THE MEASUREMENT OF SCIENTIFIC AND TECHNICAL ACTIVITIES

Proposed Standard Practice for Surveys of Research and Experimental Development

"FRASCATI MANUAL"
1980

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
The Organisation for Economic Co-operation and Development (OECD) was set up under a Convention signed in Paris on 14th December 1960, which provides that the OECD shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development;
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The Members of OECD are Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.
This is the fourth edition of the "Proposed Standard Practice for the Measurement of Scientific and Technical Activities", more generally known as the "Frascati Manual". It does not reflect major changes in concepts, definitions or basic classifications. However, considerable efforts have been made to improve its layout and drafting. Significant additions have been made to the text, notably a new Chapter I addressed mainly to non-specialists which situates Research and Experimental Development (the main topic of the Manual) within the broader framework of all Scientific and Technical Activities.

Two chapters have also been added at the end. Chapter VII deals with R & D deflators and exchange rates and is based on Secretariat experience gained in the writing of "Trends in Industrial R & D in Selected OECD Member Countries (1967-1975)". Chapter VIII separates out and extends the discussion of the measurement of Government R & D funding and its distribution by socio-economic objectives.

With this fourth edition the Manual can be said to have reached maturity. It owes a great deal to the efforts of Mr. Humphrey Stead of Statistics Canada who prepared the first draft. The final text has been prepared by the Secretariat in line with the recommendations of the group of National Experts on R & D statistics which met several times during the revision process.

The Secretariat hopes that the present edition will both be welcomed by those experts who have been using the Frascati Manual for almost twenty years and will prove useful to the many others in a wide range of countries who are currently starting work on topics which involve measuring scientific and technical activities. It is noteworthy that, as well as appearing in the official OECD French and English versions, preceding editions of the Manual have been translated into Japanese, Serbo-croat, Portuguese (in Brazil) and German (two versions, one German and one Austrian). The present edition will shortly be appearing in Dutch, Spanish and Italian.

D. Z. BECKLER
Director for Science, Technology and Industry
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# Chapter VIII

**The Socio-Economic Objectives of Government R & D Funding**

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Chapter I

AIM AND SCOPE OF THE MANUAL

1.1 A PRELIMINARY WORD TO THE USER OF R & D DATA

1. This Manual has been written by and for the national experts in Member countries who collect and issue national R & D data and who submit responses to OECD biennial R & D surveys (ISYs) aided by the staff of the OECD Science and Technology Indicators Unit who annotate, issue and compare these responses. Although the maximum use is made of examples, from Chapter II onwards, the Manual is still a rather technical document and is intended mainly as a reference work.

2. The present Chapter is addressed principally to non-experts and is designed to put them in the picture. It both provides a summary of the coverage and contents of the Manual, which may help them to use the body of the text, and also indicates why certain types of data are, or are not, collected, what problems of comparability they pose and what can be said about their accuracy.

1.2 THE RELATIONSHIP BETWEEN THE FRASCATI MANUAL AND OTHER INTERNATIONAL STANDARDS

3. R & D is an activity which is carried out throughout an economy but which has certain special characteristics which distinguish it from the larger family of scientific activities and from the economic activities of which it is a part.

4. Thus, the Frascati Manual fits within UNESCO recommendations on all scientific and technological activities but it is specific to R & D and to the needs of OECD Member countries which have rather similar economic and scientific systems which distinguish them from non-OECD countries. Nonetheless, United Nations classifications are used as far as possible (e.g. System of National Accounts - SNA; International Standard Industrial Classification - ISIC; International Standard Classification of Occupations - ISCO; International Standard Classification of Education - ISCED) but in some cases they have had to be adjusted to fit R & D requirements.

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Furthermore, wherever possible, the Manual draws on the experience of regional organisations within the OECD area, notably Nordforsk and the European Communities (EEC).

1.3 R & D AND RELATED ACTIVITIES

1.3.1 Research and Experimental Development (R & D)

5. The Manual deals only with the measurement of research and experimental development (comprising basic research, applied research and experimental development). A full definition may be found in Chapter II.

6. R & D is an activity which is related to a number of others with a scientific and technological base. Although, these other activities are often very closely linked to R & D through flows of information and in terms of operations, institutions and personnel, they must be excluded when measuring R & D. R & D and these related activities may be considered under two headings: the family of scientific and technological activities (STA) and the process of scientific and technological innovation.

1.3.2 Scientific and Technological Activities (STA)

7. The concept of STA has been developed by UNESCO. Thus, according to its "Recommendation Concerning the International Standardization of Statistics on Science and Technology"*, scientific and technological activities comprise:

"...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. These include such activities as R & D, scientific and technical education and training (STET) and the scientific and technological services (STS)...

R & D (which is defined by UNESCO on the same lines as by OECD) has, thus, to be distinguished both from STET and STS. The STET cover:

"...all activities comprising specialised non-university higher education and training, higher education and training leading to a university degree, post-graduate and further training, and organised lifelong training for scientists and engineers. These activities correspond broadly to ISCED levels 5, 6 and 7."

The STS are defined as ... "activities concerned with research and experimental development and contributing to the generation,

*) See Bibliography after the annexes. Throughout this volume, an asterisk denotes a reference to the Bibliography.
dissemination and application of scientific and technical knowledge. The STS are divided by UNESCO into nine subclasses for the purposes of surveying which can be summarised as follows:

- S + T activities of libraries etc.;
- S + T activities of museums etc.;
- Translation, editing, etc. of S + T literature;
- Surveying (geological, hydrological, etc.);
- Prospecting;
- Data collection on socio-economic phenomena;
- Testing, standardization and quality control etc.;
- Client counselling including public agricultural and industrial advisory services etc.;
- Patent and licence activities by public bodies.

8. A large part of Chapter II of this Manual deals with the definitions and conventions to be applied to distinguish R & D which is being measured from STET and the STS which are not. As the specific UNESCO definitions of individual STS are not always suitable for this narrower purpose (for example, museums often include R & D among their S + T activities) a slightly different subdivision is used in Chapter II of the present Manual. For the same reason the definition of STET in Chapter II differs slightly from the UNESCO definition quoted above in its treatment of post-graduate studies, part of which should be considered as R & D in OECD surveys.

1.3.3 R & D and Scientific and Technological Innovation

9. Scientific and technological innovation may be considered as the transformation of an idea into a new or improved saleable product or operational process in industry and commerce or into a new approach to a social service. It thus consists of all those scientific, technical, commercial and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes and equipment or the introduction of a new approach to a social service. R & D is only one of these steps.

10. Besides R & D, six activities may often be distinguished in the innovation process:

i) **New product marketing** is the set of activities necessary to the successful introduction of a new product or process into the market. Its costs are those of market research and test marketing; the nonrecurring costs of establishing distribution, maintenance, and sales channels and advertising systems including the initial outlay on advertising.
ii) Patent work is the filing of patent applications and the carrying out of searches for prior patents in connection with the product or process being introduced or improved.

iii) Financial and organisational changes may be required to finance the innovation and to permit the company to successfully exploit it. These include the non-recurring costs of financial planning, raising additional capital, corporate restructuring and retraining of sales and maintenance personnel and exclude the interest paid on borrowed funds and the foregone interest on own funds used.

iv) Final product or design engineering is the further modification of a product or process after the R & D phase is completed in recognition of market or manufacturing requirements. For instance, it includes the cost of industrial design for aesthetic value and of preparing production drawings, part lists and specifications.

v) Tooling and industrial engineering covers all changes in production machinery and tools, in production and quality control procedures, methods and standards required to manufacture the new product or to use the new process.

vi) Manufacturing start-up includes the cost of retraining personnel in the new techniques or in the use of new machinery, trial production runs and the cost of items damaged because of faulty equipment, procedures and operator errors.

11. Furthermore, in the case of innovations based on government R & D programmes, there may be a significant "demonstration" stage in the process. "A demonstration is a project involving an innovation operated at or near full scale in a realistic environment for the purpose of (i) formulating national policy or (ii) promoting the use of innovation."* It should be noted that the data collected and published by the International Energy Agency at OECD cover Research, Development and Demonstration ("R D and D").

12. Possibly the greatest source of error in measuring R & D lies in the difficulty of locating the cut-off point between experimental development and the related activities which are required during the realisation of an innovation. Errors at this point are particularly significant because, though many innovations may require costly R & D, the costs of preparing the invention for production are often higher still. Section 2.3.4 of Chapter II is devoted to guidelines, conventions and examples designed to deal with these problems.
1.4 R & D INPUT AND OUTPUT

13. The term "R & D statistics" covers a wide range of possible statistical series measuring the resources devoted to R & D stages in the activity of R & D and the results of the activity. At present only R & D inputs are included in official R & D statistics and, thus, in the body of the Manual. This is regrettable since we are more interested in R & D because of the new knowledge and inventions which result from it than in the activity itself.

14. Possible ways of measuring R & D output are discussed in Annex II "The Measurement of Output of R & D". While indicators of the output of R & D are clearly needed to complement input statistics, they are far more difficult to define and collect. More methodological work is required before any international standard practice may be recommended.

15. In the meantime, input statistics have proved to be valuable indicators, as shown in various national and international reports, for example, "Trends in Industrial R & D in Selected OECD Member Countries, 1967-1975"* and the "Science Indicators"* series of the U.S. National Science Board. They provide useful measures of the scale and direction of R & D in various countries, sectors, industries, scientific fields and other categories of classification. Administrations concerned with economic growth and productivity rely on R & D statistics as one possible type of indicator of technological change. Advisors concerned not only with science policy but also industrial policy and even general economic and social policies use them extensively. R & D statistics are now an essential background element in many government programmes and provide an important tool for evaluating them.

1.5 NATURAL SCIENCES AND ENGINEERING (NSE) AND SOCIAL SCIENCES AND HUMANITIES (SSH)

16. The Manual deals not only with R & D in the Natural Sciences and Engineering (NSE) which cover the physical sciences, the life sciences, including the medical and agricultural sciences, plus engineering but also the Social Sciences and Humanities (SSH).

17. The first two versions of the Manual covered only the Natural Sciences and Engineering. The Social Sciences and Humanities were incorporated in the third revision,* adopted in 1974. Although the Manual recommends standard practices, it is understood that, for various reasons, some deviations from the standards may still have to be accepted for the SSH. Experience in different Member countries has not been the same: some find surveys can cover all sciences in...
all sectors equally, others find common procedures are not always appropriate. For example, few countries collect data on SSH R&D in industrial firms.

18. The special problems of measuring SSH R&D are raised as they occur in the various chapters of the Manual.

1.6 MEASURES OF R&D INPUTS

19. For statistical purposes two inputs are measured: expenditures on R&D and people working in R&D. Both inputs are normally measured on an annual basis: so much spent during a year, so many person-years used during a year. Both series have their strengths and weaknesses and, in consequence, series of both kinds are necessary to secure an adequate representation of the effort devoted to R&D.

1.6.1 R&D Expenditures

20. The basic measure is "intramural expenditures", i.e. all expenditures for R&D performed within a statistical unit or sector of the economy. For R&D purposes both current and capital expenditures are measured. Depreciation payments are excluded. Further details of the coverage and content of R&D expenditures are given in Chapter V of the Manual (see 5.3.2).

21. R&D is an activity for which there are significant transfers of resources between units, organisations and sectors 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. Chapter V deals with ways of tracing the flow of R&D funds. It is stressed that such flows should be based on the reply of the performer of the R&D and not on that of the source of funds (see 5.3.3). Guidelines are suggested for the treatment of "public General University Funds" i.e. that part of university research which is financed from the general grant from ministries of education destined for both education and research. Such flows may represent up to 90 per cent of all university research and an important share of all public support for R&D.

22. The main disadvantage of R&D input series expressed in monetary terms is that they are affected by differences in price levels over time and between countries. It can be shown that in many cases general price indices (such as the implicit Gross Domestic Product deflator) do not accurately reflect trends in R&D prices, nor do current exchange rates necessarily reflect the balance of R&D prices between countries. Methods of developing special R&D deflators and R&D exchange rates are discussed in Chapter VII.
1.6.2 R & D Personnel

23. Personnel is a more concrete measure and, since labour costs normally account for 50-70 per cent of total R & D expenditures, is also a reasonable short-term indicator of efforts devoted to R & D. The measurement of the personnel engaged in R & D is also of fundamental importance in the longer term. Unless people with certain training and qualifications are available, organised R & D is almost impossible. Education and training are lengthy processes; personnel data are, therefore, essential to realistic science policy planning.

24. R & D personnel data, narrower in coverage than most expenditure series, are not affected in the same way by differences in currency values. There are, however, problems as to how to reduce such data to their full-time equivalent (FTE) or person-years on R & D (see Section 5.2.3).

25. A wide variety of persons are needed in the national R & D effort: from the Nobel prize-winner to the winner's secretary, from the designer of space experiments to the breeder of laboratory animals. Because of the range of skills and education required, it is essential to classify R & D personnel into categories.

26. There are two systems now used by OECD Member countries to classify persons engaged in R & D. Section 5.2.4 of the Manual contains definitions for both a classification by occupation (linked as far as possible to the International Standard Classification of Occupation - ISCO)* and a classification by level of formal qualification (based entirely on the International Standard Classification of Education - ISCED).* While it would be desirable to have data based on both approaches, most Member countries use only one of the two. This means that for about half the OECD area, data is available by occupation only and for the other half by qualification only which poses serious problems of international comparability. It might be argued that in an efficient system there should be no major difference between the two approaches, for example, that all those employed as researchers would have university degrees and that all university graduates working on R & D would be employed as researchers. In practice, this is not entirely true. For example, a number of mature researchers do not have university level qualifications, though they do have other post-secondary qualifications or equivalent experience. Conversely, an increasing number of young university graduates are employed not as researchers but as high level technicians or as secretaries etc.

1.6.3 R & D Facilities

27. Indicators of facilities available for R & D may be envisaged but are seldom collected and are not discussed in the Manual.
Standardized equipment, library facilities, laboratory space, journal subscriptions and standardized computer time would all be possible measures.

1.6.4 National R & D Efforts

28. Although R & D activities are widespread throughout the economy, they are often perceived as a national whole for science policy purposes i.e. as the "national R & D efforts". One of the aims of the Manual is, thus, to establish specifications for R & D input data which can be collected from a wide range of performers but which can also be aggregated to find meaningful national totals. The main expenditure aggregate used for international comparison is the Gross Domestic Expenditure on R & D (GERD) which covers all expenditures for R & D performed on national territory in a given year. (It includes domestically performed R & D which is financed from abroad but excludes R & D funds paid to abroad, notably to international agencies.) The corresponding personnel measure does not have a special name. It comprises total personnel working on R & D (in FTE) on national territory during a given year. International comparisons are sometimes restricted to researchers (or university graduates) because it is considered that researchers are the true core of the R & D system.

1.7 CLASSIFICATION SYSTEMS FOR R & D

29. In order to understand the R & D activity and its role one must examine it both in terms of the organisations performing and funding R & D (institutional classification) and in terms of the nature of the R & D programmes themselves (functional distributions).

30. It is usual to use institutional basic classifications in national (and international) R & D surveys as they facilitate the survey process, combined with functional distributions in order to obtain a fuller understanding of the situation described by the statistics.

1.7.1 Institutional Classifications

31. In this approach interest is focused on the characteristic properties of the performing or funding institutions. All units are classified according to their principal (economic) activity. In this institutional approach the whole of the R & D resources of the unit classified are allocated to one class or sub-class. The advantage of this approach is that R & D data are generally collected within the same framework as regular economic statistics which makes for ease of surveying and facilitates comparisons between R & D and other
economic data. The main disadvantage is that it does not exactly describe the R & D activities of the unit which may not always be directly related to its "official" activity.

32. Chapter III of the Manual deals with the institutional classifications used. In order to ensure maximum comparability with regular economic or social statistics these are, as far as possible, based on existing United Nations classifications. The main institutional classification of national R & D efforts is that by sector. Five sectors are identified: Business Enterprise, Government, Private Non-Profit (PNP), Higher Education and Abroad. Sub-classifications are given for three of the four national sectors (Business Enterprise, PNP and Higher Education) and additional institutional classifications are suggested which are designed to reveal international differences in sectoring.

1.7.2 Functional Distributions

33. In this approach which is discussed in Chapter IV interest is focused on the character of the R & D itself. In a functional analysis the nature of the R & D activities performed by the unit is examined and the activities are broken down in various ways to show their distribution by type of activity, product field, objective, detailed field of science, etc. Thus the functional approach provides data which are more detailed and, since international differences in institutional patterns have less influence, theoretically more internationally comparable than those resulting from classification by an institution. It is, however, sometimes difficult to apply in practice. This is particularly true for the analysis by type of activity (basic research, applied research and experimental development) which is, on the one hand, of undoubted science policy interest but, on the other hand, is based on an oversimplified model of the working of the scientific and technological system and also contains an important element of subjective assessment by the respondent. This question is further discussed under heading 4.2.3.

34. It should be noted that although these functional distributions are more detailed than the institutional classifications they are still not detailed enough to be of use to one significant class of potential users of R & D data, i.e. the person who is interested in only one very specific sub-item such as a subfield of science or a product field (holography or computer controls for machine tools). It has already been noted that this Manual is essentially designed to measure national R & D efforts and to categorise them in various ways. Few individual Member countries have been able to push through subcategorisation to such a detailed level except for special inventories of specific fields and it is doubtful that such detail would be obtainable at the OECD level.
1.8 R & D SURVEYS, RELIABILITY OF DATA AND INTERNATIONAL COMPARABILITY

35. While a certain amount of R & D data can be derived from published sources, there is no substitute for a special R & D survey and most of the text of the Manual is drafted on the assumption that such surveys will be made of at least all the major national performers of R & D. Nevertheless, it may be necessary for both respondents and surveying agencies to make estimates and this question is discussed at length in Chapter VI.

36. It is hard to generalise about how far such estimates are necessary or how far they affect the reliability of the data as the situation will vary from country to country. Nevertheless, it is generally the case that the degree of "subjective" estimation by respondents is probably highest for the breakdown between basic research, applied research and experimental development and the degree of "rule of thumb" estimation by survey agencies is probably highest for R & D in the Higher Education sector. As a consequence, these data should be treated with circumspection.

37. Even if national surveys provide R & D data which are reasonably accurate and relevant to national users' needs, they may not be internationally comparable. This may simply be because national definitions or classifications clearly deviate from international norms. Such cases are generally documented in footnotes. A more complex case is where the national situation does not correspond to the international norms. This is often the case with sector analysis, where for administrative reasons apparently similar institutions fall into different sectors in different countries. Again national perception of these norms may be different. This appears to be the case both in type of activity analysis and for the analysis of R & D personnel by occupation. Such differences are impossible to quantify.

1.9 THE OBJECTIVES OF GOVERNMENT R & D FUNDING

38. All the above-mentioned problems occur to a marked degree in the analysis of government R & D funding by socio-economic objectives. On the other hand, this is a major topic of interest to users as reflected, for example, in the recommendations of the First and Second Ad Hoc Review Groups on OECD Work on R & D Statistics (see Annex I).

39. In the present version of the Manual this topic is discussed in a separate short Chapter VIII. The chapter is short because although a significant amount of methodological work has already been done at OECD (and in two regional organisations within the OECD area) a detailed set of guidelines for this type of analysis has not yet been
agreed. The chapter is separate because although the definitions in Chapter II apply to government funding the specification in the succeeding chapters which are essentially designed for performer-based reporting often do not.

40. In this type of analysis we are interested essentially in government intentions or objectives when committing money to R & D. R & D funding is, thus, defined by the funder (including public GUF) and may be both forecast (forward budgets) or retrospective (final budget or out-turn). Whereas R & D statistics proper are collected by means of especially designed surveys, government R & D funding data generally have to be derived at some stage or another from national budgets which already have their own standard national methods and terminology. The resulting analysis will always be a balance between what is desirable from the R & D point of view and what is available from the budget or allied sources.

41. The aim of classifying R & D funding by socio-economic objective is to assist government science policy formulation. Consequently, the categories have to be broad and the series are intended to reflect the amount of resources devoted to each primary purpose (defence, industrial development, etc.). Governments in OECD countries generally pursue science policies and thus distribute their R & D funds in ways which match, to a large extent, the twelve broad categories used by OECD. Nevertheless, the fit is never perfect. Because of this and because of methodological constraints in the way they are compiled, the strict level of international comparability is probably lower for government R & D funding data than for most of the other series discussed in the Manual.

1.10 A FINAL WORD TO THE USER OF R & D DATA

42. To conclude, four general points about the use of both R & D statistics and R & D funding data:

i) Such series are only a summary quantitative reflection of very complex patterns of activities and institutions. For this reason, it can be dangerous to use them "neat". They should, as far as possible, be analysed in the light of any relevant qualitative information. Particularly in the case of international comparisons, the size, aspirations and institutional arrangements of the countries concerned should be taken into consideration.

ii) Users generally refer to R & D data with a question in mind: "Is our national university research effort declining?" "Does my firm spend a higher proportion of its funds on basic research than the average for my industry?" etc.
In order to answer these questions it is necessary to identify the basic data relevant to each one which are then used to construct an R & D indicator to answer the question. However, some basic data may be accurate enough to answer one question but not another. For example, government R & D funding data are usually accurate enough to answer general questions about trends in easily defined objectives: "Is there any sign that defence R & D is picking up again in the OECD area?" - but are not suitable for specific questions for less easily defined objectives - "Does my country spend more or less in absolute terms on environmental protection R & D than country X?"

iii) One way of constructing such indicators which is particularly useful for making international comparisons is to compare R & D inputs with a corresponding economic series, for example, by taking GERD as a percentage of the Gross Domestic Product. Such broad indicators are fairly accurate but, although the classifications and norms used to collect R & D statistics are as far as possible compatible with those for general statistics, it is much more difficult to make detailed comparisons between R & D and non-R & D series both because of the residual differences in methodology and because of defects in the non-R & D data.

iv) The problems of data quality and comparability which have been noted above are characteristic of the whole range of data on dynamic socio-economic activities - such as employment or international trade - which are important to policy makers, managers, analysts and others. The philosophy underlying the evolution of R & D statistical standards in this Manual has been to identify and gradually resolve these problems through exploring various approaches and learning from Member countries' experience.
Chapter II

BASIC DEFINITIONS AND CONVENTIONS

2.1 RESEARCH AND EXPERIMENTAL DEVELOPMENT (R & D)

43. 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.

R & D is a term covering three activities: basic research, applied research and experimental development. (1) 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 that 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.

2.2 ACTIVITIES TO BE EXCLUDED FROM R & D

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

45. These activities will be discussed here under three headings:

- Education and training (see 2.2.1);
- Other related scientific and technological activities (see 2.2.2);
- Other industrial activities (see 2.2.3).

1) Described in detail in Chapter IV.
The definitions here are practical and designed solely to exclude these activities from R & D. They are thus slightly different from the broader concepts of "STET", "STS" and "innovation" discussed in Chapter I.

2.2.1 Education and Training

46. All education and training of personnel in the natural sciences, engineering, medicine, agriculture, the social sciences and the humanities in universities and special institutions of higher and post-secondary education. However, bona fide research by post-graduate students carried out at universities should be counted, wherever possible, as a part of R & D (see also 2.3.2).

2.2.2 Other Related Scientific and Technological Activities

47. The following activities should be excluded from R & D except where carried out solely or primarily for the purposes of an R & D project (see also examples in section 2.3.1):

2.2.2.1 Scientific and Technical Information Services

48. 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

except where 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).

2.2.2.2 General Purpose Data Collection

49. 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 collection conducted solely or primarily as part of the R & D process is 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 the 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. But data collected for other or general purposes such as quarterly sampling of unemployment, should be excluded even if exploited for research. Market surveys are excluded.

2.2.2.3 Testing and Standardization

50. Refers to the maintenance of national standards, the calibration of secondary standards and routine testing and analysis of materials, components, products, processes, soils, atmospheres, etc.

2.2.2.4 Feasibility Studies

51. Investigation of proposed engineering projects using existing techniques in order to provide additional information before deciding on implementation. 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.

2.2.2.5 Specialised Medical Care

52. Refers to routine investigation and normal application of specialised medical knowledge. There may, however, be an element of R & D in what is usually called "advanced medical care", carried out, for example, in university hospitals.

2.2.2.6 Patent and Licence Work

53. All administrative and legal work connected with patents and licences. (However, patent work connected directly with R & D projects is R & D.)

2.2.2.7 Policy Related Studies

54. Policy in this context refers not only to national policy but also to policy at the regional and local levels, as well as that of business enterprise in the pursuit of their economic activity. Policy related 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.

2.2.3 Other Industrial Activities

55. These can be considered under two, to some extent overlapping, headings:
2.2.3.1 Industrial Innovation (not elsewhere classified)

56. All those scientific, technical, commercial and financial steps, other than R & D, necessary for the successful development and marketing of a manufactured product and the commercial use of the processes and equipment.*

2.2.3.2 Production and Related Technical Activities

57. Industrial production and distribution of goods and services and the various allied technical services in the Business Enterprise sector and in the economy at large, together with allied activities using the disciplines of the social sciences such as market research.

2.3 THE BOUNDARIES OF R & D

2.3.1 The Basic Criterion

58. The basic criterion for distinguishing R & D from related activities is the presence in R & D of an appreciable element of novelty.

(Supplementary criteria are suggested in Chapter VI - see 6.3.3). One aspect of this criterion is that a particular project may be R & D if undertaken for one reason but if carried out for another reason will not be considered R & D. This is shown in the following examples:

a) In the field of medicine, routine autopsy on the causes of death is simply the practice of medical care and not R & D; special investigation of a particular mortality in order to establish the side effects of certain cancer treatments is R & D. Similarly, routine tests such as blood and bacteriological tests carried out for doctors, are not R & D but a special programme of blood tests in connection with the introduction of a new drug is R & D.

b) 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.

c) R & D activities in the mechanical engineering industry often have a close connection with design and drawing work. Usually there are no special R & D departments in small and medium size companies in this industry and R & D problems are mostly dealt with under the general heading "design and
drawing. If calculations, designs, workshop drawing 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 standardization (e.g. jigs, machine tools) or to promote the sale of products (e.g. offers, leaflets, spare parts catalogues) they should be excluded from R & D.

d) Many social scientists perform work in which they bring established methodologies and facts of the social sciences to bear on a particular problem, but which cannot be classified as research. The following are examples of work which might come in this category and are not R & D: interpretative commentary on the probable economic effects of a change in the tax structure, using existing economic data; forecasting future changes in the patterns of the demand for social services within a given area arising from an altered demographic structure; operations research (OR) as a contribution to decision making, e.g. planning the optimal distribution system for a factory; the 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.

2.3.2 Problems at the Borderline Between R & D, and Education & Training

2.3.2.1 General Approach

59. 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. In the absence of complete and accurate information, measurement of the share of R & D is generally based on estimates of the proportion of working time devoted to this activity by university staff. This is a very important estimate, especially in the social sciences and humanities where a particularly high proportion of research is carried out in the universities.

2.3.2.2 The Case of Post-graduate Studies

60. The borderline between R & D and Education and Training is particularly hard to establish in the case of post-graduate education (i.e at ISCED level category 7) which involves training in research. The activities of both the post-graduate students themselves and of their teachers need to be taken into consideration.

61. Parts of the curricula for post-graduate studies (ISCED level category 7) are highly structured, involving, for instance, study
schemes, set courses, compulsory laboratory work, etc. Here, the teacher is disseminating education and training in research methods. Typical activities for students under this heading are attending compulsory courses, studying literature on the subject concerned, learning research methodology, etc. These activities do not fulfill the criterion of novelty specified in the definition of R & D.

62. In addition, in order to obtain a final qualification at postgraduate level (ISCED 7) students are also expected to prove their competence by undertaking a relatively independent study or project and by presenting its results. As a general rule, these studies contain the elements of novelty required for R & D projects. The relevant activities of such students should, therefore, be attributed to R & D, any supervision by the teacher should also be considered as R & D. In addition to R & D performed within the framework of courses of postgraduate education, it is possible for both teachers and students to be engaged on other R & D projects.

63. Finally, such students at this level are often attached to or directly employed by the establishment concerned and have contracts or are bound by a similar engagement, which oblige them to do some teaching at lower levels or to perform other activities such as advanced medical care whilst allowing them to continue their studies and to do research.

