Organisation for Economic Co-operation and Development

THE MEASUREMENT OF SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES

PROPOSED GUIDELINES FOR COLLECTING AND INTERPRETING TECHNOLOGICAL INNOVATION DATA

OSLO MANUAL

European Commission **Eurostat**

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Chapter 1

OBJECTIVES AND SCOPE OF THE MANUAL

1. INTRODUCTION

1. It is now accepted that the development and diffusion of new technologies are central to the growth of output and productivity. But our understanding of the innovation process, and its economic impact, is still deficient. For example, we are clearly in the throes of a major technological revolution, with the world economy being reshaped by new information technologies and by fundamental change in fields such as biotechnology and materials science. Yet these radical technological shifts are not being reflected in improvements in total factor productivity and in output growth rates.

2. Attempts to understand such puzzles have come to focus, in recent years, on the critical importance of parts of the innovation process other than R&D, in particular as they affect diffusion rates. These are areas in which we face serious difficulties, however, in particular due to the absence of reliable and systematic data. Success in refining the analysis of innovation, and in tackling the policy problems it poses, will depend in part on the ability to improve the information available.

3. The first version of the *Oslo Manual*, issued in 1992, and the surveys undertaken using it, notably the Community Innovation Survey (CIS) organised by the EC, showed that it is possible to develop and collect data on the complex and differentiated process of innovation.

4. This second edition of the manual takes the original framework of concepts, definitions and methodology and updates them to incorporate survey experience and improved understanding of the innovation process and also to take in a wider range of industries. It provides guidelines by which comparable innovation indicators can be developed in OECD countries, and discusses the analytical and policy problems to which the indicators are relevant. The Manual has two objectives: to provide a framework within which existing surveys can evolve towards comparability; and to assist newcomers to this important field.

5. The aim of the present chapter is to give an overview of the coverage and contents of the manual (see Box 1), so as to help such newcomers and other non-experts use the body of the text, and also to indicate why certain types of data are or are not collected and to flag the main problems of setting norms to provide comparable indicators.

2. FACTORS INFLUENCING THE SCOPE OF THE MANUAL

6. How can one decide on the appropriate scope, structure, terminology and so on for internationally comparable data collection? The variety of subjects that pioneering and more recent innovation surveys have taken in is evidence that an extensive range of data is potentially available. Obviously, a survey covering all the ground of these previous investigations would be so cumbersome as to be quite impracticable. That means identifying priorities, and selecting the topics, industries and survey approaches on which to concentrate. There is also a need to distinguish between data which are best collected on a regular basis, and matters which can be tackled more effectively by one-off projects.

Box 1. Structure of the manual

The body of the manual starts with a general discussion of points that are likely to have some effect on the choice of indicators (Chapter 2):

- an adequate conceptual understanding of the structure and characteristics of the innovation process and its implications for policy making;
- the key unresolved problems which further data could clarify;
- consequences for the scope of the manual.

It continues with definitions, criteria and classifications which are relevant for studies of industrial innovation:

- basic definitions of technological product & process – TPP – innovation and innovation activities (Chapter 3);
- institutional classifications (Chapter 4).

After that, suggestions and recommendations are advanced for national and international TPP innovation surveys:

- measuring aspects of the TPP innovation process (Chapter 5);
- measuring the expenditure on TPP innovation (Chapter 6);
- innovation survey procedures (Chapter 7).

The manual closes with a set of annexes dealing with topics which either offer alternative procedures to those generally recommended or which are of relevance but not sufficiently developed for inclusion in the body of the manual:

- the "object" approach to data compilation/collection (Annex 1);
- the collection of non-technological innovation data (Annex 2).

2.1 Understanding the innovation process and the implications for innovation policy

7. In constructing innovation indicators the information needs of policy makers and analysts are a paramount consideration. Chapter 2 reviews these needs, which are part of the broad information system that helps to reduce uncertainty in policy making and which have been influenced, even since the first version of this manual, by developments in the economics of innovation.

8. Thus innovation policy has only recently emerged as an amalgam of science and technology policy and industrial policy. Its appearance signals a growing recognition that knowledge in all its forms plays a crucial role in economic progress, that innovation is at the heart of this "knowledge-based economy", and also that innovation is a more complex and systemic phenomenon than was previously thought. Systems approaches to innovation shift the focus of policy towards an emphasis on the interplays between institutions, looking at interactive processes both in the creation of knowledge and in its diffusion and application. The term "National Innovation System" has been coined for this set of institutions and flows of knowledge.

9. For the purposes of reaching a conceptual framework for the present manual, Chapter 2 centres on what it describes as "the innovation dynamo" of dynamic factors shaping innovation in firms which draw on and are influenced by transfer factors, the science and engineering base and wider framework conditions.

10. Chapter 2 further develops the concept of the innovation dynamo, discussing the economic significance of technological change and the associated theories. As in the previous version of the manual, it concentrates on innovation at the level of the firm and more particularly the neo-Schumpeterian approach and the chain-link model of innovation which views innovation in terms of interaction between market opportunities and the firm's knowledge base and capabilities. However, it is not the purpose of the discussion to adhere to any particular model of innovation but rather to illustrate that innovation is a complex, diversified activity with many interacting components, and that sources of data need to reflect this.

11. In consequence of the policy and analytical needs already expressed, six key areas for study are identified at the end of Chapter 2: corporate strategies, the role of diffusion, sources of information for innovation and obstacles to innovation, inputs to innovation, the role of public policy in industrial innovation, and innovation outputs.

2.2 Experience on the supply side

12. The first edition of the manual was tested in surveys in a wide range of OECD countries. The bulk were undertaken as part of the Community Innovation Survey (CIS), which was jointly initiated by Eurostat and DGXIII [SPRINT Programme, European Innovation Monitoring System (EIMS)]. This used a common questionnaire developed from the one appended to the first version of this manual. Thirteen countries represented by national contractors took part in the exercise (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain and the United Kingdom), which covered technological innovation in manufacturing industry. This exercise provided a wide range of experience, as the organisations involved in the CIS had different expertise which led to a variety of methods and approaches (see *Evaluation of the CIS Survey – Phase I*, EIMS publication n°.11). At the time of writing, pilot studies were under way on surveying technological innovation in services.

13. The majority of other OECD countries also tested the concepts and classifications in the first edition of the *Oslo Manual* in full or partial surveys and with varying degrees of success for the different types of questions. Hence this second version is based on extensive practical experience of how far firms are able to understand and apply the concepts involved, of survey practice and of the problems involved in compiling and interpreting the resulting data.

3. SCOPE OF THE MANUAL

14. For reasons summarised at the end of Chapter 2:

- the manual covers innovation in the business enterprise sector only;
- it deals with innovation at the level of the firm;
- it concentrates on technological product and process (TPP) innovation, with optional guidelines for other forms such as organisational change;
- it covers diffusion up to "new to the firm";

3.1 Sectoral coverage

15. Innovation can of course occur in any sector of the economy, including government services such as health or education. The guidelines in this manual are essentially designed to deal with

innovations in the business enterprise sector and more particularly in manufacturing, construction, utilities and marketed services. They have been extensively tested for manufacturing by the CIS survey and similar surveys in other OECD Member countries.

16. Innovation in services, which was not covered in the first version of this manual, is complex and has special characteristics which are described in Chapter 2. So far there have only been individual, mainly pilot, surveys of innovation in services, and the recommendations in the current manual are based on less firm ground than for manufacturing.

3.2 Innovation at the level of the firm

17. This manual deals with changes which take place at the level of the individual firm. It does not cover some other categories of innovation discussed for example by Schumpeter, such as the opening of a new market, the conquest of a new source of supply of raw materials or semi-manufactured goods, or the re-organisation of an industry.

18. For the purposes of the first three chapters of this manual the generic term "firm" is used. It is given a specific statistical definition in Chapter 4, dealing with classifications. Exactly what definition is used in a study or survey may have an impact on the results. In the case of multinational corporations their subsidiaries may be organised in different ways. A given innovation may be introduced country by country or market by market, or may be implemented simultaneously throughout the group. Where the subsidiaries are in fact franchises, and thus separate enterprises for survey purposes (often the case in services), the matter is even more complicated.

3.3 Technological product and process innovation

19. A firm can make many types of changes in its methods of work, its use of factors of production and its types of output which improve its productivity and/or commercial performance. An exhaustive study of such changes would be unwieldy in terms both of data collection and of subsequent analysis.

20. Different analytical approaches can be used to select a subset of these changes for further study, for example all those related to the diffusion of information technologies – IT, or those involving intangible investment (R&D, software, training, marketing etc.) (see Section 6 below). This manual deals with changes which involve a significant degree of **novelty** for the firm. It excludes changes which are "more of the same", *for example the purchase of further copies of IT equipment of a model already installed somewhere in the firm*.

21. The body of the manual concentrates on new and significantly improved **products (**goods and services) **and processes**. It is recognised that purely organisational innovation is widespread and may result in significant improvements in firm performance.[1] However, since there has been relatively little practical experience on this topic, it is currently dealt with in an annex (Annex 2).

22. The main text deals with "**technologically**" new or improved products and processes. The meaning of the label "technological", as applied to products and processes, and its precise scope in surveys and studies, can be unclear. This is particularly true in an international context. It is not always easy to distinguish between the special meaning attributed here, the dictionary definitions of the word (or its nearest equivalent in some languages) which may differ subtly between countries, and the overtones of the word to which respondents may react. For example, it was felt that in the service industries "technological" might be understood as "using high-tech plant and equipment".

23. Chapter 3 proposes definitions backed up by examples. For the purposes of the introductory discussion in Chapters 1 and 2, a working description of TPP innovation will be sufficient.

24. *A technological product innovation is the implementation/commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these*.

25. The distinction between "technological" novelty and other improvements rests largely on the "performance characteristics" of the products and processes concerned, and its applicability in practice will depend on the degree to which such characteristics and their degree of novelty are an important factor in sales in the firm/industry concerned. For example, it is easier to understand and apply to goods and services which are traded between firms, particularly high-tech manufacturing ones, than to consumer goods and services. One can readily imagine a set of performance characteristics for *computer chips, computers, paper mills, plastic granules or even computer services or commercial insurance cover,* and some conventions at least about what constituted "new or improved" characteristics which would be comprehensible to both buyer and seller. But what are the "objective performance characteristics" of *an Italian (or Chinese) meal, a presentation (or CD) of Aida, a man's necktie (designer, fake-designer, chainstore, etc.), a pair of trainers, a jar of face cream or a barrel of domestic soap powder*? How far do consumers base their decision to purchase them on "performance characteristics"? How far do producers identify new products in these "technological" terms?

26. Because of the lack of criteria for answering these questions, technological product innovation as defined in this manual excludes changes in products which provide largely subjective improved customer satisfaction based on personal taste and aesthetic judgement, and/or derived from following fashions, and/or brought about largely by marketing. However, since such changes are extremely important in certain industries and involve the same or similar activities as TPP innovation (design, marketing, etc.), they have been separately identified under the heading "other creative product improvements".

3.4 Diffusion of innovation

27. **Diffusion** is the way in which TPP innovations spread, through market or non-market channels, from their first worldwide implementation to different countries and regions and to different industries/markets and firms. Without diffusion, a TPP innovation will have no economic impact. In order to include some degree of diffusion, as recommended in Chapter 2, the minimum entry to the system described in this manual has been set at "new to the firm". This decision means that the complete diffusion of a new technology through a firm after its first adoption/commercialisation is not included.

28. However, by covering all products and processes with performance characteristics which are new to the firm, the exercise goes well beyond some earlier studies which concentrated on key technologies and their initial introduction at world and sometimes national level.

29. It is also proposed (Chapter 5) to collection information from innovating firms on the probable industry of utilisation of their technologically new or improved products. Chapter 2 mentions alternative methods of obtaining data on the diffusion of technology.

4. PROVIDING DATA ON THE KEY ISSUES

4.1 Factors influencing TPP innovation

30. Corporate strategies, sources of information for innovation and obstacles to innovation are identified as key areas for study in Chapter 2. Sets of questions designed to elicit information on these topics are given in Chapter 5. For each a possible list of factors is given. It is recommended that firm views should be registered either on a binary base (important/not important) or for a short range of possible answers (very important through to irrelevant). This semi-quantitative approach has been chosen because it is easier for respondents, though the results are difficult to analyse. The lists within each topic have been revised in the light of the results of the CIS survey.

4.2 TPP innovation activities and expenditures

31. TPP innovation activities are all those scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of technologically new or improved products or processes. Some may be innovative in their own right, others are not novel but are necessary for implementation.

32. Various policy and analytical studies cited in Chapter 2 provide breakdowns of these activities matching their particular viewpoints. Establishing a single list for statistical use is thus a problem, particularly as the capacity of the firms concerned to think and supply data in these terms must also be taken into consideration.

33. Furthermore, innovation is not a linear process and there may be important loops back in the system (see Chapter 2). The main activities involved are R&D, other acquisition of knowledge (patents, licences, technical services, etc.), acquisition of machinery and equipment (both incorporating new technology and for standard use when producing a new product), various other preparations for production/delivery, including tooling up, staff training, etc., and, last but not least, marketing (see Chapter 3). Of these, only R&D and the acquisition of machinery incorporating new technology are automatically TPP innovation activities. The others are only included if they are required for the implementation of TPP innovations, not if they are undertaken in connection with organisational innovation, other creative improvements or straightforward capital or production extension.

34. During a given period the innovation activities of a firm may be of three kinds:

- **Successful** in leading up to the implementation of a new or technologically improved product or process.
- **Aborted** before the implementation of a new or technologically improved product or process, because the project runs into difficulties, because the idea and know-how is sold or otherwise traded to another firm, or because the market has changed.
- **Ongoing,** activities which are in progress but have not yet reached implementation.

35. Expenditures are measured on the basis of the sum of these three kinds of activity over a given period of time (see Chapter 6). The alternative is to collect information on total expenditures on activities leading up to individual innovations. Firms seem to have had considerable difficulties in reporting a full set of data whichever approach was used. However, this is an essential set of data for the purposes of economic analysis, if only to identify the share of R&D spending in the total cost of the new products and

processes to which it is intended to contribute. It is hoped that, with successive exercises, firms will find their own interest in costing their innovation activities.

4.3 The TPP innovating firm and the impact of TPP innovation

36. One of the first steps when presenting the results of an innovation survey is to take the proportion of firms which are "innovating" as opposed to "non-innovating". This proportion threatens to become a "magic number" comparable to the percentage of GDP devoted to R&D. It is a figure that requires some care in presentation and interpretation. A first point is that it is best calculated taking into account industrial structure crossed, if possible, with a breakdown by size of firm; a global figure can be very misleading (suitable breakdowns are recommended in Chapter 4). Furthermore, it is important to ensure that only TPP innovations have been included, not organisational innovations or even other creative improvements. The definition of the firm used may also have an impact. The case of franchises, mentioned above, is an example. *Are all "quick photo development" outlets in a chain to be considered innovating firms if they are all supplied with the same improvement to their equipment?*

37. The TPP innovating firm (defined in Chapter 3) is one that has implemented technologically new or significantly improved products, processes or combinations of products and processes during the period under review. It is a firm with **successful** innovation activities during the period. Within this category it may be interesting to divide out firms which have only "passive" TPP innovation, *i.e.* those which have innovated exclusively by importing technology incorporated in new machinery and equipment. Furthermore it is recommended that firms which have been set up during the period under review should only be included in the innovating category if at their founding they have introduced a TPP innovation which is new to their operating market, or if they have implemented a TPP innovation later during the period under review. (Further practical guidelines are given in Chapter 6.)

38. The impact of TPP innovation can be measured by the percentage of sales derived from new or improved products (as described in Chapter 6). Here again there are problems in interpreting the resulting indicator. For firms entering business during the (three-year) period under consideration, all products are in principle new and the percentage of sales derived from new or improved products is 100 by definition. A convention that allows this distortion to be avoided is proposed in Chapter 3, Section 6.

39. The indicator is also influenced by the length of the product's life cycle. Within product groups with shorter life cycles, there is a more frequent need for innovation compared with product groups with longer life cycles.

40. It is also suggested in Chapter 5 that information should be collected on the impact of TPP innovations on factors of production.

5. SOME SURVEY ISSUES

5.1 Approach to data collection

41. There are two main approaches to collecting data on TPP innovations by firms: the "subject approach" which starts from the innovative behaviour and activities of the enterprise as a whole; and the "object approach" which concentrates on the number and characteristics of individual innovations.

42. When preparing the first version of the manual it was decided that the subject approach was more amenable to international standardisation, and it was retained as the basis for the original guidelines. However, recognising the strengths of the object approach for certain types of questions (or surveys), the

basic definitions in Chapter 3 and institutional classifications in Chapter 4 in the present version of the manual have been framed in a way which is suitable for both approaches and a special annex has been added on the object approach (Annex 1). The specifications in Chapters 5 to 7 are essentially intended for enterprise-based innovation surveys, though they may also be of interest for other types.

5.2 Survey methods

43. To reach international comparability of these enterprise-based innovation surveys, it is important to harmonize their main characteristics as far as possible. Guidelines are given in Chapter 7.

44. The target population for innovation surveys should be as uniform as possible. In the case of sample surveys, the sample frames should correspond as closely as possible to the target population. All large firms belonging to the target population should be included in the survey. For smaller firms a stratified random sample according to size and industry should be drawn.

45. In order to achieve a satisfactory response rate, the questionnaire should be as short as possible and should include clearly formulated questions and instructions. This may involve expressing the formal definitions in Chapter 3 in ways which are appropriate and meaningful to respondents in the industry concerned, notably in the service industries.

46. In the data collection phase, particular attention should be paid to checking the reliability and consistency of data and to the reminder procedures. International comparability of the resulting data will be further improved by uniform methods of imputing missing values, weighting factors, principles for presenting results, etc.

6. THE RELATIONSHIP BETWEEN THE *OSLO MANUAL* AND OTHER INTERNATIONAL STANDARDS AND RELATED CONCEPTS

47. Innovation takes place throughout the economy but has certain special characteristics that distinguish it from the more specific scientific and technological activities which it usually involves and from the economic activities of which it is part.

6.1 S&T activities: the Frascati family of manuals

48. There are two basic families of S&T indicators which are directly relevant to the measurement of TPP innovation: resources devoted to R&D; and patent statistics.

49. R&D data are collected through national surveys according to the guidelines laid down in the *Frascati Manual* (OECD, 1993). These data have proved valuable in many studies: for example, the effects of R&D on productivity have been measured by econometric techniques, at the country, sector and firm levels. These data have two main limitations. First, R&D is an input. Although it is obviously related to technical change, it does not measure it. Second, R&D does not encompass all the efforts of firms and governments in this area, as there are other sources of technical change, such as learning-by-doing, which escape from this narrow definition.

50. A patent is a legal property right over an invention, which is granted by national patent offices. A patent provides to its owner a monopoly (with limited duration) for exploiting the patented invention, as a counterpart for disclosure (which is intended to allow a broader social use of the discovery). Patent statistics are increasingly used in various ways by technology students as indicators of the output of invention activities. The number of patents granted to a given firm or country may reflect its

technological dynamism; examination of the technologies patented can give some hints on the directions of technological change. The drawbacks of patents as indicators are well known. Many innovations do not correspond to a patented invention; many patents correspond to invention with a near zero technological and economic value, whereas a few of them have very high value; many patents never lead to innovation [see OECD (1994), "The Measurement of Scientific and Technological Activities: Using Patent Data as Science and Technology Indicators – Patent Manual" OCDE/GD(94)114].

51. These two basic families of statistics are complemented by several others, including statistics on scientific publications (bibliometrics), publications in trade and technical journals (so-called "LBIO": literature-based indicators of innovation output), the technology balance of payments, and activity in high-tech sectors (investment, employment, external trade). Moreover, some information on innovation and innovation activities can be drawn indirectly from many other sources, such as business surveys or education statistics.

52. Wherever possible this manual draws on the concepts and classifications set out in other volumes in the set of OECD manuals for the measurement of scientific and technological activities (see Box 2), especially the *Frascati Manual* on the resources devoted to R&D (OECD, 1993). This particularly applies to a number of additional questions on R&D and other S&T activities recommended for inclusion in TPP innovation surveys in Chapters 5 and 6.

6.2 Other economic norms and classifications

53. Because of the need to place innovation in a wider context, both conceptually and in terms of databases, United Nations guidelines and classifications are used as far as possible, notably the System of National Accounts – SNA (CEC *et al*., 1994) and the International Standard Industrial Classification – ISIC Rev. 3 (UN, 1990) plus, as this is a joint OECD/EC manual, the corresponding European norms, notably the Statistical Classification of Economic Activities in the European Community – NACE Rev. 1 – Series 2E.

Box 2. The "Frascati Family" of Guidelines for the Measurement of Scientific and Technological Activities

Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual, fifth edition (OECD, 1993).

Main Definitions and Conventions for the Measurement of Research and Experimental Development (R&D): A Summary of the *Frascati Manual 1993* [OCDE/GD(94)84].

Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data – TBP Manual (OECD, 1990).

OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual, second edition (OECD/EC/Eurostat, 1996).

The Measurement of Scientific and Technological Activities: Using Patent Data as Science and Technology Indicators – Patent Manual [OCDE/GD(94)114].

The Measurement of Human Resources Devoted to S&T – Canberra Manual [OECD/EC/Eurostat, OCDE/GD(95)77].

6.3 Other related concepts and surveys

54. As noted above, there are other ways of examining changes in firms which improve their productivity and performance. Here we shall examine just two of them, intangible investment and the generation and adoption of information technology – IT.

55. *Intangible investment* covers all current expenditure for the firm's development which is expected to give a return over a longer period than the year in which it is incurred. There is no standard definition, but it is generally taken to cover expenditure on non-routine marketing, training, software and some other similar items, in addition to current expenditure on R&D. It covers current expenditure on TPP innovation but also comprises elements which are not part of TPP current innovation expenditure (for example it includes all of the firm's training and marketing expenditure in general, not simply training or marketing in connection with the introduction of technologically new products and processes). It does not cover tangible investment such as capital TPP innovation expenditure, which includes capital expenditure on R&D, acquisition of new machinery and equipment related to TPP innovations.

