Chapter 7

Business enterprise R&D

This chapter provides guidance on the measurement of research and experimental development (R&D) performed in the Business enterprise sector, the sources of funding, breakdowns of the statistics by main economic activity, employment size of the business enterprise and geography. The indicators of R&D activity for the sector include R&D expenditure, R&D personnel, sources of R&D funds, the distribution of the R&D by basic research, applied research and experimental development. There is a discussion of breaking down the statistics by the industry orientation (the product field or the industry served) and why this should be considered. Distributions by fields of R&D (FORD), by socioeconomic objectives, geographic location and by specific technology areas are discussed. The chapter ends with a review of survey design, data collection and estimation in the sector. The resulting statistics support policy discussion related to dominant and emerging industries, concentration of R&D in regions, industries and enterprises, and the industry served by R&D performed by enterprises in the sector.

7.1. Introduction

7.1 For most industrialised countries, the Business enterprise sector accounts for the largest share of R&D expenditures and personnel. In analysing this sector and the units within it, it is important to take into account the multiple approaches used by companies to manage their R&D activities. In particular, related businesses may jointly fund, generate, exchange and use R&D knowledge in diverse and assorted ways. Complex business structures, particularly used by multinational enterprises (MNEs), are challenging for R&D measurement. Also, for some businesses, R&D is an occasional, rather than an on-going activity and therefore more difficult to identify and measure. From a policy perspective, collecting information from businesses on the role of government as a provider of financial support for R&D and on interactions with the public science and research base is particularly relevant. From a methodological perspective, the collection of data from business enterprises also entails a number of practical challenges, ranging from identifying R&D performing firms to obtaining information on R&D as required in this manual through to dealing with confidentiality and the minimisation of response burden.

7.2. Coverage of the Business enterprise sector

7.2 As detailed in Chapter 3, the Business enterprise sector comprises:

- All resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders. This group includes all other types of quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognised by law as separate legal entities from their owners, and set up for the purpose of engaging in market production at prices that are economically significant. They include both financial and non-financial corporations.
- The unincorporated branches of non-resident enterprises deemed to be resident and part of this sector because they are engaged in production on the economic territory on a long-term basis.
- All resident non-profit institutions (NPIs) that are market producers of goods or services or serve business. The former NPI category comprise independent research institutes, clinics and other institutions whose main activity is the production of goods and services for sale at prices designed to recover their full economic costs. The latter category of NPIs serving business comprises entities controlled by business associations and financed by contributions and subscriptions.

- Specifically excluded are units that belong to the Higher education sector as described in Chapter 3, Section 3.5, and in Chapter 9. However, commercial firms owned by higher education institutions, for example as a result of agreements that give the university a major shareholding position in a spin-off company set up by staff and/or students, should be treated as business enterprises.

7.3 The Business enterprise sector includes both **private enterprises** (either publicly listed and traded, or not) and government-controlled enterprises (see Chapter 3, Section 3.5), which in this manual are termed "**public enterprises**". (The terms "private enterprises" and "public enterprises" are used interchangeably with the term "private business enterprises" and "public business enterprises", respectively.) For public enterprises, the borderline between the Business enterprise and Government sectors is defined by the extent to which the unit operates on a market basis, i.e. whether its principal activity is the production of goods or services for market at economically significant prises. A government research institute that may occasionally receive a considerable amount of revenue from the sale or licensing of its intellectual property should not be considered a public enterprise if the majority of its R&D activities are carried out with a non-commercial intent. On the other hand, a government-controlled institute whose operations rely on fees for providing R&D services and access to research infrastructure that fully reflect the economic cost of such services should be classified as a public enterprise. The concept of "public" sector is wider than that of "government".

7.4 In line with the SNA, **Non-profit institutions controlled by or primarily serving business enterprises**, such as trade associations, industry-controlled research institutes, etc., should be classified as part of the Business enterprise sector even if the institutions operate on the basis of subscriptions that barely cover their operating costs and draw significantly on government grants that allow them to break even. In general, NPIs that are created and managed by associations of businesses whose activities they are designed to promote, such as chambers of commerce and agricultural, manufacturing or trade associations, and that are financed by contributions or subscriptions from the businesses concerned which provide core or project-based support for their R&D, should be treated as part of the Business enterprise sector.

7.5 The market activities of **unincorporated enterprises** owned by households (i.e. some types of partnerships and even self-employed consultants or contractors undertaking R&D projects for another unit at an economically significant price) are included in the Business enterprise sector whenever practicable.

7.6 As indicated in Chapter 3, the activities of **individuals** who pursue in their own time and at their own expense their personal interests as researchers or inventors are currently beyond the scope of the institutional approach to R&D statistics presented in this manual.

7.7 As defined in the SNA, a **joint venture** involves the establishment of a corporation, partnership or other institutional unit in which each party legally

has joint control over the activities of the unit. The units operate in the same way as other units except that a legal arrangement between the parties establishes joint control over the unit. Joint ventures should also be classified on the basis of the units they predominantly serve, whenever possible taking into account established SNA practice.

7.8 When a separate institutional unit is created to manage a joint venture, it should have the same industrial classification as the institutional unit that has the greatest interest in this partnership. In some instances, R&D partnerships may have a formal, independent status, and in which case should also be classified on the basis of the units they predominantly serve.

7.3. Statistical units and reporting units

7.9 Business enterprises organise their R&D funding and performance activities at various possible levels in order to better meet their own objectives. Strategic decisions concerning the financing and direction of the R&D efforts may be taken at the enterprise group level, regardless of national boundaries, while the day-to-day management of R&D operations, possibly including decisions on the type of expenditures on R&D performance and on the hiring of human resources to be devoted to R&D, may occur at lower levels in the organisation. The activities of MNEs engaged in R&D may occur in more than one country, making those responsible for decision-making hard to identify and survey. These factors may impact the classifications identified with a statistical unit and influence the choice of reporting unit (both defined in Chapter 6).

Statistical unit

7.10 The statistical unit for the Business enterprise sector will generally be the enterprise, defined in Chapter 6.

7.11 As a general requirement, all the statistical units included in an R&D survey population should be properly identified on the basis of a number of descriptive variables, which are usually available from statistical business registers. Identification variables (or tags as described in Chapter 3) should include: an identification code, a location variable (geography), a variable on the kind of economic activity undertaken and a size variable. Additional information on the economic or legal organisation of a statistical unit, as well as on its ownership, could be extremely helpful and make the survey process more effective and efficient.

Reporting unit

7.12 The choice of reporting units in the Business enterprise sector will vary from country to country, depending on institutional structures, the legal framework for data collection, traditions, national priorities, survey resources and ad hoc agreements with the business enterprises. When an enterprise is heterogeneous with regard to its economic activities and carries out significant

amounts of R&D for several kinds of activities, it may be advisable that data are collected from (reported by) more detailed statistical units, e.g. on a kind-of-activity basis or even an establishment basis when regional location is an important. This manual can make no overarching recommendation concerning the choice of reporting unit to be queried by each individual country. Rather, national statistical offices should ensure the additivity of the R&D performance and personnel data and the appropriate handling of funding flow data, regardless of the collection approach taken. The selection of an appropriate reporting unit should be made in line with the general guidance provided in Chapter 6 for the identification of statistical and reporting units and with the recommendation to avoid collecting data from a reporting unit that is not required to keep formal accounting records.

7.13 Because there may be information that companies may have readily available only at higher levels of aggregation, national statistical offices may have to engage with these units to ensure that business enterprise R&D statistics conform to the principles of national statistics, separating their activities by jurisdiction and distinctive lines of business. Profiling business groups is an important activity that should be undertaken, whenever possible, in a coordinated fashion with those agencies and officials responsible for business registers. In some cases, for synergy or comprehensiveness, the compilers of R&D statistics may decide it is appropriate to sample all enterprises within the consolidated set of enterprises that are resident in the country.

7.14 The enterprise group level may play a prominent role as a reporting unit because questionnaires may be filled or responses approved by a central administrative office. In the case of holding companies, a number of different approaches may be used, for example, asking them to report the activities for the enterprises they hold in the industries of the actual activity, or forwarding the questionnaire to the actual R&D-performing company at the holding company's request.

