UNESCO INSTITUTE for STATISTICS

United Nations Educational, Scientific and Cultural Organization

Science, Technology and Innovation Statistics

Training material for capacity building workshops

Developed by the UNESCO Institute for Statistics

January 2012

Contents

Abbreviations

Eurostat	Statistical Office of the European Union
FT	Full-time
FM	Frascati Manual
GERD	Gross Domestic Expenditure on R&D
HRST	Human resources for science and technology
ICT	Information and communication technology
LCU	Local currency unit
NSE	Natural Sciences and Engineering
OECD	Organisation for Economic Co-operation and Development
OM	Oslo Manual
PT	Part-time
R&D	Research and (experimental) development
S&T	Science and technology
SME	Small and medium-sized enterprise
SSH	Social Sciences and Humanities
STA	Science and technology activities
STET	Scientific and technological education and training at broadly the third level
STI	Science, technology and innovation
STS	Science and technology services
STAM	UNESCO Manual for Statistics on Scientific and Technological Activities
TG	UIS Technical Guide no. 5: Measuring R&D: Challenges Faced by Developing Countries
UIS	UNESCO Institute for Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization

Introduction[1]

Innovation is now universally regarded as an engine of economic growth in developing as well as developed countries – it is therefore an important driver of poverty alleviation. To set effective innovation policies, policy-makers need trustworthy indicators to benchmark and monitor these policies. In order to increase internationally comparability, these indicators need to be based on common standards. These standards have been developed over the last 50 years, in particular at the OECD by its member countries.

The countries that have developed the standards are generally developed countries, but there is a need in developing countries as well to measure science and technology. The UNESCO Institute for Statistics has been carrying out capacity building and training workshops for developing countries since 2005. Although other relevant subjects are discussed as well, the main focus of these workshops is on science and technology (S&T) statistics, research and development (R&D) statistics and innovation statistics.

Over the years, a number of standard presentations have evolved around these topics. This document has taken this information out of the presentations in order to put it together in one place, for the benefit of participants at future workshops. In essence, it is a summary of the main methodologies as laid down in the Frascati Manual, the Oslo Manual, the UNESCO Manual for Statistics on Scientific and Technological Activities and the UIS Technical Paper on Measuring R&D: Challenges Faced by Developing Countries. Most of the content is copied from these publications.

This document covers the following five presentations of an UIS capacity building workshop:

1. Introduction to Frascati Manual: Definitions on R&D-STA-Innovation.
2. Introduction to Frascati Manual: Measurement of R&D personnel.
3. Introduction to Frascati Manual: Expenditure devoted to R&D.
4. Measuring R&D in Developing Countries: Annex to the Frascati Manual and UIS Technical Guide on Measuring R&D – Challenges Faced by Developing Countries.
5. Innovation Surveys in Developing Countries: Oslo Manual.

Exercises and solutions to the three exercises, which are usually part of UIS workshops, are presented in two separate documents. These exercises deal with the following topics:

1. What is R&D and what's not?
2. Measurement of R&D personnel, calculation of full-time equivalent.
3. Building the GERD matrix.

[1] This version of this document was completed in September 2011. Comments are welcome and should be directed at m.schaaper@unesco.org.

Chapter 1: Measuring Science, Technology and Innovation: Definitions from a Statistical Perspective

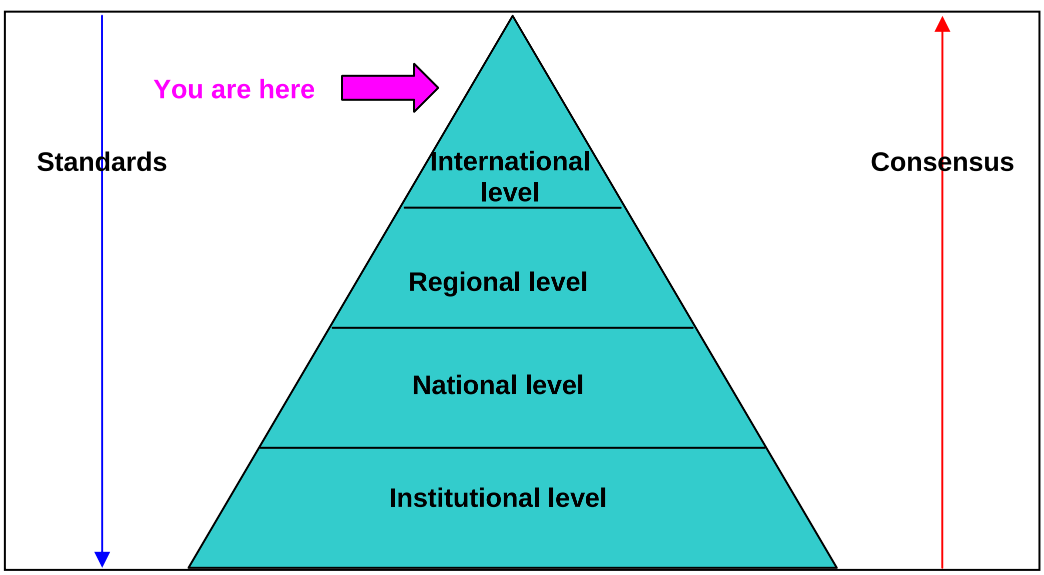
Introduction

The objective of this chapter is to give an overview of existing definitions of science, technology and innovation (STI) from a statistical point of view. As such, it is a worked-out version of a PowerPoint presentation that is usually presented as one of the first agenda items of a UIS capacity building workshop on S&T statistics. While the PowerPoint only presents the main points, this chapter provides detailed definitions and references to the relevant paragraphs of the Frascati Manual, the Oslo Manual and the UNESCO Manual for Statistics on Scientific and Technological Activities.[2]

There is a multitude of concepts around the subject of science, technology and innovation (STI), such as knowledge-based economy or national innovation system. Usually, these concepts are not defined properly, and even if they are defined properly, this is not done from a statistical point of view. However, the definitions in this chapter have been developed by statisticians, based on their experience in collecting data.

The definitions discussed in this chapter have been the result of consensus building by national experts at the international level, usually at international or regional organisations, such as the OECD, UNESCO and Eurostat. Figure 1 below explains the process.

Figure 1: Standardisation of indicators



Different countries may have different definitions of the various concepts, and even within a country, the various institutions may have definitions that are relevant to their own situation, but that are not harmonised with other institutions. However, for the sake of international

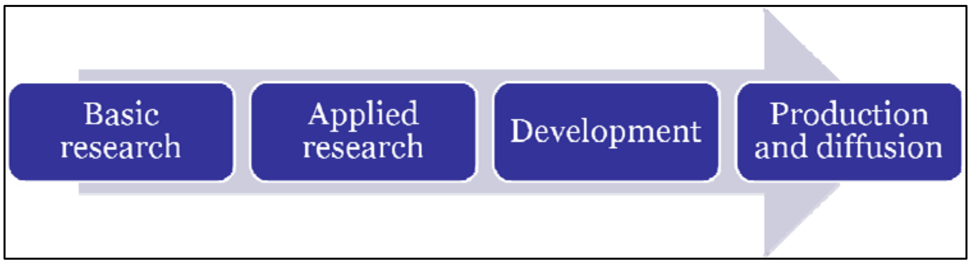
[2] In the remainder of this document, FM §xx refers to paragraph number xx of the Frascati Manual. Similarly, OM stands for Oslo Manual and STAM stands for the UNESCO Manual for Statistics on Scientific and Technological Activities.

comparability, it is essential that concepts are harmonised at the international level. To achieve this, countries compromise to reach consensus. The standards that result from this consensus are laid down in manuals and eventually become the standard for the collection of internationally comparable statistics. These standards are the subject of discussion in this document.

Frameworks

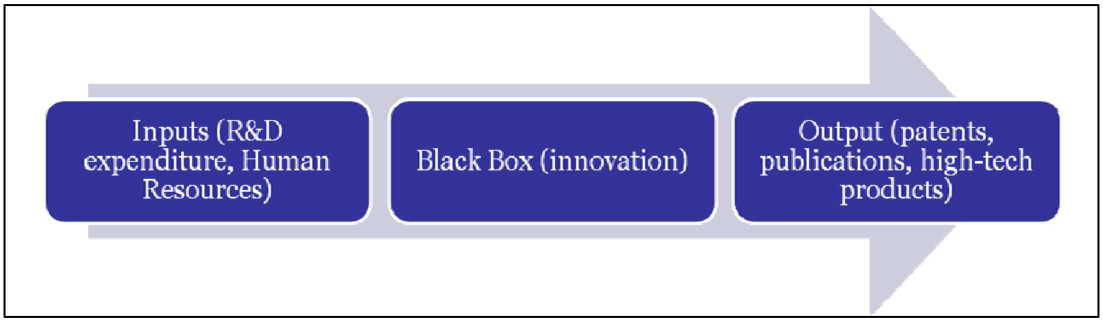
When the statisticians developed the definitions of science, technology and innovation, the main aim was international comparability and applicability in practice, rather than to conceptualise a specific framework. Nevertheless, a linear model of innovation has been used in the past, which has a number of benefits for the sake of defining indicators. Figure 2 shows the structure of the linear model. It suggests that basic research leads to applied research, after which the stage of experimental development eventually leads to the production and diffusion of new goods and services.

Figure 2: A linear model of innovation



One of the advantages of this model is that it is possible to match this model with a model of STI indicators. The idea is, as portrayed in Figure 3, that inputs into the system leads to outputs. Inputs are the money and people invested in R&D, while the outputs are patents, publications and new goods and services. The process that converts inputs into outputs is a bit of a black box, often coined with the term innovation.

Figure 3: A linear model of STI indicators



As a result, to statistically describe the innovation system, we need R&D indicators, innovation indicators and indicators on publications, patents and new products (often high-tech products). The linear model is easy to understand, however, it is now generally accepted that it does not do justice to reality. There are numerous feedback and feed-forward loops and linkages between the actors. Therefore what is need is a systems approach that takes these linkages into account.

Despite the criticism of the linear model, STI indicators still follow to a large extent the model of Figure 3. In recent years, innovation indicators have been developed that try to do this, but there is still a long way to go. This document focuses only on the input and process indicators (innovation), which are generally collected through surveys. For output indicators, different sources and compilation methods approaches are used that are outside the scope of this document.

UNESCO and OECD guides

STI is a broad concept and encompasses many activities. There is no clear-cut definition, but there are several concepts that are part of STI or related to STI which have been defined. UNESCO and the OECD were both involved in standard setting as early as in the 1960s. Although these organisations did not always take the same direction, at least they share a common definition of R&D.

UNESCO developed the concept of Scientific and technological activities (STA) and included it in its "Recommendation concerning the International Standardisation of Statistics on Science and Technology" (UNESCO, 1978) and released the UNESCO Manual for Statistics on Scientific and Technological Activities (UNESCO, 1984). These documents have not been updated since.

The OECD has been more prolific, and has produced a whole range of manuals and guidelines, starting in 1963 with the Frascati Manual. Most of the OECD standards have been revised, often more than once. Table 1 below gives an overview of these manuals and frameworks. A table with links can be found in the References.

Table 1: "Frascati family" of OECD Manuals and related manuals/frameworks

Type of data	Title
Frascati family of Manuals	
R&D	Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development (6th Edition, 2002)
Innovation	OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual (3rd Edition, 2005)
S&T personnel	The Measurement of Human Resources Devoted to Science and Technology – Canberra Manual (1995)
Patents	OECD Patent Statistics Manual (2009)
Technology balance of payments	Included in Chapter 4 of the Handbook of Economic Globalisation Indicators (2005)
Other methodological frameworks for S&T	
High-technology	Included in Chapter 4 of the Handbook of Economic Globalisation Indicators (2005)
Bibliometrics	"Bibliometric Indicators and Analysis of Research Systems, Methods and Examples", by Yoshiko Okubo (OECD, STI Working Paper 1997/1)
Globalisation	Handbook of Economic Globalisation Indicators (2005)
Information Society	Guide to Information Society Measurements and Analysis (2nd edition, 2009)
Biotechnology	Framework for Biotechnology Statistics (2005)
Productivity	Measuring Productivity. Measurement of aggregate and industry-level productivity growth (2001)

Definitions

The remainder of this chapter will provide definitions, examples and borderline cases of the concepts of STI. Although there is no agreed framework for STI, for the purpose of statistical definitions, we can think of a model as in Figure 4. The Figure takes as basic element science and technology activities (STA) as defined by UNESCO in 1978.

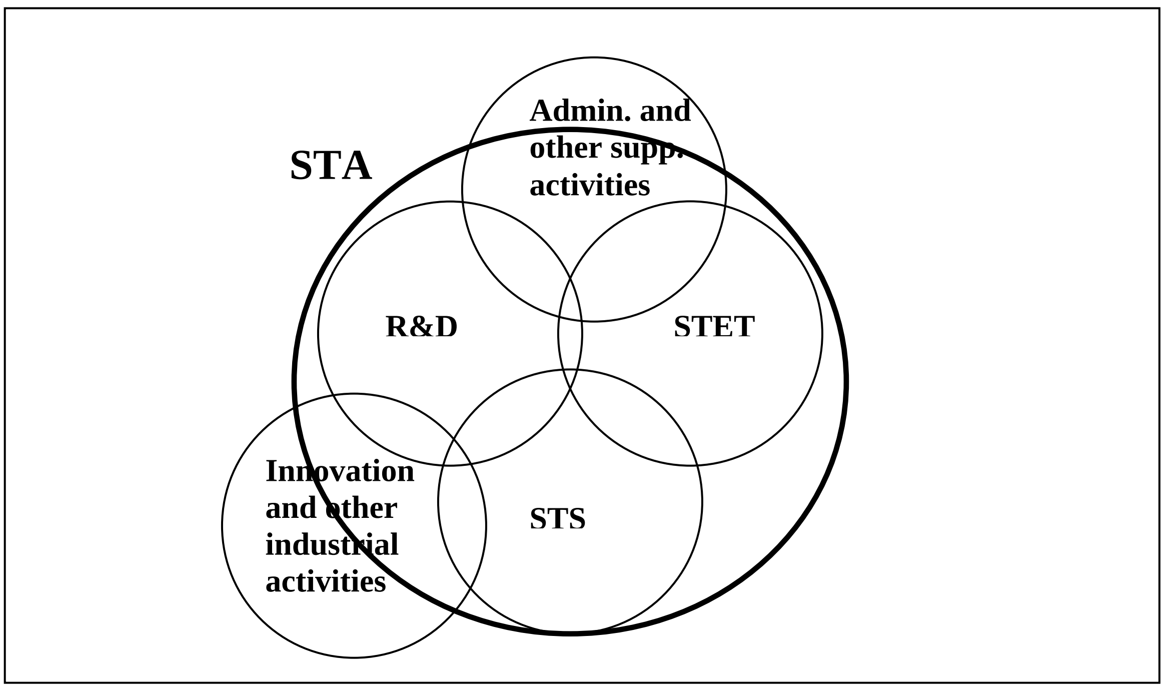
For statistical purposes, **Scientific and Technological Activities (STA)** can be defined as all systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology, that is the natural sciences, engineering and technology, the medical and the agricultural sciences (NS), as well as the social sciences and humanities (SSH). (STAM p.17)

Scientific and technological activities comprise:

- Research and experimental development (R&D);
- Scientific and technical education and training (STET);
- Scientific and technological services (STS). (FM §19, STAM p. 17)

Figure 4 shows the breakdown of Scientific and Technological Activities into its three main components. The Figure furthermore shows two additional categories that are related to and are sometimes part of STA. Although in theory the three main categories are mutually exclusive, they are shown here as overlapping. Allocating the overlapping part to one or the other category is one of the main tasks of the statistician, and forms an important part of the various manuals. These areas will be discussed later, when borderline cases, specific cases and examples are discussed.

Figure 4: An STI indicators "framework"



The three main categories and innovation have been defined as follows.

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. (FM §63)

Scientific and technological education and training at broadly the third level (STET) can be defined as 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 lifelong training for scientists and engineers. (STAM p.30)

Scientific and technological services (STS) can be defined as any activities concerned with scientific research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge. (STAM p.30)

An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. (OM §146)

Research and experimental development (R&D)

Although R&D has been defined similarly by UNESCO and the OECD, the Frascati Manual of the OECD will be taken as guideline. The Frascati Manual was first published in 1963. By now it has been revised five times. The sixth edition published in 2002 and it has become the *de facto* world standard.

The basic criterion for distinguishing R&D from related activities is the presence in R&D of **an appreciable element of novelty** and the resolution of scientific and/or technological uncertainty, *i.e.* when the solution to a problem is not readily apparent to someone familiar with the basic stock of common knowledge and techniques for the area concerned. (FM §84)

The term R&D covers three activities: basic research, applied research and experimental development.