56. *Information technology* covers both hardware and software. Their development and diffusion is believed to have had a major impact on the pattern of production and employment in a wide range of industries. In the case of hardware it may be interesting not only to know when a company innovates by first introducing a technologically new or improved piece of IT equipment but also the IT proportion of its total stock of equipment including subsequent purchases of further machines of the same model. Information of this kind can be obtained through special IT surveys which are developments of earlier "manufacturing technology" surveys (US Bureau of the Census, 1988 and 1992; Statistics Canada 1988 and 1992/93; Australian Bureau of Statistics, 1993).

57. Mapping the development, production, adaptation and use of software is a more complex matter as these activities are carried out throughout the economy. A special capital category has been defined in the System of National Accounts (EC *et al.*, 1993) and survey guidelines have been established for the computer services industry (UN, 1992), but the associated data collection is still under development.

7. FINAL REMARK

58. This manual is based on a consensus of views on the demand for innovation indicators and the underlying policy needs and economic theory, on the definitions and coverage of innovation and on the lessons to be learned from previous surveys. Managed jointly by the OECD and the European Commission, it has been written for and by experts from some thirty countries who collect and analyse innovation data. Finding consensus has sometimes meant reaching compromises and agreeing to conventions. Furthermore, the complexity of the innovation process itself makes it difficult to establish absolutely precise guidelines. Nevertheless this manual does present a robust set of guidelines which can be applied to produce meaningful indicators of TPP innovation.

Chapter 2

NEEDS FOR THE MEASUREMENT OF INNOVATION

1. INTRODUCTION

59. "The knowledge-based economy" is an expression coined to describe trends in the most advanced economies towards greater dependence on knowledge, information and high skill levels, and an increasing need for ready access to all of these. A major OECD study[2] has placed great stress on the importance of these trends for policy:

"Today, knowledge in all its forms plays a crucial role in economic processes. Nations which develop and manage effectively their knowledge assets perform better. Firms with more knowledge systematically outperform those with less. Individuals with more knowledge get better paid jobs. This strategic role of knowledge underlies increasing investments in research and development, education and training, and other intangible investments, which have grown more rapidly than physical investment in most countries and for most of the last decades. The policy framework should thus put central emphasis on the innovative and knowledge-creating and using capacity of OECD economies. Technological change results from innovative activities, including immaterial investments such as R&D, and creates opportunities for further investment in productive capacity. This is why, in the long term, it creates jobs and more income. A main task for governments is to create conditions that induce firms to engage in the investments and innovative activities required for enhancing technical change."

60. Within the knowledge-based economy, innovation is seen to play a central role, but until recently the complex processes of innovation have been insufficiently understood. Better understanding, however, has emerged from many studies in recent years.[3] At the macro-level, there is a substantial body of evidence that innovation is *the* dominant factor in national economic growth and international patterns of trade. At the micro-level – within firms – R&D is seen as enhancing a firm's capacity to absorb and make use of new knowledge of all kinds, not just technological knowledge.

61. Other factors which influence firms' abilities to learn are also seen to be of fundamental importance. Ease of communication, effective channels of information, skills transmission and the accumulation of knowledge, within organisations and between them, are highly important. In particular, management and an appropriate strategic outlook are key factors. They determine much of the scope for the external linkages and the positive attitudes inside firms that promote receptivity to the adoption of improved practices and improved technology. According to a recent European Commission Green Paper:[4]

"The innovative firm thus has a number of characteristic features which can be grouped into two major categories of skills:

- **strategic skills:** long-term view; ability to identify and even anticipate market trends; willingness and ability to collect, process, and assimilate technological and economic information;

- **organisational skills:** taste for and mastery of risk; internal co-operation between the various operational departments, and external co-operation with public research, consultancies, customers and supplier; involvement of the whole of the firm in the process of change, and investment in human resources."

62. Better awareness of the significance of innovation has made it a major item on the policy agenda in most developed countries. Innovation policy grew primarily out of science and technology policy, but it absorbed significant aspects of industry policy as well. As the understanding of innovation improved, there were substantial changes in the development of innovation-related policies. Initially, technological progress was assumed to be achieved through a simple linear process starting with basic scientific research and progressing in a straightforward manner through more applied levels of research, embodying the science in technological applications, and marketing. Science was seen as the driver, and all that government needed was science policy. Fresh thinking about innovation has brought out the importance of systems and led to a more integrated approach to the delivery of innovation-related policies.

2. ECONOMICS OF INNOVATION

63. Innovation is at the heart of economic change. In Schumpeter's words, "radical" innovations shape big changes in the world, whereas "incremental" innovations fill in the process of change continuously. Schumpeter proposed a list of various types of innovations:[5]

- introduction of a new product or a qualitative change in an existing product;
- process innovation new to an industry;
- the opening of a new market;
- development of new sources of supply for raw materials or other inputs;
- changes in industrial organisation.

64. It is crucial to know why technological change occurs, why firms innovate. The reason put forward, based on Schumpeter's work, is that firms are seeking rents. A new technological device is a source of some advantage for the innovator. In the case of productivity-enhancing process innovation, the firm gets a cost advantage over its competitors, which allows it to gain a higher mark-up at the prevailing market price or, depending on the elasticity of demand, to use a combination of lower price and higher mark-up than its competitors to gain market share and seek further rents. In the case of product innovation, the firm gets a monopoly position due either to a patent (legal monopoly) or to the delay before competitors can imitate it. This monopoly position allows the firm to set a higher price than would be possible in a competitive market, thereby gaining a rent.

65. Other work has emphasized the significance of competitive positioning. Firms innovate to defend their competitive position as well as to seek competitive advantage. A firm may take a reactive approach and innovate to prevent losing market share to an innovative competitor. Or it may take a proactive approach to gain a strategic market position relative to its competitors, for example by developing and then trying to enforce higher technical standards for the products it produces.

66. Technical change is far from smooth. New technologies compete with established ones, and in many cases replace them. These processes of *technological diffusion* are often lengthy, and usually involve incremental improvement both to new and established technologies. In the resulting turbulence, new firms replace incumbents who are less capable of adjusting. Technical change generates a reallocation of resources, including labour, between sectors and between firms. As Schumpeter pointed out, technical change can mean creative destruction. It may also involve mutual advantage and support among competitors or among suppliers, producers and customers.

67. Much technological knowledge displays the features of a *public good*, as the costs of making it available to many users are low compared to the cost of its development and, once disseminated, users cannot be denied further access to it. This characteristic is a source of two main problems for private innovators. The first is spillover of the benefits of innovation (positive externalities), the fact that the social return on innovation is usually higher than the private return (customers and competitors benefit from a firm's innovations). The second problem is another aspect of the first – the knowledge cannot be appropriated. In such a case the firm cannot capture all the benefits generated by its innovation, which lessens the incentive to invest in innovative activities. Thus, where technological knowledge has public good characteristics, there is a failure in the market forces (*market failure*) that would otherwise be expected to motivate firms to innovate.

68. From this theoretical stand, many studies have derived statistical data and indicators that refer mainly to the cost of innovation and to the private and social rates of return on innovation activities. In such work, the private return on technological activities has been inferred through econometric methods involving the estimation of production functions that relate the inputs and outputs of innovation activities at the firm or aggregate level. To the extent that technological knowledge displays public good characteristics, science and technology policies have been conceived as responses to lessened incentive and other market failures such as risk and transaction costs. The main policy tools have been government direct funding of research, especially basic research (government as a provider of a public good), and patents (property rights).

69. Technological knowledge is also increasingly being understood to display other characteristics such as accumulation (which results in increasing returns) and influencing the dynamics of markets so that they remain far from equilibrium (and tend to be pushed away from, not towards, equilibrium). These have resulted in the more recent developments of "Evolutionary Economics"[6] and "New Growth Theory".[7]

70. The evolutionary approach emphasizes the importance of technological variety and diversity and the ways in which variety translates into technological opportunities and outcomes. These influence the ability of firms to innovate and the "trajectories" or directions in which firms innovate. A corollary is that statistical data need to be highly disaggregated, based on firm-level competences and skills, networking and technology "scanning". There is also a need for data to map the specificities of systems at various levels, and to indicate the types, levels and effectiveness of interactions between firms, notably via the adoption of innovations, and interactions with other institutions, both nationally and internationally.

71. The higher-level or systems view of innovation emphasizes the importance of the transfer and diffusion of ideas, skills, knowledge, information and signals of many kinds. The channels and networks through which this information circulates are embedded in a social, political and cultural background, they are strongly guided and constrained by the institutional framework. The "National Systems of Innovation" (NSI) approach studies innovating firms in the context of the external institutions, government policies, competitors, suppliers, customers, value systems, and social and cultural practices that affect their operation.[8]

72. System approaches to innovation shift the focus of policy towards an emphasis on the interplay between institutions, looking at interactive processes in the creation of knowledge and in the diffusion and application of knowledge. It has led to a better appreciation of the importance of the conditions, regulations and policies within which markets operate – and hence the inescapable role of governments in monitoring and seeking to fine-tune this overall framework. There is for example a recognition that issues of system failure should be considered along with issues of market failure. A major OECD study concludes:[9]

"The many factors that influence individual firms' behaviour include the variety of government policies that affect each of them. A systemic approach to policy targeting is needed because:

- there is no simple policy answer to problems as complex as those raised by technology/employment relationships in a knowledge-based economy;
- an efficient policy strategy must combine a number of macroeconomic and structural policy actions;
- the coherence of the policy package is a condition of success, and it depends on the validity of the policy framework as well as on the quality of the process of policy formulation."

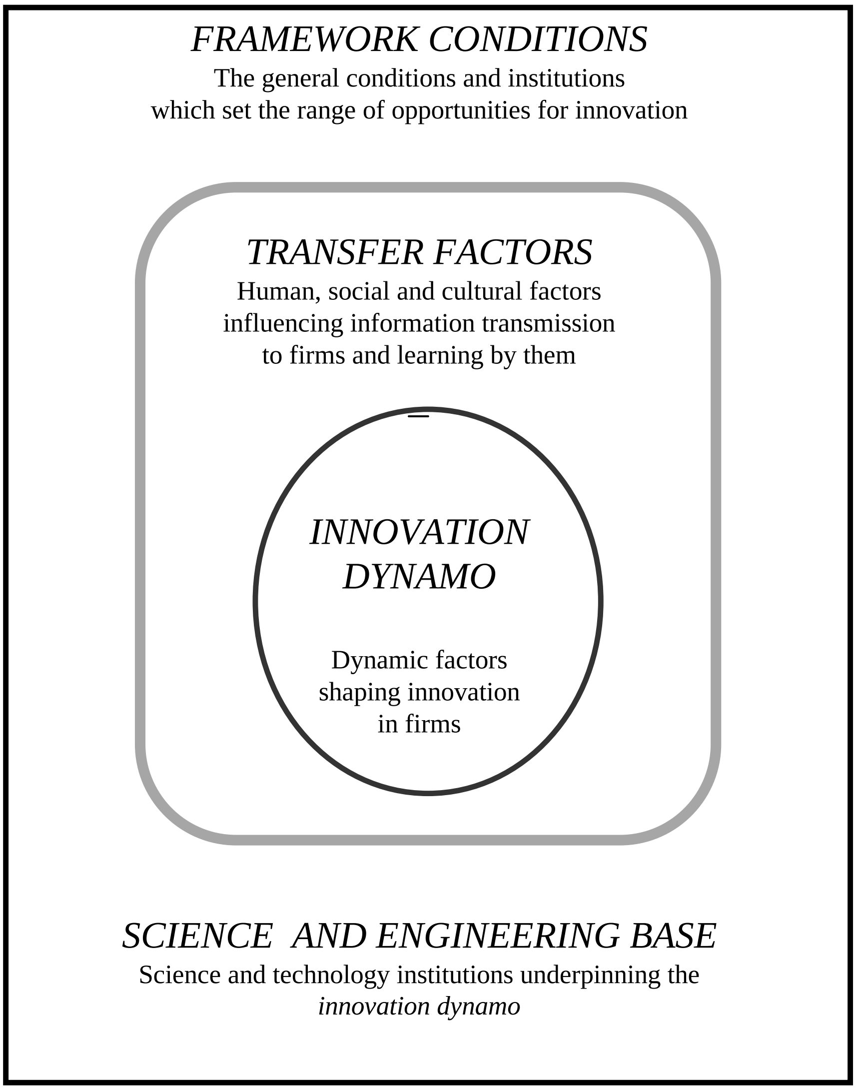
3. TOWARDS A CONCEPTUAL FRAMEWORK

73. Collecting quantitative data requires a framework, explicit or not, which makes it possible to organise and understand this data. It presupposes ideas about the nature of the subject, its essential features, and what is important and what is not.

74. There are three major categories of factors primarily relating to innovation. These concern business enterprises ("firms"), science and technology institutions, and issues of transfer and absorption of technology, knowledge and skills. In addition, the range of opportunities for innovation is influenced by a fourth set of factors – the surrounding environment of institutions, legal arrangements, macroeconomic settings, and other conditions that exist regardless of any considerations of innovation.

75. These four broad categories or domains of factors relating to innovation can be presented as a map that points to areas where policy leverage might be applied to business innovation, or to areas that need to be taken into account when policy initiatives are shaped. This is a way of presenting the policy terrain for a generalised national system of innovation. While the emphasis in the literature is on national systems, it is also clear that in many instances similar considerations apply at the local and transnational levels.

Figure 1. The innovation policy terrain – a map of issues



76. The outline ***map***[10] in Figure 1 labels these four general domains of the ***innovation policy terrain*** as follows:

- the broader *framework conditions* of national institutional and structural factors (*e.g.* legal, economic, financial, and educational) setting the rules and range of opportunities for innovation;

- the *science and engineering base* – the accumulated knowledge and the science and technology institutions that underpin business innovation by providing technological training and scientific knowledge, for example;

- *transfer factors* are those which strongly influence the effectiveness of the linkages, flows of information and skills, and absorption of learning which are essential to business innovation – these are factors or human agents whose nature is significantly determined by the social and cultural characteristics of the population; and

- the *innovation dynamo* is the domain most central to business innovation – it covers dynamic factors within or immediately external to the firm and very directly impinging on its innovativeness.

3.1 Framework conditions

77. The external arena within which firms can manoeuvre and change, and which thus surrounds innovation activities at the firm level (the innovation dynamo), comprises institutions and conditions which have mostly been established (or have developed) for reasons unconnected to innovation. These factors determine the broad parameters within which firms exist and carry out their business. They therefore have substantial effects on business innovation. This general institutional environment provides the ***framework conditions*** within which innovation can occur.

78. The component elements include:

- the *basic* ***educational*** *system for the general population*, which determines minimum educational standards in the workforce and the domestic consumer market;

- the ***communications*** *infrastructure*, including roads, telephones and electronic communication;

- ***financial*** *institutions* determining, for example, the ease of access to venture capital;

- ***legislative*** *and macro-economic settings* such as patent law, taxation, corporate governance rules – and policies relating to interest and exchange rates, tariffs and competition;

- ***market*** *accessibility*, including possibilities for the establishment of close relations with customers as well as matters such as size and ease of access;

- ***industry structure*** *and the competitive environment*, including the existence of supplier firms in complementary industry sectors.

3.2 Science and engineering base

79. Scientific knowledge and engineering skills are a primary support for business innovation. In most countries, these reside and are further developed in public sector science and technology institutions. The worldwide output of scientific knowledge from these institutions provides an essential understanding and theoretical base for business innovation.

80. The differences in the nature of activities within science and technology institutions and innovating firms need to be understood. There are significant motivational differences between the communities within these two domains. Achievement is generally recognised in different ways, and reward structures are also different. In science, individuals tend to have a stronger role than the institutions which employ them. On the other hand, “the firm” (and hence organisational issues such as teamwork and strategy) tends to be more important than the individual in business innovation and technology. However, networks of individuals – and thus many aspects of social behaviour – are of key importance in the transfer of information both among scientists and among those involved in business innovation. The national science and technology institutions can act as effective local conduits to this base and can provide the skilled personnel to fill key positions concerned with innovation. For much of business innovation they also provide sources of specialist advice, fruitful interaction and collaboration, and significant technological advances – often having their origin in their own scientific needs for improved instrumentation.

81. The elements of the national ***science and engineering base*** include:

- The specialised **technical training** system.

- The **university** system.

- The support system for **basic research** (radical breakthroughs and long-term benefits aside, basic scientific research is sometimes perceived as providing little direct benefit to business innovation. However, its indirect benefits can be very substantial. Scientific investigation often requires the development of highly sophisticated and ultra-sensitive equipment. Thus, many areas of basic research provide fertile ground for the training of skilled technology-oriented scientists – whose experience can often be successfully directed to industrial problems.).

- **Public good R&D activities –** funding programmes and institutions generally directed towards areas such as health, the environment and defence.

- **Strategic R&D activities** – funding programmes and institutions directed towards "pre-competitive R&D" or generic technologies.

- **Non-appropriable innovation support –** funding programmes and institutions directed towards research in areas where it is difficult for individual enterprises to appropriate sufficient benefit from their own in-house research.

3.3 Transfer factors

82. Research on innovation has identified a number of human, social and cultural factors which are crucial to the effective operation of innovation at the firm level. These factors are mostly based around *learning*. They relate to the ease of communication within organisations, informal interactions, co-operation and channels of information and skills transmission between and within organisations, and social and cultural factors which have a pervasive influence on how effectively these activities and channels can operate. A key point from research on innovation is that much essential knowledge, particularly technological knowledge, is unwritten. Thus some kinds of information can only be transferred effectively between two experienced individuals – through transmission to a receptive individual who has enough expertise to understand it fully, or by physical transfer of the people who are carriers of the knowledge. It is *learning* by firms as a whole (*i.e.* diffusion of knowledge to a broad range of key individuals within them) that is critical to firms' innovative capabilities.[11]

83. Broadly, these ***transfer factors*** may be listed as:

- formal and informal ***linkages between firms***, including networks of small firms, relationships between users and suppliers, relationships between firms, regulatory agencies and research institutions, and stimuli within "clusters" of competitors, can all produce information flows conducive to innovation or lead firms to be more receptive to it;

- the ***presence of expert technological "gatekeepers"*** *or receptors* – individuals who, through many means, keep abreast of new developments (including new technology and codified knowledge in patents, the specialised press and scientific journals), and maintain personal networks which facilitate flows of information – can be crucial to innovation within a firm;

- ***international links*** are a key component of the networks through which information is channelled – networks ("invisible colleges") of international experts are a key means of transmitting up-to-date scientific understanding and leading-edge technological developments;

- the degree of ***mobility*** of expert technologists or scientists will affect the speed at which new developments can spread;

- the *ease of industry* ***access to public R&D*** *capabilities*;

- ***spin-off company formation*** – usually involving the transfer of particular skilled individuals – is often a valuable means of achieving commercialisation of new developments arising out of public sector research;

- ***ethics, community value-systems, trust and openness*** that influence the extent to which networks, linkages and other channels of communication can be effective, by affecting the informal dealings between individuals which underpin many business arrangements, and setting the parameters and accepted rules of behaviour within which communication and exchanges of information occur; and

- ***codified knowledge*** in patents, the specialised press and scientific journals.

3.4 Innovation dynamo

84. The complex system of factors shaping innovation at the firm level is referred to as the "innovation dynamo". Placing the innovation dynamo at the centre of the map recognises the importance of the firm for an economy to be innovative. It is therefore important to understand what characteristics make firms more or less innovative and how innovation is generated within firms. The propensity of a firm to innovate depends, of course, on the technological opportunities it faces. In addition, firms differ in their ability to recognise and exploit technological opportunities. In order to innovate, a firm must figure out what these opportunities are, set up a relevant strategy, and have the capabilities to transform these inputs into a real innovation – and do so faster than its competitors. But it would be misleading to stop there. Many technological opportunities do not just arise on their own, but are devised by firms in order to fulfil some strategic goal (*e.g.* satisfying an identified market demand). Innovation capability consists of a set of factors, which the firm either has or has not, and ways of combining these factors efficiently.

85. The technological capability of a firm is partly embedded in its labour force. Skilled employees are a key asset for an innovative firm. Without skilled workers a firm cannot master new technologies, let alone innovate. Apart from researchers, it needs engineers who can manage manufacturing operations, salespeople able to understand the technology they are selling (both to sell it and to bring back customers' suggestions), and general managers aware of technological issues.

86. Capability also depends on the characteristics of the firm: the structure of its labour force and facilities (skills, departments), its financial structure, its strategy on markets, competitors, alliances with other firms or with universities, and above all its internal organisation. Many of these aspects are complementary. A particular skill structure will go hand in hand with a particular type of strategy, financial structure and so on.

87. The options open to a firm which wants to innovate, *i.e.* to change its technological assets, capabilities and production performance, are of three kinds: strategic, R&D and non-R&D.

- **Strategic:** As a necessary background to innovation activity, firms have – explicitly or not – to make decisions about the types of markets they serve, or seek to create, and the types of innovations they will attempt there.

- **R&D:** Some of the options relate to R&D (in the *Frascati Manual* sense, including experimental development that goes well beyond basic and applied research):

  – the firm can undertake basic research to extend its knowledge of fundamental processes related to what it produces;

  – it can engage in strategic research (in the sense of research with industrial relevance but no specific applications) to broaden the range of applied projects that are open to it, and applied research to produce specific inventions or modifications of existing techniques;

  – it can develop product concepts to judge whether they are feasible and viable, a stage which involves: i*)* prototype design; *ii)* development and testing; and *iii)* further research to modify designs or technical functions.

