the nonprofit sector has been the smallest sector in terms of R&D, it has not warranted continual, annual surveys of its R&D performance. As indicated in Section 2, nonprofit R&D based on Federal support, and R&D at nonprofit-administered FFRDCs, have been obtained from the Federal Funds survey. Nonprofit R&D performance supported by industry funds and by funds from the nonprofit sector itself, however, could only be obtained from surveys of the nonprofit sector. Because few such surveys were conducted, estimates based on imputations were made for the years in which surveys of the nonprofit sector were not conducted.

The historical/inherited data for nonprofits contain some of those estimates, going up to calendar year 1973, which were provided in Section 1. This section will provide data for subsequent years, regarding nonprofit R&D performance (and its character-of-work-components) supported by industry and nonprofit funding.

Performing sector:	Total U.S.	Federal Govt.	Industry				Industry FFRDCs	Universities & colleges					U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]		[37 h]	[38 h]	[39 h]
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]		[37 r]	[38 r]	[39 r]
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]		[37 f]	[38 f]	[39 f]
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]		[40]	[41]	[42]
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]		[79 h]	[80 h]	[81 h]
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]		[79 r]	[80 r]	[81 r]
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]		[79 f]	[80 f]	[81 f]
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]		[82]	[83]	[84]
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]		[121 h]	[122 h]	[123 h]
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]		[121 r]	[122 r]	[123 r]
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]		[121 f]	[122 f]	[123 f]
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]		[124]	[125]	[126]
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]		[163 h]	[164 h]	[165 h]
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]		[163 r]	[164 r]	[165 r]
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]		[163 f]	[164 f]	[165 f]
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]		[166]	[167]	[168]
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																				<b>From Budget of the United States</b>		
R&D / revision / forecast			[4 rf]			[6 rf]															[79 fB]	
Applied / revision / forecast									[92 rF]				[97 rF]									[121fB]
Develop. / revision / forecast									[134 rF]				[139 rF]									[163fB]

## Estimations and Forecasts of [16] and [17] for 1998-2000

The data in 1973 for these source-components of nonprofit R&D – [16] and [17] – were based on a survey done for that year, and may consequently be regarded as observations. The next *full* survey of the nonprofit sector was not done again until quite recently, for R&D in the years 1996 and 1997, though partial surveys had been conducted for the years 1981, 1982, and 1983. As indicated in the historical/inherited data,  $[16]_{1973} = \$105.00$  million, and  $[17]_{1973} = \$211.00$  million. According to the most recent survey of the nonprofit sector,  $[16]_{1996} = \$730.17$  million,  $[16]_{1997} = \$808.73$  million,  $[17]_{1996} = \$2,573.58$  million, and  $[17]_{1997} = \$2,803.59$  million. The average annual growth rate in [16] between 1973 and 1996 was therefore 8.80 percent, and the average annual growth rate in [17] over the same period was 11.49 percent.

The 1996-97 survey provided a new expenditures benchmark for R&D performance by NPOs which was higher than previous NSF estimates for this sector. For example, NSF staff estimated nonprofit R&D performance at \$5.6 billion for 1997 before the current survey data became available. These lower estimates were based on nonprofit data in other NSF R&D expenditures surveys. With the exception of Federal R&D funding to the nonprofit sector (see below), the new higher NSF estimates of nonprofit performance by source of funds, based on the results of the current nonprofit survey, are incorporated in National Patterns of R&D Resources: 2000 Data Update.

For an estimate of Federal funding in support of NPO R&D performance reported in the National Patterns, NSF will continue to rely on information provided by the Federal agencies that fund NPOs (as reported to the NSF Survey of Federal Funds for research and Development). In 1997, Federal agencies reported obligations of \$3.0 billion to NPOs and of \$0.8 billion to federally-funded research and development centers administered by NPOs. These amounts compare with the \$3.7 billion in Federal R&D funding reported by NPO performers on the current nonprofit R&D survey. The decision to use source-reported, rather than performer-reported, data in the National Patterns reports is because the Federal Funds survey is—and will continue to be—collected annually.

For the years in between 1973 and 1996, estimates of [16] and [17] were made based on the simplifying assumption that there was a constant rate of growth for these variables across time. That is:

$$\begin{aligned} [16]_{1973+m} &= [16]_{1973} \{ [16]_{1996} / [16]_{1973} \}^{m/23} && \text{for all integers } m, \quad 0 < m < 23 \\ [17]_{1973+m} &= [17]_{1973} \{ [17]_{1996} / [17]_{1973} \}^{m/23} && \text{for all integers } m, \quad 0 < m < 23 \end{aligned}$$

Table 18 displays the numbers associated with these estimates.