64. The borderlines between R & D and Education at ISCED level 7 are illustrated in Table II.1 which, together with much of the above text, is based on the Nordic Manual "Statistics of Resources Devoted to Higher Education"*. The more practical problems of applying these concepts are dealt with in Chapter V (see 5.2.2.2).

2.3.3 Problems at the Borderline between R & D and Other Related Scientific and Technological Activities

2.3.3.1 General Approach

65. Difficulties in the separation of R & D from other scientific and technological activities are caused by the performance of several activities at the same institution. In survey practice the identification of the R & D portion is facilitated by certain rules of thumb. Two typical illustrations of the use of these may be cited:

- 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). In so far 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 from R & D.
<table>
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<th>Education &amp; Training at Level 7</th>
<th>R &amp; D</th>
<th>Other Activities</th>
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<tr>
<td><strong>Teachers</strong></td>
<td>1. Teaching students at level 7</td>
<td>3. Supervision of R &amp; D projects required for students' qualification at level 7</td>
<td>5. Teaching at levels lower than 7.</td>
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<tr>
<td></td>
<td>2. Training students at level 7 in R &amp; D methodology, laboratory work, etc.</td>
<td>4. Supervision of other R &amp; D projects and performance of own R &amp; D projects.</td>
<td>6. Other activities.</td>
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<tr>
<td><strong>Post-graduate Students</strong></td>
<td>1. Course work for formal qualification including independent study, work etc.</td>
<td>2. Performing and writing up R &amp; D projects required for formal qualification.</td>
<td>4. Teaching at levels lower than 7.</td>
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<td></td>
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<td>3. Any other R &amp; D activities.</td>
<td>5. Other activities.</td>
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</table>
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.

**Examples**

a) 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 apply only to the cases where 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 as 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.

b) Public bodies and consumer organisations often operate laboratories where the main purpose is testing and standardization. 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.

c) General purpose data collection is particularly important to social science research, since without it many elements 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. on survey methods, sampling methodologies and small area statistical estimates). Whenever possible, such R & D should be identified and appropriate estimates included with the main R & D sectoral data.

### 2.3.3.2 Specific Cases

66. In certain cases the theoretical criteria for distinguishing between R & D and related technological activities are particularly difficult to apply. Space exploration and mining and prospecting are two areas where large amounts of resources are involved and so any variations in the way they are treated will have important effects on
the international comparability of the resulting R&D data. For this reason, the following conventions apply in these two cases:

2.3.3.2.1 Space Exploration

67. The difficulty with space exploration is that, in some respects, much space activity may now be considered routine; certainly the bulk of the costs are incurred for the purchase of goods and services which are not R&D. However, the object of all space exploration is still to increase the stock of knowledge so that it should all be included in R&D. It may be necessary to separate these activities associated with space exploration, including the development of vehicles, equipment and techniques, from those involved in the routine placing of orbiting satellites or establishment of tracking and communication stations.

2.3.3.2.2 Mining and Prospecting

68. Mining and prospecting sometimes cause problems due to a linguistic confusion between "research" for new or substantially improved resources (food, energy, etc.) and the "search" for existing reserves of natural resources which blurs the distinction between R&D and surveying and prospecting. In theory in order to establish accurate R&D data, the following activities should be identified, measured and summed:

   i) The development of new surveying methods and techniques.
   ii) Surveying undertaken as an integral part of a research project on geological phenomena.
   iii) Research on geological phenomena per se undertaken as a subsidiary part of surveying and prospecting programmes.

In practice, the third of these presents a number of problems. It is difficult to frame a precise definition which would be meaningful for respondents to national surveys. The sums involved are probably relatively small in practice but a misreading by respondents might lead to large amounts of "search" resources being counted as R&D. For this reason, only the following activities should be included in R&D:

- The development of new or substantially improved methods and equipment for data acquisition and for the processing and study of the data collected and for the interpretation of these data;
- Surveying undertaken as an integral part of an R&D project on geological phenomena per se including data acquisition, processing and interpretation undertaken for primarily scientific purposes.

It follows that 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.

2.3.4 Problems on the Borderline Between R & D and Other Industrial Activities (see also Table II.2).

2.3.4.1 General Approach

69. Care must be taken to exclude activities which, though undoubtedly a part of the innovation process, rarely involve any R & D, e.g. design engineering, patent filing and licensing, "tooling up" and market research. Similar difficulties may arise in distinguishing public technology based services such as inspection and control from related R & D, as for example in the area of foods and drugs.

70. A precise definition of the cut-off point between experimental development and production cannot be stated in such a way that it is applicable to all industrial situations - instead, it would be necessary to establish a series of conventions or criteria by type of industry. However, the basic rule laid down by the National Science Foundation (NSF) provides a practical basis for the exercise of judgement in difficult cases. Slightly expanded, it states:

"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, then the work is no longer R & D."

2.3.4.2 Specific Cases

71. Some common problem areas are described below:

2.3.4.2.1 Prototypes

72. A prototype is an original model on which something new is patterned and of which all things of the same type are representations or copies. It is a basic model possessing the essential characteristics of the intended product. Applying the NSF criterion, the design, construction and testing of prototypes normally falls within the scope of R & D. This applies whether only one or several prototypes are made and whether consecutively or simultaneously. But when any necessary modifications to the prototype(s) have been made and testing has been satisfactorily completed, the boundary of R & D has been reached. The construction of several copies of a prototype
to meet a temporary commercial, military or medical need after suc­
cessful testing of the original, even if undertaken by R & D staff,
is not part of R & D.

2.3.4.2.2 Pilot Plants

73. The construction and operation of a pilot plant is a part of
R & D as long as the principal purposes are to obtain experience and
to compile engineering and other data to be used in:
- evaluating hypotheses;
- writing new product formulae;
- establishing new finished product specifications;
- designing special equipment and structures required by a new
process;
- preparing operating instructions or manuals on the process.
But if, as soon as this experimental phase is over, a pilot plant
switches to operating as a normal commercial production unit, the
activity can no longer be considered R & D even though it may still
be described as "pilot plant". As long as the primary purpose in
operating a pilot plant is non-commercial, it makes no difference in
principle if part or all of the output happens to be sold. Receipts
from this source should not be deducted from the cost of R & D acti­
ity. However, as soon as pilot plant begins to operate as a normal
production unit, the effect is more or less the same as the sale of a
pilot plant.

2.3.4.2.3 Very Costly Pilot Plants and Prototypes

74. It is very important to look closely at the nature of very cost­
ly pilot plants or prototypes, for example the first of a new line of
nuclear power stations or of ice-breakers. They may be constructed
almost entirely from existing materials and using existing technology
and they are often built for use simultaneously for R & D and to pro­
vide the primary service concerned (power generation or ice­
breaking). The construction of such plants and prototypes should not
be wholly credited to R & D. For further details see Chapter V
[5.3.2.3.4 and 5.3.3.2.2 (i) and (ii)].

2.3.4.2.4 Trial Production

75. After a prototype, with any necessary modifications, has been
satisfactorily tested, the costs of the first trial production runs
should not be attributed to R & D since the primary objective is no
longer to make further improvements to the product but to get the
production process going. The first units of a trial production run
for a mass production series should not be considered as R & D proto­
types, even if they are loosely described as such. Normally, the
costs of trial product runs of "experimental production", including
tooling-up for full-scale production (tool making and tool try-out) are not to be included in R & D.

2.3.4.2.5 Trouble-shooting

76. Trouble-shooting occasionally brings out the need for further R & D but more frequently it involves the detection of faults in equipment or processes and results in minor modifications of standard equipment and processes. It should not, therefore, be included in R & D.

2.3.4.2.6 "Feed-back" R & D

77. After a new product or process has been turned over to production units, there will still be technical problems to be solved, some of which may demand further R & D. Such "feedback" R & D should be included.
**Table II.2**

**SOME BORDERLINE CASES BETWEEN R & D AND OTHER INDUSTRIAL ACTIVITIES**

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototypes</td>
<td>Include in R &amp; D</td>
<td>As long as the primary objective is to make further improvements.</td>
</tr>
<tr>
<td>Pilot plant</td>
<td>Include in R &amp; D</td>
<td>So long as the primary purpose is R &amp; D</td>
</tr>
<tr>
<td>Design and drawing</td>
<td>Divide</td>
<td>Include design required during R &amp; D. Exclude design for production process</td>
</tr>
<tr>
<td>Trial production and tooling-up</td>
<td>Exclude</td>
<td>Except &quot;feed-back&quot; R &amp; D</td>
</tr>
<tr>
<td>After-sales service and trouble-shooting</td>
<td>Exclude</td>
<td>Except &quot;feed-back&quot; R &amp; D</td>
</tr>
<tr>
<td>Patent and licence work</td>
<td>Exclude</td>
<td>All administrative and legal work connected with patents and licences. (Except patent work directly connected with R &amp; D projects.)</td>
</tr>
<tr>
<td>Routine tests</td>
<td>Exclude</td>
<td>Even if undertaken by R &amp; D staff</td>
</tr>
<tr>
<td>Data collection</td>
<td>Exclude</td>
<td>Except when an integral part of R &amp; D</td>
</tr>
<tr>
<td>Public inspection control, enforcement of standards, regulations</td>
<td>Exclude</td>
<td></td>
</tr>
</tbody>
</table>
Chapter III

INSTITUTIONAL CLASSIFICATIONS

3.1 THE APPROACH

78. The institutional approach focuses on the characteristic properties of the performing or funding institutions and all the R & D resources of the unit are classified to one class or sub-class according to the unit's principal activity.

3.2 UNIT SURVEYED AND UNIT CLASSIFIED

3.2.1 The Unit Surveyed

79. The unit surveyed is the entity from which the recommended items of data are collected. These will vary from sector to sector, from country to country, depending on institutional structures, the legal situation affecting data collection, tradition, national priorities and survey resources. In some countries, data may be collected from scientific units; in others it may be gathered only at a higher level of institutional aggregation. The Manual can make no recommendation to Member countries concerning the unit surveyed. However, whenever Member countries provide statistics for international comparisons, the surveyed units should be specified.

3.2.2 The Unit Classified

80. The unit classified is the entity for which the required statistics are compiled. So far as possible, this unit should be uniform, within sectors, for all countries. In practice, however, this is never completely achieved. One reason is the common one of different structures and different names (or misleadingly similar names). Another reason is the interaction with the unit surveyed. If the unit surveyed is larger than the unit classified (for example, if the survey is undertaken by contracting firms who are requested to make separate returns for each establishment or by contracting institutes with a request to respond at project level) there may be problems distributing the data into the appropriate classification units. Various
3.3 SECTORS

3.3.1 Reasons for Sectoring

81. In order 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 units classified should be grouped into sectors of the economy, following as closely as possible existing standard classifications of economic activities. This offers a number of substantial practical advantages:

i) Different questionnaires and survey methods can be used for each sector to take into account the different "mixes" of activities, different accounting systems or different response possibilities of the organisations.

ii) When measuring expenditure, the sectoral approach offers the most reliable way of building up national aggregates.

iii) Sectoring offers a framework for the analysis of flows of funds between the R & D funding and performing agencies.

iv) Since each sector has its own characteristics and its own blend of R & D, this classification also throws some light on differences between the level and direction of R & D in different countries.

v) Insofar as the sectors chosen are based on the framework of an existing standard classification, it may be possible to relate R & D to other statistical series, thus facilitating the interpretation of the role of R & D in economic development and the formulation of science policy.

vi) The institutions of the various sectors are sensitive to differing government policy initiatives.

3.3.2 Choice of Sectors

82. The System of National Accounts (SNA)* states that "...in any national accounting system transactors are necessarily grouped...but they need not be grouped in the same way in all parts of the system and, indeed, it is not desirable that they should be." The following definitions are based largely on the SNA with the difference that Higher Education has been established as a separate sector and house-holds have, by convention, been merged with the Private Non-Profit sector.

83. Five sectors are identified and discussed below:
- Business Enterprise (see 3.4);
- Government (see 3.5);
- Private Non-Profit - PNP (see 3.6);
- Higher Education (see 3.7);
- Abroad (see 3.8).

These are, in turn, divided into sub-sectors appropriate to each sector.

3.3.3 Problems of Sectoring

84. In view of the diverse ways in which most contemporary institutions have developed, the definitions of the sectors that follow cannot be logically precise because, like the SNA from which they are partly drawn, they are based on a combination of sometimes conflicting criteria such as function, aim, economic behaviour, sources of funds and legal status.

85. Thus, it will not always be clear in which sector a given institute should be classified and an arbitrary decision may have to be made. Institutions may lie on the borderline between two sectors or the conceptual distinction may be clear but established legal and administrative affiliations or political considerations may prevent the application of this conceptual distinction in practice.

86. When two countries classify institutions with the same or similar functions in different sectors, the survey results will not be completely internationally comparable. Such divergencies are unavoidable as R & D surveys are primarily undertaken to serve national purposes. For international surveys, however, data should be collected and submitted in as much detail as possible in order to leave room for rearrangement for international comparisons. This is a reason for the "other institutional sub-classifications" included for each sector.

3.4 BUSINESS ENTERPRISE SECTOR

3.4.1 Coverage

87. This sector includes:

- All firms, organisations and institutions whose primary activity is the production of goods or services for sale to the general public at a price intended approximately to cover at least the cost of production.
- The private non-profit institutes mainly serving them.

88. The core of the sector is made up of private enterprises whether or not they distribute profit. Amongst these enterprises may be found
<table>
<thead>
<tr>
<th>Industry groups of the business enterprise sector</th>
<th>Component industries</th>
<th>ISIC reference:(1)</th>
<th>ISIC contents Activities in, or Manufacture of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURE</td>
<td>Agriculture</td>
<td>Major Division 1</td>
<td>Agriculture, hunting, forestry and fishing.</td>
</tr>
<tr>
<td>MINING</td>
<td>Mining</td>
<td>Major Division 2</td>
<td>Mining and quarrying (including crude petroleum and natural gas extraction/production).</td>
</tr>
<tr>
<td>ELECTRICAL GROUP</td>
<td>Electrical Machinery</td>
<td>383 except 3832</td>
<td>Electrical machinery apparatus, appliances and supplies n.e.c.</td>
</tr>
<tr>
<td></td>
<td>Electronic Equipment and Components</td>
<td>3832</td>
<td>Radio, television and communication equipment and apparatus</td>
</tr>
<tr>
<td>CHEMICAL GROUP</td>
<td>Chemicals Drugs Petroleum Refining</td>
<td>351, 352 except 3522 3522 353, 354</td>
<td>Industrial chemicals/other chemical products n.e.c. Drugs and medicines. Petroleum refineries; miscellaneous products of petroleum and coal.</td>
</tr>
<tr>
<td>AEROSPACE</td>
<td>Aerospace</td>
<td>3845, part of 3820</td>
<td>Aircraft (including space vehicles, hovercraft and specialised parts); missiles and rockets.</td>
</tr>
<tr>
<td>TRANSPORT EQUIPMENT (except Aerospace)</td>
<td>Motor Vehicles</td>
<td>3843</td>
<td>Motor vehicles n.e.c. (excluding agricultural, road building and industrial tractors).</td>
</tr>
<tr>
<td></td>
<td>Ships Other Transport</td>
<td>3841 3842, 3844, 3849</td>
<td>Shipbuilding and repairing. Railroad equipment, motorcycles and bicycles, transport equipment n.e.c.</td>
</tr>
<tr>
<td>BASIC METALS</td>
<td>Ferrous Metals</td>
<td>371</td>
<td>Iron and steel basic industries.</td>
</tr>
<tr>
<td></td>
<td>Non-Ferrous Metals</td>
<td>372</td>
<td>Non-ferrous metal basic industries.</td>
</tr>
<tr>
<td></td>
<td>Fabricated Metal Products</td>
<td>381</td>
<td>Fabricated metal products (except machinery and equipment).</td>
</tr>
<tr>
<td>MACHINERY</td>
<td>Instruments</td>
<td>385</td>
<td>Professional and scientific and measuring and controlling equipment n.e.c. Photographic and optical goods.</td>
</tr>
<tr>
<td></td>
<td>Office and Computing Machinery</td>
<td>3825</td>
<td>Office, computing and accounting machinery.</td>
</tr>
<tr>
<td>CHEMICAL-LINKED</td>
<td>Food, Drink and Tobacco</td>
<td>31.0</td>
<td>Food, beverages and tobacco.</td>
</tr>
<tr>
<td></td>
<td>Textiles, Footwear and leather</td>
<td>32.0</td>
<td>Textiles, wearing apparel and leather.</td>
</tr>
<tr>
<td></td>
<td>Rubber and Plastic Products</td>
<td>355, 356</td>
<td>Rubber products n.e.c.; plastic products n.e.c.</td>
</tr>
<tr>
<td>OTHER MANUFACTURING</td>
<td>Stone, Clay, Glass</td>
<td>36.0</td>
<td>Non-metallic mineral products except products of petroleum and coal.</td>
</tr>
<tr>
<td></td>
<td>Paper and Printing</td>
<td>34.0</td>
<td>Paper and paper products, printing and publishing.</td>
</tr>
<tr>
<td></td>
<td>Wood, Cork and Furniture</td>
<td>33.0</td>
<td>Wood and wood products, including furniture.</td>
</tr>
<tr>
<td></td>
<td>Other Manufacturing</td>
<td>39.0</td>
<td>Other manufacturing industries.</td>
</tr>
<tr>
<td>TOTAL MANUFACTURING</td>
<td>Total Manufacturing</td>
<td>Major Division 3</td>
<td>Manufacturing.</td>
</tr>
<tr>
<td>SERVICES</td>
<td>Utilities</td>
<td>Major Division 4</td>
<td>Electricity, gas and water.</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>Major Division 5</td>
<td>Construction.</td>
</tr>
<tr>
<td></td>
<td>Transport, Storage</td>
<td>71.0</td>
<td>Transport and storage.</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>72.0</td>
<td>Communication services rendered to the public whether by post, wire or radio and whether intended to be received audibly or visually.</td>
</tr>
<tr>
<td></td>
<td>Scientific and Engineering Services</td>
<td>8324, 9320</td>
<td>Engineering, architectural and technical services n.e.c. Research and scientific institutes n.e.c. (see para. 26).</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Major Division 6</td>
<td>Wholesale and retail trade, restaurants and hotels.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major Division 8 n.e.c</td>
<td>Financing, insurance, real estate and business services.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major Division 9</td>
<td>Community, social and personal services.</td>
</tr>
<tr>
<td>TOTAL SERVICES</td>
<td>Total Services</td>
<td>Major Divisions 4-9</td>
<td>Utilities and services.</td>
</tr>
<tr>
<td>TOTAL BUSINESS ENTERPRISE SECTOR: See Section 3.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

some firms for which R & D is the main activity (commercial R & D laboratories).

89. In addition, it includes public enterprises ("industries of government", SNA* 5.10-5.12) mainly engaged in selling the kind of goods and services which are often produced by business enterprises, though as a matter of policy the price set for these may be less than the full cost of production. In order to qualify as "sales" in this context, the charges should be related to the amount (quality and quantity) of the goods and services furnished and the decision to purchase them should be voluntary. Examples are nationalised mining and manufacturing units, electricity producers and distributors, railways, postal and telecommunication services, broadcasting, etc.

90. The sector also includes private non-profit institutions and associations "...mainly serving business enterprises and entirely, or mainly, financed and controlled by these units". (SNA* Table 5.1). Elsewhere the SNA recommends that "...it is best to include these bodies among industries as long as they are not wholly or mainly financed and controlled by organs of government" (paragraph 5.14). Actually, for R & D statistical surveys, it is desirable to concentrate on the control and administration of the institutes. Thus, an industrial research institute mainly financed by government should be included in the Business Enterprise sector only if it is effectively administered by a board of directors or governors drawn from firms in the industry(ies) served.

3.4.2 The Principal Sector Sub-Classification

3.4.2.1 Classification List

91. For international comparisons of R & D statistics, units in the Business Enterprise sector are classified into a number of significant industry groups and sub-groups by the International Standard Industrial Classification (ISIC)*. Table III.1 shows a rearrangement of ISIC which is suitable for such comparisons.

3.4.2.2 Unit Classified

92. R & D may be organised in a number of ways by business enterprises. R & D may be carried out, on a continuing basis, in ancillary units attached to establishments or in central ancillary units serving several establishments of an enterprise. In some cases, separate legal entities may be established to provide R & D services for a family of related legal entities.

93. The choice of the unit classified must be determined by the nature of the information normally collected. While this is described in detail in Chapter V, we can state here that one of the most fundamental questions concerns the sources of funds for R & D. This will generally concern the legal entity which controls the performance of
the R & D rather than the smaller units which actually carry out the work. The R & D unit may have to prepare a budget and record its costs but only the central administration of the company may know where the money actually came from to cover the expenditures. Contracts and taxation must involve a legal entity.

94. The enterprise-type unit is, therefore, recommended as the statistical unit for the Business Enterprise sector. In most cases, the legal entity as defined on page 17 of the English version of the International Standard Industrial Classification of all Economic Activities (ISIC)* is the appropriate unit. However, when the R & D carried out on behalf of a family of legal entities is centralised in a legal entity, the family itself should be the unit classified (Ibid pages 18-19).

3.4.2.3 Criterion of Classification

3.4.2.3.1 Firms

95. The nature of the principal activity of the unit determines the industrial classification. "The enterprise-type unit should be classified to the division of the ISIC which covers the kinds of activity of the constituent establishments which account for the preponderant amount of value added...If data are not available on the value added in the establishments or kind-of-activity units of enterprises, figures of the employment of, or wages and salaries paid by, these units might be used in order to determine their preponderant class of activities" (Ibid pages 21-22).

3.4.2.3.2 Institutes Serving Enterprises

96. According to ISIC, institutes whose main economic activity is "Engineering, architectural and technical services" should be classified in ISIC 8324 and institutes whose main economic activity is R & D ("Research and scientific institutes") should be classified in ISIC 9320. Nevertheless, until such time as product field tables are fully available (see Section 4.3) it is preferable, for the purposes of international comparison, to classify such institutes with the industries by which they are administered or which they serve. For example, a textile research institute should be included with firms in the textile industry. Any institutes which cannot be identified with any one industry should be assigned to group "scientific and engineering services not assigned to another industry" (i.e. ISIC 8324 n.e.c. + ISIC 9320 n.e.c.).

3.4.3 Other Institutional Sub-Classifications

3.4.3.1 Type of Institution

97. The nature of the R & D performed by an entity in the Business Enterprise sector often reflects the type of entity. The following classification by type of institution is recommended:
- Private enterprise;
- Public enterprise;
- Private non-profit institutions serving enterprises.

98. Public enterprises are distinguished from private enterprises on the basis of control. SNA* 5.55 makes the following recommendation:

"Because of the many forms in which government may exercise control over enterprises, it is difficult to describe the means of influencing the management of an enterprise which, in all cases, indicate who effectively controls a given enterprise. The important consideration in determining whether the public authorities are in control is: do they exercise an effective influence in all the main aspects of management; not merely such influence as is derived from the use of their regulatory powers of a general kind."

3.4.3.2 Size of Institution

99. The extent and nature of the R & D programmes of entities in the Business Enterprise sector are normally affected by the size of the entity. Two size classifications are possible: one based on revenue or other financial items, one on employment. Employment is preferable since it is a less ambiguous measure (e.g. total revenue including investment income, operating revenue, sales, turnover, extra-enterprise sales only, might all be used for the financial classification).

Since this classification is based on the assumption of the likelihood of some sort of relationship between size of enterprise and resources available for R & D, non-commercial institutions should be separated from the commercial enterprises as their high ratios of R & D inputs to size are not comparable to those of enterprises for whom R & D is auxiliary. For the same reason, enterprises and institutes whose primary activity is R & D should be separated from the other commercial enterprises. It seems best, therefore, to confine this classification to statistical units in the manufacturing industries (and possibly even to commercial enterprises only).

100. The following size groups (according to number of employees) are recommended:

<table>
<thead>
<tr>
<th>For larger economies</th>
<th>For smaller economies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1,000</td>
<td>Under 100</td>
</tr>
<tr>
<td>1,000 - 1,999</td>
<td>100 - 499</td>
</tr>
<tr>
<td>2,000 - 4,999</td>
<td>500 - 999</td>
</tr>
<tr>
<td>5,000 - 9,999</td>
<td>1,000 - 1,999</td>
</tr>
<tr>
<td>10,000 - 24,999</td>
<td>2,000 - 4,999</td>
</tr>
<tr>
<td>25,000 and above</td>
<td>5,000 and above</td>
</tr>
</tbody>
</table>
3.5 GOVERNMENT SECTOR

3.5.1 Coverage

101. This sector is composed of:

All departments, offices and other bodies which furnish but
normally do not sell to the community those common services
which cannot otherwise be conveniently and economically pro­
vided and administer the state and the economic and social
policy of the community. (Public enterprises are included
in the Business Enterprise sector.)

102. According to the SNA* definition of "producers of government ser­
ves" (with the exception of publicly controlled institutes of higher
education) it should include all bodies, departments and establish­
ments of government - central, state or provincial, district or
county, municipal, town or village - which engage in a wide range of
activities, for example, administration; defence and regulation of
the public order; health, education, cultural, recreational and other
social services; promotion of economic growth and welfare and technol­
ogical development. The legislature, executive, departments, establish­
ments and other bodies of government should be included, irrespec­
tive of their treatment in the actual government accounts. It is
immaterial whether they are accounted for in ordinary or extraordinary
budgets, or in extrabudgetary funds. The following types of organisa­
tions should be included as well:

- Non-profit organisations which primarily serve government, i.e.
bodies which are not established with the aim of earning a
profit and which are mainly engaged in research and similar
activities with regard to publicly administered functions.
- Non-profit bodies entirely or mainly both financed and con­
trolled by government except those dispensing higher education.

3.5.2 The Principal Sector Sub-Classification

3.5.2.1 Classification List

103. The standard international classification for use within the
Government sector is that shown in SNA Table 5.3 ("Classification of
the purposes of government")*. Unfortunately it is not considered
appropriate for the classification of R & D activities. Hence no
standard sub-classification is recommended at this time for the pur­
poses of international comparison.

3.5.2.2 Unit Classified

104. ISIC* recommends that when data are combined with those collected
from legal business entities, the statistical unit should be similar
3.5.2.3 Criterion of Classification

105. In the absence of a recognised classification list, no recommendations can be made at this time.

3.5.3 Other Institutional Sub-Classifications

106. The following classifications are mainly designed to reveal differences between countries in the coverage of the Government sector resulting usually from variations in institutional arrangements.

3.5.3.1 Level of Government

107. Statistical units should be classified into three categories according to the level of government involved:
- Central and Federal Government units;
- Provincial and State Government units;
- Local and Municipal Government units.

3.5.3.2 Type of Institution

108. When there are important groups of units at the borderline between Government and other sectors (e.g. units administered or controlled by government but situated at, or otherwise associated with, higher education units; or units serving industry but financed and controlled by government) it is desirable to identify them separately when reporting to international organisations. (For this particular classification, the unit classified may be an establishment-type rather than an enterprise-type unit.)

3.6 PRIVATE NON-PROFIT SECTOR

3.6.1 Coverage

109. This sector includes:
- Private or semi-public organisations which are not established primarily with the aim of making a profit (except for those controlled by institutions in the other sectors).
- Private individuals or households.

110. Institutions in the sector are usually maintained by fees, dues and donations from members and sponsors and by grants from governments and enterprises. They may also obtain revenue from the direct sale of some of their products and services such as publications or special studies. The sector consists primarily of voluntary associations (scientific and professional societies, health-orientated groups),
philanthropic foundations and research institutes supported by the associations and foundations. In many countries, private non-profit organisations have a special tax status, so that registers of them are maintained by the appropriate taxation authority.

111. The following types of private non-profit organisations should, however, be excluded from this sector:
- Those mainly rendering services to enterprises;
- Those which primarily serve government;
- Those entirely or mainly financed and controlled by government;
- Those offering higher education services or controlled by institutes of higher education.