- **Basic research** is 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.
- **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.
- **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. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units. (FM §64)

For survey purposes, R&D must be distinguished from a wide range of related activities with a scientific and technological basis. These other activities are very closely linked to R&D both through flows of information and in terms of operations, institutions and personnel, but as far as possible, they should be **excluded** when measuring R&D. (FM §65)

Possibly the greatest source of error in measuring R&D is the difficulty of locating the cut-off point between experimental development and the related activities required to realise an innovation. Errors in this respect are particularly significant. (FM §24)

Activities to be excluded from R&D fall under four headings: (FM §66)

- Education and training (however, research by students at the PhD level carried out at universities should be counted, whenever possible, as a part of R&D);
- Other related scientific and technological activities;
- Other industrial activities;
- Administration and other supporting activities.

More details on the inclusions in and exclusions from R&D follow later in this chapter. Guidance on measuring R&D personnel and R&D expenditure will be provided in Chapters 2 and 3 respectively.

Scientific and technological education and training at broadly the third level (STET)

The activities of STET correspond broadly to levels 5, 6 and 7 of ISCED 1976 – the version of the classification which was current at the time the STA Manual (1984) was written. ISCED has been revised since. STET broadly corresponds to levels 5 and 6 of the latest revision (ISCED 1997). However, the classification is again under review with a new version expected to be adopted towards the end of 2011.

STET covers not only the high-level educational and training activities carried out within colleges, universities, etc., but also includes specialized advanced training courses for scientific and technical manpower provided by public and non-public institutions which do not form an integral part of the traditional education system.

The “education and training” activities should be separated from R&D activities and from scientific and technological services. Thus, the research aspects of post-graduate training should be included in R&D. (STAM p.30)

Scientific and technological services (STS)

The common denominator of this composite group of scientific activities, which are defined and illustrated below, is the direct or indirect link with R&D, from which they may be distinguished by the fact that they do not have the character of innovation. Therefore any work aiming at establishing new methodologies, procedures and techniques used in these services should be regarded as R&D. (STAM p.30)

Detailed scientific and technological services comprise:

i. S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information-processing departments;
ii. S&T services provided by museums of science or technology, botanical and zoological gardens and other S&T collections (anthropological, archaeological, geological, etc.);
iii. Systematic work on the translation and editing of S&T books and periodicals;
iv. Topographical, geological and hydrological surveying; 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;

v. Prospecting and related activities designed to locate and identify oil and mineral resources;

vi. 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.;

vii. Testing, standardization, metrology and quality control; regular routine work relating to 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;

viii. 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;

ix. Activities relating to patents and licences. (STAM, pp. 31-33)

Innovation

The Oslo Manual deals with the measurement of innovation. The first edition was published by the OECD in 1992, after which it became a joint publication of the OECD and Eurostat, the statistical office of the European Commission. In the second edition, which was published in 1997, the coverage was expanded to services. The third edition, published in 2005, further broadened the scope to also include marketing and organisational innovation. The Oslo Manual is used by many countries as the base for their national innovation surveys. It also forms the base for the Community Innovation Surveys from the EU.

Innovation will be further discussed in Chapter 5.

Activities to be excluded from R&D

Other related scientific and technological activities

Other related scientific and technological activities should be excluded from R&D except when carried out solely or primarily for the purposes of an R&D project. (FM §69)

These activities comprise:
- Scientific and technical information services;
- General purpose data collection;
- Testing and standardisation;
- Feasibility studies;
- Mineral exploration;
- Specialised health care;
- Patent and licence work;
- Policy-related studies;
- Routine software development.

Of note is that these activities are very similar to the Scientific and technological services defined above.

Scientific and technical information services
The specialised activities of:

- Collecting
- Coding
- Recording
- Classifying
- Disseminating
- Translating
- Analysing
- Evaluating

by

- Scientific and technical personnel
- Bibliographic services
- Patent services
- Scientific and technical information, extension and advisory services
- Scientific conferences

are to be excluded, except when conducted solely or primarily for the purpose of R&D support (e.g. the preparation of the original report of R&D findings should be included in R&D). (FM §70)

General purpose data collection
General purpose data collection is undertaken generally by government agencies to record natural, biological or social phenomena that are of general public interest or that only the government has the resources to record. Examples are routine topographical mapping; routine geological, hydrological, oceanographic and meteorological surveying; astronomical observations. Data collected solely or primarily as part of the R&D process are included in R&D *(e.g.* data on the paths and characteristics of particles in a nuclear reactor). The same reasoning applies to the processing and interpretation of the data. The social sciences, in particular, are very dependent on an accurate record of facts relating to society in the form of censuses, sample surveys, etc. When these are specially collected or processed for the purpose of scientific research, the cost should be attributed to research and should cover the planning, systematising, etc., of the data. However, data collected for other or general purposes, such as quarterly sampling of unemployment, should be excluded from R&D even if exploited for research. Market surveys should also be excluded. (FM §71)

Testing and standardisation
Testing and standardisation are excluded from R&D. This concerns the maintenance of national standards, the calibration of secondary standards and routine testing and analysis of materials, components, products, processes, soils, atmosphere, etc. (FM §72)

Feasibility studies
Investigation of proposed engineering projects, using existing techniques to provide additional information before deciding on implementation, is not R&D. In the social sciences, feasibility studies are investigations of the socio-economic characteristics and implications of specific situations (*e.g.* a study of the viability of a petrochemical complex in a certain region). However, feasibility studies on research projects are part of R&D. (FM §73)

Specialised health care
This concerns routine investigation and normal application of specialised medical knowledge. There may, however, be an element of R&D in what is usually called “specialised health care”, when it is carried out, for example, in university hospitals. (FM §74)

Patent and licence work
This includes all administrative and legal work connected with patents and licences. However, patent work connected directly with R&D projects is R&D. (FM §75)

Policy-related studies
Policy-related studies are excluded from R&D. These studies cover a range of activities, such as the analysis and assessment of the existing programmes, policies and operations of government departments and other institutions; the work of units concerned with the continuing analysis and monitoring of external phenomena *(e.g.* defence and security analysis); and the work of legislative commissions of inquiry concerned with general government or departmental policy or operations. (FM §76)

Other industrial activities

Excluded from R&D are other innovation activities, i.e. all scientific, technical, commercial and financial steps, other than R&D, necessary for the implementation of new or improved products or services and the commercial use of new or improved processes). These activities include acquisition of technology (embodied and disembodied), tooling up and industrial engineering, industrial design n.e.c., other capital acquisition, production start-up and marketing for new and improved products. Production and related technical activities are excluded as well. (FM §79-80)

Administration and other supporting activities

This category has two components:

- *Purely R&D-financing activities*: the raising, management and distribution of R&D funds to performers by ministries, research agencies, foundations or charities is not R&D.
- *Indirect supporting activities*: this covers a number of activities which are not themselves R&D but which provide support for R&D. By convention, R&D personnel data cover R&D proper but exclude indirect supporting activities, whereas an allowance for these is included under overheads in R&D expenditure of performers. Typical examples are transportation, storage, cleaning, repair, maintenance and security activities. Administration and clerical activities undertaken not exclusively for R&D, such as the activities of central finance and personnel departments, also come under this heading. (FM §81-83)

Boundaries and borderline cases of R&D

Boundaries

A particular project may be R&D if undertaken for one reason, but not if carried out for another, as shown in the following examples:

- Routine tests such as blood and bacteriological tests carried out for doctors are not R&D, whereas a special programme of blood tests in connection with the introduction of a new drug is R&D.
- The keeping of daily records of temperatures or of atmospheric pressure is not R&D but the operation of a weather forecasting service or general data collection. The investigation of new methods of measuring temperature is R&D, as are the study and development of new systems and techniques for interpreting the data.
- R&D activities in the mechanical engineering industry often have a close connection with design and drawing work. In small and medium-size enterprises (SMEs) in this industry, there is usually no special R&D department, and R&D problems are mostly dealt with under the general heading “design and drawing”. If calculations, designs, working drawings and operating instructions are made for the setting up and operating of pilot plants and prototypes, they should be included in R&D. If they are carried out for the preparation, execution and maintenance of production standardisation or to promote the sale of products, they should be excluded from R&D. (FM §85)

Limits between R&D and teaching and training

In institutions of higher education, research and teaching are always very closely linked, as most academic staff do both, and many buildings, as well as much equipment, serve both purposes. (FM §86)

Because the results of research feed into teaching, and because information and experience gained in teaching can often result in an input to research, it is difficult to define where the education and training activities of higher education staff and their students end and R&D activities begin, and *vice versa*. Research required for a PhD level degree usually contains the elements of novelty required for R&D and should, therefore, be attributed to R&D, and any supervision by the teacher should be as well. Its elements of novelty distinguish R&D from routine teaching and other work-related activities. (FM §87)

Closely allied to the problem of identifying the R&D element of postgraduate students' work is that of extracting the R&D component of the time spent by academic supervisors on supervising these students and their research projects. (FM §95)

Such supervision activities should be included in R&D only if they are equivalent to the direction and management of a specific R&D project containing a sufficient element of novelty and having as its object to produce new knowledge. In such cases, both the academic staff member's supervision and the student's work should be included as R&D. If the supervision merely deals with the teaching of R&D methods and the reading and correction of theses and dissertations or the work of undergraduate students, it should be excluded from R&D. (FM §96)

Table 2: Borderline between R&D and education and training at the PhD level

	Education and training at level 6	**R&D**	**Other activities**
Teachers	1. Teaching students at level 6. 2. Training students at level 6 in R&D methodology, laboratory work, etc.	3. Supervision of R&D projects required for student qualification at level 6 4. Supervision of other R&D projects and performance of own R&D projects	5. Teaching at levels lower than level 6 6. Other activities
Post-graduate students	1. Course work for formal qualification.	2. Performing and writing up independent studies (R&D projects) required for formal qualification 3. Any other R&D activities	4. Teaching at levels lower than level 6 5. Other activities

Source: FM Table 2.2

Personal education of academic staff covers time spent on activities such as continued professional learning ("own reading"), attendance at conferences and seminars, etc. In distinguishing R&D from related activities, the question of whether "own reading" should be included as part of R&D activities is often raised. It is certainly part of the general professional development of research staff and, in the long term, the knowledge and experience gained are incorporated into the researcher's thinking about, if not into the actual implementation of, R&D. Own reading, in fact, constitutes a cumulative process, and when the information gained from this activity is translated into research activity, it will be measured as R&D. Only personal education carried out specifically for a research project should be considered as an R&D activity. (FM §99-101)

The borderline between R&D and related scientific and technological activities

Institutions or units of institutions and firms whose principal activity is R&D often have secondary, non-R&D activities (e.g. scientific and technical information, testing, quality control, analysis). Insofar as a secondary activity is undertaken primarily in the interests of R&D, it should be included in R&D activities; if the secondary activity is designed essentially to meet needs other than R&D, it should be excluded.

Institutions whose main purpose is an R&D-related scientific activity often undertake some research in connection with this activity. Such research should be isolated and included when measuring R&D. (FM §102)

Some examples at the borderline between R&D and related scientific and technological activities are:

- The activities of a scientific and technical information service or of a research laboratory library, maintained predominantly for the benefit of the research workers in the laboratory, should be included in R&D. The activities of a firm's documentation centre open to all the firm's staff should be excluded from R&D even if it shares the same premises as the company research unit. Similarly, the activities of central university libraries should be excluded from R&D. These criteria only apply when it is necessary to exclude the activities of an institution or a department in their entirety. Where more detailed accounting methods are used, it may be possible to impute part of the costs of the excluded activities to R&D overheads. Whereas the preparation of scientific and technical publications is, generally speaking, excluded, the preparation of the original report of research findings should be included in R&D.
- Public bodies and consumer organisations often operate laboratories whose main purpose is testing and standardisation. The staff of these laboratories may also spend time devising new or substantially improved methods of testing. Such activities should be included in R&D.
- General-purpose data collection is particularly important to social science research, since without it many aspects of this research would not be feasible. However, unless it is collected primarily for research purposes, it should not be classified as a research activity. On the other hand, the larger statistical institutes may carry out some R&D (e.g. conceptual and methodological work in relation to the development of completely new or substantially modified surveys and statistical systems, work on sampling methodologies, small area statistical estimates). Whenever possible, such R&D should be included. (FM §103).

The borderline between R&D and other industrial activities

Care must be taken to exclude activities which, although undoubtedly a part of the innovation process, rarely involve any R&D, *e.g.* patent filing and licensing, market research, manufacturing start-up, tooling up and redesign for the manufacturing process. (FM §110)

Table 3 describes some cases at the borderline between R&D and other industrial activities and its treatment according to the FM.

Table 3: Some cases at the borderline between R&D and other industrial activities

Item	Treatment	Remarks
Prototypes	Include in R&D	As long as the primary objective is to make further improvements.
Pilot plant	Include in R&D	As long as the primary purpose is R&D.
Industrial design and drawing	Divide	Include design required during R&D. Exclude design for production process.
Industrial engineering and tooling up	Divide	Include “feedback” R&D and tooling up industrial engineering associated with development of new products and new processes. Exclude for production processes.
Trial production	Divide	Include if production implies full-scale testing and subsequent further design and engineering. Exclude all other associated activities.
After-sales service & troubleshooting	Exclude	Except “feedback” R&D.
Patent and licence work	Exclude	All administrative and legal work connected with patents and licences (except patent work directly connected with R&D projects).
Routine tests	Exclude	Even if undertaken by R&D staff.
Data collection	Exclude	Except when an integral part of R&D.
Public inspection control, enforcement of standards, regulations	Exclude	

Source: FM Table 2.3

The borderline between experimental and pre-production development

If the primary objective is to make further technical improvements on the product or process, then the work comes within the definition of R&D. If, on the other hand, the product, process or approach is substantially set and the primary objective is to develop markets, to do pre-production planning or to get a production or control system working smoothly, the work is no longer R&D. (FM §111)

The vast bulk of design work in an industrial area is geared towards production processes and as such is not classified as R&D. There are, however, some elements of design work which should be considered as R&D. These include plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the conception, development and manufacturing of new products and processes. (FM §124)

In most cases, the tooling-up and industrial engineering phases of any project are considered to be part of the production process. (FM §126)

The borderline between R&D administration and indirect supporting activities

To carry out R&D activities, funds must be provided and the project and its financing must be managed. The R&D funding activities of policy agencies, such as ministries of science and technology or research councils, do not constitute R&D. In the case of in-house management of R&D projects and their financing, a distinction is made between direct support for R&D by persons such as R&D managers closely associated with individual projects, who are included in both the personnel and expenditure series, and persons such as financial directors, whose support is indirect or auxiliary and who are included in the expenditure series only as an element of overheads. (FM §26)

In R&D statistics, the practice is that personnel data should cover only R&D proper, whereas expenditure data should cover the full cost of R&D, including the indirect supporting activities which are treated as overheads. (FM §131)

Some activities, such as the provision of library or computer services, are R&D proper if they are intended exclusively for R&D, but indirect supporting activities if they are provided by central departments for both R&D and non-R&D uses. The same argument applies for management, administration and clerical activities. When these contribute directly to R&D projects and are undertaken exclusively for R&D, then they are part of R&D proper and included in R&D personnel. Typical examples are the R&D manager who plans and supervises the scientific and technical aspects of the project or the person who produces the interim and final reports containing the results of the project. It remains a moot point whether the bookkeeping associated with a specific R&D project is direct (R&D proper) or indirect (ancillary) activity. By convention, it is R&D proper rather than an indirect supporting activity if it is carried out in close proximity to the R&D. (FM §132)

Specific cases and examples

Basic research, applied research and experimental development

Table 4 presents some examples to illustrate the difference between basic research, applied research and experimental development, focusing on the natural sciences.

Table 4: A few examples illustrating the concepts of fundamental research, applied research and experimental development in the natural sciences

Fundamental research	Applied research	Experimental development
1. Study of the numerical solutions of differential equations.	Study of the numerical solutions of differential equations to be used for describing undulation (e.g. for describing intensity and velocity of transmission of radio-waves).	Development of computer programmes for the numerical solution of differential equations used for describing undulation.
2. Study of pressure conditions and buoyancy of solids in gas streams.	Study of pressure conditions and buoyancy of solids in streaming air with a view to obtaining aerodynamic data required for the construction of missiles and aircraft.	Development of the body (fuselage) of an aircraft-prototype.
3. Study of the geological setting of geothermal fields and of the geothermal processes going on in order to obtain basic knowledge on their origin.	Study of geothermal sources with a view to possibilities of utilizing these natural reservoirs of steam and hot water.	Development of processes for using the geothermal steam or hot water for the production of electric power, for heating purposes or as a source of extractable minerals.

