S&T Indicators

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1- Introduction

UNESCO developed the broader 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). In addition to R&D, scientific and technological activities comprise scientific and technical education and training (STET) and scientific and technological services (STS). The latter services include, for example, S&T activities of libraries and museums, translation and editing of S&T literature, surveying and prospecting, data collection on socio-economic phenomena, testing, standardisation and quality control, client counseling and advisory services, patent and licensing activities by public bodies. R&D (defined similarly by UNESCO and the OECD) is thus to be distinguished from both STET and STS. In addition, R&D and technological innovation is also discussed however this is the subject of a separate document to be presented during this workshop.

There is no doubt that S&T plays a pivotal role in the economic and social development of any developed country. Developing countries that realized the importance of the role of S&T, have taken measures to develop their S&T systems and hence the emerging new economic forces in the world today. These include The Frascati Family OECD Manuals and other relevant OECD Framework Documents. In the present document, we shall discuss the role of S&T Indicators in setting the scene for a solid S&T system aiming at developing R&D and innovation capabilities in a given country.

The aim of this document is to outline the most important parts of the Frascati Manual, however we shall concentrate on the two most important sections related to the measurement of R&D Personnel and measurement of Expenditures devoted to R&D as the most important inputs. Major issues in Methodology are also presented followed by the importance of S&T indicators in policy making.

2- The Frascati manual.

The Frascati Manual is one of the most important documents in the field of S&T Indicators, particularly R&D. In this section we shall summarise the Frascati Manual and will discuss chapter 5 and 6 in details under sections 3 and 4 below as they are the core of data collection in two of the major inputs related to R&D.

Chapter 1. Aim and Scope of the Manual. This discusses a preliminary word to the user of R&D data, the relationship between the Frascati Manual and other international standards, R&D input and output, R&D and related activities. This is followed by R&D in all fields of science and technology, measures of R&D inputs (personnel, expenditures, R&D facilities, National R&D efforts, globalisation of R&D and R&D co-operation). And finally classification systems for R&D, R&D surveys, reliability of data and international Comparability.

Chapter 2. Basic Definitions and Conventions. This chapter outlines **r**esearch and experimental development (R&D), activities to be excluded from R&D, the boundaries of R&D and identifying R&D in software development, in the social sciences and humanities and in service activities and industries.

Chapter 3. Institutional Classification. In this chapter the reporting unit and the statistical unit, sectors including the business enterprise sector and reasons for sectoring and problems of sectoring. This is followed by the government sector, private non-profit sector, higher education sector and abroad sector.

Chapter 4. Functional Distribution. This chapter deals with type of R&D, product fields, fields of science and technology and socio-economic objectives. Fields of science and technology shall be discussed elsewhere in view of its importance in unifying fields under investigation.

Chapter 5 deals with measurement of R&D personnel and Chapter 6 deals with measurement of expenditures devoted to R&D and are both discussed in detail in the present document.

Chapter 7. Survey Methodology and Procedures. This is also an important chapter dealing with the scope of R&D surveys, identifying target population and survey respondents, working with respondents, estimation procedures and reporting to the OECD or to other international organizations.

Chapter 8. Government Budget Appropriations or Outlays for R&D by Socio-economic Objectives (GBAORD). This is the last chapter and deals with relationship with other international standard, sources of budgetary data for GBAORD, coverage of R&D, definition of government, coverage of government budget appropriations and outlays, distribution by socio-economic objectives and main differences between GBAORD and GERD data.

3- Measurement of R&D Personnel

In compiling R&D data, it may be difficult to isolate the R&D activities of indirect support staff from those of other R&D staff. In theory, however, the following activities are included in personnel and expenditure data if they are carried out in the R&D unit:
– Performing the scientific and technical work for a project.
– Planning and managing R&D projects.
– Preparing the interim and final reports for R&D projects.
– Providing internal services for R&D projects, *e.g.* computing or library and documentation work.
– Providing support for the administration and financial aspects of R&D projects.