- **Non-R&D:** The firm may engage in many other activities that do not have any straightforward relation to R&D, and are not defined as R&D, yet play a major role in corporate innovation and performance:

  – it can identify new product concepts and production technologies: *i)* via its marketing side and relations with users; *ii)* via the identification of opportunities for commercialisation resulting from its own or others' basic or strategic research; *iii)* via its design and engineering capabilities; *iv)* by monitoring competitors; and *v)* by using consultants;

  – it can develop pilot and then full-scale production facilities;

  – it can buy technical information, paying fees or royalties for patented inventions (which usually require research and engineering work to adapt and modify), or buy know-how and skills through engineering and design consultancy of various types;

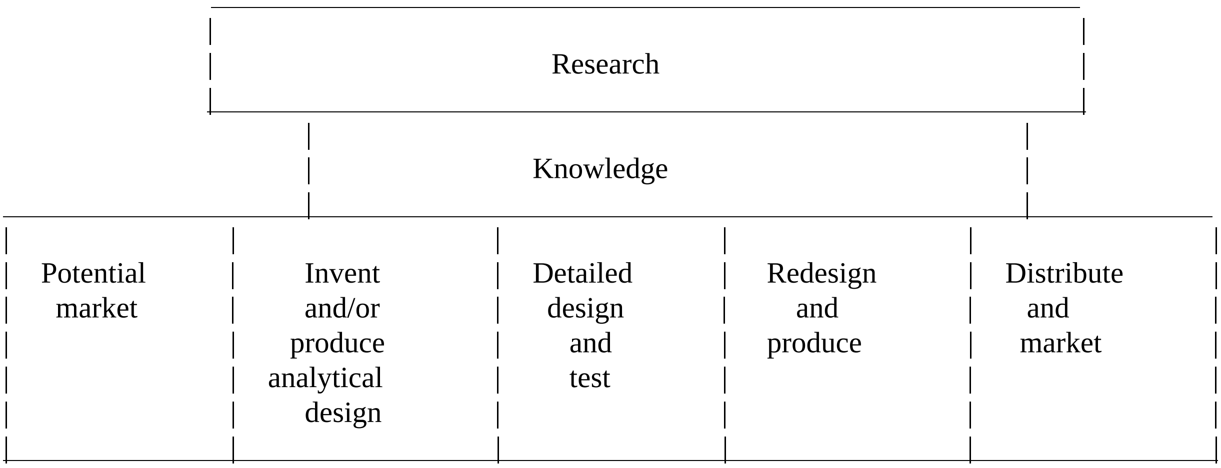
  – human skills relevant to production can be developed (through internal training) or purchased (by hiring); tacit and informal learning – "learning-by-doing" – may also be involved;

  – it can invest in process equipment or intermediate inputs which embody the innovative work of others; this may cover components, machines or an entire plant;

  – it can reorganise management systems and the overall production system and its methods, including new types of inventory management and quality control, and continuous quality improvement.

88. Many attempts have been made to construct models to shed light on the way innovation is generated within firms, and how it is influenced by what goes on outside firms. One useful approach is the "chain-link model" of Kline and Rosenberg[12] (Figure 2).

Figure 2. The chain-link model of innovation[13]



89. The chain-link model conceptualises innovation in terms of interaction between market opportunities and the firm's knowledge base and capabilities. Each broad function involves a number of sub-processes, and their outcomes are highly uncertain. Accordingly, there is no simple progression; it is often necessary to go back to earlier stages in order to overcome difficulties in development. This means feedback between all parts of the process. A key element in determining the success (or failure) of an innovation project is the extent to which firms manage to maintain effective links between phases of the innovation process: the model emphasizes, for instance, the central importance of continuous interaction between marketing and the invention/design stages.[14]

90. What is the role of research in innovation? In the chain-link model, research is viewed not as a source of inventive ideas but as a form of problem-solving, to be called upon at any point. When problems arise in the innovation process, as they are bound to do, a firm draws on its knowledge base at that particular time, which is made up of earlier research findings and technical and practical experience. The research system takes up the difficulties which cannot be settled with the existing knowledge base, and so extends it if successful.

91. This approach has implications for how we understand "research". Given that it can relate to any stage of innovation, research is a complex and internally differentiated activity with, potentially, a wide variety of functions. It is an adjunct to innovation, not a precondition for it. Many research activities will be shaped by the innovation process, in fact, and many of the problems to be tackled will derive from innovative ideas that were generated elsewhere. Accordingly, for the chain-link approach, research cannot be seen simply as the work of discovery which precedes innovation.

92. Rothwell[15] has discussed a number of other approaches to model construction, including parallel models involving high levels of functional integration. He suggests the extension of these to "fifth generation" or SIN (system integration and networking) models that also provide for changes in the technologies through which technological change itself is transmitted.

93. **It is not the purpose of this discussion to present any particular model of innovation as definitive. Some serious question marks hang over all the available models. The point to be noted, however, is that innovation is a complex, diversified activity with many interacting components, and sources of data need to reflect this.**

4. DECIDING PRIORITIES

94. Governments around the world are now faced with a host of problems related to development of indicators relevant to the knowledge-based economy. OECD Ministers for Science and Technology have called for better indicators to be developed in this area:[16]

> "… the rapidly accumulating body of research on innovation, including the emerging new growth theory, has important implications for the development of science and technology policies as well as other policies affecting national innovation performance. … Ministers agreed that there is a need for Member countries to collaborate to develop a new generation of indicators which can measure the innovation performance and other related output of a knowledge-based economy."

95. Recommendations are also given in the European Commission *Green Paper*:

> "... regular statistical surveys of technological innovation should be organised in the Member States. The surveys should make it possible to measure also the costs and the benefits stemming from innovative activities and to arrive at a better understanding of the factors which determine innovation."

96. It is essential to feed the debate on policy issues with information and analysis of many aspects of innovation. Ideally, a comprehensive information system should be constructed that covers all types of factors within the innovation policy terrain. This would place governments in a strong position to deal appropriately with any particular policy issues that might arise. In practice, only parts of such a system can be covered by indicators, while other parts call for qualitative information. Moreover, as policy and indicator analysts are well aware, indicators will only occasionally relate neatly to a single factor or issue, and more often than not will relate to a range of matters and only partially to each. Any broad information or monitoring system will also need to be supplemented with case studies where specific in-depth analysis is required. As far as possible, it will also be important to consider a range of indicators and other information wherever possible – even if attention is to be directed to a highly specific issue or a relatively narrow range of issues.

4.1. Six areas for investigation

4.1.1 Corporate strategies

97. Corporate strategies are not easily classified by means of a survey. But firms can be asked how they perceive the development of their markets and the importance of various strategic choices in connection with the development of products and markets. The mix of strategic choices is likely to vary from industry to industry. Because the particular pattern is of policy significance, every effort should be made to obtain data classified by type of strategy.

4.1.2 The role of diffusion

98. The importance of the diffusion of new developments throughout an economy should not be overlooked. An innovation may have little effect unless it is widely applied beyond its place of origin (first in the world) in other countries, industries and even firms in the same industry.

99. A difficulty in much analysis of technological change and productivity growth is that it is extremely hard to track flows of innovation and technological change from one industry to another, and hence to trace the spillover of productivity-raising activity.[17] How do firms incorporate innovations that have been developed elsewhere? Also, what is the weight of diffusion in relation to innovation?

100. One objective of further survey work should be to clarify these inter-industry flows. Focusing merely on firms' internally produced innovations gives a misleading picture of the economic impact of innovation on technological change. Some distinction is required between internal and external sources/destination of the results of innovating activities.

101. A separate but related issue concerns the role of inter-firm co-operation via shared R&D, licensing, joint ventures and so on. In many industries, co-operative arrangements have become so widespread that it is difficult to distinguish the individual processes of innovation, and sometimes even to see where the firms' boundaries are.

102. All this has obvious implications for policy, much of which is aimed, explicitly or implicitly, at promoting R&D, and pays far less attention to the other parts of the innovation process. In particular invention capability is often given precedence over technology adoption capability, yet the latter is a key component in a firm's performance.

4.1.3 Sources of information for innovation and obstacles to innovation

103. The general objective here should be to relate the technological assets and strategies of firms to the scope of their sources of information for innovation and to the obstacles which they perceive. Most firms have a wide range of potential sources of technical information. Their importance will vary with the firm's technological capabilities and strategy.

104. It is important to distinguish between internal and external (or endogenous and exogenous) sources of change. Internally, interest is likely to focus on the role – or roles – of the R&D department, and the involvement of all parts of the firm, particularly the marketing side, in decisions to innovate and on innovation activities. Externally, the focus will be on public research institutions as sources of technical information, and on inter-firm or inter-industry technology flows. Consideration of external sources of innovation or technological change ought logically to extend to international sources of technology, and be structured in such a way as to throw light on some of the unresolved problems with the technology balance of payments.

105. A problem to be resolved here is the classification of firms and industries that is used to analyse technology flows. Pavitt speaks of "supplier-dominated firms", "production-intensive firms" and "science-based firms", and uses the SPRU database to analyse connections between them. Archibugi *et al.* use a similar classification in analysis of the Italian data.[18]

106. The underlying issue here, which has considerable significance for policy, is that relatively little is known about what factors of environment, opportunity or regulation actually determine the locus of innovation[19] in complex networks of enterprises where innovation can obviously occur at a variety of places.

107. Obstacles to innovation are significant for policy as well, since a good proportion of government measures are in one way or another aimed at overcoming them. Many obstacles – skill shortages, problems of competence, finance, appropriation – are relatively straightforward to assess with survey methods.

4.1.4 Inputs to innovation

108. One starting point for analysis of innovation activity could be R&D, which takes on a wide variety of functional forms related to problem-solving. For example, it is often argued that firms need to

perform R&D in order to recognise and use, and hence adopt, technologies that have been developed elsewhere.[20]

109. Although it is desirable to include a measure of R&D within the survey, the core task is to integrate an understanding of the R&D contribution with an account of the non-R&D inputs to the innovation process. These inputs were described earlier in this chapter. It would be most useful to have an overview of the balance which firms strike between R&D and non-R&D activities, and the pattern of these balances in particular industries and across all industry. A wider understanding of these distributions, and their variation across industry, is of obvious importance for innovation policy.[21] They may also be of assistance in decisions on the desirable balance of government policy measures relating to R&D and non-R&D aspects of innovation. Collecting the information may pose serious practical difficulties, especially when firms have many divisions, but it is one of the most important possibilities of this type of survey work.[22]

4.1.5 The role of public policy in industrial innovation

110. Given that publicly funded R&D often accounts for a substantial proportion of total R&D in OECD economies, there is a clear need to understand its industrial effects more clearly. But R&D is only one element of public policy with effects on innovation performance.

111. Other areas can also promote innovation performance, or restrict it (education and the supply of skills; taxation policy and accounting regulations; industrial regulation, including environmental regulation, health standards, quality controls, standardization and so on; the legal system of intellectual property rights and hence problems of appropriability and the operation of the patent and copyright systems; the operation of the capital market). These aspects of public policy can be examined via questions on firms' perceptions of obstacles to innovation.

112. With the data on R&D, it is useful to explore the extent to which industrial applications may depend on basic research results from universities and publicly funded laboratories.[23]

4.1.6 Innovation outputs

113. Perhaps the most interesting aspect of these surveys is their potential capacity to measure directly the output of innovation activities. Past surveys have revealed that a very high proportion of firms had introduced innovations within the previous year, which shows that innovation activity is far more widespread than R&D data would suggest, for R&D is quite highly concentrated, both industrially and geographically.[24] However, the definition of what constitutes an innovation poses a number of definitional difficulties. Most products, and certainly the processes by which they are made, are complex systems. Change thus has to be defined in terms of:

- The attributes and performance characteristics of the product as a whole.

- Changes in components of the product which improve its efficiency, including the nature of the services which it delivers. Sub-system changes of this kind may be very small in scale but their cumulative impact can be considerable, and important from an analytical perspective.

114. Various definitional issues will be addressed in Chapter 3 including: distinguishing between a new product and a technologically improved product (minor aesthetic or technical improvements are considered product differentiation and not an innovation); how "new" is to be defined; and comparing

firms using definitions of the type of novelty to assist questions about the proportion of sales or exports these new or improved products account for.

4.2 How to measure and scope for measurement

115. The great variation in innovation processes, in terms of their objectives, organisation, cost, use of research, and so on, also means variation in the problems and constraints which firms must overcome in order to undertake successful technological change. This suggests discriminating between those aspects of the innovation process which can and cannot be measured, and clarifying the links between the measurement approach and the underlying process.

116. Innovation surveys of the type outlined in this manual mainly supply information concerning the innovation dynamo and the surrounding transfer factors (see Figure 1 above), which emphasize the importance of the firm for innovation. Focusing on the firm will affect the scope of measurement in ways which are now briefly discussed:

- What do we want to measure?
- How do we want to measure it?
- Where do we want to measure it?

4.2.1 "What do we want to measure?": Technological product & process – TPP – innovations

117. This manual deals with innovation at the level of the firm. When firms innovate, they are engaging in a complex set of activities with multiple outcomes, some of which, moreover, can reshape the boundaries and nature of the firm itself. The problem is to decide which of these activities and outcomes should and can be measured.

118. This manual concentrates on two of Schumpeter's categories, **new and improved products and processes, with the minimum entry set as "new to the firm"** in order to take in the recommendations on diffusion. However, practical experience has shown that not all the changes in products (and to a much lesser extent processes) which firms see as being new or improved match the model of technical change described above. This is not merely a matter of excluding changes which are insignificant, minor or do not involve a significant degree of novelty, but also of deciding how to treat aesthetic changes in products which may have an important effect on their appeal to customers and thus on the performance of the firm concerned. **This manual deals only with "technological" innovation, which requires an objective improvement in the performance of a product**.

119. In undertaking innovation firms must in some way change the stock of tangible and intangible assets which they possess. The intangible assets can be seen in part as capabilities and competences, which are built up via learning processes. Given that innovation is multifaceted, one key element of innovation is organisation, and this is an area which has received considerable attention in recent years. Organisation is essentially a process for the gathering, management and use of information, and for the implementation of decisions based on such information. Such processes have a strongly intangible dimension, but taken together they make up the learning capacity of the firm and as such are a central element in innovation capability. These are specific institutional "rules of the game" which regulate possible modes of organisation on a broad level, but within such institutional parameters firms can and do exhibit considerable diversity. If we look at firms from an information-theory and learning point of view, it seems clear that "organisation" may have very little to do with formal structures.

120. From this standpoint organisation is a critical dimension of innovation, but its measurement appears to be very difficult both conceptually and in practice. Moreover organisational change is highly firm-specific, making it still more difficult to summarise in aggregate, sector or economy-wide statistics. **In consequence, organisational innovation has not been included in the measures recommended in the body of the manual.**

121. A statistical approach can be fruitful here, but in many respects case studies alone can cast light on some important features of organisational change. For more details on the collection of non-technological innovation data, see Annex 2.

4.2.2 "How should it be measured?": Choice of the survey approach

122. There are two main approaches to collecting data on innovations:

- The "subject approach" survey starts from the innovative behaviour and activities of the firm as a whole. The idea is to explore the factors influencing the innovative behaviour of the firm (strategies, incentives and barriers to innovation) and the scope of various innovation activities, and above all to get some idea of the outputs and effects of innovation. These surveys are designed to be representative of each industry as a whole, so the results can be grossed up and comparisons made between industries.

- The other survey approach involves the collection of data about specific innovations (usually a "significant innovation" of some kind, or the main innovation of a firm) – the "object approach". This starts by identifying a list of successful innovations, often on the basis of experts' evaluations or new product announcements in trade journals. The suggested approach is to collect some descriptive, quantitative and qualitative data about the particular innovation at the same time as data is sought about the firm.

123. From the point of view of current economic development, it is the differential success of firms which shapes economic outcomes and is of policy significance. It is the subject, the firms, which count, and **the first approach has been chosen as the basis for these guidelines**.

124. The subject approach is also more amenable to international standardization. The proposed definitions and classifications are therefore primarily framed for use when designing firm-based innovation surveys, but the intention has been to make them useful for other types of innovation surveys as well. More information concerning the object approach (including literature-based innovation surveys) is given in Annex 1.

4.2.3 "Where should it be measured ?": Sectoral coverage

125. Innovation can of course occur in any sector of the economy, including government services such as health or education. Given the focus on the firm, the concepts and definitions that will be presented in this manual are mainly designed to deal with innovations in **the business enterprise sector**.

126. The previous version of this manual dealt only with innovation in manufacturing industry. Since then the spotlight for employment and production issues has turned to services, hence the need to find out more about their technological activities. It is already clear that services are the main users of innovation generated in manufacturing industries (OECD, 1995). Recent R&D surveys suggest that they are playing an important role in generating knowledge (OECD, 1996). In many fields the limit between industry and

services as innovative sectors is blurring (*e.g.* software takes an increasing share in most innovations reported as coming from industry). Hence the need to extend innovation surveys to the services.

127. This is not easy, for four reasons:

- The characteristics of innovation in the service industries are different from those in manufacturing industries. Service innovation is often immaterial in nature and therefore difficult to protect. Services have a higher degree of customisation. There is a closer interrelationship between the development of new services and the processes to produce them.

- There are differences in the statistical context. There are well-established statistical programmes for the goods handling services, including wholesale and retail trade, freight and transportation. This means that there are robust measures of production, investment, prices and financial activity for these industries that make it easier to distinguish differences between innovators and non-innovators and to draw policy inferences. For industries not directly related to the handling of goods, the statistical picture, as a background for the measurement of innovation, is less clear and some of these service industries are economically significant as well as being instruments of technological and social change. These industries include communications, finance, insurance and real estate, entertainment and business services.

- Service industry firms tend to be smaller than those in manufacturing, and less concentrated. This has methodological implications for sample surveys and industry estimates.

- Not all service industries are the same. They require different skills, organise their production and marketing functions differently, make use of different levels of technology and serve different markets. They may have different propensities to engage in international trade, and to innovate, and they respond differently to economic conditions.

128. Nevertheless, the definitions and concepts used in this manual have been adapted, on the basis of experience gained so far, to apply to **TPP innovations in manufacturing, construction, utilities and marketed services.**

Chapter 3

BASIC DEFINITIONS

INTRODUCTION

129. This chapter is the first step towards deriving a statistical framework from the concepts and priorities in Chapter 2, by describing the phenomena about which information can be collected on an internationally comparable basis. It aims to provide a set of coherent and as far as possible precise definitions of the different types of innovations, innovation activities and hence innovating firms. The complexity of the innovation process and the variations in the way it occurs in different types of firms and industries means that clear-cut definitions are not always possible and conventions have to be adopted. Wherever possible examples are given to illustrate categories and the recommended distinctions between them.

1. TPP INNOVATION

130. **Technological product and process (TPP) innovations** comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been **implemented** if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial **activities**. **The TPP innovating firm** is one that has implemented technologically new or significantly technologically improved products or processes during the period under review.

131. The minimum entry is that the product or process should be new (or significantly improved) to the firm (it does not have to be new to the world).

132. TPP innovations relating to primary and secondary activities are included, and so are process innovations in ancillary activities.

2. MAIN COMPONENTS OF TPP INNOVATION

133. TPP innovations can be broken down between product and process, and by the degree of novelty of the change introduced in each case.

2.1 Technological product innovation

134. The term “product” is used to cover both goods and services.

This is in line with the System of National Accounts (EC *et al.*, 1993).

135. **Technological product innovation** can take two broad forms:

- technologically new products;[25]

- technologically improved products.[26]

136. **A technologically new product** is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge.

137. *The first microprocessors and video cassette recorders were examples of technologically new products of the first kind, using radically new technologies. The first portable cassette player, which combined existing tape and mini-headphone techniques, was a technologically new product of the second type, combining existing technologies in a new use. In each case the overall product had not existed before*.

138. **A technologically improved product** is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems.

139. Technologically improved products may have both major and minor effects on the firm. *The substitution of plastics for metals in kitchen equipment or furniture is an example of the use of higher-performance components. The introduction of ABS braking or other sub-system improvements in cars is an example of partial changes to one of a number of integrated technical sub-systems.*

140. The distinction between a technologically new product and a technologically improved product may pose difficulties for some industries, notably in services.

2.2 Technological process innovation

141. **Technological process innovation** is the adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organisation, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional production methods, or essentially to increase the production or delivery efficiency of existing products.

142. In some service industries, the distinction between process and product may be blurred. For example, a process change in telecommunications to introduce an intelligent network may allow the marketing of a set of new products, such as call waiting or call display. Examples of innovation in service industries are presented in Box 1.

Box 1. Examples of TPP innovations in selected service industries

Wholesaling of machinery, equipment and supplies

- Creation of web sites on the Internet, where new services such as product information and various support functions can be offered to clients free of charge.
- Publication of a new customer catalogue on CD (compact disc). The pictures can be digitally scanned and recorded directly on the CD where they can be edited and linked to an administrative system giving product information and prices.
- New data processing systems.

Road transport companies

- Use of cellular phones to reroute drivers throughout the day. Allows clients greater flexibility over delivery destinations.
- A new computer mapping system, used by drivers to work out the fastest delivery route (*i.e.* from one destination to another). This makes it possible to offer clients faster deliveries.
- The introduction of trailers with eight globe-shaped containers instead of the usual four.

Post and telecommunications companies

- Introduction of digital transmission systems.
- Simplification of the telecommunications net. The number of layers in the net has been reduced by using fewer but more highly automated switching centres.

Banks

- The introduction of smart cards and multipurpose plastic cards.
- A new bank office without any personnel where clients conduct "business as usual" through the computer terminals at hand.
- Telephone banking which allows clients to conduct many of their banking transactions over the phone from the comfort of their own homes.
- Switching from image scanning to OCRs (Optical Character Readers) in the handling of forms/documents.
- The "paperless" back-office (all documents are scanned for entry into computers).

Software consultancy and supply companies

- The development of a whole range of different customer packages in which clients are offered varying degrees of assistance/support.
- The introduction of new multimedia software applications that can be used for educational purposes and thus eliminate the need for a real life human instructor.
- Making use of object-oriented programming techniques in automatic data processing systems development.
- The development of new project management methods.
- Developing software applications through computer-aided design (CAD).

Technical consultancy companies

- A new method of purifying water abstracted from lakes for use as household drinking water.
- Offering customers a new "supply control system" which allows clients to check that deliveries from contractors meet specifications.
- The development of a standard for construction work carried out in already densely built-up areas (where care has to be taken not to inflict damage on any of the surrounding buildings).

Advertising and marketing companies

- Delivering lists of potential customers on diskette together with a list filing system (software) that allows the client firms themselves to analyse and draw samples from the list.
- Being able to assist clients in direct marketing campaigns by offering to distribute pre-labelled advertising leaflets, etc., addressed to selected households.
- Initiating a control process to check by phone with random households that they are actually receiving the adverts/leaflets they are supposed to.
- Delivering the software applications needed for clients themselves to be able to analyse data along with statistical databases.

3. DIFFUSION OF TPP INNOVATIONS: INSTITUTIONAL NOVELTY

143. **Worldwide TPP innovation** occurs the very first time a new or improved product or process is implemented. **Firm-only TPP innovation** occurs when a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries.

144. Between the two come degrees of diffusion of technologically new or improved products and processes. These can be broken down in various ways, for instance by operating market (new to the operating market, easy to understand for survey respondents) or by geographical area (new to the country or region, of policy interest) (see Chapter 2).