Source: STAM pp. 24-25

Table 5 presents a similar picture, but focusing on the social science and humanities.

Table 5: A few examples illustrating the concepts of fundamental research, applied research and experimental development in the social sciences and of fundamental and applied research in the humanities

Fundamental research	Applied research	Experimental development
1. Study of the causal relations between economic conditions and social development.	Study of the economic and social causes of the drift of agricultural workers from rural districts to towns for the purpose of preparing a programme to halt this development in order to support agriculture and prevent social conflicts in industrial areas.	Development and testing of a programme of financial assistance to prevent rural migration to large cities.
4. Study of the reading process in adults and children, i.e. investigation how human visual systems work to acquire information from symbols such as words, pictures and diagrams.	Study of the reading process for the purpose of developing a new method of teaching children and adults to read.	Development and testing of a special reading programme among immigrant children.
5. Study of the international factors influencing the national economic development.	Study of the specific international factors determining the economic development of a country in a given period with a view to formulating an operational model for modifying foreign trade policy of government.	-
7. Study of the historical development of a language.	-	-

Source: STAM p. 25

Mining and prospecting

In the case of mining and prospecting, the following activities count as R&D:

- The development of new surveying methods and techniques.
- Surveying undertaken as an integral part of a research project on geological phenomena.
- Research on geological phenomena per se, undertaken as a subsidiary part of surveying and prospecting programmes. (FM §106)

On the other hand, the surveying and prospecting activities of commercial companies will be almost entirely excluded from R&D. For example, the sinking of exploratory wells to evaluate the resources of a deposit should be considered as scientific and technological services. (FM §108)

Clinical trials

For the purposes of international comparison, by convention, clinical trial phases 1, 2 and 3 can be treated as R&D. Phase 4 clinical trials, which continue testing the drug or treatment after approval and manufacture, should only be treated as R&D if they bring about a further scientific or technological advance. (FM §130)

Identifying R&D in software development

For a software development project to be classified as R&D, its completion must be dependent on a scientific and/or technological advance, and the aim of the project must be the systematic resolution of a scientific and/or technological uncertainty. In addition to the software that is part of an overall R&D project, the R&D associated with software as an end product should also be classified as R&D. (FM §135-136)

The nature of software development is such as to make identifying its R&D component, if any, difficult. Software development is an integral part of many projects which in themselves have no element of R&D. The software development component of such projects, however, may be classified as R&D if it leads to an advance in the area of computer software. Such advances are generally incremental rather than revolutionary. Therefore, an upgrade, addition or change to an existing programme or system may be classified as R&D if it embodies scientific and/or technological advances that result in an increase in the stock of knowledge. Use of software for a new application or purpose, however, does not by itself constitute an advance. (FM §137)

Examples of R&D in software

- R&D producing new theorems and algorithms in the field of theoretical computer science.
- Development of information technology at the level of operating systems, programming languages, data management, communications software and software development tools.
- Development of Internet technology.
- Research into methods of designing, developing, deploying or maintaining software.
- Software development that produces advances in generic approaches for capturing, transmitting, storing, retrieving, manipulating or displaying information.
- Experimental development aimed at filling technology knowledge gaps as necessary to develop a software programme or system.
- R&D on software tools or technologies in specialised areas of computing (image processing, geographic data presentation, character recognition, artificial intelligence and other areas). (FM §140)

Software-related activities of a routine nature which do not involve scientific and/or technological advances or resolution of technological uncertainties are not to be included in R&D. Examples are:

- Business application software and information system development using known methods and existing software tools.
- Support for existing systems.
- Converting and/or translating computer languages.
- Adding user functionality to application programmes.
- Debugging of systems.
- Adaptation of existing software.
- Preparation of user documentation. (FM §141)

R&D in the Social Sciences and Humanities (SSH)

The following are examples of work which might fall into this routine category are generally not R&D: commentary on the probable economic effects of a change in the tax structure, using existing economic data; use of standard techniques in applied psychology to select and classify industrial and military personnel, students, etc., and to test children with reading or other disabilities. (FM §144)

Criteria for identifying R&D in services

Defining the boundaries of R&D in service activities is difficult, for two main reasons: first, it is difficult to identify projects involving R&D; and, second, the line between R&D and other innovative activities which are not R&D is a tenuous one. Identifying R&D is more difficult in service activities than in manufacturing because it is not necessarily "specialised". Also, in service companies, R&D is not always organised as formally as in manufacturing companies (i.e. with a dedicated R&D department, researchers or research engineers identified as such in the establishment's personnel list, etc.). (FM §145-148)

The following are among the criteria that can help to identify the presence of R&D in service activities:

- Links with public research laboratories.
- The involvement of staff with PhDs, or PhD students.
- The publication of research findings in scientific journals, organisation of scientific conferences or involvement in scientific reviews.
- The construction of prototypes or pilot plants. (FM §149)

Examples of R&D in banking and insurance

- Mathematical research relating to financial risk analysis.
- Development of risk models for credit policy.
- Experimental development of new software for home banking.
- Development of techniques for investigating consumer behaviour for the purpose of creating new types of accounts and banking services.
- Research to identify new risks or new characteristics of risk that need to be taken into consideration in insurance contracts.
- Research on social phenomena with an impact on new types of insurance (health, retirement, etc.), such as on insurance cover for non-smokers.
- R&D related to electronic banking and insurance, Internet-related services and e-commerce applications.
- R&D related to new or significantly improved financial services (new concepts for accounts, loans, insurance and saving instruments). (after FM §151)

Examples of R&D in other service activities

- Analysis of the effects of economic and social change on consumption and leisure activities.
- Development of new methods for measuring consumer expectations and preferences.
- Development of new survey methods and instruments.
- Development of tracking and tracing procedures (logistics).
- Research into new travel and holiday concepts.
- Launch of prototype and pilot stores. (after FM §151)

Chapter 2: Measuring R&D Personnel

Personnel data measure the resources going directly to R&D activities. Expenditure data measure the total cost of carrying out the R&D concerned, including indirect support (ancillary) activities. (FM§289)

Both inputs are necessary to secure an adequate representation of the effort devoted to R&D. This chapter deals with R&D personnel, while the next will look at R&D expenditure.

Definition of R&D Personnel

R&D personnel are all persons employed directly on R&D, as well as those providing direct services such as R&D managers, administrators, and clerical staff. (FM §294)

Persons providing an indirect service, such as canteen and security staff, should be excluded, even though their wages and salaries are included as an overhead cost when measuring expenditure. (FM §295)

Two approaches may be used to classify R&D personnel: the most commonly used is by occupation, the other is by level of formal qualification. Each approach has advantages and disadvantages. Occupation series reflect the present use of resources and thus are more useful for R&D analysis. Qualification series are important for broader analyses, for example for setting up total personnel databases and for forecasting needs and supplies of highly qualified S&T personnel. The approach by occupation is however preferable for international comparisons of the numbers of personnel employed in R&D. (FM § 297-299)

Classification by occupation

R&D personnel can by classified by the following three types of occupation:

- Researchers
- Technicians
- Other supporting staff

Researchers

Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned. (FM §301)

Researchers are classified in ISCO-88 Major Group 2, “Professionals”, and in “Research and Development Department Managers” (ISCO-88, 1237). By convention, members of the armed forces with similar skills who perform R&D should also be included. (FM §302)

Managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher’s work also fall into this category. Their rank is usually equal or superior to that of persons directly employed as researchers and they are often former or part-time researchers. (FM §303)

Postgraduate students at the PhD level engaged in R&D should be considered as researchers. They typically hold basic university degrees (ISCED level 5A) and perform research while working towards the PhD (ISCED level 6). (FM §305)

All postgraduate students working on R&D and receiving funding for this purpose (in the form of a salary from the university or a scholarship or another sort of funding) should in principle be included in R&D personnel headcounts. However, it may be necessary, for practical reasons, to reduce coverage to those students for whom the corresponding R&D expenditures and full-time equivalence can be estimated. (FM §324)

Technicians and equivalent staff

Technicians and equivalent staff are 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. (FM §306)

Technicians and equivalent staff are classified in ISCO-88 Major Group 3, “Technicians and Associate Professionals”, notably in Sub-major Groups 31, “Physical and Engineering Science Associate Professionals”, and 32, “Life Science and Health Associate Professionals”, and in ISCO-88, 3434, “Statistical, Mathematical and Related Associate Professionals”. Members of the armed forces who work on similar tasks should also be included. (FM §307)

Their tasks include:

- Carrying out bibliographic searches and selecting relevant material from archives and libraries.
- Preparing computer programmes.
- Carrying out experiments, tests and analyses.
- Preparing materials and equipment for experiments, tests and analyses.
- Recording measurements, making calculations and preparing charts and graphs.
- Carrying out statistical surveys and interviews. (FM §308)

Other supporting staff

Other supporting staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects. (FM §309)

Other R&D supporting staff are essentially found in ISCO-88 Major Groups 4, “Clerks”; 6, ”Skilled Agricultural and Fishery Workers”; and 8, ”Plant and Machine Operators and Assemblers”. (FM §310)

Included under this heading are all managers and administrators dealing mainly with financial and personnel matters and general administration, insofar as their activities are a direct service to

R&D. They are mainly found in ISCO-88 Major Group 2, “Professionals”, and Minor Group 343, “Administrative Associate Professionals” (except 3434). (FM §311)

Persons providing indirect services to R&D, such as security, cleaning, maintenance, canteen staff, etc should be excluded.

Classification by level of formal qualification

ISCED provides the basis for classifying R&D personnel by formal qualification. Six classes are recommended for the purposes of R&D statistics. They are defined exclusively by level of education, regardless of the field in which personnel are qualified. (FM §312)

- *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 tertiary level diplomas (ISCED level 5B):* Holders of other post-secondary tertiary (ISCED level 5B) 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.
- *Holders of other post-secondary non-tertiary diplomas (ISCED level 4):* Holders of other post-secondary non-tertiary (ISCED level 4) diplomas in all fields. This class includes holders of degrees preparing students for studies at level 5, who although having completed ISCED level 3, did not follow a curriculum which would allow entry to level 5, *i.e.* pre-degree foundation courses or short vocational 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. (FM §313-318)

Full details of ISCED can be found in UNESCO (2006). ISCED is currently (August 2010) under review with a new version expected to be adopted towards the end of 2011.

Measurement and data collection

The measurement of personnel employed on R&D involves three exercises:

- Measuring their number in headcounts.
- Measuring their R&D activities in full-time equivalence (person-years).
- Measuring their characteristics. (FM §325)

Headcount data

Headcount (HC) data are data on the total number of persons who are mainly or partially employed on R&D. (FM §326)

Headcount data allow links to be made with other data series, for example education or employment data or the results of population censuses. This is particularly important when examining the role of R&D employment in total stocks and flows of scientific and technical personnel. Headcount data are the most appropriate measure for collecting additional information about R&D personnel, such as age, gender or national origin. (FM §326-327)

Possible approaches and options

- Number of persons engaged in R&D at a given date (*e.g.* end of period).
- Average number of persons engaged in R&D during the (calendar) year.
- Total number of persons engaged in R&D during the (calendar) year. (FM §329)

Full time equivalent - FTE

The Frascati manual does not provide a concise definition of full time equivalent. The following is however a reasonable definition.

A **full-time equivalent** is the number of hours that represent what a full time employee would work over a given time period, for example, a year or a pay period. (http://accounting.suite101.com/article.cfm/calculating_employee_fulltime_equivalents)

Series based on the number of full-time equivalent staff are considered to be a true measure of the volume of R&D. (FM §331)

R&D may be the primary function of some persons (*e.g.* workers in an R&D laboratory) or it may be a secondary function (*e.g.* members of a design and testing establishment). It may also be a significant part-time activity (*e.g.* university teachers or postgraduate students). To count only persons whose primary function is R&D would result in an underestimate of the effort devoted to R&D; to do a headcount of everyone spending some time on R&D would lead to an overestimate. The number of persons engaged in R&D must, therefore, also be expressed in full-time equivalents on R&D activities. (FM §332)

One FTE may be thought of as one person-year. In other words, 1 FTE is equal to 1 person working full-time on R&D for a period of 1 year, or more persons working part-time or for a shorter period, corresponding to one person-year. Thus, a person who normally spends 30% of his/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 is employed at an R&D unit for only six months, this results in an FTE of 0.5. (FM §333)

The following formula can be used to calculate R&D personnel in FTE.

FTE =	**(Dedication to the employment: FT/PT) x (Portion of the year active on R&D) x (Time or portion spent on R&D)**

The following examples indicate how this formula could be used in the calculation of FTE figures.

- 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 full time R&D worker who is spending 100% of time on R&D, is employed at an R&D institution only for six months → (1 x 0.5 x 1) = 0.5 FTE;
- A full time employee spending 40% of time on R&D during half of the year (person is only active for 6 months per year) → (1 x 0.5 x 0.4) = 0.2 FTE;
- A part-time employee (working 40% of a full time year) engaged only in R&D (spending 100% of time on R&D) during a year → (0.4 x 1 x 1) = 0.4 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.

Another option is to calculate FTEs based on the average hours worked per week, or devoted to each activity per week.

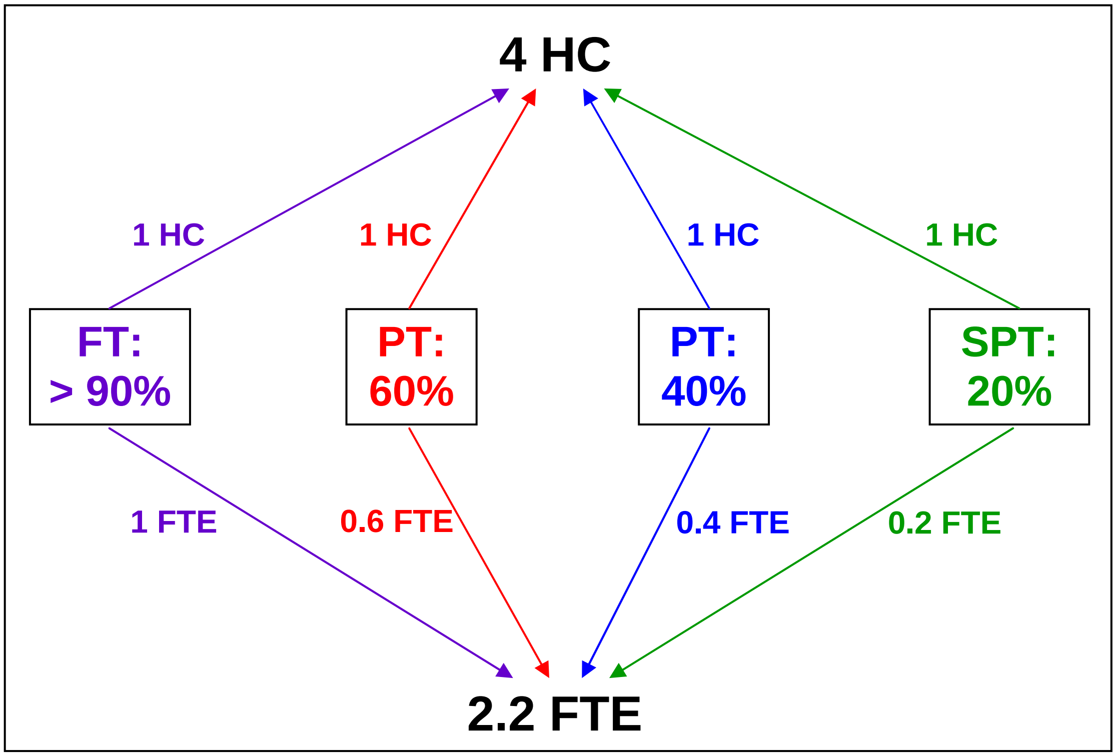
In some cases, it may be more practical to survey the FTE of R&D personnel as of a specific date. If, however, there are significant seasonal variations in R&D employment (e.g. temporary staff hired by governments at the end of the university teaching year), allowance should be made for these variations in order to allow for comparison with data based on FTE during a period. FTE during a period is more appropriate. (FM §335)

FTE calculation

Calculating full-time equivalents (FTE) is key to adequately calculating the Gross Domestic Expenditure on R&D (GERD). Since researcher's salaries are a significant part of GERD, it is important to include in the GERD only the proportion of the salaries devoted to R&D, this is, the FTE R&D salaries. If the HC salaries are included, GERD will be significantly overestimated.

Figure 5 provides an example of converting headcount data into full-time equivalents. In the statistical unit under scrutiny, there are four people who are working on R&D. the first person works more than 90% of his/her time on R&D and can therefore be considered full-time personnel. Hence, this converts into one FTE. The second person works only 60% of his or her time on R&D, and therefore that one HC converts into 0.6 FTE. Similarly, the third person works only 40% of his or her time on R&D, which converts into 0.4 FTE, while the last person converts into 0.2 FTE. Adding these numbers up leads to 4HC, which converts into 2.2 FTE.

