

# Data quality, concepts and methodology - How to read the gross domestic expenditures on research and development (GERD) matrix

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## Introduction to GERD terminology

Research and development expenditures in Canada are estimated annually by type of sector, by sources of funds and by science type using a series of surveys supplemented by modeling:

- Type of sector – Research and development (R&D) expenditures can be spent by organizations within six sectors in Canada: federal government organizations; provincial government organizations; provincial research organizations; business enterprises; higher education organizations (including universities and affiliated teaching hospitals); and private non-profit organizations.
- Sources of funds – Intramural research and development (R&D) expenditures are spent within organizations performing the R&D. The organizations can fund their own R&D or undertake R&D on behalf of other organizations. The R&D performing organizations indicate the source of funds, by sector, for their intramural R&D expenditures. In the GERD matrix, the source of funds data is shown by funding sector.
- Science type – Research and development (R&D) expenditures are spent by organizations performing in either the natural sciences and engineering or the social sciences and humanities. Only intramural R&D expenditures in the natural sciences and engineering for the provincial research organizations and business enterprises are included in the GERD.

Organizations of any type can perform and/or fund R&D at any time. GERD data include intramural R&D expenditures only. Therefore, the payments of organizations for R&D performed by other organizations, or extramural R&D expenditures, are not included.

## Definition of GERD

Gross domestic expenditures on Research and Development (GERD) is the total value of *intramural* research and development expenditures (R&D) of all organizations in *performing* sectors. As there are two dimensions to the reporting of R&D expenditures (by performing sector and by funding sector) the data are presented in a matrix. GERD data are based on the source of funds provided by the performing sector.

## Tabular results

The GERD matrix contains total R&D expenditures for each of the performing sectors (federal government, provincial governments, provincial research organizations, business enterprises, higher education and private non-profit organizations).

Each of the performing sectors indicates the funding sectors for their intramural R&D expenditures. This is an important distinction because it explains the financial sources of performers' R&D activities. The funding sectors include all of the performing sectors and foreign sources of funds.

## Data sources used to populate the tabular results

Federal government intramural R&D expenditures are estimated by the annual Federal Science Expenditure and Personnel survey. Intramural R&D expenditures represent spending on R&D performed by federal departments and agencies.

Prior to 1974, estimates of provincial government S&T expenditures were made using provincial estimates and Public Accounts. In 1974, Ontario, Alberta and Nova Scotia sought survey assistance from Statistics Canada with the collection of S&T spending data from their respective governments. Since then, participation by provincial governments in the collection of S&T survey data has been inconsistent. The program was cancelled after the 1977/1978 reference year. The program was reinstated in 1984 under a new business model with participating provinces funding part of the program costs. In 2010/2011 the Provincial Scientific Activities Survey participants included: Prince Edward Island, Ontario, Manitoba,

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Saskatchewan, Alberta and British Columbia. The program was cancelled after 2010/2011 release. Currently research and development expenditures of the provincial government are modeled.

The annual survey of the Research and Development Activities of Provincial Research Organizations is the source of expenditure data displayed in the column for provincial research organizations.

The business enterprise sector's R&D expenditure data is comprised of two sources of data: questionnaire data and administrative data from Canada Revenue Agency (CRA). There are two annual questionnaires: The Survey of Research and Development in Canadian Industry (RDCI); and a survey supplement, The Energy Research and Development Expenditures by Area of Technology.

An estimation model is used to populate R&D intramural expenditures for the higher education sector.

The annual survey of Research and Development in Private Non-Profit Organizations provides national R&D expenditure data for this sector.

## Tabulation notes

Funding sector R&D expenditures shown in the GERD matrix do not equal extramural R&D spending of individual funding sectors for a number of reasons including: differences in financial years of the organizations funding the R&D and the organizations performing the R&D; the time it takes to perform the R&D; organizations sub-contracting parts of the R&D work to organizations in other sectors; payments for work that is related to the R&D but not part of the contracted R&D; differences in the costs of performing the R&D and the payments for the R&D work; and R&D performing organizations not indicating accurately their sources of funds by funding sector.

