

Session Number: Session 3  
Time: Tuesday, 26 August, AM

*Paper Prepared for the 30th General Conference of  
The International Association for Research in Income and Wealth*

**Portoroz, Slovenia, August 24-30, 2008**

R&D Satellite Accounts and Gross Fixed Capital Formation:  
Where Should the Asset Boundary be Drawn for Non-market R&D Activity?

Carol A. Robbins, Francisco Moris, and John Jankowski

For additional information please contact:

Carol A. Robbins  
Bureau of Economic Analysis  
U.S. Department of Commerce  
[Carol.robbs@bea.gov](mailto:Carol.robbs@bea.gov)

Francisco Moris  
Division of Science Resource Statistics  
National Science Foundation  
[fmorisor@nsf.gov](mailto:fmorisor@nsf.gov)

John Jankowski  
Division of Science Resource Statistics  
National Science Foundation  
[jjankows@nsf.gov](mailto:jjankows@nsf.gov)

**This paper is posted on the following website: <http://www.iariw.org>**

The views expressed in this paper are those of the authors and do not reflect the official positions of the Bureau of Economic Analysis or the National Science Foundation.

## **Abstract**

When R&D activity is treated as gross fixed capital formation in the national accounts, where should we draw the line between current expense and capital formation? Answering this question in both a conceptual and a practical manner has proved most challenging for non-market R&D producers, such as governments and nonprofit universities. We evaluate alternatives that can be implemented with internationally comparable data and propose that R&D activity which serves as a repeatedly used input to the production of government and other non-market output should be treated as asset-forming. Using data on U.S. federal budget expenditures for R&D activity sorted by economic objective, we find that about 84 percent of these expenditures fit the definition of gross fixed capital formation between 1981 and 2004. Using our proposed measure, the impact of treating R&D as gross fixed capital formation in the national accounts is an increase in the level of GDP of 2.7 percent. When all non-market R&D activity is treated as asset-forming, the level of GDP increases by 2.9 percent.

## **Frequently Used Abbreviations**

AUTM Association of University Technology Managers  
BEA Bureau of Economic Analysis, Department of Commerce  
DOE Department of Energy  
OECD Organization for Economic Co-operation and Development  
GBAORD government budget appropriations or outlays for R&D  
GDP gross domestic product  
GERD gross domestic expenditures for R&D  
GFCF gross fixed capital formation  
NASA National Aeronautics and Space Administration  
NIH National Institutes of Health  
NSF National Science Foundation  
R&D research and experimental development  
USPTO U.S. Patent and Trademark Office

## **A. Introduction**

The accounting treatment of research and development (R&D) expenditures is a topic of considerable international interest. Both financial accounting standards and national accounting standards are moving toward recognizing these expenditures as creating assets for their owners, rather than as viewing them as current expenses. The upcoming revision of the international guidelines for national accounting, the System of National Accounts, recommends that measures of R&D output, developed from R&D expenditures, be treated as investment, or gross fixed capital formation (GFCF).<sup>1</sup>

The reasons for recognizing expenditures for research and development and other intangibles as assets are compelling. These expenditures create inputs to production that increase future output and decrease future costs. They also create intellectual property that can be sold or licensed. As the national accounting community develops recommendations for recognizing R&D expenditures as capital forming assets, a key question emerges: Where should we draw the line between current expense and capital formation?

Answering this question in both a conceptual and a practical manner has proved most challenging for non-market R&D producers, such as governments and nonprofit universities. No consensus has emerged on what recommendations to use to determine how much of these non-market entities' R&D expenditures should be considered an asset.

Decisions about where to draw this line have a direct impact on the level of gross domestic product (GDP). Although the R&D activity of governments and nonprofit

---

<sup>1</sup> United Nations Statistical Commission (2008), SNA Revision Draft, paragraph 10.104

entities is already measured as part of GDP, when R&D is treated as GFCF, there is an additional flow to GDP from these newly recognized assets. This flow represents the value of the capital services generated from R&D assets.

In this paper, we evaluate several alternatives for drawing this line or boundary, focusing on indicators of ownership, economic benefits, basic research, and use of R&D as an input to the production of non-market output. We compare alternative estimates of investment (GFCF) in R&D for the federal government and the resulting impact on the level of GDP, based on data from the Bureau of Economic Analysis (BEA)'s R&D Satellite Account. We evaluate these alternatives with data on patenting and licensing income, as well as the results of interviews with technology transfer professionals from federal government agencies and large research universities.

We find that the production of non-market output approach and data on the economic objectives of federally-budgeted R&D expenditures provide the best estimate of the share of government R&D expenditures fitting the definition of an asset in the System of National Accounts (SNA). This alternative is developed using R&D expenditure data that are collected for almost all Organization for Economic Co-operation and Development (OECD) countries, and thus, comparable estimates can be prepared for cross-section analysis. Using these objectives, federal government GFCF totaled \$81.3 billion in 2004; this compares with a total estimate from BEA's 2007 R&D Satellite Account of \$96.6 billion when all federally-funded R&D is treated as GFCF.

In the sections that follow, we first review the different ways that R&D satellite accounts from different countries have interpreted the SNA definition of an asset and implemented the asset boundary for non-market R&D (Section B). Next, in Section C,

we evaluate data on federal government and university patenting and licensing to determine whether these data can be used to identify the portion of non-market R&D that is asset forming. We find that these data alone are insufficient to identify either effective ownership or economic benefits. In Sections D and E we turn to data collected for the U.S., which have been organized into categories for international comparability based on the Frascati Manual. In Section D we report the results of interviews with federal government and university technology transfer officials about the relationship between basic research expenditures and measures of intellectual property creation. This information is used to evaluate whether basic research for non-market producers should be excluded from R&D investment. In Section E, we use data on R&D expenditures by economic objective to develop a set of guidelines for asset-forming R&D for non-market producers. We propose that when a non-market entity finances or performs R&D to be used repeatedly as an input to the production of non-market output, this R&D activity fits the definition of an asset. Using estimates from BEA's R&D Satellite Account, we compare federal government R&D investment and impacts on the level of GDP across different options for the asset boundary for federally-funded R&D. In Section F we describe the availability of internationally comparable data for this type of estimate. We conclude the paper with a discussion of the limitations of cross-country comparisons using this method.

## **B. Background**

By way of background, in this section we review alternative interpretations of the asset boundary for R&D in experimental R&D satellite accounts produced to date. According to the SNA, assets serve a store of value and have two key characteristics:

- They have ownership rights enforceable by institutional units, either individually or collectively, and
- They provide economic benefits to their owner by holding or using them over a period of time.<sup>2</sup>

The requirement of economic benefits is captured in the 2008 SNA in the following way: “In principle, R&D that does not provide an economic benefit to its owner does not constitute a fixed asset (Paragraph 10.104).” For market producers, such as private businesses whose output is sold in the market, a consensus has emerged among national accountants that R&D that is purchased or performed for internal use should be treated as asset-forming.<sup>3</sup>

The status of the R&D activity of non-market producers has proved more difficult to reconcile. One perspective on this is that when these non-market producers give unrestricted access to knowledge they produce or finance, the definition of an asset may not be met for this freely available R&D. An alternative perspective emphasizes the collective benefits to the community at large from government-owned and other non-market assets; this perspective would therefore favor treating all the R&D activity of non-market producers as asset forming.<sup>4</sup>

The proposed methods for identifying economic benefits and effective ownership include: Directly surveying non-market producers about how they intend to

---

<sup>2</sup>SNA 1993, paragraph 13.12.

<sup>3</sup> As noted in Aspden (2008), at its last meeting in April 2008, the OECD task force on R&D and intellectual property agreed that: “As a general rule, all R&D purchased or produced on own account by market producers should be treated as GFCF.” Also, in a widely cited National Bureau of Economic Research paper, Corrado, Hulten and Sichel (2005) treat all industrial R&D as asset forming for the purposes of productivity analysis. For financial accounting, standards differ both internationally and based on whether the R&D has been performed internally or acquired.

<sup>4</sup> These views are more fully described in Aspden (2005).

use the R&D they perform or finance; examining patent data; using budget data for R&D expenditures based on economic objectives; and using existing data to exclude basic research expenditures for government and universities from GFCF.<sup>5</sup>

R&D data are collected for most OECD in these three categories:<sup>6</sup>

- Basic Research: experimental or theoretical work undertaken primarily to acquire new knowledge of underlying foundations of phenomena and observable facts, without any particular application or use in view.
- Applied Research: original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily toward a specific practical aim or objective.
- Experimental Development: directed toward producing new materials, products, and devices; installing new processes, systems, and services; or substantially improving those processes, systems, and services.

### **R&D Satellite Account Interpretations of the Asset Boundary**

The asset boundary for R&D activity has been implemented in experimental satellite accounts in at least two different ways-- the exclusion of non-market R&D and the exclusion of some form of basic research. A case against the capitalization of non-market R&D is found in de Haan and van Rooijen-Horsten of Statistics Netherlands:

“Knowledge created in the public domain misses any form of ownership. Although the government can be identified as the financer and performer of R&D, it is not necessarily true that the government is also the owner of this public knowledge. The comparison, made by some, with museums and public libraries is unjustified. Museums and libraries are access devices to knowledge which are clearly subject to ownership. They are (legally) owned by the government or by any other private institute. The owner could at any point in time decide to sell the asset or to levy access fees. This is simply impossible for knowledge once it has been made freely accessible to the public.”<sup>7</sup>

---

<sup>5</sup> Aspden (2008).

<sup>6</sup> OECD (2002).

<sup>7</sup> de Haan and van Rooijen-Horsten (2004).

