

21. SCIENCE AND RESEARCH

Science refers to a consistent system of verifiable observations and findings on a given set of phenomena as well as of methods used to obtain, process, explain in theory, and apply these observations and findings.

Research and development (R&D) and its results are one of key factors ensuring competitiveness of economy in developed countries. In the course of time scientific learning of the world became an integral part of intellectual needs of a human being. Adequate support of R&D is one of top priorities in all developed countries, because maintaining R&D at a certain level ensures continuous development of society, improves competitiveness of a given economy and is one of the most important driving forces of the economic growth.

Technologies take three fundamental forms: (i) **tangible**: knowledge embodied in physical objects (machinery, equipment, instruments, etc.); (ii) **intangible**: knowledge accumulated in people (human capital), information embodied in electronic media and documents (software, plans, projects, results of observations, mathematical calculations, maps, etc.) and (iii) **institutional**: arrangement of activities and relations (organizational structure, management system, standards, regulations, etc.). Hence, while science is concerned about how and why certain things happen, technology is focussed on the means of their implementation.

Notes on tables

Table 21-1. Human resources in science and technology

Human resources in science and technology (HRST) as defined in the Canberra Manual (Manual on the Measurement of Human Resources devoted to S&T, OECD, Paris, 1995) are people who **fulfil at least one** of the following conditions:

- having **tertiary education** (ISCED levels 5A, 5B and 6);
- not having tertiary education but being **employed in S&T occupations** (CZ-ISCO-88 major groups 2 and 3).

Persons who satisfy both the condition of having completed tertiary education and the condition of S&T occupation make up the **HRST core** (they are the most valuable people for the HRST system taking an active part in scientific and technological development).

Table 21-2. Persons with tertiary education

In the Czech Republic they are persons who attained tertiary education in any field of study. Tertiary education is defined in ISCED 97 (International Standard Classification of Education) and includes ISCED levels 5A, 5B and 6 (see Chapter 23. Education).

Table 21-3. Employed in science and technology occupations

Persons employed in science and technology (S&T) occupations are those who have main job in science (CZ-ISCO major group 2: Professionals) or technology (CZ-ISCO major group 3: Technicians and associate professionals) occupations that is their main source of income.

The data come from the Labour Force Sample Survey (LFSS) of the CZSO (the table presents average annual data). More detailed data on the LFSS are available in Chapter 10. Labour Market, part B.

Table 21-4. Tertiary education students and graduates of science and engineering fields of education (CZ-ISCED 97)

The table gives the total **number of tertiary education students and graduates** (ISCED levels 5A, 5B and 6) in the fields of **science** (life sciences, physical sciences, mathematics and

statistics, computing) and **engineering, manufacturing and construction** (engineering and engineering trades, manufacturing and processing, architecture and building) defined in ISCED 97 (ISCED broad groups 4 and 5). Tertiary education students and graduates of science and engineering fields of education represent potential (students) and real (graduates) inflows of HRST.

The data come from data sources of the Institute for Information on Education. The table contains expert estimates based on statistical data on higher professional schools (as at 30 September), graduates (for school year) and Union Information from Students' Registers (outputs for students refer to 31 December, for graduates to calendar year). Expert estimates are based on data by fields of study and a table of correspondence between KKOV (National Classification of Education), ISCED 97 and fields of study. Since a field of study with the same code may have various contents depending on university and thus its classification to codes of ISCED 97 may not be quite clear, the data should be taken as expert estimates.

Data for universities and data for higher professional schools are collected differently, using different methodologies, so data cannot be summed to provide a total.

Due to revision of the ISCED and KKOV converter the data in time series may differ from the previously published data.

Tables 21-5 to 21-10. **Research and development**

The terms **research** and **development** in the Czech Republic are defined in the Act on R&D Support from Public Funds. R&D is defined as **systematic creative work carried out for the purpose of obtaining or using new knowledge**.