112. By convention, all R & D activities of the general public (households) should be included in this sector. Their role in the performance of R & D is extremely small (individual inventors working in their own time and with their own facilities) but they are a source of funds for R & D, for example, by making donations to foundations. Sometimes, R & D grants or contracts are formally placed with individuals who are primarily employed in another sector, for example, grants made direct to university professors. It is suggested that such persons should only be considered as "households" if the R & D project concerned will be done entirely in their own time without any use of their employing unit's staff or facilities. They should otherwise be included along with the latter.

3.6.2 The Principal Sector Sub-Classification

3.6.2.1 Classification List

113. Statistical units in the Private Non-Profit sector are classified into the six major fields of science and technology suggested in the UNESCO "Recommendation Concerning the International Standardization of Statistics on Science and Technology"*. These fields are:
- Natural sciences;
- Engineering and technology;
- Medical sciences;
- Agricultural sciences;
- Social sciences;
- Humanities.

For further details concerning the constituent sciences, see Table III.2.

3.6.2.2 Unit Classified

114. The legal entity is the recommended statistical unit (SNA 5.71).
<table>
<thead>
<tr>
<th>Fields of science and technology</th>
<th>Component sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural sciences</td>
<td>Astronomy, bacteriology, biochemistry, biology, botany, chemistry, computer sciences, entomology, geology, geophysics, mathematics, meteorology, mineralogy, physical geography, physics, zoology, other allied subjects.</td>
</tr>
<tr>
<td>Engineering and technology</td>
<td>Engineering proper, such as chemical, civil, electrical and mechanical engineering, and specialized subdivisions of these; forest products; applied sciences such as geodesy, industrial chemistry, etc.; architecture; the science and technology of food production; specialized technologies or interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology, other allied subjects.</td>
</tr>
<tr>
<td>Medical sciences</td>
<td>Anatomy, dentistry, medicine, nursing, obstetrics, optometry, osteopathy, pharmacy, physiotherapy, public health, other allied subjects.</td>
</tr>
<tr>
<td>Agricultural sciences</td>
<td>Agronomy, animal husbandry, fisheries, forestry, horticulture, veterinary medicine, other allied subjects.</td>
</tr>
<tr>
<td>Social sciences</td>
<td>Anthropology (social and cultural) and ethnology, demography, economics, education and training, geography (human, economic and social), law, linguistics, management, political sciences, psychology, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S &amp; T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences.</td>
</tr>
<tr>
<td>Humanities</td>
<td>Arts (history of the arts and art criticism, excluding artistic &quot;research&quot; of any kind), languages (ancient and modern languages and literature), philosophy (including the history of science and technology), prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, etc., religion, other fields and subjects pertaining to the humanities and interdisciplinary, methodological, historical and other S &amp; T activities relating to the subjects in this group.</td>
</tr>
</tbody>
</table>
3.6.2.3 Criterion of Classification

115. The statistical unit should be classified to the field of science and technology which best describes the predominant nature of activities performed or funded by the institution.

3.6.3 Other Institutional Sub-Classifications

116. In countries with a large Private Non-Profit sector, it may be useful to distinguish between the resources of:

- government-linked units;
- independent PNP units;
- individuals or "households".

3.7 HIGHER EDUCATION SECTOR

3.7.1 Coverage

117. The sector is comprised of:

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

118. This sector is not a SNA sector. It has been separately identified by the OECD (and by UNESCO) because of the important role played by universities and similar institutions in the performance of R & D.

3.7.2 The Principal Sector Sub-Classification

3.7.2.1 Classification List

119. Statistical units in the Higher Education sector, like those in the Private Non-Profit sector, are classified into six major fields of science and technology as follows:

- Natural sciences;
- Engineering and technology;
- Medical sciences;
- Agricultural sciences;
- Social sciences;
- Humanities.

For further details concerning the constituent fields, see Table III.2.
3.7.2.2 Unit Classified

120. Since the enterprise-type unit would almost invariably be involved in more than one of the six major fields of science and technology, a smaller statistical unit is necessary. An establishment-type unit is, therefore, recommended: the smallest homogeneous unit predominantly involved in only one of the six fields and for which a complete (or almost complete) set of factor input data can be obtained. Depending on the size of the institution and national terminology, the statistical unit could be a research institute, a "Centre", a department, a faculty, a hospital or a college.

3.7.2.3 Criterion of Classification

121. The statistical unit should be classified to the field of science or technology which seems to most accurately describe its principal activity as reflected, for example, by the occupations of most of the unit's professional staff. Where R & D data for this sector are estimates made by the surveying authority, other supplementary criteria may have to be used such as the institutional location of the unit.

3.7.3 Other Institutional Sub-Classifications

122. Statistical units should also be classified by type of main activity. Four types may be identified:
- Teaching units (e.g. faculty or departments);
- Research units (e.g. institute or centres);
- Medical units (e.g. clinic or health centre, or university hospitals);
- Testing units and other (e.g. agricultural experiment stations).

123. For some countries, it may also be interesting, for the purposes of international comparison, to know the breakdown between public and private universities and between universities proper and other post-secondary institutions.

3.8 ABROAD

3.8.1 Coverage

124. This sector consists of:
- All institutions and individuals located outside the political frontiers of a country except for vehicles, ships, aircraft and space satellites operated by domestic organisations and testing grounds acquired by such organisations.
3.8.2 The Principal Sector Sub-Classification

The principal sector sub-classifications are essentially designed to classify the whole R & D activities of a performing unit. However, "Abroad" occurs in R & D surveys only as a source of funds for R & D performed by units already classified in one of the four national sectors or as a destination for their extramural R & D expenditures. Thus, as it occurs only as a sub-item of the R & D resources of a unit classified the choice of a standard sub-classification does not arise.

3.8.3 Other Institutional Sub-Classifications

The sector may be divided into the four sectors used for domestic R & D, in addition to a fifth: international organisations. The recommended classification is, therefore:

- Business Enterprise;
- Other National Governments;
- Private Non-Profit;
- Higher Education;
- International Organisations.

When financial flows for R & D between national and foreign Business Enterprise sectors are significant, they should be sub-divided. In this case, the flows between related enterprises should be distinguished from those between unrelated companies.
4.1 THE APPROACH

128. In the functional approach the nature of the R & D activity of the performing unit is examined rather than its principal (economic) activity. The R & D resources of the performing unit are distributed to one or more functional classes on the basis of the characteristics of the R & D itself, usually examined at the project level but sometimes in even further detail. The survey approaches described in this Chapter are thus unique to the field of R & D statistics. Although, in theory, functional distributions are quite appropriate for personnel data, they are generally confined to R & D expenditure.

129. The existing standard nomenclatures used in institutional classifications may also be used for functional distributions (e.g. field of science). However, much nomenclature is used only for functional distributions (e.g. type of activity). In most cases, statistics on R & D distributed by function are already classified by institution. For example, R & D is almost always classified by sector and sub-sector prior to its functional distribution. In fact, most functional distributions are not appropriate for all sectors (see Table IV.2).

4.2 TYPE OF ACTIVITY

4.2.1 Utilisation

130. The breakdown by type of activity is currently recommended for use in all four national sectors of performance. It is usually easier to apply to R & D in the NSE than in the SSH. For the purposes of international comparison, the break should be based on current expenditures only. It may be applied at project level but some R & D projects may have to be sub-divided between activities.

4.2.2 The Distribution List

131. Three types of R & D may be distinguished:
   - basic (or fundamental) research (see 4.2.2.1);
- applied research (see 4.2.2.2); and
- experimental development (see 4.2.2.3).

4.2.2.1 Basic Research

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

Basic research analyses properties, structures and relationships with a view to formulating and testing hypotheses, theories or laws. The results of basic research are not generally sold but are usually published in scientific journals or circulated to interested colleagues. Occasionally, basic research may be "classified" for security reasons.

Basic research is usually undertaken by scientists who may set their own goals and to a large extent organise their own work. However, in some instances basic research may be oriented or directed towards some broad fields of general interest. Such research is sometimes called "oriented basic research".

4.2.2.2 Applied Research

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.

Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving some specific and predetermined objectives. It involves the consideration of the available knowledge and its extension in order to solve particular problems. In the Business Enterprise sector the distinction between basic and applied research will often be marked by the creation of a new project to explore any promising results of a basic research programme.

The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods or systems. Applied research develops ideas into operational form. The knowledge or information derived from it is often patented but may also be kept secret.
4.2.2.3 Experimental Development

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

138. In the social sciences, experimental development may be defined as the process of translating knowledge gained through research into operational programmes, including demonstration projects undertaken for testing and evaluation purposes. The category has little or no meaning for the humanities.

4.2.3 Criteria for Distinguishing between Types of Activity

140. There are many conceptual and operational problems associated with these categories which, as defined, may be considered archetypal. They seem to imply a sequence and a separation which rarely exist in real life. The three types of activity may sometimes be carried out in the same centre by substantially the same staff. Moreover, there may be movement in both directions. When an R & D project is at the applied research/development stage, for example, some funds may have to be spent on additional experimental or theoretical work to acquire new knowledge of the underlying foundations of the relevant phenomena before further progress can be made. Furthermore, some research projects, notably in the SSH, may genuinely straddle more than one category. For instance, study of the variables affecting the educational attainment of children drawn from different social and ethnic groups may simultaneously involve both basic and applied research.

141. The following examples illustrate the general differences between basic and applied research and experimental development in the natural sciences and engineering and in the social sciences and humanities.

4.2.3.1 Examples in the Natural Sciences and Engineering:

142. a) The study of a given class of polymerisation reactions under various conditions, of the yield of products, and of their chemical and physical properties, is basic research. The attempt to optimise one of these reactions with respect to the production of polymers with given physical or mechanical properties (making it of particular utility) is applied research. Experimental development then consists of the "scaling up" of the process optimised at the laboratory level and the investigation and evaluation of potential methods of production of the polymer and perhaps of articles to be made from it.
b) The study of the absorption of electro-magnetic radiation by a crystal in order to obtain information on its electron band structure is basic research. The study of the absorption of electro-magnetic radiation by this material under varying conditions (for instance temperature, impurities, concentration, etc.) in order to obtain some given properties of radiation detection (sensitivity, rapidity, etc.) is applied research. The preparation of a device using this material in order to obtain better detectors of radiation than those already existing (in the considered spectral range) is experimental development.

c) The determination of the amino-acid sequence of an anti-body molecule would be basic research. Such investigations undertaken in an effort to distinguish between anti-bodies of various diseases would be applied research. Experimental development would then consist of devising a method for synthesising the anti-body for a particular disease, based on the knowledge of its structure, and clinically testing the effectiveness of the synthesised anti-body on patients who have agreed to accept experimental advanced treatment.

4.2.3.2 Examples in the Social Sciences and Humanities

143. a) Theoretical investigation of the factors determining regional variations in economic growth is basic research; however, such an investigation performed for the purpose of developing government policy would be applied research. The development of operational models based upon laws revealed through research for the modification of regional disparities would be experimental development.

b) Analysis of the environmental determinants of learning ability is basic research. The analysis of the environmental determinants of learning ability for the purpose of evaluating education programmes designed to compensate for environmental handicaps is applied research. The development of means of determining which educational programme would be used for particular classes of children would be experimental development.

c) The study of a hitherto unknown language to establish its structure and grammar is basic research. Analysis of regional or other variations in the use of a language to determine the influence of geographical or social variables on the development of a language is applied research. No meaningful examples of experimental development in the humanities have been found.
4.3 PRODUCT FIELDS

4.3.1 Utilisation

144. The distribution of R & D by product fields, for the present, is confined to the Business Enterprise sector. It could also be applied to other sectors but then the distribution list suggested in the next section would have to be modified to account for the different orientation of R & D carried out in non-commercial institutions.

145. Product field analysis focuses on the actual industrial orientation of the R & D carried out by institutions in the Business Enterprise sector. R & D data are thus distributed to categories which are more comparable internationally and which permit more detailed analysis. For example, R & D expenditures by product field are better for comparison with commodity and production statistics than are the unmodified institutionally classified data.

146. In theory, basic research, at least unorientated basic research, cannot be assigned to product fields. In practice, the basic research carried out by a firm is generally orientated towards some field which interests the firm because of commercial applications. Since the product fields identified in the next section are so broad, a firm should be able to assign even its basic research to a field which effectively describes its orientation. It is recommended, therefore, that all three types of activity be considered in the product field distribution. R & D undertaken in the expectation that it will be applied to processes rather than products should be included.

147. At this time, it is recommended that only current intramural expenditures be considered for international comparisons. This recommendation is made because a number of Member countries are unable to include capital expenditures whereas those who can do so are, on the whole, able to report current separately from capital for the purposes of international comparisons. It should be applied at project level.

4.3.2 The Distribution List

148. The list recommended depends on the reason for the distribution, i.e. the intended use of the statistics. Trade data are classified by the national equivalent of the Standard International Trade Classification (SITC)*; industrial output data are classified by the national equivalent of the International Standard Industrial Classification (ISIC)*. At present, both comparisons with industrial output data and with trade data are popular with analysts. For reasons of symmetry with the institutional classification for the Business Enterprise sector (see Table III.1) the distribution list here is framed in terms of ISIC as shown in Table IV.1. The main disadvantage of this is that the present version of ISIC was established in the mid-1960s and is completely out of date as far as "new" science and technology-based products are concerned.
Table IV.1
ISIC ARRANGED FOR THE PURPOSES OF R & D STATISTICS
(Product field analysis)

<table>
<thead>
<tr>
<th>Product</th>
<th>ISIC No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fish, game, primary agricultural and forestry products.</td>
<td>1</td>
</tr>
<tr>
<td>2. Unrefined mining products (including coal, crude petroleum and natural gas).</td>
<td>2</td>
</tr>
<tr>
<td>3. Electrical industrial machinery and apparatus.</td>
<td>3831</td>
</tr>
<tr>
<td>4. Radio, TV and communication equipment and apparatus.</td>
<td>3832</td>
</tr>
<tr>
<td>5. Electrical products n.e.c.</td>
<td>residual 383</td>
</tr>
<tr>
<td>6. Industrial chemicals.</td>
<td>351</td>
</tr>
<tr>
<td>7. Drugs and medicines.</td>
<td>3522</td>
</tr>
<tr>
<td>8. Petroleum and gasoline (refined); petroleum and coal products.</td>
<td>353 + 354</td>
</tr>
<tr>
<td>9. Chemical products n.e.c.</td>
<td>352 (except 3522)</td>
</tr>
<tr>
<td>10. Aircraft.</td>
<td>3845</td>
</tr>
<tr>
<td>11. Missiles and spacecraft.</td>
<td>partial 3829</td>
</tr>
<tr>
<td>12. Motor vehicles.</td>
<td>3843, 3844</td>
</tr>
<tr>
<td>13. Ships.</td>
<td>3841</td>
</tr>
<tr>
<td>14. Transport equipment n.e.c.</td>
<td>residual 384</td>
</tr>
<tr>
<td>15. Primary iron and steel products.</td>
<td>371</td>
</tr>
<tr>
<td>16. Primary non-ferrous metal products.</td>
<td>372</td>
</tr>
<tr>
<td>17. Fabricated metal products (except machinery and equipment).</td>
<td>381</td>
</tr>
<tr>
<td>18. Engines and turbines.</td>
<td>3821</td>
</tr>
<tr>
<td>19. Agricultural machinery and equipment.</td>
<td>3822</td>
</tr>
<tr>
<td>20. Office, computing and accounting machinery.</td>
<td>3825</td>
</tr>
<tr>
<td>21. Heavy ordnance and artillery.</td>
<td>partial 3829</td>
</tr>
<tr>
<td>22. Machinery n.e.c.</td>
<td>residual 382</td>
</tr>
<tr>
<td>23. Professional and scientific equipment, measuring and controlling equipment n.e.c., photographic and optical goods.</td>
<td>385</td>
</tr>
<tr>
<td>24. Food, beverages and tobacco.</td>
<td>31</td>
</tr>
<tr>
<td>25. Textiles, clothes and leather products.</td>
<td>32</td>
</tr>
<tr>
<td>26. Rubber and plastic products n.e.c.</td>
<td>35, 356</td>
</tr>
<tr>
<td>27. Non-metallic mineral products (except petroleum and coal products).</td>
<td>36</td>
</tr>
<tr>
<td>28. Paper and paper products; printing and publishing.</td>
<td>34</td>
</tr>
<tr>
<td>29. Wood and wood products, including furniture.</td>
<td>33</td>
</tr>
<tr>
<td>30. Other manufactured products.</td>
<td>39</td>
</tr>
<tr>
<td>31. Electricity, gas and water.</td>
<td>41</td>
</tr>
<tr>
<td>32. Water works and supply.</td>
<td>42</td>
</tr>
<tr>
<td>33. Construction.</td>
<td>50</td>
</tr>
<tr>
<td>34. Basic research n.e.c.</td>
<td></td>
</tr>
<tr>
<td>35. Other.(1)</td>
<td></td>
</tr>
</tbody>
</table>

1) Includes R & D not orientated towards a product or a manufacturing process, as well as R & D for which no identification is possible.
4.3.3 Criteria of Distribution

149. Two criteria for distributing R & D by product field are feasible. According to one, the allocation should be made taking the nature of the product into consideration. The alternative distribution is based on the use of the product in terms of the enterprise's economic activities.

150. At present no recommendation is possible since most Member countries lack experience in this area. It is hoped that a recommendation may be made in the next revision of the Manual.

4.3.3.1 Nature of Product

151. When applying the "nature of product" criterion, the R & D input is distributed according to the type of product being developed.

152. The guidelines contained in the form used by the National Science Foundation* to survey R & D in industry are good examples of operational criteria:

"Costs should be entered in the field or product group in which the research and development project was actually carried on, regardless of the classification of the field of manufacturing in which the results are to be used. For example, research on an electrical component for a farm machine should be reported as research on electrical machinery. Also, research on refractory bricks to be used by the steel industry should be reported as research on stone, clay, glass and concrete products rather than primary ferrous metals, whether performed in the steel industry or the stone, clay, glass and concrete industry."

153. These guidelines should pose few problems for most R & D projects on product development. R & D on processes may be more difficult to deal with. If the results of the R & D will clearly be embodied in materials or equipment, then the guidelines should be applied to those products. If not, then the process should be allocated to the product it is destined to produce. Furthermore, enterprises engaged in broad R & D programmes need rather detailed records or consultations with R & D personnel in order to provide complete estimates.

154. The advantage of this approach is that any enterprise in any industry carrying out R & D on a given product should select the same product field, no matter the expected use of the product, it should, therefore, result in comparable interfirm and especially international data. The main disadvantage is that R & D on products which are assembled from a wide range of components, such as aircraft, may be underestimated.

4.3.3.2 Use of Product

155. The criterion of use of product is applied in order to distribute an enterprise's R & D among the economic activities which are supported...
by its R & D programme. The R & D is, therefore, distributed according to the relation to the enterprise's industrial activities of the product (or process) under development.

156. The R & D of an enterprise active in only one industry would be assigned to the product field characteristic of that industry, except when R & D is being carried out on a product or process in order to enable the enterprise to engage in a new industry.

157. When an enterprise is active in more than one industry, then the use of the product* must be considered. For example, the R & D carried out on an electrical component for a farm machine (NSF guidelines above) could be distributed in several ways:

a) For an enterprise active only in a machinery industry, this is R & D for agricultural machinery.
b) For an enterprise active only in electrical supplies, this is R & D for electrical products n.e.c.
c) For an enterprise active in the machinery and electrical industries, the use of the electrical component will determine the choice of product field:
   i) If the electrical component is sold separately, the product field should be electrical products.
   ii) If the electrical component is included in farm machines sold by the enterprise, the product field should be agricultural machinery.

158. The "use of product" approach is intended to provide R & D data as comparable as possible with other economic statistics, particularly value-added. It is, therefore, particularly useful when dealing with enterprises active in more than one industry.

4.4 DETAILED FIELDS OF SCIENCE AND TECHNOLOGY

4.4.1 Utilisation

159. The detailed fields of science and technology distribution differs from the major field classification described in Chapter III (see 3.6.2; 3.7.2) in three ways. First, in this approach it is the R & D itself which is examined rather than the main activity of the performing unit, secondly, the resources are usually distributed at the project level within each performing unit and, lastly, as its title suggests, a much more detailed list of fields should be used. Such a distribution is most easily applied in the Higher Education and Private Non-Profit sectors. Sometimes the units surveyed in the Government sector may also be able to break down their R & D activities by detailed field of science but this has very rarely been attempted in the Business Enterprise sector.
160. It is recommended as a classification for all R & D carried out by units in the Higher Education and Private Non-Profit sectors.

4.4.2 The Distribution List

161. Unfortunately, at the time of writing no up-to-date detailed standard international classification of fields of science and technology, suitable for the functional distribution of R & D activities, is available and no recommendation can be made. Nevertheless, it is suggested that any such national classification developed should be compatible with the UNESCO major field list quoted in Chapter III (Table III.2).

4.4.3 The Criteria of Distribution

162. Resources should be allocated to the various fields of science and technology on the basis of the focus of R & D activities measured in terms of expenditure or of the occupational field in which R & D personnel actually work, usually at project level. Although increasing amounts of R & D are carried out by interdisciplinary groups, the allocation of sizeable amounts of R & D to an interdisciplinary category would greatly reduce the utility of international comparison on the basis of fields of science. R & D programmes or projects which are interdisciplinary should, wherever possible, be prorated amongst the fields identified in whatever list used.

4.5 SOCIO-ECONOMIC OBJECTIVES

4.5.1 Utilisation

163. This sub-chapter deals with the functional analysis of the primary socio-economic objectives of intramural R & D as reported retrospectively by the performer. This approach should not be confused with the analysis by socio-economic objectives of government R & D funding which is dealt with in Chapter VIII (which deals with the objectives of total government intended R & D expenditure - intramural and extramural - as reported by the funder, often on the basis of budget data).

164. Some Member countries have found the present distribution to be useful to break down R & D performed in several sectors, whereas others have not thought it worthwhile attempting in any of them. For this reason no general recommendations can be made as to its utility.

165. Performer-based reporting of the socio-economic objectives of R & D is most easily applied in the Government and Private Non-Profit sectors (or to the entire "institutes" survey sector) though individual countries have applied it in the Higher Education sector and
even for selected objectives in the Business Enterprise sector. Where used, it should be applied to total intramural expenditures for total NSE plus SSH R & D.

4.5.2 The Distribution List

166. The same distribution list is suggested as for government R & D funding in Chapter VIII, that is:

1. Development of agriculture, forestry and fishing.
2. Promotion of industrial development.
3. Promotion and rational use of energy.
4. Transport and telecommunications.
5. Urban and rural planning.
6. Protection of the environment.
8. Social development and services.
9. Exploration and exploitation of the earth and atmosphere.
10. General advancement of knowledge n.e.c.
11. Civil space.

4.5.3 The Criteria for Distribution

167. R & D should be distributed according to the primary objective of the project. As in the case of product field analysis there are two approaches to distribution. One may look at the project content itself (similar to the "nature of product" approach) or at the end or purpose which the project is intended to serve (similar to the "use of product" approach). As this type of functional distribution is as yet not very widespread, it is not possible to give any recommendation on which approach should be used for performer-based analysis by socio-economic objective.

168. Note that when this type of analysis is attempted in the Higher Education sector "public general university funds - GUF" (see 5.3.3.3.3) should be distributed between objectives and should not be grouped in "General Advancement of Knowledge n.e.c."
Table IV.2
UTILITY OF FUNCTIONAL DISTRIBUTIONS LISTED IN CHAPTER IV

<table>
<thead>
<tr>
<th>TYPE OF ACTIVITY</th>
<th>BUSINESS ENTERPRISE</th>
<th>GOVERNMENT</th>
<th>PNP</th>
<th>HIGHER EDUCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>Recommended for current expenditure - NSE</td>
<td>Recommended for current expenditure - NSE</td>
<td>Recommended for current expenditure - NSE</td>
<td>Recommended for current expenditure - NSE</td>
</tr>
<tr>
<td>Personnel</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>PRODUCT FIELD</td>
<td>Expenditure</td>
<td>Recommended</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Personnel</td>
<td>Possible</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>DETAILED FIELD OF SCIENCE</td>
<td>Expenditure</td>
<td>Unlikely</td>
<td>Possible</td>
<td>Recommended</td>
</tr>
<tr>
<td>Personnel</td>
<td>Unlikely</td>
<td>Possible</td>
<td>Recommended</td>
<td>Recommended</td>
</tr>
<tr>
<td>SOCIO-ECONOMIC OBJECTIVE</td>
<td>Expenditure</td>
<td>Possible for selected objectives only</td>
<td>Possible</td>
<td>Possible</td>
</tr>
<tr>
<td>Personnel</td>
<td>Unlikely</td>
<td>Possible</td>
<td>Possible</td>
<td>Unlikely</td>
</tr>
</tbody>
</table>
5.1 INTRODUCTION

169. Two measures of input are possible:
- Personnel employed on R & D (see 5.2);
- Expenditures on R & D (see 5.3).

They are normally both expressed in terms of some 12 month period. Both can be aggregated to derive national totals within which the other classifications and distributions can be applied.

5.2 PERSONNEL

5.2.1 Introduction

170. The measurement of personnel employed on R & D involves two exercises:
- identifying which types of personnel should be initially included (see 5.2.2);
- measuring their R & D activities in full-time equivalence (person-years) (see 5.2.3).

5.2.2 Initial Coverage

5.2.2.1 Definition

171. All persons employed directly on R & D should be counted, as well as those providing direct services such as R & D managers, administrators and clerical staff.

172. Those 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 in the measurement of R & D expenditure.
5.2.2.2 Treatment of Administrative Staff

173. In vertically integrated bodies with both an R & D funding and an R & D performing function, it may be difficult to decide at what levels administrators are actually directly employed on R & D (i.e. initially included here and in labour costs), at what levels they are providing a service to R & D (included in overheads) and at which point both they and expenditures on their services should be wholly excluded from R & D data.

5.2.2.3 Treatment of Post-Graduate Students

174. Chapter II included a somewhat theoretical discussion of how to measure the R & D activities of post-graduate students. Thus, in theory, all post-graduate students should be initially included. In practice, coverage should be reduced to those who are likely to perform significant amounts of R & D.

175. A first distinction can be made according to the level of studies. According to ISCED,* programmes at post-graduate level (ISCED 7) are of two types:

"...One is mainly an extension of the classroom-laboratory-seminar type of learning characteristic of category 6 and leading usually to a higher degree such as a master's degree or a higher professional qualification such as a specialist qualification in medicine; the other consists mainly of original research, usually of a largely independent nature, resulting in a dissertation worthy of publication and culminating in a degree or other award of the highest level (usually a doctorate). This category (7) could be sub-divided into two "level" categories (e.g. 7 and 8) on the above basis because the two kinds of programmes are so different in content and method."

176. Post-graduate students on "taught" courses can probably be safely excluded from R & D estimates in most countries, whereas those on "research based" courses should be included as far as possible. However, it may be necessary, for practical reasons, to further reduce coverage to such students for whom the corresponding R & D expenditures can be estimated. Given the varying ways in which higher post-graduate studies are organised and financed in Member countries it is not possible to give any very precise recommendations. It is however suggested that post-graduates who are actually employed by higher education units should always be included as should those who receive earmarked research or post-graduate training grants (whether from public or private sources) which are awarded specifically for work on a given topic within a given programme or in a given unit. In the latter case the student does not freely choose his or her research topic but rather receives a "quasi-salary" for organised
work in a preselected field. Such "earmarked" grants are typically distributed by research councils or similar bodies. However, independent post-graduate students on research-based courses, i.e. those who are self-financed or who receive a general grant for their studies (especially where the grant is based on financial need rather than the topic of study), may be excluded if there is no reasonable way of estimating the corresponding expenditures.

5.2.3 Full-Time Equivalence (Person-Years)

5.2.3.1 Reasons for the Approach

177. 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 post-graduate students). To count only persons employed in R & D establishments would result in an underestimate of the effort devoted to R & D; to do a head-count of everyone spending some time on R & D would lead to an overestimate. The number of persons engaged in R & D should, therefore, be expressed in full-time equivalents (FTE).

