

American Statistical Association, Joint Statistical Meeting, Toronto, August 8-12, 2004

Improving the Measurement of Research and Development in the United States

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Abstract

The United States pioneered in the collection and publication of data on R&D expenditures. Today, that collection takes place against the backdrop of OECD guidelines contained in the Frascati and Oslo Manuals, and can be compared with programs conducted by statistical agencies in other countries. The National Academy of Science findings and recommendations are being made with an appreciation of the need for supporting international comparability, as well as for informing international bodies as to the need for and possibilities of collecting R&D and innovation data from public and private agencies. This paper summarizes the international context of the collection of these statistics, and draws lessons from the international community.

Disclaimer: The views expressed are those of the author and should not be attributed to Statistics Canada, or to the Panel on Research and Development Statistics at the National Science Foundation convened by the Committee on National Statistics of the U.S. National Academy of Sciences.

Session 138, August 9, 2004
Final Version. July 21, 2004

1. Introduction

The measurement of research and development (R&D) activity, and of innovation in the business enterprise sector, have been going on for decades and much of the early work was done in the United States. In 2003, at the request of the National Science Foundation (NSF), the U.S. National Academies of Sciences Committee on National Statistics (CNSTAT) convened a Panel to review the surveys and reports on R&D, managed by the Science Resources Statistics (SRS) Division of the NSF. While the work of the Panel (National Research Council 2004) has not been completed, it is an opportune time to look at some of the outcomes that could result from this process.

This paper examines industrial R&D measurement, and that of innovation, and suggests areas where work could be done to make the results both more useful within the U.S., and internationally. It argues for a strengthening of the analytical and survey capacity within the SRS Division so that it can explore and advise on issues of current economic and social interest. Two examples are the extent to which industrial R&D in the U.S. is funded from abroad, and the implications of that, and the opportunities for wealth creation through innovation which could be enhanced by a better understanding of this activity in U.S. industry.

1.1 The Early Days of R&D and Innovation Surveys

The seminal paper in the U.S. in this subject is the report by Vannevar Bush (1945), *Science – The Endless Frontier*, in which the author noted the variety of sources and arbitrary definitions in use in the measurement of R&D activity in the 1940s. That report was followed by the establishment of the National Science Foundation in 1950, and the NSF commissioned the first industrial R&D survey by the U.S. Bureau of Labor Statistics in 1953. This was taken over by the U.S. Department of Commerce in 1957.

It was in this period that the Organization for European Economic Co-operation (OEEC), the predecessor of the Organization for Economic Co-operation and Development (OECD), was looking at standardizing the definition of research and experimental development and providing guidelines for the measurement and interpretation of data on R&D. The leading countries in this exercise were the United States, Japan, Canada, the United Kingdom, the Netherlands and France and the process, described in OECD (2002: Appendix 1), led to the *Proposed Standard Practice for Surveys of Research and Development* (OECD 1963). This, known as the 'Frascati Manual', is now in its sixth edition (OECD 2002).

Innovation surveys evolved in a similar way. There was a period of experimentation in the 1980s in a number of countries, followed by the first attempt at codification of the knowledge gained in the *Proposed Guidelines for Collection and Interpreting Technological Innovation Data: Oslo Manual*, OECD (1992). The countries involved in the experimental period included the United States, Canada, the Nordic Countries, Italy and Germany, which put in place the first annual survey of innovation activities.

The evolutionary pattern of experimentation, standardization and consensus management of the concepts and definitions just described has been repeated since at the OECD in a number of areas (OECD 2002:16). Once the concepts and definitions have been standardized, their evolution is based on new experience contributed by leading countries, and accepted by other OECD member countries in the revision process. This has now happened five times for the Frascati Manual. The Oslo Manual, which was first published as an OECD manual, became a joint undertaking with Eurostat, the statistical office of the European Communities, in the course of the first revision published in 1997. The manual is now in the process of being revised for the second time. In the case of both manuals, experts from the United States played significant roles in shaping the first editions.

In what follows the present state of R&D and innovation measurement are examined selectively to illustrate areas of possible development. In the case of R&D, the focus is on expenditure, rather than on personnel data.