7.4. Institutional classifications for statistical units

Identification codes

7.15 An identification code is a unique number assigned to a statistical unit included in a survey's target population. The availability of identification codes is extremely relevant for R&D statisticians, who are usually dealing with potential R&D performers identified on the basis of a range of different statistical and administrative sources. Identification codes should avoid the duplication of units in the population as well as the partial overlap between units (to the extent that statistical units should refer to different organisational levels: establishments, enterprises, groups). A code is essential for an effective sampling process and, if applicable, for collecting administrative data (when the same codes are used also for administrative purposes). From the perspective of users of R&D statistics, identification codes allow for matching micro-data from different

sources, including R&D surveys, other business surveys or administrative data collections, and they facilitate longitudinal analyses when the structure of a unit changes over time. When statistical business registers already have available identification codes, it is preferable to use such codes when compiling R&D data.

Classification according to main economic activity

7.16 A business enterprise may operate in one or more economic activities. Enterprises, as institutional (statistical) units, are classified according to their principal activity. In practice, the majority of production units perform activities of a mixed character. The International Standard Industrial Classification (ISIC) (United Nations, 2008a) is the relevant reference document for the international classification of economic activities or industries. Enterprises might be engaged in any economic activity, including agriculture, mining, manufacturing and services.

7.17 Countries that use national (or regional) industrial classification systems rather than ISIC should use concordance tables to convert their industrially classified data to ISIC for international reporting and comparison purposes. The preferred reporting of the main economic activity of a single statistical unit should allow for detail at the ISIC "class" level (4 digits) and therefore "group" level (3 digits). Nevertheless, it should not be made available at a level higher than that of a "division" (2 digits). The adoption of industrial classifications that differ from ISIC – such as NAICS in North America or NACE in Europe – has no impact on the production of R&D statistics as long as they are consistent with ISIC in the definition of industries (usually, direct correspondence is assured at the 1 and 2 digits level and indirect correspondence at the 3 and 4 digits level).

7.18 No industry should be excluded from the reporting of R&D activities. All economic activities included in the ISIC Classification potentially could perform R&D, although with varying levels of probability. Therefore every unit belonging to every industry could be assigned a level of probability for being an R&D performer. In this respect, appropriate methodologies will have to be developed and implemented to deal with industries whose enterprises have, on average, a low probability of being identified as R&D performers (such as agriculture or household services). In such cases, a preliminary screening is recommended before including enterprises from such industries in regular R&D surveys.

7.19 The identification of a principal activity is necessary to classify a statistical unit into a main economic activity category. In order to determine the principal activity of a unit, the shares of its value added for its different economic activities (if more than one) must be known. In practice, however, unless this is obtained from a central register, it is often difficult to obtain such detailed information, so the activity classification has to be determined by using substitute criteria. Whenever possible, national statistical offices that compile R&D data should avoid making separate classification decisions and should use

available information from business registers or other administrative sources of comparable quality. This information is essential in sampling surveys to properly draw a representative sample of enterprises.

7.20 Practical challenges arise in the context of large enterprises with multiple economic activities and complex structures. Such large enterprises can also account for a very large share of R&D. The relevance of industry classifications in measuring R&D totals is further clarified below in Section 7.6. National statistical offices should strive to find the appropriate equilibrium between maintaining a minimum degree of homogeneity with regards to the economic activity of the business enterprise and taking into account the extent to which the business enterprise can provide the requested information on its activities.

Classification according to public or private status and by affiliation status

7.21 Following the recommendations given in Chapter 3, Section 3.4, the following classification of business enterprises is recommended:

- private domestically controlled business enterprises (not controlled by government or by non-resident institutional units).
- public business enterprises (subject to control by government units).
- parents or members of a domestic or foreign group.
- foreign-controlled business enterprises (controlled by non-resident institutional units). The interest in this category is further explained in Chapter 11 on R&D globalisation.

7.22 R&D data compilers may also wish to apply classifications that reflect the legal status of different enterprises (e.g. publicly listed, non-incorporate enterprises, etc.) in order to meet specific user needs within their own countries.

Classification according to size of the business enterprise

7.23 Units may be classified according to size on the basis of employment, revenues or other economic and financial attributes. Employment is often a less ambiguous measure and therefore preferable, but even in this case some countries may prefer to use the number of persons employed (recommended in this manual), while others may opt for the number of employees, the difference between them being determined by the number of owner-managers and unpaid personnel.

7.24 Classification by size is relevant for stratification, sampling, types of survey form targeting, and presentation of statistical results. In some countries, statistical regulations limit the surveying of very small enterprises. Since R&D performance tends to be a highly concentrated activity, the under-coverage of smaller performers may not have substantial impacts on reported aggregate totals but could significantly distort other types of R&D-based statistics and

analysis. For this reason, all possible means should be used to ensure the most comprehensive possible coverage.

7.25 The size of the enterprise is an identification variable essential for sample design and data estimation, as well as for the proper management of data collection activities. A definition of size based on the average number of persons employed is recommended because of its simplicity, general applicability, usefulness and international comparability. A size variable can be used to intentionally exclude units from the target population (e.g. enterprises below a given size threshold, if applicable) or to adapt the data collection methods to the size and organisation of the targeted units.

7.26 It is recommended that all the units belonging to the Business enterprise sector, irrespective of their main economic activity and of their size, be considered potential R&D performers. In countries where small or micro enterprises are excluded from regular R&D surveys in compliance with statistical regulations or because of practical and technical constraints, some effort should be made to identify to overall contribution of these small or micro enterprises to the business R&D total.

7.27 The following size groups (based on the number of persons employed) are proposed for classifying business enterprises:

1-4

5-9

10-19

20-49

50-99

100-249

250-499

500-999

1 000-4 999

5 000 and above

For practical reasons, given the ubiquity of zero employment businesses in registers and the impossibility for them to perform R&D, it is recommended that they should be excluded from the scope of R&D surveys.

7.28 These categories have been chosen for a variety of reasons, in particular for consistency with the size classification usually adopted for micro-enterprises (including enterprises with less than 5, 10 or 20 persons employed, depending on country-specific practices) or for small and medium-sized enterprises (including enterprises with less than 250 or 500 persons employed, depending on country-specific practices). Thus, these ten categories are not proposed for joint use, but rather to provide a classification structure on which country-specific practices could be based. Nonetheless, it is recommended that

all countries maintain groups with breaks at 9, 49 and 249 persons employed so that internationally comparable statistics can be available for small, medium-sized and large enterprises. For large economies, it is recommended that a break at 999 persons employed also be maintained.

Classification according to geographic location

7.29 Another key classification variable is the unit's geographic location. While the residency is usually defined in terms of "country of residency", the location can be available at different levels of detail: States or regions (according to the administrative organisation at country level), local areas (towns or municipalities) or addresses. When dealing with reporting units that differ from statistical units – or multiple reporting units for a single enterprise – care should be used to identify the specific location relevant for a data compilation.

7.5. Indicators of R&D activity in business enterprises

7.30 The R&D activity undertaken by the units belonging to the Business enterprise sector is measured in terms of expenditures both for R&D and for R&D personnel. These two sets of indicators are often available according to the recommendations given in Chapter 4 and Chapter 5, respectively, and business R&D expenditure may be functionally distributed according to guidance described in Section 7.6.

R&D expenditure

7.31 In order to ensure coherence between R&D and non-R&D information available from respondents, national statistical offices compiling R&D data should review accounting relationships, when practical to do so. For instance: R&D labour costs should be lower than total labour costs (or even equal under the condition that all the persons employed would be involved full time in R&D). R&D capital expenditure similarly should be included in, and therefore be no larger than, the overall capital expenditure of the enterprise. Total R&D costs should generally not exceed the value added generated by the enterprise in a reference year. For enterprises that undertake continuous R&D, R&D might possibly be a stable fraction of value added over a multi-year period. Monitoring these relationships should help reduce the misreporting of R&D data and thereby improve overall data quality.