5.2.3.2 Measurement in Person-Years

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

179. Theoretically, the reduction to FTE should be made for all R & D personnel initially included. In practice, it may be acceptable to count all persons spending more than 90 per cent of their time on R & D (e.g. most persons in R & D laboratories) as 100 per cent FTE and, correspondingly, to completely exclude all persons spending less than 10 per cent of their time on R & D.

180. Personnel should be measured as the person-years expended on R & D over the same period as the expenditure series.

5.2.3.3 FTE on a Fixed Date

181. In some cases it may be more practical to survey the FTE of personnel on R & D 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 to permit comparison.
with data based on FTE during a period. Where the fixed date approach is used and data is collected annually for the first or last day of the expenditure period, two year moving averages should be used when comparing with R & D expenditure data.

5.2.4 Categories of R & D Personnel

182. There are two systems now used by OECD Member countries to classify persons engaged in R & D. It is, unfortunately, not possible to recommend one system to all countries. The Manual, therefore, contains definitions for both a classification by occupation and a classification by level of formal qualification.

5.2.4.1 Classification by Occupation

183. The standard international classification in this field is the International Standard Classification of Occupation (ISCO).* This does not have a separate class for R & D workers outside the NSE and places teachers in a separate group. It can, however, be adapted to suit some aspects of an R & D survey. The main definitions of function which follow are especially framed for R & D surveys. A list of suggested ISCO classes to be included in each OECD function is given in Table V.1.

5.2.4.1.1 Researchers (RSE)

184. Researchers are scientists or engineers engaged in the conception or creation of new knowledge, products, processes, methods and systems.

185. Also included are managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work. They are usually of a rank equal to or above that of persons directly employed as researchers and will often be former or part-time researchers.

186. Professional titles may vary from institution to institution, from sector to sector and from country to country (see 5.2.2.2).

187. Post-graduate students engaged on R & D should be considered as researchers (see 5.2.2.3).

5.2.4.1.2 Technicians and Equivalent Staff

188. Technicians participate in R & D projects by performing scientific and technical tasks normally under the supervision of scientists and engineers. Equivalent staff perform the corresponding tasks under the supervision of researchers in the social sciences and humanities.
Table V.1
SUGGESTED RELATION BETWEEN OECD AND ISCO CLASSES

<table>
<thead>
<tr>
<th>OECD Class</th>
<th>ISCO Classes</th>
<th>ISCO Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers</td>
<td>Chemists, physicists, physical scientists, n.e.c.</td>
<td>011,012,013</td>
</tr>
<tr>
<td></td>
<td>Biologists, medical scientists and related scientists, bacteriologists and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>related scientists, agronomists and related scientists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statisticians, mathematicians and actuaries, systems analysts</td>
<td>081,082,083</td>
</tr>
<tr>
<td></td>
<td>Economists</td>
<td>090</td>
</tr>
<tr>
<td></td>
<td>Lawyers, jurists, n.e.c.</td>
<td>121,129</td>
</tr>
<tr>
<td></td>
<td>Sociologists, psychologists, anthropologists, geographers, historians and</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>political scientists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Librarians, archivists and curators</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>Civil, electrical, mechanical, chemical, metallurgical, mining and</td>
<td>022-029</td>
</tr>
<tr>
<td></td>
<td>industrial engineers, and engineers n.e.c.</td>
<td>incl.</td>
</tr>
<tr>
<td></td>
<td>University and higher education teachers</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>Administrators and managerial workers (part)</td>
<td>Major group 2</td>
</tr>
<tr>
<td>Technicians and equivalent</td>
<td>Physical and life science technicians</td>
<td>014 and 054</td>
</tr>
<tr>
<td>staff</td>
<td>Surveyors, draughtsmen, civil, electrical, mechanical, chemical, metallurgical,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mining and other engineering technicians</td>
<td>031-039</td>
</tr>
<tr>
<td></td>
<td>Statistical and mathematical technicians, including computer programmers</td>
<td>084</td>
</tr>
<tr>
<td></td>
<td>(Survey interviewers)</td>
<td>(none)</td>
</tr>
<tr>
<td>Other supporting staff</td>
<td>Agricultural, service and production and related workers</td>
<td>Major groups 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Clerical workers and related workers</td>
<td>Major group 3</td>
</tr>
<tr>
<td></td>
<td>Administrators and managerial workers n.e.c.</td>
<td>Major group 2</td>
</tr>
</tbody>
</table>
189. Their tasks include:
- carrying out bibliographic searches and selecting relevant material from archives and libraries;
- preparing computer programs;
- carrying out experiments, tests and analyses;
- preparing materials and equipment for experiments, tests and analyses;
- recording measurements, making calculations and preparing charts and graphs;
- maintaining and operating specialised R & D equipment and machinery;
- carrying out statistical surveys and interviews.

5.2.4.1.3 Other Supporting Staff

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

191. Include under this heading 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.

5.2.4.2 Classification by Formal Qualification

192. The International Standard Classification of Education (ISCED)* provides the basis for classifying R & D personnel by formal qualification. Four classes are recommended for the purposes of R & D statistics (see also Annex IV). They are defined exclusively by level of education regardless of the field concerned.

5.2.4.2.1 Holders of University Level Degrees (ISCED level categories 6 and 7)

193. Holders of third-level degrees of university level in all fields (ISCED level categories 6 and 7). Includes holders of degrees earned at universities proper and also at specialised institutes of university status.

5.2.4.2.2 Holders of Other Post-Secondary Diplomas (ISCED level category 5)

194. Holders of third-level diplomas not equivalent to a university degree in all fields (ISCED level category 5). Studies are typically specialised in subject matter, presented at a level that requires the equivalent of full second level education for their mastery. They provide an education of a more "practical" orientation than that of the universities. Many of the courses are offered in part-time, evening, sandwich and refresher programmes.
195. Examples are the Hogere Beroepsopleidingen - HBO (the Netherlands), Higher National Certificates and Higher National Diplomas (the United Kingdom), Brevet de Technicien Supérieur and qualifications from Instituts Universitaires de Technologie - IUT (France). Such diplomas may be held not only in the NSE but also in the SSH, e.g. Higher National Diploma in Business Studies (the United Kingdom) or senior secretarial courses at IUT (France).

5.2.4.2.3 Holders of Diplomas of Secondary Education (ISCED level category 3)

196. Holders of diplomas at the second level, second stage (ISCED level category 3). The class includes not only all ISCED level category 3 diplomas obtained within the academic school system but also the equivalent level category 3 vocational diplomas obtained from other types of educational establishments.

197. Examples are the Middelbare Beroepsopleidingen - MBO and Voorbereidend Wetenschappelijk Onderwys - VWO (the Netherlands), General Certificate of Education - Advanced Level, Ordinary National Certificates and Ordinary National Diplomas (the United Kingdom).

5.2.4.2.4 Other Qualifications

198. Includes all those with secondary diplomas at less than ISCED level category 3 or with incomplete secondary qualifications or education not falling under any of the other three classes.

5.2.5 National Aggregates

199. The recommended aggregate is for total person-years spent in the performance of R & D on national territory for a given 12 month period. This should be broken by sector and by occupation and/or formal qualification as shown in Tables V.2(a) and (b). The other institutional classifications (and sometimes the functional distributions) are applied within this framework.

200. It would be desirable to have a useful measure of all high level personnel working on R & D. Unfortunately, because of the continued existence of alternative classifications by occupation and by qualification this is not possible.

5.2.6 Cross-Classification between Occupation and Qualification

201. Both systems have their strengths and their weaknesses when used to classify R & D personnel. However, since each is associated with a body of useful related statistics (employment by occupation, educational statistics) it is desirable to classify R & D personnel by both occupation and by qualification. It is recommended, furthermore, that perhaps every five years or every third ISY, data be collected for a cross-classification between occupation and qualification.
### Table V.2(a)

**TOTAL NATIONAL R & D PERSONNEL (IN FTE) BY SECTOR AND BY OCCUPATION**

<table>
<thead>
<tr>
<th>Sector Occupation</th>
<th>Business Enterprise</th>
<th>Private Non-Profit</th>
<th>Government</th>
<th>Higher Education</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technicians</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Equivalent Staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Supporting Staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table V.2(b)

**TOTAL NATIONAL R & D PERSONNEL (IN FTE) BY SECTOR AND BY LEVEL OF QUALIFICATION**

<table>
<thead>
<tr>
<th>Sector Qualification</th>
<th>Business Enterprise</th>
<th>Private Non-Profit</th>
<th>Government</th>
<th>Higher Education</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Post-Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table V.3

**R & D PERSONNEL CLASSIFIED BY OCCUPATION AND BY FORMAL QUALIFICATION**

<table>
<thead>
<tr>
<th>Qualification Holders of:</th>
<th>Researchers (RSE)</th>
<th>Technicians &amp; Equivalent Staff</th>
<th>Other Supporting Staff</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISCED 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISCED 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other post-secondary diplomas (ISCED 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary diplomas (ISCED 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other qualifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>71</td>
</tr>
</tbody>
</table>
If the use of full-time equivalence proves impractical for the cross-classification, it may be preferable to distinguish between full-time and part-time workers on R & D.

202. There will normally be a general correspondence between researchers and university graduates in that most research will have university level diplomas though a few will have lower qualifications supplemented by experience on the job. However, the correspondence is more tenuous for the other occupation categories. It is increasingly common to find university graduates with NSSE degrees employed as technicians. Similarly, other supporting staff may hold diplomas at all levels (e.g. financial directors with university degrees in accountancy, senior secretaries with ISCED 5 diplomas, etc.). A cross-classification such as the one suggested above is useful for any attempt to understand another country’s R & D personnel statistics, to evaluate the international comparability of these statistics or, indeed, for discussing trends in a country’s own R & D labour force.

5.2.7 Other Personnel Classifications

203. A number of other classifications have been found useful for science and educational policy. Several are identified in the UNESCO Recommendation*. However, these are usually only recommended for part of the R & D labour force and are generally more relevant to occupation classes than to qualification classes. Given the fact that some half Member countries do not collect occupation data the following classifications can only be suggested in rather unsatisfactory alternative forms:

- researchers (or holders of university level degrees) by level of university degree;
- researchers and technicians and equivalent staff (or holders of post-secondary degrees and diplomas) by field of study;
- researchers (or holders of university level degrees) by sex, age, length of service, etc.

5.3 EXPENDITURE

5.3.1 Introduction

204. Expenditures on R & D may be spent within the statistical unit (intramural) or outside it (extramural). The full procedures for measuring these expenditures are:

i) to identify the intramural expenditure on R & D performed by each statistical unit;
ii) to identify the sources of funds for these intramural R & D expenditures as reported by the performer;

iii) to identify the extramural R & D expenditures of each statistical unit; and

iv) to 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 context.

205. Nevertheless, it is the first two stages which are essential and which generally suffice for stage (iv). R & D expenditure data should be compiled on the basis of performers' reports of intramural expenditures. The collection of extramural expenditures is, however, also desirable as a supplementary source.

5.3.2 Intramural Expenditures

5.3.2.1 Definition

206. Intramural expenditures are all expenditures for R & D performed within a statistical unit or sector of the economy, whatever the source of funds.

207. 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.

5.3.2.2 Current Expenditures

208. Current expenditures are composed of labour costs and other current costs. (Also see 5.3.2.3.3.)

5.3.2.2.1 Labour Costs of R & D Personnel

209. 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 not included in the R & D personnel data (such as security personnel and maintenance staff) should be excluded and considered with other current costs.

210. In the case of post-graduate students performing R & D, the corresponding share of their grants, stipends, etc., should, wherever possible, be included.

211. Labour costs are almost always the largest component of current expenditure. Member countries may find it useful to collect or otherwise secure labour costs by personnel element (e.g. researchers, technicians and equivalent staff, other supporting staff etc.). These extra classifications will be particularly helpful in the construction of cost indices for R & D expenditures.
5.3.2.2 Other Current Costs

212. These comprise non-capital purchases of materials, supplies and equipment to support R & D performed by the statistical unit in a given year. Examples of the former are: water and fuel (including gas and electricity), books, journals, reference materials, subscriptions to libraries, scientific societies and so on, imputed or actual cost of small prototypes or models made outside the research organisation, materials for laboratories (chemicals, animals etc.). Expenditures on services (hired or purchased) for R & D are included. Examples of such services are security; storage; use, repair and maintenance of buildings and equipment; computer services and printing of R & D reports. Administrative and other overhead costs (such as interest charges and library, office, post and telecommunications and insurance costs) should also be included, prorated if necessary to allow for non-R & D activities within the same statistical unit.

5.3.2.2.3 Exclusion of Depreciation

213. All depreciation provisions for building, plant and equipment, whether real or imputed, should be excluded from the measurement of intramural expenditures. This is proposed for three reasons:

i) If depreciation (an allowance to finance the replacement of existing assets) were included in current expenditures, then the addition of capital expenditures would result in double-counting.

ii) The actual sums set aside for depreciation are useless for purposes of international comparison because of differences in tax laws.

iii) In the Government sector, no provision is normally made for depreciation of fixed assets. Consequently, even within a country, comparisons between sectors cannot be made unless depreciation provisions are excluded and aggregates for a national series cannot be compiled unless the sector totals are put on a comparable basis.

5.3.2.3 Capital Expenditures

214. Capital expenditures are the annual gross expenditures on fixed assets used in the R & D programme of statistical units. They are composed of expenditures on:

- land and buildings;
- instruments and equipment.

5.3.2.3.1 Land and Buildings

215. 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. Depreciation is excluded (see 5.3.2.2.3).

5.3.2.3.2 Instruments and Equipment

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

5.3.2.3.3 Conventions for Distinguishing between Current and Capital Items

217. In measuring actual capital expenditure, small tools and instruments and minor improvements to existing buildings will normally be excluded, as in most accounting systems these items are usually carried on current expenditure accounts. The boundary between "minor" and "major" items varies slightly between countries according to taxation practices and between different firms and organisations in the same country according to accounting practices. But these differences are rarely significant and it is neither necessary nor practical to insist on any rigid standard for this purpose. Thus, national conventions will govern the allocation of expenditures to current or to capital. Nevertheless, in those countries where expenditures on very expensive prototypes (e.g. aircraft) or equipment with a limited life (e.g. launching rockets) are considered current expenditures, such conventions should always be made explicit.

5.3.2.3.4 Identifying the R & D Content of Capital Expenditures

218. Occasionally the R & D term of a fixed asset may be known at the time of acquisition. In this case, only a portion of the costs should be attributed to R & D capital expenditures. Similarly, when a fixed asset will be used for more than one activity and neither the R & D nor the non-R & D activities predominate (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. In the first case, the R & D proportion could be based on R & D term compared to the expected life of the asset. In the second case, the proportion could be based on numbers of R & D personnel using the facility compared to the total 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).

5.3.2.3.5 Sale of R & D Capital Goods

219. The sale or transfer of fixed assets originally acquired for R & D creates a problem. The disposal of such assets could be considered as a disinvestment in R & D. However, no adjustment to recorded capital expenditures should be made. The statistical unit's capital R & D expenditures should not be reduced accordingly, either
currently or retrospectively (for the years in which the capital costs were recorded). Current revisions can cause anomalies such as negative intramural R & D expenditures. Retrospective revisions are difficult and confusing.

5.3.3 Sources of Funds

5.3.3.1 Methods of Measurement

220. R & D is an activity where there are 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:

- **Performer-based** reporting of the sums which one unit, organisation or sector has received from another unit, organisation or sector for the performance of intramural R & D.
- **Source-based** reporting of extramural expenditures which are the sums a unit, an organisation or a sector reports having paid to another unit, organisation or sector for the performance of R & D.

221. The first of these approaches is strongly recommended.

5.3.3.2 Criteria for Identifying Flows of R & D Funds

222. For such a flow of funds to be correctly identified two criteria must be fulfilled:

- There must be a direct transfer of resources;
- This transfer must be both intended and used for the performance of R & D.

5.3.3.2.1 Direct Transfer

223. Such transfers may take the form of contracts, grants or donations and may take the form of money or of other resources (e.g. staff or equipment lent to the performer). When there is a significant non-monetary transfer, the current value has to be estimated since all transfers must be expressed in financial terms.

224. Resources may be transferred in a number of ways not all of which may be considered direct.

225. **Contracts or grants** paid for the performance of current or future R & D are clearly identifiable as a transfer of R & D funds.

226. 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 practice, the beneficiary would not normally be able to make such an estimate nor, indeed, might the donor.
227. In some cases, a firm's R&D project may be financed by loans from a financial institution, an affiliated company or a government. Loans which are to be repaid are not to be considered transfers; loans which may be forgiven are to be considered transfers (by convention).

228. There are also a variety of other government incentives for R&D in the Business Enterprise sector. Examples are the remission of income taxes for industrial R&D, the payment by a government, on demand and after audit, of a certain portion of some or all of firms' R&D expenditures, bonuses added to R&D contracts to encourage a firm in its own R&D, remission of taxes and tariffs on R&D equipment and the reimbursement of part of a firm's costs if it hires more R&D staff. For the present, even where these transfers can be separately identified, they should not be counted as direct support for R&D. The statistical units should, thus, report gross expenditures as incurred, even when their actual costs may be reduced because of remissions, rebates or post-performance grants.

5.3.3.2.2 Transfer to be both Intended and Used for R&D

229. In many cases of R&D transfers this criterion can be taken for granted. There are, however, a number of cases where its application can clarify the situation (particularly where there is a difference between the report of the performer and the funder):

i) One is the case when 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 performing R&D funded by the first unit. For example, suppose 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 carry out no R&D themselves and would report no R&D funded by the government. These expenditures should be considered by the government laboratory, for R&D statistics, to be intramural capital and intramural other current costs respectively.

ii) Another case occurs where there are transfers of funds which are loosely described by the source as "development contracts" for "prototypes" which actually result in no R&D being 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). This is largely constructed by the performer using existing materials and existing technology with R&D needed only 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.

iii) Another is the case where one unit receives money from another and uses it for R & D although the funds were not paid out for that purpose. For example, a research institute may finance some of its work through receipts from royalties and profits from the sales of goods and services. Although these funds are received from other units and other sectors they should not be considered as transfers for R & D but as coming from the "retained receipts" of the performing unit itself as the purchasers of the institute's goods and services did not intend to transfer funds for R & D.

5.3.3.3 Identifying the Sources of Flows of R & D Funds

230. 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 from other sectors and sub-sectors. Usually they can do this without too much difficulty but there are one or two problem areas.

5.3.3.3.1 Influence of the Type of Unit Classified

231. The amount of transferred funds reported will be affected by the type of statistical unit on which the data are based. This particularly concerns flows between organisations within the same sector. For instance, government departments may well charge one another for the performance of R & D but this will usually be considered as intramural to the Government sector. Similarly, a business enterprise may, for accounting reasons, charge for the R & D done by one of its establishments for another, but consider the work to be intramural as far as the enterprise is concerned. The decision on where to draw the boundary is an arbitrary one and the important point again is to comment fully in any published tables.

5.3.3.3.2 Sub-Contracting and Intermediaries

232. Further problems arise when the money passes through several organisations. This can occur when R & D is sub-contracted, as is sometimes the case in the Business Enterprise sector. The performer should indicate, so far as possible, the original source that provided the funds for R & D. 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 projects. Well known examples are the Stifterverband für die Deutsche Wissenschaft
and the Deutsche Forschungsgemeinschaft in Germany. In such cases it is acceptable to regard these organisations as the source, although it is preferable to attempt to retrace the funds to their original sources.

5.3.3.3 Public General University Funds (GUF)

233. However, probably the largest single area of disagreement about sources of funds analysis occurs with "public General University Funds" (GUF). Universities usually draw on three types of funds to finance their R & D activities:

i) R & D contracts and earmarked grants received from government and other outside sources. These should be credited to their original source.

ii) Income from endowments, shareholdings, property plus receipts from the sale of non-R & D services such as fees from individual students, subscriptions to journals, sales of serum or agricultural produce. These retained receipts are clearly the universities' "Own Funds". In the case of private universities these may be a major source of funds for R & D.

iii) 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. In this case there is a conflict between the principle of tracing the original source and that of using the performer's report and also some disagreement about how criterion 5.3.3.2.2 (paragraph 229) concerning the intentions of the funder should be applied. In the first approach one argues 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. Using the second approach one argues that as it is within the universities that the decisions are taken to commit money to R & D out of a pool which contains both "Own Funds" as narrowly defined in (ii) above and public General University Funds, the sums concerned should be credited to Higher Education as a source of funds.

234. Granting mechanisms, attitudes and government/university relations differ in Member countries, so that no standard procedure is recommended at the survey level. However, it should be made clear which procedure has been adopted and what are the amounts involved so that the public GUF element can be reclassified where necessary for the purposes of international comparison.
5.3.4 Extramural Expenditures

235. Data on the extramural R & D expenditures of statistical units are a useful supplement to the information collected on intramural expenditures. These extramural expenditure data are essential to provide statistics on R & D performed abroad but financed by domestic institutions. But they may also be helpful to those analysing the flows of funds reported by performers, particularly if there are gaps in the survey coverage.

5.3.5 National Totals

5.3.5.1 Gross Domestic Expenditure on R & D (GERD)

GERD is total intramural expenditure on R & D performed on the national territory during a given period.

237. It includes R & D performed within a country and funded from abroad but excludes payments made abroad for R & D. 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 (see Table V.4). The GERD and GERD matrix are fundamental to the international comparison of R & D expenditures. They also provide the accounting system within which the institutional classifications and functional distributions may be applied.

5.3.5.2 Gross National Expenditure on R & D (GNERD)

238. The GNERD is an optional supplementary aggregate which comprises total expenditure on R & D financed by institutions of a country 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 (see Table V.5).
Table V.4
GROSS DOMESTIC EXPENDITURE ON R & D (GERD)

<table>
<thead>
<tr>
<th>Funding Sector</th>
<th>Sector of Performance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Enterprise</td>
<td>Private Non-Profit</td>
<td>Government</td>
</tr>
<tr>
<td>Total financed by the Business Enterprise sector</td>
<td>Total financed by the P.N.P. sector</td>
<td>Total financed by the Government sector</td>
</tr>
<tr>
<td>Public GUF</td>
<td>Total financed by Public GUF</td>
<td></td>
</tr>
<tr>
<td>Higher Education</td>
<td>Total financed by the Higher Education sector</td>
<td></td>
</tr>
<tr>
<td>Abroad</td>
<td>Total financed from Abroad</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Total performed in the Business Enterprise sector</td>
<td>Total performed in the P.N.P. sector</td>
</tr>
</tbody>
</table>
Table V.5
GROSS NATIONAL EXPENDITURE ON R & D (GNERD)

<table>
<thead>
<tr>
<th>Funding Sector</th>
<th>Sector of Performance</th>
<th>Total financed by the Business Enterprise sector</th>
<th>Total financed by the P.N.P. sector</th>
<th>Total financed by the Government sector</th>
<th>Total financed by Public GUF</th>
<th>Total financed by the Higher Education sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Enterprise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Non-Profit</td>
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<td>Government</td>
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<tr>
<td>Public GUF</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Higher Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Business Enterprise</td>
<td>Total performed in the Business Enterprise sector</td>
<td>Total performed in the P.N.P. sector</td>
<td>Total performed in the Government sector</td>
<td>Total performed in the Higher Education sector</td>
<td>Total performed Abroad. GNERD</td>
</tr>
</tbody>
</table>
Chapter VI

SURVEY PROCEDURES

6.1 SURVEYS AND ESTIMATES

239. Although the preparation of statistics on R & D will require both survey data and estimations, there is no satisfactory substitute for a special survey. Whilst a certain amount of information about recent trends in R & D resources can be obtained from published materials such as annual reports of science councils or major R & D performing institutions, such data can give only an approximate measure of R & D efforts. Not only will the concepts of R & D used by various organisations often differ from the Frascati definition, they may also change over time. It is also extremely difficult to secure all data for the same time period and to track down flows of funds from financial statements without incurring double-counting. However, for various reasons (such as the lack of satisfactory records, the costs of statistical surveys and the need to restrict statistical demands on respondents) surveys cannot always provide all the information required.

240. Estimates are a necessary supplement to surveys (respondents are often required to make estimates in order to provide "survey" information). Based on relationships derived from survey data, incomplete information may be used to provide adequate aggregate trends or totals without requiring a costly survey. Indeed, the R & D inputs of one major sector, Higher Education, are very often partially or wholly estimated. In all cases, when statistics are released, full information on the sources and generation of the statistics should be provided.

6.2 IDENTIFYING SURVEY RESPONDENTS

241. The identification and selection of survey respondents will depend on the institutions, the statistical framework and the relevant statutes of Member countries. Only in a few Member countries, is it possible for the surveying agency to make an exhaustive survey of
R & D performers and funders. Generally, the extent of the survey is limited by numerous constraints. For example, the number of respondents may have to be restricted to keep costs down; an R & D survey may have to be taken in conjunction with another survey with acceptable but not ideal respondents; surveys of some groups may require the participation of other agencies with different data needs and hence different questions to respondents.

It is not possible to make detailed recommendations on survey methods which would be relevant to all Member countries, as the size and structure of national R & D potentials vary very considerably. The following hints are given for the four sectors identified in Chapter III, though it is recognised that in some countries a different system of sectoring may be used for surveying than for reporting the data. Thus some countries undertake three surveys: firms, institutes and higher education teaching establishments and then redistribute the institutes between the four standard sectors of performance.

6.2.1 Business Enterprise Sector

There are at least two feasible approaches for establishing the survey population of the Business Enterprise sector. One is to survey a sample drawn from the entire sector, choosing the sample on the basis of the company data available to the methodologists, such as employees and sales, by industry and region. However, R & D is a statistically rare event among smaller enterprises. The other is to try and survey only firms supporting R & D. This requires more information to select the firms and several Member countries do this by making an exhaustive "post-card survey" at regular intervals (say five years) to identify the maximum number of potential R & D performers or funders who can then be contacted for a full survey.

Sources of useful information include lists of firms receiving government grants and contracts for R & D, directories of R & D laboratories, members of industrial research associations, employers of very highly qualified personnel, and lists of firms claiming tax deductions for R & D. In practice a combined approach is often used, with a full survey of known performers plus sampling designed to ensure that the smaller R & D performers are also covered.

6.2.2 Government Sector

Identifying those Federal or Central government units who are likely to be performing or funding R & D in the NSE is usually relatively easy but the task may be more difficult in the case of provincial or local government agencies, and/or in the case of the social sciences (typically, respondents will not be active in both the NSE
and the SSH). In general, in this sector, potential respondents either have concentrations of scientists and engineers with higher degrees or have a mandate for the financial support of R&D in the other sectors.

6.2.3 Private Non-Profit Sector

246. There are typically relatively few institutions in the Private Non-Profit sector that perform or fund R&D. However, in many countries this sector is also statistically undercovered, especially where PNP institutes are dealt with separately rather than within a wider "institutes sector" survey. If not available from other sources (e.g. directories, income tax exemption lists) an adequate list can probably be compiled by asking a number of researchers and research administrators in other sectors to identify Private Non-Profit institutions which they know are supporting R&D.

6.2.4 Higher Education Sector

247. Institutions are readily identified in the Higher Education sector since there is already a considerable amount of information published by universities, ministries of education, etc. The problem of identification arises if the statistical unit chosen is a component of a university: the smaller the unit or the more of them in an institution, the more of a problem identification becomes. It is often desirable, when components of a university are surveyed, to have the central administration co-ordinate the response. In this way some omissions may be detected. The university may also effectively do the first stage edit of returns and may also, as first stage collector, improve response rates.

6.3 WORKING WITH RESPONDENTS

6.3.1 Encouraging Co-operation

248. In many cases, R&D performers are also users of R&D statistics. They should, therefore, be willing to co-operate fully with a survey agency. Unfortunately, especially in the case of larger institutions, the responding unit is usually not the user unit and hence has no interest in the data supplied or in the final statistics. In some institutions, such as government departments or universities, it may be possible to survey through liaison officers from user units. The institution itself thereby seems to be requiring the data: at least there is some tacit approval of the survey. Alternatively, if initial contacts are sufficiently high level or centralised, user and respondent units may be brought together. The survey
agency must be able to demonstrate the use of the data to respondents and should attempt to ensure that the resulting statistics are made available to respondents.