These authors recommend that all non-market R&D be excluded from the asset boundary, except where it is patented or otherwise held exclusively by its user, such as the results of defense-related research. According to the work of de Haan and van Rooijen-Horsten, this exclusion accounted for 39 percent of the Netherlands total R&D output in 1999.

The Australian Bureau of National Statistics excluded pure basic research in its 2004 experimental R&D satellite account; this exclusion accounted for just over ten percent of R&D expenditures. Pure basic research is a subcomponent of basic research and emphasizes the absence of an economic motive: It is “carried out for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems or to transfer the results to sectors responsible for their application.”<sup>8</sup> However, most countries, including the U.S., do not collect this category of expenditures.

The experimental satellite accounts developed for Canada and the United Kingdom (UK) have thus far taken a more inclusive approach to this non-market R&D. Galindo-Rueda (2007) draws a parallel between the R&D that the government undertakes and with the treatment of toll-free roads in the SNA. This parallel is one of the reasons for treating government R&D activity as asset-forming in the UK Satellite Account. The 2008 Canadian Research and Development Satellite Account makes no separation for freely available R&D -- all is included as an asset. The conceptual reasons for this choice included societal ownership and the economic benefits to society of government-funded R&D (Statistics Canada (2008)). Thus far, BEA’s R&D Satellite Account has also included all R&D activity as GFCF.

---

<sup>8</sup> Frascati Manual (2002), paragraph 243.



### **C. Intellectual Property Indicators for Business, Government, and Universities**

This section review indicators of patenting and licensing income for both the U.S. federal government and universities and also compares them with similar indicators for market performers. Evaluated by intellectual property outcomes, government and university R&D activity do not produce patents and licensing income comparable to that of U.S. corporations. Using equivalent standards based on patenting and licensing income, the asset boundary for GFCF would exclude most federal and university R&D activity. However, in a series of interviews with technology transfer officials at federal government agencies, we find that these agencies are not using patenting and licensing income as the main measure of the value of their R&D activity. We also found that patenting was too narrow an indicator of whether the federal government agencies could control the results of their R&D activity.

#### **Patenting and Licensing Income**

Patenting of R&D results is an indicator that the owner anticipates economic benefit from the R&D activity, since the cost of acquiring and maintaining patent protection allows for technology licensing or subsequent sale. Thus, information about the extent of patenting for different sectors of the economy provides an indication of how R&D performers protect and plan to use the results of their R&D. Chart 1 shows the relative sector shares of R&D investment funding in 2004 based on BEA's 2007 R&D satellite account, and Chart 2 shows patents issued to U.S. owners based on U.S. Patent and Trademark Office (USPTO) data. With intramural and extramural R&D combined,

the federal government funded 31 percent of U.S. R&D investment in 2004. However, the federal government was issued less than one percent of the patents in that year.<sup>9</sup>

Chart 3 shows the distribution of patents across the agencies of the federal government for 2004, with the Department of Defense and the National Institutes of Health showing the most patent activity.

According to the USPTO, the share of total patents issued to universities made up just four percent of total patents, even though universities have been issued more patents than federal agencies in recent years. Chart 4 shows the time series of patents filed and issued to research universities based on data from the Association of University Technology Managers (AUTM). The rising trend of patents filed suggests that the share of patents issued to universities is likely to rise a bit further in coming years. Chart 5 shows the time series of licenses and invention disclosures from the same data source.

Licensing incomes received by federal agencies and universities are also a lower order of magnitude compared to U.S. corporations. While federal government funding of R&D investment was \$96.6 billion and intramural performance of R&D was \$25.2 billion in 2004, the licensing income for the inventions of federal agencies was \$96.8 million in 2003– the last year the federal government produced consolidated statistics for this measure.<sup>10</sup> Based on BEA’s R&D Satellite Account, universities and colleges funded \$8 billion of R&D investment and performed \$33 billion of R&D output in 2004. In the same year, according to AUTM data, the gross royalties these institutions received totaled slightly over \$1 billion.<sup>11</sup>

---

<sup>9</sup> This is for utility patents issued to U.S. owners. Utility patents are granted for non-obvious inventions with a practical application, and are the most common type of patent issued.

<sup>10</sup> Department of Commerce, Office of the Secretary, *2004 Summary Report of Federal Lab Transfer*.

<sup>11</sup> NSF SRS, Science and Engineering Indicators, 2008. Appendix table 5-42.

These direct measures of patenting and licensing income contrast with the metrics of U.S. corporations. Corporations funded 63 percent of U.S. R&D investment in 2004 (\$200.9 billion) and were issued 81 percent of the patents issued to U.S. owners.<sup>12</sup> Although economy-wide measures of corporate income from licensing are imprecise, U.S. corporate income from royalties provides an order-of-magnitude measure. This income was \$141 billion in 2004, according to U.S. Internal Revenue Service data, and about half of that can be attributed to the licensing of industrial technology and patents.<sup>13</sup> The U.S. company that is consistently issued the most patents –IBM– was issued 3651 patents in 2006, earned \$352 million in licensing and royalty-based fees, and reported \$6.1 billion in research development and engineering expenses.<sup>14</sup>

These differences between R&D effort and intellectual property outcomes suggest that government and university R&D activity is intended to be used quite differently from that of market producers. Viewed in terms of patents and licensing income alone, the benefits of the federal government’s R&D effort are not comparable to that of private business.

### **Mechanisms outside of patenting to maintain control of the results of R&D**

As part of the interviews we conducted for this project, we asked technology transfer officers at federal government agencies how their agencies maintained control of the results of R&D activity and how that R&D provided benefits to the government.

They described several means other than patenting to protect the results of their

---

<sup>12</sup> The U.S. corporate total includes the small amount of patents issued to nonprofits.

<sup>13</sup> Robbins (2008)., 2004 Royalty income from Internal Revenue Service, Statistics of Income Division, Returns of Active Corporations, Form 1120, Table 16--Balance Sheet, Income Statement, Tax, and Selected Other Items, by Major Industry.

<sup>14</sup> Financial data from the December 31, 2006 10-K filing with the United States Securities and Exchange Commission, patent statistic from the U.S. Patent Office.

intramural R&D activity; furthermore, they noted that the language of their contractual arrangements provided them with the use of the R&D produced by extramural performers. They also told us that R&D activity conducted to fulfill the mission of their federal agencies could be made freely available without diminishing its value to the agency.

Research exemptions from patent infringement liability provide a degree of protection for the results of federal agency R&D activity. For example, although the majority of the research conducted by Agricultural Research Service (ARS) at the U.S. Department of Agriculture (USDA) is put into the public domain, this approach does not limit the ability of the government to use the results of the research, according to an ARS technology transfer official. The intellectual property regime in the U.S. covering biological plant materials, the Plant Variety Act, provides a research exemption that specifically allows work in the public domain. In cases where the results of USDA-funded R&D are patented or licensed, the USDA reserves the right to have others use the research for non-commercial purposes. Outside of plant-related research, there has traditionally been a research exemption from patent infringement that allows patented inventions to be used for experimental purposes and in the regulatory process for testing of pharmaceuticals.<sup>15</sup>

Copyrighting, rather than patenting, often protects the new software products produced with R&D expenditures. In the US, federal government employees cannot hold copyrights on work created in the course of their government employment, but this provision does not apply to the Federally-funded Research and Development Centers

---

<sup>15</sup> For universities that engage in licensing activity, the research exemption may no longer provide protection from infringement, since a 2002 court decision has found this exemption to be inapplicable when an institution engages in any commercial activity (Baer (2006)).

(FFRDCS) that are operated to support federal agency goals. Taking into account the activity of these FFRDCS, more licenses are negotiated for copyrighted software and biological materials than for patents at the Department of Energy, according to a technology transfer official there.

In addition to these mechanisms, a series of technology transfer laws enacted in the U.S. since 1980 play an important role in maintaining the federal government's right to use the results of the R&D that it funds through extramural performers. These laws have provided a relatively consistent and well-defined set of intellectual property policies that can be understood to result in the simultaneous creation of two assets, an invention that can be patented and held as property by its performer, and a perpetual, royalty-free license allowing the federal agency that funds the R&D to use the resulting invention.<sup>16</sup>

The basic provisions of these laws are that universities, other non-profits, and small businesses must disclose inventions within two months to the federal agencies that fund their research projects. If the recipient chooses to assert ownership and to commercialize the invention, the recipient must notify the federal agency within two years from the invention disclosure. In exchange for title to the innovation, the recipient of federal funding must:

- attempt to commercialize the invention and manufacture substantially in the U.S, preferably licensing to small business when possible;
- provide the U.S. government with a royalty-free right to use the invention; and
- share royalties with the inventor.

These provisions cover grants as well as contracts. The law provides two additional provisions that provide additional rights to the federal government. The first is that the

---

<sup>16</sup> Stevenson-Wydler Act and the Patent and Trademark Law Amendments Act (better known as the Bayh-Dole Act)

funding agency is allowed, in “exceptional circumstances,” to decide to retain title. The second is that the funding agency may also exercise “march-in rights” that require compulsory licensing for reasons of health or safety.

Federal agency technology transfer officials repeatedly stressed that patenting and licensing income, alone, were insufficient indicators of either the ability of the federal government to effectively control the results of the R&D it funds or performs. Similarly, they did not view patenting and licensing income, alone, as representative of the value of federal R&D efforts.

#### **D. Basic Research as Non-asset-Forming R&D for Non-market Producers**

In this section, we evaluate the proposal that basic research expenditures for government and universities provide a reasonable measure of non-asset forming R&D activity. We focus on basic research expenditures and a conservative measure of benefits and intellectual property outcomes – patenting and licensing income. We evaluate this option based on the responses to interviews with technology transfer officials from universities and federal labs.

