# From R&D statistics to S&T Indicators: National and international use of S&T data

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## Statistics vs Indicators:

"Statistics" may be described as:

"...facts which are obtained from analysing information expressed in numbers, for example information about the number of times that something happens (statistics is also a branch of mathematics concerned with the study of information that is expressed in numbers" (definition from the British "Collins Cobuild English Dictionary").

"Indicators" may be explained as:

"... a set of statistics arranged to answer a specific question (or to "ring a bell" or give an "early warning"...)

### Transforming R&D Statistics into S&T Indicators – An Example:

According to OECD statistics (source; "Main Science and Technology Indicators") the total R&D expenditures in 2007 ("GERD"), expressed in <u>national currency</u>, were some 39.489,5 million Euros in France and 35.1 billion kronùr in Iceland, i.e. two not really comparable expenditures figures.

Expressed <u>in current US dollars</u> (calculated at ppp's = purchasing power parity rates) the corresponding expenditures were 43.359,5 million dollars in France but 305 million dollars in Iceland, i.e. here we get a somewhat better relative indication of the R&D efforts of the two countries that, however, does not really take into account their size (population).

An additional step in the indicators' calculation then shows us that, seen <u>as a percentage of the GDP</u>, France was clearly less R&D intensive than Iceland (2.08 and 2.75 per cent respectively) and this difference is confirmed if we look at another commonly used indicator, that of national R&D <u>expenditures per capita</u> of total population (680 and 980 dollars, respectively).

# PRINCIPAL CRITERIA FOR CHOOSING THE BEST INDICATORS

Indicators should be :

- 1. Policy-Relevant (useful to "customers")
- 2. Analytically Sound
- 3. Measurable

# Broad Definitions of Science and Technology

The British "Collins-Cobuild English Dictionary" suggests the following definitions:

- "Science is the study of the nature and behavior of natural things and the knowledge that we obtain about them".
- "A science is a particular branch of science such as physics, chemistry, or biology..."
- "A science is the study of some aspect of human behavior, for example sociology or anthropology".
- "Technology refers to methods, systems and devices which are the result of scientific knowledge being used for practical purposes".

# The UNESCO Broad Concept of "Scientific and Technological Activities" (STA)

### S&T Activities ("STA") are:

"...systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology".

The STA include such activities as

- R&D (research and experimental development);
- Scientific and technical education and training at broadly the third level ("STET"), and
- The scientific and technological services ("STS")...»

Research and Experimental Development – "R&D" (definitions from the OECD "Frascati Manual")

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".

**Prime criterion** R&D should involve "a considerable element of novelty" (in contrast to the routine S&T activities, in general).

• The basic definition of the R&D also suggests three sub-classes, by "type of activity":

## The three sub-classes, by "type of activity":

### **1. Basic research** (or "fundamental research") defined as:

"...experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view".

### 2. Applied research is:

" also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective".

### 3. Experimental development is:

"...systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed".

# Other Scientific and Technology Indicators (UNESCO definitions)

#### Scientific and Technical Education and Training at Broadly the Third Level («STET")

« ...all activities comprising specialized non-university higher education and training, higher education and training leading to a university degree, post-graduate and further training, and organized life-long training for scientists and engineers. These activities broadly correspond to ISCED levels 5, 6 and 7 ».

#### Scientific and Technological Services (« STS »):

«...activities concerned with research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge ».

<u>Source</u>: « Recommendation concerning the International Standardization of Statistics on Science and Technology » (UNESCO 1978)

# The UNESCO List of Scientific and Technological Services (STS)

- S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information processing departments;
- S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections (anthropological, archaeological, geological, etc.);
- Systematic work on the translation and editing of S&T books and periodicals (with the exception of textbooks for school and university courses);
- Topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations; surveying of soils and of plants, fish and wildlife resources; routine soil, atmosphere and water testing, the routine checking and monitoring of radioactivity levels;
- Prospecting and related activities designed to locate and identify oil and mineral resources;
- The gathering of information on human, social, economic and cultural phenomena usually for the purpose of compiling routine statistics, e.g. population censuses; production, distribution and consumption statistics; market studies, social and cultural statistics, etc.;
- Testing, standardization, metrology and quality control; regular routine work on the work on the analysis, checking and testing, by recognized methods of materials, products, devices and processes, together with the setting up and maintenance of standards and standards of measurement;
- Regular routine work on the counselling of clients, other sections of an organization or independent users, designed to help them to make use of scientific, technological and management information. This activity also includes extension and advisory services organized by the State for farmers and for industry but does not include the normal activities of projects planning or engineering offices;
- Activities relating to patents and licences; systematic work of a scientific, legal and administrative nature on patents and licences carried out by public bodies.