249. In other cases respondents have no use for the statistics derived from their data. Occasionally it may be possible to work with or through trade associations or other groups with which these respondents are professionally associated. Besides better response, such co-operation may result in surveys tailored to the interests of these groups and in questionnaires designed to use the normal records and concepts of the groups. However, any tailoring must not result in data incompatible with those collected elsewhere.

250. In all cases a good questionnaire is essential; a minimum of clear and logical questions with the best possible definitions, examples and forms design. A test of draft questionnaires with a sample of respondents is highly recommended.

251. The extent to which follow-up procedures are used will depend on the level of quality of response, the number of units surveyed and the resources available to the surveying authority. It is rarely feasible to make personal contact with all the units surveyed. One possibility is to plan a follow-up programme for each enquiry, aiming to visit all the main units over a given period. Another is to limit the follow-up to a sub-sample, checking a few organisations very thoroughly. This does not, of course, preclude making personal contact with respondents who require guidance or who submit unsatisfactory returns.

6.3.2 Estimating Procedures

252. Almost all respondents will have to make some estimates. Not only is the activity of R & D vague in itself but it is inextricably linked to a number of other activities. Furthermore, an institution's R & D may not be satisfactorily reflected either in its organisation or in its records and accounts.

253. R & D is not just what R & D laboratories and research institutes do. It is both less and more than this, since very few of the surveyed institutions have only one activity. The measurement of R & D inputs may be carried out in three stages:

- Identification of all specialised R & D units and the measurement of their total activity;
- Estimation of the non-R & D portions of their activity and subtraction of these estimates from the totals;
- Estimation of the inputs used for R & D in other units and addition of these estimates to the totals.

254. In practice, minor deviations from the strict R & D definition may be overlooked in order to better utilise existing records or to
otherwise ease the burden on respondents. In some cases, particularly in the Higher Education sector, it may be necessary to resort to very crude ratios to estimate R & D inputs.

6.3.3 Operational Criteria

255. Operational criteria must be developed which are suitable for the sector being surveyed. Thus, on questionnaires intended for the Business Enterprise sector it would be appropriate to give guidance for distinguishing between R & D and pre-production but a Government questionnaire might concentrate on the difference between R & D and data collection and information. Government units may need criteria to distinguish between contracts to industry for goods and services required for intramural R & D and those awarded for industrial R & D. Criteria with the same intent but different wording may be useful in the Business Enterprise surveys. Nor should differences within a sector be overlooked. For example, operational definitions and examples appropriate for the oil and gas industry are probably not really suitable for the electrical products industry. In discussion with respondents, general supplementary criteria are often useful. An example of such a list is shown in Table VI.1.

256. During R & D surveys respondents may have great practical difficulties in applying the theoretical distinctions described in earlier chapters to the wide range of projects in progress in their organisation. As surveying agencies are not always in a position to check the responses they receive and are usually obliged to accept them as given, it is of utmost importance that they provide the institutions surveyed with the maximum of explanation and guidance to complement the formal definitions and to ensure uniformity.

257. There are four important tools available to achieve this objective:

i) explanatory notes;
ii) hypothetical examples;
iii) guidance to individual respondents;
iv) documentation on treatment of different cases.

For obvious reasons, this Manual deals exclusively with (i) and (ii). However, the basis of formal definition and distinction has to be complemented with information of types (iii) and (iv). In order to secure consistency in the guidance given by the surveying agencies, it is essential to develop a documentation on how difficult borderline cases have been solved. This documentation can also serve as a valuable source of examples for (ii) and could help countries to develop more uniform classification practices.
Table VI.1
SUPPLEMENTARY CRITERIA FOR SEPARATING R & D FROM RELATED SCIENTIFIC, TECHNOLOGICAL AND INDUSTRIAL ACTIVITIES

| A. What are the objectives of the project? |
| B. What is new or innovative about this project? |
| - Is it seeking previously undiscovered phenomena, structures or relationships? |
| - Does it apply knowledge or techniques in a new way? |
| - Is there a significant chance that it will result in new (extended or deeper) understanding of phenomena, relationships or manipulative principles, of interest to more than one organisation? |
| - Are the results expected to be patentable? |
| C. What staff are working on the project? |
| D. What methods are being used? |
| E. Under what programme is the project being funded? |
| F. How general are the findings or results of the project likely to be? |
| G. Does the project fall more naturally into one of the other scientific, technological or industrial activities? |

6.4 THE SURVEYING AGENCY

6.4.1 Responsibilities to Respondents
258. Respondents are asked to spend time on a task which, in many cases, is of no direct benefit to them and completing a questionnaire on R & D may even seem to be a waste of time and money. The surveying agency has the responsibility to minimise this apparent waste and to always be alert to possible respondent requirements for R & D statistics. It also has the responsibility to keep confidential data confidential and ensure that users are aware of respondent concerns.

6.4.2 Editing Procedures
259. Besides the normal editing of questionnaires based on historical and arithmetic checks, the surveying agency must often edit for transaction consistency. The reports on a transaction made by the financing organisation and the performer are likely to differ because of different reference periods, bookkeeping practices, methods of
estimation and interpretations of concepts. A government agency may report funding action during its fiscal year while a firm under contract may report funds spent during a similar but not identical 12 month period. The financing organisation may consider the whole of the contract to be experimental development whereas the performer correctly reports only that portion of the work which involves novelty.

260. There are thus sources of errors on both sides but, as a rule, the performer is in a much better position to make the estimates and adjustments. There are other practical reasons for relying primarily on reports by performers of the sources of funds for their intramural expenditures rather than on funders' reports of extramural expenditure. Insofar as they finance some R & D with their own funds, performers must be surveyed anyway. The intramural expenditures may be linked to the R & D personnel for the same institutions. The risk of double-counting is minimised since a given sum of R & D money cannot be spent by more than one performer at a time. In addition, foreign sources of funds cannot be surveyed.

6.4.3 Estimations

6.4.3.1 Non-Respondents

261. Generally, the surveying agency will have to estimate for important non-respondents using past returns, the reports of others who have transactions for R & D with them, or the reports of comparable institutions. Here, extramural expenditure data may be useful: for example, a performer's records may not permit R & D contracts to be readily identified or a recipient of substantial R & D funding may not participate in the survey. Sometimes, sub-sectors, or even whole sectors, may have to be estimated to create the national totals for selected years. Extrapolation from benchmark surveys, using some related series as a trend indicator, is a common way of making such estimates. Given the subjective nature of even the most conscientiously reported data, surveying agencies should not hesitate to make estimates to supplement survey data. The models or methods used to make estimates should, however, always be indicated together with the results of the survey.

6.4.3.2 The Higher Education Sector

262. The Higher Education sector generally requires large-scale estimations. The distinction between R & D, teaching and other activities is not always obvious in theory (see 2.3.2) let alone in practice, especially in the case of post-graduate studies (see 2.3.2.2). It is an expensive and complex matter to undertake a full survey of R & D activities in this sector and this may only be possible at
rather long intervals. In order to prevent this vital sector from being omitted in the intermediary years it is, therefore, often necessary for the survey agency to make estimates based on ratios derived from time-budget studies or other sources.

263. An additional complication arises from the fact that only some university R & D projects are financed by contracts, grants or other earmarked funds. Others are supported, normally without any administrative record, by public General University Funds (e.g. the cost of the unsponsored research carried out by a faculty member might involve a portion of the teacher's salary, the cost of supplies used, computer costs, library and general university overheads). The total cost of R & D could be estimated, using personnel ratios and various university expenditures. The difference between this estimate and sponsored R & D funds is the contribution of General University Funds. For some purposes it may be sufficient to consider these as the universities' Own Funds and the residual costs of R & D may then be considered as being paid by the Higher Education sector. For the purposes of international comparison it is desirable to show the original source for funds from the general university budget which are used to support R & D, particularly in the case of public GUF. In this case, the original sources of the General University Funds must be prorated and the ratios applied to the residual R & D cost estimates.

6.4.4 Reporting to OECD and to Other International Agencies

264. Authorities carry out R & D surveys to obtain data which are relevant to national pre-occupations and which are collected within the framework of national institutional arrangements. Discrepancies between national practices and the international norms in this or other manuals are, thus, inevitable. Nevertheless, every effort to reduce the impact of such discrepancies should be made when reporting these data to OECD or to other international organisations by making adjustments or estimates even where this will result in R & D data in international sources differing from those in national documents. If national authorities are unwilling to make such adjustments on their own responsibility, they might aid the Secretariats to make informed estimates. Where such adjustments cannot be made, full technical notes should be submitted to the international organisation concerned. Discrepancies are generally of two kinds:

i) Where there is an explicit difference in approach between national R & D surveys and that recommended in this Manual; and

ii) Where there are "implicit" differences between the standard national economic or educational classifications used in
countries' surveys and the corresponding international classifications recommended in this Manual.

It is important to identify and report both kinds of discrepancy. Furthermore, it should be recognised that some classifications recommended in this Manual are not designed to give data which are interesting in their own right at national level or even at international level but rather to yield information which throws light on the international comparability of data (notably, the classifications by type of institution in Chapter III) or is useful for making further calculations (e.g. type of cost data is necessary for calculating R & D deflators, see Chapter VII). These results are, thus, very valuable to the Secretariat even though they may be of little immediate interest to national authorities.
Both these questions involve identifying and summing up differences in price levels for resources devoted to R&D. In the case of deflators, the price changes occur over time and the question is of interest both within individual countries and at international level. In the case of R&D exchange rates the question is only of interest for international comparisons and work is a good deal less advanced.

7.1 R&D Deflators

7.1.1. Introduction

7.1.1.1. The Need for R&D Deflators

As longer R&D expenditure time series become available for Member countries, it becomes increasingly necessary to adjust these for changes in prices, particularly since the acceleration in inflation since the early 1970s in most Member countries. The simplest solution is to use a general price index such as the implicit Gross Domestic Product (GDP) index but, given the special characteristics of R&D costs, this is probably only acceptable in countries with very low rates of inflation. The optimum solution would be to calculate special R&D deflators based on weights and prices which were specific to R&D. The cost and complexity of this exercise rules it out except for specialised analysis.

The most common approach is to use weights derived from R&D surveys combined with proxy prices.

7.1.1.2. Early OECD and National Efforts

Work at the OECD was originally governed by five guidelines laid down in the previous edition of the Frascati Manual*, i.e.:

- Deflators should be produced for homogeneous sectors of the economy, whether or not these correspond with the existing sectoral approach;

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- They should be of Laspeyres form;
- In view of the relative importance of manpower in R & D activities (almost 50 per cent of expenditure) they should receive special attention;
- Practical characteristics of this work should take precedence over theoretical niceties;
- The best possible use should be made of existing sources of information."

270. Since then, Member countries and the OECD Secretariat have been active in this area, particularly in preparing deflators for the Business Enterprise sector. National experts have presented papers on their experience at various meetings. Some of the methodologies described have been very detailed but most have been on broadly the same lines as those developed by the Secretariat for the OECD study of industrial R & D trends in Member countries from 1967 to 1975*.

7.1.1.3. Outline of the Approaches Illustrated in this Chapter

271. The text which follows describes some fairly simple ways of calculating R & D deflators, using weights derived from R & D surveys and proxy prices derived from various national or international sources. Three such methods are explained and illustrated:

- Applying a composite index number to all expenditures using fixed weights (see 7.1.2);
- As above but using changing weights (see 7.1.3);
- Applying separate price indices to the individual expenditure items within sub-classes of a sector (see 7.1.4).

Further details are given on the preparation of sub-weighted indices for labour costs (see 7.1.5). A technical presentation of the calculation of R & D deflators will be found in Annex IV.

272. Rather than describe the methods in a technical way, they are presented as examples for the Business Enterprise sector in an imaginary country. The methodology would be the same for other sectors, though the proxy price indices selected might be different. In this example it is assumed that the Business Enterprise sector is made up of only two industries: (i) Chemicals and (ii) Engineering. R & D statistics are maintained on four classes of expenditure: (i) labour costs, (ii) other current costs, (iii) land and buildings and (iv) instruments and equipment as shown for the period 1970-1980 in Table VII.1.
### Table VII.1

**Basic Data: R & D Expenditure of the Business Enterprise Sector**

(millions of current national currency)

#### A. Chemical Industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Type of Cost</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td></td>
<td>530</td>
<td>300</td>
<td>36</td>
<td>94</td>
<td>960</td>
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#### B. Engineering Industry

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#### C. Sector Total-BERD (A + B)

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<th>Instruments &amp; Equipment</th>
<th>TOTAL</th>
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<td>82</td>
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</table>
7.1.2 Method I - Calculating a Composite Price Index Using Fixed Weights

7.1.2.1 The Weighting System

273. This is the simplest method. The base year for both weights and the prices is taken to be 1970. The 1970 weighting system is based on total BERD (Total intramural R & D expenditures of the Business Enterprise Sector) as shown in Table VII.1.C. It is, thus:

| Labour Costs ... | ... | ... | 57.1% |
| Other Current Costs ... | ... | ... | 32.2% |
| Land and Buildings ... | ... | ... | 3.1% |
| Instruments and Equipment ... | ... | ... | 7.6% |

100.0%

7.1.2.2 Selecting the Proxy Price Indices

274. Proxy price indices for each of these classes are selected from the country's National Accounts or other general sources as shown in Table VII.2. The choice of such proxy price indices is the most important step in the preparation of an R & D deflator and should be made with great care. It is not possible to make firm recommendations, as the amount and type of price index data available varies from country to country. Furthermore some series would be relevant for a deflator for industrial R & D but not, for example, for university R & D.

**Table VII.2**

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs (1)</th>
<th>Other Current Costs (2)</th>
<th>Land and Buildings (3)</th>
<th>Instruments and Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>111.9</td>
<td>100.0</td>
<td>110.0</td>
<td>108.4</td>
</tr>
<tr>
<td>1972</td>
<td>126.3</td>
<td>99.3</td>
<td>121.0</td>
<td>112.0</td>
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<tr>
<td>1973</td>
<td>139.6</td>
<td>109.6</td>
<td>129.0</td>
<td>111.0</td>
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<tr>
<td>1974</td>
<td>157.3</td>
<td>150.0</td>
<td>147.0</td>
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<td>1975</td>
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<td>148.6</td>
<td>160.0</td>
<td>139.0</td>
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<td>1976</td>
<td>197.6</td>
<td>154.9</td>
<td>174.7</td>
<td>147.1</td>
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<td>1977</td>
<td>215.6</td>
<td>153.4</td>
<td>190.3</td>
<td>151.4</td>
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<tr>
<td>1978</td>
<td>236.5</td>
<td>162.5</td>
<td>207.4</td>
<td>155.9</td>
</tr>
<tr>
<td>1979</td>
<td>257.4</td>
<td>164.8</td>
<td>225.5</td>
<td>162.8</td>
</tr>
<tr>
<td>1980</td>
<td>281.9</td>
<td>168.0</td>
<td>245.9</td>
<td>170.9</td>
</tr>
</tbody>
</table>

1) Average weekly earnings in manufacturing industry.
2) Average wholesale price index for materials and supplies consumed by manufacturing industry.
3) Implicit price index for Gross Fixed Capital Formation, "Non-residential buildings" (from National Accounts).
4) Implicit price index for Gross Fixed Capital Formation, "Machinery and other equipment" (from National Accounts).
7.1.2.2.1 Proxies for Labour Costs

275. In the case of Labour Costs two general approaches are possible, either using average R & D labour cost per total R & D person-years or using quite separate proxy series based on wages and salary data. The former type of series are specific to R & D but will not be very exact if there is a significant change in the occupation/qualification pattern within the R & D labour force over the period. Given that such changes have occurred in most Member countries, it is perhaps preferable to use independent wages and salaries data as has been done in the example in Table VII.2. Here one should be careful to select series which are as comparable as possible with the R & D data. Thus, earnings data are generally preferable to rates, and weekly or monthly earnings are preferable to hourly payments. The use of salary scales as proxies for trends in Labour Costs poses some serious problems, notably concerning "grade drift", changes in employers' social security payments and other "fringe benefits", and declining "quantity" of labour inputs due to shorter hours and longer holidays.

7.1.2.2.2 Proxies for Other Current Costs

276. A wide range of proxy indices can be used for Other Current Costs. In the example (see Table VII.2) the average wholesale price index for materials and supplies consumed by manufacturing industry has been used. Other possible choices would have been the implicit price index of the Domestic Product of Industry (DPI) or the consumer price index (excluding food and beverages). This class includes expenditure on fuel and power and it is necessary to select an index which reflects when increased energy prices hit R & D in the sector concerned.

Table VII.3
CALCULATION OF A FIXED WEIGHT INDEX FOR THE BUSINESS ENTERPRISE SECTOR (Method I)

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>TOTAL (HERD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>57.1</td>
<td>32.2</td>
<td>3.1</td>
<td>7.6</td>
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<tr>
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<td>63.9</td>
<td>32.2</td>
<td>3.4</td>
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<td>3.8</td>
<td>8.5</td>
<td>116.4</td>
</tr>
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<td>1973</td>
<td>79.7</td>
<td>35.3</td>
<td>4.0</td>
<td>8.4</td>
<td>127.4</td>
</tr>
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<td>1974</td>
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<td>48.3</td>
<td>4.6</td>
<td>9.4</td>
<td>152.1</td>
</tr>
<tr>
<td>1975</td>
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<td>47.8</td>
<td>4.9</td>
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</tr>
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<td>11.2</td>
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<td>7.6</td>
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</table>
7.1.2.2.3 Proxies for Capital Expenditures

277. Expenditures on Land and Buildings absorb a relatively low share of R & D expenditure and a suitable index can easily be selected from the relevant classes of Gross Fixed Capital Formation (GFCF) from National Accounts. The same approach can be used for R & D expenditure on Instruments and Equipment though it is arguable how far such general price indices reflect changes in R & D instrument costs.

7.1.2.3 Calculating and Applying the Deflator

278. The index is found by taking a weighted average of the proxy indices using the same (i.e. fixed) weights for the whole period. Thus, in this approach the overall index for 1971 is:

\[(0.571 \times 111.9) + (0.322 \times 100.0) + (0.031 \times 110.0) + (0.076 \times 108.4) = 107.7\]

and that for 1972:

\[(0.571 \times 126.3) + (0.322 \times 99.3) + (0.031 \times 121.0) + (0.076 \times 112.0) = 116.4\] etc.

279. The full calculation of the deflator is shown in Table VII.3. This composite index (the Total column in Table VII.3) is the unique deflator in this method and is applied not only to total Business Enterprise expenditures (BERD) but also to the two component industries' expenditures. Table VII.6(a) shows the results when this deflator is applied to the original current price data from Table VII.1.

7.1.3 Method II - Calculating a Composite Price Index With Changing Weights

7.1.3.1 The Weighting System

280. Alternatively a composite price index may be made up, weighted by the relative expenditures on each class of goods or services in BERD in each year as already quoted in Table VII.1. The resulting weights are shown in Table VII.4.

7.1.3.2 The Proxy Price Indices

281. These are the same as in Method I (see Table VII.2).

7.1.3.3 Calculating and Applying the Deflator

282. The price index for each class of expenditure is obtained by multiplying each price index by the proportion of that class to total expenditures in that year. For example, the price index of 1971 is:
### Table VII.4
WEIGHTS USED FOR METHOD II (BASED ON BERD - Table VII.1)

<table>
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<th>Year</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>TOTAL (BERD)</th>
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### Table VII.5
CALCULATION OF A COMPOSITE PRICE INDEX FOR THE BUSINESS ENTERPRISE SECTOR (Method II)

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<th>Labour Costs</th>
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<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>TOTAL</th>
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<td>116.5</td>
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<td>34.9</td>
<td>2.7</td>
<td>6.3</td>
<td>128.2</td>
</tr>
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<td>4.7</td>
<td>5.9</td>
<td>152.7</td>
</tr>
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<td>5.9</td>
<td>7.4</td>
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### Table VII.6(a) - (b)

#### a) R & D EXPENDITURES DEFLATED ACCORDING TO METHOD I

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#### b) R & D EXPENDITURES DEFLATED ACCORDING TO METHOD II

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</tr>
<tr>
<td>1971</td>
<td>975</td>
<td>2278</td>
</tr>
<tr>
<td>1972</td>
<td>924</td>
<td>2410</td>
</tr>
<tr>
<td>1973</td>
<td>868</td>
<td>2317</td>
</tr>
<tr>
<td>1974</td>
<td>932</td>
<td>2409</td>
</tr>
<tr>
<td>1975</td>
<td>996</td>
<td>2445</td>
</tr>
<tr>
<td>1976</td>
<td>955</td>
<td>2309</td>
</tr>
<tr>
<td>1977</td>
<td>957</td>
<td>2265</td>
</tr>
<tr>
<td>1978</td>
<td>976</td>
<td>2237</td>
</tr>
<tr>
<td>1979</td>
<td>997</td>
<td>2220</td>
</tr>
</tbody>
</table>

98
and that for 1972:
\[(0.573 \times 126.3) + (0.318 \times 99.3) + (0.027 \times 121.0) + (0.082 \times 112.0) = 116.5\] etc.

283. Table VII.5 shows the full calculation of the deflator. Here, as in Method I, a unique deflator is generated which is then applied to the data for the component industries (from Table VII.1) as shown in Table VII.6(b).

284. The effect of using Methods I and II can be seen by comparing the results in sections (a) and (b) of Table VII.6.

7.1.4 Method III - Deflating Each Industry's R & D Separately

7.1.4.1 The Weighting System

285. In this system each of the four sub-classes of expenditure (Labour Costs, Other Current Costs, Land and Buildings, Instruments and Equipment) is deflated separately for each of the two industries (Chemicals and Engineering).

7.1.4.2 The Proxy Price Indices

286. The most appropriate indices must be selected for each expenditure class and, as far as possible, separate proxy series should be used for each industry. In the example in Table VII.7 "Average Weekly Wages and Salaries" are taken as proxies for Labour Costs and these are available separately for the Chemical industry and for the Engineering industry. Similarly, "Wholesale Prices for Materials and Supplies" consumed by the two industries are separately available and are taken as proxies for Other Current Expenditures. Given the low weight of capital expenditures, separate industry indices have not been selected and those already used for the preceding methods are retained.

7.1.4.3 Applying the Indices and Calculating an Implicit Deflator

287. Applying these price indices from Table VII.7 to the current R & D expenditures of the two industries from Table VII.1 yields deflated expenditures with 1970 as the base year. For example, 1971 Labour Costs in the Chemical industry, expressed in 1970 prices, would be:
\[600 \div 1.137 = 528\]
The detailed results are shown in Table VII.8.

288. In this method deflated R & D expenditures in the Business Enterprise sector is the sum of deflated expenditures in each cost
Table VII.7
SEPARATE PROXY PRICE SERIES FOR LABOUR COSTS
AND OTHER CURRENT COSTS, BY INDUSTRY,
USED FOR METHOD III

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs(1)</th>
<th>Other Current Costs(2)</th>
<th>Capital Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chemical Industry</td>
<td>Engineering Industry</td>
<td>Chemical Industry</td>
</tr>
<tr>
<td>1970</td>
<td>100</td>
<td>100</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>113.7</td>
<td>113.7</td>
<td>102.0</td>
</tr>
<tr>
<td>1972</td>
<td>127</td>
<td>126</td>
<td>100.0</td>
</tr>
<tr>
<td>1973</td>
<td>145</td>
<td>142</td>
<td>107.3</td>
</tr>
<tr>
<td>1974</td>
<td>163</td>
<td>161</td>
<td>175.3</td>
</tr>
<tr>
<td>1975</td>
<td>184</td>
<td>181</td>
<td>181.2</td>
</tr>
<tr>
<td>1976</td>
<td>200</td>
<td>197</td>
<td>185.4</td>
</tr>
<tr>
<td>1977</td>
<td>219</td>
<td>215</td>
<td>181.1</td>
</tr>
<tr>
<td>1978</td>
<td>238</td>
<td>235</td>
<td>185.0</td>
</tr>
<tr>
<td>1979</td>
<td>259</td>
<td>256</td>
<td>189.0</td>
</tr>
<tr>
<td>1980</td>
<td>283</td>
<td>279</td>
<td>195.0</td>
</tr>
</tbody>
</table>

1) "Average Weekly Wages and Salaries" price index.
2) "Wholesale Prices for Materials and Supplies".

class and industry. An "implicit" price index can be found by comparing BERD at fixed and at current prices as is shown in the last column of the BERD Section of Table VII.8. The implicit deflator can then be compared with those in Tables VII.3 and VII.5.

7.1.5 More Detailed Treatment of Labour Costs

289. Labour is typically the major cost item. It is, therefore, desirable when suitable salary price indices are available, to create a sub-system for Labour Costs for each sector.