Chart 6 shows the time series of federal government R&D investment, as estimated in BEA’s R&D Satellite Account, and federal government investment adjusted to exclude basic research for the years 1981 to 2004. Compared with the Satellite Account estimate, excluding basic research would result in a level of federal R&D investment that was 27 percent smaller on average. Because the share of basic research in federal funds for R&D has been rising, the level of federal R&D investment in 2004 would be 39 percent lower. These data are shown in table 2.

To evaluate the accuracy of this exclusion, we looked for data linking R&D expenditures by type to outcome measures. A direct relationship between basic research expenditures and patenting would suggest that the exclusion of basic research from GFCF would not be appropriate. Federal agencies and large universities collect both types of data. In a series of interviews with technology transfer staff at nine large research universities and with the federal agencies involved in the largest shares of intramural basic research, we asked whether basic research expenditures directly resulted in patents, licensing income, and other forms of intellectual property for the agency. While there were differences in the nature of basic research across agencies and universities, the technology transfer officials responded that basic research obligations directly produced patents and licensing income, but it was not possible to quantify the link. They also indicated it was not possible to isolate R&D funding streams that did not produce patents and licensing income. For the agency that funds the largest amounts of basic research, we were told that basic research expenditures were more likely to produce patents than applied research and development expenditures.

Charts 7 and 8 show the federal government agencies that funded the largest amounts of R&D activity in 2004. Within the Department of Health and Human Services, the funder of the largest amount of basic research is the National Institutes of Health (NIH).<sup>17</sup> According to a technology transfer official there, basic research expenditures were more likely to produce patents than applied research expenditures or development expenditures because early stage research tends to form the basis for NIH

---

<sup>17</sup> Within the Department of Health and Human Services, the National Institutes of Health accounted for all but two million dollars of the Department's \$14.8 billion of obligations for basic research in 2004. Intramural basic research made up \$2.7 billion of the \$14.8 billion, and R&D performed by universities and nonprofit entities made up another \$10.6 billion. (NSF (2007)).

inventions. Thus patent protection tends to be in place before clinical trials. A clinical trial is one example of applied research that NIH would be involved in. Typically, if they filed a patent application, it would be based on pre-clinical research.

The Department of Energy's (DOE) Office of Science is another federal agency that funds and performs large amounts of basic research; an official there reported that patents and other inventions frequently result from basic research expenditures. Similarly, for NASA and the Department of Agriculture, basic research resulted in patents and licenses. Technology transfer officials at NASA noted that basic research, rather than applied research or development, can result in the most valuable licenses. The reason for this is that basic research more often produces inventions are fundamentally different from anything that came before. Except for the respondent from the Department of the Navy, none had tracking systems in place to link basic research expenditures directly to measures of patenting and licensing income.

We asked the same questions of technology transfer officials at large research universities and received similar responses to what we heard from federal agencies. Officials noted that at least some of patent portfolio or licensing income was undoubtedly associated with knowledge classified as basic research at the time of patenting or licensing execution. These officials noted that there was a skewed distribution of licensing outcomes: a particular technology or product line could account for as much as 90 percent of an institution's licensing income. However, none were able to quantify a relationship between these intellectual property outcomes and basic research based on available records.



Based on these interviews, it is clear that using basic research as a measure of non-asset forming R&D would exclude assets that are protected by patents, and would exclude R&D expenditures that provide licensing income. For this reason, limiting asset forming R&D expenditures for governments and universities to applied research and experimental development would underestimate GFCF. Although data are not available to quantify the relationship between R&D expenditures and intellectual property outcomes, given the variety of ways the federal agencies protect and use the results of their R&D activity, excluding basic research appears to us to be too blunt and inexact for use as the asset boundary.

#### **E. Using Objectives of Non-market R&D activity to Estimate Asset Formation**

In this section, we propose an asset boundary that focuses on gaining economic benefits through use as an input to production.<sup>18</sup> We use data on the economic objectives of federally-funded R&D expenditures to identify expenditures that are used in the production of non-market output, and thus are capital inputs to non-market production.

What specifically is this non-market production? We use the definition of the 1993 SNA, where “other non-market output” includes output that is produced by non-profit institutions or governments because either:

- “it is technically impossible to make individuals pay for collective services because their consumption cannot be monitored or controlled...” or
- Although they could charge, they “choose not to do so as a matter of social or economic policy. The most common examples are the provision of education or health services, free or at prices that are not economically significant, although other kinds of goods and services may also be supplied (SNA 1993, 6.49)”

---

<sup>18</sup> The Frascati Manual refers to these objectives as “socio-economic,” for simplicity we refer to them as economic objectives.

## **R&D activity and Non-market Output**

Although government agencies in the U.S. receive licensing income, we have found no evidence that this is the primary motivation of federal R&D programs. For universities and colleges, total licensing income is more substantial but is still unlikely to be the primary motivation of R&D. Aside from the potential for generating income directly, we identify three main reasons for the funding or performing of R&D by non-market producers: 1) to carry out a particular, well-specified mission that is part of the provision of non-market output, 2) to increase the supply of an undersupplied commodity-- publicly available knowledge, and 3) to serve as a catalyst to market performers that may lead to increased innovation and productivity growth.<sup>19</sup>

What are the economic benefits that these goals provide to the non-market producer? Clearly, there are direct economic benefits from R&D intended for repeated use to produce national defense, education, or health care; this type of R&D should be treated as GFCF for the non-market producer. The benefits from the other two objectives are indirect at best, unless R&D expenditures intended for these goals simultaneously provide intellectual property or income to the non-market producer. With this in mind, we propose some general guidelines for the boundary between GFCF and consumption of R&D output for non-market producers:

- Count as GFCF expenditures for R&D activity that provide a direct economic benefit to the non-market producer by lowering the cost or raising the quality or quantity of non-market output.
- Exclude from GFCF expenditures for R&D activity where the main purpose of the activity is something other than income or the production of non-market output. These exclusions include both R&D that is primarily intended to increase market sector innovation as well as R&D that is primarily intended to increase public knowledge without directly entering into further non-market production.

---

<sup>19</sup> Heisey, King, Rubenstein, and Shoemaker (2006).

The excluded R&D expenditures should be treated as consumption expenditures, rather than as GFCF.

The main purpose of this boundary is to allocate the R&D expenditures of non-market producers. In some cases, private businesses fund R&D in universities and other non-profit institutions in order to increase innovation or solve a technical problem. While our proposed guidelines exclude this R&D from non-market GFCF, these expenditures may well be considered a business purchase of R&D, and treated as GFCF for the business.

### **Parsing U.S. Federal R&D Budget Data by Economic Objectives**

In the US, the NSF provides data on federal government budget appropriations or outlays for R&D by economic objectives (GBAORD) to the OECD.<sup>20</sup> We use these data to parse the existing estimate of federal government investment (GFCF) in R&D from BEA's R&D Satellite Account into two components. One component fits the definition of GFCF described above, and a separate component, additions to public innovative and scientific knowledge, is outside the asset boundary for non-market R&D.

Table 1 shows several columns describing the mapping of objectives to GFCF that we used. The first two columns show the objectives and general information about what is intended to be included based on the Frascati Manual. The third column shows the federal agency budget components that NSF has allocated to each objective, and in parentheses, the percentage share for each objective in the data NSF reported to OECD for the year 2004. The column on the far right shows whether we have assigned this

---

<sup>20</sup> Available at OECD stat <http://stats.oecd.org/wbos/Index.aspx>

category to GFCF or excluded it. NA indicates the category is not applicable for the U.S. data.

Together, defense and health care are the two objectives that made up about three quarters of federal agency funds for R&D in 2004. Since defense is a government service that falls fully within the definition of non-market output, we classify this R&D as non-market GFCF.

Health-related R&D is more complicated: In the U.S., market entities, government entities, and private non-profit entities provide health services. Early stage research at government labs or universities may subsequently be incorporated into products that private businesses develop and market. Indeed, the goal of NIH-funded research is to create information that flows into the public knowledge base. We classify health-related R&D as an input to non-market output because the federal government pays for or provides a very large portion of health care through Medicare, Medicaid, the Veterans Administration, and the Armed Forces health services. Thus, improving quality or lowering costs directly benefit this non-market production.