# The Frascati Manual sectors of R&D performance, finance and employment:

#### The Business Enterprise (BE) sector:

"All firms, organisations and institutions whose primary activity is the market production of goods and services (other than higher education) for sale to the general public at an economically significant price, and the private non-profit institutions mainly serving them." Note: Public enterprises are included in the BE sector.

#### The Government sector:

"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".

#### The Higher Education (HE) sector

"All universities, colleges of technology and other institutions 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 or associated with higher education institutions".

#### The Private Non Profit (PNP) sector:

"Non-market, private non-profit institutions serving households (i.e. the general public) and Private individuals or households."

#### (Funds from...) Abroad:

"All institutions and individuals located outside the political borders of a country... and all international organisations (except business enterprises) including facilities and operations within the country's borders".

## Intramural vs Extramural R&D Expenditures

### Intramural expenditures

...all expenditures for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds

### **Extramural expenditures**

... the sums a unit, organisation or sector reports having paid or committed themselves to pay to another unit, organisation of sector for the performance of R&D during a specific period. This includes acquisition of R&D performed by other units and grants given to others for performing R&D.

# R&D Expenditures by Type of Cost

#### Labour Costs of the R&D Personnel:

The labour costs cover the total annual wages and salaries, including all associated social security, retirement or pension scheme contributions, holiday pays etc. for all the staff directly engaged in R&D.

#### **Other Current Costs:**

comprise purchases of materials, supplies and small equipments to support the R&D performed by the unit surveyed (examples: costs for electricity, water, fuel, books, journals, reference materials, subscriptions to libraries, laboratory animals, rents for offices and research facilities, post and telecommunications, insurance, etc. (also administrative and other overhead costs, if necessary pro-rated).

#### **R&D** Capital Expenditures:

The capital expenditures are the annual gross expenditure on fixed assets used in R&D programmes of the statistical units. They should be reported in full for the period when they took place and should not be registered as an element of depreciation.

#### R&D Expenditures on Lands and Buildings:

.expenditures for land acquired for R&D (examples: testing grounds, sites for laboratories, buildings constructed or purchased, expenditures for major improvements and repairs). In case of lands and buildings acquired for more purposes than R&D proper, some kind of pro-rating estimation may be needed.

#### **R&D** Expenditures on Instruments and Equipments:

major instruments and equipment acquired for use in the performance of R&D.

#### **Computer Software:**

the acquisition of separately identifiable computer software for use in the performance of R&D, including programme descriptions and supporting materials for both systems and applications software. Annual licensing fees for the use of acquired computer software are also included". (first time introduced in the 2002 Frascati Manual):

# NATIONAL R&D TOTALS – By performance and finance

#### GROSS DOMESTIC EXPENDITURE ON R&D (GERD) (Expenditure)

TIN Sect	National Sectors of R&D Performance							
wic tor	Business Enterprise sector	Government Sector	Higher Education sector	Private Non-Profit sector (PNP)	Total			
Business enterprise					Total financed by the enterprise sector			
Government					Total financed by the Government sector			
Higher education					<u>Total financed</u> by the Higher Education			
Public GUF					Total Public GUF			
Private Non-Profit					Total financed by the PNP sector			
Funds from abroad					<u>Total financed</u> from Abroad			
TOTAL	<u>Total performed</u> in the Business Entreprise sector (BERD)	Total performed in the Government sector (GOVERD)	Total performed in the Higher Education sector (HERD)	Total performed in the PNP sector	GERD			