2. U.S. R&D Data

The Panel report will cover a number of gaps and methodological issues. This section looks at a subset of issues and their importance for policy analysis in an international context. They can be divided into issues of coverage and of methodology. The foreign funding of business enterprise sector R&D in United States is a coverage example. Estimates of spending on basic and applied research and experimental development in the U.S. Higher Education Sector may be a methodological issue. While this leaves out the government sector, there is a discussion of the difference between government funding for R&D and the reporting of the amount received by other sectors for the performance of R&D. Finally, there is a note on international comparisons.

2.1 Foreign Funding for R&D in the Business Enterprise Sector

In the most recent Indicators Report is the following statement:

“Although data exist on foreign sources of R&D funding for other countries, there are no data on foreign funding sources of U.S. R&D performance” (National Science Board 2004:4-57).

Both foreign funding for the performance of R&D, and the payments made by U.S. firms for R&D performed abroad, have policy implications. The rate of change of both the import and the export flows are indicators of the degree of internationalization of the activity of research and development. Comparing the change in these flows with those for other countries provides an indication of where R&D is happening, and where it is not. There are at least two kinds of flows.

U.S. firms may be charging affiliates abroad for R&D services performed by the head office in the U.S. This appears as foreign funding for U.S. R&D, but all of the benefits, in terms of the generation of new knowledge, and the training of highly qualified researchers, are retained in the U.S. What goes abroad is the outcome of this work.

On the other hand, there may be payments to U.S. firms made by firms abroad that need a specific R&D service to complement that of their own research program. In this case, the knowledge developed in the U.S. is transferred to the foreign firm which integrates it with its own knowledge in order to produce better products, processes or means of delivery of their products. This could be mutually beneficial if the intellectual property in the transfer is well managed.

The same is true of payments abroad for R&D services. Is this simply a payment of the U.S. firm to its parent abroad to cover its share of the R&D program of the multi-national enterprise, or is this a purchase of new R&D knowledge that is integrated into the R&D program of the U.S. firm?

At the moment, none of these questions can be addressed by the data collected from the NSF industrial R&D survey. A small change could provide data on foreign funding for R&D, by country of origin, and on whether the payment was to an affiliate or not.

Many of the issues related to foreign involvement in U.S. R&D were examined and, recommendations made, in 1996 by a National Academy of Engineering Committee on Foreign Participation in U.S. Research and Development (National Academy of Engineering 1996). However all of the financial information on R&D was based on the domestic R&D expenditure of U.S. affiliates of foreign-owned firms. The additional issues related to the payments abroad, and receipts from abroad, for R&D services could not be addressed as there were no data.

2.2 Basic and Applied Research and Experimental Development

An international and domestic debate relates to the impact of increased linkage between industry and higher education. It attracted sufficient interest to be the subject of an OECD international workshop in Oslo in 2001, which also examined the relevance of the current definitions of basic and applied research in a time of blurring boundaries

One issue arises because firms are seeking more opportunities to work with universities, and in some countries this is actively encouraged by granting organizations. On the other side, universities which, in the past may have rejected close ties with industry, are more open to collaborative arrangements, and contract research and the revenue and relevance that this involvement brings. The concern is that academics will redirect their interest from basic research to applied and continue on into experimental development. If this is actually happening, the source of new ideas from basic research for future invention and innovation may be at risk. There is also concern about public accessibility of basic research done as part of a university-industry partnership (OECD 2001:para. 11), but the question addressed here is whether basic research is declining.

To respond to this question there are data in the Indicators Report (National Science Board 2004:Tables 4-7, 4-11 and 4-15) going back to 1953 on basic and applied research and on experimental development in universities and colleges. However the footnotes must be read, especially c, which states that:

Adjustments have been made to university R&D for 1998 and later years to eliminate double counting of funds passed through from one academic institution to another. The character-of-work estimation procedure for university and college R&D also was revised for 1998 and later years; hence, these data are not directly comparable with data for 1997 and earlier years.