GERD data are presented separately for total sciences, for natural sciences and engineering, and for social sciences and humanities. A total science is the sum of natural sciences and engineering and social sciences and humanities.

GERD data presented in these matrix tables are used to compare Canada's R&D performance internationally. They are assembled based on guidelines presented in the Organization for Economic Co-operation and Development's *Frascati Manual* (2002).

## Data sources and methodology

### Definitions

Gross domestic expenditure on research and development (GERD) is a statistical series, constructed by adding together the intramural expenditures on research and development (R&D) as reported by the performing sectors. As a term used by OECD Member countries, it is defined as "total intramural expenditure on R&D performed on the national territory during a given period. GERD includes R&D performed within a country and funded from abroad but excludes payments for R&D performed abroad".<sup>1</sup>

GERD is often displayed as a matrix of performing and funding sectors. The GERD and GERD matrix are fundamental to the national and international examination of R&D expenditures.

The matrix illustrates three aspects of a country's R&D effort:

- it shows how much R&D each sector performed over a 12-month period;

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- it shows the amount of R&D each sector financed over a 12-month period (as indicated by the R&D performing sector); and
- it indicates the flow of funds between sectors.

The GERD is an indicator of science and technology (S&T) activities; it is appropriately used as a summary of R&D activities and the basic flow of funds. General guidelines to follow when using a summary statistical series such as the GERD, include:

- Such series provide only a summary of very complex patterns of activities. The series should, therefore, be used in conjunction with other relevant information;
- Users generally refer to R&D data with a question in mind: "Is our national university research effort declining?" "Does my firm spend a higher proportion of its funds on R&D than the average for my industry?" etc. It is, therefore, necessary to identify the basic data relevant to each question in order to know which R&D indicator is best suited to answering the question. The user should keep in mind that the data used for the R&D indicator may be accurate enough to answer one question but not another.

## Provincial and Territorial estimates of GERD

In a country as large as Canada it is useful to have a general idea of where R&D activities are located to indicate the level of scientific and technical endeavor in a particular area and to use the statistics in association with other regional data. For these reasons, an estimate of the provincial and territorial distribution of the Canadian GERD has been prepared.

The definition of GERD in a provincial and territorial context is similar to that provided above.

The expenditures are assigned to the province or territory in which the performing establishment is located. Personnel may live in an adjoining province (e.g., the National Capital Region) and materials and equipment will often come from another province/territory or country; these factors must be taken into consideration when using GERD as a regional indicator of S&T activity.

The funding shown is of R&D carried out in a province or territory; it is not R&D funding from a province or territory. For example, when the federal government is shown as the funder for R&D in a province, the funds are received from the central government and are to be spent on R&D in an establishment in that province. The federal government, of course, raises funds from many sources, outside of that province. Similarly, when R&D is shown as being funded by the business enterprise sector, the funds are not necessarily raised from activities within the province. Most provincial governments provide minimal funding towards federal government performance, so statistical zeros are applied.

The provincial and territorial R&D expenditures for the business enterprise sector are collected on the Research and Development in Canadian Industry Survey. This survey does not collect sources of funds by province or territory. The provincial and territorial distribution by sources of funds of the business enterprise sector R&D expenditures is derived through a modeling system, which prorates values based on reported business enterprise provincial and territorial R&D. The provincial and territorial distribution of total R&D is proportionally distributed to the reported national sources of funds.

## Limitations of GERD

The GERD, like any other social or economic statistic, can only be approximately true. Different components are of different accuracy: sector estimates probably vary from 5% to 15% in accuracy. However, the GERD estimates are sufficiently reliable for their main use as an aggregate indicator for science policy.

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One of the most important problems relating to GERD concerns its definition. There remains some ambiguity in defining precisely what constitutes R&D or, for example, in a continuing project, determining the precise point at which the project passes the boundary of R&D and becomes exploitation of a process or product on which it may be said that the R&D stage has been completed. This ambiguity is perhaps less serious in internal time series, where it may be expected that the year-to-year application of the definitions by the same reporting units are at least consistent.