NOTE: Coincidentally, the new estimates for industry support for nonprofit performance [16] and for nonprofit support for nonprofit performance [17] resulted in figures that did not differ considerably from several of the previously published statistics. (For example, based on small surveys the previously published data for 1982 for [16] was \$250 million and for [17], \$525 million. The revised estimates are \$224 million and \$562 million, respectively.)

**Table 16. Estimates of [16] and [17] for 1974-1995, Based on the Assumption of Constant Growth Rates**

(millions of current dollars)				
Calendar Year	Observed Data from Surveys		Estimated Data	
	[16]	[17]	[16]	[17]
1973	105.00	211.00		
1974			114.24	235.24
1975			124.29	262.26
1976			135.22	292.39
1977			147.12	325.98
1978			160.06	363.43
1979			174.14	405.18
1980			189.46	451.73
1981			206.13	503.63
1982	250	525	224.26	561.49
1983			243.99	625.99
1984			265.46	697.90
1985			288.81	778.08
1986			314.22	867.47
1987			341.86	967.12
1988			371.94	1,078.23
1989			404.66	1,202.09
1990			440.26	1,340.19
1991			478.99	1,494.15
1992			521.13	1,665.80
1993			566.98	1,857.17
1994			616.86	2,070.53
1995			671.13	2,308.39
1996	730.17	2,573.58		
1997	808.73	2,803.59		

Calendar-year estimates and forecasts still had to be made for [16] and [17] for 1998-2000. In order to make these estimates and forecasts, possible leading indicators were considered for these variables.

Percent changes in industry funding to industry, i.e., percent changes in [5], appeared similar to percent changes in industry funding to nonprofits, [16]. Using the years 1996 and 1997 for data, an “elasticity” was estimated of changes in [16] with respect to changes in [5]:

:

$$\theta_{[16][5]} = \frac{\frac{[16]_{1997} - [16]_{1996}}{[16]_{1996}}}{\frac{[5]_{1997} - [5]_{1996}}{[5]_{1996}}} = 1.034$$

$$\theta_{[17][12]} = \frac{\frac{[17]_{1997} - [17]_{1996}}{[17]_{1996}}}{\frac{[12]_{1997} - [12]_{1996}}{[12]_{1996}}} = 1.195 \quad 59$$

Similarly, an elasticity was observed for changes in nonprofit funding to nonprofits, [17], with respect to nonprofit funding to academia, [12]:

Given estimates and forecasts for [5] and [12], for calendar years 1998-2000, these elasticities were used to generate estimates of [16] and [17] for the same years, as shown in Table 19.

### **Estimates and Forecasts of the Character-of-Work Components of [16] and [17]**

The character-of-work subdivisions for [16] (industry support to nonprofits) and [17] (nonprofit support for nonprofit R&D performance) for basic research and applied research are discussed in this section for 1973 to 2000 (excluding the inherited data). As was the case with other variables in the database, the development components were calculated as a last step, by default, as simply the difference between the total R&D variable and its basic research and applied research components. (That is, [142] = [16] – [58] – [100] ; [143] = [17] – [59] – [101].)

For 1973 to 1996, or for all  $i = 0, 1, \dots, 23$  for years  $1973 + i$  :

$$\{[58]/[16]\}_{1973+i} = \{[58]/[16]\}_{1973} + (i/23)\{ \{[58]/[16]\}_{1996} - \{[58]/[16]\}_{1973} \}$$

$$\{[59]/[17]\}_{1973+i} = \{[59]/[17]\}_{1973} + (i/23)\{ \{[59]/[17]\}_{1996} - \{[59]/[17]\}_{1973} \}$$

$$\{[100]/[16]\}_{1973+i} = \{[100]/[16]\}_{1973} + (i/23)\{ \{[100]/[16]\}_{1996} - \{[100]/[16]\}_{1973} \}$$

$$\{[101]/[17]\}_{1973+i} = \{[101]/[17]\}_{1973} + (i/23)\{ \{[101]/[17]\}_{1996} - \{[101]/[17]\}_{1973} \}$$

For 1998-2000, in the absence of additional information, these ratios are assumed to take on the same values they had 1997, according to the *Nonprofit Survey*. (See Table 18.) **Table 17. Estimation of [16] and [17] for 1998-2000**