The other objectives we assign to GFCF are also those where the government is either the main or only provider of services. These objectives include regulatory services, economic and health statistics, weather services, transportation planning, mapping, and other resources for navigation. Objectives mainly intended to increase publicly available knowledge, rather serve as inputs to non-market production, are identified for the U.S. as non-oriented research and exploration, and exploitation of space. Non-oriented research consists of NSF funding of extramural research, broadly

directed at promoting the progress of science,<sup>21</sup> and the R&D expenditures of the Department of Energy's Office of Science, which performs basic research in a wide number of scientific disciplines.<sup>22</sup> Most of NASA's budget is assigned to exploration and exploitation of space and excluded from GFCF. Although this could be viewed as a form of government production, NASA's objectives of the advancement of scientific knowledge about the universe, the solar system, and space travel fit better with additions to public scientific knowledge than to the production of nonmarket output.<sup>23</sup>

We also exclude the R&D activity primarily intended to increase industrial productivity, including agricultural productivity, from GFCF. For the small share that is agriculture-related (two percent in 2004), our best estimate based on examining budget data is that slightly under half of this category would be allocated to GFCF if these expenditures had been parsed by project rather than as larger aggregates. The main economic benefits of the promotion of agriculture, forestry, fisheries, and food production accrue to market producers rather than the production of non-market output. However, research devoted to food safety, human nutrition, environmental stewardship, and agricultural statistics would be inputs to the production of government services.<sup>24</sup>

---

<sup>21</sup> National Science Foundation, Strategic Plan, 2006  
[http://www.nsf.gov/pubs/2006/nsf0648/NSF-06-48\\_3.pdf](http://www.nsf.gov/pubs/2006/nsf0648/NSF-06-48_3.pdf)

<sup>22</sup> Department of Energy, Office of Science, Strategic Plan, 2004,  
[http://www.science.doe.gov/about/Strategic\\_Plan/Feb-2004-Strat-Plan-screen-res.pdf](http://www.science.doe.gov/about/Strategic_Plan/Feb-2004-Strat-Plan-screen-res.pdf)

<sup>23</sup> NASA FY 2006 Budget Request. Having included as GFCF the category that includes exploration and exploitation of the earth (because U.S. citizens live on it) we acknowledge that the exclusion of this space-related research is judgment call. Since the federal government is the primary provider of space-related exploration, and NASA conducts R&D to create machines that travel and explore the solar system, a reasonable case could be made that space exploration is non-market production. For most countries this is a small budget category; for the US, it is substantial. We welcome discussion on this point.

<sup>24</sup> USDA Budget Summary 2006, Research Education, and Economics,  
<http://www.usda.gov/agency/obpa/Budget-Summary/2006/12.REE.htm>  
U.S. Forest Service R&D Highlights, <http://www.fs.fed.us/research/rd-highlights-2006.pdf>

Table 2 shows federal government GFCF in R&D from 1981 to 2004 based on BEA's 2007 R&D Satellite Account and the mapping described in table 1 (these results are labeled /3/). An addendum item, "Additions to Public Innovative and Scientific Knowledge," shows the R&D outside of the asset boundary. There are two reasons for this separate reporting. First, because these expenditures may increase private sector output and thus indirectly affect economic growth, they may be of interest to policy makers and academic researchers. Second, countries will necessarily differ on the scope of their non-market sector and may therefore make different assignments of GFCF for non-market producers than the ones we are proposing. Reporting both components will make the adjustments more transparent.

## **Evaluation**

How much does the choice for the asset boundary matter? We estimate the impact on the level of R&D-adjusted GDP using two alternatives for federally-funded R&D. Table 3 compares these alternatives with the results from BEA's 2007 R&D Satellite Account. For the US, federally-funded R&D accounts for an annual average of 88 percent of the R&D funded by non-market producers for the years 1981 to 2004; thus these estimates provide a good indication of the aggregate impact of the alternatives. Over this period, the level of R&D-adjusted GDP is on average 2.9 percent higher when all federally-funded R&D is treated as asset-forming (inclusive option). When federally-funded basic research is excluded from GFCF, the level of R&D-adjusted GDP is on average 2.6 percent higher. Using the economic objectives to identify GFCF, the level of

---

R&D-adjusted GDP is 2.7 percent higher.<sup>25</sup> Thus, making the adjustment has a small but noticeable effect on the aggregate impact of treating R&D as investment in the National Accounts.

Using economic objectives, the excluded expenditures primarily intended to produce benefits to market producers are relatively small-- 2 percent for agricultural production and technology, and 0.4 percent for industrial technology (table 1). The estimates are more sensitive to the exclusion of space exploration from non-market output, since this category accounts for 7.7 percent of federally-funded R&D expenditures in 2004.

Our use of GBAORD data to estimate GFCF assumes that the federal government has effective control of the results of the R&D it funds so that government production can benefit from the research. For the US, the federal government's right to royalty-free licensing and the ability to claim title to R&D others perform is important evidence that the government has effective control not only over the R&D it performs, but also over the R&D that which it funds. It is certainly true that the performers of extramural R&D also receive benefits from the R&D they perform with federal funding. We have not attempted to augment the stock of these performers' R&D to account for this. It is not impossible that the performer of extramural R&D could even receive a greater benefit from an R&D project than does the federal agency that funded it. This is, however, similar to the risk inherent in capitalizing R&D with expenditure data: both winning and losing efforts are capitalized.

---

<sup>25</sup> When these objectives are applied to all of the R&D expenditure funded by non-market producers, not just those of the federal government for the years 1981 to 2004, the level of GDP adjusted for R&D as GFCF is also 2.7 percent higher.

## **F. International Comparability**

Basic research expenditures and GBAORD data are available for most OECD countries (table 4), so internationally comparable estimates are possible with both of these approaches. Based on our findings, excluding all basic research would exclude R&D activity that creates intellectual property and provides an economic benefit to the federal government. However, to our knowledge, only Australia collects data on pure basic research that might prove a closer measure of non-asset forming R&D.

A different set of data, Gross Domestic Expenditures on R&D (GERD) by performer, is also available for many countries. When both are available, which approach is preferable: Performed-based GERD or budget-based GBAORD? For countries where R&D satellite accounts implicitly assign R&D ownership to the performer, GERD data may fit better. GERD are intended to be reported retrospectively by performers, and the Frascati Manual suggests that they are more accurate than GBAORD data, which are developed based on budget documents and thus are forward-looking.<sup>26</sup> This case necessitates a separate method to determine how to treat R&D output that businesses fund but universities perform. As noted earlier, some of this may be a business purchase of R&D. A benefit of the approach we used here is that when there is evidence that the government can use the results of the R&D that it funds in non-market production, GBAORD can be used to estimate government GFCF directly.

Finally, the use we have made of data based on economic objectives requires a set of judgments about the extent to which each activity is primarily non-market output. Using the SNA definition of non-market production, it is clear that when countries differ in the goods and services that government and other non-market producers choose to

---

<sup>26</sup> OECD (2002). Frascati Manual. Paragraph 476



provide, the boundary for non-market R&D may vary accordingly. Thus, there are inevitable limits to international comparability and imposing the same set of objectives on all countries will be an approximation of reality.

## **G. Conclusion**

Where should national accounts draw the line when adding intangibles to the asset boundary? For satellite accounts created to highlight a particular aspect of economic activity in a national accounting framework, the measure of R&D activity should be broad and inclusive. For the incorporation of R&D as an intangible asset in the core accounts, many countries may prefer a measure of asset-forming non-market R&D that does not require either a revision or reinterpretation of the definition of an asset in the SNA. In the absence of data to directly link government and university R&D expenditures to resulting indicators of effective ownership and economic benefits, we have explored the alternatives, focusing on data available for many countries.

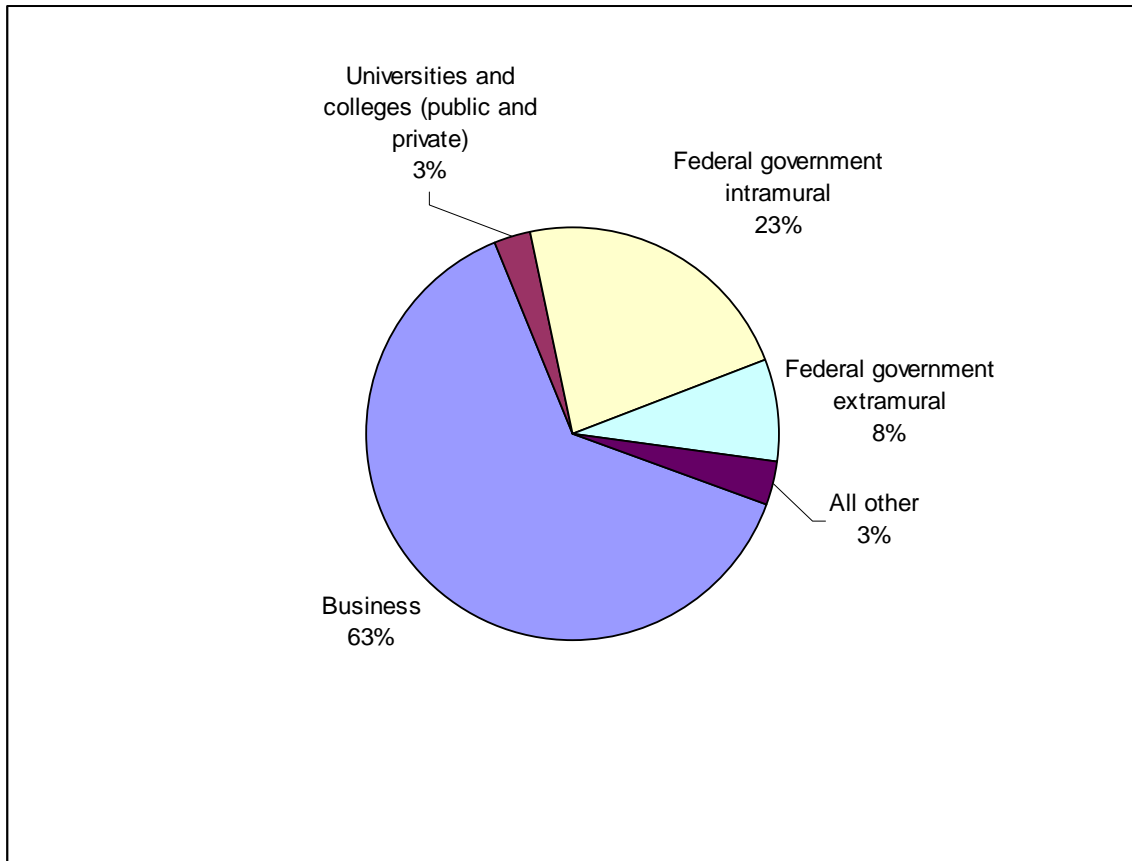
For non-market producers, such as governments and universities, the boundary option we have proposed links R&D expenditures by economic objectives to the production of non-market output and characterizes the R&D as asset forming when it is intended to be used in non-market production. Our proposed boundary excludes government-funded R&D that is primarily intended to benefit the market sector, and the R&D activity that is primarily intended to add to the stock of public knowledge without a practical objective in mind. For the US, this alternative is preferable to the exclusion of basic research expenditures for government and universities because these expenditures produce intellectual property and income as well as contribute to the production of non-market output.

