United Nations
Educational, Scientific and
Cultural Organization

UNESCO
INSTITUTE
FOR
STATISTICS

Monitoring and Evaluation :

R&D Data and indicators

UN-Wide Training Course

Amman, Jordan, 15-19 April 2018

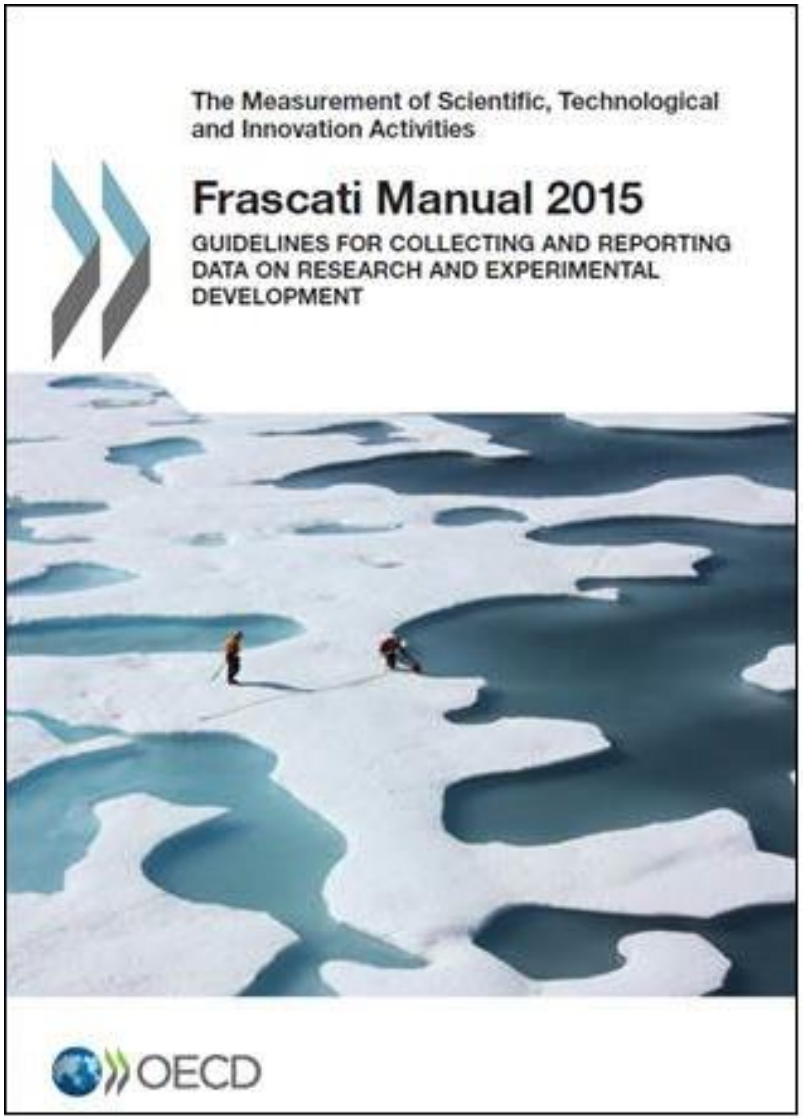



Overview

- What do we measure : R&D and Innovation?
- Why do we measure?
- How do we measure? Inputs R&D
- What is the process?
- Challenges for developing countries?
- R&D indicators and SDGs

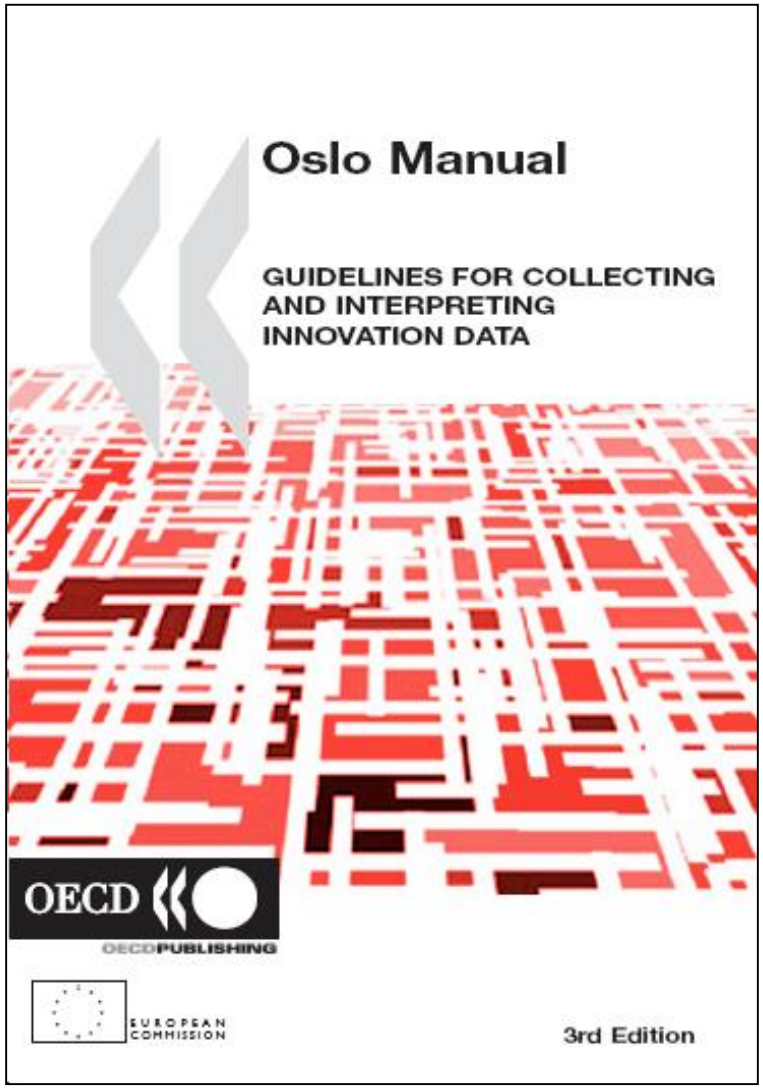
Research and Development

- First edition published in 1963!
- Just revised
- 7th edition published in October 2015
- De facto world standard
- Including context of developing countries mainstreamed in 2015 manual



