



Puerto Rico Institute of Statistics

Survey of Science and Technology 2014-15: Research and Development (R&D)

Support Information

Research and Experimental Development (R&D), for the purposes of this survey, is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

R&D covers both formal R&D and informal or occasional R&D.

The term R&D covers three activities:

- **Basic research:** experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
- **Applied research:** original investigation undertaken in order to acquire new knowledge, which differs from basic research in that it is directed primarily towards a specific practical aim or objective.
- **Experimental development:** systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

For the purposes of this survey, the term R&D does not cover activities lacking an appreciable element of novelty or routine or activities that do not lead to the resolution of scientific and/or technological uncertainty. [The Appendix of this Questionnaire provides further detail as to the inclusion or exclusion of specific activities].



DEFINITIONS

[Taken from Frascati Manual, OCDE, 2002]

Research and Experimental Development (R&D):

comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

The term R&D covers three activities:

- **Basic research:** experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
- **Applied research:** also original investigation undertaken in order to acquire new knowledge, it differs from basic research in that it is directed primarily towards a specific practical aim or objective.
- **Experimental development:** systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

R&D covers both formal R&D in R&D units and informal or occasional R&D in other units.

For purposes of this survey, the term R&D **does not apply** to activities lacking an appreciable element of novelty, or to routine activities that do not lead to the resolution of scientific and/or technological uncertainty.

The following activities should be excluded from R&D:

- Education and training
- Other related scientific and technological activities, except when carried out solely or primarily for the purposes of an R&D project. That means that the following are excluded: general purpose data collection, routine tests, maintenance of national standards, feasibility studies, specialized health care, administrative and legal work connected with patents and licenses, policy-related studies, routine software development, and other specialized activities like collecting, coding, recording,

classifying, disseminating, translating, analysis and evaluation.

- Other industrial activities of innovation, like the acquisition of technology (embodied and disembodied), tooling up and industrial engineering, industrial design n.e.c., other capital acquisition, production start-up and marketing for new and improved products. Also excluded are the industrial pre-production and production and distribution of goods and services and the various allied technical services in the business enterprise sector and in the economy at large, together with allied activities using social science disciplines, such as market research.
- The raising, management and distribution of R&D funds to performers, and indirect support activities.

R&D Personnel [question 3.4]: All persons employed directly in R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff.

Researchers: professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.

Managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work also fall into this category.

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

Technicians: persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers.

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



Definitions of research areas *[question 6.1.]*

Natural sciences: Mathematics and computer sciences, physical sciences, chemical sciences, earth and related environmental sciences and biological sciences.

Engineering and technology: civil engineering, electrical engineering, electronics, chemical engineering, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialized subdivisions, as well as the science and technology of food production, and specialized technologies.

Medical sciences: basic medicine, clinical medicine and health sciences.

Agricultural sciences: agricultura, fisheries and allied sciences, as well as veterinary medicine.

Social sciences: psychology, economics, educational sciences, anthropology, ethnology, demography, administration, law, linguistics, political sciences, sociology, among others.

Humanities: history, archaeology, numismatics, palaeography, genealogy, languages, philosophy, arts, religion, among others.

Specific areas

Information and Communication Technologies (ITC): Refers to the development of software, hardware and information technology services, as well as to technological developments in communications systems.

Nanotechnology: the creation and utilization of materials, devices, and systems sized at the level of atoms and molecules. This includes R&D in the range of 1 to 100 nanometers.

Biotechnology: The application of S&T to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.

Socio-economic objectives *[question 6.2.]*

Exploration and exploitation of the Earth: covers research with objectives related to the exploration of

the Earth's crust and mantle, seas, oceans and atmosphere, and research on their exploitation. It also includes climatic and meteorological research, polar exploration and hydrology. It does not include soil improvement and land use, research on pollution, and fishing.

Infrastructure and general planning of land use: covers research on infrastructure and land development, including research on the construction of buildings and research into protection against harmful effects in town and country planning but not research into other types of pollution.

Control and care of the environment: covers research into the control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal in the environment and the effects on man, species (fauna, flora, micro-organisms) and the biosphere. Development of monitoring facilities for the measurement of all kinds of pollution is included. The same is valid for the elimination and prevention of all forms of pollution in all types of environment

Protection and improvement of human health: covers research aimed at protecting, promoting and restoring human health, broadly interpreted to include health aspects of nutrition and food hygiene. It ranges from preventive medicine, including all aspects of medical and surgical treatment, both for individuals and groups, and the provision of hospital and home care, to social medicine and paediatric and geriatric research.

Production, distribution and rational utilisation of energy: covers research into the production, storage, transportation, distribution and rational use of all forms of energy. It also includes research on processes designed to increase the efficiency of energy production and distribution, and the study of energy conservation.

Agricultural production and technology: covers all research on the promotion of agriculture, forestry, fisheries and foodstuff production. It includes: research on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture; research on the impact of agricultural and forestry activities on the environment; research in the field of developing food productivity and technology.



Industrial production and technology: covers research on the improvement of industrial production and technology. It includes research on industrial products and their manufacturing processes, except where they form an integral part of the pursuit of other objectives (e.g. defence, space, energy, agriculture).