3.1 Minimum coverage

145. This manual covers all these levels as the minimum entry level is "new to the firm".

146. The relationship between the two sets of categories defined so far is shown in Figure 3.

147. During the process of diffusion, one firm's new or improved product may become another firm's new or improved process. *For example, a more powerful model of computer is a technologically improved product for the business machinery industry but might constitute an entirely new technological process for an accountancy firm. Furthermore the accountancy software used with it might be an established product of the computer services industry but a completely new process to the accountancy firm.*

148. The matter is more complicated when we look at the goods-handling services/distributive trades (wholesale and retail distribution, transport and storage), which generally diffuse technologically new or improved products which have been designed, produced and implemented by their suppliers without themselves providing any technological value-added. Trading of such new or improved products should not generally be considered as TPP innovation for the wholesaler or retail outlet or transport and storage firm. However, if such a firm begins to deal with a completely new line of goods, that may be considered a product innovation. *For example, a new software package is a technological product innovation for the computer service firm. For the wholesaler or retail outlet distributing it, it is a new product in the catalogue but not a technological product innovation unless the company had never previously distributed any software products.*

149. It follows that TPP innovation in the distributive trades will largely be process innovation, *for example the introduction of just-in-time delivery by a wholesaler, or computer-controlled inventories for a retailer*. It is suggested that where the diffusion of a new or improved product as described above does require some technological activity by the distributing firm, it should be treated as process innovation.

3.2 Coverage within the firm

150. Firms may have principal, secondary and ancillary activities, as defined in the System of National Accounts (CEC *et al.*, 1993).

151. Innovations may be implemented for both the principal and secondary production activities of a firm.

152. *For example, a computer hardware company may issue a major upgrade of a program which it sells as a separate secondary product, or a restaurant may introduce gaming machines as a new secondary service product.*

153. Technological innovation can occur both in the production process and/or products of the firm and in ancillary supporting activities supplied by its purchasing, sales, accounting, computing or maintenance departments. In practice it will be very difficult to identify product innovation in ancillary services.

154. Technological process innovation in ancillary activities is included.

For example, the computerisation of the sales or finance department may be considered a TPP innovation.

Figure 3. Type and degree of novelty and the definition of innovation

			INNOVATION			*Not innovation*
			Maximum	**Intermediate**	**Minimum**	
			New to the world	**(a)**	**New to the firm**	**Already in firm**
TPP INNOVATION	**Technologically new**	**Product**				
		Production process				
		Delivery process				
	Significantly technologically improved	**Product**				
		Production process				
		Delivery process				
Other innovation	**New or improved**	**Purely organisation**				
Not innovation	**No significant change, change without novelty, or other creative improvements**	**Product**				
		Production process				
		Delivery process				
		Purely organisation				

TPP innovation ☐ Other innovation ☐ Not innovation ☐

(a) Could be geographical e.g. new to country or region.

4. DISTINGUISHING BETWEEN TPP INNOVATION AND OTHER CHANGES IN THE FIRM OR INDUSTRY

155. TPP innovation must be distinguished (see Figure 3) from:

- organisational innovation;
- other changes in products and processes.

4.1 Organisational innovation

4.1.1 Coverage

156. Organisational innovation in the firm includes:

- the introduction of significantly changed organisational structures;

- the implementation of advanced management techniques;
- the implementation of new or substantially changed corporate strategic orientations.

157. In principle, organisational change counts as innovation only if there is a measurable change in output, such as increased productivity or sales. But this section is not designed to clarify the borderlines between innovative and non-innovative organisational change. It is described here with the aim of distinguishing it from TPP innovation. For those who may wish to collect data on organisational innovation a fuller description is given in Annex 2.

4.1.2 Borderline cases: organisational change in manufacturing and service processes

158. Whereas the complete reorganisation of a firm is "organisational innovation", the reorganisation of its production facility can be considered as TPP innovation. The introduction of *just-in-time systems*, for example, should be treated as process innovation as it has a direct effect on the production of products for the market.

159. In service industries, technological process innovation includes improved capabilities embodied in organisations and routines as long as these have resulted in a measurable change in output. *For example, implementation of a quality standard such as ISO 9000 is not a TPP innovation unless it results in a significant improvement in the production or delivery of goods or services.*

4.2 Other changes in products and processes

160. These are changes which:

- are insignificant, minor, or do not involve a sufficient degree of novelty;
- make "other creative improvements" where the novelty does not concern the use or objective performance characteristics of the products or in the way they are produced or delivered but rather their aesthetic or other subjective qualities.

161. **Many borderline cases will clearly occur in both these areas, and the final judgement about the nature of the change rests with respondents and/or persons selecting TPP innovations to include in databases.**

4.2.1 Excluding insignificant or non-novel changes

(a) Ceasing to use a process or to market a product

162. Stopping doing something is not a TPP innovation, although it may improve a firm's performance. For example, *TPP innovation does not occur when a television constructor ceases to produce and sell a combined television and video, or a property development agency or construction company stops building retirement villages.*

(b) Simple capital replacement or extension

163. The purchase of more machines of a model already installed, even if extremely sophisticated, is not a technological process innovation. A new model is defined as one with clearly improved

specifications, not merely one with a new number or title in the manufacturer's catalogue. *In the case of software, for example, the purchase of a new version of a set of programs for Windows may be considered a technological process improvement, whereas the acquisition of interim updates which do not add significantly to the programs' performance is not.*

164. One possible test here is whether or not the personnel concerned need training before they can use the new machine or software. This does not, however, cover the diffusion of further copies through a firm.

(c) Changes resulting purely from changes in factor prices

165. TPP innovation requires a change in the nature (or use) of the product or process. A change in price of a product or of the productivity of a process resulting exclusively from changes in the price of factors of production is not an innovation.

166. *For example, innovation does not occur when the same model of PC is constructed and sold at a lower price simply because the price of computer chips falls.*

(d) Custom production

167. Firms engaged in custom production, making single and often complex items to a customer's order, have to analyse every product to see whether it fits the definitions of TPP innovation set out above. Unless the one-off item displays significantly different attributes to products that the firm has previously made, it is not to be regarded as a technological product innovation.

168. In borderline cases a criterion for qualifying as a TPP innovation could be that the planning phase includes construction and testing of a prototype or other research and development activities in order to change one or more of the product's attributes.

(e) Seasonal and other cyclical changes

169. In certain industries such as clothing and footwear there are seasonal changes in the type of goods or services provided which may be accompanied by fashion changes in the products concerned (see Section 4.2.2 below). Typically a given type of product will reappear after a period of absence. This should not be treated as innovation unless the returning product has been technologically improved. *For example, the introduction of the new season's anoraks by a clothing manufacturer is not a TPP innovation unless, for example, they have a lining with improved characteristics; nor is the annual reopening of a store's ski department.*

(f) Product differentiation

170. Product differentiation is the introduction of minor technical (or aesthetic) modifications in order to reach a new segment of the market, to increase apparent product range or to reposition a product in relation to a competing one. It can only be considered technologically improved product innovation if changes significantly affect the performance or properties of the product concerned or the use of materials or components therein.

171. *For example, the retitling and repackaging of an existing soft drink popular with older people, to establish a link with a football team in order to reach the youth market, is not TPP innovation*.

172. New models of complex products, *such as cars or television sets*, are product differentiation if the changes are minor compared with the previous models, *for example offering a radio in a car*. If the changes are significant, based on new designs or technical modifications to sub-systems for example, the improved products could be considered technologically improved product innovations.

4.2.2 TPP innovation and other creative product improvements

173. Technological innovation requires an objective improvement in the performance of a product or in the way in which it is delivered. In the case of many goods and services sold directly to consumers or households, the firm may make improvements in its products which make them more attractive to the purchasers without changing their "technological" characteristics. These improvements may have a considerable effect on the firm's sales, and it may well view them as innovations. They are not, however, TPP innovations.

174. *For example, change in clothing production is very largely a matter of fashion. For these firms, rapid introduction of the latest colours and cut is a key element in their competitiveness. But colour and cut do not change the essential characteristics or performance of clothing, i.e. that it should keep the body at an appropriate temperature, be comfortable to wear and easy to maintain. Technologically improved products here almost always involve the use of new materials diffused by the textile industry and, before that, the chemical industry. For example, the introduction of drip-dry shirts, or "breathable" waterproof mountain gear, is a technological product innovation.*

175. *In the travel industry, on-line booking and information services are technological innovations, whereas offering package tours with new themes is not. Offering a telephone service from trains is a technological innovation, changing the colour scheme on the rolling stock is not.*

176. In some industries the surroundings in which a service is offered are important. The maintenance or improvement of these surroundings is not TPP innovation unless it is associated with a significant objective improvement in the service product or the way in which it is produced or delivered. *For example repainting, re-carpeting or completely restyling a restaurant is not TPP innovation. The introduction of computer-controlled ordering and billing, or of micro-wave ovens, does constitute TPP innovation.*

5. TPP INNOVATION ACTIVITIES

177. TPP innovation activities are all those scientific, technological, organisational, financial and commercial steps, including investment in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products or processes. Some may be innovative in their own right, others are not novel but are necessary for implementation.

5.1 Relation with implementation of TPP innovations

178. During a given period the TPP innovation activities of a firm may be of three kinds:

- **Successful** in leading up to the implementation of a technologically new or improved product or process.
- **Aborted** before the implementation of a technologically new or improved product and process, because the project runs into difficulties, because the idea and know-how is sold or otherwise traded to another firm, or because the market has changed.

- **Ongoing,** work in progress which has not yet reached implementation. Such activities may be undertaken to lead to a specified new or improved product or process or have more diffuse aims as in the case of basic or general technological research.

5.2 The components and coverage of TPP innovation activities

179. Innovation is a complex process, as outlined Chapter 2, and the scale of activity required for a TPP innovation in a firm may vary considerably. For example, the in-house development of a radically different and sophisticated electronic product for the mass market will involve many more steps than the introduction of an improved process resulting from technology incorporated in a pre-programmed machine purchased for the purpose.

180. Innovation activities may be carried out within the firm or may involve the acquisition of goods, services or knowledge from outside sources, including consulting services. Thus a firm may acquire external technology in disembodied or embodied form.

181. The list of activities below is not exhaustive. Its aim is to explain when certain activities should be included in TPP innovation. More practical guidance is given in the chapter on measuring innovation expenditure. Activities leading to purely organisational innovation are dealt with in Annex 2.

5.2.1 Acquisition and generation of relevant knowledge new to the firm

(a) Research and experimental development

182. Research and experimental development (R&D) comprises 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 (as defined in the *Frascati Manual*).

183. Construction and testing of a prototype is often the most important phase of experimental development. A prototype is an original model (or test situation) which includes all the technical characteristics and performances of the new product or process. The acceptance of a prototype often means that the experimental development phase ends and the other phases of the innovation process begin (further guidance on this will be found in the *Frascati Manual*).

184. Software development is classified as R&D as long as it involves making a scientific or technological advance and/or resolving scientific/technological uncertainty on a systematic basis.

(b) Acquisition of disembodied technology and know-how

185. Acquisition of external technology in the form of patents, non-patented inventions, licences, disclosures of know-how, trademarks, designs, patterns and computer and other scientific and technical services related to the implementation of TPP innovations, plus the acquisition of packaged software that is not classified elsewhere.

(c) Acquisition of embodied technology

186. Acquisition of machinery and equipment with improved technological performance (including integrated software) connected to technological product or process innovations implemented by the firm.

5.2.2 Other preparations for production

(a) Tooling up and industrial engineering

187. Changes in production and quality control procedures, methods and standards and associated software required to produce the technologically new or improved product or to use the technologically new or improved process.

(b) Industrial design n.e.c.

188. Plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the production of technologically new products and the implementation of new processes.

(c) Other capital acquisition

189. Acquisition of buildings, or of machinery, tools and equipment – with no improvement in technological performance – which are required for the implementation of technologically new or improved products or processes, *for example, an additional moulding or packaging machine to produce and deliver a technologically improved CD-ROM player.*

(d) Production start-up

190. This may include product or process modifications, retraining personnel in the new techniques or in the use of the new machinery, and any trial production not already included in R&D.

5.2.3 Marketing for new or improved products

191. Activities in connection with the launching of a technologically new or improved product. These may include preliminary market research, market tests and launch advertising, but will exclude the building of distribution networks to market innovations.

5.3 Borderline cases

192. Of all the above types of work, only R&D and the acquisition of machinery incorporating new technology are by definition TPP innovation activities. The others may or may not be, depending on the reasons for which they are carried out.

5.3.1 Design

193. *Industrial design* is an essential part of the TPP innovation process. Though it is listed above in the same subsection as tooling up, industrial engineering and production start-up, it may also be a part of the initial conception of the product or process, *i.e.* included in research and experimental development, or be required for marketing technologically new or improved products.

194. *Artistic design* activities are TPP innovation activities if undertaken on a technologically new or improved product or process. They are not if undertaken for other creative product improvement, for example purely to improve the appearance of the product without any objective change in its performance.

5.3.2 Training

195. Training is a TPP innovation activity when it is required for the implementation of a technologically new or improved product or process, *for example in order for production workers to be able to identify the desired consistency of a new type of yoghurt in a food factory, for a marketing manager to understand the characteristics of the improved braking system on a new model of car in order to prepare the market launch, or for staff to be able to use different Windows programs after the introduction of a Windows-based PC network in the firm.*

196. Training in a firm is not a TPP innovation activity when it is undertaken solely in connection with “organisational innovation” or “other creative product improvement”, or when it is not oriented towards a specific improvement in productivity at the level of the firm. *For example, the following are not TPP innovation activities: training in existing production methods for new employees, general upgrading training for individuals (supervisors, managers, etc.), ongoing computer training, language classes.*

5.3.3 Marketing

197. Marketing is a TPP innovation activity when it is required for the implementation of a technologically new or improved product (or, more infrequently, a new process). It is not a TPP innovation activity when it is undertaken for purely organisational innovation, *for example a campaign to promote a firm’s new structure and corporate image*, or as part of other creative product improvement, *for example publicity for the spring range of clothing*, or to maintain market share for products which are essentially unchanged, *for example soap powder*.

5.3.4 Software

198. The development, acquisition, adaptation and use of software pervade TPP innovation activities. On the one hand, developing new or substantially improved software, either as a commercial product or for use as an in-house process (TPP innovation in its own right), involves research and experimental development and a range of post-R&D innovation activities. On the other, many of the innovation activities for other TPP innovations involve the use of software as a process and hence its acquisition and adaptation.

6. THE TPP INNOVATING FIRM

199. The TPP innovating firm is one that has implemented technologically new or significantly improved products or processes or combinations of products and processes during the period under review. It is a firm with **successful TPP innovation activities** (see Section 5.1 above) during the period.

200. A firm which has had **aborted TPP innovation activities** is not included, nor is one which, at the end of the period under review, has **ongoing TPP innovation work in progress** which has not yet resulted in implementation.

201. In theory all firms which have come into existence during the period under review have implemented new products or processes. **In practice the following is recommended:**

By convention **TPP innovating firms comprise**:

- **firms which were in existence** at the beginning of the period under review and **which have implemented products or processes during the period which are technologically new (or improved) for the said firm**;

- **firms which have come into existence** during the period under review **and which:**

  - at their founding implemented products or processes which are technologically new (or improved) for the operating market of the firm;

  - after their founding implemented products or processes later during the period which are technologically new (or improved) for the said firm.

It is recognised that this may be difficult to apply in practice. For further details and recommendations on appropriate periods see Chapter 5, Section 3.

7. THEORY AND PRACTICE

202. The above definitions describe in detail the types of data which are to be collected or compiled in order to ensure that they are precise and as far as possible logically coherent. It is for those designing survey forms to draw on these definitions to express the concepts in ways that are appropriate and meaningful to respondents in the industries concerned, for example when explaining the concept of significantly improved performance in products in a way that is appropriate to firms in some services where the word "technological", on its own, may mislead the respondent.

Chapter 4

INSTITUTIONAL CLASSIFICATIONS

1. THE APPROACH

203. The institutional approach focuses on the characteristic properties of the innovative firm, and all characteristics of innovation activities, and their inputs and outputs, are classified to one class or subclass according to the unit's principal activity.

2. THE UNITS

204. A clear distinction has to be made between the reporting and the statistical units. The **reporting unit** is the entity from which the recommended items of data are collected. They may vary from sector to sector and from country to country, depending on institutional structures, the legal status of data collection, tradition, national priorities and survey resources. It is therefore almost impossible to make international recommendations about the reporting unit for innovation surveys. However, whenever countries provide statistics for international comparisons, the reporting units should be specified.

205. The **statistical unit** is the entity for which the required data is compiled. It may be observation units on which information is received and statistics are compiled, or analytical units which statisticians create by splitting or combining observation units with the help of estimations or imputations in order to supply more detailed and/or homogeneous data than would otherwise be possible.

206. As far as possible, the statistical unit should be uniform for all countries. In practice, however, this goal is never completely achieved. One reason is that structures are different from country to country. Another is the interaction with the reporting unit. If the reporting unit is larger than the statistical unit, there may be problems in distributing the data into the appropriate classification units.

207. Taking into account how innovation activities are usually organised, the enterprise-type unit is the most appropriate statistical unit in innovation surveys in many cases. The enterprise[27] or the legal entity defined in paragraphs 78 and 79 of ISIC Rev. 3 is the appropriate unit. However, when considering large enterprises which are engaged in several industries, a smaller unit like the kind-of-activity unit[28] (KAU), [29] "an enterprise or part of an enterprise which engages in one kind of economic activity without being restricted to the geographic area in which that activity is carried out", may be more appropriate.

208. For regional analysis, the local unit[30] or similar units may be more appropriate.[31] It should be kept in mind that information on some variables should not be collected at the level of local (or similar) units as they refer directly to the enterprise. An example is information on objectives of innovations. They refer to strategic decisions at the enterprise level, and cannot be related to local units.

209. In innovation surveys, multinational enterprises with different parts of the innovation process located in different countries may merit special treatment. When national units are used as statistical units, the links between units of multinational enterprises in different countries are not taken into account. As a consequence, national results may be misleading. Solutions for this problem should be developed in the frame of the ongoing, more general, discussion on globalisation.

3. CLASSIFICATION BY MAIN ECONOMIC ACTIVITY

210. Statistical units of innovation surveys can be broken down by quite different variables. Perhaps the most important variable is the **principal economic activity of the statistical unit** (“industry”). The International Standard Industrial Classification of all Economic Activities (ISIC Rev. 3) and the statistical classification of economic activities in the European Community (NACE Rev. 1) respectively are appropriate international classifications for this purpose.

211. The **criteria for classification** by principal activity of these statistical units should be determined by “the class of ISIC (NACE) in which the principal activity, or range of activities, of the unit is included”.[32] According to ISIC, this principal activity should be determined by reference to the value added of the goods sold or the services rendered by the activities. If this is not possible, the principal activity can be determined on the basis of the gross output of the goods sold or services rendered by each of the activities, or the number of persons assigned to them.[33]

212. The proposed **classification list** is presented in Table 1 (on the next page), which contains a special arrangement of the divisions, groups and classes of ISIC Rev. 3/NACE Rev. 1 for the purpose of innovation statistics. This table should be seen as the basic arrangement which may be further split, or aggregated, for specific purposes.

4. CLASSIFICATION BY SIZE

213. The other essential classification of statistical units for innovation surveys is by size. Although different variables can be used to define the size of a statistical unit in innovation surveys, **it is recommended that size should be measured on the basis of the number of employees**. This recommendation is in line with similar proposals in other manuals in the Frascati family. Given the strata requirements in sample surveys (see Chapter 7), and given that innovation activities are carried out in units of all sizes but, unlike R&D, are quite widely conducted in small and medium-sized units, the following size classes are recommended:

Classification of statistical units for innovation surveys by size

Number of employees:

- <20
- 20 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 - 999
- 1 000 - 4 999
- 5 000 and above.

Table 1. Industrial classification proposed for innovation survey in the business enterprise sector based on ISIC Rev. 3 and NACE Rev. 1

Title	ISIC Rev. 3 Division/Group/Class	NACE Rev. 1 Division/Group/Class
MANUFACTURING	15 to 37	15 to 37
Food Products & Beverages	15	15
Tobacco Products	16	16
Textiles	17	17
Wearing Apparel & Fur	18	18
Leather Products & Footwear	19	19
Wood & Cork (not Furniture)	20	20
Pulp, Paper & Paper Products	21	21
Publishing, Printing & Reproduction of Recorded Media	22	22
Coke, Refined Petroleum Products & Nuclear Fuel	23	23
Chemicals & Chemical Products	24	24
Chemical Products less Pharmaceuticals	*24 less 2423*	*24 less 24.4*
Pharmaceuticals	*2423*	*24.4*
Rubber & Plastic Products	25	25
Non-metallic Mineral Products	26	26
Basic Metals	27	27
Basic Metals, Ferrous	*271+2731*	*27.1 to 27.3 + 27.51/52*
Basic Metals, Non-ferrous	*272+2732*	*27.4 + 27.53/54*
Fabricated Metal Products (except Machinery & Equipment)	28	28
Machinery n.e.c.	29	29
Office, Accounting & Computing Machinery	30	30
Electrical Machinery	31	31
Electronic Equipment (Radio, TV & Communications)	32	32
Electronic Components (includes Semiconductors)	*321*	*32.1*
Television, Radio & Communications Equipment	*32 less 321*	*32 less 32.1*
Medical, Precision & Optical Instruments, Watches, Clocks	33	33
(Instruments)	34	34
Motor Vehicles	35	35
Other Transport Equipment	*351*	*35.1*
Ships	*353*	*35.3*
Aerospace	*352+359*	*35.2+35.4+35.5*
Other Transport n.e.c.		
Furniture, Other Manufacturing n.e.c.	36	36
Furniture	*361*	*36.1*
Other Manufacturing n.e.c.	*369*	*36.2 to 36.6*
Recycling	37	37
ELECTRICITY, GAS & WATER SUPPLY	40+41	40+41
CONSTRUCTION	45	45
MARKETED SERVICES	50 to 74	50 to 74
Sale, Retail, Maintenance & Repair of Motor Vehicles & Motorcycles	50	50
Other Wholesale Trade	51	51
Other Retail Trade	52	52
Hotels & Restaurants	55	55
Land Transport & via Pipelines	60	60
Water Transport	61	61
Air Transport	62	62
Supporting & Auxiliary Transport Activities, Travel Agencies	63	63
Post & Telecommunications	64	64
Post	*641*	*64.1*
Telecommunications	*642*	*64.2*
Financial Intermediation	65 to 67	65 to 67
Real Estate, Renting	70+71	70+71
Computer & Related Activities	72	72
Software Consultancy & Supply	*722*	*72.2*
Other Computer Services n.e.c.	*72 less 722*	*72 less 72.2*
Research & Development	73	73
Other Business Activities n.e.c.	74	74
Architectural, Engineering & other Technical Activities	*742*	*74.2*

5. OTHER CLASSIFICATIONS

5.1 Type of institution

214. A further useful classification of statistical units for innovation surveys might be by **type of institution**. This breakdown seems particularly important when the statistical unit is of the enterprise type, and in view of the increasing internationalisation of innovation activities. Taking into account these considerations, and a similar proposal for R&D statistics in the *Frascati Manual*, it is recommended that when enterprises are the statistical units in innovation surveys they should be classified as follows:

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

- Private enterprise:
  - national;
  - multinational.
- Public enterprise;[34]
- Other units.