Figure 5: An example of HC-FTE conversion



Note: FT stands for full-time, PT for part-time and SPT for "significantly" part-time.

Of note is that it could also be that the second person, for example, works full-time on R&D, but only has a (60%) part-time job, leading to an FTE of 0.6 FTE. Similarly, the third person may have a job of only 4 days per week (i.e. 80%), which is for half of the time devoted to R&D and for the other half to other activities, leading to a FTE of (80% * 0.5 =) 0.4 FTE. Finally, it is also possible that the fourth person worked full-time on R&D, but left the unit after 20% of the year (roughly 2.5 months).

A number of restrictions apply to the actual measurement of FTE. It is therefore impossible to avoid differences in the methodology used for different countries and sectors. To improve international comparability regardless of the measurement methods used, the details of the methods employed should be made public. (FM §336)

FTE measurement in the higher education sector

To obtain appropriate data on R&D personnel in the higher education sector, it may be necessary to carry out time-use surveys or studies. Such surveys can be a source of valuable data even if they are only carried out once every five or ten years. (FM §339)

There are two interrelated problems for measurement of R&D personnel:

- Definition of the working time.
- Calculation of full-time equivalence. (FM §340)

Definition of working time

The one aspect of an academic teacher's/researcher's workload that is usually well-defined is the number of his/her teaching hours in the academic year. Absolute working time varies according to a number of factors, such as:

- Number of teaching hours per week;
- Demands made by examinations and student supervision on teachers' time;
- Administrative duties, which vary according to the time of year;
- Nature of R&D activities and deadlines imposed for publication and/or presentation of results;
- Student vacation periods. (FM §341)

The working pattern of the staff therefore is very flexible. It has been found that much of their professional activity – notably R&D – is carried out outside "normal working hours". (FM §342)

Calculation of full-time equivalence

Calculation of full-time equivalent R&D personnel must be based on total working time. Accordingly, no one person can represent more than one FTE in any year and hence cannot perform more than one FTE on R&D. (FM §343)

Sources for FTE measurement

Countries can use various kinds of time-use surveys or other methods to establish a basis for identifying the share of R&D in total university activities (*i.e.* for calculating R&D coefficients). R&D coefficients are fractions or proportions of the statistics covering the higher education sector's total resources. They serve as a tool for calculating/estimating the shares of personnel and expenditure data attributable to R&D. (FM Annex 2 §4)

Caution must be exercised when using time-use surveys in higher education surveys. Staff in institutions of higher education combine research with a range of other duties, such as teaching, administration and supervision. It may therefore be difficult for respondents to identify unambiguously that part of their time (working or otherwise) that is devoted exclusively to R&D. (FM Annex 2 §5)

Two methods for time-use studies can be distinguished:

- Those based on researchers' own evaluation of the distribution of their working time.
- Those based on estimates by the heads of university departments or institutes. (FM Annex 2 §7)

Methods based on researchers' own evaluation of the distribution of their working time

One type of this kind of survey is on the distribution of working time during the whole year: Respondents are asked to estimate the allocation of their working time over a whole year according to various categories of work-related activities. Table 6 gives an example of a use-of-time classification, with two categories of "research" (in bold). Other categories are possible. (FM Annex 2 §9-10)

Table 6: Example of a time-use classification

Undergraduate teaching time	… %
Postgraduate course-work time	… %
Postgraduate research time	**… %**
Personal research time	**… %**
Administration	… %
Examinations	… %
Student counseling	… %
Unallocable internal time	… %
External professional time	… %
Total time	**100%**

Methods based on estimates by the heads of university departments or institutes

In most countries, R&D statistics for the higher education sector are based on a combination of information obtained at central administrative and institute level and information supplied by individual staff members. These countries have found it convenient to include questions on time use at a more aggregate level in a questionnaire addressed to the university institutes, rather than make time-use studies of individual researchers. The method is cheaper than those described above and puts a less heavy burden on respondents. In this case, the questionnaires are usually addressed to the head of the institute, who is assumed to have the knowledge of ongoing activities needed to supply sufficiently accurate estimates. (FM Annex 2 §20-21)

Methods based on other sources (e.g. R&D coefficients)

While surveys are the most systematic and accurate way of collecting information on time use, they are not always suited to the resources and/or needs of individual countries. They require a great deal of time and money and can make heavy demands on the resources of producers of statistics. Therefore, alternative data collection methods are needed to accommodate resource constraints and meet information needs. (FM Annex 2 §25, 27)

Non-survey-based R&D coefficients are derived in a number of ways, ranging from informed guesses to sophisticated models. (FM Annex 2 §28)

They may be derived in several ways, depending on the information available to the responsible statistical unit. Sources of information: Employment contracts may specify time allowed for some activities; the job descriptions of some categories of employee may provide useful input. Some institutions may have established full or partial coefficients for their own planning or evaluations; other countries with similar education systems may have derived relevant coefficients; Research grants given to different institutions; S&T publications, etc. (FM Annex 2 §31)

The accuracy of the coefficients depends on the quality of the judgement used in calculating them. It is essential that experienced and knowledgeable persons participate in the work. (FM Annex 2 §29-30)

When choosing the most appropriate survey method, the following factors have to be considered: the resources available to the producers of statistics; the desired level of quality of the statistics; the burden that can reasonably be laid on university administrations and individual respondents; special features of the country. (FM Annex 2 §6)

Tables recommended by Frascati Manual

- Total national R&D personnel by sector and by occupation (HC & FTE)
- Total national R&D personnel by sector and by level of qualification (HC & FTE)
- Researchers and, if possible, other categories of R&D personnel (HC), by:
  - Sex
  - Age: Under 25 years; 25-34 years; 35-44 years; 45-54 years; 55-64 years; 65 years and more. (FM §346-348)

Chapter 3: Measuring R&D Expenditure

General issues

The basic measure is "intramural expenditures".

Intramural expenditures are all expenditures for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds. (FM §358)

Another measure, "extramural expenditures", covers payments for R&D performed outside the statistical unit or sector of the economy. For R&D purposes, both current costs and capital expenditures are measured. In the case of the government sector, expenditures refer to direct rather than indirect expenditures. Depreciation costs are excluded. (FM §34)

R&D is an activity involving significant transfers of resources among units, organisations and sectors and especially between government and other performers. It is important for science policy advisors and analysts to know who finances R&D and who performs it. (FM §35)

Measuring R&D expenditure

A statistical unit may have expenditures on R&D either within the unit (intramural) or outside it (extramural). The full procedure for measuring these expenditures is as follows:

- Identify the intramural expenditure on R&D performed by each statistical unit.
- Identify the sources of funds for these intramural R&D expenditures as reported by the performer.
- Aggregate the data by sectors of performance and sources of funds to derive significant national totals.
- Optional: Identify the extramural R&D expenditures of each statistical unit. (FM §356)

The most important national total is Gross domestic expenditure on R&D (GERD), which is defined as total intramural expenditure on R&D performed on the national territory during a given period (FM §423).

R&D expenditure refers to resources actually spent on R&D activities, rather than only budgeted. Therefore, the way to obtain sound data is to rely on responses of R&D performers, rather than funding agencies. (FM §357)

R&D expenditure: current costs

Current costs are composed of:

- **labour costs** of R&D personnel (annual wages and salaries and all associated costs or fringe benefits); and
- **other current costs** (non-capital purchases of materials, supplies and equipment to support R&D, including water, gas and electricity; books, journals, reference materials, subscriptions to libraries, scientific societies, etc.; materials for laboratories such as chemicals or animals, costs for on-site consultants, administrative and other overhead costs (e.g. office, post and telecommunications, insurance), costs for indirect services (e.g. security; storage; use, repair and maintenance of buildings and equipment; computer services; and printing of R&D reports), labour costs of non-R&D personnel). (FM §360-364)

Current costs may be prorated if necessary to allow for non-R&D activities within the same statistical unit. (FM §364)

R&D expenditure: capital expenditure

Capital expenditures are the annual gross expenditures on fixed assets used in the R&D programmes of statistical units, including land and buildings, instruments and equipment, and computer software. Expenditure should be reported in full for the period when it took place and should not be registered as an element of depreciation. (FM §374)

All depreciation provisions for building, plant and equipment, whether real or imputed, should be excluded from the measurement of intramural R&D expenditures. (FM §375)

Sources of funds

Criteria for identifying flows of R&D funds

For a flow of funds to be correctly identified, two criteria must be fulfilled:

- There must be a direct transfer of resources.
- The transfer must be both intended and used for the performance of R&D. (FM §393)

Public general university funds (GUF)

To finance their R&D activities, universities usually draw on three types of funds:

- R&D contracts and earmarked grants received from government and other outside sources. ***These should be credited to their original source.***
- Income from endowments, shareholdings and property, plus surplus from the sale of non-R&D services such as fees from individual students, subscriptions to journals and sale of serum or agricultural produce. ***These are the universities' "own funds".***
- The general grant they receive from the ministry of education or from the corresponding provincial or local authorities in support of their overall research/teaching activities. As government is the original source and has intended at least part of the funds concerned to be devoted to R&D, ***the R&D content of these public general university funds should be credited to government as a source of funds,*** for the purposes of international comparisons. (FM §405)

Institutional classification

To facilitate the collection of data, the description of institutional flows of R&D funds and the analysis and interpretation of R&D data, the statistical unit(s) classified should be grouped by sectors of the economy, following as closely as possible standard classifications of economic activities. (FM §156)

Five sectors are used for the purpose of sectoring R&D:

- **Business enterprise** (all firms, organisations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price, as well as the private non-profit institutions mainly serving them. Includes public enterprises). (FM §163)

- **Government** (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, as well as NPIs controlled and mainly financed by government, but not administered by the higher education sector. Public enterprises are excluded.) (FM §184)

- **Higher education** (All universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status; all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions). (FM §206)

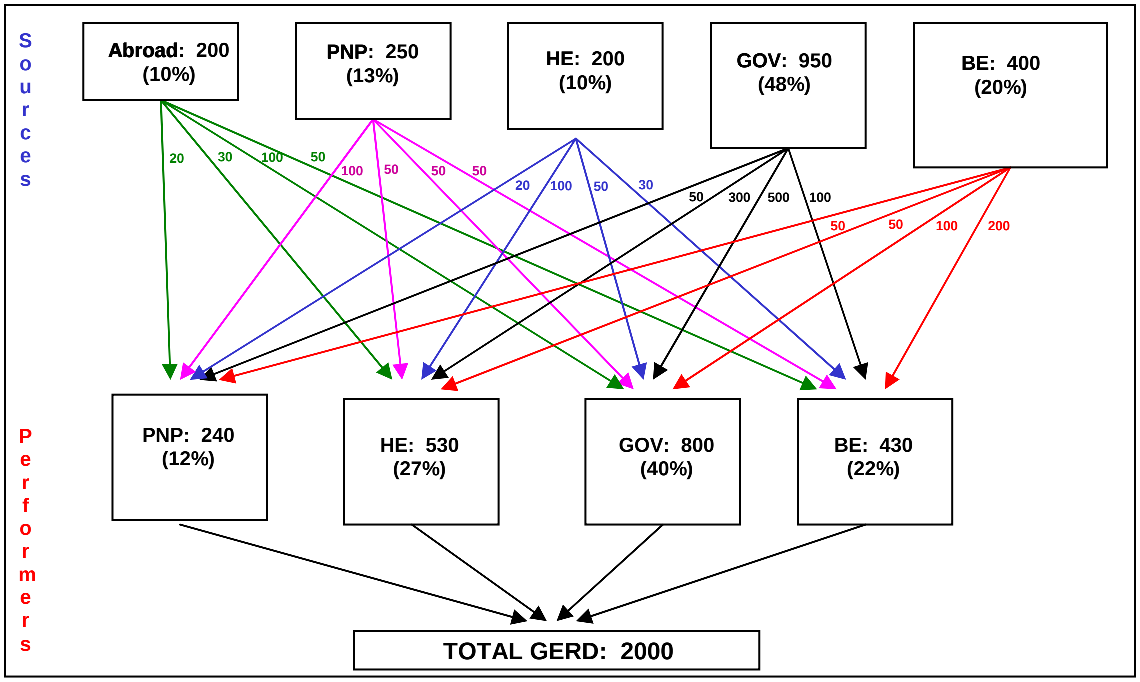
- **Private non-profit** (Non-market, private non-profit institutions serving households (*i.e.* the general public), private individuals or households).(FM §194)

- **Abroad** (All institutions and individuals located outside the political borders of a country, except vehicles, ships, aircraft and space satellites operated by domestic entities and testing grounds acquired by such entities; all international organisations (except business enterprises), including facilities and operations within the country's borders). (FM §229)

With the aid of these sectors we can break down GERD by sector of performance and by source of funds as in the example diagram below (Figure 6). The Figure shows that in the country, 2000 local currency units (LCU) were devoted to (intramural R&D). The business sector performed 430 LCU of GERD, or 22% of the total. Similarly, in government research institutes 800 LCU was spent on R&D, the higher education spent 530 LCU and the PNP sector accounted for the remaining 240 LCU. Abroad is not a performing sector, because we are only looking at intramural R&D.

The top part of the Figure shows the sources of funds. For example, the business sector funded 400 LCU worth of R&D activities. Half of this money went to the business sector, usually but not necessarily meaning businesses financing their own R&D. 100 LCU went from the business sector to government institutes, while the remaining 120 LCU went in equal measure to the higher education sector and the PNP sector. For the other sectors similar observations can be made. Of note is that 10% of the R&D expenditure in the country was financed by foreign entities.

Figure 6: GERD by sector of performance and source of funds



This diagram can then be used to fill the GERD matrix as shown in Table 7.

Table 7: The GERD matrix of performing and funding sectors

Source of funds	Sector of performance				Total
	BES	**GOV**	**HE**	**PNP**	
Business enterprise	200	100	50	50	*400 - financed by BE*
Government	100	500	300	50	*950 -financed by GOV*
Public general university funds (GUF)			Included above		*financed by GUF*
Higher education	30	50	100	20	*200 - financed by HE*
Private non-profit (PNP)	50	50	50	100	*250 - financed by PNP*
Funds from abroad ▪ Foreign enterprise o Within the same group o Other ▪ Foreign government ▪ European Union ▪ International organisation ▪ Other	50	100	30	20	*200 - financed by abroad*
Total	*430 Total performed by BE*	*800 Total performed by GOV*	*530 Total performed by HE*	*240 Total performed by PNP*	*2000 TOTAL GERD*

Source: FM Table 6.1

Classifications

R&D data can be broken down in various ways. In the FM, the following classifications are discussed:

- Institutional classification (as discussed above)
- Type of activity
- Fields of Science
- Socio-Economic Objective

Collecting the data in a way that allows tabulating these data will assist the policy makers in setting effective S&T policies.

Type of activity

Type of activity data are R&D data broken down by basic research, applied research and experimental development as was discussed in Chapter 1 of this document.

Fields of Science (FoS 2007)

Table 8 shows how R&D data should be distributed when classifying by fields of science.

Table 8: Distribution list according to the OECD Fields of Science 2007 classification

1. Natural Sciences
1.1 Mathematics
1.2 Computer and information sciences
1.3 Physical sciences
1.4 Chemical sciences
1.5 Earth and related environmental sciences
1.6 Biological sciences
1.7 Other natural sciences

2. Engineering and Technology
2.1 Civil engineering
2.2 Electrical, electronic, information eng.
2.3 Mechanical engineering
2.4 Chemical engineering
2.5 Materials engineering
2.6 Medical engineering
2.7 Environmental engineering
2.8 Environmental Biotechnology
2.9 Industrial biotechnology
2.10 Nano-technology
2.11 Other engineering and tech.