The following are service or indirect support activities to be excluded from the personnel data but to be included in the expenditure data as overhead:
- Specific services to R&D provided by central computer departments and libraries.
- The services of central finance and personnel departments.
- Security, cleaning, maintenance, canteens, etc

Coverage and definition of R&D personnel
With the greater use of consultants, it is proposed to request on-site consultants' full-time equivalence (FTE) on R&D in R&D surveys and to highlight the corresponding costs in "Other current costs" in R&D survey results. In the case of outsourcing, consultant costs clearly fall under extramural expenditures.

Categories of R&D personnel
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. While both are perfectly reasonable and linked to two different UN classifications – the International Standard Classification of Occupations (ISCO) (ILO, 1990) and the International Standard Classification of Education (ISCED) (UNESCO, 1997) – the differences between them lead to problems of international comparability.

Classification by occupation
Researchers
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.

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. Postgraduate students at the PhD level engaged in R&D should be considered as researchers.

Technicians and equivalent staff

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. 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.

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.

Other Supporting Staff

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".

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

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".

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. These are:

a) Holders of university degrees at PhD level (ISCED level 6)

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

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

Holders of tertiary-level degrees below the PhD level in all fields. This category includes holders of degrees earned at universities proper and also at specialised institutes of university status.

c) Holders of other tertiary level diplomas (ISCED level 5B)

Holders of other post-secondary tertiary 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.

d) Holders of other post-secondary non-tertiary diplomas (ISCED level 4)

Holders of other post-secondary non-tertiary 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.

e) Holders of diplomas of secondary education (ISCED level 3)

Holders of diplomas at the secondary level, upper stage. 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.

Treatment of postgraduate students

The difficulty of establishing the borderline between the R&D and education and training activities of postgraduates (and of their teachers) in countries where they are a recognised group are discussed in general terms in Chapter 2 of the Frascati manual.

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.

Measurement and data collection

Headcount data

Headcount data are also the most appropriate measure for collecting additional information about R&D personnel, such as age, gender or national origin. Such data are needed to conduct analytical studies and implement recruitment or other S&T policies aimed at reducing gender imbalances, shortages of personnel or the effects of ageing, "brain drain", etc. There is an increasing demand from S&T policy makers for such data.

The OECD *Manual on the Measurement of Human Resources devoted to S&T – Canberra Manual* (OECD/Eurostat, 1995) presents a set of guidelines aimed at measuring the stocks and flows of scientific and technical manpower. Researchers and technicians represent an important subset of human resources devoted to S&T (HRST), and experience has shown that R&D surveys are the most appropriate instrument for collecting headcount data. Population censuses, labour force surveys or population registers are useful complementary data sources but cannot be used systematically to obtain R&D personnel data.

Full-time equivalence (FTE) data

While data series measuring the number of R&D staff, and notably researchers, have many important uses, they are not a substitute for a series based on the number of full-time equivalent staff. The latter is a true measure of the volume of R&D and must be maintained by all member countries for international comparisons.

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.

Measurement in person-years
One FTE may be thought of as 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 counseling) 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. Personnel should be measured as the number of person-years on R&D over the same period as the expenditure series.
FTE on a fixed date
In some cases, it may be more practical to survey the FTE of R&D personnel as of a specific date. Where the fixed-date approach is used and data are collected annually for the first or last day of the expenditure period, it is recommended that two-year moving averages should be used for comparisons with R&D expenditure data.
Recommended national aggregates and variables
The two recommended aggregates are for:
- The number of personnel employed in R&D measured in head counts.
- Total FTE spent in the performance of R&D on national territory for a given 12-month period.

These should be broken down by sector and by occupation and/or formal Qualification. In case only one classification can be provided, priority should be given to the distribution by occupation.
Other Recommendations.
Cross-classification data by occupation and qualification could also be used. It is also recommended to collect data on researchers (as if possible other categories) of R&D personnel broken down by sex and age. Finally, regional breakdown of total R&D personnel and researchers by region is also recommended.