To define multinational private enterprises, the approach in the *Frascati Manual* may be followed: there, multinationals are defined as having more than 50 per cent "foreign ownership of capital".[35]

5.2 Other

215. Many other variables have been proposed for analytical purposes as breakdowns for statistical units in innovation surveys. They include:

- ***Form of activity,*** with the categories:
  - for manufacturing: mass production / custom production / process industry;
  - for services: capital intensive *(such as air & sea transport)* / computation intensive *(such as financial services, or design services)* / professional *(such as consultancy or legal services)* / skill-intensive *(such as restaurant services, hairdressing, etc.: broadly, personal services)* / labour intensive.
- ***Type of goods produced,*** with the categories: consumer goods / intermediate goods / investment goods.
- ***R&D intensity***, the ratio between R&D expenditure and sales (calculated from the information collected in the innovation survey).
- ***Export intensity***, the exports of the enterprise as a ratio of sales (also collected in the innovation survey). Or
- ***Membership of a group***.

216. These breakdowns may be useful for specific purposes but are not generally recommended, as they usually refer to sub-populations. One example may clarify this. Classification by R&D intensity is recommended only if R&D-performing innovators are analysed. Units in certain industries, along with small and medium-sized units, are particularly innovative, yet do not perform R&D. Classifying all statistical units in innovation surveys by R&D intensity would therefore lead to a fairly large group of units with an R&D intensity of zero and quite heterogeneous innovation activities.

Chapter 5

MEASURING ASPECTS OF THE INNOVATION PROCESS

217. A number of aspects of the innovation process will be discussed in this chapter. Survey experience means that a set of tried and tested questions, of proven value for analytical purposes, can now be recommended. The list has of course to be kept within bounds, or it will be too burdensome for firms. At the same time, some optional questions are also suggested for further testing in national surveys.

218. The innovation process has its starting point in the objectives of the firm, and is assisted or hampered by a range of factors. The types of innovations that emerge from the process can be described in different ways. Perhaps the most important indicators (and the most difficult and controversial ones) describe the influence of innovation on the performance of the firm. Further indicators describe diffusion of innovation and other related themes such as R&D, patenting and the acquisition/diffusion of technology.

219. The indicators may be binary yes/no data: the factor is important/not important. Alternatively, they may rank factors on an ordinal scale: first ascertaining whether a factor is relevant or not (0 = not relevant), then running from 1 (not important) to 5 (very important), or from 1 (not important) to 3 (important).

220. A number of indicators will now be described. It may not in fact be possible or practicable to include all of them in a single survey. The large number of questions would probably cut the response rate, and the cost could well be too high. Hence, when national survey results are to be used for international comparisons, it is important to select a set of the most useful and commonly used questions, based on common definitions.

1. OBJECTIVES OF INNOVATION

221. It is recommended that a firm’s reasons for engaging in innovation activity should be identified via its economic objectives in terms of products and markets, and how it rates a number of goals that process innovation can bring within reach. The question should relate to all of its innovation activities. Several objectives will usually be relevant.

Economic objectives of innovation:

- **replace products being phased out;**
- **extend product range:**
  - within main product field;
  - outside main product field;
- **develop environment-friendly products;**

- **maintain market share;**
- **increase market share;**
- **open up new markets:**
  - abroad;
  - new domestic target groups;
- **improve production flexibility;**
- **lower production costs by:**
  - reducing unit labour costs;
  - cutting the consumption of materials;
  - cutting energy consumption;
  - reducing the reject rate;
  - reducing product design costs;
  - reducing production lead times;
- **improve product quality;**
- **improve working conditions;**
- **reduce environmental damage.**

2. FACTORS ASSISTING OR HAMPERING INNOVATION

222. Two sets of factors will be considered here:

- the innovation process is assisted by a variety of sources of information: internal sources (within the firm), external market sources, educational and research institutions, and generally available information;
- innovation may be hampered by economic factors, ones relating to the enterprise, and with a miscellany of others.

It is recommended that information should be collected on both these aspects.

223. The sets overlap to some degree, so a factor may assist in one case and be an obstacle in another. The question should relate to all of the firm's innovation activities.

2.1 Sources of information for innovation

224. The list shows sources which have been found relevant in a number of surveys. It can be modified to meet national requirements.

Sources of information:

Internal sources within the firm or business group:

- in-house R&D;
- marketing;
- production;
- other internal sources.

External market/commercial sources:

- competitors;
- acquisition of embodied technology;
- acquisition of disembodied technology;
- clients or customers;
- consultancy firms;
- suppliers of equipment, materials, components and software.

Educational/research institutions:

- higher education institutions;
- government research institutes;
- private research institutes.

Generally available information:

- patent disclosures;
- professional conferences, meetings and journals;
- fairs and exhibitions.

225. Some of these items can, if desired, be further divided into domestic and foreign sources.

2.2 Factors hampering innovation activities

226. The list shows obstacles or barriers to innovation that have been found relevant in a number of surveys. They may be reasons for not starting innovation activities at all, or reasons for innovation activities not leading to the expected results. The list can be modified to meet national requirements.

Factors hampering innovation activities:

Economic factors

- excessive perceived risks;
- cost too high;
- lack of appropriate sources of finance;
- pay-off period of innovation too long.

Enterprise factors

- innovation potential (R&D, design, etc.) insufficient;
- lack of skilled personnel;
- lack of information on technology;
- lack of information on markets;
- innovation expenditure hard to control;
- resistance to change in the firm;
- deficiencies in the availability of external services;
- lack of opportunities for co-operation.

Other reasons

- lack of technological opportunity;
- lack of infrastructure;
- no need to innovate due to earlier innovations;
- weakness of property rights;
- legislation, norms, regulations, standards, taxation;
- customers unresponsive to new products and processes.

3. IDENTIFYING TPP INNOVATING FIRMS

227. From the policy viewpoint, indicators of the outcomes of the innovation process are perhaps the most important results of innovation surveys. They are also the most problematic ones.

228. **The simplest indicator relates to the population of innovating firms, as defined in Chapter 3, Section 6. It is obtained by counting the number of firms with successful TPP innovation activities during the last three years**; they comprise firms which were in existence at the beginning of the period and which have implemented TPP innovations during the period which are new (or improved) for the said firm, and firms which have come into existence during the period and which at their foundation implemented TPP innovations which are new (or improved) for the operating market of the said firm, or which, after their foundation, implemented TPP innovations which are new (or improved) for the firm.

229. Firms which have aborted TPP innovation activities are not included, nor are ones which, at the end of the period, have ongoing TPP innovation work in progress that has not yet resulted in implementation.

230. At the same time, in order to preserve the link with expenditure on total innovation activities and obtain the full expenditure input, it is recommended that the number of firms engaged in innovation activities during the reference period but which have not introduced any innovations, due either to aborted projects or to project timespan, should be counted **separately.** The characteristics of this group may be quite different to those of firms not engaged in innovation activities.

231. **A filter question on the results of innovation activities should be asked to discriminate between innovators and non-innovators, and information on structural changes in the enterprise within the reference period (notably the date of such changes) should also be collected**.

4. THE IMPACT OF INNOVATIONS ON THE PERFORMANCE OF THE ENTERPRISE

232. Various indicators can be used to measure the impact of innovations on the performance of the firm. These indicators are:

- the proportion of sales due to technologically new or improved products;
- the results of innovation effort;
- the impact of innovation on the use of factors of production.

4.1 Proportion of sales due to technologically new or improved products

233. A question about the share of sales and exports due to technologically innovative products put on the market within the last three years has been included in most of the innovation surveys carried out to date. Experience with this question has been encouraging, in spite of some problems of interpretation.

234. When constructing this indicator, firms established during the reference period must be treated separately, as new products will by definition account for all their sales. For these firms, only products new to their operating market (see below) are included. Firms which have come into existence as the

result of mergers, demergers and other kinds of reorganisation should not be treated as newly established firms if similar activities were carried on previously.

235. **It is recommended that this question should be put as:**

Percentage share of sales due to:

- technologically new products (as defined in Chapter 3, Section 2.1) commercialised during the last three years;

- technologically improved products (as defined in Chapter 3, Section 2.1) commercialised during the last three years;

- products that are technologically unchanged, or subject only to product differentiation, <u>produced with changed production methods</u> (see Chapter 3, Section 2.2) during the last three years;

- products that are technologically unchanged, or subject only to product differentiation, produced with unchanged production methods during the last three years.

236. The sales due to technologically new products and technologically improved products may be further broken down by:

- sales due to products that are new or technologically improved for the operating market of the firm;

- sales due to products that are new or technologically improved only for the firm.

237. Preferably, respondents should supply their best estimates of the actual percentages. When presenting the results by industry, size of firm and so on, the percentages should be weighted by sales.

238. These indicators are directly influenced by the length of product lives. They are likely to be higher in product groups where life cycles are short and innovation can be expected to occur more frequently. But innovation of that kind is not necessarily the most significant or most technologically advanced. High shares of sales of technologically new or significantly changed products do not necessarily indicate a high innovation rate.

239. In order to take into account the effects of product life on this indicator, it is suggested that the firm should be asked to give an estimate of the average length of its products' life cycles. This information could be used to weight the percentage shares suggested above. An alternative way of putting this question is to ask how often the firm usually introduces innovations.

240. Other factors have also to be considered when interpreting the data obtained with these indicators:

- firms engaged in custom production will often have higher shares of technologically new or significantly improved products than firms engaged in batch or mass production, or firms in the process industries;

- younger firms will have higher shares of technologically new products than older firms;

- firms with the objective of replacing products being phased out (see Section 1 of this chapter) will have higher shares of technologically new products than firms with the objective of extending their product range.

4.2 Results of innovation effort

241. In order to form a picture of how innovation affects general performance, it is suggested that some general data on the firm should be collected, for the beginning and end of the three-year period:

- sales year t and t-2;
- exports year t and t-2;
- employees year t and t-2;
- operating margin year t and t-2.

242. The data may be collected via the innovation survey, or taken from other available sources. Information of considerable interest may be derived from comparisons of these indicators for the populations of innovating and non-innovating firms.

243. Panel surveys open up interesting possibilities for combining innovation variables with other variables on the firm, in order to analyse the results of innovation.

4.3 Impact of TPP innovation on the use of factors of production

244. One of the results of innovation, especially process innovation, is usually a change in the production function, *i.e.* a change in the use of factors of production.

245. ***It is suggested that a question could be included on how TPP innovations have influenced the use of factors of production, i.e. manpower use, material consumption, energy consumption and utilisation of fixed capital***.

246. This information can be obtained more simply by asking firms if there has been a major, minor or nil change in the use of factors of production as a result of TPP innovation. Another possibility is to quantify the changes, at least roughly.

247. This indicator, which gives a rough approximation of impact, may refer to TPP innovations introduced over the last three years or to a broader evaluation of how innovation has influenced performance indicators.

4.3.1 Average cost reductions due to technological process innovations

248. ***It is suggested that the question should first ask if the technological process innovations introduced during the last three years have led to reductions in the average cost of products produced with these processes. If yes, a quantification of the cost reduction is then requested***.

5. DIFFUSION OF INNOVATION

249. In Chapter 1 **diffusion** is defined as the way in which innovations spread, through market or non-market channels, from first implementation anywhere in the world, to other countries and regions and to other industries/markets and firms. In order to map innovation activities and form a picture of some of the links involved, and of the level of diffusion of advanced technologies, the following topics are proposed.

5.1 User sectors

250. In theory, innovations can be classified by three criteria:

- the sector of main economic activity of the producer;
- the technological group (product group) to which the innovation belongs;
- the probable sector of utilisation.

251. The first criterion is discussed more fully, under classifications, in Chapter 4.

252. Respondents may be asked to identify the technological or product group for their most important innovation (see Annex 1).

253. The third point may be dealt with by ***asking firms to indicate the proportions of sales due to technologically new or improved products by the sector of main economic activity of their main client(s) for those technological product innovations***. The same question may also be asked for the firm's most important innovation(s) (see Annex 1).

254. For some firms or industries, a high proportion of sales via wholesalers will make the responses of little use in indicating the pattern of diffusion.

5.2 Surveys of use of advanced technologies in the manufacturing process

255. Several countries have carried out surveys of the use of selected new technologies in manufacturing, and in one case in the service sector as well. They describe an important aspect of diffusion of innovation, *i.e.* the extent to which innovations in the form of new embodied technology are used in production. Specialised manufacturing surveys, focusing mainly on micro-electronic applications, have also been conducted at some point by many OECD countries.

256. In surveys of manufacturing technology, information was requested about use, planned use and non-use of certain specified technologies. They showed that technology use surveys are easily run and analysed and are readily compared internationally. They can also be designed for specific industries.

257. The problem is to produce a list of advanced technologies which are recognised by the industry concerned and are not so advanced as not to be used at all. The technologies must be sufficiently used for statistics about their use and planned use across an industry to provide useful information to the policy maker. The list should concentrate on some well defined specific technologies. Items that are too general, such as biotechnology or information technology, will probably not yield much useful information.

258. Another source of problems is negotiating international comparability. This has three components: the list of technologies; either an agreed concordance between the industrial classifications used, or the use of an agreed international industrial classification; and the use of common coverage criteria.

259. Use and planned use of technologies can be linked to other questions related to innovation. Questions on whether the technology used was modified to improve productivity, or ease of use, give insight into the propensity to innovate on the factory floor.

260. Innovation in management practice can be linked to technology use. In manufacturing, for example, a firm supplying a client which wants "just-in-time" delivery may wish to improve its quality control and assurance to reduce the reject rate. As part of improving quality, the firm may adopt statistical process control (SPC) and, as a consequence, use automated sensors in its production process. The client firm may use automated supervisory control and data acquisition (SCADA) and both supplier and client may be linked by a computer network.

261. Barriers to innovation can also be probed in surveys of technology use as questions can be asked about the availability of highly qualified and skilled people to work with the new technology, and the availability of funds to purchase technology and to train workers.

262. Technology use surveys are considered a relatively straightforward way of obtaining information on innovation diffusion that is relevant to policy. While they can be integrated with innovation surveys, they are also of use as an independent source of reproducible and internationally comparable statistical information relevant to industry and trade policy.

263. Surveys of technology use should be encouraged and, when appropriate, integrated into the broader context of the innovation surveys.

6. SPECIAL QUESTIONS

264. A number of other topics relevant to the innovation process will now be considered: questions on R&D which are not presented in the *Frascati Manual* (and hence not usually included in R&D surveys), and questions on patenting and the acquisition/diffusion of technology.

6.1 Special questions on R&D

265. All the innovation surveys which have been carried out to date overlap to some extent with R&D surveys (see Chapter 7, Section 2); R&D expenditures, for instance, are included in both. In some cases there are other common topics as well. The overlap may well be unavoidable, as the institutions responsible for the innovation survey do not necessarily have access to data at enterprise level from the R&D survey. It sheds additional light on R&D: almost all the innovation surveys so far have recorded many more enterprises carrying out R&D than are covered by R&D surveys. One reason may be that occasional or informal R&D is excluded from R&D statistics in some countries, another that the complexity of the R&D questionnaire discourages smaller firms from responding; another could be that the surveys cover different statistical populations. The firms that innovation surveys reach, but R&D surveys do not, are usually small or medium-sized ones.

266. Starting from the assumption that at least in most countries innovation surveys will be separate from R&D surveys, some questions on R&D feasible for inclusion in innovation surveys are

recommended below. In many countries these questions could be included in the R&D survey as well. All questions on R&D should be strictly in line with the definitions and classifications of the *Frascati Manual*.

267. **It is recommended that information should be requested on R&D expenditure and R&D personnel, except if the information is available from other related R&D surveys or sources.** The question on R&D expenditure overlaps with the question on innovation expenditure, which might cause a problem. In addition, it is suggested that the question should ask whether the R&D activity is performed on a continuous or an occasional basis. Distribution of R&D expenditure between product-oriented and process-oriented R&D could also be requested.

268. An important question deals with R&D co-operation with other firms, institutes and universities, both inside the country concerned and in other countries or country groups (transnational co-operation).

269. **It is recommended that a question on R&D co-operation by partner and country group should be included in innovation surveys**.

6.2 Questions on patents and the appropriability of innovations

270. Patent data, whether applications or grants, are not indicators of innovation outputs; they are indicators of inventions, not necessarily leading to innovations. But questions about patenting are essential for a deeper understanding of the innovation process. The basic general series, of course, are the numbers of patents applied for and granted by firm, available from various national and international data banks. Questions on patenting have been included in a number of countries' R&D or innovation surveys.

271. ***It is suggested that firms should be asked to evaluate the effectiveness of various methods for maintaining and increasing competitiveness of innovations introduced during the last three years***. The methods could be:

- patents;
- registration of design;
- secrecy;
- complexity of product design;
- having a lead time advantage over competitors.

6.3 Questions on the acquisition/diffusion of technology

272. Technology balance of payments (TBP) questions have been included in innovation surveys at two levels of detail.

273. The more ambitious approach asks questions about expenditure on and revenue from patents, licences, know-how, technical assistance and other kinds of traded technology.

274. In the other approach, no monetary data at all are collected, only information on whether the firm has acquired domestic or foreign technology and sold technology on the domestic or foreign market.

275. The methodology here is described in the OECD *TBP Manual*. But the feasibility of asking for detailed TBP information in innovation surveys is uncertain; it is probably best left to a separate survey. The less ambitious approach is therefore recommended for innovation surveys.

276. In order to obtain some picture of the connections between acquisition of technology, innovation and sale of technology**, it is recommended that the innovation survey should at least ask if the firm has acquired technology from the domestic or foreign market (if possible sub-divided by region) or sold technology to the domestic or foreign market (similarly sub-divided).** The information should, if possible, be further sub-divided by type of transaction (patents, non-patented inventions, licences, know-how, trade marks, services with a technological content, use of consultancy services, acquisition/transfer of technology through the purchase/sale of an enterprise, through the purchase/sale of equipment, mobility of skilled personnel, etc.).

Chapter 6

MEASURING EXPENDITURE ON INNOVATION

277. Measuring the total cost of TPP innovation activities in firms and industries is one of the major aims of innovation surveys. As stated in the *Frascati Manual*, R&D is only one step in the innovation process. R&D expenditure, therefore, is only one part of the financial input. Examining the expenditure on all aspects of TPP innovation may facilitate more meaningful calculations of the return on investments in innovation.

278. Expenditure on TPP innovation includes all expenditure related to those scientific, technological, commercial, financial and organisational steps which are intended to lead, or actually lead, to the implementation of technologically new or improved products and processes.

1. THE METHOD OF MEASUREMENT

279. Although the present guidelines are mainly oriented to the subject approach, survey questions on innovation expenditure may be put in two ways:

⇒ The total expenditure on innovation activities for the firm in a given year (= **the subject approach** or **innovation budget approach).**

⇒ Total expenditure for innovations implemented in a given year or during a given period regardless of the year in which the expenditure occurs (= **the object approach).**

280. There is a fundamental difference between the two approaches, hence the results obtained are different. Since both have been used in a number of innovation surveys, it seems worthwhile to clarify the relation between them.

281. The **subject approach** covers expenditure for implemented, potential and aborted TPP innovation activities as defined in Chapter 3. In this respect, it is a straightforward extension of traditional R&D measurement. The actual R&D portion corresponds to the expenditure covered by *Frascati Manual* R&D surveys: therefore it comprises R&D expenditure which is not directly related to a specific innovation project. Not many enterprises keep separate records of other TPP innovation expenditure, but experience has shown that it is quite possible for them to give acceptable estimates of the non-R&D portion.

282. Innovative firms typically perform more than one innovation project at the same time, and these projects may involve rather different resources and may span various periods. Large firms usually have more innovation projects than small firms. When collecting data on the main project(s) only, a far greater amount of total innovation expenditure will be missed for large firms than for small ones. This will also have an impact on innovation expenditure at industry level, depending on sector concentration. International comparability and comparability across industries and firm size classes is thus more easily facilitated by the subject approach.

283. Other advantages of the subject approach are higher comparability of the innovation expenditure data with data from the National Accounts, and comparability between innovative and non-innovative

firms. Furthermore, there is a clearly defined relation between the unit of measurement and the population of all firms which is the objective of the analyses based on the data collected.

284. Disadvantages have to do with the lack of correspondence between the innovation effort and its impact on sales and the difficulty of linking the results with characteristics of innovations such as length of product life cycle, time needed for successful development, appropriability conditions, etc. At the same time, there is not always a close link between an innovation project and the innovation which is introduced to the market. An implemented innovation may be the result of various projects, and a single innovation project may be the basis for many innovations. There are also severe measurement problems in identifying the various sources of funds for TPP innovation expenditure.

285. In the **object approach** the sum reported comprises total expenditure on TPP innovations, or on the main TPP innovation(s), that have been implemented during a given period. It excludes expenditure on TPP innovation projects that have been aborted or are still in progress, and on general R&D not connected to any specific product or process application. This approach seems particularly suitable for innovation surveys starting from a set of successful TPP innovations or of TPP innovations which have been implemented. But it could also be used in surveys of the TPP innovation activities of enterprises in general.