3. Medical and Health Sciences
3.1 Basic medicine
3.2 Clinical medicine
3.3 Health sciences
3.4 Health biotechnology
3.5 Other medical sciences

4. Agricultural Sciences
4.1 Agriculture, forestry, and fishery
4.2 Animal and dairy science
4.3 Veterinary sciences
4.4 Agricultural biotechnology
4.5 Other agricultural sciences

5. Social Sciences
5.1 Psychology
5.2 Economics and business
5.3 Educational sciences
5.4 Sociology
5.5 Law
5.6 Political science
5.7 Social and economic geography
5.8 Media and communications
5.9 Other social sciences

6. Humanities
6.1 History and archaeology
6.2 Languages and literature
6.3 Philosophy, ethics and religion
6.4 Art
6.5 Other humanities

Socio-economic objectives (SEO) (based on NABS 2007)

The list of socio-economic objectives has been updated since it appeared in the FM, and is now according to NABS 2007. NABS is a French acronym, which stands for "Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets", which was developed for EU reporting. The revised list (NABS 2007) is as follows:

1. Exploration and exploitation of the earth
2. Environment
3. Exploration and exploitation of space
4. Transport, telecommunication and other infrastructures
5. Energy
6. Industrial production and technology
7. Health
8. Agriculture
9. Education
10. Culture, recreation, religion and mass media
11. Political and social systems, structures and processes
12. General advancement of knowledge
13. Defence

Chapter 4: Measuring R&D – Challenges Faced by Developing Countries

Although the Frascati Manual (FM) was originally written for R&D surveys in OECD countries, it is used extensively in developing countries. However, the characteristics of research systems in developing countries differ significantly from the ones that gave rise to the current statistical standard. Therefore, to provide guidance to developing countries on how to adapt the standards proposed in the FM to suit their own unique situations when measuring R&D, the UIS has produced a Technical Guide on challenges faced by developing countries when measuring R&D.

This Guide provides suggestions on how the concepts in the FM should be interpreted to ensure that data better reflect the particular characteristics of R&D activity in developing countries while still maintaining international comparability. In addition, it also provides recommendations for specific situations that fall outside the framework of the FM and offers suggestions on how to strengthen STI statistical systems in developing countries as well. The Guide has served as the basis for an Annex to the FM

The remainder of this chapter reproduces the Executive Summary of the Guide. The Guide in full can be downloaded from the UIS website (UIS, 2010).

Executive Summary of UIS Technical Paper no. 5

Innovation is now universally regarded as an engine of economic growth in developing as well as developed countries – it is therefore an important driver of poverty alleviation. To set effective innovation policies, policy-makers need trustworthy indicators to benchmark and monitor these policies. Research and experimental development (R&D) is an important component of a country's national innovation system (NIS) and R&D statistics are among the most widely used indicators to monitor the NIS.

The methodology to measure R&D is detailed in the Frascati Manual (FM), which has been in use for almost fifty years. Despite this longevity, developing countries sometimes face problems when trying to apply the FM standards to the situation in their country. This Technical Paper provides guidance on a number of challenges that are relevant to developing countries and which may not be elaborated on clearly enough in the FM. The following situations that may present challenges to measuring R&D in developing countries are addressed in this document:

1) Developing countries are a heterogeneous group, extending from the least developed countries to emerging economies. Consequently, their innovation systems and associated R&D measurement systems exhibit wide variety both internally -- by institution, sector and region -- and internationally. In addition, despite the increasing presence of developing countries in global R&D, there is still a marked lack of demand for science, technology and innovation (STI) indicators from policy-makers in developing countries. Even if the demand does exists, there are often significant problems with compiling the data due to a lack of coordination at the national level, a lack of cooperation by research institutions, universities and businesses, and a generally weak statistical system in the country.

2) A concentration of innovation activities by sector or in a small set of institutes may lead to volatility and inconsistencies in statistics. The lower emphasis on R&D in the business sector may reflect the way R&D is organized. Business enterprises that cater mainly to the local market may experience reduced competitive pressure, making systematic R&D the exception rather than

the rule. R&D may therefore be commissioned *ad hoc* to deal with production issues and is thus informal as well as difficult to capture.

3) In the higher education sector, the increasing number of private universities makes it useful to distinguish between public and private higher education and to further break up private higher education into government-dependent and independent private institutions. Further disaggregation into private-for-profit and private-not-for-profit higher education institutions should also be considered to track where most research is carried out.

4) The landscape of R&D expenditure is changing, which affects the collection of data. R&D used to be largely funded by the government but now new sources of funds are emerging – foundations, non-governmental organizations (NGOs) and especially foreign organizations play an important role. Although the FM recommends the collection of primary data through direct surveys, the use of secondary data from the national budget and the budgetary records of public R&D performing units has been a widely adopted practice for obtaining a rough estimate of R&D expenditure. However, using budget data may not reflect true R&D expenditure as it harbours the risk of double counting, especially when a mix of budget data and survey data is used.

5) Tallying the number of researchers in a given country presents further challenges. In certain cases, an underestimation occurs while in others, an overestimation is generated. In some developing countries, salaried researchers may not have research budgets or unpaid researchers may undertake research. In other scenarios, academic staff may hold part-time contracts at more than one university. Even if academic staff have contracts that specify the amount of time to be spent on conducting research, it is difficult to enforce especially where there is a lack of resources. Estimating the time spent on research and hence the calculation of the full-time equivalent (FTE) for research staff – particularly in the higher education sector – is fraught with difficulties. This directly impacts the calculation of R&D expenditure.

Likewise, capturing the time contributed to R&D by doctoral students and their tutors is a common problem. Researchers in foreign institutions present an additional challenge as their mode of working may differ from that of researchers in national institutions. Researchers may spend a considerable period working abroad but still retain their positions at home while visiting researchers (who normally work abroad and are visiting a particular country for a certain duration) fall into a different category and present yet another significant phenomenon to be taken into account.

R&D survey data need to be complemented with information from other sources. As such, the problem of accurately identifying researchers and the time they spend on research could be addressed in part through sensitive interviews by peers who understand local circumstances. When using secondary sources to calculate the number of researchers, however, it is necessary to verify the figures by surveying institutions in order to confirm coverage and avoid double counting.

6) Clinical trials are an area of growth in some developing countries. Identifying research personnel in the extended clinical trials value chain may be difficult as their involvement is occasional and harbours a risk of double counting (i.e. as personnel in the trial and as academic staff).

The following convention should be used to account for the R&D personnel involved in clinical trials:

- Medical doctors and other professionals with at least ISCED 5A degrees (UNESCO, 2006) should be considered researchers;

- Nurses and other staff with qualifications below ISCED 5A should be categorized as technicians.

Involvement in clinical trials may be a part-time activity for doctors in their medical practice. As such, it is important to calculate the FTE of the staff involved. It is equally important to carefully attribute the expenditure and FTE to the correct sectors (i.e. higher education, business, private non-profit) as higher education researchers might be engaged in clinical trial supervision for a private company, for example.

7) A number of special types of activity warrant attention when measuring R&D as they rest on the borderline of what is considered R&D. The following are activities that are discussed in the Paper:

- In the case of traditional knowledge, it is important to set boundaries. Activities that establish an interface between traditional knowledge and R&D are considered R&D. However, the storage and communication of traditional knowledge in traditional ways is excluded.

- Reverse engineering is important in many developing countries. However, this generally falls outside the scope of R&D. Only if reverse engineering is carried out in the framework of an R&D project to develop a new (and different) product, should it be considered R&D.

- Minor or incremental changes are the most frequent type of innovation activity in emerging economies and developing countries. The activities leading to minor, incremental changes or adaptations should in principle not be counted as R&D activities unless they are part of, or result from, a formal R&D project in the firm.

- Surveys should measure R&D in the social sciences and humanities across all sectors. Development research and other social change projects should only be considered R&D so long as they are in a development and testing phase. Once the project goes to scale, it is no longer R&D. In some countries, research on religion has a particular importance. In principle, research on religion is a part of the humanities, thus institutions performing it should be included in R&D surveys.

- There are areas of growth and improvement in R&D measurement that should be addressed. Survey coverage should be extended to software development and system engineering R&D activities of leading firms in the financial services sector as well as small and medium sized enterprises in the R&D value chains of these leading firms.

8) Finally, given their importance in developing countries, it may be useful to create a foreign institutions (FI) sub-sector within each major sector of performance. In countries where the FI sector is deemed important and significantly impacts R&D statistics, it could be treated as a separate sector that ranks at the same level as other sectors of performance. If a country decides to establish an FI sector, it is recommended that this sector include foreign government institutes,

foreign private non-profit (PNP) institutes and international organizations. Foreign companies, however, should remain in the business sector while foreign higher education institutes should remain in the higher education sector. Funding from this sector that helps finance other sectors should be labelled as funds from “abroad”.

STI statistical systems are often weak in developing countries. A number of recommendations are elaborated in this Paper to help strengthen these systems:

- Institutionalize R&D statistics;
- Establish registers;
- Demonstrate value and build support;
- Document survey procedures and estimations.

Lastly, there is a perceived need for further data and information beyond the FM definition of R&D to augment STI statistics with data on related S&T activities. These activities include scientific and technological services (STS) and scientific and technological education and training (STET).

Chapter 5: Measuring Innovation

Introduction

The Oslo Manual (OM), a joint publication of the OECD and Eurostat, presents the guidelines for collecting and interpreting innovation data. It is the central reference document for the statistical definition of innovation and forms the basis for surveys of innovation throughout the world. The first edition of the Oslo Manual was published in 1992. In the second edition, which was published in 1997, the coverage was expanded to services.

Both the first and the second editions used the technological product and process (TPP) definition of innovation. This reflected a focus on firms' technological development of new products and new production techniques and their diffusion to other firms. (OM §5)

The third edition, published in 2005, expands the innovation measurement framework in three important ways. First, it places greater emphasis on the role of linkages with other firms and institutions in the innovation process. Second, it recognises the importance of innovation in less R&D-intensive industries, such as services and low-technology manufacturing. Finally, the definition of innovation is expanded to include two additional types of innovation, namely: organisational and marketing innovation. This last edition of the Oslo Manual also includes an Annex on measuring innovation in developing countries, which the UIS had the responsibility for coordinating. (OM §7)

Why measure innovation?

The relationship between innovation and economic development is widely acknowledged. Innovation is key to the growth of output and productivity, and therefore also crucial for poverty alleviation. Furthermore, while R&D plays a vital role in the innovation process, much innovation activity is not R&D-based, yet relies on highly skilled workers, on interactions with other firms and public research institutions, and on an organisational structure that is conducive to learning and exploiting knowledge (OM §72). These factors should be captured by innovation policies. These policies, in order to be effective, should be evidence-based. In this sense, innovation data are required to better understand innovation and its relation to economic growth, as well as to provide indicators for benchmarking national performance.

An innovation measurement framework

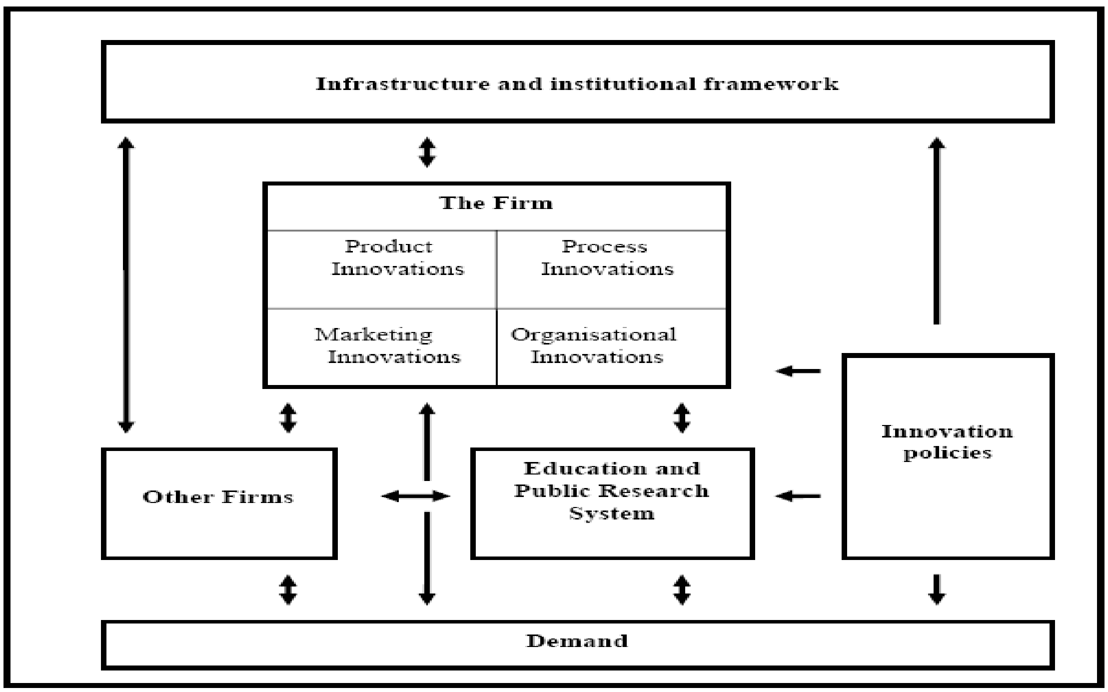
As previously mentioned, the link between innovation and economic change is of central interest. Through innovation, new knowledge is created and diffused, expanding the economy's potential to develop new products and more productive methods of operation. Such improvements depend not only on technological knowledge, but also on other forms of knowledge that are used to develop product, process, marketing and organisational innovations. Specific types of innovation can differ greatly in their impact on firm performance and on economic change. For this reason, it is important to be able to identify the implementation and impacts of different types of innovation. (OM §99)

Figure 7 depicts this framework from the perspective of the firm, the target of innovation surveys. The main characteristics of the framework described are (OM §100):

- Innovation in the firm;
- Linkages with other firms and public research institutions;
- The institutional framework in which firms operate; and
- The role of demand.

Innovation can occur in any sector of the economy, including government services, such as health or education. The OM's guidelines, however, are essentially designed to deal with innovations in the business enterprise sector alone, that is to say, in the firm. This includes firms from manufacturing, primary industries and the services sector. In this context, innovation in firms refers to planned changes in a firm's activities with a view to improving the firm's performance.
It is worth highlighting that innovation is also important for the public sector. However, less is known about innovation processes in non-market-oriented sectors. Much work remains to be done to study innovation and develop a framework for the collection of innovation data in the public sector. Indeed, much work is currently underway to measure innovation in the public sector and in due time guidelines will appear on that topic too. (OM §27-28)

Figure 7: The innovation measurement framework



Source: OM Figure 2.1

Measuring innovation

Definition

An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. (OM §146)

Examples of innovation can be found in Annex B of the Oslo Manual.

Types of innovations

Four types of innovations are distinguished: product innovations, process innovations, marketing innovations and organisational innovations. This classification maintains the largest possible degree of continuity with the previous definition of technological product and process innovation used in the second edition of the Manual. Product innovations and process innovations are closely related to the concept of technological product innovation and technological process innovation.

Marketing innovations and organisational innovations broaden the range of innovations covered by the Oslo Manual as compared to the previous definition. (OM §155)

The **four types of innovation** are defined as follows:

- **Product innovation**: introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. (OM §156)
  The term "product" is used to cover both goods and services. Product innovations include both the introduction of new goods and services and significant improvements in the functional or user characteristics of existing goods and services. (OM §157)
  New products are goods and services that differ significantly in their characteristics or intended uses from products previously produced by the firm. Significantly improvements to existing products can occur through changes in materials, components, and other characteristics that enhance performance. (OM §158, 160)

- **Process innovation**: implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. (OM §163)
  Process innovations can be intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products. Production methods involve the techniques, equipment and software used to produce goods or services. Delivery methods concern the logistics of the firm and encompass equipment, software and techniques to source inputs, allocate supplies within the firm, or deliver final products. (OM §164-166)
  Process innovations include new or significantly improved methods for the creation and provision of services. Process innovations also cover new or significantly improved techniques, equipment and software in ancillary support activities, such as purchasing, accounting, computing and maintenance. (OM §167-168)

- **Marketing innovation**: implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. (OM §169)
  Marketing innovations are aimed at better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales. The distinguishing feature of a marketing innovation compared to other changes in a firm's marketing instruments is the implementation of a marketing method not previously used by the firm. It must be part of a new marketing concept or strategy that represents a significant departure from the firm's existing marketing methods. New marketing methods can be implemented for both new and existing products. (OM §170-171)
  Here product design changes refer to changes in product form and appearance that do not alter the product's functional or user characteristics. They also include changes in the packing of products. New marketing methods in product placement primarily involve the introduction of new sales channels. Sales channels here refer to the methods used to sell goods and services to customers, and not logistics methods (transport, storing and handling of products) which deal mainly with efficiency. (OM §172-173)
  New marketing methods in product promotion involve the use of new concepts for promoting a firm's goods and services. Innovations in pricing involve the use of new pricing strategies to market the firm's goods or services. New pricing methods whose

sole purpose is to differentiate prices by costumer segments are not considered innovations. (OM §174-175)

- **Organisational innovation**: implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. (OM §177)
  Organisational innovations can be intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labour productivity), gaining access to non-tradable assets (such as non-codified external knowledge) or reducing costs of supplies. The distinguishing features of an organisational innovation compared to other organisational changes in a firm is the implementation of an organisational method (in business practices, workplace organisation or external relations) that has not been used before in the firm and is the result of strategic decisions taken by management. (OM §178-179)
  Organisational innovations in business practices involve the implementation of new methods for organising routines and procedures for the conduct of work. Innovations in workplace organisation involve the implementation of new methods for distributing responsibilities and decision making among employees for the division of work within and between firm activities (and organisational units), as well as new concepts for the structuring of activities. New organisational methods in a firm's external relations involve the implementation of new ways of organising relations with other firms or public institutions. (OM §180-182)

A common feature of an innovation is that it must have been **implemented**. A new or improved product is implemented when it is introduced on the market. New processes, marketing methods or organisational methods are implemented when they are brought into actual use in the firm's operations. (OM §150)

Changes which are not considered innovations (OM §198-204)

- Ceasing to use a process, a marketing method or an organisation method, or to market a product;
- Simple capital replacement or extension;
- Changes resulting purely from changes in factor prices;
- Customisation;
- Regular seasonal and other cyclical changes; and
- Trading of new or significantly improved products.