(millions of current dollars)										
Calendar Year	Observed Data from Surveys		Elasticities		Percent Changes in		Estimated Percent Changes in		Estimated Values Based on Percent Changes	
	[16]	[17]	[16] with respect to [5]	[17] with respect to [12]	[5]	[12]	[16]	[17]	[16]	[17]
	1996	730	2,574							
1997	809	2,804	1.034	1.195						
1998					8.536	8.075	8.823	9.949	880	3,083
1999					10.531	6.843	10.885	8.144	969	3,326
2000					10.828	6.635	11.192	7.896	1,073	3,586

**Table 18. Percentage Splits of [16] and [17] for Basic Research and Applied Research**

Year	[58]/[16]	[59]/[17]	[100]/[16]	[101]/[17]
1973	46.667	42.654	34.286	39.336
1974	47.189	43.351	33.876	38.707
1975	47.711	44.047	33.467	38.078
1976	48.233	44.744	33.057	37.449
1977	48.756	45.441	32.648	36.820
1978	49.278	46.138	32.239	36.191
1979	49.800	46.834	31.829	35.562
1980	50.322	47.531	31.420	34.933
1981	50.845	48.228	31.010	34.304
1982	51.367	48.924	30.601	33.675
1983	51.889	49.621	30.191	33.046
1984	52.411	50.318	29.782	32.417
1985	52.934	51.015	29.372	31.788
1986	53.456	51.711	28.963	31.159
1987	53.978	52.408	28.554	30.530
1988	54.500	53.105	28.144	29.901
1989	55.023	53.801	27.735	29.272
1990	55.545	54.498	27.325	28.643
1991	56.067	55.195	26.916	28.014
1992	56.589	55.892	26.506	27.385
1993	57.112	56.588	26.097	26.756
1994	57.634	57.285	25.688	26.127
1995	58.156	57.982	25.278	25.498
1996	58.678	58.678	24.869	24.869
1997	55.524	55.524	25.343	25.343
1998	55.524	55.524	25.343	25.343
1999	55.524	55.524	25.343	25.343
2000	55.524	55.524	25.343	25.343

## Section 12. Final Constant-Dollar Conversions and Final Summations

The remaining exercises for the completion of the database are straightforward. All constant-dollar variables are converted from their nominal-variable equivalents using the GDP Implicit Price Deflator. (See the section, “Notation Used in This Report” and Section 5). For example, [20] = 100 [2] / [170], or more generally:

$$[X + 18] = 100 [X] / [170] \text{ for all } X \text{ such that } 0 < X < 19 \text{ OR } 42 < X < 61 \text{ OR } 85 < X < 103 \text{ OR } 127 < X < 145.$$

Furthermore, as suggested by the table of *National Patterns* variables, the following sums are taken:

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Non-profit FFRDCs	Funding Sector:	Federal Govt.	Industry	Non-profits
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.2	Total	Federal Govt.	Nonfed. Govt.	Industry	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.	Performing Sector	Total	Total	Total
<b>Final R&amp;D Expenditure Data for the <i>National Patterns</i> and <i>Science and Engineering Indicators</i> reports</b>																						
<b>Total R&amp;D</b>																						
Historical	[1 h]	[2 h]	[3 h]	[4 h]	[5 h]	[6 h]	[7 h]	[8 h]	[9 h]	[10 h]	[11 h]	[12 h]	[13 h]	[14 h]	[15 h]	[16 h]	[17 h]	[18 h]	[37 h]	[38 h]	[39 h]	
Recently Reported	[1 r]	[2 r]	[3 r]	[4 r]	[5 r]	[6 r]	[7 r]	[8 r]	[9 r]	[10 r]	[11 r]	[12 r]	[13 r]	[14 r]	[15 r]	[16 r]	[17 r]	[18 r]	[37 r]	[38 r]	[39 r]	
Forecast Last Years	[1 f]	[2 f]	[3 f]	[4 f]	[5 f]	[6 f]	[7 f]	[8 f]	[9 f]	[10 f]	[11 f]	[12 f]	[13 f]	[14 f]	[15 f]	[16 f]	[17 f]	[18 f]	[37 f]	[38 f]	[39 f]	
Constant Dollars	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]	[36]	[40]	[41]	[42]	
<b>Basic Research</b>																						
Historical	[43 h]	[44 h]	[45 h]	[46 h]	[47 h]	[48 h]	[49 h]	[50 h]	[51 h]	[52 h]	[53 h]	[54 h]	[55 h]	[56 h]	[57 h]	[58 h]	[59 h]	[60 h]	[79 h]	[80 h]	[81 h]	
Recently Reported	[43 r]	[44 r]	[45 r]	[46 r]	[47 r]	[48 r]	[49 r]	[50 r]	[51 r]	[52 r]	[53 r]	[54 r]	[55 r]	[56 r]	[57 r]	[58 r]	[59 r]	[60 r]	[79 r]	[80 r]	[81 r]	
Forecast Last Years	[43 f]	[44 f]	[45 f]	[46 f]	[47 f]	[48 f]	[49 f]	[50 f]	[51 f]	[52 f]	[53 f]	[54 f]	[55 f]	[56 f]	[57 f]	[58 f]	[59 f]	[60 f]	[79 f]	[80 f]	[81 f]	
Constant Dollars	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]	[73]	[74]	[75]	[76]	[77]	[78]	[82]	[83]	[84]	
<b>Applied Research</b>																						
Historical	[85 h]	[86 h]	[87 h]	[88 h]	[89 h]	[90 h]	[91 h]	[92 h]	[93 h]	[94 h]	[95 h]	[96 h]	[97 h]	[98 h]	[99 h]	[100 h]	[101 h]	[102 h]	[121 h]	[122 h]	[123 h]	
Recently Reported	[85 r]	[86 r]	[87 r]	[88 r]	[89 r]	[90 r]	[91 r]	[92 r]	[93 r]	[94 r]	[95 r]	[96 r]	[97 r]	[98 r]	[99 r]	[100 r]	[101 r]	[102 r]	[121 r]	[122 r]	[123 r]	
Forecast Last Years	[85 f]	[86 f]	[87 f]	[88 f]	[89 f]	[90 f]	[91 f]	[92 f]	[93 f]	[94 f]	[95 f]	[96 f]	[97 f]	[98 f]	[99 f]	[100 f]	[101 f]	[102 f]	[121 f]	[122 f]	[123 f]	
Constant Dollars	[103]	[104]	[105]	[106]	[107]	[108]	[109]	[110]	[111]	[112]	[113]	[114]	[115]	[116]	[117]	[118]	[119]	[120]	[124]	[125]	[126]	
<b>Development</b>																						
Historical	[127 h]	[128 h]	[129 h]	[130 h]	[131 h]	[132 h]	[133 h]	[134 h]	[135 h]	[136 h]	[137 h]	[138 h]	[139 h]	[140 h]	[141 h]	[142 h]	[143 h]	[144 h]	[163 h]	[164 h]	[165 h]	
Recently Reported	[127 r]	[128 r]	[129 r]	[130 r]	[131 r]	[132 r]	[133 r]	[134 r]	[135 r]	[136 r]	[137 r]	[138 r]	[139 r]	[140 r]	[141 r]	[142 r]	[143 r]	[144 r]	[163 r]	[164 r]	[165 r]	
Forecast Last Years	[127 f]	[128 f]	[129 f]	[130 f]	[131 f]	[132 f]	[133 f]	[134 f]	[135 f]	[136 f]	[137 f]	[138 f]	[139 f]	[140 f]	[141 f]	[142 f]	[143 f]	[144 f]	[163 f]	[164 f]	[165 f]	
Constant Dollars	[145]	[146]	[147]	[148]	[149]	[150]	[151]	[152]	[153]	[154]	[155]	[156]	[157]	[158]	[159]	[160]	[161]	[162]	[166]	[167]	[168]	
<b>Data from the Survey of Federal Funds for Research and Development, Used to estimate some of the <i>National Patterns</i> Variables</b>																						
R&D / revision			[4 rf]			[6 rf]																
/ forecast																						[79 fB]
Applied / revision									[92 rF]					[97 rF]								
/ forecast									[92 fF]					[97 fF]								[121fB]
Develop. / revision									[134 rF]					[139 rF]								
/ forecast									[134 fF]					[139 fF]								[163fB]