A second difficulty arises with regards to survey design. The people best qualified to apply the R&D definitions and classifications - scientific and technical personnel engaged in the direct management of S&T activity - rarely participate in the statistical agency's data collection process. Because the data collected are concerned not with scientific and technical content, but financial and labour inputs to achieving this content, the questionnaires tend to be addressed to and completed by financial and management staff. This is a fundamental problem of all surveys addressed to large organizations, whether they are public or private.

These two problems account for the limited amount of geographic and scientific detail in the published GERD. The amount of detail presented, for example, in the Canadian GERD as published by Statistics Canada is limited by the nature of the surveys, and the other data collection and analysis instruments. Nor is it possible to increase the amount of detail because this would require switching to new kinds of data collection instruments in a vastly expanded survey operation.

Another reason for the limited detail about sectors stems from the fact that R&D is often a secretive endeavor. Private sector companies usually want to surprise competitors with a new product. Thus the money spent on the R&D may be reported, but details about R&D projects would not. Similarly, a government department such as National Defense might report R&D expenditures but not the nature and detail of the respective R&D projects.

To summarize, the GERD serves as a general indicator of R&D activity and not as a detailed inventory of R&D projects within an organization, sector, or province. It is an estimate and as such can show trends in R&D expenditures by sector and sub-sector, by province and country, from year-to-year. In this capacity, the GERD estimates are sufficiently reliable for their main use as an aggregate indicator for science policy.

## **R&D performers and funders categorized**

### **Sectoring**

Considering that the GERD is the aggregate of the total R&D expenditures of the performing sectors, it is useful now to look at these sectors individually. Sectors are reviewed in terms of an international (OECD) framework for measuring R&D expenditures. There are four major sectors of R&D performance and five for funding:

- Government;
- Business enterprises;
- Higher education;
- Private non-profit organizations;
- Foreign (funding only).

The sectors for the GERD, as chosen and defined by the OECD, are based largely on existing United Nations classifications and in particular, the System for National Accounts (SNA). Under the general heading of "Institutional classifications", the OECD approach focuses on the characteristic properties of the performing and funding institutions. Each statistical unit is classified according to its principal

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economic activity and, consequently, the whole of the R&D resources of the unit classified are allocated to one sector or sub-sector.

## Government

The OECD definition of this sector is: "All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector)".<sup>2</sup>

Public enterprises such as Petro-Canada and Ontario Hydro are excluded from this sector and included in the business enterprise sector. Many non-profit organizations and bodies, however, are included in this sector if they either serve or are controlled by government, or both.

In Canada the distribution of GERD amongst the government sub-sectors is published. The sub-sectors are the federal government, the provincial governments and the provincial research organizations (PRO's). Currently Canada has seven PRO's. They are the New Brunswick Research and Productivity Council, the "Centre de recherche industrielle du Québec (CRIQ)", the Industrial Technology Centre (Manitoba), the Saskatchewan Research Council, Yukon Research Centre, the Nunavut Research Institute and the Aurora Research Institute (Northwest Territory).

## Business enterprise

This sector is composed of all firms, organizations and institutions whose primary activity is the production of goods or services for sale to the general public at a price intended approximately to cover at least the cost of production as well as non-profit institutes serving such firms. Included are government-owned enterprises such as Ontario Hydro and Canadian National Railways.

## Higher education

This sector is composed of all universities, colleges of technology and other institutes of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating **under the direct control of** or **administered by** higher education establishments.

A major source of data for the HERD estimation model is the Canadian Association of University Business Officers (CAUBO) Financial Information on Universities and Colleges (FIUC) survey. Of particular importance is sponsored research.

## Private non-profit organizations (PNP)

This sector comprises private or semi-private organizations which are not established primarily with the aim of making a profit.

It consists of voluntary associations (scientific and professional societies, health-oriented groups), philanthropic foundations and research institutes supported by the associations and foundations. These kinds of institutions are usually maintained by fees, dues and donations from members and sponsors and by grants from governments and enterprises. They may also obtain revenue from the sale of their products such as publications or special studies.