http://www.oecd.org/sti/inno/frascati-manual.htm

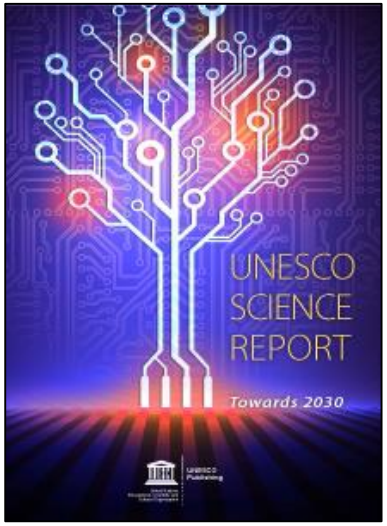
Measuring Innovation: Oslo Manual

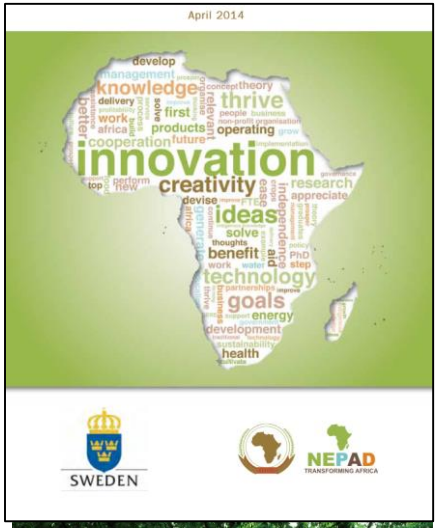


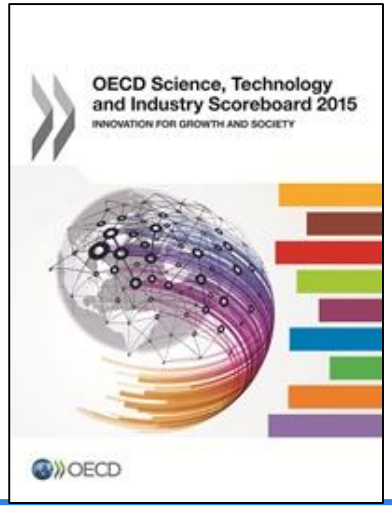
- Oslo Manual: Guidelines for collecting and interpreting innovation data
- Joint publication of OECD and EU
- 1st edition 1992
- 2nd edition 1997 → coverage expanded to services
- 3rd edition 2005 → expanded to organizational and marketing innovation
- UIS - Annex measuring innovation in developing countries (OM, 2005)
- 4th edition: Revision is underway (*OM4*)
- Used for CIS and national innovation surveys

http://www.oecd.org/innovation/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm

Examples of reports







UN Statistical Year Book

UNDP: Human Development Report

WB: World Development Indicators

Why data is needed?
Why measuring?

- Accountability for spending of public funds
- Informed strategy and forecasting; evidence-base
- Coordination of plans and budgets
- Monitoring policies and activities
- Evaluation of programmes and projects
- Benchmarking and international comparisons

Indirect benefits:

- Learning; bringing stakeholders closer
- Improving management of R&D

Data needed for SDGs

17 SDGs - 169 SDG targets, 40 selected with greatest relevance to STI, covering innovation, health, ecosystems, food security, habitat and education

- **SDG 9**: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- **Target 9.5**: Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending

Indicators tell a story

- ✓In which areas should I invest predominantly?
- ✓In which areas am I already investing?
- ✓Which are important economic sectors, in mining, agriculture, industry, services, etc?
- ✓What are national or regional peculiarities? (health, environment, utilities, defense,…)
- ✓Are there sufficient links of universities and institutes to industry?

Measuring Science, Technology and Innovation (STI):

Definitions from a statistical perspective

STA: Definition
(from UNESCO Manual for STA)

Scientific and Technological Activities (STA) can be defined as all systematic activities which are closely concerned with:

generation, advancement, dissemination, and application of scientific and technical knowledge

and applies to:

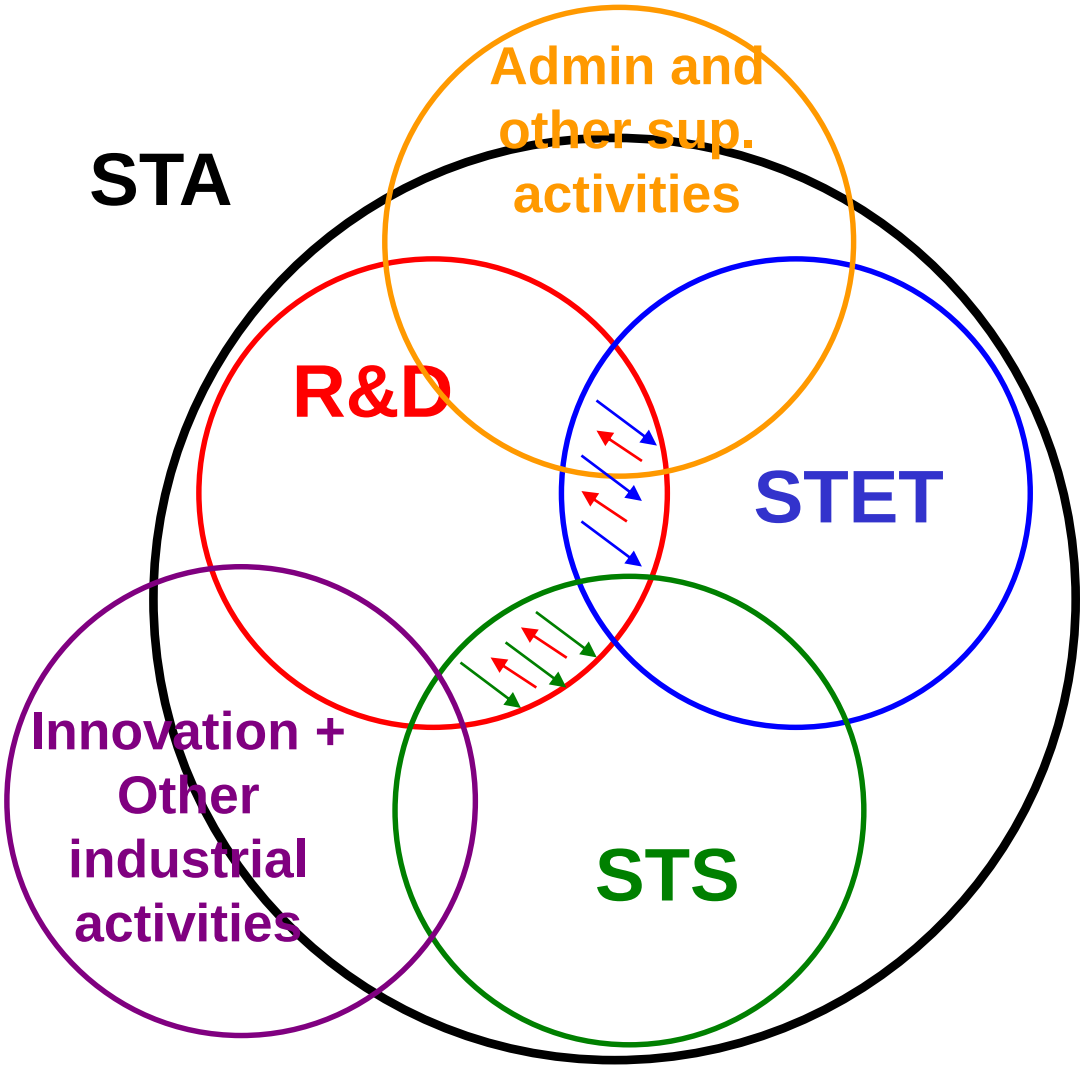
all fields of science and technology.

STA coverage

Scientific and technological activities comprise:

- Research and experimental development (R&D)
- Scientific and technical education and training (STET)
- Scientific and technological services (STS)

An indicators “framework”



Common features of R&D

- Novel (aimed at new findings)
- Creative (based on original concepts; not obvious)
- Uncertain (outcome, cost, time allocation not known a priori)
- Systematic (planned and budgeted)
- Transferable and/or reproducible (should be the potential to transfer results)

-- All five criteria are to be met, at least in principle, every time an R&D activity is undertaken whether on a continuous or occasional basis --

STET: Definition
(from UNESCO Manual for STA)

Scientific and technological education and training at broadly the third level (STET) can be defined as all activities comprising:

- Specialized non-university higher education
- All university education
- Organized lifelong training for scientists and engineers

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STS: Definition
(from UNESCO Manual for STA)

Scientific and technological services (STS) can be defined as any activities:

- Concerned with scientific research and experimental development
- Contributing to the generation, dissemination and application of scientific and technical knowledge

Ex: information and documentation activities provided by libraries, archives, databanks; services provided by museums, botanical and zoological gardens; Extension, advisory services, feasibility studies; patents, licenses

Back to R&D activities:

Examples:

- **Routine tests** such as blood and bacteriological tests carried out for medical checks are **not R&D**; **special programme of blood tests** for patients taking a new drug is **R&D**.
- **Keeping daily records** of temperatures or of atmospheric pressure is **not R&D**; **investigation of new methods** of measuring temperature is **R&D**, as is the **study and development of new models** for weather prediction.

→ *novelty and uncertainty about the final results of the study, transferability of the results for broader use, apply here.*

Examples (1): how to differentiate types of R&D - natural sciences

- The development of a new method for the classification of immunoglobulin sequences → **Basic research**
- Investigations undertaken in an effort to distinguish between antibodies for various diseases → **Applied research**
- Devising a method for synthesising the antibody for a particular disease on the basis of knowledge of its structure and clinical tests of the effectiveness of the synthesised antibody on patients who have agreed to accept an experimental advanced treatment → **Experimental development**

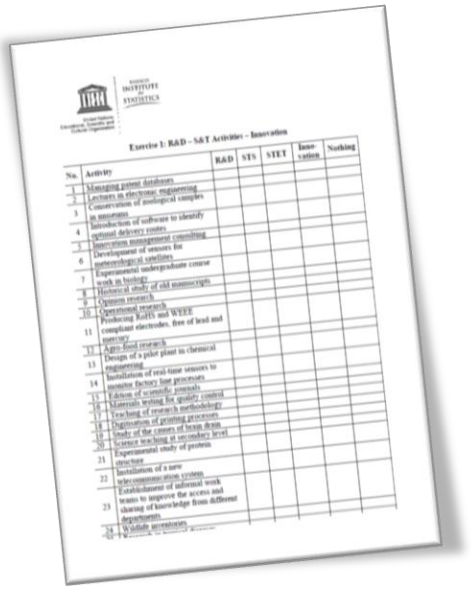
Examples (2): how to differentiate types of R&D - history

- Historians study the history and human impact of glacial outburst floods in a country → **Basic research**
- Historians examine past societies' responses to catastrophic natural events in order to understand how contemporary society might better respond to global climate change → **Applied research**
- Using research findings, historians design a new museum exhibit on the adaptations of past human societies to environmental changes; this serves as a prototype for other museums and educational installations → **Experimental development**

BOUNDARIES AND EXCLUSIONS FROM R&D

- **Product development vs Experimental development**
- **Limits between R&D and teaching and training**
- Service or indirect support activities
- R&D and traditional knowledge