286. The main advantages of this approach are to permit more specific links to the output of the innovation process. If the survey is done on the level of one or more TPP innovations, it is easier to link spending to characteristics of innovations such as time needed for successful development, appropriability conditions, length of product life cycle, the role of government R&D projects, as well as certain aspects of technology diffusion. Moreover, the object approach makes it possible to analyse the relationship between successful TPP innovation activities and their impact on economic performance. These advantages are limited, however, because an implemented innovation may be the result of various projects, and a single innovation project may be the basis for many innovations. Measurement problems with regard to a detailed breakdown by source of funds for TPP innovation projects are also less severe using the object approach.

287. With the object approach firms have to go back into their financial records to report accurate figures for earlier years, and that may prove difficult. It also assumes that companies have information about innovation expenditure at project level, which is rarely the case. Another problem is the definition of the criteria for “the main project(s)”, which sometimes vary even within enterprises and so may well vary between enterprises, industries and countries. This hampers international comparability as well as comparability between firms and industries.

288. Some elements of the object approach can be integrated into innovation surveys using the subject approach in order to obtain more details on the innovation process. In this case it is essential to define clearly the relation between subject items and object items within the questionnaire.

289. Innovation surveys which follow the subject approach can generate information on the **level of the main innovation(s) in a given year**. Innovation expenditure provides the link between the subject and the object approach by collecting total innovation expenditure for the main innovation project(s) following the object approach and also data on the innovation budget in a given year following the subject approach. In this way we can relate data collected at the level of an innovation, or the main innovations, (*e.g.* time to reach commercialisation, expected payback period) to the overall innovation activities of a firm. Again, the key problem seems to be the definition of the criteria for “the main project(s)”. More details are provided in Annex 1, Using the Object Approach for Collecting Innovation Data.

290. **In the light of the advantages and the disadvantages of both approaches, the subject approach is recommended for reporting on TPP innovation expenditure. This chapter is primarily concerned with the subject approach, although most of the definitions and advice apply more or less to the object approach as well.**

2. SUGGESTED BREAKDOWNS

291. Total **expenditure** for TPP innovation activities comprises current and capital expenditure incurred for the types of innovation activities defined in Chapter 3.

292. It is recommended that data should be collected on the breakdown of total TPP innovation expenditure by type of TPP innovation activity as well as a breakdown by type of expenditure (current innovation expenditure *vs.* innovation expenditure relating to capital goods). Information on TPP innovation expenditure by source of funds is also desirable given the importance attached to financing constraints in policy discussions.

2.1 Bottom-up or top-down method

293. In principle there are two methods for collecting data on innovation expenditure and detailed breakdown by innovation activity. In the bottom-up approach, the amount of innovation expenditure for each single type of innovation activity is collected and their sum provides the total innovation expenditure of the firm. The top-down approach, on the contrary, starts by asking for the sum of total innovation expenditure and follows with a question on the breakdown of this total by type of activity. **The bottom-up method is recommended as it yields more reliable results**. However, not all items in a breakdown by type of activity are easily available within firms (and some items may not be available at all for some firms), so a top-down approach may make it easier for some firms to respond and could be used to provide estimates of innovation expenditure by type of expenditure or type of innovation activity.

294. If possible, replies on the breakdowns of TPP innovation expenditure should all be expressed in monetary terms. Nevertheless, if this is thought too difficult, a possibility would be to ask for the total together with estimated percentage breakdowns for the components. Recent experience suggests that item non-response to these questions may be reduced if firms can choose between a monetary or a percentage statement.

2.2 Breakdown by type of expenditure

295. **Expenditure for TPP innovation activities should, if possible, be broken down into current and capital expenditure**. This is most important if the data are to be compared with those on intangible investment, with which innovation expenditure is sometimes confused (see Section 2.1.1 below).

296. **Current innovation expenditures** are composed of *labour cost* and *other current costs:*

- ***Labour costs*** comprise annual wages and salaries and all associated costs of fringe benefits such as bonus payments, holiday pay, contributions to pension funds and other social security payments, payroll taxes and so on. The labour costs of persons not involved in TPP innovation activities (such as security personnel and maintenance staff) should be excluded and considered with other current costs.

- ***Other current costs*** comprise non-capital purchases of materials, supplies, services and equipment to support TPP innovation activities performed by the firm in a given year.

297. **Capital expenditures for innovation** are the annual gross expenditures on fixed assets used for the TPP innovation activities of the firm. They should be reported in full for the period when they took place and not be shown as a depreciation item. They are composed of expenditures on *land and buildings*, on *instruments and equipment* and, in line with the revised System of National Accounts (SNA), on *computer software*, which is a component of intangible investment and considered as capital formation:

- ***Land and buildings*** includes the acquisition of land and buildings for TPP innovation activities including major improvements, modifications and repairs.

- ***Instruments and equipment*** includes major instruments and equipment acquired for use in the TPP innovation activities of the firm.

- ***Computer software,*** in line with the revised SNA, includes computer software, program descriptions and supporting materials for both systems and applications software for use in the TPP innovation activities of the firm. Included are purchased software and software developed on own account (if the expenditure is large) for TPP innovation activities. Large expenditure on the purchase, development or extension of computer databases that are expected to be used for more than one year, whether marketed or not, for use in the TPP innovation activities of the firm are also included.

298. All depreciation provisions for building, plant and equipment, whether real or imputed, should be excluded from the measurement of intramural expenditure.

299. TPP innovation, especially technological process innovation, often entails the installation of new machinery and equipment. Three cases may be identified:

- The installation of machinery and equipment with improved technological performance (*i.e.* which improves the firm's production methods) (see Chapter 3, Section 5.2.2) is a technological process innovation. The cost of the equipment is to be shown as capital expenditure for TPP innovation. From a different perspective, this is a component of gross fixed investment by the firm; the classification approach taken here is, however, directed at gaining an understanding of expenditure on the diffusion of innovations.

- The installation of machinery and equipment with no improvement in technological performance (*i.e.* which does not improve production methods), but which is needed to produce a technologically new product *(e.g. an additional moulding or packaging machine),* is not a technological process innovation. The cost of equipment is, however, shown as capital expenditure for TPP innovation.

- Other purchases of machinery and equipment are not considered technological process innovations and are not to be included in TPP innovation expenditure. *For example the extension of production capacity by adding more machines of a model already in use, or even replacing machines with more recent versions of the same model, are not TPP innovations*.

300. Enterprises often face severe problems in supplying reliable estimates of capital expenditure for TPP innovation activities. To assist them here, it is suggested that data on *total capital expenditure* (including capital expenditure not related to TPP innovation activities) should be collected as well. This

will also help check the reliability of TPP innovation expenditure data and give a picture of the relation between TPP innovation expenditure and tangible investment.

2.2.1 The relation between intangible investment and TPP innovation expenditure

301. *Intangible investment* covers all current expenditure for the firm’s development which is expected to give a return over a longer period than the year in which it is incurred. There is no standard definition, but it is generally taken to cover expenditure on non-routine marketing, training, software and some other similar items, in addition to current expenditure on R&D.

302. *Current expenditure on TPP innovation* is clearly a part of intangible investment. Intangible investment comprises elements which are not part of TPP current innovation expenditure. For example, only training in connection with the introduction of technologically new or improved products and processes is classified as TPP innovation expenditure, whereas intangible investment includes all of the firm’s training expenditure. Marketing in connection with the introduction of technologically new or improved products and processes is classified as TPP innovation expenditure. Intangible investment, on the other hand, includes marketing expenditure in general (*e.g.* improving the image of the firm, or capturing new markets with no direct connection to technologically new or improved products and processes).

303. At the same time, TPP innovation expenditure includes tangible investment such as *capital expenditure* on R&D, acquisition of new machinery and equipment related to TPP innovations.

2.3 Breakdown by type of innovation activity

304. The descriptions of expenditure items which should be included under various categories of TPP innovation activities are based on the definitions of TPP innovation activities in Chapter 3, Section 5.

305. The following breakdown should be viewed as a general guideline for both manufacturing and services. For the service sector, not all of the elements seem to be important, and some should be omitted. For example, recent experience suggests that expenditure items such as design, industrial engineering and trial production may not be relevant for the service sector. Conversely, an activity such as software, which pervades TPP activities, may be easier to identify and may be of interest for services.

306. In order to facilitate comparison with R&D expenditure **it is recommended that information should be collected on the breakdown by TPP innovation activity for total TPP innovation expenditure (current and capital expenditure). The following breakdown is recommended:**

- **R&D expenditure;**
- **expenditure for the acquisition of disembodied technology and know-how;**
- **expenditure for the acquisition of embodied technology;**
- **expenditure for tooling up, industrial engineering, industrial design and production start-up, including other expenditure for pilot plants and prototypes not already included in R&D;**

- **expenditure for training linked to TPP innovation activities;**

- **marketing for technologically new or improved products.**

2.3.1 R&D expenditure

307. This includes total intramural and extramural expenditure on R&D as defined in the *Frascati Manual* (see also Chapter 3, Section 5.2.1.*a)*. If intramural and extramural expenditure on R&D are evaluated separately, this will assist comparison with R&D survey data.

308. *Intramural R&D expenditure:* this item comprises all expenditure on R&D performed within the firm as defined in the *Frascati Manual* and as reported in R&D surveys. In most cases all this R&D is intended to contribute to the introduction of technologically new or improved products or processes in the firm concerned. However, where a firm carries out R&D purely as a service for another enterprise (or government agency), to contribute exclusively to innovation by the latter, an attempt should be made to identify the funds concerned so that they can be excluded in order to *avoid double-counting* when total (intramural and extramural) expenditure is summed over industries. R&D which is not directed towards specific new products and processes but is intended to expand the knowledge base of a firm is also covered here.

309. *Extramural R&D expenditure:* this comprises the acquisition of R&D services**.**

2.3.2 Expenditure for the acquisition of disembodied technology and know-how

310. This item comprises expenditure on the acquisition of disembodied technology as defined in Chapter 3, Section 5.2.1.*b)*. Expenditure for R&D services is to be excluded here.

2.3.3 Expenditure for the acquisition of embodied technology

311. This item comprises expenditure on the acquisition of machinery and equipment with improved technological performance, including major software, directly related to technologically new or improved processes as defined in Chapter 3, Section 5.2.1.*c)*.

2.3.4 Expenditure for tooling up, industrial engineering, industrial design and production start-up (including other expenditure for pilot plants and prototypes not already included in R&D)

312. This item comprises mainly:

- expenditure for *tooling up* and *industrial engineering* as defined in Chapter 3, Section 5.2.2.*a)*, including organisational development in connection with production start-up;

- expenditure for *industrial design* of technologically new or improved products or processes as defined in Chapter 3, Section 5.2.2.*b)*, insofar as it is not already included in R&D expenditure;

- expenditure for *testing* technologically new or improved products or services (testing of prototypes is part of R&D, and so excluded here);

- expenditure for *other capital* acquisition as defined in Chapter 3, Section 5.2.2.*c)*, required for the implementation of TPP innovation;

- expenditure for *production start-up* as defined in Chapter 3, Section 5.2.2.*d)*, except expenditure on retraining personnel which is proposed as part of a separate class;

- expenditure for *trial production* and *pilot plants* insofar as they are not already included in R&D (trial production is included in R&D if production implies full-scale testing and subsequent further design and engineering; pilot plants are included in R&D as long as the primary purpose is R&D);

- *other* expenditure related to *prototypes* insofar as it is not already included in R&D;

- expenditure for satisfying *regulatory requirements*: these may include drug registration, satisfying environmental regulations, and a range of other standards and requirements (for environmental protection, for example).

2.3.5 Expenditure for training linked to TPP innovation activities

313. This item consists mainly of expenditure for training required for the implementation of technologically new or improved products or processes (training for other activities should be excluded, see Chapter 3, Section 5.3.2). Initial training is as a rule not part of innovation expenditure. TPP innovation expenditure, therefore, mainly comprises subsequent training which covers various different forms of training linked to TPP innovation. Measurement of training is discussed in more detail in Chapters II and III of the forthcoming *OECD Training Statistics Manual*.

2.3.6 Marketing for technologically new or improved products

314. This item comprises expenditure on activities in connection with the launching of technologically new or improved products as defined in Chapter 3, Section 5.2.3.

2.4 Measurement problems

315. Several innovation surveys have collected data on both the R&D and the non-R&D part of total innovation expenditure. It turned out that many firms had difficulty in reporting innovation expenditure. The non-R&D items, in particular, are not usually directly available from their accounting systems. The foremost problem, accordingly, is not “which data to collect” but “how to collect reliable data” on innovation expenditure other than R&D expenditure.

316. Questionnaire design is crucial for the quality of the data collected on innovation expenditure. Small changes in the definitions or explanations given in the part of the questionnaire dealing with TPP innovation expenditure, and changes in layout or in the sequence of questions or items, will all affect the information gathered.

317. To evaluate the reliability of answers, it may be useful to ask firms to indicate the degree of uncertainty by saying whether their figures are based on detailed accounts or are fairly accurate or rough estimates. Although this kind of question may well raise the share of participants who give rough estimates only, the response rate may be higher.

2.4.1 The borderline between R&D and non-R&D innovation expenditure

318. In recent innovation surveys some firms had problems in differentiating between total innovation expenditure and R&D expenditure, especially at the borderline between R&D and non-R&D expenditure. Recent experience has shown that R&D expenditure measured as a share of total innovation

expenditure and R&D expenditure measured in a separate question (a *Frascati*-type question) do not match, even when both types of questions are asked in the same questionnaire. This reflects different methods of R&D accounting inside firms; sometimes they do not fully conform to the *Frascati* definition of R&D expenditure, and include some non-R&D activities. Detailed explanations, and the questionnaire layout, will help enterprises give consistent answers on R&D. This problem is especially acute for industries whose innovation consists to a large extent of design activities *(e.g. automobile manufacturing).*

319. Care must be taken to exclude activities which are part of the innovation process but rarely involve any R&D *(e.g. patent work, licensing, market research, manufacturing start-up, process re-engineering, tooling up).* At the same time, some activities are at least partly counted as R&D *(e.g. pilot plants, prototypes, industrial design, process development).*

320. The basic criterion for distinguishing R&D activities from non-R&D innovation activities "is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty" (see *Frascati Manual*, para. 79). This criterion implies "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" (*Frascati Manual,* para. 80).

321. The *Frascati Manual* (para. 112) suggests using the rule originally laid down by the US National Science Foundation as a rough guideline for distinguishing between R&D and non-R&D activities:

> *"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."*

322. It is recommended that the guidelines in the *Frascati Manual*, paragraphs 111-132, should be applied to innovation surveys. In a number of cases individual firms, especially in some industries, will continue to have problems in allocating some of their innovation activities to R&D and others to non-R&D.

2.4.2 Other difficulties

323. A breakdown of each of the above type-of-activity categories into intramural and extramural expenditure would supply desirable information. But this is not feasible for most enterprises, and so is not recommended here.

324. As a consequence, special care has to be taken when aggregating individual firm numbers to industry or national figures, because of double-counting. To make rough estimates of the amount of double-counting, it seems useful to know whether or not expenditure for external services is included or not.

325. TPP innovation expenditure in a given year can sometimes be misleading. Small firms in particular do not perform TPP innovation activities all the time. Collecting TPP innovation expenditure for a multi-year period thus provides useful additional information on TPP innovation activities. But restricted availability of data within firms is a serious obstacle to the multi-year approach.

326. One way of dealing with this would be to ask, in addition, whether innovation expenditure in previous years was well above, or well below, the reported amount for the year in question. Furthermore,

to facilitate estimates of the most recent trends in innovation expenditure it seems worthwhile to ask whether innovation expenditure is scheduled to grow, fall or stay at the same level. This seems to be especially desirable from an innovation policy viewpoint.

2.5 Breakdown by source of funds

327. It is important to know how TPP innovation expenditure is financed, for instance in order to evaluate the role of public policy and internationalisation in the innovation process. The following classification by source of funds is suggested:

List of sources of funds:

- own funds;
- funds from related companies (subsidiary or associated companies);
- funds from other business enterprises;
- funds from government (loans, grants, etc.);
- funding from supranational and international organisations (EC, etc.);
- other sources.

328. It is enough, for a variety of policy and research issues, to collect information on whether or not each source is used, instead of seeking an estimate, probably imprecise, of the amount (either in monetary or percentage terms) contributed by each source. This will considerably reduce the response burden on firms, and hence increase the total response rate to the survey as well as cutting item non-response to this question.

329. To evaluate the role of government procurement in innovation, it is useful to know whether or not a firm participates in government procurement (regional, national or international) related to innovative products and processes. This may provide a useful substitute for a detailed breakdown by source of funds.

Chapter 7

SURVEY PROCEDURES

330. The correct application of statistical methodology is crucial for the collection and analysis of innovation data. Based on theoretical knowledge, and on practical experience in recent innovation surveys at national and international level, this chapter gives recommendations on key elements for the collection and analysis of innovation data.

331. Following these recommendations will generally lead to comparable results over time and across countries. Particular circumstances may require a country to use another methodology. That will not cause problems as long as the results are still comparable.

1. POPULATIONS

332. Innovation activities take place in all parts of an economy: in manufacturing, the service industries, public administrations, the health sector and even private households. All units of an economy which fulfil, or may fulfil, the restricted coverage conditions set out in Chapter 2 (**innovators** or **non-innovators**) are possible units for innovation surveys.

333. In reality, for various theoretical and practical reasons, a survey will not cover all possible units. The concept of innovation is still unclear in some parts of the economy, especially with respect to non-market-oriented activities. It is therefore recommended that innovation surveys should primarily refer to innovation activities in market-oriented industries. These should include manufacturing industries as well as market-oriented service industries. As long as knowledge about innovation activities in service industries remains fairly limited, at this early stage of the methodology's development, a concentration on technology-intensive service industries is preferable.

334. Innovative activities take place in small and medium-sized units as well as large ones. In theory, innovation surveys should therefore include units of all sizes. For practical reasons, however, only units with at least 10 employees should be surveyed, to ensure international comparability. This threshold may be higher for specific industries, and lower for some service industries.

335. All units with 10 employees or more belonging to one of the industries mentioned above form the **target population** of innovation surveys. The target population includes innovators and non-innovators, R&D performers and non-R&D performers.

336. In practice it is almost impossible to identify and approach all units in the target population, regardless of the type of survey. For example, the frame underlying the survey (such as a register) may include units which no longer exist, or units which no longer belong to the target population. At the same time it may not contain units which in fact belong to the target population. The units included in the basis for the survey form the **frame population**.

337. When preparing a survey, the target and frame populations should be as close as possible. Institutions performing innovation surveys should make every possible effort to reduce error due to differences between the two. In most cases error would be unacceptably high if the frame population were defined on the basis of applications for R&D subsidies (underlying assumption: only R&D performers have innovative activities; further problem: not all R&D performers ask for subsidies), or on the basis of

information on former innovators. In some cases the frame population may be identified through an *ad hoc* survey or using existing surveys.

2. SURVEY METHODS

2.1 Census or sample survey

338. Innovation data may be collected through census or sample surveys. Resource limitations and response burden will in most cases rule out a survey of the entire population (census). If sample surveys are designed, the units should be selected on the basis of a random procedure (random sample surveys). Sample surveys should be representative of the basic characteristics of the target population, such as industry or size.

339. A census may be unavoidable in some cases. It may be a legal requirement that all business surveys have to be censuses. In addition, when the frame population is fairly small (*e.g.* in small countries) and more complex sampling techniques like stratification techniques are proposed, proper sampling may produce a sample size which is relatively close in size to the frame population. In such cases censuses may be worth considering.

2.2 Mandatory or voluntary survey

340. Innovation surveys may be mandatory, or voluntary. If they are voluntary, higher non-response rates have to be expected. Low response rates may lead to very low numbers of replies, which cannot be used for further analysis. This effect could be compensated to some extent, in the case of sample surveys, by higher sampling fractions. But increasing the sampling fractions does not solve the basic problem of bias due to high non-response rates.

341. To follow the development of the innovation process over time, panel (sample) surveys offer special opportunities. Notably they will allow analysts to look at links between different variables over time. Panel surveys require special care in selecting the units and in the treatment of refusing, dying and newly created units.

2.3 The frame population

342. A necessary condition for any innovation survey is a frame with basic information on all units of the frame population. As a minimum, it must contain the names and addresses of all units. Telephone and fax numbers are desirable. In addition, the frame should include information on key variables such as industry, size or region.

343. An ideal frame is an up-to-date official business register established for statistical purposes. Such registers are usually kept by national statistical offices. Other registers may be used as well, depending on their quality. If the registers form the basis for several surveys, such as the innovation survey, the R&D survey and the general business statistics survey, the information collected in the innovation survey can be restricted to issues specific to innovation. Other information, for example on R&D or on general economic variables like sales, exports or investments, can be taken directly from the other surveys based on the registers. Accordingly, basing different surveys on a single business register compiled for statistical purposes is desirable. If such links between surveys are not possible, general economic information and information on R&D must also be collected in innovation surveys.

2.4 Survey methods and suitable respondents

344. Various methods and techniques can be used for the collection of information, including postal surveys and personal interviews. Once innovation surveys are well established, automated data exchange between reporting units and the surveying institute may be possible as well.

345. These methods each have different strengths and weaknesses. Postal surveys are well established and comparatively less expensive, but present problems as well. Experience has shown that questionnaires for postal surveys have to be extremely well designed in order to get sufficient response rates (for more details, see below), and the surveying agency should encourage phoning from respondents for clarification and assistance. Several reminders are usually necessary to increase response rates to an acceptable level. Another difficulty is that reminders may generate different answers from different respondents in the same firm. Additional action can be taken to increase response rates further: sending a cover letter from the minister, sending basic results of previous innovation surveys (if any), or a promise to send respondents the main findings from the current survey.

346. Most of the problems with postal surveys can be avoided when data is collected by personal interview. The quality of the results should be far higher. Item and unit non-response rates should be much lower, so that a far smaller number of units need to be approached to achieve the same quality. Despite these obvious advantages, this method is not recommended for general use as the cost is still fairly high, and in most cases too high.

347. Combining the advantages of postal and interview methods and avoiding their weaknesses could be the best solution. CATI techniques take this course, and so does the Canadian approach where individual questionnaires are designed for each unit, based on information gained through personal contact (*e.g.* on the telephone) with the most suitable respondent there. The unit-specific questionnaires are then sent by mail.