R&D personnel

7.32 There is a similar need for consistency on the personnel totals for the reporting enterprises and the collected R&D data. The measurement of the R&D workforce in business enterprises, as well as the involvement of external personnel in intramural R&D activities (see Chapter 5), can be challenging. It is suggested that the reporting unit check first for R&D activity carried out in the reference period by the persons employed by the enterprise. Full coverage of their

contribution to R&D – both in terms of time (full-time equivalent) and labour costs – is facilitated if the unit directly utilises their payroll data so that part-time workers and trainees are included. If such data are available from their business register or administrative sources, national statistical offices should check for coherence of personnel totals: for example, total internal R&D personnel should not be larger than total personnel.

7.33 A further step is to identify all external contributors to intramural R&D, which could include a broad range of profiles/positions: self-employed consultants, contractors' employees acting as intramural consultants, leased personnel, etc. A significant effort is requested of respondents in order to identify personnel who contribute an appreciable effort (in terms of time – see Chapter 5, Section 5.3) to the unit's intramural R&D.

7.34 The distribution of the R&D personnel by function (researchers, technicians and equivalent staff, or other supporting staff) is discussed extensively in Chapter 5, with the recommendations presented there being totally relevant to the Business enterprise sector. Both FTE and headcount data are to be collected, as are additional demographic distributions of those totals for characteristics such as sex, age, level of qualification, etc. (see Section 5.4). The functional distribution of the R&D personnel should be based on a direct observation of the role actually played by the individuals involved in intramural R&D, independently of their formal role in the enterprise. As a common practice, no direct relationship can be assumed between the formal (contractual) skill level (even described in terms of occupation) of a person employed and the type of their contribution to intramural R&D. It is commonly observed, for instance, that persons who participate as "researchers" in the intramural R&D activities of an enterprise have a formal job position of either "technicians" or "managers", rather than "researchers".

7.6. Functional distributions for Business enterprise intramural R&D expenditure (BERD)

7.35 The main aggregate statistic used to describe R&D performance within the Business enterprise sector is BERD, Business enterprise Expenditure on R&D. BERD represents the component of Gross domestic expenditure on R&D (GERD) (see Chapter 4) incurred by units belonging to the Business enterprise sector. It is the measure of expenditures on intramural R&D within the Business enterprise sector during a specific reference period. There are a number of variables for which BERD might be usefully compiled, distributed and reported. Some distributions have widespread international applicability and interest; others will have country-specific relevance for analytical and policy-making purposes. Below is a list of the recommended distributions that national statistical offices should compile in order to best address international comparability needs. Most all of the recommended functional distributions are possible only by separately identifying the activity within individual statistical units and then accumulating unit-distributed details

for the sector as a whole (e.g. R&D by source of funds). Other reported distributions of BERD will derive naturally from accumulating the total R&D of statistical units based on their initial institutional classification criteria (e.g. R&D by main economic activity and size of enterprise). Surveys and other data collection efforts should be undertaken with these recommendations in mind.

Distribution of BERD by sources of R&D funds

7.36 As described in Chapter 4, Section 4.3, it is recommended that five major sources are considered when collecting and reporting on the source of funds for BERD, according to the sector where the funds originate: Business enterprise (which includes both internal funds and external funds received from other enterprises), Government, Higher education, Private non-profit and Rest of the world (Table 7.1).

Table 7.1. **Identifying sources of funds for intramural R&D in the Business enterprise sector**

Sources of funding
Business enterprise sector
Own enterprise (internal funds)
Other enterprises in the same group
Other unaffiliated enterprises
Government sector[1]
Central or federal
Provincial or state
Other government sector bodies
Higher education sector
Private non-profit sector
Rest of the world
Business enterprise
Enterprises in the same group
Other unaffiliated enterprises
Government sector
Higher education sector
Private non-profit sector
International organisations (including supranational)

1. It is recommended to separately identify R&D exchange funds from R&D transfer funds.

Funds from the Business enterprise sector

7.37 This manual does not recommend a specific approach for collecting data on BERD sources of funds. Some countries may estimate total intramural R&D and then determine the individual sources of funds. In such cases, internal business funds might be measured as a residual, after having accounted for all

external sources contributing to the intramural R&D effort. Other countries may ask respondents to separately report intramural R&D paid for with internal funds and intramural R&D paid for by others in order to accommodate data extraction from financial accounts. This latter approach might facilitate reporting from businesses that keep their internally funded intramural R&D physically and financially separate from contracted intramural R&D (e.g. for defence-related activities because of security considerations).

7.38 In the Business enterprise sector, internal funds include the reserve or retained earnings (i.e. profits that have not been redistributed as dividends), sales of the unit's ordinary products (other than R&D), capital raised in the form of equity, debt or other hybrid instruments (e.g. funds raised on financial markets, loans from banks, venture capital, etc.). Deductions from income tax liability arising as a result of government incentives for R&D that has been carried out in the past are also internal funds, as they need not be used to fund R&D in the current reference period. Given the high relevance of this category, individual countries may choose to enquire about these specific internal sources of funds to identify, for instance, the impact of specific R&D policies, but no specific breakdown for those funds is recommended in this manual.

7.39 Under some circumstances, an enterprise might need to apply for loans/borrowing to fund its R&D. In broad terms, a loan is a debt provided by one unit (institution or household) to another unit with an interest rate. Thus, when an R&D performing enterprise, as a borrower, receives a given amount of money from a lender to fund its R&D activities, the enterprise is committing itself to pay back to the lender at a later time an equal amount of money plus remuneration for the service as interest on the debt. Loan amounts are to be included as part of internal funds since, in fact, the external source anticipates that the loaned funds will be paid back. The cost of borrowing money is not included as R&D. The same reasoning applies when guarantees to access loans are provided by external units or when interest is totally or partially covered by other sources of funds (as is sometimes the case for government-subsidised R&D loans). Such support is to be included as part of internal funds.

7.40 It is recommended to separately identify funds received both from other domestic unaffiliated enterprises and from affiliated enterprises that are part of the same domestic group. Both categories of enterprises are considered external sources of funds. For most international reporting on BERD, the Business enterprise sector source of funds is the sum of business enterprise internal funds plus funds from domestic unaffiliated enterprises plus funds from affiliated enterprises that are part of the same domestic group. See also Section 7.7 on reporting extramural R&D.

7.41 In the case of both affiliated and unaffiliated enterprises located abroad, these should be separately requested and are to be presented as part of the Rest of the world.

Funds from the Government sector

7.42 In the case of funding for intramural R&D received from government, it is important to ensure that respondents separately identify funds received without an expectation of compensatory R&D (e.g. funds received through grants) from funds received in exchange for R&D, typically in the form of procurement contracts from government institutions. Some enterprises may find it difficult to differentiate between R&D procured by public enterprises and that procured by government units. It may also be difficult in practice to separate exchange funds and transfer funds, depending on the allocation of risk and rights on the uncertain outcome of the business R&D being funded by government. The ultimate intention is to distinguish between the two categories introduced in Chapter 4, Section 4.3. For example, it is not unusual that a business enterprise uses the term "contract" in the context of grant agreements, but every effort should be made to categorise such funds accurately.

7.43 Some countries may wish to collect information on the level of government that is providing the funds for R&D, and possibly even the specific institutions or schemes. Considering the most widespread practices, a distinction between central/federal funds and regional/state funds is usually adopted (often jointly with the split between transfer funds, like grants, and exchange funds, like procurement contracts' revenues).

7.44 For reporting purposes and to the extent practical, the original source of funding should be identified, even when an intermediary public or private institution is responsible for the actual transfer of funds. In many cases the beneficiary enterprise can report only about the intermediary institution, i.e. the most proximate source of funding.

7.45 Some governments provide dedicated forms of tax relief with the aim of encouraging the funding or performance of R&D. Guidance on the separate measurement of this type of support is provided in Chapter 12. As explained in Chapter 4 (Section 4.3.), this manual recommends that the cost of R&D performance that is "funded" on the expectation of future revenue or forgone tax, or claims realised in the current period against past performance, should be reported as internal funds, and not as sources of government support.

Funds from the Rest of the world

7.46 In collecting data on funding from abroad, it is often relevant to identify the sector from which the funding originates, as in the case of domestic funding sources. As previously indicated, it is particularly important to identify funding from affiliated business enterprises located abroad separately from other non-affiliated non-resident firms. Different countries will identify different international and supranational funding organisations and agencies as relevant funding sources. For member countries of the European Union, one such funding source might be "EU institutions and other bodies".