4- Measurement of 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.
– Identify the extramural R&D expenditures of each statistical unit.
– Aggregate the data by sectors of performance and sources of funds to derive
significant national totals. Other classifications and distributions are then compiled within this framework.

A- Intramural expenditures

Expenditures made outside the statistical unit or sector but in support of intramural R&D (*e.g.* purchase of supplies for R&D) are included. Both current and capital expenditures are included.

Current costs
Current costs are composed of labour costs and other current costs:
Labour costs of R&D personnel
These comprise annual wages and salaries and all associated costs or fringe benefits, such as bonus payments, holiday pay, contributions to pension funds and other social security payments, payroll taxes, etc. The labour costs of persons providing indirect services not included in the personnel data (such as security and maintenance personnel or the staff of central libraries, computer departments or head offices) should be excluded and included in other current costs. Labour costs are often the largest component of current costs. It would be useful to collect or otherwise secure labour costs by type of personnel (*e.g.* researchers, technicians and equivalent staff, other supporting staff, etc.).
Other current costs
These comprise non-capital purchases of materials, supplies and equipment to support R&D performed by the statistical unit in a given year. Examples are: water and fuel (including gas and electricity); books, journals, reference materials, subscriptions to libraries, scientific societies, etc.; imputed or actual cost of small prototypes or models made outside the research organisation; materials for laboratories (chemicals,

animals, etc.). Costs for on-site consultants should be included in other current costs and identified separately if possible. Administrative and other overhead costs (*e.g.* office, post and telecommunications, insurance) should also be included, prorated if necessary to allow for non-R&D activities within the same statistical unit. All costs for indirect services should be included here, whether carried out within the organisation concerned or hired or purchased from outside suppliers. Examples of such services are: security; storage; use, repair and maintenance of buildings and equipment; computer services; and printing of R&D reports. Internet charges should be excluded.

Indirectly paid current costs

R&D activities may incur costs which are often not paid by the sector but borne by institutions classified in other sectors of the economy, usually the government sector. Two examples are: i. Rents for research facilities and ii. Social security costs and pensions for R&D personnel.

Value added tax (VAT)

Data on R&D expenditure, on both a provider and a funder basis, should be at factor cost. This means excluding VAT and similar sales taxes from the measured cost of the R&D and specifically of R&D financed by government. More difficulties may arise in the higher education and private nonprofit sectors where VAT included in goods and services purchased as part of an R&D project may not be reclaimable; it will therefore be regarded by the respondents as a legitimate part of their expenditures.

Capital expenditures

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

Capital expenditures are composed of expenditures on: i. Land and buildings, ii.Instruments and equipment and iii. Computer software.

Land and buildings

This comprises land acquired for R&D (*e.g.* testing grounds, sites for laboratories and pilot plants) and buildings constructed or purchased, including major improvements, modifications and repairs.

Instruments and equipment

This covers major instruments and equipment acquired for use in the performance of R&D including embodied software.

Computer software

This includes acquisition of separately identifiable computer software for use in the performance of R&D, including programme descriptions and supporting materials for both systems and applications software. Annual licensing fees for the use of acquired computer software are also included.

Identifying the R&D content of capital expenditures

Occasionally, the R&D term of a fixed asset may be known at the time of acquisition. In this case, the appropriate portion of the expenditure for the acquisition of the asset should be attributed to R&D capital expenditures. Similarly, when the R&D term of the asset is not known and a fixed asset will be used for more than one activity and neither the R&D nor any of the non-R&D activities predominates (*e.g.* computers and associated facilities; laboratories used for R&D, testing, and quality control), the costs should be prorated between R&D and other activities. This proportion could be based on numbers of R&D personnel using the facility, compared to total personnel, or on administrative calculations already made (*e.g.* the R&D budget may be charged a certain portion of the capital cost; a certain proportion of time or floor space may be assigned to R&D).

Sale of R&D capital goods

The sale/transfer of fixed assets originally acquired for R&D creates a problem. Their disposal could be considered as a disinvestment in R&D. However, no adjustment should be made to recorded capital expenditures.