Social structures and relationships: covers research on social objectives, as analysed in particular by social and human sciences, which have no obvious connection with other socio-economic objectives. This analysis includes quantitative, qualitative, organisational and forecasting aspects of social problems.

Exploration and exploitation of space: covers all civil space research and technology. Although civil space research is not in general concerned with particular objectives, it frequently has a specific goal, such as the increase of general knowledge (e.g. astronomy), or relates to particular applications (e.g. telecommunications satellites).

Non-oriented research: This covers all those appropriations or outlays which are earmarked for R&D but which cannot be attributed to an objective. A supplementary breakdown by field of science may be useful.

Other civil research: covers civil research which cannot (yet) be classified to a particular socio-economic objective.

Defense: includes all R&D programs undertaken primarily for defense reasons, regardless of their content or whether they have secondary civil applications. Thus, the criterion is not the nature of the product or subject (or who funds the program) but the

objective. The objective of defense R&D is the creation or enhancement of techniques or equipment for use by national, overseas or multinational armed forces.

Biotechnology

DNA (Coding) related technology: genomics, pharmaco-genetics, gene probes, DNA sequencing/synthesis/amplification, genetic engineering.

Proteins and molecules (functional blocks) related technology: protein/peptide sequencing/synthesis, lipid/protein glyco-engineering, proteomics, hormones and growth factors, cell receptors/signalling/pheromones.

Cell and tissue culture and engineering : cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/ immune stimulants, embryo manipulation.

Process biotechnologies: bioreactors, fermentation, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation and biofiltration.

Gene therapy, viral vectors. Sub-cellular organisms.

Bioinformatics: Software development, data bases for management, analysis and integration of data in genomic and proteomic (large scale study of proteins), sequences of process models and biological systems.

Nanobiotechnology: Instruments or materials developed by the combination of nanoscale engineering and biology, for the study of biosystems and applications in drug administration, diagnostics, etc.



R&D IN SPECIFIC SECTORS

R&D in software development

For a software development project to be classified as R&D, its completion must be dependent on a scientific and/or technological advance, and the aim of the project must be the systematic resolution of a scientific and/or technological uncertainty.

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

In addition to the software that is part of an overall R&D project, the R&D associated with software as an end product should also be classified as R&D.

A scientific and/or technological advance in software may be achieved even if a project is not completed, because a failure can increase knowledge of the technology of computer software by showing, for example, that a particular approach will not succeed.

Should be included in R&D:

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

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

Examples are:

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

R&D in the social sciences and humanities

For the social sciences and humanities, an appreciable element of novelty or a resolution of scientific/technological uncertainty is again a useful criterion for defining the boundary between R&D and related (routine) scientific activities. This element may be related to the conceptual, methodological or empirical part of the project concerned. Related activities of a routine nature can only be included in R&D if they are undertaken as an integral part of a specific research project or undertaken for the benefit of a specific research project. Therefore, projects of a routine nature, in which social scientists bring established methodologies, principles and models of the social sciences to bear on a particular problem, cannot be classified as research.

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

R&D in service activities

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

- Links with public research laboratories.
- The involvement of staff with PhDs, or PhD students.
- The publication of research findings in scientific journals, organization of scientific conferences or involvement in scientific reviews.
- The construction of prototypes or pilot plants

Examples of R&D in banking and insurance:

- Mathematical research relating to financial risk analysis.
- Development of risk models for credit policy.



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

Examples of **R&D in other service activities**:

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

R&D and industrial 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 preproduction planning or to get a production or control system working smoothly, the work is no longer R&D.

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

Specific cases:

- **Prototypes**: Included in R&D, as long as the primary objective is to make further improvements.
- **Pilot plant**: Included in R&D, as long as the primary purpose is R&D.
- **Industrial design and drawing**: Include design required during R&D. Exclude design for production process.
- **Industrial engineering and tooling up**: Include “feedback” R&D and tooling up industrial engineering associated with development of new products and new processes. Exclude for production processes.
- **Trial production**: Include if production implies full-scale testing and subsequent further design and engineering. Exclude all other associated activities.
- **After-sales service and trouble-shooting**: excluded from R&D.
- **Patent and license work**: excluded from R&D.
- **Routine tests**: excluded from R&D.
- **Data collection**: excluded from R&D.

Clinical trials

Before new drugs, vaccines or treatments can be introduced on the market, they must be tested systematically on human volunteers to ensure that they are both safe and effective. These clinical trials are divided into four standard phases, three of which take place before permission to manufacture is accorded. For the purposes of international comparison, by convention, clinical trial phases 1, 2 and 3 can be treated as R&D. Phase 4 clinical trials, which continue testing the drug or treatment after approval and manufacture, should only be treated as R&D if they bring about a further scientific or technological advance. Moreover, not all activities undertaken prior to permission to manufacture are considered to be R&D, especially when there is a significant wait after the completion of phase 3 trials, during which marketing and process development activities may be started.

[Most definitions and explanations included in this Appendix are quotations from the Frascati Manual, OCDE, 2002. This Manual contains the internationally agreed-upon definitions and methodologies used to estimate the resources dedicated to Research and Development in each country].