Research is creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of human beings, culture and society, using methods allowing confirmation, widening or refuting of knowledge obtained. It includes:

- **basic research**, which is experimental or theoretical work undertaken to acquire knowledge of the basis of observed phenomena, to explain their causes and possible impacts when using obtained findings;
- **applied research**, which is experimental or theoretical work undertaken to acquire new findings for future use in practice. The part of applied research whose results are used in developing new products, technologies and services designed for business under special regulations (e.g. Commercial Code; the State Enterprise Act) is referred to as industrial research.

Development is systematic creative work drawing on existing knowledge gained from research and/or practical experience to produce new materials, products or equipment, introduce new or improved technologies, systems and services, including acquisition and testing of prototypes, pilot plants or demonstration plants.

The R&D data contained in this part of the chapter come from the annual R&D survey measuring human and financial resources designed for R&D activities. The survey is fully governed by EU and OECD methodological principles laid down in the Frascati Manual (OECD, Paris 2002) and Commission Regulation (EC) on statistics on science and technology.

Reporting units in the R&D survey are all legal and natural persons conducting R&D (creative work undertaken on a systematic basis to acquire new knowledge or use it in practice) in the Czech Republic as their principal (CZ-NACE Division 72 – Scientific research and development) or secondary economic activity, irrespective of the number of personnel, sector or CZ-NACE activity.

The R&D indicators are observed in the following four key **R&D sectors** derived from institutional sectors and sub-sectors used in the national accounts:

- **business enterprise sector**, which comprises all companies, organizations and institutions whose principal activity is market production of goods or services for sale to the general public at an economically significant price;
- **general government sector**, which comprises institutions of central and local government, except for publicly managed higher education institutions. This sector includes especially workplaces of the Academy of Sciences of the Czech Republic and other places of research under the competence of ministries (on 1 January 2007 the statute of most of these entities changed to

public research institutions), public libraries, archives, museums and other cultural establishments conducting R&D as their secondary activity;

- **higher education sector**, which comprises universities and other institutions of post-secondary education. It also includes all research institutes, experimental facilities and clinics whose work is directly controlled or managed by higher education institutions or they are associated with them. Since 2005, in compliance with OECD methodology, the sector also includes teaching hospitals. This sector is not a separate institutional sector of national accounting but has been separately identified by the OECD for its important role in R&D;
- **non-profit institutions serving households sector** (referred to as the “private non-profit sector”), which comprises private institutions, including private persons and households, whose primary aim is not profit formation but providing non-market services to households. They include, e.g., associations of research organizations, societies, unions, movements, federations or foundations.

Table 21-6. R&D personnel and R&D expenditure: by region

The data are broken down by **region** according to the **location** of R&D activities of reporting units, which are mainly individual faculties of universities but also certain research institutes under the competence of ministries.

Table 21-7. R&D personnel: by sector and occupation

R&D personnel include researchers, technicians and other supporting and administrative staff in the reporting units.

By occupation, R&D personnel are split into:

- **researchers**: professionals engaged in the conception or generation of new knowledge, products, processes, methods and systems or managing of such projects. They are mostly scientific specialists or heads of R&D departments;
- **technicians and equivalent staff** (referred to as “technicians”): persons who participate in R&D activities by performing scientific and technical tasks involving the application of concepts and operational methods, usually under the supervision of researchers;
- **other supporting staff** (referred to as “other personnel”): skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D activities or directly associated with such activities; included are also managers and office staff who provide direct support for R&D.