Libraries

Although payments for current purchases of books, periodicals and annuals should be assigned to other current costs, expenditure for the purchase of complete libraries, large collections of books, periodicals, specimens, etc., should be included in the data under expenditure on major equipment, especially if made when equipping a new institution.

B- Sources of funds

1-Methods of measurement
R&D is an activity involving significant transfers of resources between units, organisations and sectors. Every effort should be made to trace the flow of R&D funds. These transfers may be measured in two ways.

One is performer-based reporting of the sums which one unit, organisation or sector has received or will receive from another unit, organisation or sector for the performance of intramural R&D during a specific period. The second is source-based reporting of extramural expenditures which are the sums a unit, organisation or sector reports having paid or committed itself to pay to another unit, organisation or sector for the performance of R&D during a specific period. The first of these approaches is strongly recommended.

2-Criteria for identifying flows of R&D funds
For such a flow of funds to be correctly identified, there must be a direct transfer of resources and the transfer must be both intended and used for the performance of R&D.

Direct transfer
Such transfers may take the form of contracts, grants or donations and may take the form of money or other resources (*e.g.* staff or equipment lent to the performer).
Contracts or grants paid for the performance of current or future R&D are clearly identifiable as a transfer of funds. Transfer of funds from the government to other sectors is particularly important to the users of R&D data.

Two categories of such government funds may be identified:
– Those that are specifically for the procurement of R&D and the results of the
R&D belong to the recipient of the output or product of the R&D, which is not necessarily the funder of the R&D.
– Those that are provided to the performers of R&D in the form of grants or other financial incentives, with the results of the R&D becoming the property of the R&D performers.

It is recommended that, where possible, both categories of transfer of government R&D funds should be identified in the R&D data of the business enterprise sector. If possible, a similar breakdown should be made for government funds to the higher education sector.

In theory, when a government allows a firm or university to use, free of charge, facilities such as a wind tunnel, observatory or launching site while carrying out R&D, the value of the service (an imputed rental) should be identified as a transfer.

In some cases, a firm's R&D project may be financed by loans from a financial institution, an affiliated company or government. Loans that are to be repaid are not to be considered transfers; by convention, loans that may be forgiven are to be considered transfers.

Transfers both intended and used for R&D
In many R&D transfers this can be taken for granted. There are instances, however, when some clarification may be required (particularly if there is a discrepancy between the performer's and the funder's report):
– In one case, a unit gives funds to another in return for equipment or services needed for its own R&D. If the provision of this equipment or these services does not require the second unit to carry out R&D, it cannot report that it performed R&D funded by the first unit. For example, a government laboratory buys standard equipment or uses an outside computer to perform calculations required for an R&D project. The equipment supplier or the computer service firm carries out no R&D itself and would report no R&D funded by the government. For R&D statistics, these expenditures
should be considered by the government laboratory to be intramural capita
and intramural other current costs, respectively.
– In a second case, the transfers of funds are loosely described by the source as "development contracts" for "prototypes", but no R&D is performed by the funder and very little by the recipient. For example, the government places a contract with an industrial firm to "develop" a "prototype" civil aircraft for a specific

use (*e.g.* treatment of oil slicks). The aircraft is largely constructed by the performer using existing materials and existing technology, and R&D is only needed to meet the new specifications. Only this portion of the contract should be reported by the performer as R&D financed by the government sector, even though the funder's accounts may
suggest at first sight that the entire contract was for R&D.

3-Identifying the sources of flows of R&D funds

Performers are usually asked to distribute their intramural expenditures between funds of the performing unit (own funds), funds from other units in the same sector or sub-sector and funds from other sectors and sub-sectors. They can usually do so relatively easily, but there are one or two problem areas.