Distribution of BERD by type of R&D

7.47 As for all other sectors, it is recommended that data are collected from business enterprises on the breakdown of R&D expenditures by type of R&D, as defined in Chapter 2 and clarified below.

- *Basic research*. Business enterprises can and do undertake "pure" basic research. However, they undoubtedly engage more in research with a view to preparing for the next generation of technologies even though they do not have in mind a specific immediate commercial application or use. Such research is basic according to the definition, as it does not have a specific use in mind, but an undefined number of future potential applications. Such research is commonly referred to as "oriented basic research". Since it is assumed that only a small share of business R&D is likely to be basic research, it is recommended that national statistical offices carefully check whether respondents reporting relatively substantial amounts of intramural expenditure on basic research correctly interpreted the meaning of basic research as defined in this manual.
- *Applied research*. This activity aims at solving a specific problem or meeting a specific commercial objective. The distinction between basic and applied research is often marked by the creation of a new project to explore promising results of a basic research programme (often moving from a long-term to a medium- or short-term perspective). Also, enterprises often need to support their "product development" activities with additional knowledge stemming from applied research activities, the results from which in turn can often have a potentially broad range of applications.
- *Experimental development*. Commonly the largest component of Business enterprise R&D, experimental development is intended to result in a plan or design for a new or substantially improved product or process, whether intended for sale or own use. Based on past research or practical experience, it includes concept formulation, design and the testing of product alternatives, and can include construction of prototypes and the operation of pilot plants (see Chapter 2, Section 2.7). It does not include routine testing, troubleshooting or periodic alterations to existing products, production lines, processes, or on-going operations. The first units of a trial production run for a mass production series should not be considered as R&D prototypes. Such activities do not explicitly meet the criteria of novelty and uncertainty. To be counted as experimental development, activities must require the knowledge/expertise of a "researcher". Further, data compilers should help respondents differentiate "experimental development" from more expansive product development (which includes commercialisation) and from pre-production development, a term often used in large-scale government defence or aerospace projects, which includes non-experimental work on products or systems such as final design engineering, tooling and industrial engineering, and user demonstrations and even sometimes low-rate initial production activities. The boundaries often may not be totally clear.

Distribution of BERD by industry orientation versus economic activity classification

R&D by main economic activity of the business enterprises

7.48 As noted earlier, institutional classification variables can be used to distribute BERD. For example, indicators of R&D expenditures and R&D personnel are regularly produced with reference to a broad range of industries. A classification variable by ISIC (United Nations, 2008a) activity should be available for all the enterprises included in the target population of an R&D survey (see Section 7.4). The aggregation of individual enterprises' intramural R&D will allow for reporting the level of R&D performed by all units belonging to a specific industry. An advantage of this type of unit-based indicator is that it can be readily matched to other industry-based economic statistics defined on the basis of the main activity, provided that the criteria for defining business enterprises as statistical units and assigning them to industries are mutually consistent.

7.49 The main economic activity of an enterprise is usually defined with reference to the economic activity that accounts for most of its economic outputs. This classification of enterprises is also relevant for R&D measurement. For example, R&D resources in business enterprises classified into the ISIC Rev.4 Division 72 should be reported as such. R&D content-based approaches correspond to the functional distribution by R&D product field or industry served presented below.

7.50 This manual acknowledges that in some countries a functional distribution of R&D by industry orientation is seen as most relevant for business R&D reporting, and full consistency with a classification of R&D performing units in terms of main economic activity is not assured. Different priorities should be compared in order to define national strategies of R&D reporting and dissemination, but it is also stressed that countries should be encouraged to adopt the international standard classifications of economic activities for the R&D domain as well.

R&D by industry orientation (product field or industry served)

7.51 The industry orientation of the R&D carried out by units in the Business enterprise sector cannot be gauged by simply taking into account their main economic activity. There are two main reasons:

- First, business enterprises can be active in exploring multiple current or possible future product lines at the same time. A company may be developing a new product to prepare entry onto a new market, which may fall outside its current specialisation portfolio. Furthermore, variations in national practices in the classification of business enterprises may lead to differences in the granularity of the detail with which data on the main activity is collected. For a number of purposes, the aggregate picture may be distorted by not taking into account the internal functional distribution of R&D (which may not

match with the composition of value added or turnover in terms of the goods and services produced).

- Second, the *implicit* assumption that the main economic activity of R&D is entirely performed internally and is used for a business's own activities is, for many businesses, not appropriate. Some enterprises may specialise in providing R&D services to other enterprises that use the R&D to support their economic activity; others may perform R&D with their internal resources on a speculative basis and choose not to use the R&D themselves but rather to let others commercialise the R&D in return for the payment of royalties and licence fees, or sell the R&D-resulting intellectual property outright. Such actions may weaken the link between the main economic activity and R&D performance and its industry orientation.

7.52 On a more practical basis, the classification by main economic activity may simply not reflect the main area of a business enterprise's R&D activity. As an example, an enterprise classified to wholesale trade could still be engaged in the sale of goods that it manufactures, and its R&D activities could be focussed entirely on improving its manufacturing production processes. General classification practices are also likely to evolve in the future as specific guidelines on how to treat different types of factory-less goods producers are implemented by national statistical offices (UNECE, 2014). These guidelines place considerable emphasis on the role of intellectual property products (IPPs), including R&D-based assets.

7.53 One approach for minimising potential measurement distortions caused by these different models for funding, performing and using R&D is to ask performers about the actual industry orientation of the R&D carried out. In principle, this should be more informative for some types of comparisons with production statistics on the basis that the knowledge input and the related economic activity that uses the knowledge can be matched.

7.54 There are different concepts that are potentially relevant to the notion of the industry orientation of R&D as well as different ways in which R&D surveys can seek to elicit this information. The industry orientation can be identified in terms of either:

- the output or product (good or service) that is expected to embed the outcome of the R&D, regardless of which industry produces it, or
- the industry likely to be making use of the expected R&D results (either as codified R&D, such as patents, or embedded in new goods and services).

7.55 Both approaches are intimately related, and from a respondent's perspective not easy to differentiate. Furthermore, R&D may be for a product that is a subcomponent of a more complex system, or for a process that will be commercialised or incorporated into the production of other goods and services. R&D may be for internal use by a given industry, or ultimately for use by the industries with which it is vertically integrated.

7.56 In light of these challenges, pragmatic solutions should be applied. One major limitation is that respondents may not be fully aware of the most likely "industry served" by its future goods and services when R&D is performed, especially in the case of basic and applied research. The use of goods and services embedding R&D results may evolve over time in line with business conditions and opportunities. Reported breakdowns may be based on heuristics informed by the experience of previous R&D efforts and internal records, including business cases for R&D projects. For non-oriented basic research or research with multiple known applications, a breakdown based on the lines of business pursued by the enterprise might be considered by respondents.

7.57 Regarding the choice of a classification system, standard international industry and product classifications are potential candidates. The ISIC classification is not designed to measure product data at any detailed level. For this purpose, a separate UN classification exists, the Central Product Classification (United Nations, 2008b). Although each category in the CPC is accompanied by a reference to the ISIC industry in which the goods or services are mainly produced (criterion of industry origin), this does not imply that all units producing these goods or services are classified there. The classification of products is based on the intrinsic characteristics of the goods or the nature of the services rendered, which results in a classification structure that is different from that used for ISIC. In the case of R&D, the use of established product or commodity-based classifications presents several challenges, since the classifications include items such as licences for the use of knowledge products. Those categories may mainly reflect the business model for undertaking and exploiting the outcomes of the R&D rather than its content. For this reason, the use of the CPC cannot be widely recommended, although countries may wish to use specific CPC categories on an ad hoc basis to meet specific user needs.

7.58 Even though no specific recommendation can be made (in order to allow for the adoption of the methods most suitable for individual country circumstances), for the purposes of distributing business R&D by industry orientation, a simplified industry list (based on ISIC or an equivalent classification) may be used, with a choice between focusing either on the industry served or on the product field. This manual acknowledges that, due to a number of practical constraints, some countries may use hybrid approaches (Table 7.2) but this should be avoided whenever possible.

