22. SCIENCE AND RESEARCH

Science and research statistics aims to provide basic data on key areas of **science, technologies and innovations** in the Czech Republic from the point of view of financial and human resources entering science, technologies and innovations as well as their results such as innovations, granted patents or external trade with high-tech production.

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.

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 by which they are implemented.

An **innovation** – it is the implementation of a new or significantly improved product (goods or service) or a process, new marketing method, or a new organisational method in business practices, workplace organisation or external relations.

Data provided in this chapter were obtained mainly from regular statistical surveys of the CZSO, primarily from the survey on research and development, statistical task GBAORD, survey on innovation activities of enterprises and other data sources of the CZSO. In some cases, data from other national data sources were obtained (e.g. Industrial Property Office of the CR or Institute for Information on Education). The survey on innovation activities of enterprises is carried out once in two years and therefore data on innovations are presented in the Statistical Yearbook of the CR every two years, i.e. they will be available again in the Statistical Yearbook of the CR 2012.

Notes on Tables

Table **22**-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:

– they have successfully completed **tertiary education** (ISCED levels 5A, 5B, and 6) in any field of study and/or

– they are **employed in science and technology occupations** (CZ-ISCO major groups 2 and 3).

Persons with completed tertiary education in **science** and **engineering** are considered from the point of view of education to be the basis of tertiary educated population for the area of science and technologies. It applies to persons with education in the area of science (life sciences, physical sciences, mathematics and statistics, and computing – ISCED field of education broad group 4) and in engineering, manufacturing and construction (ISCED broad group 5).

Among persons employed in science and technology occupations there is a very narrow group of persons called **scientists and engineers**. They are scientists and professionals employed in physical, mathematical, and engineering occupations (CZ-ISCO, sub-major group 21) and life science and health occupations (CZ-ISCO, sub-major group 22).

Data originate from the Labour Force Sample Survey (LFSS) of the CZSO (the table provides average data of the relevant year). More detailed data on the LFSS are available in the Chapter **10.** Labour Market, part B.

In 2010 the methodology changed and therefore as for persons employed in science and technology the data for the year 2010 are not fully comparable with those of previous years.

*Table **22**-2. **Persons with tertiary education***

   Tertiary level of education is defined according to the International Standard Classification of Education (ISCED-97) and it comprises 5A, 5B, and 6 levels. Tertiary education is split into higher education and higher professional education. Higher education is provided at universities and higher professional education is provided by higher professional schools. In the Czech Republic, since 2001, higher education has been divided to three levels: bachelor's degree programme, master's degree programme, and doctoral degree programme (see Chapter **23**. Education).

   Data on persons with completed tertiary education in **science and engineering fields of education** and persons with completed tertiary education in **doctoral degree programmes** at universities are from the point of view of qualified human resources for science and technology considered to be the most important.

   Data originate from the Labour Force Sample Survey (LFSS) of the CZSO (the table provides average data of the relevant year). More detailed data on the LFSS are available in the Chapter **10.** Labour Market, part B.

*Table **22**-3. **Scientists and engineers***

   Scientists and engineers are a narrow group of experts employed in science and technology occupations. They increase the existing stock of knowledge, apply scientific or artistic concepts and theories, teach about the foregoing in a systematic manner or engage in any combination of these activities in the following fields that is their main source of income:

– Physical, mathematical and engineering science professionals (CZ-ISCO sub-major group 21) or

– Life science and health professionals (CZ-ISCO sub-major group 22).

   The data on the **numbers** of scientists and engineers come from the Labour Force Sample Survey (LFSS) of the CZSO (the table presents average data of the relevant year). More detailed data on the LFSS are available in the Chapter **10.** Labour Market, part B.

   In 2010 the methodology changed and therefore the data for the year 2010 are not fully comparable with those of previous years.

   Data on **wages** of scientists and engineers come from structural wage statistics. The amount of the average gross monthly wage shown in the table is not estimated for the entire population and it applies to the survey sample (about 1.7 million employed persons). More detailed data on structural wage statistics in the breakdown by occupation (Classification of Occupations, CZ-ISCO) are available in Chapter **10.** Labour Market, part A, namely in the notes below the Tables **10**-4 and **10**-5.

*Table **22**-4. **Students and graduates of universities of science and engineering fields of education***

   The table contains the total **number of higher education students and graduates** (ISCED levels 5A 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).