Exercise…



Exercise:

R&D – S&T Activities – Innovation

Measuring (R&D)

Data collection

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Data collection: R&D Survey

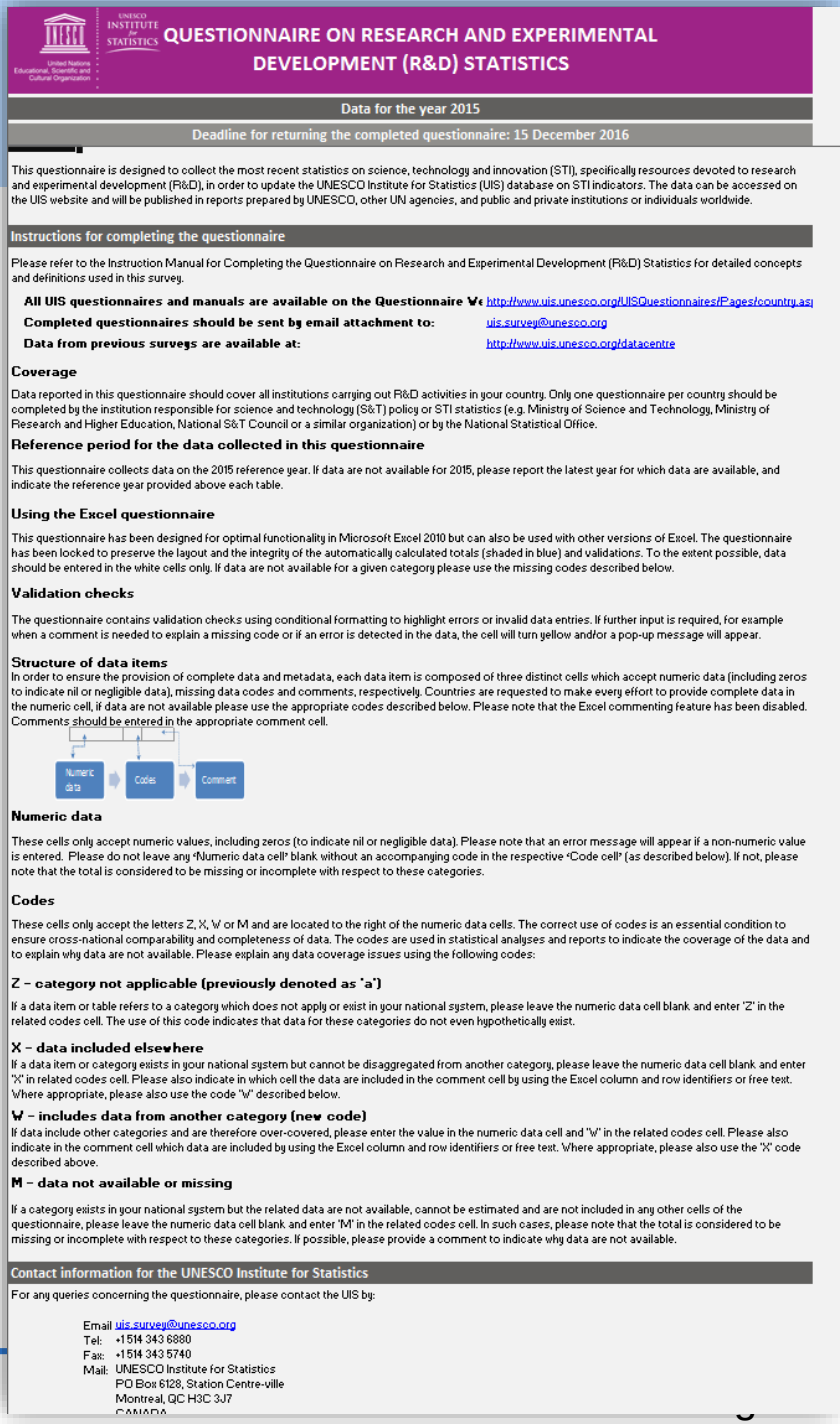
R&D Personnel

- By sector of employment, function, qualification, seniority, age and field of science
- In headcount and FTE
- By gender

R&D Expenditure

- By sector of performance and source of funds
- By type of activity, type of cost and field of science

→ *Both inputs are necessary to secure an adequate representation of the effort devoted to R&D*



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QUESTIONNAIRE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (R&D) STATISTICS

Data for the year 2015

Deadline for returning the completed questionnaire: 15 December 2016

This questionnaire is designed to collect the most recent statistics on science, technology and innovation (STI), specifically resources devoted to research and experimental development (R&D), in order to update the UNESCO Institute for Statistics (UIS) database on STI indicators. The data can be accessed on the UIS website and will be published in reports prepared by UNESCO, other UN agencies, and public and private institutions or individuals worldwide.

Instructions for completing the questionnaire

Please refer to the Instruction Manual for Completing the Questionnaire on Research and Experimental Development (R&D) Statistics for detailed concepts and definitions used in this survey.

All UIS questionnaires and manuals are available on the Questionnaire We http://www.uis.unesco.org/UISQuestionnaires/Pages/country.asp

Completed questionnaires should be sent by email attachment to: uis.survey@unesco.org

Data from previous surveys are available at: http://www.uis.unesco.org/datacentre

Coverage

Data reported in this questionnaire should cover all institutions carrying out R&D activities in your country. Only one questionnaire per country should be completed by the institution responsible for science and technology (S&T) policy or STI statistics (e.g. Ministry of Science and Technology, Ministry of Research and Higher Education, National S&T Council or a similar organization) or by the National Statistical Office.

Reference period for the data collected in this questionnaire

This questionnaire collects data on the 2015 reference year. If data are not available for 2015, please report the latest year for which data are available, and indicate the reference year provided above each table.