7.59 In the ISIC 2008 classification (ISIC Rev4), "Division 72, Scientific research and development" includes the activities of two types of research and development as defined in this manual: natural sciences and engineering; and social sciences and the humanities. (ISIC 72, and this manual, excludes market research – see Class 7320, ISIC Rev4.) ISIC 72 captures units primarily involved in the provision of R&D services to affiliated companies or third parties. Some of these units may provide undifferentiated services to industry; in some cases these may be companies involved in developing new products or in providing

Table 7.2. **Proposed activity-based classifications for the Business enterprise sector**

Classification	Classification basis	Criterion and classification	Implementation of the classification criterion	Other features and potential limitations
Main economic activity (Recommended for all units in all institutional sectors)	Institutional: All the R&D expenditures or personnel reported by the statistical unit are allocated to the industry corresponding to the unit's classification.	Main activity of the statistical unit, as by ISIC or national/regional implementation of this industry classification.	Turnover, gross value added or other sufficiently close criteria. R&D compilers can rely on classifications used for other business statistics, as available in registers. In that case, no further questions are required.	In most cases this enables improved consistency with (business) economic statistics on production and employment. The classification may over-allocate R&D units and resources to specific service industries (chiefly, wholesale) in enterprises active in multiple economic activities and where the composition of turnover or value added (or other classification criteria) does not match the distribution of R&D activity within the enterprise.
Industry orientation (industry served / product field) (Recommended for business enterprises, in addition to the main economic activity approach)	Functional distribution: The statistical unit distributes its R&D resources across different lines of business for which the R&D is relevant.	Based on the industrial orientation of the R&D, which can be based on the notion of industry served or type of product embedding the outcomes of the R&D (eventually reclassified in ISIC terms).	Necessarily implemented through dedicated survey question(s). There are different possible ways to formulate the question so that it captures the intended concept.	High policy and user relevance on the economic activities potentially benefiting from the R&D. Implies some additional reporting burden for enterprises. Some of them may have limited awareness about final use of their R&D, especially for basic and applied research.
Hybrid approaches (Not recommended, except when no alternative is available)	Functional combined with institutional. For some firms, their R&D resources are apportioned on a functional basis, while for others their entire R&D is allocated to a given sector.	A functional distribution approach is applied to the one group of firms, while for the other, the main activity criterion is applied.	Different approaches: - Simple extension of main activity classification, applying distributional classification to R&D sector only. - Functional distribution constrained to large firms, small firms not asked product distribution question to avoid burden. - Use of functional distribution as an alternative to main economic activity.	The approach is justified only when reliable information on the main economic activity of R&D units is not available (for instance, from business registers) or burden considerations prevent asking about industry orientation. The results are more difficult to compare internationally, due to different combination criteria.

their customers with new technological or organisational knowledge. In general it is recommended that in an industry orientation distribution, R&D performed by enterprises whose main economic activity is ISIC 72 be attributed to the relevant industries served (usually the ISIC industries most of its customers belong to). The same applies to companies that specialise in the leasing of intellectual property (Group 774, ISIC Rev4).

7.60 It is recommended that all business enterprises be classified by main economic activity, and it is strongly suggested that their intramural R&D expenditures be distributed on an industry orientation basis, regardless of their size and activity. In principle, capital R&D expenditure should be excluded from a classification by product field or industry served, thus only the current R&D expenditure is expected to be distributed according to these criteria. The reasoning is that only a unit's current R&D performance could be linked to some expected results and to the potential users of those results. In practical terms, enterprises may find it easier to report on their total R&D expenditure. In order to assure consistency between the set of data provided by different countries, it is recommended to clearly report in the R&D metadata which approach was used to collect and distribute this data. Whenever possible, for those countries reporting for all BERD, it would be useful to indicate the amount by which it may differ from the distribution that would apply to current R&D expenditures only, based on the proportion of capital expenditure out of total R&D within a given industry.

Combining main activity and industry orientation information

7.61 For some analytical purposes, it can be relevant to provide cross-tabulations of industry orientation breakdowns by the main activity of R&D performers. These tabulations could provide the basis for constructing ad hoc R&D supply-use matrices that show the relationship between the performers of R&D and the likely R&D uses. Such matrices might be used for R&D impact analyses. If practical, countries are encouraged to produce these analytical compilations, which also might be used to help assess the quality of the data provided by respondents.

Distribution of BERD by fields of R&D

7.62 The distribution of BERD on the basis of fields of R&D (FORD) is a common practice in only a small number of countries. While a breakdown for most of the activities already identified as "basic" or "applied" research should be possible in FORD terms, the distribution of experimental development across FORD categories can be problematic for businesses. In many countries, businesses seldom maintain their records for R&D projects and activities by such

categories, and it is arguable that experimental development by businesses is likely to involve interdisciplinary technology areas and a combination of multiple fields that are not easily and individually identified. Because of such difficulties, this manual cannot specifically recommend such a breakdown of BERD across FORD fields. If however countries do choose to report a FORD distribution, it is recommended that they adopt the FORD categories identified in Chapter 3, Section 3.4; more detailed classification is found online in annex guidance to this manual available at *http://oe.cd/frascati*.

Distribution of BERD by socioeconomic objective

7.63 Few countries currently attempt to distribute their BERD across socio-economic objective categories. Although it is possible that much R&D could be classified on an ad hoc basis to categories representing societal goals, business are unlikely to view their R&D allocations in such terms. Therefore, this manual makes no explicit recommendation to provide such a breakdown. On the other hand, in countries where specific policies are aimed at influencing the functional orientation of business sector R&D (such as for health, the environment, energy or defence), it could be relevant to collect information on the contribution of business R&D to the achievement of specific objectives of social or political relevance. Given that such collections likely would reflect very country-specific circumstances, caution is recommended in comparing the resulting data at an international level.

Distribution of BERD by geographic location

7.64 Countries may find it useful to compile the separate totals for distribution of BERD by location/region. When a unit's BERD is classified entirely into its main location or centre of operations, this may fail to represent where the R&D is actually performed. It is not uncommon for a business enterprise to have activities at multiple locations. As described in Section 7.4, each statistical unit should have a geographic location classification variable. This variable may or may not be relevant for identifying where an enterprise's R&D takes place. An enterprise may have a dedicated R&D department/division at a site outside of the geographic location of its production facilities that determined its classification variable. Further, an enterprise could perform R&D (including occasional R&D) at multiple locations (establishments) spread across multiple geographic locations. The choice of geographic distribution is determined according to national and international needs. Guidance for distributing R&D by region is found in online annex guidance to this manual available at *http://oe.cd/frascati*.

Distribution of BERD by specific technology areas

7.65 Further guidance for collecting and compiling business R&D data beyond the specific recommendations identified in this chapter is found in online annex guidance to this manual available at *http://oe.cd/frascati*. Examples include

questions on R&D enabling and general purpose technologies. User interest in these questions includes the processes for generating new technologies as well as their diffusion and application patterns.

7.66 Most of the OECD statistical work on the measurement of technologies is based on methodologies, procedures and classifications developed for the measurement of ICT- and biotechnology-related phenomena. The relationship between ICT and R&D statistics has been addressed by developing ICT indicators based on the classification of R&D by main activity and product field. More recent efforts have been pursued in the area of nanotechnology, applying the general model of biotechnology, and there is broad interest in capturing, across a range of industries and research fields, the impact of software R&D (see Box 4.1 in Chapter 4 for suggested guidance on collecting software R&D). Several countries include questions on these technology areas in their business R&D surveys, although methodologies differ, for example, to the extent that they allow the same R&D resource to be attributed to different technologies, since these might easily overlap (e.g. bio-nano R&D activities).

7.67 Since 2005, the OECD has adopted specific guidelines on the production of biotechnology R&D statistics (OECD, 2005) and, more recently, a statistical project has been launched to collect data on nanotechnology R&D at international level. Several countries have already adapted their R&D surveys to collect this kind of information from business enterprises and a statistical Compendium is regularly published by the OECD.

7.68 Data users have shown strong interest in technology application areas (e.g. health, energy, agro-bio, green- or low-carbon-related R&D). These categories generally are related to specific socio-economic objectives, but often cut across several objectives. Moreover, there is interest in much greater granularity than is usually possible for surveys to collect in a consistent fashion. While it is important for R&D national statistical offices to consider how best to provide information on efforts undertaken by business enterprises that are relevant to societal challenges, no general guidelines or recommendations can be provided at this point. Definitions and strategies for collecting R&D data on specific technology areas should be developed through extensive consultation between statisticians, policy makers, data users and subject-matter experts.