$$[1+N] = [2+N] + [3+N] + [6+N] + [7+N] + [13+N] + [14+N] + [18+N]$$

$$[3+N] = [4+N] + [5+N]$$

$$[7+N] = [8+N] + [9+N] + [10+N] + [11+N] + [12+N]$$

$$[14+N] = [15+N] + [16+N] + [17+N]$$

$$[37+N] = [2+N] + [4+N] + [6+N] + [8+N] + [13+N] + [15+N] + [18+N]$$

$$[38+N] = [5+N] + [10+N] + [16+N]$$

$$[39+N] = [12+N] + [17+N]$$

for all  $N = 0, 42, 84,$  and  $126.$

## **Appendix A**

### **Original Survey Data Used To Impute Other Historical Data**

In each year from 1983 to the present there has been a survey of the industrial sector and one of the academic sector. However, in some of the prior years these surveys had been skipped entirely or have been incomplete in the sense of including measures of components like basic research. Likewise, complete surveys of the nonprofit sector had been carried out only in the years 1953-1957, 1964, 1966, 1969, 1973, and 2000. Based on additional information from partial surveys, from other resources, and from indirect data about R&D performance derived from data on R&D funding, the missing data had been imputed or estimated in the preparation of National Patterns reports during the 1970s and 1980s. These data estimates, along with the observed survey data, became the set of historical data presented above in the section, "Historical Data that are Inherited by Each New Report". Table A-1 below provides only the original data acquired directly from surveys for the years 1953-1983. Some of these data have since been supplemented and revised.

**Table A-1. Original survey data collected for 1953-1983**

(millions of current dollars)

Performing Sector:	Total U.S.	Federal govt.	Industry (including Industry-administered FFRDCs)			Universities & Colleges					U&C FFRDCs	Other Nonprofit institutions (including nonprofit-administered FFRDCs)			
			Total	Federal govt.	Industry	Total	Federal Govt.	Industry	U&Cs (incl. nonfederal govt)	Non-Profits		Federal govt.	Total	Federal govt.	Industry
<b>Total Research and Development</b>															
1953		1,010	3,630	1,430	2,200							108	54	26	28
1954	5,644	1,020	4,070			290	160	22	80	28	141	123			
1955		905	4,640									135			
1956		1,040	6,605	3,328	3,277							152			
1957		1,220	7,731	4,335	3,396							174	86	37	51
1958		1,374	8,389	4,759	3,630	456	254	39	121	42	293				
1959		1,640	9,618	5,635	3,983										
1960		1,726	10,509	6,081	4,428										
1961		1,874	10,908												
1962		2,098	11,464	6,435	5,029										
1963		2,279	12,630	7,270	5,360										
1964	18,854	2,838	13,512	7,720	5,792	1,275	917	40	235	83	629	600	433	55	112
1965		3,093	14,185	7,740	6,445										
1966	21,846	3,220	15,548	8,332	7,216	1,715	1,261	42	304	108	630	733	525	70	138
1967		3,396	16,385	8,365	8,020										
1968		3,494	17,429	8,560	8,869	2,149	1,573	55	390	131	719				
1969		3,503	18,308	8,451	9,857							870	616	93	161
1970		4,079	18,067	7,779	10,288	2,335	1,648	61	461	165	737				
1971		4,228	18,320	7,666	10,654										
1972		4,590	19,552	8,017	11,535	2,630	1,795	74	574	187	753				
1973	30,718	4,762	21,249	8,145	13,104	2,884	1,985	84	613	202	817	1,006	690	105	211
1974		4,911	22,887	8,220	14,667	3,023	2,032	96	677	218	865				
1975		5,354	24,187	8,605	15,582	3,409	2,288	113	749	259	987				
1976		5,769	26,997	9,561	17,436	3,729	2,512	123	810	284	1,147				
1977		6,012	29,825	10,485	19,340	4,067	2,726	139	888	314	1,384				
1978		6,811	33,304	11,189	22,115	4,625	3,059	170	1,037	359	1,717				
1979		7,417	38,226	12,518	25,708	5,361	3,595	194	1,198	374	1,935				
1980		7,632	44,505	14,029	30,467	6,061	4,096	238	1,326	401	2,246				
1981		8,425	51,810	16,382	35,428	6,845	4,561	293	1,555	436	2,486				
1982		9,141	58,650	18,483	39,512	7,324	4,759	339	1,735	491	2,479				
1983		10,582	65,268	20,542	42,861	7,883	4,980	388	1,936	579	2,737				
<b>Basic research</b>															
1953		101	151									46			
1954		102				136	90				39				
1955		90													
1956		104	253												
1957		122	271									82			
1958		126	295			281	178				78				
1959		173	320												
1960		160	376									131	80	21	30
1961		206	395												
1962		251	488	143	345										
1963		255	522	147	375										
1964		314	549	165	384	1,003	768				191				
1965		364	592	186	406										
1966		385	624	173	451	1,303	1,008				227				
1967		435	629	202	427										
1968		432	642	180	462	1,649	1,251				276				
1969		532	618	160	458										
1970		577	602	158	444	1,796	1,296				269				
1971		586	590	134	456										
1972		625	593	130	463	2,022	1,420				244				
1973	3,946	608	631	132	499	2,053	1,454				297	357	218		
1974		696	699	163	536	2,154	1,523				390				
1975		734	730	157	573	2,410	1,694				439				
1976		786	819	185	634	2,549	1,841				512				
1977		914	911	210	701	2,800	2,007				600				
1978		1,029													
1979		1,089	1,158	265	893	3,612	2,572				1,015				
1980		1,182				4,024	2,852				1,124				
1981		1,302	1,614	301	1,313	4,589	3,251				1,261				
1982		1,465				4,883	3,403				1,317				
1983		1,690	2,223	463	1,760	5,324	3,565				1,472				