Sub-contracting and intermediaries

Problems arise when funds pass through several organisations. This may occur when R&D is sub-contracted, as sometimes happens in the business enterprise sector. The performer should indicate, as far as possible, the original source of the funds for R&D. The same problems arise for EU funding, as the funds first go to the main contractor and are then distributed among the other participants (sub-contractors). In some countries, intermediary non-performing organisations play an important role in the financing of R&D by distributing among performers grants received from several different sources but not "earmarked" for specific purposes. In such cases, while it is acceptable to regard these organisations as the source, it is nonetheless preferable to attempt to trace the funds to their original sources.

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". In the case of private universities, these may be a major source of R&D 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. One could argue that, 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 clarity, publicly financed GERD is divided into two sub-categories: direct government funds and GUF.

As far as possible, the following sources of funds should be identified in R&D surveys:
– Business enterprise sector:
– Government sector:
– Private non profit sector.
– Higher education sector.
– Abroad.

C- Extramural expenditures

For the acquisition of services closely related to intramural R&D activities, the borderline between intramural and extramural expenditures is not always clear. If these services are separate R&D projects, the expenditures can in most cases be regarded as extramural R&D. If they are certain tasks (not necessarily R&D as such) necessary for the intramural R&D of the unit but contracted out, they can generally be regarded as intramural R&D expenditure (other current costs). In principle, the same rules apply to consultants. However, costs for on-site consultants come under other current costs as their R&D activity is a direct part of the R&D activity of the unit.

Data on the extramural R&D expenditures of statistical units are a useful supplement to the information collected on intramural expenditures. The collection of these data is therefore encouraged. These extramural expenditure data are essential for providing statistics on R&D performed abroad but financed by domestic institutions. They may also be helpful to those analysing the flows of funds reported by performers, particularly if there are gaps in survey coverage.

The focus of R&D data is necessarily individual countries, and it is very difficult to track international flows of R&D funds. In the context of the Extramural expenditures are the sums a unit, organisation or sector reports having paid or committed hemselves to pay to another unit, organisation or sector for the performance of R&D
during a specific period. This includes acquisition of R&D performed by other units and grants given to others for performing R&D. For the distribution of extramural R&D, the following classification is recommended:
– Business enterprise sector:
– Government sector.
– Private non-profit sector.
– Higher education sector.
– Abroad.

D- Reconciling differences in performer-based and source-based reporting

In principle, the estimated total of R&D expenditure within a country based on performer reports should equal the total based on reports from those funding R&D (including funder reports to abroad). In practice, however, this is not likely to be the case owing to sampling difficulties and reporting differences.

In addition to reporting differences arising as a result of sampling error (estimates of GERD are often obtained from sample surveys instead of surveys of the entire population), countries have difficulty in reconciling funder and performer data for several reasons.

Funders' and performers' views of whether the work being performed meets the definition of R&D may differ. For example, in the US defence industry, the emergence of new non-traditional contractors (including large telecommunications carriers, small high-technology firms) and increased R&D funding of more generalised technical, analytical and professional contracts (whose deliverables may be a small component of the overall defence R&D project) have resulted in differing interpretations of what constitutes R&D.

The financing may be provided by an intermediary, making it difficult for the performer to know the original source of funds (see paragraph 404). A related problem is funding that goes outside of the funding sector but comes back to the sector as externally funded R&D.

Contracts for research often extend over more than one year, with the result that there may be timing discrepancies between funder and performer.

In many countries, it may be difficult to identify firms that pay for R&D performed overseas. In fact, in cases of multinational firms, an enterprise in one country may not know precisely how much it is funding R&D in another. It may merely make a payment to a head office in another country for a range of services, one of which is R&D.

A variant is the reconciliation of GBAORD data, which is essentially government funder data (appropriations rather than expenditures, however), to R&D performer data. In this case, the lack of comparability may be due to the performance of a different amount of R&D than was expected at the appropriations stage; it may also be due to an imprecision in the budget appropriations that does not allow for separate identification of appropriations that are specifically targeted to R&D.

In addition to the business enterprise and government sectors, problems for reconciling funder- and performer-based R&D data arise for other major funders of R&D, such as research councils and abroad.