7.7. Functional distributions for extramural R&D in the Business enterprise sector

7.69 Business enterprises may also provide funds to others for the performance of extramural R&D; further, business enterprises may both purchase R&D from others and sell R&D to others. These circumstances affecting statistical units in all economic sectors are covered in detail in Chapter 4 (notably Section 4.3 on Measurement of funds for extramural R&D and on Sales and Purchases of R&D). Because the enterprise is the unit of interest for R&D statistics, R&D funds from one member “A” of an enterprise group to another member “B” of the same

group should be reported as the by member "A" of the extramural performance of member "B". In line with the recommendations given in Chapter 4, the following abbreviated distribution is recommended for business enterprises funding R&D performed extramurally and for tracking the purchases and sales of R&D:

Domestic:

- Business enterprise sector:
  - Enterprises in the same group
  - Other unaffiliated enterprises
- Government sector
- Higher education sector
- Private non-profit sector.

Rest of the world:

- Business enterprise sector:
  - Enterprises in the same group
  - Other unaffiliated enterprises
- Government sector
- Higher education sector
- Private non-profit sector
- International organisations.

Survey design: framing the R&D population

7.70 The identification of the reference (target) population is the first step of every statistical activity. For business R&D data collections, the target population is all businesses performing R&D (or funding R&D as is described in Chapter 4, Section 4.3 related to the measurement of funds for extramural R&D) and located in a given territory (usually, a country). As recommended in Chapter 6.3, R&D surveys of the Business enterprise sector should identify and include in their populations all businesses located in a given territory known or very likely to perform (or fund) R&D with reference to a single period of time. In turn, this population of businesses known or likely to perform R&D is considered a sub-population of the universe of active businesses, any of which could potentially perform R&D. Consequently, it is also recommended to survey a sample of all other firms in order to identify R&D performers about which it is not known *a priori* whether they actually perform or are highly likely to perform R&D. Realistically, in many countries most micro-businesses – which often comprise the majority of the Business enterprise population – are very unlikely to perform (or fund) R&D. Therefore, on a practical level, such micro-businesses are often treated (for statistical purposes) as being outside the

scope of "potential" R&D performers. A common practice by national statistical offices is to use a single "business register", which includes all active businesses in a given year, for all of its all business surveys.

Business registers

7.71 Business registers are major tools for compiling R&D statistics, but may not be sufficient to identify the relevant population to be surveyed about R&D. Although they provide essential information on key characteristics of enterprises potentially included in an R&D survey sample (e.g. size, industry, ownership, age, etc.), business registers often do not include information on their actual R&D or likelihood for R&D performance. As a result, a common practice is to survey the total population of enterprises (or a subset of them, possibly identified in terms of size and industry) only for exploratory purposes, i.e. to single out, or screen for, those enterprises with R&D potential. In collecting R&D data, it is recommended to target only enterprises with some evidence of at least likely R&D potential, in order to reduce the data collection costs and burden on respondents.

7.72 Since R&D performance in the Business enterprise sector is a rare event (i.e. a small percentage of business enterprises is usually involved in R&D), every effort should be made to identify and monitor enterprises with high R&D potential. In this respect, simple random sampling may not be the most reliable way of determining R&D – companies that appear to be similar in terms of what they offer to the market may in fact have very different R&D strategies, and random sampling may not yield sufficiently reliable estimates.

7.73 On the other hand, many countries have neither a comprehensive and up-to-date business register nor a directory of companies that perform R&D. And even when a business register does exist, it is important – before launching a survey – to ascertain that it has been properly updated, that it includes only active companies, and that it excludes ghost or shelf companies. Without a complete business register (or similar business enterprise lists), it will not be possible to produce reliable census or sample estimates, or even undertake an accurate R&D screening survey.

7.74 Assuming that sufficiently complete information on the total population of active enterprises is available (either from a business register or from other sources), it is rather straightforward to carry out a purposive survey that deliberately sets out to identify R&D performers and then elicit the required data from them directly. This entails surveying all firms known to or highly likely to perform R&D. In order to carry out the purposive survey, an ad-hoc business register (or directory) of firms that perform R&D should be developed. Eliciting and compiling this information is time-consuming and represents an important investment in future surveys.

Compiling directories of potential R&D performers

7.75 When no prior directory of R&D performers in the Business enterprise sector exists, a significant amount of work may have to be done before launching an R&D survey to create a list or inventory of businesses that are highly likely to be R&D performers. The following may be useful sources of information on firm behaviour that might help identify such businesses:

- Chamber of Commerce/Industries, trade associations, professional associations, associations of R&D performing firms. A good starting point is to seek out these various associations and ask their information offices what they know about the R&D activities of associated firms (and if they are allowed to disclose information on individual firms). Associations of performers might be able to share directories of associates and related information.
- Publicly traded company listings, such as national stock exchanges. Working through the businesses listed on the main stock exchange is a necessary task.
- Company annual reports, trade journals, directories of R&D laboratories. A base list of R&D performing firms can be created by reviewing R&D expenditures that are included in financial reports or regular accounting systems. These sources should also be reviewed for specific information related to R&D activities, particularly the construction of prototypes, establishing pilot plants, etc.
- Registers of publicly funded research grants/contracts for R&D. In more sophisticated environments, ministries dealing with science and technology or research – usually the most relevant national research grant funders – may have a list of business beneficiaries of research or innovation grants. Lists of contributors to international research programs are also easily accessible.
- Lists of enterprises claiming tax relief for R&D activities and projects. Close cooperation between business survey managers and the government departments responsible for R&D tax incentives, import facilitation, export promotion and price controls may also help identify R&D performers.
- Lists of enterprises reporting R&D activities in previous R&D surveys, in innovation surveys or other structural business surveys.
- Lists of enterprises having filed for a patent application during the past several years. This is an indicator, again, of possible R&D activity.
- Registers of approved clinical trials or similar administrative registers.

7.76 A survey frame of businesses with R&D can be developed through consultation of these sources and direct interaction with known R&D performers. Efforts to identify actual R&D performers should focus first on large firms in industries that usually exhibit a high level of R&D intensity. When attempting to identify R&D performers among several hundred large firms, a sequential process may be implemented, prioritising areas of most likely R&D performance

and then focusing on the connections of the identified performers with other enterprises to which they are related through supply chains, competitors, etc. Unless published information confirms the existence of R&D, direct interaction is needed with firms to verify the existence of R&D activities. One approach would be to conduct a two-stage survey to first identify R&D performers using a very short questionnaire, possibly embedded in other business surveys, and then to target those firms reporting R&D activities with a more extensive questionnaire.

Survey strategies

7.77 Countries use a broad range of practices in conducting business R&D surveys. In all cases, however, the identification of the population of known and highly likely business enterprise R&D performers is an essential first step in the data collection process. Unlike the situation for other sectors where directories of higher education or government institutions are available and fully known, business enterprise R&D surveys are largely dependent on the quality of the available frame and on its reliability for preventing under- or over-coverage of R&D activities.

7.78 Assuming the existence of a highly reliable frame, national statistical offices may conduct either a census or a sample survey. In order to take into account the high concentration of R&D activities (in terms both of expenditure and personnel) in a relatively small group of size classes and industries, a census is usually recommended for this cohort of business enterprises, since they may have a higher probability of having undertaken R&D activities in the reference year. Very large, known R&D performers are included in this "take all" survey group.

7.79 In turn, those enterprises with a lower probability of having been engaged in R&D in the reference year could be surveyed either by census or by sample. This approach is based on the assumption that all potential R&D performers are actually included in the frame and that the probability of finding additional performers outside the frame is negligible, or might include only small or micro-enterprises.

7.80 If a reliable survey frame (directory of potential R&D performing businesses) does not exist, a different approach is needed. In this case, it is possible that a non-negligible number of R&D units could still be unidentified or that a few large R&D performers may not yet be included in the frame. Under such conditions, a survey of large, known R&D performers (preferably, by census) should be complemented by a sample survey of a sub-population of the overall business register (or similar register) where most of the missing units could be assumed to be included with a given degree of probability (mostly on the basis of a cross-classification by size and industry). Also in this case, a two-stage survey (screening for R&D performance plus data collection) may be recommended in order to reduce the data collection costs and statistical burdens on enterprises.