Using the Excel questionnaire

This questionnaire has been designed for optimal functionality in Microsoft Excel 2010 but can also be used with other versions of Excel. The questionnaire has been locked to preserve the layout and the integrity of the automatically calculated totals (shaded in blue) and validations. To the extent possible, data should be entered in the white cells only. If data are not available for a given category please use the missing codes described below.

Validation checks

The questionnaire contains validation checks using conditional formatting to highlight errors or invalid data entries. If further input is required, for example when a comment is needed to explain a missing code or if an error is detected in the data, the cell will turn yellow and/or a pop-up message will appear.

Structure of data items

In order to ensure the provision of complete data and metadata, each data item is composed of three distinct cells which accept numeric data (including zeros to indicate nil or negligible data), missing data codes and comments, respectively. Countries are requested to make every effort to provide complete data in the numeric cell, if data are not available please use the appropriate codes described below. Please note that the Excel commenting feature has been disabled. Comments should be entered in the appropriate comment cell.

Numeric data

These cells only accept numeric values, including zeros (to indicate nil or negligible data). Please note that an error message will appear if a non-numeric value is entered. Please do not leave any "Numeric data cell" blank without an accompanying code in the respective "Code cell" (as described below). If not, please note that the total is considered to be missing or incomplete with respect to these categories.

Codes

These cells only accept the letters Z, X, W or M and are located to the right of the numeric data cells. The correct use of codes is an essential condition to ensure cross-national comparability and completeness of data. The codes are used in statistical analyses and reports to indicate the coverage of the data and to explain why data are not available. Please explain any data coverage issues using the following codes:

Z – category not applicable (previously denoted as 'a')

If a data item or table refers to a category which does not apply or exist in your national system, please leave the numeric data cell blank and enter 'Z' in the related codes cell. The use of this code indicates that data for these categories do not even hypothetically exist.

X – data included elsewhere

If a data item or category exists in your national system but cannot be disaggregated from another category, please leave the numeric data cell blank and enter 'X' in related codes cell. Please also indicate in which cell the data are included in the comment cell by using the Excel column and row identifiers or free text. Where appropriate, please also use the code 'W' described below.

W – includes data from another category (new code)

If data include other categories and are therefore over-covered, please enter the value in the numeric data cell and 'W' in the related codes cell. Please also indicate in the comment cell which data are included by using the Excel column and row identifiers or free text. Where appropriate, please also use the 'X' code described above.

M – data not available or missing

If a category exists in your national system but the related data are not available, cannot be estimated and are not included in any other cells of the questionnaire, please leave the numeric data cell blank and enter 'M' in the related codes cell. In such cases, please note that the total is considered to be missing or incomplete with respect to these categories. If possible, please provide a comment to indicate why data are not available.

Contact information for the UNESCO Institute for Statistics

For any queries concerning the questionnaire, please contact the UIS by:

Email uis.survey@unesco.org
Tel: +1 514 343 6880
Fax: +1 514 343 5740
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PO Box 6128, Station Centre-ville
Montreal, QC H3C 3J7
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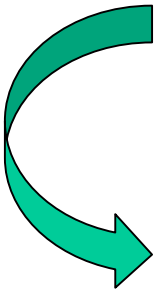
UIS 2015 and 2016 Surveys on R&D: response rates & published data

Regions	Countries & territories covered	Q2015		Q2016		Published data (as of June 2017)	
		Effective responses (i.e. only with data)		Effective responses (i.e. only with data)			
Sub-Saharan Africa	44	4	9%	5	11%	34	77%
Arab States	**21**	**6**	**29%**	**8**	**38%**	**15**	**71%**
Central and Eastern Europe	8	5	63%	7	88%	8	100%
Central Asia	9	5	56%	7	78%	8	89%
East Asia and the Pacific	22	6	27%	6	27%	12	55%
South and West Asia	9	2	22%	2	22%	6	67%
Latin America and the Caribbean	9	1	11%	1	11%	3	33%
North America and Western Europe	2	0	0%	0	0%	0	0%
Sub-total (only from UIS R&D survey)	**124**	**29**	**23%**	**36**	**29%**	**86**	**69%**
OECD + Eurostat countries	*46*	45	*100%*	*45*	*100%*	*45*	*100%*
RICYT countries	*26*	19	*73%*	*19*	*73%*	*19*	*73%*
Total countries & territories (incl. OECD, Eurostat, RICYT)	**196**	**93**	**47%**	**100**	**51%**	**150**	**77%**

Input indicators

- **R&D Personnel**
  - **All persons** engaged **directly in R&D**, as well as those providing direct services for the R&D activities
    - » **Researchers**
    - » **Technicians**
    - » **supporting staff**



Classification that refers to the ‘actual function’

Key to distinguish R&D personnel…

Researchers

professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods

Technicians and equivalent staff

- tasks require **technical knowledge** and experience (in engineering, physical and life sciences, or SHS and arts)
- perform scientific and technical tasks involving the **application** of concepts and operational methods, and the use of research equipment, normally **under the supervision of researchers**

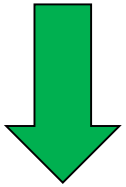
Other supporting staff

skilled and unskilled craftsmen, and **administrative, secretarial and clerical staff participating in R&D projects** or **directly** associated with such projects

How to measure R&D personnel?

1. Measuring their number in headcounts (HC): total number of individuals contributing to R&D

2. Measuring their R&D activities in full-time equivalent (FTE): person-years



R&D : primary or secondary function; part-time activity
(*e.g.* university teachers or postgraduate students)

Including only individuals whose primary function is R&D → **underestimation;**
Including everyone spending any time at all on R&D → **overestimation**

The number of persons engaged in R&D must, therefore, also be expressed both in HCs and FTEs

Full-time equivalents (FTEs) of R&D personnel

One FTE = one individual full-time on R&D, or more persons part-time or for a shorter period on R&D, corresponding to one person-year.