Diffusion and degree of novelty

Diffusion is the way in which innovations spread, through market or non-market channels, from their first worldwide implementation to different consumers, countries, regions, sectors, markets, and firms. Without diffusion, an innovation will have no economic impact. The minimum entry for a change in a firm's products or functions to be considered as an innovation is that it must be new (or significantly improved) to the firm. (OM §37)

By definition, all innovations must contain a **degree of novelty**. The following three concepts for the novelty of innovations can be distinguished: (OM §205)

- New to the firm;
- New to the market; and
- New to the world.

Specifically:

- **New to the firm:** A product, process, marketing method, or organisational method may already have been implemented by other firms, but if it is new to the firm (or in case of products and processes: significantly improved), then it is an innovation for that firm. (OM §207)
- **New to the market:** An innovation is new to the market when the firm is the first to introduce the innovation on its market. It is worth highlighting that the market is simply defined as the firm and its competitors. Therefore, the geographical scope is subject to the firm's own view of its operating market and can include both domestic and international firms. (OM §209)
- **New to the world:** Lastly, an innovation is new to the world when the firm is the first to introduce the innovation for all markets and industries, domestic and international. This, hence, implies a qualitatively greater degree of novelty than new to the market. (OM §210)

A related concept is a **radical innovation**. It can be defined as an innovation that has a significant impact on a market and on the economic activity of firms in that market. This concept focuses on the impact of innovations as opposed to their novelty. The impact can, for example, change the structure of the market, create new markets or render existing products obsolete. However, it might not be apparent whether an innovation is disruptive until long after it has been introduced. This makes it difficult to collect data on disruptive innovations within the period reviewed in an innovation survey. (OM §211)

Innovation activities

Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation. (OM §149)

Innovation activities vary greatly in their nature from firm to firm. Some firms engage in well-defined innovation projects, such as the development and introduction of a new product, whereas others primarily make continuous improvements to their products, processes and operations. Both types of firms can be innovative: an innovation can consist of the implementation of a single significant change, or of a series of smaller incremental changes that together constitute a significant change. (OM §151)

Innovation activities for product and process innovations: (OM §314-339, 351)

- ***Intramural (in-house) R&D**:* This comprises all R&D conducted by the enterprise as defined by the Frascati Manual and as reported in R&D surveys. It includes both R&D intended to contribute to the development and implementation of product, process, marketing or organisational innovations and basic research that is not directly related to the development of a specific innovation. Note that, following the Frascati definition, intramural R&D also includes the acquisition of capital goods that is directly related to R&D. (OM §321, 351)
- ***Extramural R&D (acquisition of R&D):*** Same activities as intramural R&D, but purchased from public or private research organisations or from other enterprises (including other enterprises within the group). In other words, this comprises the acquisition of R&D services. It also includes the acquisition of R&D services from units of multinational enterprises located abroad. (OM §322, 351)

- ***Acquisition of other external knowledge:*** In addition to R&D, enterprises may acquire technology and know-how in a number of forms and from a variety of sources in connection with the development and implementation of innovations. This includes the acquisition of rights to use patents and non-patented inventions, licences, disclosures of know-how, trademarks, designs and patterns from other enterprises and institutions such as universities and government research institutions, other than R&D. Acquisition of external knowledge may also include computer services and other scientific and technical services for product and process innovations activities. (OM §323-325, 351)
- ***Acquisition of machinery, equipment and other capital goods:*** This category refers to goods specifically purchased for use in product and process innovation activities of the firm. This includes the acquisition of: land and buildings (including major improvements, modifications and repairs); machinery, instruments and equipment (including computer hardware); and computer software. This category only includes the acquisition of capital goods for innovation that is not included in R&D activities. (OM §326-330, 351)
- ***Other preparations for product and process innovations****:* This includes other internal activities related to the development and implementation of product and process innovations that are **not** included in R&D. They include development activities that are either partially excluded as R&D (such as industrial design, engineering and set-up, and trial production) or fully excluded (such as patent and licence work, production start-up and testing), and development activities for product or process innovations that do not meet the novelty requirement for R&D (i.e., they are new to the firm but not new to the market). (OM §331-336, 351)
- ***Market preparations for product innovations:*** This comprises activities aimed at the market introduction of new or significantly improved goods or services, such as preliminary market research, market tests, and launch advertising. (OM §337, 351)
- ***Training:*** This comprises all the training (including external training) that is required for implementing a product or process innovation. (OM §338-339, 351)

Innovation activities for marketing and organisational innovations: (OM §340-343, 351)

- ***Preparations for marketing innovations:*** This comprises activities related to the development and implementation of new marketing methods not previously used by the firm. It includes development and planning of new marketing methods and work involved in their implementation. Activities related to marketing innovations include only those for developing and implementing new marketing methods, not expenditures for using these methods in daily business. This category also includes acquisition of other external knowledge and of machinery, equipment, and other capital goods and training that are specifically related to marketing innovations. (OM §340-341, 351)
- ***Preparations for organisational innovations:*** This includes the development and planning of new organisational methods and the work involved in their implementation. This category also includes acquisition of other external knowledge and of machinery, equipment and other capital goods and training activities that are specifically related to organisational innovations. (OM §342-343, 351)

Kinds of innovation activities (OM §42)

During a given period, a firm's innovation activities may be of three kinds:

- ***Successful*** in having resulted in the implementation of an innovation (though not necessarily commercially successful);
- ***Ongoing***, work in progress, which has not yet resulted in the implementation of an innovation; and
- ***Abandoned*** before the implementation of an innovation.

Classifying firms by degree of innovativeness

- The **innovative firm** is one that has introduced an innovation during the period under review. Such innovations need not have been a commercial success, since many innovations fail. The innovative status of a firm can be defined in several ways. The basic definition of an innovative firm is a firm that has implemented at least one innovation, while a product or process innovator is defined as a firm that has implemented either a product or a process innovation. (OM §47, 212)
- An **innovation-active firm** is one that has had innovation activities during the period under review, including those with ongoing and abandoned activities. In other words, firms that have had innovation activities during the period under review, regardless of whether the activity resulted in the implementation of an innovation, are innovation active. (OM §215)
- **Potentially innovative firms are** a subset of innovation-active firms, those that have made innovation efforts (i.e. conducted innovation activities) but have not achieved results (innovations) during the period of analysis. Inside this group, might be found businesses that have innovated in the past, or businesses that may innovate in the near future. Assisting this category of firms to overcome the obstacles that prevent them from being innovative is a key element in innovation policies, especially in developing countries. (OM Annex A §505-506)

Factors influencing innovation

Identifying the factors that drive innovation and those that hinder it is of great value for understanding the innovation process and for formulating innovation policy. (OM §382)
These factors are here emphasised.

Objectives and effects of innovation

Enterprises may engage in innovation activity for a number of reasons. Their **objectives** may involve products, markets, efficiency, quality or the ability to learn and to implement changes. Identifying enterprises' motives for innovating and their importance is of help when examining the forces that drive innovation activities, such as competition and opportunities for entering new markets. (OM §44, §386)

Enterprises may or may not succeed in achieving their objectives by implementing innovations, or innovations may have other or additional effects than those that initially motivated their implementation. While **objectives** concern enterprises' motives for innovating, **effects** concern the actual observed outcomes of innovations. The same factors may play a role in both objectives and effects of innovation, although they will be interpreted differently. Table 9 lists factors that are relevant to objectives and effects for all four types of innovations. A number of the factors may be relevant for more than one type of innovation. In particular, product and marketing innovations or process and organisational innovations may have a number of factors in common. (OM §387)

It is recommended to collect data on the objectives or effects of innovations implemented by enterprises during the period under review. It is recommended to use an ordinal scale to ask enterprises whether the factor is relevant and, if so, its importance. Questions on both the objectives of innovation and their actual effects can provide valuable information on enterprises' innovation activity. However, it may not be possible to include both questions in innovations surveys. The choice between the two questions may depend on which is considered most useful for policy. However, a drawback of questions on effects is that the impact of recent innovations may not be felt within the time period of the survey. The disadvantage of questions on objectives is that the actual effects may differ substantially from expectations. (OM §390)

Table 9: Factors relating to the objectives and effects of innovation

Relevant for:	Product innovations	Process innovations	Organisational innovations	Marketing innovations
Competition, demand and markets:				
• Replace products being phased out	*			
• Increase range of goods and services	*			
• Develop environment-friendly products	*			
• Increase or maintain market share	*			*
• Enter new markets	*			*
• Increase visibility or exposure for products				*
• Reduced time to respond to customer needs		*	*	
Production and delivery:				
• Improve quality of goods and services	*	*	*	
• Improve flexibility of production or service provision		*	*	
• Increase capacity of production or service provision		*	*	
• Reduce unit labour costs		*	*	
• Reduce consumption of materials and energy	*	*	*	
• Reduce product design costs		*	*	
• Reduce production lead times		*	*	
• Achieve industry technical standards	*	*	*	
• Reduce operating costs for service provision		*	*	
• Increase efficiency or speed of supplying and/or delivering goods or services		*	*	
• Improve IT capabilities		*	*	
Workplace organisation:				
• Improve communication and interaction among different business activities			*	
• Increase sharing or transferring of knowledge with other organisations			*	
• Increase the ability to adapt to different client demands			*	*
• Develop stronger relationships with customers			*	*
• Improve working conditions		*	*	
Other:				
• Reduce environmental impacts or improve health and safety	*	*	*	
• Meet regulatory requirements	*	*	*	

Source: OM Table 7.1

Other measures of impacts on enterprise performance - the impact on turnover

It is generally difficult to ask for quantitative measures of the effects of innovations in surveys, even for very rough estimates, as the calculations often require substantial analysis on the part of the enterprise. An important aspect for all analyses of the impact of innovations is the time lag between an innovation and its impact. Some effects may materialise over the course of the observation period, while others may take longer. (OM §394-395)

An indicator on the proportion of turnover due to new or significantly improved products provides important information on the impact of product innovations on the overall makeup of turnover (*i.e.* the share of turnover from new products) and on the degree of innovativeness of the enterprise. (OM §397)

Questions on the proportion of turnover due to product innovations should refer to the impact of product innovation over the observation period on the turnover in the reference year (*i.e.* the last year of the observation period). **It is recommended to ask enterprises to estimate the percentage share of total turnover in the reference year that is due to:** (OM §398)

- New or significantly improved goods and services introduced during the observation period that were new to the market;
- New and significantly improved goods and services introduced during the observation period that were new to the firm, though not new to the market; and
- Products that were unchanged or only marginally modified during the observation period.

Similar approaches can be used to measure the outcomes of other types of innovations. (OM §49, 403-404)

Factors hampering innovation activities

Innovation activity may be hampered by a number of factors. There may be reasons for not starting innovation activities at all; there may be factors that slow innovation activity or affect them negatively. These include: economic factors, such as high costs or lack of demand; enterprise factors, such as lack of skilled personnel or knowledge; and legal factors, such as regulations or tax rules. Table 10 lists factors that could act as barriers to innovation. (OM §45, 410)

Questions on barriers to innovation can provide information on a number of issues relevant for innovation policy. Small and medium-sized enterprises (SMEs) may identify a lack of available finance as an important barrier to investments in innovation. Enterprises may be concerned about a lack of demand for new products at the prices that enterprises would need to charge to make the innovation worthwhile. Enterprises may not have the skilled personnel needed to engage in innovation activities, or their innovation activities may be slowed because they are unable to find the necessary personnel on the labour market. A lack of infrastructure may be an important barrier to innovation, in particular outside of large cities. Other reasons may be that the enterprise lacks knowledge relating to technologies or markets that would be needed to develop an innovation, or that the enterprise is unable to find suitable partners for joint innovation projects. (OM §411)

Table 10: Factors hampering innovation activities

Relevant for:	Product innovations	Process innovations	Organisational innovations	Marketing innovations
Cost factors:				
• Excessive perceived risks	*	*	*	*
• Cost too high	*	*	*	*
• Lack of funds within the enterprise	*	*	*	*
• Lack of finance from sources outside the enterprise:				
Venture capital	*	*	*	*
Public sources of funding	*	*	*	*
Knowledge factors:				
• Innovation potential (R&D, design, etc.) insufficient	*	*		*
• Lack of qualified personnel:				
Within the enterprise	*	*		*
In the labour market	*	*		*
• Lack of information on technology	*	*		
• Lack of information on markets	*			*
• Deficiencies in the availability of external services	*	*	*	*
• Difficulty in finding co-operation partners for:				
Product or process development	*	*		
Marketing partnerships				*
• Organisational rigidities within the enterprise:				
Attitude of personnel towards change	*	*	*	*
Attitude of managers towards change	*	*	*	*
Managerial structure of enterprise	*	*	*	*
• Inability to devote staff to innovation activity due to production requirements	*	*		
Market factors:				
• Uncertain demand for innovative goods or services	*			*
• Potential market dominated by established enterprises	*			*
• **Institutional factors:**				
• Lack of infrastructure	*	*		*
• Weakness of property rights	*			*
• Legislation, regulations, standards, taxation	*	*		*
Other reasons for not innovating:				
• No need to innovate due to earlier innovations	*	*	*	*
• No need because of lack of demand for innovations	*			*

Source: OM Table 7.2

Linkages

The innovative activities of a firm partly depend on the variety and structure of its links to sources of information, knowledge, technologies, practices and human and financial resources. Each linkage connects the innovating firm to other actors in the innovation system: government laboratories, universities, policy departments, regulators, competitors, suppliers and customers.

Innovation surveys can obtain information on the prevalence and importance of different types of linkages, as well as on the factors that influence the use of specific linkages. (OM §50)

Types of external linkages: (OM §51, 265-274)

- ***Open information sources*** provide openly available information that does not require the purchase of technology or intellectual property rights, or interaction with the source. (OM §51, 265-268)
- ***Acquisition of knowledge and technology*** results from purchases of external knowledge and capital goods (machinery, equipment, software) and services embodied with new knowledge or technology that do not involve interaction with the source. (OM §51, 269-270)
- ***Innovation co-operation*** requires active co-operation with other firms or public research institutions for innovation activities (and may include purchases of knowledge and technology). (OM §51, 271-274)

Sources for transfers of knowledge and technology

The potential sources for the three types of linkages are similar, though some are only relevant as openly available sources of knowledge and technology. In addition to the external linkages, the internal sourcing of information is also important. The identification of which parts of the enterprise (e.g. R&D, marketing, production, distribution) are important sources of information for innovation activities provides information on the flow of knowledge within the enterprise. (OM §275-276)

Table 11 shows sources for all three types of linkages and indicates for which types each source is relevant. It includes internal sources, other enterprises, public and non-profit research institutions and a number of general information sources. The definition of several sources must be adapted to country-specific terminology to clearly differentiate between commercial laboratories, government research institutes and private non-profit research institutes. (OM §276)

Table 11: Sources for transfers of knowledge and technology

	Open information sources	Sources for purchases of knowledge & technology	Co-operation partners
Internal sources within the enterprise:			
• R&D	*		
• Production	*		
• Marketing	*		
• Distribution	*		
Other enterprises within the enterprise group	*	*	*
External market and commercial sources:			
• Competitors	*	*	*
• Other enterprises in the industry	*	*	*
• Clients or customers	*		*
• Consultants/consultancy firms		*	*
• Suppliers of equipment, materials, components, software or services	*	*	*
• Commercial laboratories	*	*	*
Public sector sources:			
• Universities and other higher education institutions	*	*	*
• Government/public research institutes	*	*	*
• Private non profit research institutes	*	*	*
• Specialised public/semi-public innovation support services	*	*	*
General information sources:			
• Patent disclosures	*		
• Professional conferences, meetings, branch literature and journals	*		
• Fairs and exhibitions	*		
• Professional associations, trade unions	*		
• Other local associations	*		
• Informal contacts or networks	*		
• Standards or standardisation agencies	*		
• Public regulations (i.e. environment, security)	*		

Source: OM Table 5.1

Appropriability

The ability of enterprises to appropriate the gains from their innovation activities is an important factor affecting innovation. If, for example, enterprises are unable to protect their innovations from imitations by competitors, they will have less incentive to innovate. On the other hand, if an industry functions well without formal protection methods, promoting these may slow the flow of knowledge and technology and lead to higher prices for goods and services. (OM §414)

The following list of methods of protection is suggested: (OM §416)

- **Formal methods:** patents, registration of design, trademarks, copyrights, confidentiality agreements and trade secrecy; and
- **Informal methods:** secrecy that is not covered by legal agreements, complexity of product design, lead time advantage over competitors.