   The data come from data sources of the Institute for Information on Education (IIE), namely from the "SIMS" database (i.e. Union Information from Students' Registers). Since a field of study with the same code may have various contents at different universities (and thus it is problematic to classify students to relevant groups of fields of study), **expert estimates of the IIE** are given for the breakdown by field of study. The expert estimates are based on data by field of study and a table of correspondence between CBBE (Classification of Basic Branches of Education), ISCED 97, and fields of study.

   Data on students of universities are always related to 31 December of the relevant year; data on graduates apply to the entire school year.

   Total sums of students do not have to be equal to the sums of types of programmes and groups of fields of study, because one student may study more fields at more universities at the same time and in the total indicator such a student is counted only once.

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

Tables 22-5 to 22-10. **Research and development**

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.*

Development *is systematic creative 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, including acquisition and testing of prototypes, pilot plants or demonstration plants.*

Characteristics of research and development *(hereinafter only R&D) are observed by the* **Annual questionnaire on research and development***, which includes questions on human and financial resources determined for R&D activities realized on the territory of the Czech Republic in all sectors of R&D performance. The statistical survey fully complies with methodological principles of the EU and OECD mentioned in the Frascati Manual (OECD, Paris 2002) and the Commission Regulation (EC) No. 753/2004 as regards statistics on science and technology.*

Reporting units *in the R&D survey are all legal and natural persons performing R&D on the territory of the Czech Republic as their principal (CZ-NACE 72 – Scientific research and development) or secondary economic activity, irrespective of the number of personnel, sector or CZ-NACE activity.*

Sector of research and development performance *is a basic category used in R&D statistics, which groups all institutional units performing R&D based on their main functions, behaviour, and targets. R&D indicators are usually measured and published, also at an international level, in four sectors of R&D performance (hereinafter only sectors) – business enterprise, government, higher education, and private non-profit. These sectors were defined based on the Nomenclature of Institutional Sectors and Subsectors (ISEKTOR) used in the National Accounts (ESA95 system) and definitions given in the Frascati Manual:*

– **business enterprise sector** *(ISEKTOR 11: Non-financial corporations; 12: Financial corporations; 141: Employers and 142: Own-account workers), which comprises all companies, organizations and institutions, principal activity of which is market production of goods or services for sale to the general public at an economically significant price. In the Czech Republic, R&D is performed in the business enterprise sector in about 2.5 thousand enterprises;*

– **government sector** *(ISEKTOR 13: General government) comprises bodies of central and local government, except for publicly managed higher education institutions (CZ-NACE 854). 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 R&D institutions), public libraries, archives, museums and other cultural establishments performing R&D as their secondary activity. In the Czech Republic, R&D is performed in the government sector at about 200 workplaces and about half of them are public research institutions;*

– **higher education sector** *(CZ-NACE 854: Higher education) comprises all public and private universities and other institutions of post-secondary education and also all research institutes, experimental facilities and clinics, work of which is directly controlled or managed by higher education institutions or they are associated with them (teaching hospitals). This sector is not a separate institutional sector but it has been separately identified by the OECD for its important role in R&D. In the Czech Republic, R&D is performed in the higher education sector in about 150 faculties of 28 public and state universities, 26 private universities and in 11 teaching hospitals;*

– **private non-profit sector** *(ISEKTOR 15: Non-profit institutions serving households, 14: Households except of 141 and 142) 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. Private non-profit sector is insignificant as for R&D performance. In 2010 its contribution to total R&D expenditure spent in the Czech Republic was only 0.5%.*

Data on R&D expenditure financed from business enterprise sources and from abroad differ from the data published before, because in 2011 they were recalculated backwards based on newly obtained information that enabled to better classify the data in the government sector.