FTE is the true measure of the volume of R&D and is considered the main R&D personnel statistic for international comparisons

Use of HCs is mostly recommended in terms of exploring the characteristics of R&D personnel, such as age, gender or national origin

FTE calculations

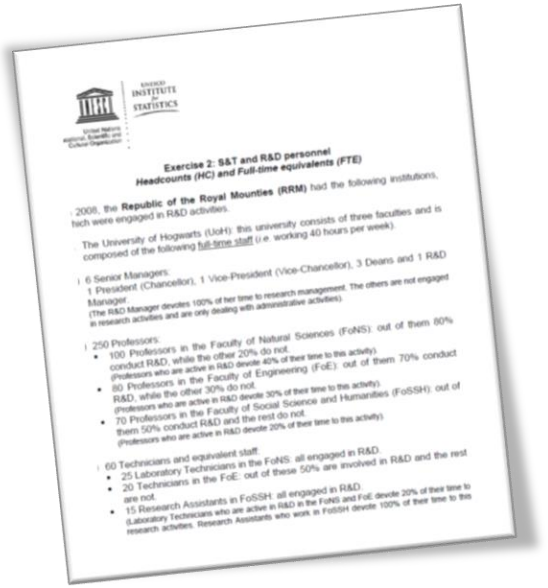
- A full time employee spending 100% of time on R&D during a year → **(1 x 1 x 1) = 1 FTE**
- A full time employee spending 30% of time on R&D during a year → **(1 x 1 x 0.3) = 0.3 FTE**
- A part-time employee (working 40% of a full time year) spending 60% of time on R&D during half of the year (person is only active for 6 months per year) → **(0.4 x 0.5 x 0.6) = 0.12 FTE**

HC & FTE & R&D Expenditure (GERD)
contd..

FTE is key to adequately calculating GERD

- Researcher's salaries are a significant part of GERD
- GERD should only include the proportion of the salaries devoted to R&D, *i.e.* FTE R&D salaries
- Including HC salaries would lead to significantly overestimated GERD

Exercise…



Exercise 2: S&T and R&D personnel
Headcounts (HC) and Full-time equivalents (FTE)

In 2008, the **Republic of the Royal Mounties (RRM)** had the following institutions, which were engaged in R&D activities.

The University of Hogwarts (UoH): this university consists of three faculties and is composed of the following full-time staff (i.e. working 40 hours per week).

- 6 Senior Managers:
  1 President (Chancellor), 1 Vice-President (Vice-Chancellor), 3 Deans and 1 R&D Manager.
  (The R&D Manager devotes 100% of her time to research management. The others are not engaged in research activities and are only dealing with administrative activities).
- 250 Professors:
  - 100 Professors in the Faculty of Natural Sciences (FoNS): out of them 80% conduct R&D, while the other 20% do not.
    (Professors who are active in R&D devote 40% of their time to this activity).
  - 80 Professors in the Faculty of Engineering (FoE): out of them 70% conduct R&D, while the other 30% do not.
    (Professors who are active in R&D devote 30% of their time to this activity).
  - 70 Professors in the Faculty of Social Science and Humanities (FoSSH): out of them 50% conduct R&D and the rest do not.
    (Professors who are active in R&D devote 20% of their time to this activity).
- 60 Technicians and equivalent staff:
  - 25 Laboratory Technicians in the FoNS: all engaged in R&D.
  - 20 Technicians in the FoE: out of these 50% are involved in R&D and the rest are not.
  - 15 Research Assistants in FoSSH: all engaged in R&D.
    (Laboratory Technicians who are active in R&D in the FoNS and FoE devote 20% of their time to research activities. Research Assistants who work in FoSSH devote 100% of their time to this

Exercise:

R&D personnel:

Calculation of Headcounts (HC) and Full-time equivalents (FTE)

Why measure R&D expenditure?

- **Amount spent of big interest to national and international policy makers**
- Statistics used to:
  - measure who conducts, who funds R&D, where it takes place, level and purpose of such activities, and interactions and collaborations between institutions and sectors
  - inform the development of fiscal and financial incentives to stimulate R&D
  - understand **how R&D contributes to econ growth, defence and socio well -being**

Categories: current and capital R&D expenditures

Current expenditures:

- **Labour costs of R&D personnel**

  annual wages and salaries and associated costs

- **Other current costs**

  purchases of materials, supplies and equipment (incl. water, gas and electricity); books, journals, subscriptions; materials for laboratories;

  administrative costs; costs for external R&D personnel

Capital expenditures:

land, buildings, machinery and equipment; capitalised computer software; intellectual property products

Measuring R&D funding flows

- R&D involves significant transfers of resources among units, organisations and sectors
  - In particular between government and other performers
- R&D expenditure = resources actually spent on R&D activities, rather than only budgeted.
- For sound data → rely on responses of R&D performers rather than funding agencies (Performers know best about actual expenditures)

Step-by-step approach

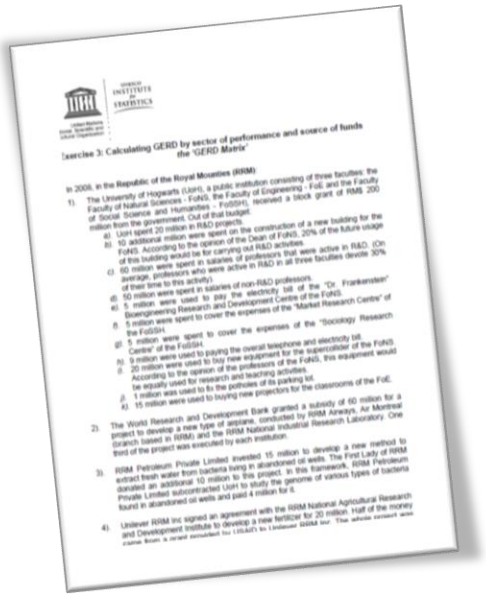
- Simplified step-by-step approach for measuring expenditures:
  - **Identify the expenditures on R&D performed within each statistical unit**
  - **Identify the sources of funds for these R&D expenditures (**Business, Government, Higher education, Private non-profit and abroad)
  - Identify the amount of **funding flows** between units

Aggregate the data by sectors of performance and sources of funds to derive significant national totals

National totals

- Gross domestic expenditure on R&D (GERD): expenditures on R&D performed on the national territory
  - but excludes payments for R&D performed by the rest of the world.
  - constructed by adding together the expenditures of the four performing sectors.
- Gross national expenditure on R&D (GNERD): expenditures on R&D financed by a country's institutions
  - it excludes R&D performed within a country but funded from the rest of the world.