7.81 Setting a minimum size threshold is irrelevant when a survey of business R&D is based on a reliable frame where individual enterprises are included if they meet country-identified indicators of likely R&D activity. On the other hand, when drawing a sample from an overall business register with the aim of identifying new potential R&D performers, it is recommended that micro-enterprises be excluded from the sample *unless* there are sufficient resources to undertake a thorough review and screening for potential R&D performers. This recommendation is based on the need to avoid the risk of inflating the number of performers that would possibly result from the high number of micro-enterprises in the overall population. This recommendation should also result in lower survey costs and a lower overall response burden.

Questionnaire design

7.82 Questionnaires are tools designed to collect data. They should be understandable, easy to use, effective and flexible. Business survey questionnaires, which are usually self-administered, are answered by a wide range of individuals working for many diverse types of enterprises. In this respect, questionnaires need to be adaptable to very different needs and conditions of use.

7.83 Electronic questionnaires offer the capability of pre-processing the delivered data – which is made possible by implementing filtering questions allowing respondents to skip irrelevant modules, and embedded edit checks. They allow for an effective interaction with respondents by preventing errors and inconsistencies in data provision. It may be necessary to adopt multi-mode data collection strategies when a relatively large number of enterprises cannot be assumed to have easy access to the Internet or access at an acceptable cost. The need for a questionnaire to be easily managed by different contacts inside a company (who have different expertise and knowledge about the enterprise's R&D expenditures, contracts and personnel) should be taken into consideration.

7.84 Several countries have implemented "combined surveys", mainly by merging business R&D surveys and business innovation surveys, as described in the Oslo Manual (OECD/Eurostat, 2005). This approach is accepted by this manual but not recommended, as it may affect the international comparability of R&D results: by asking questions about both R&D and innovation in a single questionnaire, respondents may find it difficult to differentiate between R&D and any number of other innovation-related activities (see Chapter 2). For countries that choose to undertake a combined innovation-R&D survey, it is recommended to: (a) deliver to respondents two questionnaires or, at least, a questionnaire with two distinct sections, making clear that the two statistical concepts are not complementary but rather overlapping; (b) reduce as much as possible the size of the combined questionnaire to make it more understandable; (c) report in a systematic way information on the data collection approach adopted (mostly when comparing the R&D results with those from other countries not using combined surveys); and (d) use a single business register as the statistical

frame for both the innovation and the business R&D survey (according to the procedures described above). These steps will also help ensure consistency with the Oslo Manual (OECD/Eurostat, 2005) guidance and recommendations.

Data collection practices

7.85 A high response rate is the goal of any statistical survey, and this is of particular importance for R&D surveys since business R&D is a rare activity (i.e. relatively few enterprises in the total Business enterprise sector are R&D performers, and they are therefore hard to find). This point is stressed both for censuses (since it is extremely difficult to make assumptions about the actual R&D performance of non-respondents) and sample surveys, as a low rate of response could lead to significant measurement biases (in addition to an increase in the sampling error). Ideally, every effort should be taken to minimise the rate of non-response. To maintain data quality standards, statistical offices should identify minimally acceptable response rates below which population estimates cannot be made; when response rates fall below an acceptable level, follow-up non-response bias analyses should be conducted. This manual cannot recommend specific non-response tolerances. Obviously, a compulsory survey is likely to obtain higher response rates than is a voluntary survey.

7.86 In practical terms, however, the unweighted average rate of response may not be the best indicator to measure the rate of coverage of the R&D phenomenon achieved by a business survey. In fact, the high heterogeneity which can be systematically observed among business R&D performers suggests that, for most countries, a full coverage of a small group of large R&D performers would account for a very high percentage of the total business R&D expenditure (as well as of the R&D personnel, although to a lesser extent).

7.87 As a consequence, specific strategies to pursue the twin objectives of increasing the overall rate of response and of assuring a nearly full coverage of the leading R&D performers should be implemented. This reinforces the need for exploiting all available sources of information to support the data collection activity. The availability of data on R&D tax credits is a case in point since this information could be useful for identifying the key performers to be specifically targeted during the data collection effort.

7.88 A range of other activities, in addition to the improvement of the frame, should be implemented to improve the quality of the R&D data collection effort. Respondents should be aware, at all times, that they are participating in a statistical survey: they should be informed of the subject of the survey and its nature, who is responsible for it and whether they have the right to choose the way to transmit the requested data (or even if they have chance to be excluded from the survey). In broader terms, the data collection team should be constantly available to answer the respondents' questions and to provide technical support and advice. This is currently a standard in most official statistical agencies, and it should be implemented by every institution that aims to produce internationally comparable business R&D data.

7.89 To evaluate the success of survey implementation and of relevant population coverage, statistical offices are encouraged to calculate response rates (RR), weighted response rates (WRR) and coverage rates (CR). These are each measures of quality and offer different perspectives, depending on what aspect is of interest. For populations that are relatively homogeneous with respect to the variables measured, there probably is very little difference in the three measures. But since R&D activity is skewed and highly concentrated in the Business enterprise sector, all three measures are relevant (see Box 7.1).

Box 7.1. **Importance of multiple measures of collection quality**

There are multiple ways of measuring coverage and response rates. In collecting intramural R&D for the Business enterprise sector, several measures of survey quality may be appropriate.

For example, if there were a population of 1 000 units within an ISIC sector that have R&D measures of

1 000 000 for 1 unit; 1 000 for 1 unit; and 1 each for the remaining 998 units,

and the statistical office drew a sample of 10 units, including the purposive selection of the units with 1 000 000 and 1 000 and a random sample of 8 units each with 1.

Below are four scenarios for data collection for which each reports a response rate (RR) of 70% (i.e. 7 of the 10 sample units respond to the survey). However, the measures take on a different light depending on which units respond (assuming 7 of 10 units respond) in the four scenarios presented below:

Unit measure and number responded				Measures of response		
Scenario	1 000 000	1 000	1	RR	WRR	CR
1	0	0	7	70.0%	87.3%	0.0%
2	0	1	6	70.0%	75.0%	0.1%
3	1	0	6	70.0%	75.0%	99.8%
4	1	1	5	70.0%	62.6%	99.9%

In this imaginary example, scenario 3 would seem to do relatively best across in terms of population count – weighted response rates (WRR) even though the unit known to have the second largest R&D expenditure in the sector did not respond. In term of the overall coverage rate (CR), scenario 4 indicates best coverage of the sector's total BERD.

Weighting and estimation

7.90 The final step in processing business R&D data collections is the production of statistical results on the level of the R&D activity undertaken by the enterprises in the compiling country (in terms of R&D expenditure and R&D personnel). For business R&D surveys, the estimation process is highly dependent on the procedures used for the identification of the reference population. A few specific cases, and related issues, are discussed here.

7.91 As a preliminary statement, this manual recommends against the use of extraneous coefficients (such as applying past sector-wide R&D/sales ratios to firms' total sales) as a means of estimating sector-wide business R&D totals. Whereas under some specific conditions coefficients might be helpful for estimating the R&D activities of institutions in other economic sectors (primarily for the Higher education sector; see Chapter 9), this is not the situation for the Business enterprise sector. Enterprises are constantly facing the choice on whether – and to what extent – to be involved in R&D activities. Intramural R&D is expensive and risky and, at any time, an enterprise could choose to abandon its internal R&D projects and switch to purchasing external R&D services or to acquiring knowledge codified in intellectual property. The high heterogeneity of business strategies, including R&D-related ones, across industries and size classes is the basic reason that this manual does not recommend the use of coefficients in the production of business R&D statistics.

7.92 Before initiating estimation procedures, the survey data should be accurately edited and validated. Outliers should be found and corrected. In order to correct for the non-response of large R&D performing enterprises, imputation – based on auxiliary information (e.g. company reports) and historical responses – is preferred over the re-weighting of other respondents' data.