Table *22-6. R&D personnel and expenditure by region*

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

Table *22-7. R&D personnel by sector of performance*

*Persons employed in research and development (hereinafter only **R&D personnel**) by **occupation**:*

*– **researchers**, who are 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**, who participate in research and development by performing scientific and technical tasks involving the application of concepts and operational methods, usually under the supervision of researchers;*

*– **other research and development 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** refers to the registered number of persons fully or partially engaged in research and development activities, employed in the reporting units in main or secondary employment as at the end of the reference year. Primarily in the higher education and partially also in the government sector, a huge amount of R&D personnel, especially researchers, have an employment contract in more entities. Therefore, in these sectors, the indicator is overestimated and thus it does not speak about the real number of persons working in R&D;*

*– **full-time equivalent (FTE)** refers to the 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. The FTE indicator also includes the number of persons working for the reporting unit under various contracts for work converted according to the methodology valid for the FTE.*

Table *22-8. R&D expenditure by sector of performance*

***Total research and development expenditure** includes all current (wage and other) and capital expenditure determined for R&D performed in observed businesses on the territory of a given country made during the reference year regardless the source of the funds.*

*The amount of R&D expenditure made in individual sectors of performance is measured by the following **main sources of funds** of R&D activities:*

*– **business enterprise**, comprising of own sources of observed enterprises determined for R&D performed in the enterprise and business enterprise sources of businesses doing their business on the territory of a given country for R&D performed in other enterprises or at universities or public research institutions. At the government and higher education sectors, financing from business enterprise sources includes mainly revenues from sale of R&D services (orders for R&D) and income from licence fees (royalties) for intangible results of R&D;*

*– **government**, which originate from the state budget or budgets of regions determined for R&D performed on the territory of the Czech Republic;*

*– **abroad**, which includes all financial sources for R&D provided from abroad. In the case of the Czech Republic, it includes mainly sources of international organizations (European Union, NATO, etc.) including their facilities and operations within the country (public sources from abroad), sources of parent companies financing R&D in their foreign affiliates in the Czech Republic, and income from*

sale of R&D services (orders for R&D) including income from licence fees (royalties) for intangible results of R&D obtained from foreign private entities (private sources from abroad).

*Besides the above-mentioned main sources, also **other national sources** contribute to R&D financing, which comprise mainly of own sources of universities and private non-profit institutions originating neither from the state budget, the business enterprise sector, nor from abroad. These sources are insignificant in the CR within the total R&D expenditure.*

Data on R&D expenditure made in the government sector financed from business enterprise sources and from private sources from abroad differ from the data published before, because in 2011 they were recalculated backwards based on newly obtained information that enabled their better classification.

*Table **22**-10. **Government budget appropriations or outlays for R&D by socio-economic objectives***

The annual statistical task GBAORD (Government Budget Appropriations or Outlays for R&D) has been carried out in the CR since 2002. The target of the task is to ensure data on the state support of R&D from government budgets in the breakdown by socio-economic objectives or identification of key areas of R&D to which the state support is directed.

The GBAORD statistical task is carried out within the EU as an obligatory survey based on the Commission Regulation (EC) No. 753/2004 and the methodology contained in the Frascati Manual (OECD, 2002) with the aim to identify key areas of R&D to which the state support of R&D is directed in the breakdown by socio-economic objectives (Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets, NABS, 1992 revision, Eurostat 1994).

In the Czech Republic, GBAORD statistics is ensured by the CZSO in cooperation with the Research and Development Council via the R&D Information System. Additional data are obtained directly from individual providers of the state support of research and development.

Total GBAORD comprise all financial sources provided from government budgets on the support of R&D including finances flowing to R&D abroad. The public sources for R&D exclude, according to the valid international methodology, support of R&D realized via loans to be repaid, pre-financing of programmes of the EU covered by income from the European Union and support of innovations.

All data on the total direct support of R&D from the state budget result from data shown in the final account of the state budget of the CR for the area of R&D. Thus, it applies to expenditure, which was really drawn for R&D in the given year and not amounts stated in the Act on the State Budget of the CR.

*Table **22**-11. **Patents granted in the Czech Republic***

*A **patent** is a public deed issued by the relevant patent office, which provides legal protection to an invention for the period of up to 20 years (provided that maintenance fees are paid), namely on the territory for which it was issued by the office. Patent protection on the territory of the Czech Republic is ensured by the Industrial Property Office of the CR (hereinafter only IPO CR).*

*Patents are granted for **inventions**, which are novelties; they are a result of activity of inventors and are industrially applicable. The following can be patented: not only products and technologies, but also chemically produced substances, drugs, industrial production microorganisms, as well as microbiological ways and products obtained by those ways. What cannot be patented, on the contrary, are discoveries or scientific theories, programmes for computers, new cultivars of plants and breeds of animals or ways of surgical or therapeutic treatment of human or animal bodies, and diagnostic methods used at human or animal bodies.*

***Patent statistics** brings information about results and successfulness of research, development and innovation activity in selected areas of technology. Data in this chapter were processed by the CZSO based on data sources of the IPO CR. Patent data are broken down according to the Patent Manual of the OECD (OECD, Paris 2009). Based on the International Patent Classification (IPC) it is possible to classify granted patents to selected technological areas.*

Patent data by **way of patent granting** are broken down to patents granted in the national way by the IPO CR or European patents validated in the Czech Republic by the IPO CR. The second possibility is used mainly by foreign applicants.