It is recommended to collect data on whether or not enterprises have used various methods of protection for their innovations during the observation period. Questions can either use a binary or an ordinal scale. Protection methods can be relevant for all types of innovations, though asking questions for all innovations types combined can make it more difficult to interpret the data (i.e. to link protection methods to specific types of innovations). (OM §420)

Innovation data collection

The correct application of statistical methodology is crucial for the collection and analysis of innovation data. Following the guidelines of the OM will generally lead to comparable results over time and across countries. Particular circumstances may require a country to use another methodology. In such cases, the methods used should be considered carefully so as to ensure that the results remain comparable. Divergence from the guidelines should be documented in sufficient detail to explain comparability issues with data from other countries. (OM §422-423)

The survey approach

There are two main approaches to collecting data on innovations: (OM §52, 377-381)

- The **"subject"** approach starts from the innovative behaviour and activities of the firm as a whole. The idea is to explore the factors influencing the innovative behaviour of the firm (strategies, incentives and barriers to innovation) and the scope of various innovation activities, and above all to examine the outputs and effects of innovation. These surveys are designed to be representative of all industries so that the results can be grossed up and comparisons made between industries; and
- The **"object"** approach involves the collection of data about specific innovations (usually a **"**significant innovation" of some kind, or a firm's main innovation). The approach involves collecting some descriptive, quantitative and qualitative data about the particular innovation at the same time as data is sought about the firm.

The OM's guidelines are oriented to the subject approach. (OM §381)

The primary statistical unit

The enterprise unit is the appropriate primary statistical unit in innovation surveys in most cases. The enterprise unit should, however, not be confused with the entity "legal unit". While legal units are independent in a legal sense, they may not necessarily constitute independent economic entities with decision-making autonomy for their productive activities. This is important for samples drawn from business registers based on legal units, as data from legal units without decision-making autonomy may not be comparable with data from enterprises. If data are collected for legal units, it is desirable to compile the data for statistical use at the enterprise level. (OM §233)

Classification by main economic activity

Statistical units of innovation surveys can be broken down according to different classifications. The most important classification is the **principal economic activity of the statistical unit** ("industry"). The International Standard Industrial Classification (ISIC Rev. 3.1[3]) is the appropriate international classification for this purpose. Countries that use a national industrial

---

[3] ISIC Rev. 4 was officially released on 11 August 2008 (UN, 2008), three years after the publication of the 3rd ed. of the Oslo Manual. Therefore ISIC Rev. 4 should be the classification adopted by countries in their innovation surveys.

classification system rather than ISIC Rev. 3.1 should use concordance tables to convert their industrially classified data to ISIC Rev. 3.1. (OM §246)

Classification by size - detailed: number of employees

For innovation surveys, size is the other essential classification of statistical units. Although different variables can be used to define the size of a statistical unit in innovation surveys, **it is recommended that size should be measured on the basis of number of employees**. In order to maintain international comparability while at the same time allowing flexibility in the number of size classes, the following size classes are recommended as a minimum: (OM §249)

Classification of statistical units for innovation surveys by size - Number of employees:

- 10-49
- 50-249
- 250 and above

More detailed breakdowns by size class may also be used, such as a size class for firms with fewer than ten employees. It is important for more detailed size classes to be consistent with the above groups. A proposal would be: (OM §249)

Classification of statistical units for innovation surveys by size - Number of employees, detailed:

- 0
- 1 - 9
- 10 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 - 999
- 1 000 - 4 999
- 5 000 and above

Classification by type of institution

A further useful classification of statistical units for innovation surveys might be by **type of institution**. This breakdown seems particularly important when the statistical unit is in general the enterprise and in view of the increasing internationalisation of innovation activities. It is recommended that when enterprises are the statistical units in innovation surveys they should be classified as follows: (OM §250)

***Classification of statistical units for innovation surveys by type of institution*:**

- *Private enterprise:*
  - National (no controlled affiliates (CA) abroad);
  - Multinational, of which there may be three types:
    - » Foreign-controlled affiliates (CAs) (where the affiliate does not control any other affiliates abroad);
    - » Foreign-controlled affiliates with CAs (parent companies under foreign control); and
    - » Parent companies with CAs abroad (parent company not under foreign control).
- *Public enterprise:*
  - Resident non-financial corporations and quasi-corporations that are subject to control by government units, control over a corporation being defined as the ability to determine general corporate policy by choosing appropriate directors, if necessary.

Data collection on innovation activities - expenditures

Total expenditure for innovation activities comprises current and capital expenditure incurred for the innovation activities previously defined. Current innovation expenditures are composed of labour costs and other current costs. Capital expenditures for innovations are composed of gross expenditures on land and buildings, on instruments and equipment and on computer software. Capital expenditures that are part of R&D are included in *intramural R&D*, while non-R&D capital expenditures linked to product and process innovations are included in *acquisition of machinery, equipment and other capital goods.* Non-R&D capital expenditures specifically linked to marketing or organisational innovations are included in *preparations for marketing innovations* and *preparations for organisational innovations*, respectively. The remaining categories of innovation activity consist solely of current expenditure. (OM §352)

Innovation surveys can collect both qualitative and quantitative data on innovation activities. Qualitative data involve questions on whether or not enterprises have engaged in an innovation activity. Quantitative data involve questions on expenditures for an innovation activity. Innovation expenditure data are among the most important and are in demand both for research and policy. However, innovation expenditure questions are also among the most difficult and time-consuming to answer. (OM §353-354)

Populations

The target population for innovation surveys concerns statistical units (innovators and non-innovators, R&D performers and non-R&D performers) in the business sector. This sector includes both goods-producing and services industries. Innovative activities take place in small and medium-sized units as well as in large units. In order to capture innovation activity in these smaller units, **it is recommended that the target population should include, at a minimum, all statistical units with at least ten employees.** This threshold may be higher for specific industries, such as Construction and Retail trade. Surveys may also find it useful to include units with fewer than ten employees. Innovation activities in these smaller units are of considerable policy interest for a number of sectors, such as high-technology manufacturing and knowledge-intensive services. (OM §425-426)

The units from which a survey sample or census is drawn form the frame population. When preparing a survey, the target and frame populations should be as close as possible. In practice, the population from which the sample or census is drawn may not be the same as the target population. For example, the frame population underlying the survey (such as a register) may include units that no longer exist, or units that no longer belong to the target population. At the same time, it may not contain units that in fact do belong to the target population. (OM §427)

The frame population is based on the last year of the observation period for surveys. Special attention should be paid to a number of changes to units that may have taken place during the observation period. Among these are: changes in industrial classifications, new units created during the period, mergers, splits of units, and units that ceased activities during the last year of the period. An ideal frame is an up-to-date official business register established for statistical purposes. National statistical offices usually keep such registers. Other registers can be used as well, provided their quality is comparable to that of the official register. The units in the register will in many countries be legal units, so the units may not all be statistical units in terms of the innovation survey. Guidelines to check the validity of the responding statistical unit should be given in the questionnaire. (OM §428-429)

If the register forms the basis for several surveys, such as the innovation survey, the R&D survey and the general business statistics survey, the information collected in the innovation survey can be restricted to issues specific to innovation. Other information, for example on R&D or on general economic variables such as employment, turnover, exports or investments, can be taken directly from the other surveys based on the register. Accordingly, it is desirable to base different types of surveys on a single business register compiled for statistical purposes. (OM §430)

Mandatory or voluntary survey

Innovation surveys can be either mandatory or voluntary. If they are voluntary, higher non-response rates should be expected. Low response rates mean a smaller sample than expected and thus higher variance. This can be compensated to some extent, in the case of sample surveys, by higher sampling fractions. However, increasing the sampling fractions does not solve the basic problem of bias in the estimates for the target population that is due to a high non-response rate, making further analyses less representative. (OM §431)

Census or sample survey

Innovation data can be collected through census or sample surveys. Resources limitations and response burdens will in most cases rule out a survey of the entire population (census). If sample surveys are utilised, the units should be selected on the basis of a random procedure (random sample units with known selection probabilities). Sample surveys should be representative of the basic characteristics of the target population, such as industry, size and region, so a stratified sample is necessary. Estimates of acceptable coefficients of variation can be used to estimate the required number of responses for reliable results. (OM §432, 434)

A census may be unavoidable in some cases. It may be a legal requirement that all business surveys must be censuses. In addition, when the frame population is fairly small (*e.g.* in small countries), proper sampling may produce sample sizes for some strata that are relatively close in size to the frame population of the strata. In such cases, censuses may be worth considering. Finally, it may be decided that all units in the frame with more than a given number of employees should be included. (OM §433)

Domains

Particular subsets of the target population may be of special interest to users or users may need detailed information at sector or regional levels. These subsets are called domains (sub-populations). To get representative results for the domains, the domains must be subsets of the sampling strata. Some potential sub-populations that can be considered are: industry groupings, size classes, regions, units that engage in R&D and innovation-active units. (OM §435)

Some guidelines for the use of domains are: (OM §436)

- Statistical units and classifications should be the same in all parts of the sample including domains;
- Methods used to calculate results for subsets should be consistent with those used for results from the main sample; and
- Deviations in data treatment or differences in the quality of the results from the domains should be documented.

Sampling techniques

Innovation surveys are in general random sample surveys. The relevant literature offers various sampling techniques, such as the simple random technique, stratification techniques, cluster sample techniques and the probability proportional to their size (pps-sample) techniques. If stratification techniques are used, some general rules should be observed with regard to the selection of the stratification variables. In principle, stratification of the population should lead to strata that are as homogeneous as possible in terms of their innovation or non-innovation activities. Given that the innovation activities of units in different industries and in different size classes can differ significantly, it is **recommended that the stratification of random sample innovation surveys should be based on the size and principal activity of the units.** (OM §437-438)

It is generally recommended that the sampling fraction of a stratum should be higher for more heterogeneous strata and also higher for smaller strata. Another factor, which should be taken into account when fixing the individual sampling fractions, is the expected response rate in each stratum. (OM §442)

The standard approach for innovation surveys is repeated cross-sections, where a new random sample is drawn from a given population for each innovation survey. An alternative or supplementary approach is to impose a panel data structure, whereby a given sample of units is surveyed more frequently and in every subsequent survey using the same set of questions. (OM §443-444)

Survey methods and suitable respondents

A variety of methods can be used to conduct innovation surveys, including postal surveys and personal interviews. Each of these methods has different strengths and weaknesses. Moreover, choosing the unit's most suitable respondent is particularly important in innovation surveys, as the questions are very specialised and can be answered by only a few people in the unit, often not those who complete other statistical questionnaires. **It is highly recommended to make a special effort to identify respondents by name before data collection starts.** (OM §446, 450)

The questionnaire

Some basic rules should be followed when designing the questionnaire for an innovation survey. Briefly, these rules are: (OM §451-455)

- **Pre-test** each questionnaire before fieldwork;
- Keep it as **simple and short** as possible;
- Pay attention to the **order** of the questions;
- Questions on a number of **qualitative indicators** can use either a **binary** or an **ordinal scale**;
- In the case of international innovation surveys, special attention should be given to the **translation** and **design** of the questionnaire;

In addition to the rules mentioned above, one should keep in mind the possible use of short-form questionnaires on a set of core questions. Short-form questionnaires can be applied in small units and units in sectors with little innovation activity and in surveying units that have not reported innovation activity in previous innovation surveys. (OM §456)

Innovation and R&D surveys

R&D and innovation are related phenomena. This can lead some countries to consider the combination of R&D and innovation surveys. There are a number of arguments for and against: (OM §457)

- With a combined survey, the overall response burden of the reporting units will be reduced (a single questionnaire, instead of two separate surveys asking some of the same questions);
- If the length of questionnaire for combined surveys is much longer than for a separate survey, response rates may decline;
- A combined survey offers scope for analysing the relations between R&D and innovation activities at the unit level. There is less scope for this with separate surveys, especially when these are carried out by different institutions;
- There is a risk that units not familiar with the concepts of R&D and innovation may confuse them in a combined survey;
- Combined surveys offer a efficient method of increasing the frequency of innovation surveys;
- Country experiences (for example, Denmark, Finland, the Netherlands, Norway, and Spain) indicate that it is possible to obtain reliable results for R&D expenditures in combined surveys; and
- The frames for the two surveys will generally be different. For example, the frame population for innovation surveys may cover industrial classifications (and small units) that are not included in R&D surveys. Combining them may involve sending questions about R&D to a large number of non-R&D performers that are included in the frame population for the innovation survey. This would increase the cost of the joint survey.

In principle, business surveys other than R&D can also be merged with innovation surveys. Additionally, business surveys on the diffusion of ICTs and on the adoption of knowledge management practices can be considered for integration with innovation surveys. (OM §458)

While the OM does not recommend the use of combined surveys, country experience indicates that they provide a feasible option for increasing the frequency of data collection. Some guidelines for conducting combined surveys are: (OM §459)

- In order to reduce the risk of conceptual confusion between R&D and innovation, the questionnaire should have two distinct sections. Separate sections should also be used when combining innovation with other types of surveys;
- To avoid declines in response rates, individual sections for R&D and innovation should be smaller than in separate surveys, so that the overall length of the combined surveys with those from separate innovation surveys should be done with care, and surveying methods should be reported;
- Comparisons of results from combined surveys with those from separate innovation surveys should be done with care, and survey methods should be reported; and
- Samples to carry out such surveys should be extracted from a common business register in order to avoid inconsistencies in the frame populations.

Estimation of results - weighting methods

The results of the sample surveys need to be weighted to obtain information that is representative for the target population. There are various methods for weighting sampling results. The simplest is weighting by the inverse of the sampling fractions of the sampling units, corrected by the unit non-response. If a stratified sampling technique with different sampling fractions is used, weights should be calculated individually for each stratum. Weights are most commonly based on the number of enterprises in a stratum. However, it may be beneficial for quantitative variables to weight the results by number of employees or turnover. In international and other comparisons it is important to ensure that the same weighting method is used. (OM §460, 462)

Estimation of results - non-response

In practice responses to innovation surveys are always incomplete, irrespective of the survey method used. Two types of missing values can be distinguished: item and unit non-responses. Unit non-response means that a reporting unit does not reply at all. Item non-response refers to the response rate to a specific question and is equal to the percentage of blank or missing answers among the reporting units. Item non-response rates are frequently higher for quantitative questions than for questions using binary or ordinal response categories. (OM §463)

Disregarding missing values and applying simple weighting procedures based only on the responses received implicitly assumes that non-respondents are distributed in the same way as respondents. If non-respondents do not follow the same distribution, for example if non-response units have a lower propensity to innovate, this practice will give biased results. A number of methods can be used to minimize the problems of non-response. An appropriate first step in dealing with missing values is to contact the respondent to collect the missing information (OM §465-466)

Presentation of results

As previously mentioned, most innovation surveys are carried out as random sample surveys. The results of these surveys will include two types of error: random errors due to the random process used to select the units, and systematic errors containing all non-random errors (bias). To get at least an idea of the variance for the results, **it is recommended to calculate both (average) values for innovation indicators and also their coefficients of variation and/or confidence intervals.** (OM §475)

The presentation of results should contain metadata, including information on the procedure used to collect data, sampling methods, procedures for dealing with non-response and quality indicators. This will allow a better interpretation and quality judgment of the data. (OM §476)

Frequency of data collection

It is recommended to conduct innovation surveys every two years. However, where this is not economically feasible, a frequency of three or four years may be chosen. To ensure comparability among respondents, surveys must specify an observation period for questions on innovation. The choice of the length of the observation period is a compromise between different requirements. It is recommended that the length of the observation period for innovation surveys should not exceed three years nor be less than one year. (OM §478-479)

Annex to the Oslo Manual, 3rd edition - Innovation Surveys in Developing Countries

After the publication of the second edition of the Oslo Manual, many developing countries in various regions of the world conducted innovation surveys. The design of these surveys was usually intended to comply with Oslo Manual standards. However, almost all of these innovation measurement exercises resulted in adaptations of the proposed methodologies, in order to capture the particular characteristics of innovation processes in countries with different economic and social structures. Adaptations were hence prepared by each country separately and with different approaches. The Bogota Manual published by RICYT (Ibero-American Network on S&T Indicators) was a first effort to compile these particularities and guide the design of cross-nationally comparable innovation surveys. (OM Annex A §481)