For the US, using the economic objectives selected in this paper to identify asset forming R&D has a similar impact on the level of GDP as does treating all non-market R&D as asset forming. For the latest year of the estimates, 2004, recognizing R&D as investment in the National Accounts leads to a level of GDP that is 2.3 percent higher when economic objectives are used to identify GFCF for the federal government and 2.4 percent higher when all federally-funded R&D is included.

An important caveat for this approach is that the data currently available for the U.S. and most other OECD countries are drawn from budget documents. These data do not have as fine a level of detail as data reported by performers on a project-by-project basis would have. For some categories, additional splitting of the data using finely grained budget data could improve the accuracy of the estimates for a particular country. However, for international comparability, the national accounts of different countries will need to use the same standards, and this will require coordination and agreement. Without this coordination and agreement, cross-country data will likely be most comparable if all R&D activity of non-market producers is treated as investment (GFCF).

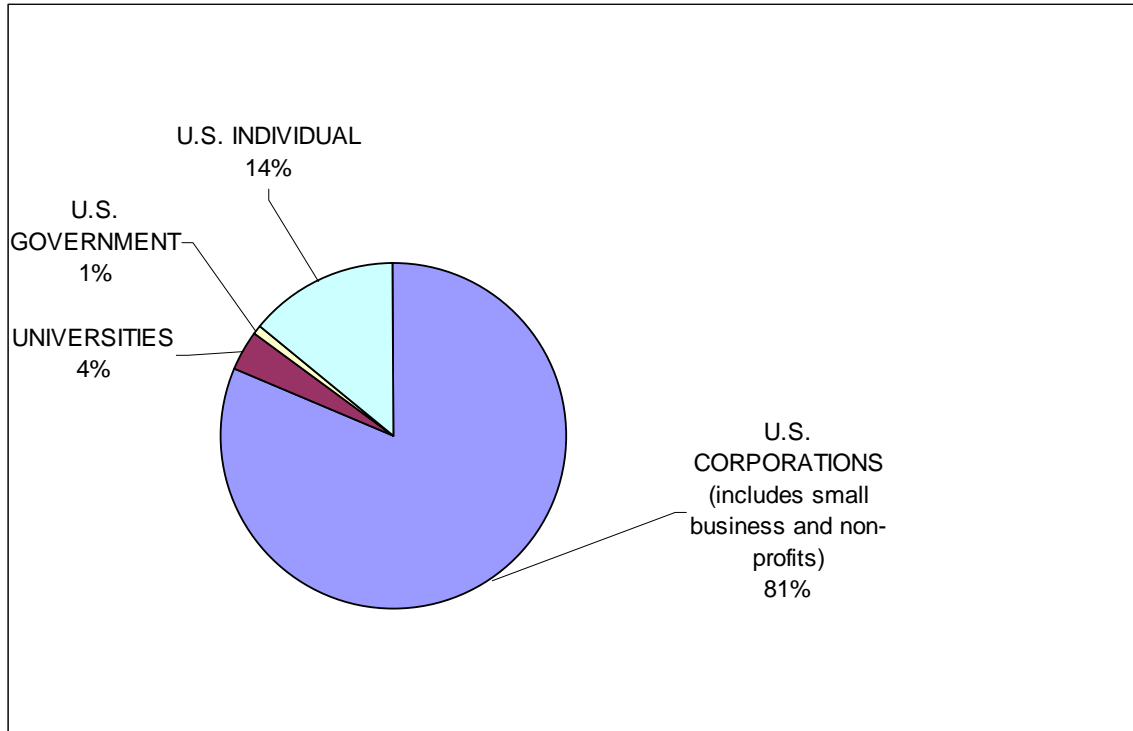
Additionally, any objective that is excluded from GFCF because of a judgment about the “main purpose” of the R&D activity risks excluding expenditures that lead to an invention that, contrary to expectations, creates economic benefits for the non-market producer. Thus we see our adjustment as an upper bound on what should be excluded from GFCF. Given the inevitable imprecision of any allocation based on aggregate data of this type, we propose reporting as an addendum item the components of non-market R&D activity excluded from GFCF. This will make the adjustments more transparent, and allow data users to make independent calculations for different purposes.

Chart 1. U.S. Funding of R&D Investment by Sector, 2004  
Source: BEA R&D Satellite Account Data



Total R&D funding of R&D investment in the U.S. in 2004 was \$316.6 billion.

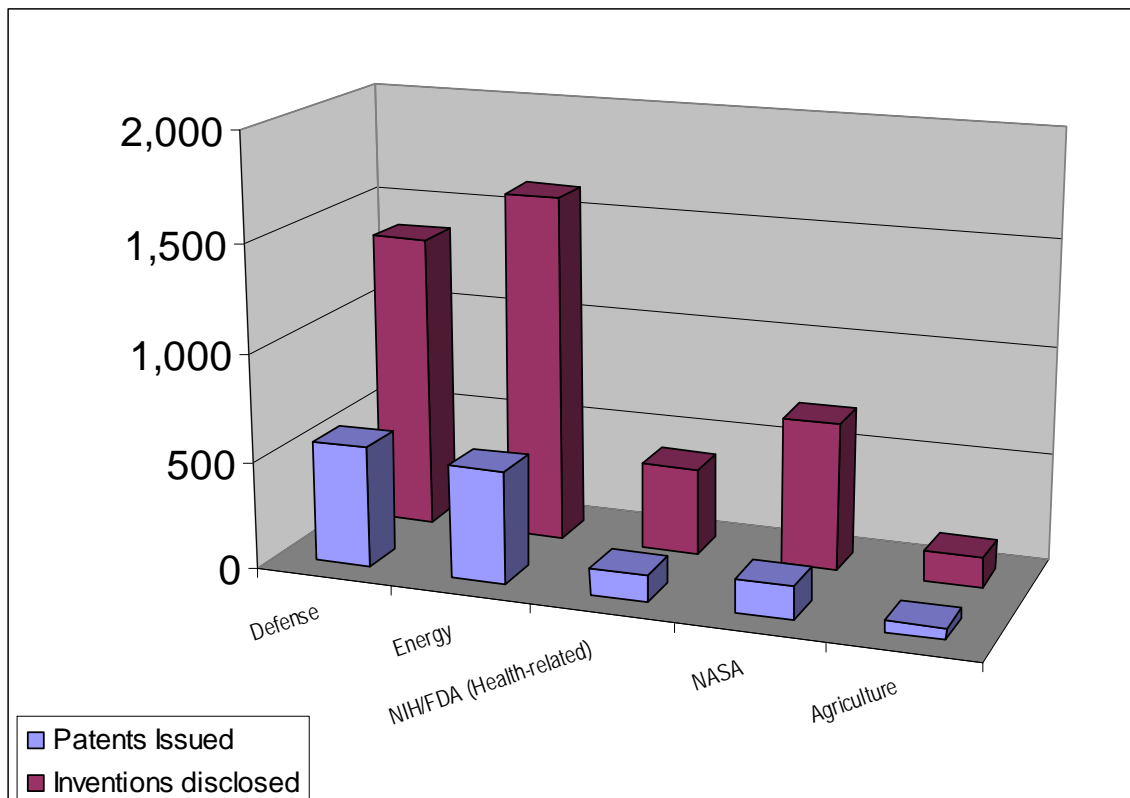
Chart 2. U.S. Patents issued in 2004 to U.S. Owners  
source: USPTO



Note: Total number of US-owned patents issued in 2004 was 86,036

Chart 3. U.S. Federal Agencies, Inventions and Patents, Fiscal year 2004

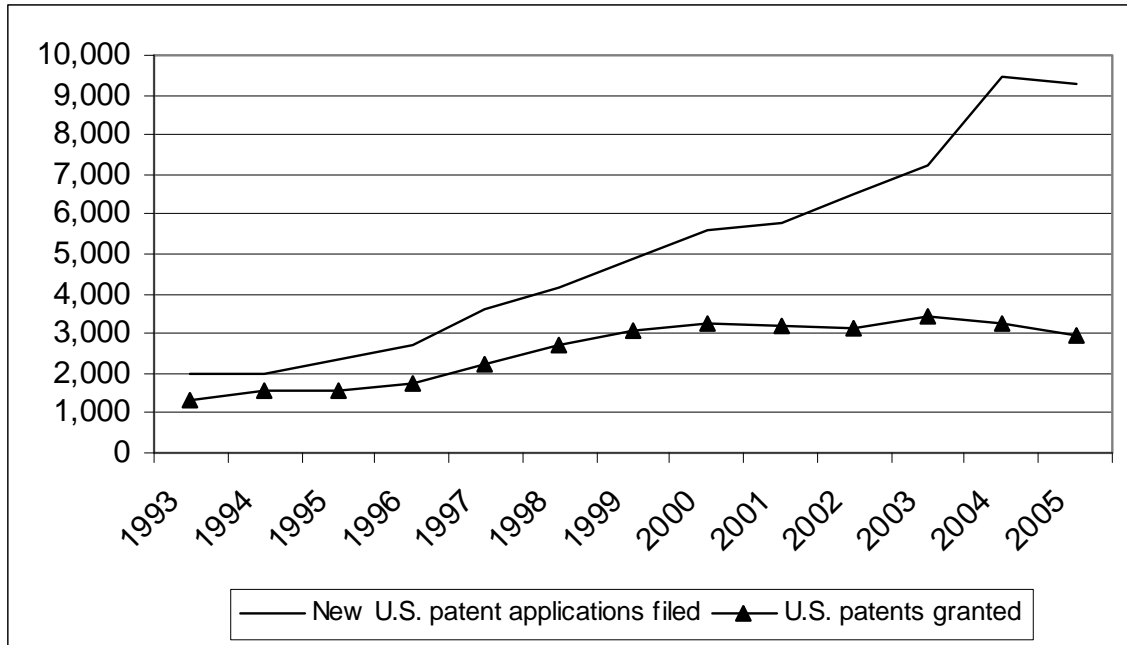
Source: NSF Science and Engineering Indicators, 2008, Appendix Table 4-53