To the extent possible, it is recommended that differences in R&D expenditure totals between those estimated from the funders of R&D and those estimated from the performers of R&D should be reported, and that causal factors for the differences, if known, should be identified. It should be recognised that such

differences are not necessarily a result of inadequate or inaccurate measurement and that providing these data will aid analytical and statistical accuracy.

E- Regional distribution

A regional distribution of R&D intramural expenditures is also recommended. For the EU member states, regional levels are given by the Nomenclature of Territorial Units for Statistics (NUTS) classification. For other OECD member countries, the regional distribution has to be determined according to national needs. In federal countries, for example, it might be the state level.

F- National totals

Gross domestic expenditure on R&D (GERD)
GERD includes R&D performed within a country and funded from abroad but excludes payments for R&D performed abroad. GERD is constructed by adding together the intramural expenditures of the four performing sectors. It is often displayed as a matrix of performing and funding sectors. GERD and the GERD matrix are the basis of international comparisons of R&D expenditures. They also provide the accounting system within which the institutional classifications and functional distributions may be applied.

It would be useful to have separate tables for defence and civil GERD, in order to map how trends in these areas affect the level and structure of total GERD. This is particularly true for countries with significant defence R&D programmes. The separation is encouraged for other countries as well, as a way to increase the comparability of data on civil R&D.

Gross national expenditure on R&D (GNERD*)*
The GNERD aggregate comprises total expenditure on R&D financed by a country's institutions during a given period. It includes R&D performed abroad but financed by national institutions or residents; it excludes R&D performed within a country but funded from abroad. It is constructed by adding the domestically financed intramural expenditures of each performing sector and the R&D performed abroad but financed by domestic funding sectors. It gives some supplementary information on R&D cooperation between different kinds of units. To allow for the identification of R&D activities of international organisations, the "Abroad" sector should have sub-categories for international organisations, as recommended in the institutional sub-classification.

Methodology

Information on R&D may be obtained from different sources, such as annual reports of research councils or major R&D-performing institutions. These data can only give an approximate measure of R&D efforts. Not only do the concepts of R&D used often differ from the definitions given in the Frascati Manual; they may also change over time. It is also very difficult to obtain all data for the same period and to avoid double counting when tracking flows from financial statements and other sources. For these reasons, statistics on R&D require regular, systematic and harmonised special surveys. Estimates are a necessary supplement to surveys and when statistics are released, full information on the sources and generation of the statistics should be provided.

Scope of R&D surveys
In theory, R&D surveys should identify and measure all financial and personnel resources devoted to all R&D activities in all R&D units. R&D surveys are mainly addressed to R&D-performing units, which may also finance R&D performed in other units. Government departments, for example, are surveyed in the context of calculating government budget appropriations or outlays for R&D. Statistical methodologies and other procedures have to be established to capture all R&D, especially for units in the business enterprise sector with little R&D.

Identifying target population and survey respondents

Only in a few member countries can the surveying agency make an exhaustive survey of all possible R&D performers. Generally, there are many constraints on the extent of surveys. Target population within a country are:
Business enterprise sector, government sector, private non-profit sector and higher education sector.

Working with respondents is a tricky job that need encouraging co-operation and operational criteria. Furthermore, in some cases estimation procedures must be followed particularly with unit and item non-response as well as estimation procedures in the higher education sector.

The production of the R&D survey conforms to the basic principles of information management, so that the information is:
Relevant, accurate, timely, complete, maintainable and interpretable.

From an international point of view, and in order to be able to show comparable data it is advised to use standards set by the UIS and based on the OECD manuals, including the Frascati. This will also involve following the fields of S&T outlined in the Revised Fields of S&T (FOS) Classification in the Frascati Manual, OECD (2006).

Inputs and outputs

According to the Frascati manual, a number of R&D indicators inputs and outputs are recognised. Four major inputs are FTE personnel, R&D expenditure, R&D facilities and National R&D efforts. Outputs usually considered are number of publications and patents. Number of publications represent the scientific production, while patents represent the applied side of R&D which ultimately should lead to innovative products or processes. Also considered under outputs are innovation surveys and technological balance of payments.