7.93 Additional guidance concerns grossing up the results of an R&D survey of an undifferentiated population of enterprises (e.g. a sample drawn from a business register). Since the sub-population of enterprises that are likely R&D performers is, in statistical terms, a rare population, before grossing up the results of a survey it is recommended that preliminary screening for non-eligible units first be undertaken. Alternatively, statistical methods should be used to minimise the possibility of introducing bias by over-estimating total business R&D activity (see Chapter 6).

Quality control related to business R&D responses

Cautionary note related to financial accounting records

7.94 As noted above, company annual reports are usually a good source to help identify likely business R&D performers. These published totals also may help assess the quality of reported survey totals and address item non-response issues (see Chapter 6). At the same time, this manual explicitly cautions that figures on R&D activities published according to national and international financial accounting standards and guidance may differ from R&D compiled according to the recommendations presented in this manual. Some R&D costs may be capitalised in companies' balance sheets and others may be posted as expenses (including depreciation, see Chapter 4) in their income-costs statements. For public reporting purposes, some companies include "technical services" performed by R&D personnel with intramural R&D (see Chapter 5 on personnel job titles).

7.95 Even when the definition of R&D is precisely the same as that recommended in Chapter 2, the composition of the accounting-based totals may differ from R&D totals compiled in accordance with this manual. For example, if the R&D is not "material" to the enterprise's total costs, those costs may not be explicitly identified. Also, the R&D paid for by others may not be accounted for separately from internally funded intramural R&D; indeed, R&D performed under contract may not be counted or perceived as R&D in financial records (Chapter 4). Especially in reports for large enterprises, the costs for intramural R&D may not be differentiated from those for extramural R&D. Consistent with most accounting standards, their annual financial reports on R&D expenses may combine internal funds for both intramural R&D and extramural R&D as long as the R&D performed is "for the benefit of" the reporting enterprise. Especially for MNEs, published R&D totals may include R&D expenses for the global group (see Chapter 12) rather than for the individual members.

Differentiating intramural from extramural R&D

7.96 There are a number of potential difficulties in accurately collecting R&D funding flows, whether as a component of a unit's intramural R&D or as part of their funding totals for extramural R&D performance.

7.97 Problems may arise when funds pass through (flow within and across) several units before reaching the performer. This may occur when R&D is sub-contracted, as may happen particularly in the Business enterprise sector. The performer should report only costs for R&D projects actually conducted rather than as input to some other unit's R&D, and indicate, to the extent possible, the original source of the funds for R&D. See Chapter 4.3 for further guidance on differentiating funds for intramural R&D from those for extramural R&D.

Potential under- and over-reporting of business R&D activity

7.98 The process to produce business R&D statistics, especially taking into account different country-specific practices, can be quite complex. Even when detailed quality reporting is available, questions remain concerning the potential under- or over-reporting of business R&D activity. On the basis of the country experiences, some best practices – in addition to the formal recommendations of this manual – can be suggested to reduce the risk of error in measuring business R&D. Two issues are particularly relevant in this respect: (i) identification of a proper reference population for business R&D surveys (avoiding under- or over-coverage in terms of performers) and (ii) identification of the actual R&D activities carried out by survey respondents (avoiding under- or over-coverage in terms of R&D performance).

7.99 The under-coverage of R&D units results from insufficient knowledge of the Business enterprise sector. Usually, under-coverage of large enterprises can be excluded by definition since they are a small part of the Business enterprise

sector and easily identified. On the other hand, under-coverage is a relevant issue for the population of small-sized performers. Given that any screening of the business population by means of statistical surveys is at best an approximation, a systematic exploitation of administrative data sources (public R&D funding, R&D tax incentives, participation in public R&D projects, patent filing, etc.) is recommended to help identify a high percentage of potential R&D performers among small and micro-enterprises. Even so, it is highly likely that some R&D performing enterprises will still be missed, and a potential (minimised) under-coverage of small performers must be accepted when interpreting R&D data. The impact of such under-coverage in terms of total R&D expenditure or personnel, however, is considered negligible in most countries.

7.100 Under-estimating the R&D performance of business enterprises has been always a concern. The adoption of some methodological recommendations given in this chapter can help to minimise this risk (for instance, by identifying the right contact within a surveyed enterprise). A few data collection best practices can help to encourage respondents:

- to consider all of the R&D activity undertaken inside the statistical unit, even that performed outside specific R&D departments, such as activity focussed on pilot testing, preparations for production, general technological development
- to include "non-obvious" R&D that is fully integrated into (usually large) development contracts for specified products/systems (knowledge embedded in products)
- to include R&D activities funded by customers on a project-specific basis.

7.101 The over-coverage of R&D performing businesses results mostly from misinterpreting the information collected from other business surveys or from administrative databases. All such sources, which are essential for identifying the reference population of R&D surveys, have to be used carefully: it is unlikely that many reference sources have adopted the exact same concepts of R&D as defined in this manual. Lists of enterprises applying for R&D tax credits is a case in point, since the concept of "R&D activity" used by tax authorities may include both the internal performance of R&D and the funding of R&D undertaken by other units. Statistical surveys therefore need to provide respondents with clear definitions of R&D (and check for the accuracy of answers) to minimise the risk of respondents' misinterpretation of what are R&D activities.

7.102 Over-estimating R&D performance by business enterprises can result from a variety of different factors:

- insufficient knowledge about the activities to be reported
- objective difficulty in discriminating R&D activities from other innovation- or technology-related activities
- the acquisition of R&D from other units that is included in the intramural performance totals (with an additional risks of double reporting).

7.103 It is difficult to overstate the risk of over-reporting since surveyed enterprises are often reluctant to adapt their own understanding of R&D phenomena (which are often influenced by accounting, fiscal and regulatory reporting requirements) to the definitions given in this manual for statistical purposes. Best practices to deal with the above-mentioned issues include an accurate checking of data collected from respondents (ideally, identifying any deviation from the expected behaviour of an enterprise as a result of its size and its main economic activity) and an appropriate treatment of outliers.

Quality control of business R&D totals

7.104 As noted in Chapter 6, the use of quality reporting standards for R&D statistics is highly recommended. In this respect, business R&D is not different from R&D performed in other sectors. Nevertheless, the methodological heterogeneity observed in business R&D surveys carried out by individual countries suggests the need for common criteria for survey/data quality reporting.

7.105 Beyond the quality reporting recommendations given by the OECD (2011) or those provided, for instance, by the United Nations (2012), some practical recommendations are given below for improving the understanding and international comparability of business R&D statistics. These reporting recommendations focus on indicators of the level of accuracy of the business R&D data estimates and on their **coherence** with other business statistics.

7.106 Since the incidence of R&D performance is rare and the population of actual R&D performers is highly skewed, an accurate and up-to-date frame is one of the most important factors in determining whether a business R&D survey will be successful and provide high-quality results. The quality of compiled business R&D statistics depends in large part on the identification of the population of known and highly likely R&D performers, which is usually largely approximated. This uncertainty in the number of potential businesses who actually perform R&D or are estimated to do so, in a statistical sense, is, in turn, the main reason why statistics on the number of performers or the rate of performers in the total population of enterprises is not usually produced.

7.107 When BERD data are released, detailed reporting on the methodology used for the data production should also be made available. More specifically, it is recommended that the dissemination of business R&D statistics at the national level include the publication of metadata: e.g. **the number of units included in the reference population** (potential R&D performers), possibly identified by their main economic activity; the **number of units surveyed by the census** and the rate of response; and the **number of units sampled** and the rate of response.

7.108 A key feature of business R&D statistics is their potential for integration with other business statistics, especially if the sampling and classification criteria for R&D surveys are the same as for the collection of other business economic variables. As a partial indicator of the level of coherence of the

estimates on R&D expenditure and personnel with other statistical indicators, a few ratios could be made available to users as metadata in parallel with the publication of the national data: the **ratio of R&D expenditure to value added** by main economic activity; the **ratio of total R&D personnel (FTE) to total persons employed** by main economic activity (for all sectors).

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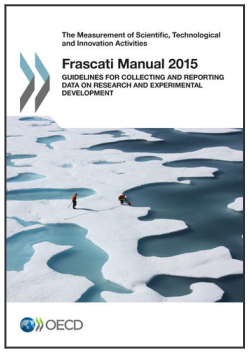

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