The number of R&D personnel is measured by two basic indicators – headcount (HC) and full-time equivalent (FTE):

- **headcount as at 31 December** refers to registered number of active R&D personnel employed (full or part-time) at the end of reference year in the reporting units;
- **full-time equivalent (FTE)** refers to average registered number of FTE R&D personnel. One FTE equals one-year (full-time) work of a member of personnel who is 100% engaged in R&D activities. For personnel engaged also in other activities, only the R&D-related working time is counted, so that overestimation of the number of personnel engaged in R&D is avoided. The indicator also includes the number of FTE persons working for the reporting unit under contract for work or contract of service. In 2005 the FTE calculation was changed in compliance with OECD requirements to improve the international comparability of national data. Starting from 2005, the FTE R&D personnel data are not comparable with those for previous years (1995–2004).

Table 21-8. Total R&D expenditure: by target sector and source of funds

Total expenditure is all R&D current and capital expenditure made within the statistical unit or economic sector irrespective of the source of funds. Included is also expenditure made outside the statistical unit but in support of R&D (e.g., purchase of supplies for R&D).

Among the sectors of R&D expenditure are the business enterprise sector, the general government sector, the higher education sector and the private non-profit sector. The sources of R&D funds include business enterprise, general government, funds from abroad and other national funds.

Funds from abroad are sources of institutions and individuals outside the political borders of the country. They are also all international organisations (European Commission, NATO, etc.), including their institutions within the country.

Table 21-10. Government budget appropriations or outlays for R&D by socio-economic objectives (GBAORD)

The data were received from the Government Council for Research and Development and the Ministry of Education, Youth and Sport of the CR. Complementary data are received directly from individual providers of state support for R&D. The methodology for data collection and processing is in the OECD Frascati Manual; data security is governed by Commission Regulation (EC) No. 753/2004. The classification of socio-economic objectives is in NABS – Nomenclature for the Analysis and Comparison of Science Programmes and Budgets (Eurostat, Rev. 1992).

Table 21-11. Enterprises with technological and non-technological innovation: 2006–2008

The data on innovation contained in this chapter were obtained from sample statistical survey taken for the period of 2006–2008 and involving a sample of reporting units selected from business enterprise sector in order to map the innovation potential of businesses in the Czech Republic. The methodology for data collection and processing is based on the OECD Oslo Manual, the European Council Decision No. 94/78 of 24 January 1994 and is fully in accordance with the methodology and recommendations of Eurostat. The basic set of statistical survey included reporting units of business enterprise sector from selected branches by CZ-NACE Rev. 2 with 10+ employees.

The subject matter of statistical survey was **technological innovation** (product innovation, process innovation, and ongoing or terminated innovation activities) and **non-technological innovation** (marketing innovation and organizational innovation).

Product innovation – products or services which are either completely new or their basic qualities are substantially better, offer a higher technical quality, well-established software or other intangible elements, wider utilization, higher satisfaction of customers.

Process innovation – new and markedly improved production technologies, new and substantially improved methods of providing services and offering the goods.

Marketing innovation – refers to introduction of a new marketing method involving important changes in product design or packaging, product placement, product support and estimation.

Organizational innovation – refers to introduction of a new organizational method in corporate business practice, job management or external relations in order to upgrade innovation capacity of an enterprise or to enhance performance.

Innovative enterprises are those which were introducing technological or non-technological innovation during the observed period. New definition of Eurostat has been in force since 2008.

Table 21-12. Innovation expenditure: 2008

In 2008, total innovation expenditure relating to innovation activities of enterprises in the observed period included: **intramural R&D, acquisition of R&D, acquisition of machinery and equipment** (progressive machinery, computer hardware specially purchased for introduction of new or markedly improved products and/or processes), **acquisition of other external knowledge** (purchase of patent rights and non-patented inventions, licences, know-how, trademarks, software and other forms of knowledge from other entities for purposes of their utilization in company innovations).

Table 21-13. Turnover of enterprises with product innovation: 2008

Total turnover of enterprises with product innovation is turnover achieved by innovative enterprises which introduced product innovation in the period of 2006–2008. **Unchanged or marginally modified products** are products and/or services lacking the element of “novelty” and are not considered as innovative.