Exercise…



Exercise 3: Calculating GERD by sector of performance and source of funds the 'GERD Matrix'

In 2008, in the Republic of the Royal Mounties (RRM)

1) The University of Hogwarts (UoH), a public institution consisting of three faculties: the Faculty of Natural Sciences - FoNS, the Faculty of Engineering - FoE and the Faculty of Social Science and Humanities - FoSSH), received a block grant of RMS 200 million from the government. Out of that budget:
   a) UoH spent 20 million in R&D projects.
   b) 10 additional million were spent on the construction of a new building for the FoNS. According to the opinion of the Dean of FoNS, 20% of the future usage of this building would be for carrying out R&D activities.
   c) 60 million were spent in salaries of professors that were active in R&D. (On average, professors who were active in R&D in all three faculties devote 30% of their time to this activity).
   d) 50 million were spent in salaries of non-R&D professors.
   e) 5 million were used to pay the electricity bill of the "Dr. Frankenstein" Bioengineering Research and Development Centre of the FoNS.
   f) 1 million were spent to cover the expenses of the "Sociology Research Centre" of the FoSSH.
   g) 5 million were spent to cover the expenses of the "Sociology Research Centre" of the FoSSH.
   h) 5 million were used to paying the overall telephone and electricity bill.
   i) 9 million were used to buy new equipment for the supercolider of the FoNS.
   j) 20 million were used to buy new equipment for the supercolider of the FoNS. According to the opinion of the professors of the FoNS, this equipment would be equally used for research and teaching activities.
   k) 1 million was used to fix the potholes of its parking lot.
   l) 1 million was used to to buying new projectors for the classrooms of the FoE.
   m) 15 million were used to buying new projectors for the classrooms of the FoE.

2) The World Research and Development Bank granted a subsidy of 60 million for a project to develop a new type of airplane, conducted by RRM Airways, Air Montreal branch based in RRM) and the RRM National Industrial Research Laboratory. One third of the project was executed by each institution.

3) RRM Petroleum Private Limited invested 15 million to develop a new method to extract fresh water from bacteria living in abandoned oil wells. The First Lady of RRM donated an additional 10 million to this project. In this framework, RRM Petroleum Private Limited subcontracted UoH to study the genome of various types of bacteria found in abandoned oil wells and paid 4 million for it.

4) Unilever RRM Inc signed an agreement with the RRM National Agricultural Research and Development Institute to develop a new fertilizer for 20 million. Half of the money came from a grant awarded by USAID's to Unilever RRM Inc. The whole research was

Exercise:

Calculating GERD by sector of performance and source of funds the 'GERD Matrix'

Carrying out R&D surveys: procedures and guidelines

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Scope and Challenges of R&D surveys

- Each country and its innovation system are unique: size and structure of R&D capacities vary. Every country has different constraints.
- One size does **not** fit all: advice is therefore of general nature.
- Each sector has different management styles, approaches and institutional culture.
- Consider the existing norms in relation to data exchange
- Costly exercise

Exhaustive surveys not possible in most countries.

Survey procedures by sector

- Government sector
- Higher education sector
- Business enterprise sector
- Private non-profit sector

Government sector

- Who should be included?
  - Public research institutes; Department-based research institutions; general administrations; statistical, meteorological, geological services, museums, hospitals; municipality level.

These institutions are usually well known. Identification generally easy.

- Conduct a census of relevant organizations/units known or assumed to perform R&D.
- Sources for survey: registers, databases, patents etc

Higher education sector

- Higher Education institutes (HEIs) are the main seat of R&D activity.
  - every effort must be made to ensure good coverage of these bodies
- The primary function of HEIs is teaching, not research:
  - good estimate of the time spent on research and research expenditure is key

Units to cover: All universities and corresponding institutions, especially those awarding degrees at the doctorate level.

Sources to identify generally easy : lists, publications databases

Contact point: VC/President or Deputy VC, Dean of Faculties, Dean of Research or, Head of Departments, etc.

Business enterprise sector

- The **enterprise** is recommended as the main statistical unit in the BE sector.
  - Some enterprises perform R&D on a regular basis, and may have one or several R&D units
  - Other enterprises perform R&D only occasionally
- Units to cover: All enterprises performing R&D, either continuously or occasionally
- A census-based survey of large enterprises and a sample of smaller ones to identify R&D performers and request the information from them.
- Contact point: through CEO, or a divisional head.

Business enterprise sector

- **Some typical issues:**
- R&D performed in business sector low in developing economies; Even in developed countries, 5-10% of firms carry out 90% of R&D.
- Although business sector is central to the goal of innovation, small percentage of firms are engaged in regular R&D activities. Many firms that innovate do not carry out in-house R&D.
- Large firms/MNC - discussion with the Chief Financial Officer or Chief Technology Officer; Missing a large firm might result in significant error.
- Publicly-owned businesses play a major role in R&D in some developing countries
- Service sector often under-reported: try to engage with leading banks, insurers, mobile telephony and ICT companies.

Private non-profit sector

- Differs significantly country by country; same challenges as in business.
- Difficulty in identifying PNPs engaged in R&D; Not clear about, status, ownership.
- Perform in-house R&D as well as contract R&D.
- Sources for identifying possible survey respondents: mainly the same as for the government sector.