7.1.5.1 The Weighting System

290. Since Labour Costs are not usually broken down by category of R & D personnel, staff and salary ratios are used to weight Labour Costs. Assume that in the base year R & D personnel in the Business Enterprise sector was distributed as follows:

<table>
<thead>
<tr>
<th></th>
<th>FTE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers (RSE)</td>
<td>9,600</td>
<td>40</td>
</tr>
<tr>
<td>Technicians</td>
<td>9,600</td>
<td>40</td>
</tr>
<tr>
<td>Other Supporting Staff</td>
<td>4,800</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>24,000</td>
<td>100</td>
</tr>
</tbody>
</table>
**Table VII.8**

DETAILED RESULTS OF DEFLATING R & D EXPENDITURES IN THE BUSINESS ENTERPRISE SECTOR USING METHOD III

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>BERD</th>
<th>Implicit BERD Deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>530</td>
<td>300</td>
<td>36</td>
<td>94</td>
<td>960</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>528</td>
<td>294</td>
<td>36</td>
<td>101</td>
<td>959</td>
<td>109.5</td>
</tr>
<tr>
<td>1972</td>
<td>512</td>
<td>316</td>
<td>18</td>
<td>79</td>
<td>925</td>
<td>116.3</td>
</tr>
<tr>
<td>1973</td>
<td>477</td>
<td>281</td>
<td>22</td>
<td>76</td>
<td>856</td>
<td>129.2</td>
</tr>
<tr>
<td>1974</td>
<td>494</td>
<td>217</td>
<td>38</td>
<td>76</td>
<td>825</td>
<td>161.9</td>
</tr>
<tr>
<td>1975</td>
<td>487</td>
<td>235</td>
<td>62</td>
<td>82</td>
<td>866</td>
<td>177.4</td>
</tr>
<tr>
<td>1976</td>
<td>510</td>
<td>282</td>
<td>76</td>
<td>75</td>
<td>943</td>
<td>189.4</td>
</tr>
<tr>
<td>1977</td>
<td>506</td>
<td>311</td>
<td>21</td>
<td>73</td>
<td>911</td>
<td>200.0</td>
</tr>
<tr>
<td>1978</td>
<td>512</td>
<td>289</td>
<td>46</td>
<td>75</td>
<td>922</td>
<td>213.2</td>
</tr>
<tr>
<td>1979</td>
<td>524</td>
<td>320</td>
<td>25</td>
<td>74</td>
<td>945</td>
<td>226.7</td>
</tr>
<tr>
<td>1980</td>
<td>537</td>
<td>327</td>
<td>23</td>
<td>79</td>
<td>966</td>
<td>243.3</td>
</tr>
</tbody>
</table>

**CHEMICAL INDUSTRY**

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>BERD</th>
<th>Implicit BERD Deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>683</td>
<td>385</td>
<td>29</td>
<td>68</td>
<td>1165</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>688</td>
<td>456</td>
<td>46</td>
<td>110</td>
<td>1300</td>
<td>107.9</td>
</tr>
<tr>
<td>1972</td>
<td>760</td>
<td>576</td>
<td>45</td>
<td>128</td>
<td>1509</td>
<td>114.6</td>
</tr>
<tr>
<td>1973</td>
<td>777</td>
<td>585</td>
<td>28</td>
<td>88</td>
<td>1478</td>
<td>127.6</td>
</tr>
<tr>
<td>1974</td>
<td>786</td>
<td>554</td>
<td>39</td>
<td>84</td>
<td>1463</td>
<td>150.0</td>
</tr>
<tr>
<td>1975</td>
<td>792</td>
<td>623</td>
<td>30</td>
<td>75</td>
<td>1520</td>
<td>160.1</td>
</tr>
<tr>
<td>1976</td>
<td>797</td>
<td>621</td>
<td>31</td>
<td>72</td>
<td>1521</td>
<td>170.1</td>
</tr>
<tr>
<td>1977</td>
<td>705</td>
<td>639</td>
<td>14</td>
<td>66</td>
<td>1444</td>
<td>177.6</td>
</tr>
<tr>
<td>1978</td>
<td>700</td>
<td>636</td>
<td>12</td>
<td>83</td>
<td>1431</td>
<td>187.9</td>
</tr>
<tr>
<td>1979</td>
<td>679</td>
<td>620</td>
<td>12</td>
<td>82</td>
<td>1393</td>
<td>198.8</td>
</tr>
<tr>
<td>1980</td>
<td>668</td>
<td>618</td>
<td>10</td>
<td>72</td>
<td>1368</td>
<td>210.7</td>
</tr>
</tbody>
</table>

**ENGINEERING INDUSTRY**

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>BERD</th>
<th>Implicit BERD Deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>1213</td>
<td>685</td>
<td>65</td>
<td>162</td>
<td>2125</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>1216</td>
<td>750</td>
<td>82</td>
<td>211</td>
<td>2259</td>
<td>108.6</td>
</tr>
<tr>
<td>1972</td>
<td>1272</td>
<td>892</td>
<td>63</td>
<td>207</td>
<td>2434</td>
<td>115.3</td>
</tr>
<tr>
<td>1973</td>
<td>1254</td>
<td>866</td>
<td>50</td>
<td>164</td>
<td>2334</td>
<td>128.2</td>
</tr>
<tr>
<td>1974</td>
<td>1279</td>
<td>771</td>
<td>77</td>
<td>150</td>
<td>2288</td>
<td>154.0</td>
</tr>
<tr>
<td>1975</td>
<td>1307</td>
<td>858</td>
<td>92</td>
<td>157</td>
<td>2386</td>
<td>166.4</td>
</tr>
<tr>
<td>1976</td>
<td>1307</td>
<td>903</td>
<td>107</td>
<td>147</td>
<td>2464</td>
<td>177.9</td>
</tr>
<tr>
<td>1977</td>
<td>1211</td>
<td>930</td>
<td>35</td>
<td>159</td>
<td>2353</td>
<td>186.2</td>
</tr>
<tr>
<td>1978</td>
<td>1212</td>
<td>925</td>
<td>58</td>
<td>158</td>
<td>2353</td>
<td>197.8</td>
</tr>
<tr>
<td>1979</td>
<td>1203</td>
<td>942</td>
<td>37</td>
<td>156</td>
<td>2338</td>
<td>210.1</td>
</tr>
<tr>
<td>1980</td>
<td>1205</td>
<td>945</td>
<td>33</td>
<td>151</td>
<td>2334</td>
<td>224.2</td>
</tr>
</tbody>
</table>

291. Assume that the average annual salary scales, adjusted where relevant for varying rates of employers' social security contributions, are:

<table>
<thead>
<tr>
<th>Units of National Currency</th>
<th>Relative Salary Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers (RSE)</td>
<td>61,670</td>
</tr>
<tr>
<td>Technicians</td>
<td>46,250</td>
</tr>
<tr>
<td>Other Supporting Staff</td>
<td>37,000</td>
</tr>
</tbody>
</table>

101
292. This yields:

<table>
<thead>
<tr>
<th></th>
<th>Quantity Ratio ($)</th>
<th>Relative Salary Ratios (%)</th>
<th>Labour Cost Ratio ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers (RSE)</td>
<td>40.0</td>
<td>x 1.00 = 40</td>
<td>48.8</td>
</tr>
<tr>
<td>Technicians</td>
<td>40.0</td>
<td>x 0.75 = 30</td>
<td>36.6</td>
</tr>
<tr>
<td>Other Supporting Staff</td>
<td>20.0</td>
<td>x 0.60 = 12</td>
<td>14.6</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>82</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table VII.9(a)-(b)

SALARIES (MONTHLY) OF SELECTED OCCUPATIONS 1970-1980
(For calculations of Detailed Labour Cost Indices)

a) Units of National Currency

<table>
<thead>
<tr>
<th>Year</th>
<th>RSE</th>
<th>Technicians</th>
<th>Clerical Staff</th>
<th>RSE</th>
<th>Technicians</th>
<th>Clerical Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>5139</td>
<td>3856</td>
<td>3105</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1971</td>
<td>5910</td>
<td>4319</td>
<td>3478</td>
<td>115</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>1972</td>
<td>6475</td>
<td>4743</td>
<td>3819</td>
<td>126</td>
<td>123</td>
<td>123</td>
</tr>
<tr>
<td>1973</td>
<td>7143</td>
<td>5398</td>
<td>4378</td>
<td>139</td>
<td>140</td>
<td>141</td>
</tr>
<tr>
<td>1974</td>
<td>7811</td>
<td>6247</td>
<td>4999</td>
<td>152</td>
<td>162</td>
<td>161</td>
</tr>
<tr>
<td>1975</td>
<td>8890</td>
<td>7018</td>
<td>5620</td>
<td>173</td>
<td>182</td>
<td>181</td>
</tr>
<tr>
<td>1976</td>
<td>9918</td>
<td>7635</td>
<td>6086</td>
<td>193</td>
<td>198</td>
<td>196</td>
</tr>
<tr>
<td>1977</td>
<td>10946</td>
<td>8329</td>
<td>6676</td>
<td>213</td>
<td>216</td>
<td>215</td>
</tr>
<tr>
<td>1978</td>
<td>12025</td>
<td>9139</td>
<td>7328</td>
<td>234</td>
<td>237</td>
<td>236</td>
</tr>
<tr>
<td>1979</td>
<td>13104</td>
<td>9987</td>
<td>8011</td>
<td>255</td>
<td>259</td>
<td>258</td>
</tr>
<tr>
<td>1980</td>
<td>14538</td>
<td>10912</td>
<td>8736</td>
<td>279</td>
<td>283</td>
<td>282</td>
</tr>
</tbody>
</table>

Table VII.10

COMPOSITE LABOUR COST INDEX

<table>
<thead>
<tr>
<th>Year</th>
<th>RSE</th>
<th>Technicians</th>
<th>Clerical Staff</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>48.8</td>
<td>36.6</td>
<td>14.6</td>
<td>100.0</td>
</tr>
<tr>
<td>1971</td>
<td>56.1</td>
<td>41.0</td>
<td>16.4</td>
<td>113.5</td>
</tr>
<tr>
<td>1972</td>
<td>61.5</td>
<td>45.0</td>
<td>18.0</td>
<td>124.5</td>
</tr>
<tr>
<td>1973</td>
<td>67.8</td>
<td>51.2</td>
<td>20.6</td>
<td>139.6</td>
</tr>
<tr>
<td>1974</td>
<td>74.2</td>
<td>59.3</td>
<td>23.5</td>
<td>157.0</td>
</tr>
<tr>
<td>1975</td>
<td>84.4</td>
<td>66.6</td>
<td>26.4</td>
<td>177.4</td>
</tr>
<tr>
<td>1976</td>
<td>94.2</td>
<td>72.5</td>
<td>28.6</td>
<td>195.3</td>
</tr>
<tr>
<td>1977</td>
<td>105.9</td>
<td>79.1</td>
<td>31.4</td>
<td>214.4</td>
</tr>
<tr>
<td>1978</td>
<td>114.2</td>
<td>86.7</td>
<td>34.5</td>
<td>235.4</td>
</tr>
<tr>
<td>1979</td>
<td>124.4</td>
<td>94.8</td>
<td>37.7</td>
<td>256.9</td>
</tr>
<tr>
<td>1980</td>
<td>136.2</td>
<td>103.6</td>
<td>41.2</td>
<td>281.0</td>
</tr>
</tbody>
</table>

7.1.5.2 Selecting the Proxy Price Indices

293. Proxy salary series must be chosen. For example, the Central Government may maintain a Pay Research Bureau in order to ensure that the salaries of public servants are comparable to equivalent workers in other sectors or professional associations may publish salary data.
for their members. Table VII.9(a) indicates actual salary series 1970-1980 for proxy categories of occupations, from which indices are derived [VII.9(b)].

7.1.5.3 Calculating and Applying the Composite Labour Cost Index

294. The composite labour cost index is created by multiplying the three salary indices in Table VII.9(b) by the appropriate cost-ratio weights. For example, the index for 1971:

\[(115.0 \times 0.488) + (112.0 \times 0.366) + (112.0 \times 0.146) = 113.5\] etc.

as shown in Table VII.10.

295. Note that this method provides a single labour cost index for the whole Business Enterprise sector. It would be possible to develop separate weighting systems for each industry by using the numbers of RSE, technicians and supporting staff in each which would result in different final labour cost indices. In a more sophisticated approach different price lines might be used for each industry.

7.2 R & D EXCHANGE RATES

7.2.1 Introduction

7.2.1.1 The Need for R & D Exchange Rates

296. Many international comparisons depend on conversion of expenditures to a common currency. Traditionally for R & D statistics this has been the United States dollar. However, there are two major disadvantages to using current exchange rates for the conversion. The first is that the exchange rates do not necessarily reflect the internal purchasing power parities (PPP) for R & D resources; the second is that many exchange rates are now floating and they may fluctuate relatively widely over a fairly short period of time. This problem of fluctuating exchange rates can be resolved by using a moving average exchange rate (a three year moving average should be sufficient) but that of establishing R & D purchasing power parities is more intractable.

7.2.1.2 Outline of the Approach Illustrated in this Chapter

297. The various possible methods of calculating such R & D exchange rates are extremely similar to those already described for R & D deflators except that years are replaced by countries. The same problems thus arise:

- Choosing a weighting system (see 7.2.2).
- Selecting proxy purchase power parities (see 7.2.3).

Here again the approach will be illustrated by means of an example, in this case how to establish an R & D exchange rate for the Higher
Education sector between country R ("Ruritania" having "ducats" as its national currency) and four other countries (A, B, C and D).

7.2.2 Choosing a Weighting System

298. The pioneering efforts in calculating R & D exchange rates made by Professor C. Freeman* in the early 1960s used a statistical method essentially similar to those involved in international comparisons of national products which were developed at the OEEC in the 1950s. The cost of the items in a typical "basket of goods" of country A was calculated at the prices of country B and their sum compared with the original cost in country A. Similarly, the typical "basket of goods" in country B was compared at its price in A and its price at home. The two resulting ratios were averaged and the ratio applied to the official exchange rate to give "purchasing power equivalent" for the field in question.

299. This method has two linked disadvantages. The first is that it yields two results and, therefore, it might be useful to see some method of averaging. It is a matter of discussion whether the arithmetic mean, the geometric or a combination of the two should be used. Secondly, the method is not transitive. Countries can only properly be compared in pairs. If we calculate a "purchasing power equivalent" between country A and country B and between country B and country C, we cannot, properly speaking, use these results to draw any comparison between country A and country C. In practice, then, we cannot use the calculations directly to find a ratio between countries A and C but must repeat the operation in each instance.

300. A new approach was used by A.S. MacDonald* in the late 1960s. The main change was that he adopted the idea of an average basket of goods (based on the arithmetic average of quantities consumed by the countries concerned of the various items included in the R & D basket). He calculated sub-exchange rates for three types of expenditure (labour costs, other current costs and capital expenditures) and then took a weighted average of these to find overall R & D exchange rates. The disadvantage of this approach is that it requires rather precise details about the actual "quantities" of inputs in the individual countries in order to calculate the "average basket of R & D goods". However, by using not actual prices but price ratios it is possible to use MacDonald's method with a weighting system based on average expenditure by type of cost.

301. Thus in our example, the weights are based on the average cost pattern in the four countries concerned:
Labour Costs 70%
Other Current Costs 20%
Land and Buildings 5%
Instruments and Equipment 5%
as shown in Table VII.11.

7.2.3 Choice of Proxy Parities
7.2.3.1 General Lack of Suitable Data
302. The main source has to be general comparisons of purchasing power, e.g. as prepared for National Accounts. Two major series of such comparisons have been made, the first by OECD* in the late 1950s and the second by the World Bank* (base year 1970) followed up by the EEC* (base year 1975). The latter cover only about half OECD Member countries. For example, in an OECD report on industrial R & D published in 1978, even though only 11 Member countries were included, coverage by the PPP studies cited above was not complete.

<table>
<thead>
<tr>
<th>Country</th>
<th>World Bank Study</th>
<th>EEC Study</th>
<th>Neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

303. The methodology used by the OECD Secretariat to calculate R & D exchange rates for the above project is described in Annex II of "Trends in Industrial R & D in Selected OECD Member Countries, 1967-1975".*

7.2.3.2 Proxies for Labour Costs
304. There are three possible approaches to this sub-class:

i) One may establish a sub-weighting system by type of personnel similar to that described in Section 7.1.5 for the deflator and compare salaries for each of these classes. The main problem here is that mentioned in Chapter V (see 5.2.4) i.e. that some countries use a break by qualification and others by occupation.
### Table VII.11
AVERAGE WEIGHTING SYSTEM FOR AN EXPERIMENTAL HERD(1)
EXCHANGE RATE (1975)

<table>
<thead>
<tr>
<th>Country</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>TOTAL (HERD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>71</td>
<td>19</td>
<td>4</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>74</td>
<td>21</td>
<td>3</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>73</td>
<td>19</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>67</td>
<td>18</td>
<td>7</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>D</td>
<td>65</td>
<td>23</td>
<td>7</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Average</td>
<td>70</td>
<td>20</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table VII.12
CALCULATION OF A ROUGH EXPERIMENTAL HERD(1) EXCHANGE RATE -
PARITIES COMPARED WITH CURRENT EXCHANGE RATES 1975

<table>
<thead>
<tr>
<th>Country</th>
<th>Labour Costs</th>
<th>Other Current Costs</th>
<th>Land and Buildings</th>
<th>Instruments &amp; Equipment</th>
<th>R &amp; D Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.309</td>
<td>1.331</td>
<td>1.256</td>
<td>1.068</td>
<td>1.300</td>
</tr>
<tr>
<td>B</td>
<td>1.221</td>
<td>1.177</td>
<td>0.999</td>
<td>1.074</td>
<td>1.196</td>
</tr>
<tr>
<td>C</td>
<td>0.726</td>
<td>0.689</td>
<td>1.033</td>
<td>1.025</td>
<td>0.749</td>
</tr>
<tr>
<td>D</td>
<td>0.631</td>
<td>0.683</td>
<td>0.693</td>
<td>1.070</td>
<td>0.667</td>
</tr>
</tbody>
</table>

### Table VII.13
HERD(1) AND HERD PER RSE (NSE + SSH) AT CURRENT AND ADJUSTED
EXCHANGE RATES 1975

<table>
<thead>
<tr>
<th>Country</th>
<th>HERD (ducats millions)</th>
<th>HERD per RSE (ducats thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Rates</td>
<td>Adjusted Rates</td>
</tr>
<tr>
<td>B</td>
<td>933</td>
<td>780</td>
</tr>
<tr>
<td>A</td>
<td>411</td>
<td>316</td>
</tr>
<tr>
<td>RURITANIA</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>C</td>
<td>503</td>
<td>672</td>
</tr>
<tr>
<td>D</td>
<td>392</td>
<td>590</td>
</tr>
</tbody>
</table>

1) Total intramural R & D expenditure in the Higher Education Sector.
ii) One may take average labour cost per R & D person-year as was done in the above-mentioned OECD study of trends in industrial R & D. *

iii) One may choose a labour-cost parity from a general purchasing power parity study. Both the general PPP studies mentioned above are based on national accounts classes. They, therefore, provide purchasing power parities for labour costs in the public sector only.

In this example for the Higher Education sector, the PPP for the “Collective Consumption of General Government: Compensation of Employees; Education” is used, as shown in Table VII.12.

7.2.3.3 Proxies for Other Current Costs and Capital Expenditures

305. For these subclasses virtually the only approach is to use data from existing PPP studies (though MacDonald did attempt to calculate ratios for instruments and equipment using foreign trade values). In the present example the following parities have been selected as proxies for Higher Education R & D prices:

<table>
<thead>
<tr>
<th>Other Current Costs:</th>
<th>Collective consumption of general government TOTAL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruments and Equipment:</td>
<td>Gross fixed capital formation: plant and machinery, arithmetic average of:</td>
</tr>
<tr>
<td></td>
<td>- office and data processing machinery;</td>
</tr>
<tr>
<td></td>
<td>- telecommunications, meters, electro-medical equipment;</td>
</tr>
<tr>
<td></td>
<td>- electronic equipment;</td>
</tr>
<tr>
<td></td>
<td>- optical instruments and photographic equipment.</td>
</tr>
</tbody>
</table>

7.2.4 Calculating and Applying the Adjusted Exchange Rates

306. In this example the exercise gives "adjusted ducats". The calculation of the parity between countries R and A, as compared with the current exchange rate, is thus:

\[
(0.7 \times 1.309) + (0.2 \times 1.331) + (0.05 \times 1.256) + (0.05 \times 1.068) = 1.300.
\]

For further details see Table VII.12. The use of a current exchange rate thus overestimates Higher Education R & D expenditures in A significantly compared with the situation in country R as can be seen from Table VII.13.
7.3 CONCLUSIONS

307. Although the work on R & D price indices and on R & D exchange rates are very similar, the former is much more advanced than the latter and several Member countries have established quite detailed systems. The problem of purchasing power parities will probably never be completely solved and it will be necessary to use partial and out-of-date studies to link some countries to the PPP of other, better documented, countries and to use vague proxies for the others such as the indices prepared by international organisations to set the living allowances of officers in different countries.
Chapter VIII

THE SOCIO-ECONOMIC OBJECTIVES OF GOVERNMENT R & D FUNDING

8.1 INTRODUCTION

308. At the last revision to the Manual some broad instructions on the collection of government R & D funding data were inserted for the first time. Since then, three OECD surveys have been held for which the majority of Member countries have submitted data on the socio-economic objectives of their governments R & D funding and it has become clear that the problems of this type of analysis are somewhat different from those for performer-based R & D surveys. For this reason a special supplement to the Manual is being prepared giving detailed guidelines for the collection and analysis of government R & D funding by socio-economic objectives(*).

309. In the meantime the present chapter outlines the main characteristics of this type of analysis, highlighting the differences between it and the standard performer-based R & D account methods discussed in the earlier chapters. It is intended to be of use not only to those collecting such data and submitting it for OECD surveys but also to those using the resulting OECD statistical series for their own studies.

8.2 RELATIONSHIP WITH OTHER INTERNATIONAL STANDARDS

310. As far as possible the definitions and distributions discussed in this chapter are compatible with the methodologies developed by the EEC (NASB)(* and NORDFORSK(*).

8.3 SOURCES OF DATA ON THE SOCIO-ECONOMIC OBJECTIVES OF GOVERNMENT R & D FUNDING

311. Data on the socio-economic objectives of R & D funding are rarely obtained by special surveys. They generally have to be
extracted in some way from national budgets which already have their own methodology and terminology. The preparation of such data is, thus, subject to special constraints and norms cannot be stated in such a categoric way as for other types of R & D data.

8.4 COVERAGE OF R & D

8.4.1 Basic Definition

312. The basic definition is that quoted at the beginning of Chapter II (see 2.1). Basic research, applied research and experimental development are all included but are not identified separately.

8.4.2 Fields of Science and Technology

313. The analysis covers NSE plus SSH without any distinction between the two.

8.4.3 Identifying R & D

314. As far as possible all the guidelines and conventions for distinguishing R & D from non-R & D activities listed in Chapter II should be applied. Particular care should be taken to check the real R & D content of budget items officially described as "Development contracts" or as "Purchase of prototypes" as discussed in Chapters II and V (see 2.3.4 and 5.3.3.2.2).

8.5 DEFINITION OF GOVERNMENT

315. According to Chapter III "government" should cover central (or federal), provincial (or state) and local government (see 3.5). For the purposes of government R & D funding, however, it is recommended that:

i) Central or Federal government should always be included.

ii) Provincial or state government should be included where its contribution is significant.

iii) Local government funds (i.e. raised by local taxes) should be excluded.
8.6 COVERAGE OF GOVERNMENT FUNDING

8.6.1 Intramural and Extramural Expenditures

Government R & D funding covers not only government-financed R & D performed in government establishments, but also government-financed R & D in the other three national sectors (Business Enterprise, Private Non-Profit, Higher Education) and also Abroad (including international organisations).

8.6.2 "Funding" and "Performer-Based" Reporting

R & D expenditures can be reported either by the agency which provided the money (funding) or the agency which actually performs the R & D. In general, the body of the Manual recommends the latter approach which is used in the standard tables in the ISY surveys. However the contrary is true for the objectives series.

Government R & D funding data should be based on the reports of the funder rather than the performer.

8.6.3 Budgetary and Extra-Budgetary Funds

Government funding clearly includes all outlays to be met from taxation.

A problem arises with money spent on R & D by government but financed from other sources. In some countries these may be included in the budget on the grounds that the agency concerned needs government permission to spend them (gross approach). In others they may be excluded and only newly voted money included (net approach). When dealing with these "extra-budgetary" sources a distinction should be made between:
- Contracts or grants from other sectors for the performance of R & D by government establishments;
- Other extra-budgetary funds such as the retained receipts of government laboratories, receipts from levies, etc.

8.6.3.1 Receipts for R & D Performed for Other Sectors

Such payment should always be credited to the sector of origin and should not be included in government R & D funding.
8.6.3.2 **Other Extra-Budgetary Funds**

320. No guidelines can be suggested but their treatment should always be made explicit in accompanying notes.

8.6.4 **Direct and Indirect Funding**

8.6.4.1 **Treatment of Public General University Funds (GUF)**

321. It is a matter of discussion whether or not such funds should be credited to government as a source of funds in standard R & D surveys. Nevertheless,

> Government funding includes public General University Funds

8.6.4.2 **Loans and Indirect Funding of Industrial R & D**

322. As far as possible the instructions in Chapter V both with regard to loans and to indirect funding apply (see 5.3.3.2.1). Thus, loans which may be forgiven should be included in government R & D funding but loans which are to be repaid and indirect support of industrial R & D via tax rebates etc. should in principle be excluded. Nevertheless, when such indirect support programmes are undertaken as part of an integrated R & D policy (for example when the sources are documented and are included in interministerial discussions of a science budget) they may be included in government R & D funding but **indirect funding should always be declared separately so that it can be excluded when making certain international comparisons**.

8.6.5 **Type of Expenditures**

8.6.5.1 **General Coverage**

323. Government funding includes both current and capital expenditure.

8.6.5.2 **Money Carried Forward**

324. In some countries it is budgetary practice to carry forward large sums from one year to another, sometimes including them in votes in successive years.

> Data should be reported for a single year and any double counting for money carried forward should be excluded.
8.6.6 Stages of Government R & D Funding

325. A number of efforts have been made to establish exhaustive typologies of all the stages of government R & D funding, from projections through to final outlays(*). However in practice the points at which it is both meaningful and practical to measure government funding vary from one country to another.

326. For this reason no detailed recommendations can be made for OECD surveys. Nevertheless it is suggested that:

- data for the current and coming years should be initial intentions data i.e. which reflect the amount the government intends to devote to R & D. Such data become obsolete once the year is completed and are therefore not generally suitable for stocking in time series;
- data for past years should be based on final measures of government R & D funding ranging from final intentions as reflected in the definitive budget to final outlays. A measure should be chosen by national authorities which can be meaningfully stocked as a time series.

8.7 DISTRIBUTION BY SOCIO-ECONOMIC OBJECTIVES

8.7.1 The Criteria for Distribution

8.7.1.1 Purpose or Content

327. Two approaches to distribution are possible:

i) according to the purpose of the R & D programme or project;
ii) according to the general content of the R & D programme or project.

The difference between the two is illustrated by the following example:

- A research project on the effects of various chemicals which could be used as weapons on human body functions. The purpose is "defence" but the general content is "human health".
- A research project to develop fuel cells to provide power in remote forest locations, financed by the Ministry of Agriculture. The purpose is "agriculture, forestry and fishing" but the R & D content is "energy".

Other examples will be found under the objective "Promotion of industrial development" (see 8.7.3.2.2).

328. The collection of purpose is the more fundamental from the viewpoint of government policy and it is this approach which is used in principle for the collection of government R & D funding by socio-economic objective.
8.7.1.2. Primary and Secondary Objectives

329. Though some government-supported R & D programmes have only one purpose, others may be supported for a number of complementary reasons. For example, a government may commit money to an aircraft project primarily for military reasons but also to encourage export sales by the aerospace industry and even to assist "spin-off" to civil aviation. However, when reporting to OECD, R & D should be classified according to its primary objective.

8.7.1.3 Identifying Primary Objectives

330. Where there are problems of identifying the primary purpose of the funder of the R & D or where there seem to be differences between the "purpose" and the "content" of a programme two principles originally developed for NASB may be of use:

i) Direct derivation
   A project which owes its existence solely to the technical needs of another programme is directly derived from the said programme and should be classified with it.

ii) Indirect spin-off
    Where the results of R & D undertaken for one purpose are subsequently reworked to give an application relevant to another objective, this is indirect spin-off and should be credited to the objective to which the subsequent R & D is oriented.

8.7.2 The Unit Distributed

331. The allocation of R & D expenditure to socio-economic objectives should be made at the level which permits the most accurate reflection of the purposes of the funder. The actual reporting level chosen (and, thus, the unit distributed) will depend on the practical possibilities of a particular situation and on the method of planning, organising and executing research programmes.

8.7.3 The Distribution

8.7.3.1 Introduction

332. The distribution list consists of twelve categories of objectives which have been drawn up primarily for use in analysis of government R & D funds. The list is experimental in the sense that it will be modified in the light of practical experience. It is also evolutionary in that it will be changed over time to reflect changes
in the concerns of governments. The descriptive text for each category of objectives is indicative rather than complete. In order to assist the Secretariat in analysis and to make it possible to provide more complete listings of the scope of the individual objectives, Member countries should report their objectives by major subcategories, especially those relevant to policy. 333. This distribution scheme draws heavily on the objective lists of Nordforsk and the European Communities (EEC) (Tables VIII.1 and VIII.2 give keys between their lists and the OECD categories). In general, it reflects the overall purposes for which funds have been committed to R & D programmes rather than the fields of science involved.

8.7.3.2 The List of Socio-Economic Objectives

8.7.3.2.1 Development of Agriculture, Forestry and Fishing

334. This group covers all R & D primarily intended to develop and support these activities (ISIC*, Major division 1), including for example relevant work on chemicals and mechanisation. It excludes R & D in favour of the food processing and packaging industries which should be included in objective 8.7.3.2.2 below.

8.7.3.2.2 Promotion of Industrial Development

335. This group includes R & D programmes whose primary objective is to support the development of industry. The core of this class will consist of R & D programmes in favour of manufacturing industry (ISIC*, Major division 3) but it also contains R & D in favour of the construction industry (ISIC, Major division 5), the wholesale and retail trade, restaurants and hotels (ISIC, Major division 6), banking, insurance and other commercial services (ISIC, Major division 8) or in favour of industry in general. It does not include R & D performed by industry (principally financed from public funds) in support of other objectives, for example in the fields of space, defence, transportation and telecommunications, although these obviously have an important secondary effect on the development of the industries concerned. If R & D is supported for a communal project it should be excluded from this class and included under the relevant objective. For example, the development of a new type of rolling stock as part of a reorganisation of the nation's railways should be classified under "transport". Redevelopment of similar rolling stock in view of export sales belongs under the present heading. Similarly R & D in support of tourism as a cultural activity should be included under objective 8.7.3.2.8, but R & D mainly intended to improve the commercial prospects of the hotel and tourism industry should be included here. (Also see 8.7.3.3)
8.7.3.2.3 Production and Rational Use of Energy

336. All R & D activities aimed at the supply, production, conservation and distribution of all forms of energy, except R & D on means of propulsion for vehicles and rockets. R & D on water as a source of energy should be included. R & D on nuclear energy should be included but reported separately. Those countries where all nuclear R & D is funded through an integrated national programme which cannot be sub-divided should report the total sum giving as many details as possible on the non-energy R & D projects included. (Also see 8.7.3.3.4.)