There is additional explanation in the August 2003 NSF Infobrief (Machen and Shackelford 2003) which describes some of the changes to the series in 1998 and more explanation is anticipated.

In response to the policy question, data for the five-year period, 1998-2002 show that basic research is 74% of expenditure in universities and colleges and that number is not changing. Prior to revision, the series for basic research for 1976 to 1996 remained robustly within 2% of 67% of expenditure, unaffected by energy shocks, recessions or structural changes in the economy.

While the official statistics demonstrates that there is no problem, there is evidence of growing collaboration of universities with industry and government (Moris and Jankowski 2002). This dichotomy between the stability of the estimates for expenditure on basic research, as a percentage of total R&D spending by universities and colleges, and the apparent increase in linkages between industry and higher education, is a matter for consideration when the NSF surveys are revised.

2.3 A Framework for Presenting R&D Data

To understand the R&D system in a country, it helps to know the sources of funds for R&D as well as the expenditure on performance, with each broken out by sector. This information can be presented in what is known as the ‘GERD Matrix’ and an example is provided in Table 1 from Canada in 2003 (Thompson 2003).

Table 1: Gross Domestic Expenditure on R&D (GERD) for Canada in 2003, by Funding and Performing Sectors, in millions of current Canadian dollars

Funding Sectors	Performing Sectors				Total
	Government	Business Enterprise	Higher Education	Private Non-Profit	
Government	2440	383	2780	21	5624
Business Enterprise	64	9150	730	8	9952
Higher Education			3603		3603
Private Non-Profit			616	25	641
Abroad	1	2527	102		2630
Total	2505	12060	7831	54	22450

Source: Statistics Canada

The table is based on what is reported by performers of R&D. However, in doing this, discrepancies are brought to light between what funders report as having been given and what performers report as having been received. This discrepancy has been a concern for some time in the SRS Division and it relates, in part, to the fact that each of the NSF R&D surveys has been developed as a separate entity, rather than as a part of an integrated system. Other factors are the differences between federal budget authority, obligations and outlays, and timing differences that affect the gap between federal funding and reported expenditure on R&D. This is being pursued by staff of the SRS Division.

The discrepancy between the reports of funders and of performers is a common problem in statistics on research and development and it can never be completely resolved. The objective is to understand the reasons for the discrepancies and to report them.

2.4 International Comparisons

Data collected in the various NSF surveys are used to respond to OECD data requests and the results appear in a variety of data bases and publications, the most widely used being the Main Science and Technology Indicators (OECD 2004). The MSTI offers 76 tables in the print version and 138 in the electronic in the electronic version where data can be compared for many of the 30 OECD member countries. For each country there is a footnote providing more information on the data in the tables, and for the U.S., the footnote is quoted below.

The R&D expenditure data for the United States are somewhat underestimates for a number of reasons:

- i) R&D performed in the Government sector covers only federal government activities. State and local government establishments are excluded;
- ii) In the higher Education sector R&D in the humanities is excluded, as are capital expenditures;
- iii) R&D expenditure in the Private Non-Profit (PNP) sector covers only current expenditure.

Depreciation is reported in place of gross capital expenditures in the Business Enterprise sector.

Higher education (and national total) data were revised back to 1998 due to an improved methodology that corrects for double-counting of R&D funds passed between institutions.

Breakdown by type of R&D (basic research, applied research, etc.) was also revised back to 1998 in the business enterprise and higher education sectors due to improved estimation procedures.

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Beginning with the 2000 Government Budget Appropriations or Outlays for R&D (GBAORD) data, budgets for capital expenditure – “R&D plant” in national terminology are included. GBAORD data for earlier years relate to budgets for current costs only.

The United States Technological Balance of Payments (TBP) data cover only “royalties and license fees” which are internationally more comparable. Other transactions, notably “other private services” have been excluded.

The footnote has been modified to add the full text for abbreviations and to exclude comments on personnel data. It is provided to show some of the areas in which the data

are not comparable OECD guidelines, and where there may be an opportunity for change as the surveys are revised.