Table 21-14. Patents granted in the Czech Republic

The **patent** is a public deed issued by national (in the Czech Republic by the Industrial Property Office) or international patent office which provides legal protection of the invention for up to 20 years on the territory for which it has been issued. A granted European Patent (EP) can be validated (by filing a Czech translation of the patent with the Industrial Property Office of the CR and paying the administrative charge) in the Czech Republic starting from 2003. Patents are granted on inventions which are novel, inventive and capable of industrial application.

The data are processed by the CZSO from data sources of IPO CR. Patent data are classified according to methodology set out in the OECD Patent Manual (OECD, Paris, 2008). The International Patent Classification (IPC) makes it possible to classify utility models and granted patents to technological areas. Patent data broken down by patent applicant's country are classified, using the fractional method (e.g., if two applicants from different countries file together a patent application, a half of the patent is assigned to each country).

Tables 21-15 and 21-16. Licences acquired and provided: patents and utility models

A **licence** is one of the possibilities to use industrial rights and intellectual property on a commercial basis. There are several criteria of dividing licences. The basic division is into licence provision (sale) – active licences, and licence acquisition (purchase) – passive licences.

A **licence agreement** refers to granting the right, in agreed scope and territory, of acquisition (purchase) or provision (sale) of patented or non-patented inventions, utility models, industrial designs, topography of semi-conductor products, new varieties of plants and animal breeds, or trademarks. The licence provider entitles the licence acquirer to exercise industrial property rights in agreed scope and territory and the licence acquirer undertakes to make agreed payment.

The data come from the annual licence survey measuring the number of licence agreements on some of the types of industrial property protection in the Czech Republic effective in the reference year and the value of licence fees paid/received by Czech entities in the reference year. Besides the total number of licence agreements effective in the reference year, the survey also measures newly concluded licence agreements, subject of licence agreements and country of contracting partner.

Data on the number of effective licence agreements and value of paid/received licence fees are the totals of data from collected questionnaires. Since the year 2007, mathematical and statistical methods have been used to make estimates for non-response.

Since 2008 the statistical form Lic 5-01 has been sent only to legal entities and, therefore, results are not fully comparable with previous years (up to 2007 also natural persons with valid licence agreements were sent the statistical form).

During the data processing for the reference year 2009, the data already published for the reference year 2008 were revised. Therefore, in some cases the data for the year 2008 do not have to correspond with the previously published data.

Table 21-17. External trade in high-tech goods

High-tech goods have been defined by the OECD in terms of the Standard International Trade Classification (SITC), Rev. 3. They are goods produced mostly in technologically advanced plants with high R&D intensity. High-tech goods are divided into nine basic groups. In 2010 EUROSTAT made an updated list of high-tech goods according to the new SITC, Rev. 4, which took effect in 2007. Due to substantial changes in the new version of this classification, the data on external trade in high-tech goods in individual categories before 2007 are not fully comparable. Therefore, only data from the year 2007 are newly published in the Statistical Yearbook. These data are not comparable with the data published in Statistical Yearbooks from previous years. Data for 2009 are preliminary.

Data come from data outputs of external trade statistics (External Trade Statistics Database of the CZSO). More detailed information is available in Chapter 11. External Trade.

Table 21-18. Technology balance of payments

Data on **receipts and payments** obtained from the **technology balance of payments (TBP)** show the volume of external trade in industrial property and advanced technology know-how. The idea and methodology of these statistics are based on the *Manual for the Measurement and Interpretation of Technology Balance of Payments Data – TBP Manual*, OECD, 1990.

Up to 2004 the data came from data sources of the Czech National Bank, namely from the current account of the balance of payments. Since 2005 the results of a CZSO direct survey among respondents on exports and imports of services have been used. Due to changes in the data collection methodology, only data starting from 2005 are published now. The individual TBP items are defined in the *EBOPS Classification (Extended Balance of Payments Services Classification)*.