8.7.3.2.4 Transport and Telecommunications

337. This includes:
- R & D directed towards better and safer transportation systems including traffic safety (except when an integral part of urban and rural planning).
- R & D on all telecommunication services (except satellites) as well as R & D on the planning and organisation of networks.

8.7.3.2.5 Urban and Rural Planning

338. R & D referring to the total planning of urban and rural areas, better housing and improvements to the community environment (e.g. siting of hospitals, sound insulation, etc.). The intention here is the integrated planning that attempts to co-ordinate various elements and create a "total environment".

8.7.3.2.6 Protection of the Environment

339. This group covers R & D directed towards an "undestroyed" physical environment. It includes all R & D on pollution: causes, diffusion and conversion, effects on man and the environment. It covers pollution in or due to: air, water, soil and sub-strata, noise, solid waste disposal and radiation. It excludes R & D designed to prevent pollution in those activities which might cause pollution; this should be assigned to the class relevant to that activity.

8.7.3.2.7 Health (Excluding Pollution)

340. R & D programmes directed towards the protection and improvement of human health. It includes R & D on food hygiene and nutrition and also R & D on radiation used for medical purposes, biochemical engineering, medical information, rationalisation of treatment and pharmacology (including testing medicines and breeding of laboratory animals for scientific purposes) as well as research relating to epidemiology, prevention of industrial diseases and drug addiction.

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Social Development and Services

341. R & D related to social and cultural problems includes, for example, social security, social services, social relations, culture, recreation and leisure, law and order, consumer protection, working conditions, labour relations, manpower development, public administration, national economy, peace and other international objectives. This group should be sub-classified in as much detail as possible using whatever classification respondents think relevant.

Exploration and Exploitation of the Earth and Atmosphere

342. This heading covers exploration and exploitation of the earth's crust and mantle, seas, oceans and the atmosphere. It does not include the study of pollution, the study of soils for agricultural purposes, or fishing. It includes R & D on meteorology (except when conducted by satellite).

General Advancement of Knowledge

343. This class includes all R & D which contributes to the general advancement of knowledge and which cannot be attributed to a specific objective. When reporting data for total public support for R & D by "purpose" this class should include, by convention, all R & D financed from general purpose grants from ministries of education, although in some countries many of these programmes may be relevant to other objectives. This convention has been adopted because of the problems of obtaining suitable data and thus of comparability. Member countries should provide the most detailed possible breakdown of the "contents" of this class by field of science and technology and, where they are able to do so, by objectives.

Civil Space

344. This class covers all civil R & D concerning space (also see 8.7.3.3.1).

Defence

345. Defence includes all R & D programmes undertaken primarily for military reasons regardless of their content or whether they have secondary civil applications. It includes nuclear and space R & D undertaken for military purposes. It does not include civil R & D financed by ministries of defence, for instance on meteorology or telecommunications.

Principal Areas of Difficulty

346. The OECD distribution as it stands is, broadly speaking, an amalgam of the EEC and the NORDFORSK classifications. As such it
does not have a truly logical structure. Furthermore, the results of
the three ISYs for which it has been used have shown that it contains
some overlapping and one or two gaps. Also there are some objectives
which are not relevant in a number of Member countries.

8.7.3.3.1 Civil Space

347. Civil space R & D is not a purpose in its own right for most
Member countries as such R & D is usually undertaken for another
purpose such as advancement of knowledge (astronomy) or for specified
applications (e.g. telecommunications satellites). Nevertheless, it
has been maintained in the list for the time being as it cannot be
deleted without greatly altering the distribution amongst the other
objectives to which it would be reallocated for the few Member
countries which do have major space programmes.

8.7.3.3.2 Mining

348. A specific problem occurs with the treatment of mining and pro­
specting. The current OECD distribution list does not include any
mention of mining or prospecting. Both NURDFORSK and NASB 1975 agree
that R & D related to "prospecting" should be included in "Explora­
tion and Exploitation of Earth and Atmosphere"; however, they part
company on "mining". According to the NORDFORSK classification, all
R & D in favour of the mining industry should be included in "Indus­
trial Development" whereas according to NASB 1975 "fuel mining and
extraction" belong in "Energy" but "mining of metals or non-metallic
minerals" (other than fuel) belongs in "Industrial Development". When
reporting to OECD, "independent" Member countries (i.e. who do
not use either NORDFORSK or NASB 1975) have tended to include most or
all mining R & D in "Exploration and Exploitation of Earth and
Atmosphere". Until such a time as full agreement can be reached on
this point, it is most important that the treatment of mining R & D
should be mentioned specifically.

8.7.3.3.3 Construction

349. A further difference occurs with respect to construction.
Logically, if one is applying main purpose analysis with the aid of
the "derivation" convention (see 8.7.1.3) then construction R & D
programmes should be broken down according to their main aim (missile
silos in "Defence", hospitals in "Health", agricultural buildings in
"Agriculture", etc. and R & D in favour of the building industry in
"Industrial Development"). This would leave a residual problem of
where to classify construction R & D n.e.c. However, NASB has chosen
the contrary approach stating that construction R & D should not be
considered as derived except in the case of "defence" and "space"
programmes. According to NASB, R & D on construction materials
belong in "Industrial Development" but general construction R & D
Table VIII.1
STANDARD KEY BETWEEN EEC (NASB 1975)
AND OECD OBJECTIVES

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<tr>
<th>OECD Objectives</th>
<th>Agriculture For. &amp; Fish. Development</th>
<th>Industrial Development</th>
<th>Energy</th>
<th>Transport &amp; Telecom.</th>
<th>Urban &amp; Rural Planning</th>
<th>Environment Protection</th>
<th>Health</th>
<th>Social Dev. &amp; Services</th>
<th>Education &amp; Training</th>
<th>Advancement of Knowledge</th>
<th>Civil Space</th>
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<td>EEC (NASB 1975) Objectives</td>
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<td>1. Earth &amp; Atmosphere</td>
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<td>6. Industrial Prod. &amp; Tech.</td>
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x) Whole class.
* ) Part of a class
Table VIII.2

STANDARD KEY BETWEEN THE NORDFORSK AND OECD OBJECTIVES DISTRIBUTION

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x) Whole class.
is included in "Urban and Rural Planning" whereas according to NORDFORSK construction R & D is included in "Industrial Development". The treatment of construction R & D also appears to vary in the "independent" countries. Here again it is most important that the approach used should be specified.

8.7.3.3.4 Production and Rational Use of Energy

350. The series and data collected and issued by the OECD Directorate for Science, Technology and Industry for government R & D funding for the objective "Production and Rational Use of Energy" as defined in 8.7.3.2.3 should not be confused with the special series collected and issued by the International Energy Agency of OECD (IEA) which covers Energy Research, Development and Demonstration expenditures or "RD & D". A definition of the latter concept will be found in Chapter I (see paragraph 11).
Annex I

BACKGROUND OF THE MANUAL

BRIEF HISTORY AND ORIGINS OF THE PRESENT MANUAL
AND OF OECD WORK ON R & D STATISTICS

1. Encouraged by the rapid growth of the amount of national resources devoted to research and experimental development (R & D), most OECD Member countries started the collection of statistical data in this field around 1960. They followed the pioneering efforts of a small number of countries, including the United States, Japan, Canada, the United Kingdom, the Netherlands and France. Differences in scope, methods and concepts, however, made international comparisons difficult and countries encountered theoretical difficulties when starting R & D surveys. An increasing need was, thus, felt for some attempt at standardization of the kind undertaken for economic statistics.

2. OECD interest in this question dates back to OEEC days. In 1957, the Committee for Applied Research of the European Productivity Agency of the OEEC began to convene meetings of experts from Member countries to discuss methodological problems. As an outcome of these meetings an Ad Hoc Group of Experts was set up, under the auspices of the Committee for Applied Research to study surveys of research and development expenditure. The Technical Secretary of the Group, Dr. J.C. Gerritsen, prepared two detailed studies on the definitions and methods employed in the measurement of R & D in the Government sector of the United Kingdom and France and later of the United States and Canada. Other members of the Group circulated papers describing the methods and results of surveys in their own countries.

3. When the Directorate for Scientific Affairs took over the work of the European Productivity Agency in 1961, the time was ripe for specific proposals for standardisation. At a meeting in February, 1962, the Ad Hoc Group (see paragraph 2) decided to convene a study conference on the technical problems of measuring R & D. In preparation for this Conference, the Directorate for Scientific Affairs appointed a consultant, Mr. C. Freeman, to prepare a draft document which was circulated to Member countries in the autumn of 1962 and
revised in the light of their comments. The "Proposed Standard Practice for Surveys of Research and Development" was discussed, revised and accepted by experts from the OECD Member countries at the conference which was held in Frascati, Italy, in June, 1963.(*)

4. Later in 1963 the OECD Directorate for Scientific Affairs invited the United Kingdom National Institute for Economic and Social Research to undertake an experimental comparison of research efforts in five Western European countries (Belgium, France, Germany, the Netherlands and the United Kingdom), the United States and the USSR.(*) The Institute study, though based on statistics from surveys undertaken before the international standards had been decided on, also tested the first draft definitions. The report concluded that the available statistical information still left a great deal to be desired; the main improvements suggested were:

   a) A more rigorous conceptual separation of research and experimental development and "related scientific activities";
   b) Careful studies in the Higher Education sector to estimate the proportion of time devoted to research by teaching staff and (post) graduate students;
   c) A more detailed breakdown of R & D manpower and expenditure data to permit, inter alia, a more exact calculation of research exchange rates;
   d) A more systematic measurement of expenditure flows between R & D sectors;
   e) More data on the flow of technological payments and of international migration of scientific manpower.

5. In 1964, following the acceptance of the Frascati Manual by the Member countries, OECD launched the International Statistical Year (ISY) on Research and Experimental Development. Member countries returned data for the year 1963 or 1964. Seventeen countries took part, many of them conducting special surveys and enquiries for the first time.

6. Following the publication of the Statistical Year findings,(*) the OECD Committee for Science Policy requested the Secretariat to prepare a revision of the Frascati Manual in the light of the experience gained. An outline of the suggestions was circulated to Member countries in March, 1968. A draft revision, incorporating most of these suggestions, was examined at the meeting of national experts held in Frascati in December, 1968. During this revision particular attention was paid to making the Manual as comparable as possible with existing United Nations' international standards such as SNA and ISIC. A revised draft was examined by a small group of experts in July, 1969 and a revised version of the Manual published in September, 1970.(*)
7. The third revision of the Manual was influenced by two series of events. First, by 1973 Member countries had participated in four ISY surveys and the accuracy and comparability of the data had much benefited from this continued experience. National survey techniques had also greatly improved. Secondly, in 1972 the OECD Committee for Scientific and Technological Policy (CSTP) set up the First Ad Hoc Review Group on R & D Statistics under the chairmanship of Mr. Cyril Silver (United Kingdom) to advise it and the Secretariat on how to make optimal use in the short term of the restricted resources available for R & D statistics at OECD while taking account of Member countries' priorities. Member countries were asked to draw up an inventory of their needs and nearly all responded. In addition to giving absolute priority to a continuation of the ISY surveys, they made a number of recommendations touching on methodology, notably concerning the need for closer contacts between the OECD and other international organisations.

8. As a result the third revision of the Frascati Manual went more deeply into those subjects already treated and examined certain new subjects. In response to a growing demand from science policy makers the scope of the Manual was expanded to cover research in the social sciences and humanities and greater stress was given to "functional" classifications, notably the distribution by "objectives" of R & D. A draft of this version was discussed at a meeting of experts held at OECD in December, 1973 and the final text was adopted in December 1974. (*)

9. Another consequence of the recommendation on timeliness of publication of the First Ad Hoc Review Group was a change in the method of putting out the ISY results. From 1967 to 1973 the statistical results of the biennial ISY surveys were edited in the form of four sector volumes plus one volume of total tables all in the OECD series of restricted documents intended for government users. The most serious disadvantage of this procedure was that no sector volumes could be prepared until data had been received from all participating Member countries. Since the 1975 ISY, data have, therefore, been edited on a country-by-country basis, each country volume also containing a section of selected international tables completed progressively as responses come in from participating countries. Once responses have been received from all Member countries, the main results of the ISY are presented in a recapitulative international volume. Furthermore, in order to present its data to a wider audience more rapidly and in a less technical form, in 1976 the Science and Technology Indicators Unit (STIU) began publishing a Science Resources Newsletter containing most recent highlights and results of the ISY surveys.

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10. When work began on the fourth revision of the Manual the national experts recommended that only an intermediate exercise should be undertaken, with no significant changes in key concepts and classifications. The main stress has been on improving drafting and layout. However, a number of revisions have been made reflecting the interests of three interested parties.

11. In 1976, following the recommendations of the First Ad Hoc Group, a Second Ad Hoc Review Group on R & D Statistics, under the chairmanship of Mr. J. Mullin (Canada) was set up by the CSTP to assist the Secretariat with further medium and long-term guidance on priorities, taking into account the needs of actual and potential users and the resources available both at the OECD and in Member countries. The general conclusions of this second group, which represented the users rather than the producers of R & D statistics, were very similar to those of its predecessor, giving highest priority to the ISY surveys. On the methodological and analytical front the Group recommended that the Secretariat should continue to work in the long term on the development of direct or proxy output indicators (such as correlations of R & D data with productivity indices; methods for the analysis of technological balances of payments, correlations between R & D and foreign trade and analysis of world patent data). As is traditional these "new" topics are discussed in an appendix to the present version of the Manual - "The Measurement of Output of R & D" (see Annex II).

12. The second interested party to this revision has been the OECD Secretariat. In recent years, the Science and Technology Indicators Unit of the Directorate for Science, Technology and Industry (DSTI) has become an important consumer of its own statistical series of R & D data, or other related data, by undertaking analytical studies, either independently or within the framework of other OECD projects, e.g. "Changing Priorities for Government R & D - An Experimental Study of Trends in the Objectives of Government R & D Funding in Twelve OECD Member Countries, 1961-1972"(*) and "Patterns of Resources Devoted to R & D in the OECD Area 1963-1971"(*) which were issued in 1975 at about the same time as the third revision of the Manual. However, since then two reports have been produced which have thrown light on important problems of international comparability. "Trends in Industrial R & D in Selected OECD Member Countries 1967-1975"(*) revealed a number of industrial classification problems and also involved experimental work to develop R & D deflators and exchange rates. In 1979, as a contribution to activities elsewhere in the DSTI, the Unit attempted to make an international comparison of trends in university R & D (also dealing with national efforts in basic research) which revealed a number of methodological points which needed clarification in the Manual. In addition, the
Secretariat has attempted to ensure that the theoretical norms in the Manual should tie in as closely as possible with the practical recommendations in the ISY questionnaires.

13. The third interested party to the revision was obviously the national experts on R & D statistics and this version takes into consideration both their individual and collective contributions to OECD expert meetings and workshops and the specific national recommendations which were made to the Secretariat. These suggestions from Member countries were presented at the annual meeting of national experts in December 1978. A small ad hoc group of experts met at the OECD Secretariat in July 1979 for more detailed discussions of a draft prepared by Mr. Humphrey Stead (Canada) as a consultant to the Secretariat. A revised version of this text incorporating the suggestions of the ad hoc group and of the Secretariat was discussed again in December 1979 and the text was finally adopted in autumn 1980.

EFFORTS OF OTHER INTERNATIONAL ORGANISATIONS

14. The problems of comparing R & D data, collected in different countries with varying institutional patterns and traditions in education and research, have been considered by other international organisations as well as by the OECD.

A. UNESCO (United Nations Educational, Scientific and Cultural Organisation)

15. The UNESCO Division of Statistics on Science and Technology has since 1965 organised the systematic collection, analysis, publication and standardization of data concerning science and technology and, more especially, R & D. The first experimental questionnaires were circulated to Member States in 1966 and standardized periodic surveys were established in 1969. In the annual surveys important basic indicators are requested whilst the biennial surveys request more detailed information and data on special topics of particular interest. A data base, at present covering some 80 countries, mainly concerning human and financial R & D resources, has been built up. Although the data compiled are still not perfectly homogeneous there are an increasing number of requests for reference to them by national users and international organisations, particularly officials responsible for the formulation and planning of science and technology policies. These survey data have, since 1969, been included in the UNESCO Statistical Yearbook, since 1973 in the United Nations Statistical Yearbook and are also used for special reports and analyses.
16. The methodology used in the surveys has been progressively developed with the aid of national experts from different continents and has been discussed at length during missions and at meetings convened by UNESCO. Its aim is the collection of information on scientific and technological activities (S & T) in a form that will provide maximum international comparability. Landmarks in the development of this methodology have been the publication of the Provisional Guide to the Collection of Science Statistics (1968),(*) the Manual for Surveying National Scientific and Technological Potential (1969)(*), and the Guide to the Collection of Statistics on Science and Technology (1977).(*) Following the methodological studies in 1975 and 1976, the Secretariat drew up, with the assistance of external specialists, a draft recommendation for consideration by a meeting of governmental experts in 1978. This committee took into consideration the necessity of international standards that could be applied to all Member States, both those having advanced systems in the field of S & T statistics and those where these are still in development. The proposal, although designed to provide standardized information on the S & T activities, concentrates on R & D. However, it proposes a gradual extension of the statistics beyond R & D.

17. The Recommendation concerning the International Standardization of Statistics on Science and Technology(*) was adopted by the UNESCO General Conference at its twentieth session in 1978. Two successive stages are proposed at the international level: the first, over a period of at least five years, will cover only R & D in all sectors of performance, together with S & T personnel resources; during the second stage, to be regarded as experimental, statistics should be extended to cover S & T services (STS) and S & T education and training at broadly the third level of education (STET).

18. UNESCO has recently published a Manual with these international standards, with a view to their application by Member States and it is hoped that the guidelines provided will lead to an improvement in the quality and comparability of international statistical data. Throughout this work, UNESCO has taken account of the experience acquired by certain regional organisations such as CMEA (Council for Mutual Economic Assistance), OECD and OAS (Organisation of American States). Co-operation has also been promoted by the creation of a Joint Working Group of UNESCO and the ECE (United Nations Economic Commission for Europe) which has studied ways of improving and developing science statistics at meetings held in 1969, 1972 and 1976.

B. The Institutions of the European Communities

19. The Sub-committee on R & D Statistics set up by CREST (the Scientific and Technical Research Committee) draws up annual
reports(*) on public R & D financing in the Member States and on the R & D appropriations of the Community institutions. The reports provide time series of data on the final R & D budgets and also the provisional budget appropriations for the current year. The collected data are processed so that they can be presented in comparable form and broken down by principal research objectives in accordance with the 1975 version of the Nomenclature for the analysis and comparison of scientific programmes and budgets (NASB).(*) Since 1978, the Subcommittee has been entrusted by CREST with the task of extending the processing of R & D data to areas outside the public sector. The work has been approached from two angles - the preparation of R & D indicators on the basis of OECD data and the drafting of a report on the analysis(*) of research potentials in the Community countries; these projects are expected to provide the foundation for a processing system covering all aspects of research and development.

C. NORDFORSK (The Scandinavian Council for Applied Research)

20. The main task of NORDFORSK (which groups research organisations in Denmark, Finland, Iceland, Norway and Sweden) is to initiate, promote and organise Nordic co-operation in scientific and industrial research. In 1968 it set up a special Committee on R & D statistics whose various working groups discussed a number of problems related to the production and analysis of R & D statistics, mainly with reference to inter-Nordic comparability of data. In 1974, the Committee published a "Nordic Manual"(*) (in the Nordic languages) which was a detailed supplement to the Frascati Manual. Selected chapters(*) of the Nordic Manual have been translated into English and have been presented by NORDFORSK at various meetings of experts at the OECD. Furthermore, guidelines for analysing R & D in government budgets have been worked out and implemented in Nordic studies.

During recent years the interest has been focussed on problems of presentation and communication of the statistical information with the aim of adapting the information to the individual needs of various consumer groups.

ACKNOWLEDGEMENTS

21. Neither the original version of this Manual nor the revised editions could have been completed without the active collaboration of R & D statisticians in all OECD Member countries and in international organisations, notably UNESCO, EEC and NORDFORSK. Particular debts of gratitude are due to the National Science Foundation which pioneered the systematic measurement of R & D.
Among those who must be mentioned in connection with the first edition of the Manual are the late Dr. J. Perlman, Professor C. Freeman and the French Délégation générale à la recherche scientifique et technique (DGRST).

The late H.E. Bishop was chairman of the 1968 Frascati meeting and Mr. H. Stead (Statistics Canada), Mr. P. Slors (Netherlands Central Bureau of Statistics) and Dr. D. Murphy (Irish National Science Council) also made major contributions to the second edition of the Manual.

Amongst those who helped to prepare the third version thanks are due to the late K. Sanow (National Science Foundation), Mr. J. Mitchell (Office of Fair Trading, United Kingdom) and Mr. K. Perry (United Kingdom Central Statistical Office) and to Mrs. K. Arnow (National Institutes of Health, United States), chairman of the 1973 experts' meeting, and to the chairmen of special topics, Mr. T. Berglund (Swedish Central Statistical Office), Mr. J. Sevin (DGRST) and Dr. F. Snapper (Netherlands Ministry of Education and Science).

The present fourth version owes a great deal to the work of Mr. H. Stead (Statistics Canada). In the chair at the various expert meetings involved were Mr. G. Dean (Central Statistical Office, United Kingdom) in 1978 and Mr. C. Falk (National Science Foundation, United States) in 1979.
Annex II

THE MEASUREMENT OF OUTPUT OF R & D

1. INTRODUCTION

1.1 Recent OECD Developments

1. The present edition of the Manual, like its predecessors, does not discuss recent developments in the measurement of the output of science and technology. Nevertheless, given the recent vogue for output indicators, it has been thought worthwhile to give a short summary of the main problems involved and of the still very provisional methods which are proposed for resolving them.

2. OECD work on direct or proxy output indicators encouraged during the late 1970s by the recommendations of the Second Ad Hoc Review Group on R & D Statistics (see Annex I:11) resulted in the organisation of two seminars in 1978 and 1979.

3. These were followed, in September 1980, by a major conference on Science and Technology Indicators, held at the OECD Headquarters in Paris, the aim of which was to reach a consensus on R & D output indicators amongst users in OECD Member countries and to examine those output indicators which seem to be most promising at an international level.

4. Specialist workshops examined various areas of indicator activity:

   - innovative activity including the measurement of innovation proper and patent statistics;
   - impact of science and technology on the economy: trade and technology, technological balance of payments and technology and productivity;
   - science indicators including bibliometric analysis, citation indices and peer reviews, and problems posed by the establishment of such science and technology indicators in general.

A plenary session of two days examined the general conclusions reached by the workshops including the role of science and technology indicators in science policy. A panel of users reported on their
needs for science and technology indicators and a second panel suggested how OECD work might generally be developed. It is hoped to publish the results of this conference at a later date. (*)

5. In the meantime, this annex (which was written well before the OECD Science and Technology Indicators Conference) gives a brief outline of some of the output measures discussed at the two earlier meetings.

1.2 Distinction between Input and Output Series

6. In the absence of output statistics it has long been the habit to consider input data, i.e. R & D expenditure and personnel, as substitute measures for output, thus implicitly considering that there is a proportional relationship between input and output. This is obviously not wholly untrue but it is not a sufficient basis for those who wish to know with greater precision what have been the results of scientific and technological activities as is currently the case in private and public sectors.

7. The ideal would be to be able to measure the direct output of scientific and technological activities in the form of new scientific and technological knowledge and also through various social and economic impacts but this is not easy to do in our current state of knowledge. For this reason one is obliged to use certain indirect methods both in the case of science and of technology.

1.3 Problems Posed by the Use of Output Indicators

8. One of the main problems is due to the type of data used. Data used to measure output have not, generally, been collected for that purpose and, thus, it is necessary to adjust them considerably, for example concerning classifications or in order to distinguish the impact of technology from other factors which may intervene. These problems arise in nearly all cases where economic data are used to measure the impact of technology (technological balance of payments, patent statistics, productivity indices). The problems examined below are apparent when using the data and so it is necessary to clearly define the methods and limitations of interpretation.

9. Problems posed by the use of such data should not lead to their rejection as they are, at the moment, the only data which are available to measure output. Imperfect as they are, they permit the construction of a rough picture of the technological profile of countries and the tracing of its evolution.

10. The development of second generation output indicators, such as the direct measurement of innovation on which several countries are working, should allow one to discard the weaker indicators. Equally,
it should produce indicators based on the nature of technology itself and, thus, enable one to measure the level of maturity of this or that technology. The problems posed by output indicators linked to industrial R & D are also posed, although somewhat differently, in the case of output indicators relating to pure and applied science, for example bibliometrics, quotation indices, etc.

11. Another problem, closely connected to the first, is not so much a technical one as one of a political and administrative nature. It is, for example, extremely rare that statistical experts involved in preparing data concerning the input of R & D are the same as those providing output data. This is due to the diversity of these data which are, in the main, collected by different organisations, thus:

- data concerning the technological balance of payments are collected and analysed by central banks or patent offices, and sometimes both;
- statistical data on patents are collected by patent offices;
- data on trade in high technology intensive products appear in the statistics on foreign trade;
- data on bibliometrics and quotation indices are collected and analysed by private firms, (*) such as ISI and Computer Horizons in the United States;
- finally, in many countries, university research institutes are working on one or more input indicators.

12. Furthermore, it should be added, that the analysis of these indicators requires specialised knowledge. It is difficult, even impossible, to analyse with precision patent statistics or to do bibliometric analyses, either at the global level or by fields of science, without the help of patent experts or of scientists who are well acquainted with the field that one proposes to analyse. Also, the analysis, or even a simple attempt at interpretation, of the data concerning innovation, patents or high technology intensive products, leads one, to some extent, into the realms of economic theory concerning these areas.

2. SELECTED MEASURES OF OUTPUT

2.1 Innovation

2.1.1 Definition

13. In Chapter I (1.3.3) scientific and technological innovation is defined(*) as the transformation of an idea into a new or improved saleable product or operational process or into a new approach to a social service. It consists of all those scientific, technical,
commercial and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes and equipment or the introduction of a new approach to a social service. So far very little work has been done on measuring social innovations. The remainder of this section, therefore, refers only to technological innovations.

2.1.2 The Measurement of Innovation

14. Innovation is defined as an activity ("...the transformation..."). However, it is also a thing - the result of the innovation activity is an innovation. In fact, only after the activity is completed, only when the product is shown to be commercially successful or the process operational can the activity be identified as innovation.

2.1.2.1 The Number of Innovations

15. Innovations can be identified and can be counted. Unfortunately, both the identification and the counting are difficult. The identification is complicated by the problems of determining whether a product or process is sufficiently "new" or "improved" to qualify as an innovation, and whether the product is sufficiently saleable or the process operational.

16. The counting is complicated by the interdependence of many innovations: a product innovation which is part of a process innovation, some innovations being a "bundle" of other innovations:

- "Additional supporting inventions and discoveries were required beyond the initiating invention in all the innovations studied... During the innovative process there is a continuous refinement of the initial invention, caused by the disclosure of unexpected problems... and the incorporation of newly available technology. Thus, the innovative process includes an iterative activity of research, problem disclosure, further research to solve the problem, etc. This activity continues beyond the first commercial or governmental utilisation of the innovation."(1)

17. Furthermore, a simple count would not mean very much. The innovations must be weighted somehow, so that minor innovations (whether rated in terms of social or technical significance or cost) are not equated to major innovations.

2.1.2.2 The Cost of Innovations

18. The cost of innovations can be measured in either expenditures or persons. Because of the nature of the records kept by innovators,

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(1) "Interactions of Science and Technology in the Innovative Process: Some Case Studies, NSF, 1973, pp. 4-7, 4-8."
financial cost is probably a better measure with which to work. However, the collection of satisfactory data on the cost of innovation has yet to be carried out on a large scale or as an ongoing process.\(^1\)

19. One indicator of expenditures on technological innovation is already developed: industrial R & D expenditures. Others may be feasible. Besides R & D, Chapter I distinguishes six other activities in the innovation process: new product marketing, patent work, financial and organisational changes, final product and design engineering, tooling and industrial engineering, and manufacturing start-up.