NIH/FDA National Institutes of Health/ Food and Drug Administration  
NASA National Aeronautics and Space Administration

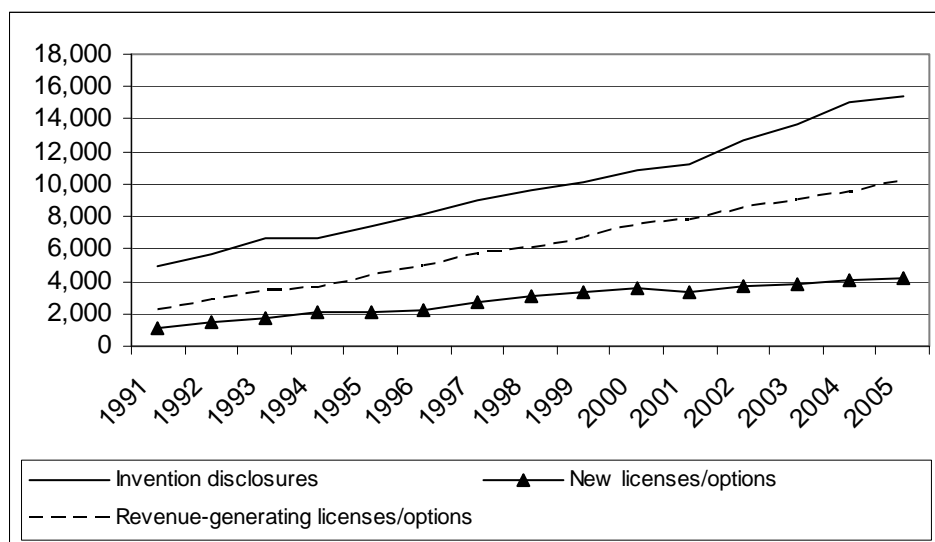
Chart 4. Patenting Activities of U.S. Universities and Colleges: 1993-2005

Source: NSF 2008 Science and Engineering Indicators, based on AUTM Data



AUTM Association of University Technology Managers  
NSF National Science Foundation

Chart 5. Universities and Colleges Licensing Activities, 1991 to 2005  
 Source: NSF 2008 Science and Engineering Indicators, based on AUTM Licensing Survey



AUTM Association of University Technology Managers  
 NSF National Science Foundation

Chart 6. Federal Government R&D Investment, Three Options, 1981-2004  
Millions of dollars, source: table 2 and BEA R&D Satellite Account

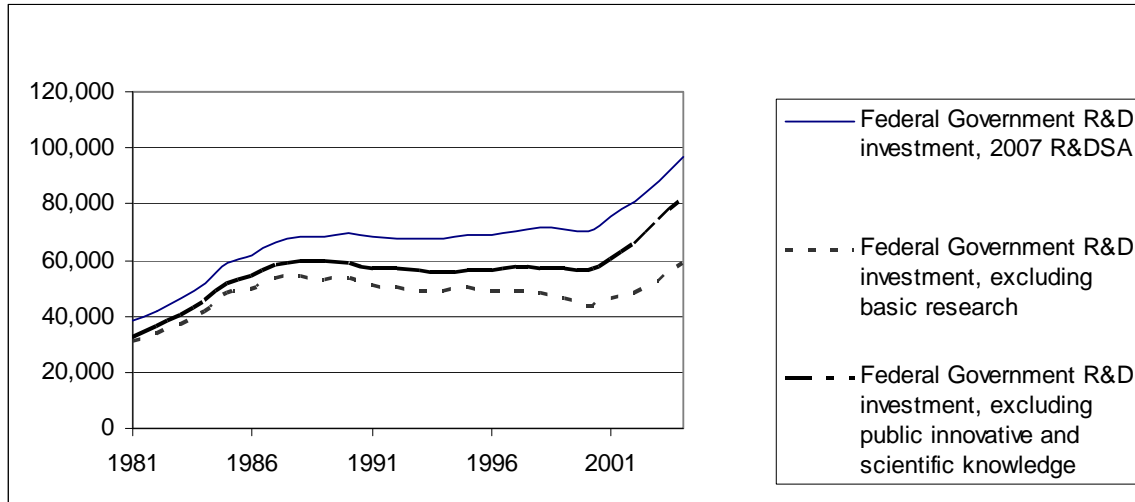
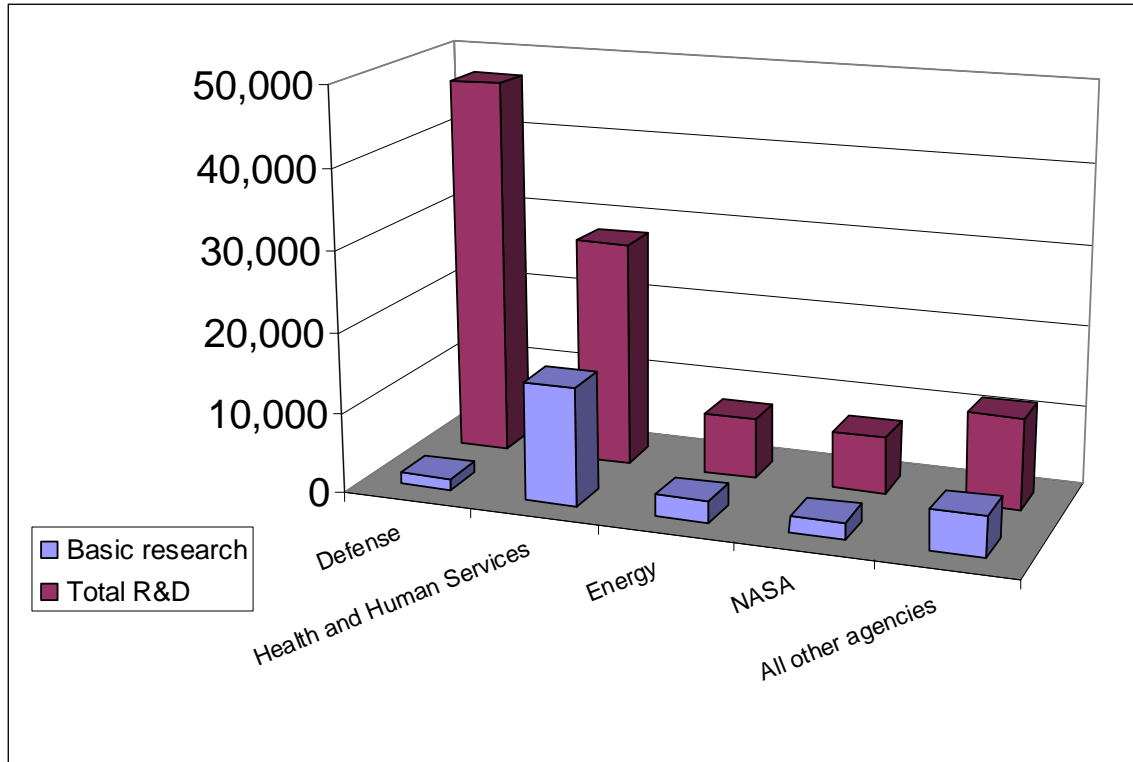


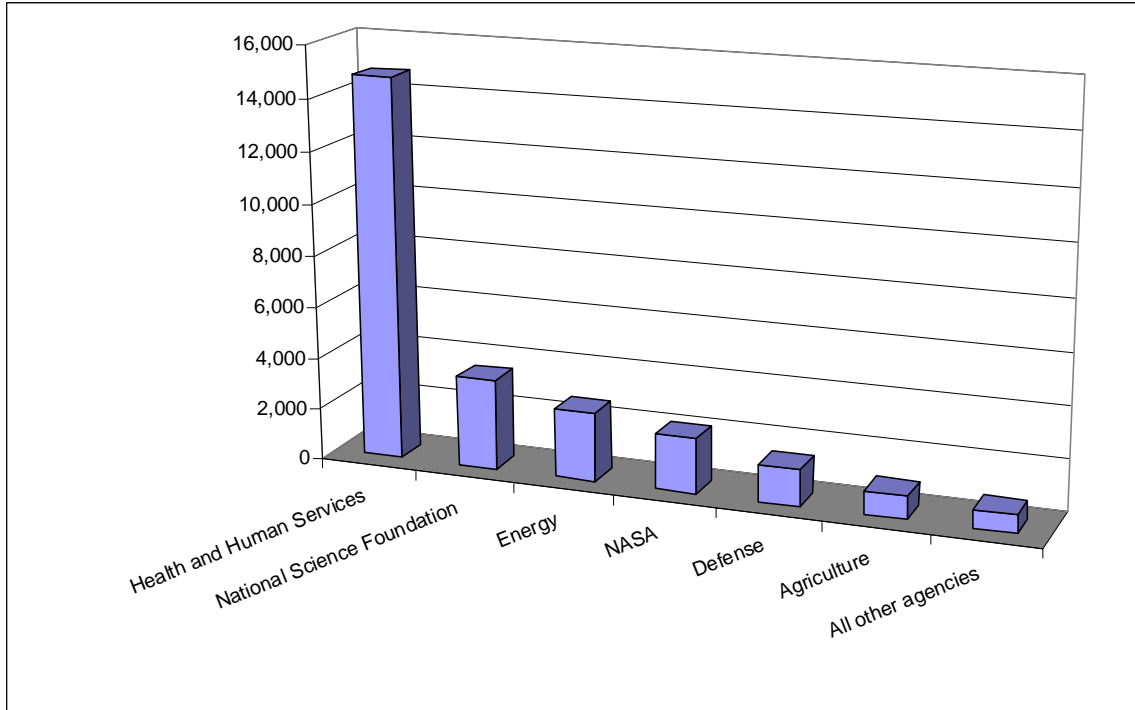


Chart 7. Major U.S. Agency Obligations for R&D and Basic Research, 2004 Millions of dollars, source: NSF