348. Choosing the most suitable respondent in the units is particularly important in innovation surveys, as the questions are highly specialised and can be answered by only a few people in the unit, usually not those who complete other statistical questionnaires. In small units, managing directors will often be good respondents. Directors responsible for technology may well be the best people to answer the questions in larger units. Several people will often be involved, but one must be responsible for co-ordinating the replies. A special effort to identify respondents, before data collection starts, is highly recommended. It will contribute greatly to a survey's success, but may prove difficult in practice. It is important that the partner in the unit has the power to decide on participation in the survey (if voluntary), and to collect the necessary data for the unit.

2.5 The questionnaire

349. All data collection techniques are based at least to some extent on a questionnaire. Some basic rules should be followed when designing the questionnaire for an innovation survey. Special attention is necessary in the case of postal surveys. Each questionnaire should be tested before use in the field (pre-test).

350. The questionnaire should be as simple and short as possible, logically structured, and have clear definitions and instructions. Generally, the longer the questionnaire, the lower the unit and item response rates. This effect can be minimised by devoting special attention to the design and layout and by giving clear and sufficient explanatory notes and examples. It is particularly important to design the questionnaire in such a way that units with no formal innovation activities will nonetheless reply.

351. Respondents' understanding of the questionnaire may well increase as they move from question to question. This means that their answers may depend on the order of the questions. Adding or deleting a category may influence answers.

352. All questions in a questionnaire should be checked to see whether a "not applicable" category is needed to distinguish this answer from item non-response.

353. Experience has shown that willingness to complete innovation questionnaires varies across groups of units. The less units feel themselves to be concerned, as is the case with many small units and in sectors where the concept of innovation is relatively unknown, the less willing they are to participate in innovation surveys. One solution may be to develop specific questionnaires for these groups, for example restricting the questionnaire to some core questions.

354. In the case of international innovation surveys, special attention should be given to the translation and design of the questionnaire. Even minor differences across national questionnaires may severely restrict the comparability of the results. Such differences may stem, for example, from translation, from changes in the order of questions, or from adding or deleting categories. A sound translation taking account of particular local circumstances (such as a country's legal system) will help avoid misunderstandings of concepts and definitions. Conceptual problems should not be masked by ambiguous translations.

2.6 Innovation and R&D surveys

355. As R&D and innovation are related phenomena, countries may think of combining R&D and innovation surveys (see Chapter 5, Section 6.1). There are a number of points for and against this:

- First, with a combined survey, the overall response burden of the reporting units would go down (a single questionnaire, instead of two separate surveys asking partly the same questions). But the individual burden may not necessarily be reduced. With two surveys the burden may be better distributed across units. In addition, combination may reduce the response rate, as the questionnaire will be longer than in either of the surveys taken separately.

- Second, a combined survey offers scope for analysing the relations between R&D and innovation activities at unit level. There is less scope for this with separate surveys, especially when they are carried out by different institutions.

- Third, units which are not very familiar with the concepts of R&D and innovation may mix them up in a combined survey. Confusion is less likely with separate surveys.

- Fourth, at least in larger units, R&D and innovation questions may be answered by different people, so a combined survey may not be an advantage.

- Finally, the frames for the two surveys are different. Combining them would involve sending questions on R&D to a large number of non-R&D performers[36] who are included in the frame population for the innovation survey; this would increase the cost of the joint survey.

356. To sum up, there are arguments both for and against combining R&D and innovation surveys, and it is not possible to give a clear recommendation. Each country running both surveys will have to decide for itself whether the pros or the cons predominate, taking the particular features of their national systems into account.

3. PERFORMANCE OF SAMPLE SURVEYS

357. In almost all cases, innovation surveys are random sample surveys. The relevant literature offers quite different sampling techniques, such as the simple random sample technique, stratification techniques or cluster sample techniques. In the past, stratified sample surveys have proved to lead to reliable results.

358. If stratification techniques are used, some general rules with regard to the selection of the stratification variables should be respected. In principle, stratification of the population should lead to strata which are as homogeneous as possible in terms of the phenomenon under consideration, *i.e.* strata of units for innovation surveys should consist of units which are as similar as possible as far as their innovation or non-innovation activities are concerned. It is common knowledge nowadays that innovation activities of units in different industries and in different size classes generally differ significantly. It is therefore recommended that the stratification of random sample innovation surveys should be based on the size and principal activity of the units.

359. The size of the units should be measured by the number of employees. Given the different types of units (see Chapter 4) and different national conventions, general recommendations on appropriate size classes are fairly difficult. Some recommendations for analytical purposes, which may also be used for stratification, are given below.

360. The stratification of units according to their principal activities should be based on the ISIC Rev. 3[37] / NACE Rev. 1[38] classifications. Here again, no general recommendations can be given as to which level of the classifications the stratification should be based on. The decision largely depends on national circumstances. Take as an example an economy specialised in the production of wood (Division 20 of ISIC Rev. 3 / NACE Rev. 1). For this country a further sub-division at group or even class level might be useful, in contrast to another economy where the production of wood is unimportant. However, units should not be aggregated above division level (second digit level of ISIC Rev. 3 / NACE Rev. 1).

361. If regional aspects are of importance, as is the case for the countries of the European Union, the stratification should also include the regional dimension. An appropriate regional classification should be used (NUTS[39] for the European Union). The stratification for EU Member States should be at NUTS Level 1 at least.

362. In order to guarantee a high rate of accuracy, the sampling fractions for the individual strata should not be the same for all strata. It is generally recommended that the sampling fraction of a stratum should be higher as the number of its units in the survey population is smaller, and as the population in the stratum is more heterogeneous. The sampling fractions should be up to 100 per cent, for example in strata with only a few units, as may be the case in strata consisting of large units in certain industries (or certain regions). Another factor which should be taken into account when fixing the individual sampling fractions is the propensity to respond in the strata. Examples of strata in which the propensity to respond may be relatively low are those consisting of smaller units, as they may not be very familiar with the concept of innovation.

363. The results of sample surveys need to be expanded to obtain information on the survey population. There are various methods for expanding sampling results. The easiest one is the free expansion technique, where the individual results are weighted by the inverse of the sampling fractions of the sampling units (raising factors). If a stratified sampling technique is used the free expansion technique should be performed individually for all strata, especially where sampling fractions differ across strata. The raising factors may be modified in the event of unit non-response above a certain threshold.

364. Expansion techniques have to be applied to both quantitative and qualitative variables, but in different ways. In the case of quantitative variables the observed values can be weighted directly; in the case of qualitative variables the frequencies must be raised.

4. ESTIMATION OF RESULTS – NON-RESPONSE PROBLEM

365. In practice the responses to innovation surveys are always incomplete, irrespective of the survey method used. Two types of missing values can be distinguished: item and unit non-responses. Unit non-response means that a reporting unit does not reply at all. Possible reasons are, for example, that the surveying institute cannot reach the reporting unit or that the reporting unit refuses to answer. In contrast, item non-response is the case when a unit does answer but at least one question is left blank. Even the extreme case where all but one of the questions are left blank may be considered item non-response.

366. Item and unit non-responses would be less of a problem if the missing values were randomly distributed over all sampling units and all questions. In reality, however, both types of missing values are biased with respect to certain characteristics of the population and the questionnaire. Experience with the Community Innovation Survey showed that unit non-responses were concentrated, for instance, in some situations ("we are faced with serious economic problems and have no time to fill in your questionnaire") or in some industries ("innovation is an unknown concept in our branch"). Item non-response is more likely when the question is (or seems to be) more difficult. A prominent example of item non-response in the Community Innovation Survey was the question on innovation expenditure.

367. Item and unit non-responses clearly affect the comparability of the results of national and international innovation surveys. Appropriate methods have to be developed and used to overcome this problem. As different methods may lead to different results, some general recommendations should be followed. Otherwise, differences in innovation results over time and/or across countries may be caused by using different concepts to reduce the bias of item and unit non-responses.

368. For practical as well as theoretical reasons, one recommended way to overcome the problem of item non-response is a group of methods called "imputation methods". Basically, imputation methods seek to estimate missing values on the basis of additional information. This information may come from the same survey, previous surveys or some other related source. A special group of imputation techniques, the hotdecking methods, were used to clean the national results from the Community Innovation Survey. The idea here is to estimate the missing values on the basis of available information in the same survey. Hotdecking methods themselves contain a large variety of methods, such as replacing the missing values for each variable by the mean of the strata, and using regression techniques or nearest neighbour techniques where the missing values are replaced by the values of the unit which is most similar with respect to other (relevant) variables. Decisions about the most appropriate hotdecking method should also be based on the type of variable (quantitative versus qualitative variables).

369. Which method to use to overcome the problem of unit non-response will depend on the level of non-response. If the non-response rate is fairly low,[40] the raising factors should be directly adjusted. In the case of free expansion, the raising factors should not be calculated on the basis of the units selected for survey but on the basis of the units which replied to the questionnaire. This procedure is based on the assumption that the innovative behaviour of responding and non-responding units is identical. This assumption could be tested through non-response analysis. Even if the assumption is wrong, the bias introduced can be disregarded as long as the fraction of non-responding units is fairly small.

370. In contrast, if the unit non-response rate is very high, no method can be recommended to solve the problem. In such a case the results of the innovation survey can only be used for descriptive purposes. No further conclusions should be drawn, even about the target population in general, as the bias will be too high.

371. In all other cases, *i.e.* when the unit non-response rate is beyond a lower threshold but less than an upper threshold, some more complicated and partly more expensive techniques are recommended. One solution would be to randomly select reporting units which have answered until the response rate is 100 per cent, *i.e.* to use the results of randomly selected units twice or even more often. Other methods are based on the results of non-response analysis. The objective of non-response analysis is to obtain information on why reporting units did not answer. In this non-response survey, non-reporting units should be contacted by phone or by mail (using very a simple questionnaire not exceeding one page) and should be asked to provide some general information such as ISIC/NACE code or size if not already available from other sources such as business registers, as well as the reason they did not answer, and to give answers to a few key points in the original survey to see whether the results are biased. This information can then be used to adjust the expansion factors.[41] The results of non-response analysis should only be used if the response rate in the non-response survey exceeds 80 per cent.

372. The results of non-response analysis can also be used directly to correct the values of innovation indicators such as the proportion of innovative units.[42]

5. PRESENTATION OF RESULTS

373. Results of innovation surveys can be used for either descriptive or inferential purposes. The objective of descriptive analysis is to describe statistical units in terms of their innovative or non-innovative activities without any conclusions for the underlying survey or target population (unless it is a census). In this type of analysis the results are taken without further weighting, as they were observed for the individual units. No generalisation of the results at the level of the survey or target population is possible, because the figure only refers to the participating units. For this kind of analysis, the unit non-response rate is of minor importance.

374. In contrast, the objective of **inferential analysis** is to draw conclusions about the survey population, *i.e.* the results should give a (representative) estimation of the situation for the observed and unobserved statistical units taken together. Inferential analysis requires weighted results. For this type of analysis, the unit non-response rate is of great importance: if the unit non-response rate exceeds a certain threshold, inferential analysis is meaningless.

375. As mentioned above, most innovation surveys are carried out as random sample surveys. The results of these surveys will include two types of error: random errors due to the random process used for the selection of the units, and systematic errors containing all non-random errors (bias). To get at least an idea of the level of error it is recommended to calculate not only (average) values for pertinent indicators such as the proportion of innovators or the average innovation expenditure per innovator, but also their standard errors and/or confidence intervals. Such intervals include the true but unknown values in the survey population with a very high probability, assuming no bias. Standard errors give a lower threshold for the unknown total error of the indicators under consideration.

376. To improve the comparability of the results of innovation surveys at international level, definition of a set of basic tables is recommended. These tables should be derived from the national tables, which may be far more detailed.

6. FREQUENCY OF DATA COLLECTION

377. Theoretical and practical considerations, as well as user needs at international, national and regional level, determine the frequency of innovation surveys. The increasing importance of innovation for the growth of economies[43] requires more regular and more up-to-date data. From this viewpoint, information on innovation activities should ideally be collected continuously, *i.e.* innovation surveys should be carried out annually. This view is strengthened by theoretical considerations indicating that innovation activities come in waves, making the results of non-annual surveys very dependent on the time at which the survey is carried out. Only a few countries, however, can afford to run innovation surveys every year.

378. There is general agreement at international level that innovation surveys should be carried out not more often than every two years, and for some variables even more rarely. If this is done, time-series analysis will also be possible, at least in the long run. Whether the frequency is two years or longer depends on a number of factors, such as the periodicity of the R&D surveys or possible national or European legal requirements.

379. In addition to general innovation surveys, more detailed studies on certain sub-populations or certain specific subjects are recommended.

ANNEX 1

USING THE OBJECT APPROACH FOR COLLECTING INNOVATION DATA

INTRODUCTION

380. Chapter 2 of this manual describes two ways of collecting innovation data. The collection of information about innovation activities from both innovating and non-innovating firms is known as the "subject approach" while the collection of information about specific innovations is known as the "object approach". These terms will be used in the remainder of Annex 1.

381. The manual recommends the subject approach as the methodology for countries to use when conducting innovation surveys. However, use of the object approach can result in valuable additional data, particularly when used in conjunction with the subject approach. This annex therefore describes the way in which the object approach might also be used by countries undertaking innovation surveys in conjunction with the subject approach. Data about specific innovations can also be compiled by using literature-based methods. These methods are discussed in the second part of this annex.

1. SURVEYS ON SPECIFIC INNOVATIONS

1.1 Issues addressed by the use of object approach data

382. In some cases, government innovation policies will be aimed at promoting particular types of innovation, and hence data are required about particular innovations. In other cases, government innovation programmes will be aimed at firms, for example, encouraging particular types of innovative behaviour, hence requiring the use of firm-level data for programme monitoring. Consequently there is a requirement for both data about innovating firms and data about the innovations they implement. Also, experience so far suggests that some types of data items are more amenable to collection at the individual innovation level rather than in respect of the particular innovating firm.

383. One area of concern for collection agencies relates to measuring innovation expenditure and relating this expenditure to the financial impacts attributable to innovation. Even for a specific innovation, expenditure is likely to occur over a number of years, which may overlap a number of different survey reference periods. Similarly, benefits may also occur over a range of time periods and these may be different to the expenditure periods. When firms introduce more than one innovation during a survey period the difficulty is further compounded. Consequently, for the whole firm it becomes extremely difficult to measure all expenditure for its innovations and then to relate it to the financial impacts. For a specific innovation, particularly the most significant innovation of the firm, the problems are not so extensive. Firms are generally able to report the expenditure on their most significant innovation, and the associated benefits.

384. Another area which cannot be adequately measured using the subject approach relates to the life cycle involved in the implementation of innovations. Many firms usually have a number of innovations

occurring at any one time, so the aggregation of such data becomes meaningless when analysed at the firm level. In contrast it is relatively easy to look at life cycle issues for specific innovations by measuring the time taken for the particular innovation to reach commercialisation and the time taken for a firm to recoup its expenditure on a particular innovation. This type of data provides additional information which is very useful for policy analysts.

385. A further area in which the object approach is seen to be extremely useful is the novelty of the innovation. For policy purposes it is quite important to be able to distinguish between the characteristics of those innovations which are new to the world, or perhaps to the country, as compared to those which are new only to the firm itself. As most firms will have introduced a range of innovations in the collection period, it is very difficult to report on novelty in respect of the firm's total innovation activities by using the subject approach. Data on the novelty of an innovation will be very useful to governments, pointing for instance to specific industries or regions which are at the leading edge in terms of new developments and those which are not.

386. The object approach can further describe an innovation by whether it is a product or a process innovation (or a combined product/process innovation) and the objectives of the innovation. Many firms will undertake both product and process innovation within a given survey period, so it becomes difficult to use this classification in analysing data collected using the subject approach. By contrast, object approach data on specific innovations probably allow them to be classified as a product innovation, a process innovation or a combination of the two.

387. Currently, data on the objectives of innovation, the areas benefiting from the innovation and the source of information or ideas for innovation are collected from firms using the subject approach. However, it is likely that these data items are more easily attributed to a particular innovation, rather than the firm's total innovation activities. Using the object approach should result in more meaningful and accurate data.

1.2. Drawbacks of using the object approach

388. The object approach could be used for the collection of data about each of the innovations undertaken by a firm. However, this would place an excessive burden on firms. They would be unable to report this level of detail and complete the forms accurately without keeping ongoing records of all their innovations. Accordingly, this application of the object approach is not recommended.

389. Since the main policy interest in respect of particular innovations focuses on the most significant ones, it is possible to restrict data collection to significant innovations. This leads to the option of collecting data in respect of the most important innovation, or perhaps a number of significant innovations. Clearly, seeking information on more than one innovation will increase the size of the database available for analysis. But the increase in data needs to be balanced with the increase in the burden on firms. Asking firms only about their most significant innovation should provide policymakers with sufficient information for analysis.

390. It is important to note that this approach will never enable statistics to be produced which purport to represent the totality of innovations which occur in a country in a given period. The resulting statistics will only represent a sub-set of the innovations occurring, and analysts will need to avoid drawing conclusions about all innovations. They will however be able to draw conclusions about significant innovations, particularly if they classify them by other characteristics, such as expenditure on the innovation, size of the firm, etc.

1.3 Implementation of the object approach

391. As described in the main body of this manual, the object approach is meant to be complementary to the subject approach and is not intended to be a replacement for it.

392. The object approach is best used as a supplement to the subject approach for compiling innovation data. In this way the object approach does not involve any surveys in addition to those which are already being undertaken; it merely involves the incorporation of a few additional questions seeking information about the most significant innovation occurring within the firm. This will also allow object approach data to be linked with data for the firm, such as financial or production data, at the unit record level to determine if there is any correlation with the main innovation.

393. The definition of the most significant innovation being undertaken by a firm is best left to the firm. Experience from a survey conducted by the Australian Bureau of Statistics (ABS) in 1994 showed that this worked well from a collection point of view, even though it resulted in data being collected for a range of different innovations. This is not seen as a major problem as it is possible to compile summary statistics by grouping similar significant innovations according to their characteristics, *i.e.* type, expenditure, life cycle, etc.

1.4 Experience in collecting data using the object approach

394. The Science Policy Research Unit (SPRU) at the University of Sussex used this approach during the 1970s and early 1980s. SPRU identified the 4 000 most significant innovations which occurred in British manufacturing industry between 1945 and 1983. Having determined which innovations were to be included in the survey, SPRU then sought information about these innovations and the characteristics of the innovating firms at the time the innovations were introduced.

395. SPRU was not the first to use this type of combined methodology. Similar and related exercises were undertaken in the United States during the mid 1970s to early 1980s. There are references to similar work being undertaken in Canada, France and Germany around the same time.

396. In more recent times, ABS in Australia and Statistics Canada collected information about the innovative activities of firms (using the subject approach), as well as collecting some information on the most significant innovation introduced by a firm on the same form or in joint surveys. This combined subject and object approach survey proved successful.

1.5 Data items amenable to collection using the object approach

397. The data items that can be collected using the object approach differ from those that can be collected using the subject approach basically because the measurement unit is different, *i.e.* main innovation *versus* innovating firm.

398. There are three main types of data that can be collected using the object approach: descriptive information, quantitative information and qualitative information. The data items outlined below are those for which it is recommended that surveying agencies collect information in respect of the most significant innovation commercialised by the firm in the survey period.

1.5.1 Descriptive data

1.5.1.1 Description of the main innovation

399. Provides brief descriptive material on the innovation process in this case.

1.5.1.2 Classification by the type of innovation

400. Provides information on the type of innovation, for example whether the innovation being described is a product or process innovation, or a new product or a changed product, or a combination of any of the above.

1.5.1.3 Novelty of the innovation

401. Provides details on the degree of novelty of the innovation. The novelty of an innovation can be defined using a number of technical variables, or in terms of the market.

a) Classification by type of novelty using technical variables

402. The information here can be obtained by ticking relevant categories:

- product innovations:
  - use of new materials;
  - use of new intermediate products;
  - new functional parts;
  - use of radically new technology;
  - fundamental new functions (fundamental new products).
- process innovations:
  - new production techniques;
  - new organisational features (introduction of new technologies);
  - new professional software.

b) Classification by type of novelty in terms of the market

403. Classification by type of novelty:

- new only to the firm;
- new to the industry in the country **or** to the operating market of the firm;
- new to the world.

1.5.1.4 Nature of innovation

404. This classification may provide valuable supplementary information as it gives some indication of the source of innovation.

Classification by nature of innovation:

- application of a scientific breakthrough;
- substantial technical innovation;
- technical improvement or change;
- transfer of a technique to another sector;
- adjustment of an existing product to a new market.

1.5.2 Quantitative data

1.5.2.1 Innovation expenditure

405. Provides details on the expenditure on the main innovation which can then be be used to put the main innovation into context by relating it to the firm's total innovation expenditure.

1.5.2.2 Impact of the innovation

406. Since there are some collection problems when trying to determine the impact of innovation at the firm level, it may also be useful to collect details at the significant innovation level, thereby allowing more accurate and detailed cost benefit analysis.

407. It is suggested that a question could be included about the share of sales and exports due to the main technological product innovation put on the market within the last three years; or on how the main technological process innovation has influenced the use of factors of production, *i.e.* manpower use, material consumption, energy consumption and utilisation of fixed capital.

1.5.2.3 Life cycle of the innovation

408. Specific project details, such as the time taken to reach the commercialisation phase or the expected cost recovery or payback period, can be collected.

409. As the main purpose of the output is to provide comparative data about innovations, and not to make inferences about the totality of innovation projects, it is possible to be less precise with the numerical information being sought from the quantitative questions. This means that range information can be provided using tick boxes, making this section of the survey form easier to complete.

1.5.3 Qualitative data

1.5.3.1 Benefits of the innovation

410. Benefits of the kind described for the subject approach are also collectable for specific innovations.

1.5.3.2 Sources of information or ideas for the innovation

411. Sources of the kind described for the subject approach are also collectable for specific innovations.

412. Although some of the data collected using the object approach are the same as those that would be collected using the subject approach, the emphasis differs considerably, and so do the answers that the firms provide. As a result, the uses of the data are also different and complement each other, with only minimal duplication.

1.5.3.3 Diffusion of innovation

413. In Chapter 1 **diffusion** is defined as the way in which innovations spread, through market or non-market channels; without diffusion, an innovation will have no economic impact. Some indicators of diffusion are presented below.

a) User sectors

414. In theory, innovations can be classified by three criteria:

- the sector of activity of the producer;
- the technological group (product group) to which the innovation belongs;
- the sector of utilisation.