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Non-profit institutes and organizations excluded from this sector are those which are controlled by enterprises, government, or higher education. Such non-profit institutes and organizations are included with the respective sectors whose interests they mainly serve.

The PNP sector appears in both the performing and funding sector for the GERD for Canada. Commencing with reference year 2000, the data for the PNP sector performing research and development are not distributed by provinces, territories or the NCR. However, the national totals of research and development by performing sector include the PNP sector. The PNP sector continues to be distributed for the funding sector.

## **Foreign**

The foreign sector is included in the GERD only as a funding sector, since by definition the GERD includes R&D performed within a country and **funded from abroad** but excludes payments made abroad for R&D. Thus, funding from the foreign sector is implicitly included in the intramural expenditures of the four performing sectors.

This sector includes all international organizations (except business enterprises), including facilities and operations within the country's borders. Foreign-owned subsidiaries are not included in this sector (e.g., Ford Canada is, for the purposes for measuring R&D expenditures, a domestic organization in the Canadian business enterprise sector, even though its parent company is the Ford Motor Company of the United States).

## **Science type**

### **Definition of natural sciences and engineering**

The natural sciences and engineering field embraces the disciplines of study concerned with understanding, exploring, developing or utilizing the natural world. Included are the engineering, mathematical, life and physical sciences.

### **Definition of social sciences and humanities**

The social sciences and humanities field embraces all disciplines involved in studying human actions and conditions and the social, economic and institutional mechanisms affecting humans. Included are such disciplines as anthropology, demography, economics, geography, history, languages, literature and linguistics, law, library science, philosophy, political science, psychology, religious studies, social work, sociology, and urban and regional studies.

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## Reference documents

Users interested in total R&D spending for a sector can refer to the CANSIM tables for the following surveys:

### Gross domestic expenditures on research and development (GERD)

Detailed CANSIM tables:

- [358-0001](#) Gross domestic expenditures on research and development, by science type and by funder and performer sector.

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### Federal Science expenditures and personnel survey

Detailed CANSIM tables:

- [358-0142](#) Federal expenditures on science and technology and its components in current dollars and 2007 constant dollars
- [358-0143](#) Federal expenditures on science and technology and its components, by type of science and performing sector
- [358-0144](#) Federal expenditures on science and technology and its components, by activity and performing sector
- [358-0145](#) Federal intramural expenditures on science and technology and its components, by type of science for the National Capital Region
- [358-0149](#) Federal expenditures on science and technology and its components, by type of science, performing sector, Canada, provinces and territories

### Research and Development in Canadian Industry (RDCI)

Detailed CANSIM tables:

- [358-0140](#) Business enterprise research and development (R&D) characteristics, by field of science or technology and North American Industry Classification System (NAICS)
- [358-0161](#) Business enterprise research and development (BERD) characteristics, by industry group based on the North American Industry Classification System (NAICS), provinces and territories
- [358-0207](#) Business enterprise intramural research and development expenditures, by sources of funds
- [358-0208](#) Business enterprise intramural research and development expenditures, by performing company employment size
- [358-0209](#) Business enterprise intramural research and development expenditures, by performing company revenue size
- [358-0210](#) Business enterprise intramural research and development expenditures, by research and development expenditure size

### Higher Education Research and Development Estimates (HERD)

Detailed CANSIM tables:

- [358-0162](#) Provincial estimates of research and development expenditures in the higher education sector, by funding sector and type of science

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## Research and Development of Canadian Private Non-Profit Organizations

Detailed CANSIM tables:

- [358-0215](#) Private non-profit organizations research and development intramural expenditures, by type of science
- [358-0216](#) Private non-profit organizations research and development intramural expenditures, by sources of funds
- [358-0218](#) Private non-profit organizations payments for research and development performed by other organizations, by type of science

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## **Notes**

1. OECD, The Measurement of Scientific and Technical Activities– Frascati Manual. Paris 2002, p.121.
2. Ibid., p.62.