Source: National Science Foundation, Division of Science Resources Statistics (2007). Federal Funds for Research and Development: Fiscal Years 2004–06.  
NASA National Aeronautics and Space Administration

Chart 8. U.S. Agency Obligations for basic research, 2004  
Millions of dollars, source: NSF



Source: National Science Foundation, Division of Science Resources Statistics (2007). Federal Funds for Research and Development: Fiscal Years 2004–06  
NASA National Aeronautics and Space Administration

Table 1. Socio-economic Objectives, Federal Agency Mapping, and Assignment to Gross Fixed Capital Formation

NABS categories (Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets) /1/	Detail	U.S. Agency Funds allocated and percent of 2004 total federal R&D expenditures/2/	GFCF or Additions to Public innovative and scientific knowledge
1. Exploration and exploitation of the earth	Includes climate and meteorological research	Department of the Interior, U.S. Geological Survey, Department of Commerce, National Oceanic and Atmospheric Administration, Corps of Engineers, Marine Mammal Commission (0.8%)	Gross Fixed Capital Formation
2. Infrastructure and general planning of land use	Includes transport and telecommunications infrastructure	Department of Transportation, Department of Commerce, Department of Homeland Security National Aeronautics and Space Administration (telecommunications component) (1.5%)	Gross Fixed Capital Formation
3. Control and care of the environment	Includes pollution-related research	Environmental Protection Agency (0.5%)	Gross Fixed Capital Formation
4. Protection and improvement of human health	Includes nutrition and food hygiene	Department of Health and Human Services Department of Veterans Affairs, Department of Labor (23.2%)	Gross Fixed Capital Formation
5. Production, distribution and rational utilisation of energy	Includes energy efficiency and conservation, excludes prospecting and vehicle and engine propulsion	Department of Energy Nuclear Regulatory Commission Tennessee Valley Authority (1.1%)	Gross Fixed Capital Formation
6. Agricultural production and technology	Promotion of agriculture, forestry, fisheries, and foodstock production, but excludes research for the food industry	Department of Agriculture, Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Department of Interior, Biological Research (2.0%)	Public innovative and scientific knowledge
7. Industrial production and technology	Includes improvement of industrial production and technology, except in other objectives, such as defense, space, energy, and agriculture	Department of Commerce, primarily National Institute of Standards and Technology (0.4%)	Public innovative and scientific knowledge
8. Social structures and relationships	Includes social objectives, including social and human sciences	Department of Education, Smithsonian Institution, Department of Labor, Health and Human Services, Social Security Administration, Department of Justice, Homeland Security, Agency for International Development (1.2%)	Gross Fixed Capital Formation
9. Exploration and exploitation of space	all civil space research, including astronomy as well as telecommunications satellites	National Aeronautics and Space Administration, excluding telecommunications component (7.7%)	Public innovative and scientific knowledge
10. Research financed from general university funds	Not applicable for performer-based data. Includes all R&D financed by general purpose grants from ministries of education	NA	NA
11. Non-oriented research	Earmarked for R&D, but not attributed to an objective	National Science Foundation and Department of Energy basic research (5.8%)	Public innovative and scientific knowledge
12. Other civil research	Unclassified	NA	NA
13. Defense	Basic research, including nuclear & space research financed by defense and other departments	Department of Defense, Part of Department of Energy, Department of Homeland Security (55.7%)	Gross Fixed Capital Formation

/1/ Source: OECD (2002), Frascati Manual, Section 8.7

/2/ Mapping of Agencies to socio-economic objectives provided by the Division of Science Resource Statistics, National Science Foundation.

Table 2. Federal Government R&D Investment; Three Options: 1981-2004

	[Millions of dollars]							
	1981	1982	1983	1984	1985	1986	1987	1988
federal government R&D investment /1/	38,514	41,971	46,215	51,762	58,806	61,446	66,398	68,024
federal government R&D investment, excluding basic research /2/	30,935	33,861	37,385	42,054	48,217	49,877	53,742	54,196
federal government R&D investment, excluding public innovative and scientific knowledge /3/	32,226	36,152	40,547	45,821	52,004	54,601	58,664	59,802
addendum items:								
federal government additions to basic research	7,579	8,110	8,830	9,708	10,589	11,569	12,656	13,828
federal government additions to public innovative and scientific knowledge	6,288	5,819	5,668	5,941	6,802	6,845	7,734	8,222
	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>
federal government R&D investment /1/	68,442	69,706	68,458	67,929	67,391	67,859	69,210	69,278
federal government R&D investment, excluding basic research /2/	53,086	53,582	51,040	50,156	48,832	48,853	50,210	49,243
federal government R&D investment, excluding public innovative and scientific knowledge /3/	59,343	59,192	57,304	56,875	56,305	55,718	56,165	56,433
addendum items:								
federal government additions to basic research	15,356	16,124	17,418	17,773	18,559	19,006	19,000	20,035
federal government additions to public innovative and scientific knowledge	9,099	10,514	11,154	11,054	11,086	12,141	13,045	12,845
	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>
federal government R&D investment /1/	70,366	71,310	71,085	70,284	75,258	80,659	88,494	96,615
federal government R&D investment, excluding basic research /2/	48,913	48,611	46,584	43,764	46,312	48,240	52,552	58,727
federal government R&D investment, excluding public innovative and scientific knowledge /3/	57,695	57,027	57,117	56,233	60,269	65,886	74,186	81,279
addendum items:								
federal government additions to basic research	21,453	22,699	24,501	26,520	28,946	32,419	35,942	37,888
federal government additions to public innovative and scientific knowledge	12,671	14,283	13,968	14,051	14,989	14,773	14,308	15,336

/1/ BEA 2007 R&D Satellite Account Estimates

/2/ Basic Research share from NSF: National Patterns of R&D Resources

/3/ Allocated based on objectives in table 1 and expenditures reported to the OECD by the National Science Foundation

Table 3. GDP, and GDP adjusted for R&D Treated as Investment: Three Alternatives for R&D funded by the Federal Government, based on BEA's 2007 R&D satellite account

[Billions of dollars]

	1981	1982	1983	1984	1985	1986	1987	1988
GDP (from the NIPAs)	3,128,435	3,255,011	3,536,665	3,933,173	4,220,262	4,462,825	4,739,471	5,103,791
Adj. GDP, inclusive option	3,220,166	3,355,156	3,645,737	4,055,856	4,352,910	4,602,674	4,885,954	5,261,742
Percent change in GDP level	2.9%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%
Adj. GDP, basic research option	3,210,285	3,344,830	3,634,798	4,044,004	4,340,841	4,589,417	4,871,696	5,245,521
Percent change in GDP level	2.6%	2.8%	2.8%	2.8%	2.9%	2.8%	2.8%	2.8%
Adj. GDP, economic objectives option	3,211,967	3,347,748	3,638,715	4,048,603	4,345,158	4,594,831	4,877,242	5,252,098
Percent change in GDP level	2.7%	2.8%	2.9%	2.9%	3.0%	3.0%	2.9%	2.9%
	1989	1990	1991	1992	1993	1994	1995	1996
GDP (from the NIPAs)	5,484,350	5,803,067	5,995,926	6,337,744	6,657,408	7,072,228	7,397,651	7,816,860
Adj. GDP, inclusive option	5,653,309	5,977,299	6,181,291	6,528,096	6,850,006	7,269,522	7,606,561	8,036,898
Percent change in GDP level	3.1%	3.0%	3.1%	3.0%	2.9%	2.8%	2.8%	2.8%
Adj. GDP, basic research option	5,634,696	5,957,833	6,159,436	6,505,441	6,825,833	7,244,523	7,582,139	8,011,620
Percent change in GDP level	2.7%	2.7%	2.7%	2.6%	2.5%	2.4%	2.5%	2.5%
Adj. GDP, economic objectives option	5,642,280	5,964,606	6,167,295	6,514,007	6,835,566	7,253,553	7,589,793	8,020,691
Percent change in GDP level	2.9%	2.8%	2.9%	2.8%	2.7%	2.6%	2.6%	2.6%
	1997	1998	1999	2000	2001	2002	2003	2004
GDP (from the NIPAs)	8,304,344	8,746,997	9,268,412	9,816,973	10,127,976	10,469,603	10,960,770	11,685,901
Adj. GDP, inclusive option	8,537,380	8,988,772	9,524,392	10,093,917	10,405,828	10,734,206	11,234,899	11,969,373
Percent change in GDP level	2.8%	2.8%	2.8%	2.8%	2.7%	2.5%	2.5%	2.4%
Adj. GDP, basic research option	8,510,957	8,961,926	9,495,393	10,061,911	10,373,771	10,699,566	11,197,689	11,930,751
Percent change in GDP level	2.5%	2.5%	2.4%	2.5%	2.4%	2.2%	2.2%	2.1%
Adj. GDP, economic objectives option	8,521,773	8,971,879	9,507,860	10,076,960	10,389,228	10,718,421	11,220,087	11,953,741
Percent change in GDP level	2.6%	2.6%	2.6%	2.6%	2.6%	2.4%	2.4%	2.3%

Notes:

NIPAs National Income and Product Accounts

GDP gross domestic product

GFCF gross fixed capital formation

Inclusive option treats all federally-funded R&D as GFCF and corresponds to the estimates of BEA's 2007 R&D Satellite Account.