Who is the right respondent?

- **Government:** PRIs, DBRIs: Head of research or research manager(s) incorporation with Accountant/personnel manger.
- **Higher education:** Dean of Faculties or Dean/Head of research/departments in collaboration with Account/personnel departments.
- **Business enterprise**: might be the CEO, or a technology/production manager. It is rare for staff in human resources or finance to have such knowledge and information.

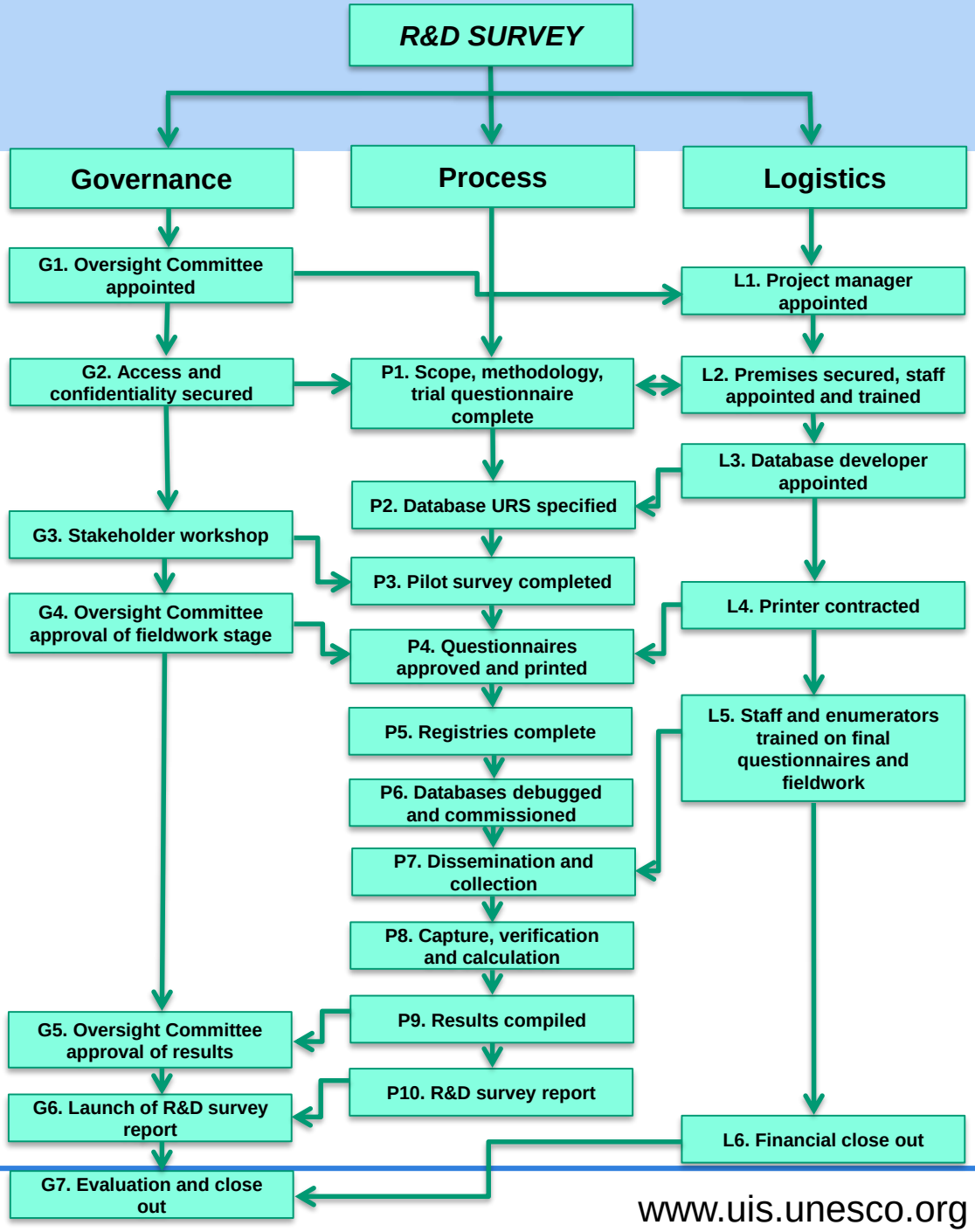
The R&D Survey: governance, logistics and process

- **The R&D Survey as a Project**: The Survey is a project studying peer institutions (stakeholders) of the NIS.
- The R&D Survey is conducted over a fixed time period, results in a final product (the R&D Survey Report).
- It is recommended to carry out the R&D survey according to an accepted project management methodology.
  - Clear beginning and deadline, logical sequence, defined objectives, verifiable indicators, specified deliverables,
  - Agreed budget and human resources.
  - Mechanisms for learning and adjustment (M&E).

An R&D Survey is structured along three result paths each with its series of Project Milestone

Governance: oversight, advice, and authority.

- **Process:** main work from design through implementation/carry out and close out.
- **Logistics:** financial, human and material resources.



Conclusions

- Definitions / classifications / methods of calculation are key
- Conducting R&D surveys is challenging / need for building capacities
- Countries to establish **sustainable and coordinated STI statistics systems**, involving line ministries (S&T Ministries or Research Councils) and National Statistical Offices, business sector

Some publications

- Data publicly available at: http://www.uis.unesco.org http://stats.uis.unesco.org/
- http://www.uis.unesco.org/ScienceTechnology/Pages/default.aspx
- UNESCO Science Report 2015
- R&D expenditure viz: http://www.uis.unesco.org/_LAYOUTS/UNESCO/research-and-development-spending/?SPSLanguage=EN
- R&D eAtlas: http://www.tellmaps.com/uis/rd/
- Women in science viz: http://www.uis.unesco.org/ScienceTechnology/Pages/women-in-science-leaky-pipeline-data-viz.aspx

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Thank you!

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