Preparation of the annex was co-ordinated by the UNESCO Institute for Statistics (UIS). A base document provided by RICYT was submitted to a panel of researchers and practitioners with experience in innovation surveys in developing countries, covering China, Thailand, Singapore, Malaysia, Hungary, India, Lebanon, South Africa, and Tanzania. The UIS drafted the final annex based on this input. (OM Annex A §482)

Characteristics of innovation in developing countries

It is widely accepted that dissemination mechanisms and incremental change account for most of the innovation occurring in developing countries, owing to the particular characteristics of the society and the economy in many of these countries which influence innovation processes in many ways. (OM Annex A §484)

Size and structure of markets and firms

While the sector of small and medium-sized enterprises (SMEs) is very significant (including a large number of micro and small and, in some countries, medium-sized businesses which are often not registered), even enterprises considered “large” in most developing countries usually operate at suboptimal production scales, with higher unit costs and far from optimal efficiency. Competitiveness is mostly based on the exploitation of natural resources or cheap labour, rather than on efficiency or differentiated products. This leads to an informal organisation of innovation and fewer R&D projects. (OM Annex A §485)

Instability

Instability in micro and small businesses may mean that some have good potential to upgrade national innovative performance and function as cradles of innovators, while some lack resources and support for any innovation. Macro level uncertainty limits any long-term innovation activity. (OM Annex A §488)

Informality

Developing countries’ economies rely significantly on informal practice. Informality is not a favourable context for innovation. The sometimes great creativity invested in solving problems in the informal economy does not lead to systematic application and thus tends to result in isolated actions which neither increase capabilities nor help establish an innovation-based development path. (OM Annex A §489)

Particular economic and innovation environments

Many enterprises in developing countries operate in unusual economic and innovation environments owing to the existence, and in some cases prevalence, of state-owned enterprises (China) or massive parastatal enterprises (some Arab states). In these environments, a lack of competition sometimes discourages innovation or drains local markets of innovative potential. On the other hand, sometimes big state-owned enterprises (for example in sectors such as oil, aerospace or telecommunications) also become technological leaders through important investments in experimental development work (as in some Latin American countries). Moreover, in countries with less developed economic systems, major government S&T policies and programmes may have more impact on innovation than the activities and strategies of private enterprises. (OM Annex A §490)

Past techno-economic paradigms have continuing economic importance in some cases; in others, a paradigm switch is delayed owing to the high costs involved, insufficient supplies of local capital and lack of credit for big technological investments. Local markets in developing countries tend to be small, sometimes as a result of a less developed infrastructure, and this reduces the scope of the enterprise's actions and the relevance of actual innovations ("new to the market" may have a different meaning in such environments). Finally, it is worth stressing that innovations in the agricultural sector have a high economic impact, owing to the sector's significant overall economic weight. (OM Annex A §491-493)

Reduced innovation decision-making powers
The dominance of externally controlled or multinational corporations results in less decision making by local enterprises or subsidiaries (especially in the area of innovation), mainly because of the division of functions in these organisations. In the last few years, this division has even been extended to independent local enterprises in the framework of international manufacturing networks. Technology transfer from multinational corporations and from abroad is therefore a fundamental source of innovation. (OM Annex A §494)

Weak innovation systems
Fewer resources are devoted to innovation activities system-wide, thereby reducing the innovation potential of enterprises. The government is a major player in R&D execution and funding, mainly owing to a low level of resources devoted to R&D by businesses. Flows of information within national systems of innovation are fragmented, and in some cases there is an absence of linkages between science and enterprises. Weak or absent linkages challenge the capacities of firms to overcome (technology-related) problems and draw firms towards solutions that mostly rely on acquisition of embodied technology. Barriers to accumulation of capabilities by firms are high and difficult to tackle, particularly in the case of high qualified human capital, local and international linkages, and tacit knowledge incorporated in organizational routines. (OM Annex A §495-497)

Characteristics of innovation
The acquisition of embodied technology (equipment) for both product and process innovation is a major component of innovation. Minor or incremental changes are the most frequent type of innovation activity in some developing countries, together with innovative applications of existing products or processes. (OM Annex A §498-499)

Organisational change is an extremely significant aspect of the innovation process. Besides its direct impact on enterprise performance, it also contributes to the enterprise's ability to absorb new technologies incorporated in machinery and other equipment. Heterogeneity frequently prevails with regard to firms' technological, organisational and managerial patterns, with "high-technology" firms coexisting with informal businesses, and with many enterprises lacking a formal organisational structure. This creates a need for organisational change, often independent of product and process innovation. (OM Annex A §500)

Innovation measurement in developing countries

Innovation measurement in developing countries has to produce results comparable to those obtained in developed countries that use the *Oslo Manual* in order to enable benchmarking and construct a coherent international system of innovation indicators. At the same time, innovation surveys need to respect and be able to pick up the previously presented characteristics of innovation in developing countries. Therefore, the definition of innovation, its subtypes (product, process, marketing, and organisational innovation), innovation activities and the innovative firm, as presented beforehand, should be applied in innovation surveys in developing countries. In addition to that, the concept of potentially innovative firm should be incorporated. (OM Annex A §501, 505)

Measurement priorities in developing countries have to take into account different responses to common questions (**why** do we measure innovation, **what** should we measure, and **how** should we measure), which result in different priorities when designing an innovation survey. The first question refers to the aims of the main functions of these surveys. The second and third help clarify the object to be measured and the most suitable methods and procedures. The third question is closely related or even derived from the first. (OM Annex A §507)

In developing countries, the responses sought from innovation surveys are less the number of innovative enterprises, or even innovation counts, than information that will allow public and private stakeholders to analyse the various innovation strategies present in the innovation system under scrutiny, and to evaluate and understand how these patterns contribute to strengthening the competitiveness of particular enterprises and more generally to economic and social development. These data allow the construction of different models of technological behaviour followed by enterprises. (OM Annex A §508)

Developing countries should guide their measurement exercises according to three measurement priorities, namely: (OM Annex A §511-518)

- Innovation capabilities (Human resources, Linkages, ICTs);
- Expenditure on innovation activities; and
- Organisational innovation.

Principal adaptations

Three main topics might be taken into account in adapting innovation surveys for developing countries: ICTs, linkages and innovation activities. (OM Annex A §519)

ICTs in innovation surveys

The role of ICTs in innovation is related both to “front-office” and “back-office” applications. In developing countries, the incorporation of ICTs in enterprises has frequently been limited to sophisticated “front-office” applications (such as Web page, call centre, e-mail or digital brochures and catalogues). However, it is considered that the main impact on the enterprise’s performance can be obtained by implementing ICTs to support or automate critical activities or processes (“back-office”). Thus, innovation surveys in developing countries should focus on the use of ICTs, which is a powerful tool for differentiating situations, since even medium and large firms frequently do not have a consolidated management system, the lack of which constitutes a serious obstacle to achieving better performance in the various areas of the business. (OM Annex A §520)

Taking into account the fact that questionnaires should be as short and simple as possible, in cases where no specific surveys on ICTs in business are available, innovation surveys should enquire about available infrastructure; use of ICTs (separating front- and back-office activities) and the ultimate purpose of ICT usage; existence of internal ICT management and development capabilities; ICT expenditure and its relationship with organisational innovation. (OM Annex A §522)

Linkages

In order to enable the weighting of the firm's different linkages, a proxy measure of complexity can be developed by crossing "type" and "objective" of the linkages. This can be done by establishing **a matrix of linkage agents** (i.e. universities, technical and vocational training institutions, technological centres, test labs, suppliers, clients, head office, enterprises belonging to the same group, other firms, consultants, R&D firms, public S&T agencies) **and types of linkage** (including open information sources, acquisition of knowledge and technology, and innovation co-operation, supplemented by complementary activities, particularly access to new sources of financing and to commercial information). (OM Annex A §523)

The innovation success of developed countries is related to the fact that they offer regional environments in which firms can reach the knowledge sources they need, combined with broad access to leading global knowledge bases. Firms in developing countries most frequently do not have access to high-end knowledge, and therefore the local environment is very important for them. Consequently, **it is recommended to include questions on the geographical location of linkages.** One possible breakdown is local, regional, national and international locations. (OM Annex A §524)

Innovation activities

The need to focus on the activities and capabilities of firms leads to more attention to some specific innovation activities, such as: (OM Annex A §525)

- "Hardware purchase", and "Software purchase" (separately, not just included in "Acquisition of machinery, equipment and other capital goods");
- "Industrial design", and "Engineering activities" (separately, not just included in "Other product and process development");
- "Lease or rental of machinery, equipment and other capital goods";
- "In-house software system development"; and
- "Reverse engineering".

Additional adaptations

It is recommended to collect data on **human resources**, from the perspective of both its composition (by qualification, type of occupation and gender) and its management. From the point of view of human resource management, it is particularly important to collect information on actions taken by firms with regard to training, including the resources involved. In order to obtain information on the innovative capabilities of enterprises, data can be collected not only on training activities that are linked to innovation, but also on general training in areas such as management and administrative training, ICT, industrial security and quality control. (OM Annex A §526)

Methodological issues for developing country contexts

Information systems specificities

The design and planning of innovation surveys in developing countries needs to take into account the **relative weakness of statistical systems**. Linkages between surveys and data sets tend to be weak or nonexistent, preventing the use of information from other surveys both in the design of the exercise and in the analysis of its results. The weakness, or sometimes lack, of official business registers, which are normally used as sample frames, is another example of this type of problem. (OM Annex A §527)

It is particularly important to involve national statistics offices (NSOs) in innovation surveys. The participation of NSOs in innovation surveys brings to the table experience in the design and application of surveys and allows the resolution of problems in registers and other background information. It also helps to obtain higher response rates and raises the possibility of making the survey compulsory. Moreover, if the sample used is the same as for other economic surveys, it presents the possibility of wider-ranging analysis. (OM Annex A §528)

Statistical systems in developing countries frequently lack the necessary information about firm performance (such as data on sales, investments, exports), only have outdated data or cannot provide data in a suitable form for statistical analysis. In such cases, a number of basic variables can be included in the innovation survey in order to enable analysis of the relationship between actions taken by firms for innovation and market performance (competitiveness). However, a tension between the need for extra questions and the response burden exists. In order to maximise response rates and improve coverage, a balance should be sought, taking into account that operational simplicity and fluidity may be detrimental to the analytical potential of the exercise. (OM Annex A §529)

Application of the survey

Interviews made in person (instead of surveys by mail or by phone) and by adequately trained staff (for instance, undergraduate or graduate students) are recommended, since they have proved to have a positive impact on the response rate and on the quality of the results obtained. This is particularly important in developing country contexts where postal services may not be reliable. Moreover, interviews conducted by qualified staff provide the respondent with immediate and relevant assistance in completing the questionnaire, thereby improving the quality of the results. (OM Annex A §530)

Questionnaire design

The questionnaire can be designed so that the sections can be separated to allow different persons in the firm to reply to different sections. It is also advisable to include guidance in the main questionnaire, in order to help the respondent understand and avoid losing the instructions. Furthermore, special attention has to be given to the language in which the questionnaire is written. The wording needs to be adapted to meet the knowledge and experience of an “average” respondent. (OM Annex A §531-533)

Frequency and other recommendations

In developing country contexts, the periodicity of innovation surveys should be every three or four years because of the high cost associated with running an innovation survey. If possible, the innovation surveys should be timed to coincide with the major international innovation surveys, such as the Community Innovation Survey (CIS) rounds in Europe, in order to obtain comparable data for similar time periods. (OM Annex A §534)

The results of the innovation surveys should be published and distributed widely, in order to encourage further participation by businesses in future rounds and to increase awareness and use by researchers and policy-makers. Diffusion mechanisms need to be included in the budget early in the exercise. (OM Annex A §535)

A frequent difficulty in obtaining reliable information on innovation in countries with a less developed statistical tradition is business's lack of appreciation of the importance of innovation and the relevant public policy instruments. Managers are frequently secretive about finance, and qualitative information is sometimes more reliable than quantitative information. The purpose of surveys needs to be clearly stated and the questions clearly formulated. Under these circumstances, an adequate legislative base for the collection of innovation statistics can help ensure the success of such an exercise. In some cases, simplified questionnaires can be designed to cover small firms, in order to encourage their participation in innovation surveys. (OM Annex A §536)

Thinking ahead

A number of important questions regarding innovation measurement in developing countries remain unanswered. However, various approaches have been tried out in different countries and deserve further research, involving issues such as: (OM Annex A §537)

- The role of **entrepreneurs** and their attitudes towards innovation;
- The intention to capture innovations driven by factors other than market forces, and in particular innovations conducted by the **public sector**;
- The adaptation of methodology to measure innovation in the primary sector (particularly in **agriculture**);
- The need for better measuring **minor or incremental changes**, including innovative applications of existing products or processes, and the so-called 'backwards integration' of technological capability; and
- The development of indicators reflecting **sub-national (regional) innovation systems**.

References

Gault, F. (2010), *Innovation Strategies for a Global Economy. Development, Implementation, Measurement, and Management*, Edward Elgar Publishing and IDRC, http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=45.

OECD (2002), *Frascati Manual 6th Edition: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris.

OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, OECD, Paris.

UIS (2010), "Measuring R&D: Challenges Faced by Developing Countries" *Technical Paper No. 5*, UIS, Montreal.

UNESCO (1978), *Recommendation Concerning the International Standardization of Statistics on Science and Technology*, UNESCO, Paris.

UNESCO (1984), *Manual for Statistics on Scientific and Technological Activities*, ST-84/WS/12, UNESCO, Paris.

UNESCO (2006), *ISCED 1997: International Standard Classification of Education*, UNESCO, Paris.

Table 12: Links to Frameworks, Guides and Manuals

Framework/Guide/Manual	Link
OECD Frascati Manual	http://www.uis.unesco.org/Library/Documents/OECDFrascatiManual02_en.pdf (E) http://www.uis.unesco.org/Library/Documents/OECDFrascatiManual02_fr.pdf (F)
OECD Revised FoS classification (2007)	http://www.oecd.org/dataoecd/36/44/38235147.pdf (E)
OECD/Eurostat Oslo Manual	http://www.uis.unesco.org/Library/Documents/OECDOsloManual05_en.pdf (E) http://www.uis.unesco.org/Library/Documents/OECDOsloManual05_fr.pdf (F)
OECD Canberra Manual	http://www.uis.unesco.org/Library/Documents/OECDCanberramanual95_en.pdf (E) http://www.uis.unesco.org/Library/Documents/OECDCanberramanual95_fr.pdf (F)
OECD Patent Statistics Manual	http://www.uis.unesco.org/Library/Documents/OECDpatentManual09_en.pdf (E) http://www.uis.unesco.org/Library/Documents/OECDpatentsmanual09_fr.pdf (F)
OECD Guide to Measuring the Information Society	http://browse.oecdbookshop.org/oecd/pdfs/free/9311021e.pdf (E)
OECD Biotechnology Framework	http://www.oecd.org/dataoecd/5/48/34935605.pdf (E) http://www.oecd.org/dataoecd/16/6/35878269.pdf (F)
OECD Handbook on Economic Globalisation Indicators	http://browse.oecdbookshop.org/oecd/pdfs/free/9205061e.pdf (E) http://browse.oecdbookshop.org/oecd/pdfs/free/9205061e.pdf (F)
OECD - Measuring Productivity	http://www.oecd.org/dataoecd/59/29/2352458.pdf (E) http://www.oecd.org/dataoecd/25/9/30117822.pdf (F)
UIS Technical Paper no. 5: Measuring R&D: Challenges Faced by Developing Countries	http://www.uis.unesco.org/Library/Documents/tech%205-eng.pdf (E) http://www.uis.unesco.org/Library/Documents/tech%205_FRE.pdf (F) http://www.uis.unesco.org/Library/Documents/...SP_....pdf (SP)

UNESCO - ISCED 97	http://www.uis.unesco.org/Library/Documents/isced97-en.pdf (E) http://www.uis.unesco.org/Library/Documents/isced97-fr.pdf (F)
UNESCO Manual for Statistics on Scientific and Technological Activities (1984)	http://www.uis.unesco.org/Library/Documents/STSManual84_en.pdf (E) http://www.uis.unesco.org/Library/Documents/STSManual84_fr.pdf (F)
UNESCO Recommendation concerning the International Standardization of Statistics on Science and Technology (1978)	http://www.uis.unesco.org/Library/Documents/STSManual78_en.pdf (E) http://www.uis.unesco.org/Library/Documents/STSManual78_fr.pdf (F)