Basic research option excludes federally-funded R&D from GFCF

Economic objectives option excludes federal -funded R&D expenditures based on Table 1.

Table 4. Availability of Frascati-based R&D data for Asset Boundary Measures

Country	Basic Research Expenditures			R&D by Detailed Socio-economic Objective			
	(total costs or sub-total current costs)			Gross Expenditures for R&D			Government Budget Appropriations or Outlays for R&D
	Government	Higher Education	Private Non- profit	Government	Higher Education	Private Non- profit	
Australia (1)	x	x	x	x	x	x	x
Austria	x	x	x	x	x		x
Belgium	x	x	x				x
Canada				x (2)			x
Czech Republic	x	x	x	x	x	x	x
Denmark	x	x	x	x	x	x	x
Finland							x
France	x	x	x				x
Germany	x	x	x				x
Greece							x
Hungary	x	x		x	x		x
Iceland	x	x	x	x	x	x	x
Ireland	x	x	x	x			x
Israel	x	x	x	x (3)			x
Italy	x	x		x			x
Japan	x	x	x	x			x
Korea	x	x	x	x	x	x	x
Luxembourg							x
Mexico	x	x	x	x	x	x	x
Netherlands	x	x	x				x
New Zealand	x	x					
Norway	x	x		x	x		x
Poland	x	x	x				x
Portugal	x	x	x	x	x	x	x
Slovak Republic	x	x	x	x	x	x	x
Spain	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x
Switzerland	x	x	x	x	x	x	x
Turkey	x			x			
United Kingdom		x		x			x
United States	x	x	x				x

Source: OECD-stat data base, Science, Technology, and Patents;

1) also has pure basic research

2) data not in the OECD database, but identified separately

3) excludes defense

## References

Aspden, Charles (2005). "Update of the 1993 SNA– Issue No. 9 and 10, Issue Paper for the Meeting of the AEG, July 2005, Extending the Asset Boundary to Include Research and Development." 2005

<http://unstats.un.org/unsd/nationalaccount/AEG/papers/m3refsearchDevelopment.pdf>

Aspden, Charles (2008). "Using Frascati Data to compile an R&D Satellite Account; EU Task Force on Research and Development," 19-20 June, 2008, Luxembourg.

Australian Bureau of National Statistics (2004). *Capitalising Research and Development in the National Accounts*. Prepared for the Fourth meeting, 17th-19th March 2004, Washington D.C., USA Canberra II Group on the measurement of non-financial assets.

Baher, Julie (2006). "Experimental Use, the Safe Harbor Exemption and Fair Use in Patent Law in the Aftermath of "Merck v. Integra"" accessed at:  
[http://cyber.law.harvard.edu/cyberlaw2005/Julie\\_Baher:\\_Experimental\\_Use%2C\\_the\\_Safe\\_Harbor\\_Exemption\\_and\\_Fair\\_Use\\_in\\_Patent\\_Law\\_in\\_the\\_Aftermath\\_of\\_Merck\\_v.\\_Integra](http://cyber.law.harvard.edu/cyberlaw2005/Julie_Baher:_Experimental_Use%2C_the_Safe_Harbor_Exemption_and_Fair_Use_in_Patent_Law_in_the_Aftermath_of_Merck_v._Integra)

Bostrom, Dana, Ashley Stevens, Stewart Howe, and Frances Toneguzzo (2004). "Association of University Technology Managers Licensing Survey: Full Report, FY 2004." Association of University Technology Managers

Bozeman, Barry (2000). "Technology Transfer and Public Policy: a Review of Research and Theory," *Research Policy*, Volume 29, 4-5, pages 627-655.

Bureau of Economic Analysis (2007). *An Introduction to the National Income and Product Accounts Methodology Papers: U.S. National Income and Product Accounts*. September.

Commission of the European Communities -Eurostat, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank (1993). *System of National Accounts 1993*, Brussels/Luxembourg, New York, Paris, Washington, DC.

Corrado, Carol, and Charles Hulten and Daniel Sichel (2005). "Measuring Capital and Technology: An Expanded Framework." *In Measuring Capital in the New Economy*, edited by Corrado, Carol, John Haltiwanger and Daniel Sichel. Chicago, University of Chicago Press.

Eisenberg, Rebecca S. (1996). "Public Research and Private Development: Patents and Technology Transfer in Government-sponsored Research," *Virginia Law Review*, Volume 82, pages 1663-1726.

Federal Lab Consortium for Technology Transfer (2006). *Federal Lab Consortium Technology Transfer Desk Reference: A Comprehensive Introduction to Technology Transfer*.

Galinda-Rueda, Fernando (2007). "Developing an R&D Satellite Account for the UK: a preliminary analysis." *Economic and Labour Market Review*, Vol.1 , No 12, December 2007.

General Accounting Office (1998). "Technology Transfer: Administration of the Bayh-Dole Act by Research Universities," GAO/RCED 98-126

General Accounting Office (2003). *Technology Transfer: Agencies Rights to Federally-Sponsored Biomedical Inventions*. GAO-03-536

de Haan, Mark, and Myriam van Rooijen Horsten (2004). "Measuring R&D Output and Knowledge Capital Formation in Open Economies." Paper prepared for the 28<sup>th</sup> General Conference of the International Association for Research in Income and Wealth, Cork, Ireland, August 22-24, 2004.

Heisey, Paul, John L. King, Kelly Day Rubenstein, and Robbin Shoemaker (2006). *Government patenting and technology transfer, Economic Research Report No 15*. U.S. Department of Agriculture, Economic Research Service.

Internal Revenue Service, Statistics of Income Division, Returns of Active Corporations, Form 1120, Table 16--Balance Sheet, Income Statement, Tax, and Selected Other Items, by Major Industry. <http://www.irs.gov/pub/irs-soi/04co16ccr.xls>

Jorgenson, Dale W., and J. Steven Landefeld (2006). Blueprint for Expanded and Integrated U.S. Accounts. in *A new Architecture for the U.S. National Accounts*." Edited by Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus. University of Chicago Press, 2006

Mowery, David C, Richard R. Nelson, Bhaven N. Sampat and Arvids A. Zedonis (2004). *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act in the United States*. Stanford, California, Stanford Business Books

National Science Foundation, Division of Science Resources Statistics (2007). *National Patterns of R&D Resources: 2006 Data Update*. NSF 07-331. Brandon Shackelford and John E. Jankowski, project officers. Arlington, VA.



National Science Foundation, Division of Science Resources Statistics (2007). *Federal Funds for Research and Development: Fiscal Years 2004–06*. NSF 07-323. John E. Jankowski, project officer. Arlington, VA.

Organization for Economic Cooperation and Development (2002). *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*. Paris.

Robbins, Carol A (2008). *Measuring Payments for the Supply and Use of Intellectual Property*, forthcoming in International Flows of Invisibles: Trade in Services and Intangibles in the Era of Globalization, edited by Marshall Reinsdorf and Matthew Slaughter, NBER Volume.

Robbins, Carol A. and Carol E. Moylan (2007). “Research and Development Satellite Account Update,” *Survey of Current Business*, October 2007. data available at: <http://www.bea.gov/national/index.htm#researchanddevelopment>

Statistics Canada (2008). “The Canadian Research and Development Satellite Account, 1997 to 2004”. Income and Expenditure Accounts Technical Series, May.

Triplett (1996). Jack E. “Depreciation in production analysis and in income and wealth accounts: Resolution of an old debate.” *Economic Inquiry*: January 1996; Volume 34, pages 93-155

U.S. Congress, Office of Technology Assessment (1995). *A History of the Department of Defense Federally Funded Research and Development Centers*, OTA-BP-ISS-157 (Washington DC: U.S. Government Printing Office, June 1995)  
<http://www.princeton.edu/~ota/disk1/1995/9501/950102.PDF>

United Nations Statistical Commission (2008). *Updated System of the National Accounts, 1993, Volume 1, Chapters 1 -17. Draft Version*  
<http://unstats.un.org/unsd/sna1993/draftingphase/volume1.pdf>

U.S. Patent and Trademark Office (2006). *Patents by Organization*.  
[http://www.uspto.gov/web/offices/ac/ido/oeip/taf/topo\\_06.htm#PartB](http://www.uspto.gov/web/offices/ac/ido/oeip/taf/topo_06.htm#PartB)

Wang, Mark, et. al. “Technology Transfer of Federally Funded R&D, Perspectives from a Forum” RAND Science and Technology Policy Institute, December 12, 2002  
[http://www.rand.org/pubs/conf\\_proceedings/2006/CF187.pdf](http://www.rand.org/pubs/conf_proceedings/2006/CF187.pdf)