2.2 Patent Statistics

2.2.1 Introduction

20. One output measure which has recently been much discussed and indeed much criticised remains, however, one of the most easily used output indicators, i.e. patent statistics. A patent is a right granted by a government to an inventor in exchange for the publication of the invention; it entitles the inventor, for an agreed period, to prevent any third party from using the invention in any way. The legal and juridical provisions for filing patent applications and for the issue and protection of patents vary widely from one country to another, but over the past ten years or so these differences have narrowed. Patent applications are received, investigated and conserved and patents are issued and published by special institutions (Institut National de la Propriété Industrielle, Patent Office) which keep records of all applications filed and all patents issued (registration of a patent takes place after a certain length of time, following a more or less rigorous investigation to establish novelty).

21. Patent statistics are compiled for administrative reasons, not for the direct measurement of invention or technological innovation. Nevertheless, patents are unparalleled as a source of information about technological progress in the distant and more recent past - in the former case, because in most industrialised countries patents have existed for at least one and sometimes two hundred years; in the latter, because they offer a unique store of information on recent technology - some experts believe that about 80 per cent of the information on technology constituted by patents can be found nowhere.

\(^1\) Three feasibility studies were carried out on behalf of the NSF in 1973-74: "The Feasibility of Monitoring Expenditures for Technological Innovation", (Practical Concepts Incorporated); "Investment in Innovation", (Midwest Research Institute); and "Surveying Investment in Innovation", (Denver Research Institute).
else, not even in technical reviews or other specialist documentation. This does not mean that the data published by the industrial property institutions can be used just as they are.

2.2.2 Problems in the Use of Patent Data as a Measure of Output

22. The use of patents to measure output poses certain problems. Most of these problems are well known, but in certain cases it is a question of received ideas which should be subjected to serious critical investigation:

- We do not know how many inventions are not patented. Patent statistics do not cover all inventions, either because some of them are not patentable or because some inventors prefer to keep their inventions secret since, while a patent does offer protection from the legal point of view, publication of an invention increases the risks of imitation.
- Smaller firms tend to patent more than larger ones. The larger the firm, the higher its expenditures on R & D and the lower, proportionately, the number of patents it applies for.
- The propensity to patent varies according to the industry. It is higher in industries where innovations can easily be imitated (mechanical engineering) and lower in industries which to some degree are defence-linked (aerospace).
- Juridical and legal provisions concerning patents (application, issue, protection) vary from one country to another and this may influence the number of patents. The best known example is the existence or non-existence of a prior test for originality. Over the past ten years, however, the differences have lessened.
- The quality of patents varies. It is hardly possible to form an opinion of what a patent is worth other than by studying it, and this cannot be done until after it has been published, that is to say several months - if not years - after it is first applied for.
- Many patents would seem to be purely strategic, i.e. designed to block possible competition, the patentees having no intention of using them. This point should be checked carefully.
- The extent to which granted patents are used and their rate of commercialisation is not always known with precision.

3. IMPACT MEASURES

3.1 Introduction

23. A certain number of series of data can be considered as proxy indicators of the impact of science and technology on the economy.
- the technological balance of payments,(1)
- trade in high technology intensive products,
- productivity indices.

These are aggregates which are influenced by technology and which vary broadly with the latter.

3.2 Technological Balance of Payments

3.2.1 Coverage

24. The technological balance of payments groups those invisible transfers measured in a country's balance of payments which concern the sale and purchase of knowledge and of information of a technological nature. In fact, it mainly covers sums received and spent for the sale and purchase of patents, licences and know-how but it may also include all transfers in respect of intellectual property such as copyright, various authors and film rights, trademarks, blueprints, etc., even in some cases including royalties for petroleum extraction and mining.

3.2.2 Problems Involved

25. The first problem is, thus, to separate the elements which are linked to or influenced by technology from those which are not. There are a number of other difficulties in interpreting these data which will be broadly listed below:

- The technological balance of payments only covers monetary transactions and excludes transactions which do not involve flows of money e.g. by exchanges of shares between firms or by exchanges of technology. Such transactions may play a very important role;
- The data may be underestimated for various fiscal or administrative reasons;
- Operations between parent and subsidiary companies may not be registered at all or, on the contrary, may be entered at exaggeratedly high rates;
- It is difficult to break down the sums concerned by industry or project;
- There may be several statistical sources providing different data for a single country, e.g. the central bank and a patent office.

1) The technological balance of payments can also be considered as an input measure (purchase of foreign technology as an alternative to R & D) or as a proxy output measure of saleable inventions.
3.3 Trade in High Technology Intensive Products

3.3.1 Coverage

26. During the last 20 years economists have considered that innovation, the output of science and technology, plays a primordial role in a country's export performance. Studies attempting to verify these theories empirically have involved examining to what extent a country's comparative advantage in a product is linked to its R & D intensity.

3.3.2 Problems Involved

27. Thus, one of the main problems that is raised in all these studies derives from the fact that, in order to establish a link between technology and international trade, it is first of all necessary to calculate a technology intensity ratio or, more frequently, a research intensity ratio and then to determine on the basis of this ratio which branches of industries and which products will be technology-intensive. Differences in the calculation of the ratio and its basis of application have given rise to somewhat divergent results, both as regards the industries or products (which are or are not technology-intensive) and as regards the results obtained in applying these ratios to international trade statistics.

28. The main problem is, thus, to identify industries and products which are highly technologically intensive. However, although it is possible to make very detailed breakdowns of foreign trade data, the R & D data used to calculate intensities are generally available at a much more aggregate level.

3.4 Productivity Indices

29. Empirical studies have demonstrated the influence of R & D on productivity growth in industries. The most frequently used measure of productivity is per capita hourly output. Variations in per capita output are taken to reflect trends in productivity. Nevertheless, comparing per capita hourly output can be affected by non-technological factors. There are also numerous interpretation problems affecting this indicator.

4. CONCLUSION

30. In lieu of a conclusion we shall cite two works of interest to any reader wishing to pursue the study of the measurement of output:

1. On the theoretical side the only work which covers practically all aspects of the measurement of output is

2. For a more practical insight into the ways in which output indicators can be used the reader is recommended to study "Science Indicators" (issued by the US National Science Foundation) volumes 1972, 1974, 1976 and 1978.
Annex III

STANDARD KEY BETWEEN ISCED LEVEL CATEGORIES
AND OECD CLASSES FOR R & D PERSONNEL BY FORMAL QUALIFICATION

The International Standard Classification of Education (ISCED)(1) comprises three levels of education sub-divided into seven level categories plus a residual category for education not defined by level.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Level Categories</th>
<th>General Coverage</th>
<th>OECD R &amp; D Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 Education preceding the first level.</td>
<td>Pre-primary</td>
<td>Not relevant</td>
</tr>
<tr>
<td>II</td>
<td>1 Education at the first level.</td>
<td>Primary</td>
<td>Other qualifications</td>
</tr>
<tr>
<td>II</td>
<td>2 Education at the second level, first stage</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>3 Education at the second level, second stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>5 Education at the third level, first stage, of the type that leads to an award not equivalent to a first university degree.</td>
<td>Post-secondary</td>
<td>Holders of other diplomas of post-secondary education</td>
</tr>
<tr>
<td>III</td>
<td>6 Education at the third level, first stage, of the type that leads to a first university degree or equivalent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>7 Education at the third level, second stage, of the type that leads to a post-graduate university degree or equivalent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>9 Education not defined by level.</td>
<td></td>
<td>Other qualifications</td>
</tr>
</tbody>
</table>

Annex IV

TECHNICAL PRESENTATION OF THE CALCULATION OF R & D DEFLATORS

I. METHOD (I) A COMPOSITE PRICE INDEX WITH FIXED WEIGHTS

Basic Data

Let \( x_{ij}^t \) be expenditures in current prices of industry \( i \) (\( i = 1, \ldots \)) for the type of cost \( j \) (\( j = 1,4 \)) and for the year \( t \) (\( t = 1,k \)).

For the price indices chosen for the year \( t \), let:

- \( \lambda^t \) = labour costs
- \( \kappa^t \) = consumer price indices for non-food items
- \( \rho^t \) = indices for non-residential construction in GFCF
- \( \sigma^t \) = indices for machinery and equipment in GFCF

\( \text{(GFCF = Gross Fixed Capital Formation).} \)

For the price indices with fixed weights (\( t_0 \): base year), let

\( g_{ij}^t \) = price indices for type of cost \( j = 1,4 \)

and for the year \( t \)

for \( j = 1 \) \( g_{1t}^t \) : labour costs.

for \( j = 2 \) \( g_{2t}^t \) : other current costs.

for \( j = 3 \) \( g_{3t}^t \) : land and buildings.

for \( j = 4 \) \( g_{4t}^t \) : instruments and equipment

with \( \sum_{j=1}^{4} g_{jt}^t = 400 \)
Calculation of the Deflator

The composite index is obtained by taking a weighted average of the trends in prices using fixed weights.

Year $t = 1$
\[ y_1^t = x_1 q_1 + x_2 q_2 + x_4 q_3 + x_4 q_4 = \frac{y_1}{y_1} \]
Year $t = 2$
\[ y_2^t = x_1 q_1 + x_2 q_2 + x_4 q_3 + x_4 q_4 = \frac{y_2}{y_2} \]
Year $t = t$
\[ y_t^t = x_1 q_1 + x_2 q_2 + x_4 q_3 + x_4 q_4 = \frac{y_t}{y_t} = 100 \]
Year $t = k$
\[ y_k^t = x_1 q_1 + x_2 q_2 + x_4 q_3 + x_4 q_4 = y_k \]

The deflated expenditures of the sector (total of $n$ industries) for the various periods will thus be:

Year $t = 1$ deflated sector
\[ \frac{1}{y_t} \left( \sum_{j} x_{tj} \frac{y_t}{y_t} \right) \]
Year $t = 2$ deflated sector
\[ \frac{1}{y_t} \left( \sum_{j} x_{tj} \frac{y_t}{y_t} \right) \]
Year $t = k$ deflated sector
\[ \frac{1}{y_t} \left( \sum_{j} x_{tj} \frac{y_t}{y_t} \right) \]

II METHOD (II) A COMPOSITE PRICE INDEX (WITH CHANGING WEIGHTS)

For this method we use the same basic data as for the previous method but the price indices with fixed weights are replaced by the intramural R & D expenditures of the enterprises by types of cost (in percentages), thus

let
\[ \pi_1^t = \text{labour costs} \]
\[ \pi_2^t = \text{other current costs} \]
\[ \pi_3^t = \text{land and buildings} \]
\[ \pi_4^t = \text{instruments and equipment} \]

for year $t$
\[ \sum_{j=1}^{4} \pi_j^t = 100 \quad \forall t = 1, k \]

The composite index for each period $t$ will be

\[ 141 \]
The deflated sector of \( n \) industries will thus be

For \( t = 1 \) deflated sector \( \frac{1}{E_1} \left( \sum_{i} \frac{p_i^1}{q_i^1} x_{ij} \right) \)

For \( t = 2 \) deflated sector \( \frac{1}{E_2} \left( \sum_{i} \frac{p_i^2}{q_i^2} x_{ij} \right) \)

......

For \( t = k \) deflated sector \( \frac{1}{E_k} \left( \sum_{i} \frac{p_i^k}{q_i^k} x_{ij} \right) \)

III METHOD (III) DEFLATING EACH INDUSTRY SEPARATELY

The same basic data is used, by a proxy series of indicators is chosen for each type of cost and each industry, therefore, we have

- \( a_{it} \) = average weekly wages for industry \( i \) and year \( t \)
- \( b_{it} \) = wholesale prices for industry \( i \) and year \( t \)
- \( c_{it} \) = index of construction in GFCF (common for all industries)
- \( d_{it} \) = index of machinery and equipment in GFCF (common for all industries)

The deflated sector of all \( n \) industries will thus be:

\[
\text{Deflated Sector}
\]

Year \( t = 1 \) \( \sum_{i=1}^{n} \left( \frac{x_{i1}}{a_{i1}} + \frac{1}{E_1} \left( \sum_{i=1}^{n} \frac{x_{i1}}{q_{i1}} a_{i1} \right) \right) = Y(i,j,t) \)

Year \( t = 2 \) \( \sum_{i=1}^{n} \left( \frac{x_{i2}}{a_{i2}} + \frac{1}{E_2} \left( \sum_{i=1}^{n} \frac{x_{i2}}{q_{i2}} a_{i2} \right) \right) = Y(i,j,t) \)

......

Year \( t = k \) \( \sum_{i=1}^{n} \left( \frac{x_{ik}}{a_{ik}} + \frac{1}{E_k} \left( \sum_{i=1}^{n} \frac{x_{ik}}{q_{ik}} a_{ik} \right) \right) = Y(i,j,t) \)

Thus, if \( t = t_0 \) for the base year, the sector's implicit deflator will be as follows:

\[
\frac{Y(i,j,t)}{Y(i,j,t_0)}, \frac{Y(i,j,t_2)}{Y(i,j,t_0)}, \ldots, 100, \ldots, \frac{Y(i,j,k)}{Y(i,j,t_0)}
\]

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Chapitre I

OBJECTIF ET PORTEE DU MANUEL

1.1 Remarque préliminaires à l'attention de l'utilisateur de données de R-D
1.2 Relation entre le Manuel de Frascati et les autres normes internationales
1.3 R-D et activités connexes
  1.3.1 Recherche et Développement Expérimental (R-D)
  1.3.2 Activités Scientifiques et Technologiques (STA)
    'Recommandation concernant la normalisation internationale des statistiques relatives à la science et à la technologie' UNESCO, Paris, 27 novembre 1978.
  1.3.3 R-D et innovation scientifique et technologique

En anglais seulement

1.4 A Preliminary Word to the User of R & D Data
1.2 The Relationship between the Frascati Manual and Other International Standards
1.3 R & D and Related Activities
  1.3.1 Research and Experimental Development (R & D)
  1.3.2 Scientific and Technological Activities (STA)
  1.3.3 R & D and Scientific and Technological Innovation

H. Stead "The Costs of Technological Innovation" Research Policy, January 1976 (Vol.3, No.1)
E. Mansfield "Economics of Technical Change" (Norton, New York, 1968)
E. Mansfield et al "Research and Innovation in the Modern Corporation" (Norton, New York, 1971)
Ch. Freeman "The Economics of Industrial Innovation" Penguin Books, 1974
Ch. Freeman "Economics of Research and Development" Ch.7 of 'Science, Technology and Society - A Cross-Disciplinary Perspective' (Spiegel-Rising - de Solla Price, Sage, London - Beverly Hills, 1977)
1.4 R&D Input and Output


1.5 Natural Sciences and Engineering (NSE) and Social Sciences and Humanities (SSH)


1.6 Measures of R & D Inputs

1.6.1 Dépenses de R & D
1.6.2 Personnel de R & D

"Classification Internationale Type des Professions (CITP)"

"Classification Internationale Type de l'Education (CITE)"

1.6.3 Moyens physiques de R & D
1.6.4 Efforts nationaux en matière de R & D

1.7 Systèmes de classification de la R & D

1.8 Enquêtes de R & D, Fidélité des données et comparabilité internationale

1.9 Les objectifs du financement public de la R & D

1.10 Conclusion à l'attention des utilisateurs de données de R & D

Chapitre II
DEFINITIONS ET CONVENTIONS DE BASE


"Manuel scandinave sur les statistiques de R & D - Chapitre 3 "Définitions et délimitations des activités de R&D" (traduction provisoire)."

2.1 Recherche et Développement Expérimental (R & D)


2.2 Activités exclues de la R & D

2.2.1 Enseignement et formation
2.2.2 Autres activités scientifiques et technologiques
2.2.3 Autres activités industrielles
   2.2.3.1 Innovation industrielle (n.e.c.)
   En anglais seulement.
   Voir également les références sous 1.3.3.
2.2.3.2 Production et activités techniques connexes

2.3 Les limites des activités de R & D

2.3.1 Le critère de base
2.3.2 Problèmes de frontière entre la R & D et l'enseignement et la formation
   2.3.2.1 Approche générale
   2.3.2.2 Études postérieures au premier diplôme universitaire (postgraduate)
   "Classification Internationale Type de l'Éducation (CIJE)"
   Manuel scandinave (en suédois) :
   "Resursstatistik för Universitet och Högskolor" (Nordisk Statistisk Sekretariat, Copenhagen, 1974).
   (Statistiques des ressources consacrées à l'enseignement supérieur).
2.3.3 Problèmes de frontière entre la R & D et les autres activités scientifiques et technologiques connexes
2.3.4 Problèmes de frontière entre la R & D et les autres activités industrielles
   En anglais seulement.


2.1 Research and Experimental Development (R & D)


2.2 Activities to be Excluded from R & D

2.2.1 Education and Training
2.2.2 Other Related Scientific and Technological Activities
2.2.3 Other Industrial Activities
   2.2.3.1 Industrial innovation (n.e.c.)
   H. Stead "The Costs of Technological Innovation" Research Policy, January 1976 (Vol. 5, No. 1)
   Also see References under 1.3.3
   2.2.3.2 Production and Related Technical Activities

2.3 The Boundaries of R & D

2.3.1 The Basic Criterion
2.3.2 Problems at the Borderline between R & D and Education and Training
   2.3.2.1 General Approach
   2.3.2.2 The Case of Postgraduate Studies
   "International Standard Classification of Education (ISCED)"
   Nordic Manual (in Swedish) :
   "Resursstatistik för Universitet och Högskolor" (Nordisk Statistisk Sekretariat, Copenhagen, 1974).
   (Statistics of Resources Devoted to Higher Education).
2.3.3 Problems at the Borderline between R & D and Other Related Scientific and Technological Activities
2.3.4 Problems at the Borderline between R & D and Other Industrial Activities

Excerpts from Appendix C: Form R-Dl (Instruction Manual)
Item 532 "Types of Activity Included in Development":
"Certaines statistiques sur l'innovation technologique dans l'industrie", Catalogue 13.555 hors série, Statistique Canada.

Chapter III
CLASSIFICATIONS INSTITUTIONNELLES

3.1 Caractéristiques de base

"Manuel scandinave sur les statistiques de R-D - chapitre 4 'Systèmes de classification et principes de classification'" (traduction provisoire).

3.2 Unité d'enquête et unité de classification
NORDFORSK - op.cit. Chapitre 4

"Manuel scandinave - op.cit. Chapitre 4.2.1 - 4.2.4." (traduction provisoire).

3.3 Sektors

3.4 Le Secteur des Entreprises
3.4.1 Champ couvert
"Système de Comptabilité Nationale" op. cit., par. 5.7 - 5.12.

3.4.2 Principale sous-classification sectorielle
"La Classification Internationale Type par Industrie (CITI)", Études statistiques - Série M No. 4, rév. 1, Nations Unies, 1968.

3.4.3 Autres sous-classifications institutionnelles

3.5 Le Secteur de l'État
3.5.1 Champ couvert
"Système de Comptabilité Nationale", op. cit., par. 5.24 - 5.30.

3.5.2 Principale classification sectorielle
"Système de Comptabilité Nationale", op. cit.,

"Selected Statistics on Technological Innovation in Industry"

Chapter III
INSTITUTIONAL CLASSIFICATIONS

3.1 The Approach

"Nordic Manual for R & D statistics - Chapter 4 'Classification Systems and Classification Principles'" (draft translation).

3.2 Unit Surveyed and Unit Classified
NORDFORSK - op. cit. Chapter 4

"Nordic Manual - op. cit. Chapter 4.2.1 - 4.2.4." (draft translation).

3.3 Sectors

3.4 Business Enterprise Sector
3.4.1 Coverage
"A System of National Accounts" op. cit., par. 5.7 - 5.12.

3.4.2 The Principal Sector Sub-classification

3.4.3 Other Institutional Sub-Classifications

3.5 Government Sector
3.5.1 Coverage
"A System of National Accounts", op. cit., par. 5.24 - 5.30.

3.5.2 The Principal Sector Sub-Classification
3.6 Le secteur des Institutions Privées sans But Lucratif (ISBP)

3.6.1 Champ couvert
"Système de Comptabilité Nationale", op. cit., par. 5.35 - 5.39.

3.6.2 Principale sous-classification sectorielle

3.6.3 Autres sous-classifications institutionnelles

3.7 Le Secteur de l'Enseignement Supérieur

3.7.1 Champ couvert

3.7.2 Principale sous-classification sectorielle
"Liste des domaines de la science et de la technologie de la "Recommandation concernant la Normalisation Internationale des Statistiques relatives à la Science et à la Technologie"" (op. cit.).

3.7.3 Autres sous-classifications institutionnelles

3.8 Le Secteur de l'Étranger

3.8.1 Champ couvert
"Système de Comptabilité Nationale", op. cit., par. 5.100 - 5.102.

3.8.2 Principale sous-classification sectorielle

3.8.3 Autres sous-classifications institutionnelles


"Instructions and Definitions for the Public Expenditure Questionnaire". OECD Department of Economics and Statistics and F.M.I. Bureau of Statistique.
Chapitre IV
DISTRIBUTIONS FONCTIONNELLES

4.1 Introduction

"Manuel scandinave sur les statistiques de R-D - chapitre 4 'Systèmes de classification et principes de classification'" (traduction provisoire).

4.2 Les types d'activité
En anglais seulement.

4.3 Les Groupes de Produits

4.3.1 Utilisation
4.3.2 Liste des groupes de produits

"Classification Type pour le Commerce International (CTCI)" revue (Publication des Nations Unies, numéro de vente 61-XVII.6).

"La Classification Internationale Type par Industrie (CITI)", Études statistiques - Série M, No. 4, Rev. 2, Nations Unies, 1968.


4.3.3 Critères de distribution
4.3.3.1 Nature du produit
En anglais seulement.

Chapter IV
FUNCTIONAL DISTRIBUTIONS

4.1 The Approach

"Nordic Manual for R & D Statistics - Chapter 4 'Classification Systems and Classification Principles'" (draft translation).

4.2 Type of Activity


4.3 Product Fields

4.3.1 Utilisation
4.3.2 The Distribution List

"Standard International Trade Classification (SITC)" Revised (UN publication, Sales No. 61-XVII.6).


4.3.3 Criteria of Distribution
4.3.3.1 Nature of Product

4.3.3.2 Utilisation du produit.
En suédois seulement.

4.4 Les disciplines scientifiques et technologiques détaillées
4.4.1 Utilisation
4.4.2 Liste de distribution
En anglais seulement.

"Recommandation concernant la normalisation internationale des statistiques relatives à la science et à la technologie" (UNESCO, Paris, 27 November 1978).

4.4.3 Critères de distribution

4.5 Les objectifs socio-économiques
(Objectifs rapportés par l'exécutant ; pour la distribution rapportée par le bailleur de fonds, voir le chapitre VIII).


En suédois seulement.

En anglais seulement.

4.4.1.2 Use of Product

4.4 Detailed Fields of Science and Technology
4.4.1 Utilisation
4.4.2 The Distribution List


4.4.3 The Criteria of Distribution

4.5 Socio-economic Objectives
(Performer-Based Objectives Reporting ; for funder-based distribution, see Chapter VIII).


Chapter V

MEASUREMENT OF PERSONNEL AND EXPENDITURE DEVOTED TO R&D

5.1 Introduction

5.2 Personnel


"Manuel scandinave sur les statistiques de R&D", pas de traduction du chapitre 5 en français.


5.2.1 Introduction

5.2.2 Champ d'application initial

5.2.2.1 Définition

5.2.2.2 Traitement du personnel administratif

5.2.2.3 Traitement des étudiants diplômés ("postgraduates")


En anglais seulement.

5.2.3 L'équivalence plein-temps (personnes/années)

5.2.4 Catégories du personnel de R&D

5.2.4.1 Classification par fonction

"Classification Internationale Type des Professions (CITP)"

5.2.4.2 Classification par niveau de qualification formelle

"Classification Internationale Type de l'Education (CITE)"

5.2.5 Agregats nationaux

5.2.6 Classification croisée fonction/qualification

5.2.7 Autres classifications du personnel

"Recommandation concernant la normalisation internationale des statistiques relatives à la science et à la technologie" - Section II, UNESCO, Paris, 27 November 1978.

5.3 Expenditure


"Manuel scandinave sur les statistiques de R-D", pas de traduction du chapitre 6 en français.

Chapitre VI

METHODES D'EXECUTION DES ENQUETES

Anglais seulement.

NORDFORSK - Handbok för Pol-statistik. Chapitre 7
(The Performance of R & D surveys)

En suédois seulement.


(Problèmes méthodologiques et possibilités statistiques de mesurer les activités de R-D).

En allemand seulement.

6.1 Enquêtes et estimations

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6.4.4 Reporting to OECD and to Other International Agencies

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7.1.2 Method I - Calculating a Composite Price Index Using Fixed Weights
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7.2 R & D Exchange Rates


"Expenditures at Constant Prices and Employment - Some International Comparisons" p. 34 and seq. of "Trade and Industry" 6 April, 1979.

7.3 Conclusions


"Expenditures at Constant Prices and Employment - Some International Comparisons" p. 34 and seq. of "Trade and Industry" 6 April, 1979.

7.1.2 Method I - Calculating a Composite Price Index Using Fixed Weights
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8.3 Sources des données du financement public pour la R-D par objectifs socio-économiques
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8.7.3.2.4 Production et utilisation rationnelle de l'énergie
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HISTORIQUE DU MANUEL. BRIEF HAPPEL
HISTORIQUE ET ORIGINES DU MANUEL ET DES TRAVAUX
DE L'OCDE DANS LE DOMAINE DES STATISTIQUES DE R & D


Traduction allemande:

"Allgemeine Richtlinien für statistische Übersichten in Forschung und experimenteller Entwicklung" - Frascati-Handbuch I. Stifterverband für die Deutsche Wissenschaft, Essen (C 1971).


Traduction portugaise:


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BACKGROUND OF THE MANUAL
BRIEF HISTORY AND ORIGINS OF THE PRESENT MANUAL AND OF OECD WORK ON R & D STATISTICS


German translation:

"Allgemeine Richtlinien für statistische Übersichten in Forschung und experimenteller Entwicklung" - Frascati-Handbuch I. Stifterverband für die Deutsche Wissenschaft, Essen (C 1971).


Portuguese translation:


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UNESCO :
"Recommandation concernant la normalisation internationale des statistiques relatives à la science et à la technologie". Paris, 27 November 1978.
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Science and Technology Indicators Unit (STIU), Directorate for Science, Technology and Industry, OECD 2, rue André-Pascal 75775 Paris Cedex 16

1.2 Distinction between Input and Output Series

En italien et en anglais.

1.3 Problems posed by the Use of Output Indicators

En anglais seulement.

En anglais seulement.

1.4 Some Notes on Linking R & D Input and Output Indicators - The Italian Case - CNR - Istituto di studi sulla ricerca e documentazione scientifica - Quaderni n. 6-7, Rome 1979.

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1.5 Problems posed by the Use of Output Indicators

En anglais seulement.

En anglais seulement.


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2.1.1 Définition
En anglais seulement.

2.1.2 La mesure de l'innovation.
En anglais seulement.

"Certaines statistiques sur l'innovation technologique dans l'industrie", catalogue 13.555 hors série, Statistique Canada.

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2.2 Statistiques sur les brevets
En anglais seulement.

3. Mesures d'impact

3.1 Introduction
3.2 Bilan des paiements technologiques
En italien et en anglais.

3.3 Échanges de produits à haute intensité technologique
En italien.

3.4 Indices de productivité
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2.1 Innovation

2.1.1 Definition
H. Stead "The Costs of Technological Innovation" Research Policy, January 1976 (Vol. 5, No. 1)

2.1.2 The Measurement of Innovation


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3. Impact Measures

3.1 Introduction
3.2 Bilan des paiements technologiques

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3.3 Échanges de produits à haute intensité technologique

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Herbert S. Kleinman "Indicators of the Output of New Technological Products from Industry". Colombus: Battelle Columbus Labs., February 1975.

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THEORIE MATHEMATIQUE DU CALCUL DES DEFLATEURS DE R-D

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The Frascati Manual is the basic source of methodology for the collection and use of statistics on research and experimental development activities in science and technology (including the social sciences and humanities). This fourth edition has been substantially reorganized to improve its usefulness.