The UNESCO Institute for Statistics is studying the S&T indicators for least developed countries (LDC). Furthermore, a number of indicators are being considered by developing countries. Some of the suggestions include major research projects and international awards. Furthermore, if we consider that innovation is playing an increasingly important role in S&T, then innovation surveys and patents production should be focused on in all future aspects related to R&D linkages with industry.

A final note, developing countries should pay more attention to standardisation, quality assurance and intellectual properties which are lacking in a great number of developing countries particularly the LDC.

5- S&T Indicators and Policy Making

According to the Oslo Manual and in order to develop policies that support innovation appropriately, it is necessary to better understand several critical aspects of the innovation process, such as innovation activities other than R&D, the interactions among actors and the relevant knowledge flows. Policy development also requires
further advances in the analysis of innovation, which in turn requires obtaining better information. Innovation shall be discussed in detail in other documents presented during the workshop.

From the general point of view of R&D in developing countries, particularly responsible R&D management systems and developed statistics systems within the countries, Gaillard (2008) proposed the division of the countries into three categories for approaching R&D measurement. These categories were intended for some of the Latin American countries, but they can be applied to developing countries outside the region. These categories are:

Group A: countries with consolidated R&D systems and developed
S&T statistics systems (Argentina, Brazil, Mexico and Chile).

Group B: countries with consolidated R&D systems and less developed S&T statistics systems (Colombia, Costa Rica, Cuba, Panama, Uruguay and Venezuela).

Group C: countries with incipient R&D systems (Nicaragua, Peru, El Salvador, Paraguay, Guatemala, Bolivia, Ecuador, Dominican Republic and Honduras).

Similarities between Latin American countries and Arab countries exist. And lessons could be drawn upon to transfer their experiences and applied in developing management systems to consolidate systems and developed statistics systems.

It is of the utmost urgency for the Arab countries to have a national central system for S&T, particularly Research, Development & Innovation in each country. The major role of such a system is to collect data related to S&T in general on a national level in collaboration with a number of sectoral systems. These would include all ministries with R&D capabilities, production sectors (governmental as well as private), business enterprises, non-governmental organization and foreign organization working within the country. As pointed out by Gaillard (2008), in the Arab region, there are essentially two approaches to the governance of science. In Egypt and the Maghreb, the role of the State is predominant in the management of the national research systems, and government funding is the main source of funding for research activities. In Machrek and the Gulf states, the initiative is left to the performers (mainly universities) and largely depends on their level of interest in participating in research activities. National bodies in charge of science are often independent although their budget comes almost totally from public sources. Lebanon and Jordan are good examples. New institutional initiatives are taking place in the Gulf states via relatively new agencies and foundations whose specific objective is to attract foreign expertise and R&D firms from abroad.

A number of Arab countries have sectoral policies for agriculture, water resources, industry etc. However, little is mentioned concerning national policies for R,D & I. The importance of having a national policy for R, D & I is to direct all capabilities towards targeting priorities outlined in such policies. This in turn will identify priorities for researchers in the universities and research centres as well as optimizing expenditure resources to finance such priorities.

Science and technology indicators represent an important diagnostic tool for policy makers to study the present capabilities and resources. Policy making starts with finding out where we stand in relation to the national, regional and international levels of knowledge and technological advancement. The strengths and weaknesses of the economy, industry etc. are taken into account along with the social needs of the country. Priorities are set depending on the needs and forecasts of the economy in general. Tools that have been used in the past were technological forecasting, the Delphi system and foresight. The last two are the most commonly used in the developed countries and to some extent some developing countries. This requires presence of a national body and integrated system with capabilities for data and statistics collection, analysis and evaluation, dissemination and periodical updating. It also requires financial capabilities for thee execution and follow-up of policies and action plans set for the advancement of the country.

7- References

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