**Table A-1. Original survey data collected for 1953-1983 (continued)**

(millions of current dollars)

Performing Sector:	Total U.S.	Federal govt.	Industry (including Industry-administered FFRDCs)			Universities & Colleges					U&C FFRDCs	Other Nonprofit institutions (including nonprofit-administered FFRDCs)			
Funding Sector:	Total U.S.	Federal govt.	Total	Federal govt.	Industry	Total	Federal Govt.	Industry	U&Cs (incl. nonfederal govt)	Non-Profits	Federal govt.	Total	Federal govt.	Industry	Non-Profits
<b>Applied research</b>															
1953															
1954						137	61				51				
1955															
1956			1,268												
1957			1,670										56		
1958			1,911			148	64				102				
1959			1,991												
1960			2,029									95			
1961			1,977												
1962			2,449	1,011	1,438										
1963		715	2,457	1,007	1,450										
1964		903	2,600	1,040	1,560	232	127				202				
1965		990	2,658	1,038	1,620										
1966		997	2,843	1,039	1,804	328	194				207				
1967		1,027	2,915	1,066	1,849										
1968		1,110	3,124	1,043	2,081	404	254				231				
1969		1,114	3,287	1,015	2,272										
1970		1,327	3,427	1,049	2,378	427	268				216				
1971		1,302	3,415	974	2,441										
1972		1,360	3,514	952	2,562	524	320				221				
1973	6,597	1,480	3,825	993	2,832	713	461				226	353	234		
1974		1,574	4,288	1,025	3,263	736	438				178				
1975		1,730	4,570	1,130	3,440	851	516				213				
1976		2,093	5,112	1,200	3,912	1,016	584				264				
1977		2,044	5,636	1,325	4,311	1,067	607				371				
1978		2,192													
1979		2,392	7,225	1,555	5,670										
1980		2,484													
1981		2,732	10,699	2,340	8,359										
1982		2,729													
1983		3,020	13,927	3,641	10,286										
<b>Development</b>															
1953															
1954						17	9				51				
1955															
1956			5,084												
1957			5,790										36		
1958			6,183												
1959			7,307			27	12				113				
1960			8,104												
1961			8,536												
1962			8,527	5,281	3,246										
1963		1,309	9,651	6,116	3,535										
1964		1,621	10,363	6,515	3,848	40	22				236				
1965		1,739	10,935	6,516	4,419										
1966		1,838	12,081	7,120	4,961	84	59				196				
1967		1,934	12,841	7,097	5,744										
1968		1,952	13,663	7,337	6,326	976	68				212				
1969		1,857	14,403	7,276	7,127										
1970		2,175	14,038	6,572	7,466	112	84				252				
1971		2,340	14,315	6,558	7,757										
1972		2,605	15,445	6,935	8,510	84	55				288				
1973	20,175	2,674	16,793	7,020	9,773	118	70				294	296	238		
1974		2,641	17,900	7,032	10,868	133	71				297				
1975		2,890	18,887	7,318	11,569	148	78				335				
1976		2,890	21,066	8,176	12,890	164	87				371				
1977		3,054	23,278	8,950	14,328	200	112				413				
1978		3,590													
1979		3,936	29,843	10,698	19,145										
1980		3,966													
1981		4,391	39,497	13,741	25,756										
1982		4,947													
1983		5,872	49,118	16,576	32,542										