415. The first criterion is dealt with via classification.

416. To date, some innovation surveys have included a question about the user sector. For the most important innovation, enterprises were asked to indicate the typical area of use. **It is suggested that questions on the product group and sector of utilisation are asked.**

1.6. Reference period relevant to the object approach

417. Unlike the subject approach, the reference period for the object approach relates to the life of the innovation project, not the different reference periods used in the rest of this manual. When relating data collected using the object approach with data collected via the subject approach, the different time frames must be considered.

2. LITERATURE-BASED INNOVATION OUTPUT INDICATORS – LBIO

418. While the first part of this annex describes the object approach within the framework of innovation surveys, this part refers to the collection of information about individual innovation cases reported in technical and trade journals. This method is often referred to as the "literature-based innovation output approach" (LBIO). While the LBIO method lacks the conventional statistical frameworks used in innovation surveys (population, sample, etc.), and is confined to product innovation data, it has the advantage that it makes only modest demands on firms' goodwill to report information. In recent years, the method has been applied in Italy (Santarelli and Piergiovanni, 1996), in the United Kingdom (Coombs *et al.,* 1996), in the United States, Austria, Ireland and the Netherlands (see various contributions in Kleinknecht and Bain, 1993).

2.1 Methodology

419. Firms have an incentive to make their new products and services known to the public when they are introduced to the market. An important communication channel consists of press releases sent to trade and technical journals. There are a few exceptions to this rule (*e.g.* products for very small market niches), but in general we can assume that the overwhelming majority of new products and services are publicised. When screening a collection of trade journals, all new products or new services mentioned in the edited part of the journals (often included in a separate "new products" section) should be taken. In order to avoid including a lot of minor and spurious innovations, it is recommended that advertisements should be ignored. In other words, only cases of innovation which the journals' editors have judged worthy of inclusion are registered.

420. The journals usually provide a brief description of the new product or service and the address and phone number of the organisation where further information about the product can be obtained. A comprehensive collection of innovation cases can be built up, provided a balanced collection of journals covering the relevant sectors is screened. It is hard to give a precise rule for journal selection. However, the following three-step procedure should lead to reasonable coverage of sectors:

- try to get the fullest possible overview of potentially relevant journals by search procedures in specialised libraries, and try to obtain sample copies;

- contact the trade associations of all sectors to be covered and ask which journals they publish and whether they usually cover new products;

- phone the public relations departments of firms in the relevant sectors and ask them to which journals they usually send press releases about innovation.

421. In general, care should be taken care to cover each major branch via at least one suitable journal. A choice between two or more journals in a branch should always be based on an inspection of sample copies. Phone calls to firms and trade organisations can also be used to obtain some expert judgement about which are the really relevant journals.

422. When collecting the data, the following points merit attention:

- Data should be collected on a real-time basis, *e.g.* by taking out a subscription to the relevant journals so that firms can be contacted soon after the announcement of the new product. Experience from past projects indicates that, even a few months after the announcement, a considerable number of firms will be hard to trace, due to bankruptcies, moving to a different region, take-overs, etc. Up-to-date collection of information has other advantages as well. For example, as the information is published in a journal, the innovating firm expects phone calls from potential clients and will be prepared to release further information. This is a good moment for a phone interview, and one can hope to be readily connected to the "right" person.

- A phone interview shortly after the announcement of the innovation can address various types of information, depending on research interests and resources. Possible questions relate to bottlenecks in the innovation process, objectives of innovation, sources of information considered important for achieving the innovation, patenting and/or licensing or other ways of appropriating innovation benefits, R&D networks and modes of technology acquisition, the role of the public R&D infrastructure or participation in government innovation programmes, etc. (for a detailed outline see Kleinknecht and Bain, 1993, pp. 195-198). The LBIO method has the important advantage of asking such questions at the project level, while in standard R&D and innovation surveys they tend to be asked at the firm level, forcing large firms to give some "average" answer across a number of projects. Moreover, certain types of information can be collected for all innovation cases or only for specific types of innovation. While there is still some room for selection, some questions should **always** be asked:

- The firm's full address.
- Its size (in terms of employment and/or sales).
- Did the firm develop the innovation itself?
- The firm's branch of principal activity.
- The sector(s) in which the firm hopes to sell the product or services.

Information on the last two points will allow intersectoral technology flows from innovation "producers" to innovation users to be traced.

- Recent LBIO studies used the following dimensions to classify all new or changed products or services:
  - the degree of complexity;
  - the type of new or changed product or service;
  - the properties of the new or changed product or service;
  - the origin of the new or changed product or service.

423. Three degrees of complexity were distinguished:

- high: the innovation is a system consisting of a larger number or parts and components, often coming from different disciplines (*e.g.* a weather satellite or an aeroplane);
- medium: the innovation is a unit consisting of a smaller number of parts and components (*e.g.* a laser printer, a textiles machine);
- low: a single innovation (*e.g.* an improved brake for a bike).

424. Five types of changes were considered:

i) a completely new or decisively changed product or service (*e.g.* a compact disk or electronic banking);

ii) a new or improved accessory product or service (*e.g.* a safer child's seat on a bike or an improved life insurance connected to a mortgage);

iii) a modestly improved product or service (*e.g.* a more energy-efficient machine or improved safety protection for credit cards);

iv) a product or service differentiation (*e.g.* a soap with a different perfume);

v) a new or changed process.

425. The second category, "accessory product or service", has been included to cover relatively "small" and less important changes. These changes are often quite "new", and would otherwise inflate the first category of "completely new or decisively changed" products.

426. All the properties (named in the short description in the journal) which distinguish the new product from existing ones should be included. The list can be lengthy, with some properties being named frequently: "more user-friendly", "safer, more reliable", "more flexible", "time-saving", "more precise", "longer life time", "better for the environment", etc. (see Kleinknecht and Bain, 1993, p. 62). Such information can be used to characterise the new or changed product more accurately, and for classification by type of change. For a distinction between a "modestly improved" product *(iii)* and a "product differentiation" *(iv)* the following rule can be applied: if at least one important property is mentioned in the journal, the product should be classified as a "modest improvement" *(iii)*; if no property is mentioned, the product should be classified as product differentiation *(iv)*.

427. For the origin of the innovation, a distinction should be made between firms which have developed an innovation themselves and firms which are just selling somebody else's innovation. A typical example of the latter are export/import firms which act only as a distribution channel for innovations developed abroad.

2.2 Strengths and weaknesses of the method

428. The statistical properties of an LBIO database may appear dubious since standard statistical sampling procedures are not applicable. As a consequence, straightforward inter-country comparisons of numbers of innovations (*e.g.* per employee or per unit of sales) are not possible. Numbers of innovations recorded will be influenced by numbers of journals available. As a result, comparisons have to be confined to ratios such as the share in total numbers of innovations taken by small firms, by certain regions or by certain sectors. For such comparisons it is not necessary to cover all innovations; it is essential, however, to collect the data in such a way that various types of firms have the same probabilities of their innovations being included. An adequate selection of journals (see above) is thus needed.

429. Compared to traditional indicators such as R&D or patents, the LBIO method results in a direct measure of innovation. It is a major advantage that it can, in principle, cover all sectors of the economy, including services and even agriculture. Moreover, it can cover innovations in very small firms. The latter are usually neglected in postal surveys, due to cut-off (*e.g.* less than 10 workers). Coverage of micro-firms is important, since past experience tells us that they take a considerable share of innovations announced in journals (Kleinknecht and Bain, 1993, p. 65). Moreover, there is still very little systematic knowledge about the innovation behaviour of micro-firms. Another major advantage of LBIO data is the ease of regional desegregation. The address of the firm selling the new product is known. Although in some cases this may not be the place where the product was developed, we do obtain a better indication of regional patterns of innovation than when using standard R&D or innovation survey data. Moreover, tracing intersectoral technology flows from innovation "producers" to innovation users is done more easily than when using postal survey data.

430. Firms have little incentive to publish process innovations. Some process innovations may be found by chance, but the method cannot give an adequate account of them. Of course, process innovations embodied in (and sold as) new investment goods will be covered.

431. Double counting should receive some attention. Many innovation cases are reported in more than one journal. In the case of identical innovations, double counts can easily be identified and deleted. But, a different problem occurs with “double” cases, which consist of close imitations by competitors of earlier (“true”) innovations. An additional problem in this context is that imitation by competitors is often not just a carbon-copy replication of an existing product. Smart imitators will frequently try to improve and differentiate the product imitated. Identifying such cases of intelligent imitation would require data collectors to have an almost encyclopaedic knowledge of new products in the various branches of industry. By following the rule of including all cases mentioned in the journals, many cases which draw more or less heavily on imitation (and also, perhaps, on additional knowledge inputs) are likely to be included. Proper application of the classification given earlier should deal adequately with imitation. For example, in the case of simple (“me-too”) imitations, there should be a high probability that the description of the innovation will make no reference to new properties compared to innovation cases published earlier in the journal. Hence, the “me-too” changed product will be classified as “product differentiation”. If the imitator has added some development of his own which results in an improved version (the improved properties being mentioned in the short description in the journal), the case would be classified as “modest improvement”.

432. Finally, the possibility of linking the LBIO data to other micro-data sets should be mentioned. LBIO data may be linked to data from standard R&D and/or innovation surveys or to published financial data on firms, which can create opportunities for new research. For example, the linking of Dutch LBIO data from 1989 to data from a national innovation survey in 1988 allowed analysts to estimate econometric models which explain a firm’s innovativeness and to compare the LBIO indicator with the ECI indicator on shares in sales of innovative products based on innovation survey results. The results suggest that the LBIO data are fairly consistent with those from innovation surveys (Brouwer and Kleinknecht, 1996, pp. 99-124).

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ANNEX 2

THE COLLECTION OF NON-TECHNOLOGICAL INNOVATION DATA

1. Introduction

433. Chapters 1 to 3 of this manual describe the context in which countries should measure the impact of change, particularly technological change. They also recognise the importance of non-technological innovation (*i.e.* organisational and managerial innovation) to the economic performance of firms.

434. Chapter 3 recognises that organisational change is only counted as technological change when there is a measurable change to a firm's output, either production or sales. Purely organisational change is not to be included in technological change.

435. The recent OECD Analytical Report on *Technology, Productivity and Job Creation* (1996) discusses a considerable body of research showing that technological and organisational change are highly interconnected. The report clearly demonstrates that technological change both "calls for and results from institutional and organisational change". It is therefore appropriate that some information relating to organisational innovation is collected in conjunction with data on technological change. Increasingly, governments will need such information for policy purposes.

436. For all these reasons it is appropriate for this revision of the *Oslo Manual* to make some initial suggestions with respect to the collection of data about non-technological innovation. This Annex outlines a proposal for the collection of data about non-technological innovation which, it is hoped, will lead to measurement of its extent and its importance to firms.

2. What is included in non-technological innovation?

437. Expressed in its simplest form, non-technological innovation covers all innovation activities which are excluded from technological innovation. This means it includes all the innovation activities of firms which do not relate to the introduction of a technologically new or substantially changed good or service or to the use of a technologically new or substantially changed process.

438. The major types of non-technological innovation are likely to be organisational and managerial innovations. Purely organisational and managerial innovations are excluded from technological innovation surveys. These types of innovation will only be included in innovation surveys if they occur as part of some technological innovation project.

439. Based on the experience gained from the 1994 Australian Bureau of Statistics (ABS) survey, the major types of organisational and managerial innovation are:

- the implementation of advanced management techniques, *e.g.* TQM, TQS;

- the introduction of significantly changed organisational structures; and
- the implementation of new or substantially changed corporate strategic orientations.

3. Experience in the measurement of non-technological innovation

440. To date, very few innovation surveys have attempted to measure the extent of non-technological innovation. In the survey conducted by the ABS[44] in respect of 1993-94, for example, the extent to which non-technological innovation occurred across all Australian industry was measured. It was largely experimental as there were no international standards to follow and it did not attempt to measure any impact on firm performance.

4. What data should be collected on non-technological innovation?

441. For a surveying agency fully to explore the concept of non-technological innovation, it needs to ask a range of questions about the particular non-technological innovations which are occurring. The ideal approach would be to conduct a separate non-technological innovation survey, but due to resource limitations and the extra reporting burden that would be placed on firms this would be impracticable.

442. Recognising that the major purpose of innovation surveys is to look at the economic impact of innovation activity, it is proposed that, as well as the core set of information relating to technological innovation, a minimum set of information be collected on non-technological innovation.

443. The minimum set of data that would need to be collected in an innovation survey is:

- the type of non-technological innovation;
- the economic benefits flowing from the non-technological innovation activity;
- the expenditure on non-technological innovation activity;
- the purpose of the non-technological innovation activity; and
- the source of ideas/information for the non-technological innovation activity.

444. The resulting data should allow policymakers to gain some insight into the non-technological innovation process and its interrelationship with technological innovation, without creating undue respondent burden for firms.

445. These questions will not measure the impact that non-technological innovation has on firm performance. To do this would require firm performance data to be linked to the non-technological innovation data. Member countries should be encouraged to undertake this type of linking and analysis.

446. It is recommended that surveying agencies develop non-technological innovation measures to be included with their surveys of technological innovation over the next few years. The minimum set of data outlined above should serve as a starting point.

NOTES

1. For example, in a recent survey 15 per cent of Australian firms reported having undertaken organisational innovation, as opposed to 13 per cent for TPP innovation.
2. OECD (1996), *The OECD Jobs Strategy – Technology, Productivity and Job Creation*, Volume 1, Paris.
3. A valuable review of recent findings on innovation is provided in Stoneman, P. (ed.) (1995), *Handbook of the Economics of Innovation and Technological Change*, and in Dodgson, M. and R. Rothwell (eds.) (1994), *The Handbook of Industrial Innovation*, both Edward Elgar, Aldershot. A complementary review dealing with additional economic implications of technological change is given in Freeman, C. (1994), "The Economics of Technical Change", *Cambridge Journal of Economics* 18 (5), pp. 463-514.
4. European Commission (1996), Green Paper on Innovation, *Bulletin of the European Union*, Supplement 5/95, Luxembourg.
5. Schumpeter, J. (1934), *The Theory of Economic Development*, Harvard University Press, Cambridge, Massachusetts.
6. See Nelson, R. and S. Winter (1982), *An Evolutionary Theory of Economic Change*, Belknap Press of Harvard University Press, Cambridge, Massachusetts.
7. See Romer, P (1986), "Increasing Returns and Long-Run Growth", *Journal of Political Economy* 94 (5), pp. 1002-1037.
8. See Lundvall, B.-A. (ed.) (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter Publishers, London; Nelson, R. (1993), *National Innovation Systems*, Oxford UP, Oxford; and Freeman, C. (1995), "The 'National System of Innovation' in Historical Perspective", *Cambridge Journal of Economics.*, 19, pp. 5-24.
9. OECD (1996), *The OECD Jobs Strategy – Technology, Productivity and Job Creation*, Volume 2, Paris.
10. This approach to mapping innovation policy issues has its antecedents in a method discussed in Department of Industry, Science and Technology (1996), *Australian Business Innovation: A Strategic Analysis – Measures of Science and Innovation 5*, Australian Government Publishing Service, Canberra.
11. The crucial significance of these issues, and their implications for policy, are thoroughly discussed in Dodgson, M. and J. Bessant (1996), *Effective Innovation Policy: A New Approach*, International Thomson Business Press, London.
12. Kline, S.J. and N. Rosenberg (1986), *op. cit.*, pp 289-291.
13. Kline, S.J. and N. Rosenberg (1986), "An Overview of Innovation", in Landau, R. and N. Rosenberg (eds.), *The Positive Sum Strategy. Harnessing Technology for Economic Growth,* National Academy Press, Washington, DC, p. 289.
14. This accords with a very solidly established result in innovation analysis, which is that innovative success depends heavily on the degree to which marketing is integrated with the technical aspects of the innovation process. For a general discussion, see Freeman, C. (1982), *The Economics of Industrial Innovation*, 2nd Edition, Pinter, London, Chapter 5, "Success and Failure in Industrial Innovation". Hansen *et al.* (1984) emphasize the point in relation to data collection, and this is one of the strengths of their survey work.
15. Rothwell, R. (1994), "Successful Industrial Innovation: Success, Strategy, Trends", in Dodgson, M. and R. Rothwell (*op. cit.*).
16. OECD Ministers for Science and Technology (1995), "Final Communiqué of the Meeting of the Committee for Science and Technology Policy at Ministerial Level, 26-27 September 1995", OECD, Paris.
17. Important work in this area includes Scherer, F. (1982), "Inter-industry Technology Flows in the United States", *Research Policy*, Vol. 11, No. 5, pp. 227-245; Jaffe, A. (1986), "Technological Opportunity and Spillovers From R&D: Evidence From Firms' Patents, Profits, and Market Value", *American Economic Review*, Vol. 76,

pp. 984-1001; Archibugi, D. (1988), "The Inter-industry Distribution of Technological Capabilities. A Case Study of Italian Patenting in the USA", *Technovation*, Vol. 7, pp. 259-274.

[18] Pavitt, K. (1984), *op. cit.*, pp. 353-364; Archibugi *et al.* (1989), *op. cit.*, Section 5.

[19] Hippel, E., von (1988), *The Sources of Innovation*, Oxford University Press, New York and Oxford, Chapters 3-5, is one of the few systematic discussions of this problem.

[20] The policy implications of this have been discussed in the UK context in Smith, K. (1989), "Public Support for Civil R&D in the UK: Limitations of Recent Policy Debate", *Research Policy*, Vol. 18, No. 2, pp. 99-110.

[21] See Terleckyj, N.E. (1980), *op. cit.*, pp. 55-61, for a discussion of some of the issues here.

[22] See the points made by Hansen, J. (1986), *op. cit.*, p. 8.

[23] Edwin Mansfield surveyed some seventy major US firms, asking for information on industrial innovations which had used the findings of university research performed within the previous fifteen years. He estimated that products based on recent academic research accounted for approximately 5 per cent of US industrial output. Mansfield, E. (1988), "The Social Rate of Return From Academic Research", Report to Division of Policy Research and Analysis, National Science Foundation, Washington, pp. 23 + vii. A similar study carried out among Japanese industrialists at the beginning of the 1980s indicated that over 60 per cent of them stated that they could not use the results of basic and applied research carried out in university laboratories, while only 27 per cent said they found them useful. As for results from government laboratories, nearly 49 per cent of the industrialists stated they were not useful, while 34 per cent said they were.

[24] Malecki, E. (1980), "Dimensions of R&D Location in the United States", *Research Policy*, Vol. 9, No. 1, pp. 2-22.

[25] Referred to as major product innovations in the earlier version of the manual.

[26] Referred to as incremental product innovations in the earlier version of the manual.

[27] For the EEA Member States the enterprise is defined as "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations." (Council Regulation (EEC) No 696/93 of 15 March 1993 on the statistical units for the observation and analysis of the production system in the Community, *OJ* No. L 76, p. 1, Section III/A of the Annex).

[28] See ISIC Rev. 3, paras. 91 to 98.

[29] "The kind-of-activity unit (KAU) groups all the parts of an enterprise contributing to the performance of an activity at class level (four digits) of NACE Rev. 1 and corresponds to one or more operational sub-divisions of the enterprise. The enterprise's information system must be capable of indicating or calculating for each KAU at least the value of production, intermediate consumption, manpower costs, the operating surplus and employment and gross fixed capital formation." (Council Regulation (EEC) No 696/93 of 15 March 1993 on the statistical units for the observation and analysis of the production system in the Community, *OJ* No. L 76, p. 1, Section III/D of the Annex).

[30] "The local unit is an enterprise or part thereof (*e.g.* a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified place. At or from this place economic activity is carried out for which – save for certain exceptions – one or more persons work (even if only part-time) for one and the same enterprise." (Council Regulation (EEC) No 696/93 of 15 March 1993 on the statistical units for the observation and the analysis of the production system in the Community, *OJ* No. L 76, p. 1, Section III/F of the Annex).

[31] For a detailed discussion of the problem of the local unit as the statistical unit in innovation surveys see Eurostat (1996), *The Regional Dimension of R&D and Innovation Statistics*, particularly part B.

[32] See (UN, 1990), ISIC Rev. 3, para. 114.

33 See (UN, 1990), ISIC Rev. 3, para. 115.

[34] For the definition, see OECD (1994), *Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual 1993*, Paris, para. 147.

[35] OECD (1994), *Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual 1993*, Paris, para. 164.

[36] For example in Canada, 40 per cent of manufacturing firms are innovative while 4 per cent perform R&D, and not all R&D performers are innovative as they do not commercialise their inventions.

[37] United Nations (1990), "International Standard Industrial Classification of All Economic Activities", Statistical Papers Series M, No. 4, Rev. 3, New York.

[38] European Commission, Council Regulation (EEC) No. 3037/90 of 9 October 1990 on the Statistical Classification of Economic Activities in the European Community, *Official Journal of the European Communities*, No. L 293, Luxembourg 1990, as amended by Commission Regulation (EEC) No. 761/93, *Official Journal of the European Communities*, No. L 83, Luxembourg 1993.

[39] Eurostat, *Nomenclature of Territorial Units for Statistics*, Luxembourg, latest edition.

[40] It is difficult, if not impossible, to define when a unit non-response rate is deemed to be high or low. However, it is generally acknowledged that the higher the unit non-response rate, the lower the comparability of results of (innovation) surveys.

[41] This approach was successfully applied in the recent German, Dutch, Irish and Danish innovation surveys (CIS).

[42] Basic methodological considerations can be found in Archibugi, D., P. Cohendet, A. Kristensen and K.-A. Schäffer (1995), *Evaluation of the Community Innovation Survey (CIS) – Phase I*, Chapter 6.4, Luxembourg.

[43] See, for example, European Commission (1996), Green Paper on Innovation, *Bulletin of the European Union*, Supplement 5/95, Luxembourg.

[44] The ABS was particularly keen to measure non-technological innovation because its 1993-94 survey was extended into the services sector. By covering both the manufacturing and services sectors the ABS was able to show the extent to which non-technological innovation occurred across the economy. Importantly, it also allowed comparison of the incidence of non-technological innovation with technological innovation. In summary, the Australian surveys showed that non-technological innovation is significant in the manufacturing sector, occurring in 24 per cent of businesses (compared with 34 per cent for technological innovation), but relatively more significant in the services sector, occurring in 14 per cent of businesses (compared with 12 per cent for technological innovation). In total, non-technological innovation is thought to have occurred in 15 per cent of firms, while technological innovation occurred in 13 per cent of firms.