### NATIONAL R&D TOTALS – By performance and finance

Table B

#### GROSS NATIONAL EXPENDITURES ON R&D (GNERD) - (funding)

ti S. N.	Sectors of performance (of domestically-financed R&D)								
nan of ur atio	Business Enterprise	Government	Higher Education	Private Non-profit	R&D Performed	TOTAL Sector			
16 20 0 <sup>3</sup> /	sector	sector	sector	(PNP) sector	Abroad	Finance			
Business						Total Enterprises			
enterprise sector						Total Enterprises			
Government sector						Total Government			
Higher Education						Total Higher			
sector						Education			
Public GUF						Total GUF			
Private Non-profit						Total Private Non-			
sector						profit			
Total National R&D Finance	T <u>otal performed</u> in the Business Entreprise sector	Total performed in the Government sector	<u>Total performed</u> in the Higher Education sector	<u>Total performed</u> in the PNP sector	<u>Total performed</u> <u>Abroad</u>	GNERD			

## Measurement of R&D (and S&T) Personnel

Two sub-classifications:

- 1. by Occupation (Broad ISCO classes)
- 2. by Level of Formal Qualification (ISCED classes) –

# R&D/S&T Personnel by Occupation

#### Researchers

 «professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and also in the management of the projects concerned.»

#### **Technicians and Equivalent Staff**

 «persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities».

#### Other supporting staff

• «skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects».

### R&D/S&T Personnel by Levels of Formal Qualification

#### Holders of university degrees at PhD level (ISCED level 6):

• "Holders of doctorate degrees of university level or equivalent in all fields (ISCED level 6. This category includes holders of degrees earned at universities proper and also at specialised institutes of university status".

#### Holders of basic university degrees below the PhD Level (ISCED level 5A)

• "Holders of tertiary-level degrees below the PhD level in all fields (ISCED level 5A). This category includes holders of degrees earned at universities proper and also at specialised institutes of university status".

#### Holders of other post-secondary diplomas (ISCED level 5B and level 4)

• "Holders of other post-secondary tertiary (ISCED level 5B) or non-tertiary (ISCED –level 4) diplomas in all fields. Subject matter is typically specialised, presented at a level requiring the equivalent of full secondary level education to master it. It provides a more practically oriented/occupation-specific education than programmes at ISCED levels 5A and 6. Many such courses are offered in part-time, evening, sandwich and refresher programmes".

#### Holders of Diplomas of Secondary Education (ISCED level 3):

• "Holders of diplomas at the secondary level, upper stage (ISCED level 3). This class includes not only all ISCED level 3 diplomas obtained in the secondary school system but also equivalent level 3 vocational diplomas obtained from other types of educational establishments".

#### **Other Qualifications:**

• "This includes all those with secondary diplomas at less than ISCED level 3 or with incomplete secondary qualifications or education not falling under any of the other four classes".

### R&D Personnel – Head-Count vs Full-Time Equivalence (FTE)

#### Head count

The «individual» (the person) is the « statistical unit" (even if only working part-time on R&D)

The Frascati Manual suggests three options for head-counts:

- 1) the total number of persons engaged in R&D on a given date (end of year, for instance);
- 2) the average number of persons engaged in R&D during the (calendar) year; or
- 3) the total number of persons engaged in R&D during the (calendar) year.

#### Full-Time Equivalence (FTE)

Measurement of "total volume" of R&D work produced by all R&D personnel together (many engaged only part-time in R&D)

The «Frascati» and «Canberra» manuals define the FTE concept as:

• One FTE may be thought of as one person-year. Thus, a person who normally spends 30 per cent of his or her time on R&D and the rest on other activities (such as teaching, university administration, and student counselling) should be considered as 0.3 FTE. Similarly, if a full-time R&D worker was employed at an R&D unit for only six months, this results in an FTE of 0.5. Since the normal working day (period) may differ from sector to sector and even from institution to institution, it is impossible to express FTE in person-hours.