3. The Challenge of Innovation

Technological innovation, as measured in a number of countries, is the introduction of new or significantly improved products to the market or the introduction of new or significantly improved processes for the production or delivery of products for the market. A product here is either a good or a service.

Innovation is a means of creating value, and understanding how that is done, and where it is done, has both economic and social implications. In OECD countries, other than the U.S., analysts look at the GDP per capita of their country, compared with that of the U.S., adjusted for 'purchasing power parity' (PPP). With the exception of Luxembourg, they find a lower value and then identify what is sometimes called an 'innovation gap'. This gives rise to policies and interventions to close the gap. Part of closing the gap is improving the propensity to innovate in the private sector and understanding this has been the rationale for three rounds of the Community Innovation Survey (CIS) in the European Union and similar surveys in other countries, such as Canada (Gault 2003), Australia and New Zealand. These surveys are producing a picture of how firms, in different size categories, produce new value from ideas. However, is this a reason for measuring innovation in the United States which already leads the pack of industrialized economies?

Not all of the states in the United States have the same GDP per capita. The value for California is higher than that for many countries, including Canada, and it presents a challenge to other states of the Union. The productivity gap then becomes a regional issue within the United States and if the means of closing the gap is the promotion of innovation there is a need for benchmarking at the start of a policy and for evaluation at the end of it, as well as for comparison with other jurisdictions. An example of regional policy is the work of the Economic Development Administration which provides 'A Guidebook for Innovation-Led Development' (Economic Development Administration 2001).

Innovation is not done in isolation. It requires the inputs of knowledge, technologies and practices from a variety of sources, and the innovative firm is part of a system of actors that may include governments, universities and colleges, competing firms and clients, and foreign institutions. Understanding innovation requires going beyond the firm to develop knowledge about the linkages and the outcomes of the activities of the firm.

Surveys of the activity of innovation and related factors provide only part of the picture and there is an argument for complementing them with case studies. For example, surveys of innovation in the steel industry over the last twenty years would have registered the disruptive innovation of the mini-mills, and the sustaining innovation of the large integrated mills, allowing analysts to make an inference about the propensity to

innovate in the steel industry. What would have been missing was the growth and improvement of the mini-mill technology and the eventual dominance of the industry by these firms. To see that, case studies were needed (Christensen 1997).

Not all surveys of technological change have focused on the introduction of new products or processes. In the U.S. there have been surveys that concentrated on the ability of firms to capture, or appropriate, the results of their inventions and their interactions with universities and national laboratories (Levin et al., 1987). The Yale I survey, as this became known, was conducted in 1983 and was followed by the Carnegie-Mellon survey in 1994 (Cohen et al., 2000, 2002). This work gave rise to surveys in Japan and there were similar surveys in Europe (Arundel et al., 1995). The point here is that there are many approaches to this subject, and there are roles for academic researchers as well as for official statisticians.

4. Conclusion

Whatever the outcome of the CNSTAT Panel report, the NSF SRS Division will be provided with encouragement to revise its portfolio of surveys in a methodologically consistent manner. This paper has pointed at some areas that should be considered in the course of this process. However, this will not provide answers to all of the questions that are being raised about R&D and innovation. For example, what has to be done if R&D expenditure is to be treated as capital investment in the System of National Accounts when this is next revised? What measures of innovation are seen to be useful to industry and to governments in the U.S.?

For there to be an informed view on these and other questions, the SRS Division requires a stronger analytical capacity to allow it to conduct or commission experimental surveys or case studies, and to interpret and publish the results. In the case of the industrial R&D survey, experimental probes could serve as a quality control on the annual survey, as well as being a source of new information. For innovation, there are a number of questions on both technological and non-technological innovation that could be explored, in consultation with potential users of the information.

Such activity would well position the NSF to contribute significantly to the international development of indicators of research and development, and of innovation, and to reap the benefit of having other countries produce comparable data. As a result of doing this, the U.S. would return to the leadership role that it held in the early days of statistical measurement in these areas.

Acknowledgement

This paper benefited from discussions with members of the CNSTAT Panel, the National Academies of Science support staff, colleagues at Statistics Canada and from the OECD community of national experts on science and technology indicators.

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