Tables 21-19 and 21-20. High-tech sector and services by activity: key indicators

The high-tech sector definition includes high-tech economic activities. These activities, which produce high added value, are in the Czech Republic newly identified in the *Classification of Economic Activities (CZ-NACE)* – tables present abbreviated names for individual categories of high-tech activities:

1. High-tech manufacturing sector:

Manufacture of pharmaceutical products:

Division 21 – Manufacture of basic pharmaceutical products and pharmaceutical preparations

Manufacture of ICT and their parts:

Group 26.1 – Manufacture of electronic components and boards

Group 26.2 – Manufacture of computers and peripheral equipment

Group 26.3 – Manufacture of communication equipment

Group 26.4 – Manufacture of consumer electronics

Group 26.8 – Manufacture of magnetic and optical media

Manufacture of other electronic and optical instruments:

Group 26.5 – Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks

Group 26.6 – Manufacture of irradiation, electromedical and electrotherapeutic equipment

Group 26.7 – Manufacture of optical instruments and photographic equipment

Manufacture of aircraft and related machinery:

Group 30.3 – Manufacture of air and spacecraft and related machinery

2. High-tech services sector (Table 21-20):

Media activities:

Division 59 – Motion picture, video and television programme production, sound recording and music publishing activities

Division 60 – Programming and broadcasting activities

Group 63.9 – Other information service activities

ICT activities:

Division 61 – Telecommunications

Division 62 – Computer programming, consultancy and related activities

Group 58.2 – Software publishing

Group 63.1 – Data processing, hosting and related activities; web portals

Group 95.1 – Repair of computers and communication equipment

Architectural and engineering activities:

Group 71.1 – Architectural and engineering activities and related technical consultancy

Group 71.2 – Technical testing and analysis

Research and development:

Group 72.1 – Research and experimental development on natural sciences and engineering

Group 72.2 – Research and experimental development on social sciences and humanities

Introduction of the new Classification of Economic Activities CZ-NACE, which replaced the previously used Industrial Classification of Economic Activities (OKEČ), has resulted not only in a different arrangement of individual activities inside the high-tech sector, but also in specification of the area of activities defined as industry or services. According to the Eurostat requirement there has been a fundamental change in definition as well as classification of new activities in high-tech services compared to the past. That is why the new data on high-tech sector are not comparable with the data published in Statistical Yearbooks from previous years.

Indicators in these tables, except for R&D expenditure (source: R&D annual survey – VTR 5-01), were obtained from the annual structural survey of business entities from selected production sectors providing a more detailed range of final data, which are available with a greater time delay. The first reference period for data processing according to the new classification CZ-NACE was the year 2008 in case of structural (annual) statistics. Data for 2005–2007 are based on the retroactive conversion of structural data, which had not been finally completed at the closing date of the Statistical Yearbook due to time and methodological demands. Therefore, the results in these tables are published as preliminary and may be subsequently revised. More detailed information about the data from annual structural survey of business entities from selected production sectors, including definitions of individual indicators, is available in Chapter 15. Industry and in Chapter 18. Trade, Hotels, Restaurants and Tourism.

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More detailed information on science and research is available in other CZSO publications published in accordance with the Catalogue of Publications 2010 in thematic group 9 – SERVICES, subgroup 96 – Science and Research:

– 9601-10 “Research and Development Indicators 2009” (Czech-English) – October 2010

– 9605-10 “Innovation Activities of Enterprises in the Czech Republic in 2006–2008” (Czech-English) – March 2010

– 9611-09 “Government Budget Appropriations or Outlays for R&D (GBAORD) in the Czech Republic in 2009” (Czech-English) – November 2010

and in publication not included in the Catalogue of Publications 2010:

– “Statistical Yearbook of Science, Technology and Innovation 2010” (Czech and English) – September 2010

Further data can be found on the website of the Czech Statistical Office at:

– http://czso.cz/eng/redakce.nsf/i/science_and_research_veda