# The OECD list of broad socio-economic objectives – (SEO) (Frascati Manual 2002)

- 1. Exploration and exploitation of the Earth
- 2. Infrastructure and general planning of land use
- 3. Control and care of the environment
- 4. Protection and improvement of human health
- 5. Production, distribution and rational utilisation of energy
- 6. Agricultural production and technology
- 7. Industrial production and technology
- 8. Social structures and relationships
- 9. Exploration and exploitation of space
- 10. Research financed from general university funds
- 11. Non-oriented research
- 12. Other civil research
- 13. Defence

The Table of Contents of the 2002 "Frascati Manual" (6<sup>th</sup> edition)

- Chapter 1: Aim and Scope of the Manual
- Chapter 2: Basic Definitions and Conventions
- Chapter 3:Institutional Classification
- Chapter 4Functional Distribution
- Chapter 5: Measurement of R&D Personnel
- Chapter 6:Measurement of Expenditures Devoted to R&D
- Chapter 7: Survey Methodology and Procedures
- Chapter 8: Government Budget Appropriations or Outlays for R&D by Socio-economic Objectives

### The annexes to the 2002 "Frascati Manual" (6<sup>th</sup> edition)

- Annex 1: Brief History and Origins of the Frascati Manual
- Annex 2: Obtaining Data on R&D in the Higher Education sector
- Annex 3: The Treatment of R&D in the United Nations' System of National Accounts
- Annex 4: R&D related to Health, Information and Communications Technology (ICT) and Biotechnology
- Annex 5: Methods of Deriving Regional R&D Data
- Annex 6: Work on S&T Indicators in Other International Organisations
- Annex 7: Other Science and Technology Indicators (Patent Statistics, The Technology Balance of Payments (TBP), Bibliometrics, High Technology Products and Industries, Innovation Statistics, Human Resources for Science and Technology (HRST);
- Annex 8: Practical Methods of Providing Up-to-date Estimates and Projections of Resources Devoted to R&D
- Annex 9: R&D Deflators and Currency Converters
- Annex 10: Supplementary Guidance on the Classification of large R&D Projects with Special Reference to the Defense and Aerospace Industries
- Annex 11: Correspondence between the Categories of R&D Personnel by Occupation in the Frascati Manual and ISCO-88 Classes

### The Principal OECD Methodological Manuals (the "Frascati family") on the Measurement of Scientific and Technological Activities

- Research and experimental development:
- "Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development" 6th Edition (OECD 2002); (http://ec.europa.eu/eurostat/ramon/statmanuals/files/Frascati\_Manual\_2002\_EN.pdf)
- "R&D Statistics and Output Measurement in the Higher Education Sector" Frascati Manual Supplement (OECD 1989);
- Revised Field of Science and Technology (FOS) classification, (OECD 2007)
- Annex on Measuring R&D in Developing Countries (0ECD-UNESCO 2012)
- **Technology Balance of Payments**: "Manual for the Measurement and Interpretation of Technology Balance of Payments Data TBP Manual" (OECD 1990);
- Innovation:"Guidelines for Collecting and Interpreting Innovation Data Oslo Manual" (3rd Edition, OECD 2005); (http://ec.europa.eu/eurostat/ramon/statmanuals/files/9205111E.pdf)
- **Patents**:- "Using Patents Data as Science and Technology Indicators Patents Manual" (2008); (http://ec.europa.eu/eurostat/ramon/statmanuals/files/OECD\_Patent\_Statistics\_Manual.pdf)
- **S&T Personnel**: "The Measurement of Human Resources Devoted to Science and Technology Canberra Manual" (OECD 1995); (http://ec.europa.eu/eurostat/ramon/statmanuals/files/Canberra\_Manual\_1992.EN.pdf)
- **High technology**:- "Revision of High-technology Sector and Product Classification" OECD, STI Working Paper 1997/2;
- **Bibliometrics**: "Bibliometric Indicators and Analysis of Research Systems: Methods and Examples", by Yoshiko OKUBO (OECD, STI Working Paper 1997/1 (OECD 1997);
- Globalisation:- "Handbook on Economic Globalisation Indicators" (OECD 2005);
- Productivity:- "Measuring Productivity Manual" (OECD 2001);
- **Biotechnology**:- "A Framework for Biotechnology Statistics (OECD 2005) and "Guidelines for a Harmonized Statistical Approach to Biotechnology Research and Development in the Government and Higher Education Sectors" OECD-DSTI December 2009 (www.oecd.org/sti)
- **Careers and Mobility of Doctorate Holders**: "Mapping Careers and Mobility of Doctorate Holders: Draft Guidelines, Model Questionnaire and Indicators Second Edition The OECD/UNESCO Institute for Statistics/Eurostat Careers of Doctorate Holders Project (STI Working Paper 2010/1)

# Thank you very much

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