Patent data broken down by **applicant's country of origin** 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).

Data on the number of patents belonging to domestic entities are further available in the breakdown by main sector, in which R&D is performed defined in the notes on Tables **22**-5 to **22**-10. Natural persons not in business are an independent category.

Table **22**-12. **Patent licences**

A **licence** is one of the possibilities to use industrial rights and intellectual property on a commercial basis. **Licence agreement** refers to granting of the right, in an agreed scope and on an agreed territory, for acquisition or provision of patented or non-patented inventions. The licensor entitles the licence acquirer to exercise industrial property rights in an agreed scope and on an agreed territory and the licence acquirer undertakes to provide some payments (licence fees) or other asset.

The basic division is according to whether the subject of a licence is **provided** (active licence) or **acquired** (passive licence).

By **subject of a licence** there are **patent licences**, the subject of which is to provide the right to use a valid patent either in the country of the purchaser or in countries, to which the purchaser of the licence intends to export the licence product, **utility model licences**, the subject of which is an industrial design or utility model, **know-how licences**, the subject of which is to provide unprotected production and technical knowledge or experience.

The Czech Statistical Office surveys data on licences valid on the territory of the Czech Republic in the area of industrial property protection since the year 2005 by the Annual questionnaire on licences. It is an exhaustive survey. From the point of view of dissemination of results of research and development and their capitalization, the most important subjects of licence agreements are provided **patent licences**, on which the CZSO primarily focuses in its survey. **Reporting units** in the survey on provided patent licences are since 2008 all legal persons with a valid patent for the territory of the Czech Republic as at 31 December of the reference year.

Data on the number of patent licensors and the value of received licence fees (royalties) are always the totals of processed data from collected questionnaires. Since the year 2007, mathematical and statistical methods have been used to make estimates for non-response.

Data on provided patent licences are available in the breakdown by institutional sector (business enterprise, government, higher education) defined in harmony with the methodology of sectors, in which R&D is performed (see definitions in the notes on Tables **22**-5 to **22**-10. Research and development).

Table **22**-13. **External trade in high-tech goods**

High-tech goods are goods produced mainly in technology intensive operations. At the same time, development of such products is accompanied by high costs either for innovation and/or for research and development. For the needs of external trade statistics, high-tech goods are defined by the Standard International Trade Classification (SITC).

In 2010, Eurostat elaborated an updated list of high-tech goods based on the new SITC Rev. 4 classification, which became effective in 2007. Due to significant changes in the new version of the classification, data on external trade with high-tech goods in individual categories before 2007 are not fully comparable and therefore the data are published in the Statistical Yearbook of the CR from 2007. According to the SITC Rev. 4, high-tech goods are divided to the following nine basic aggregations:

– Electronics-telecommunications,

– Electrical machinery,

– Pharmacy,

– Chemistry,

– Aerospace,

– Non-electrical machinery,

– Scientific instruments,

– Computers-office machines,

– Armament.

*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 **22**-14. **Technology balance of payments***

Technology balance of payments is the main basis characterizing sale/purchase of intangible technology of a given country in relation to other economies. Data on receipts (or payments) received within external trade with technology services express technological level of an economy or rather inform about the scope of external trade with industrial property and knowledge related to advanced technologies.

*Basic methodology and concept of **technology balance of payments statistics**, which comprises external trade with technology, is based on the Technology Balance of Payments Manual (TBP Manual, OECD, 1990).*

***Data on exports and imports of technology** come from a direct survey of the CZSO among respondents on exports and imports of services. Individual TBP items (receipt/payment items) are defined based on the EBOPS (Extended Balance of Payments Services Classification) as follows:*

Royalties and licence fees (code 266);

Acquisition/disposal of non-produced, non-financial assets (code 640, 480 in EBOPS);

Computer services (code 263);

Architectural, engineering and other technical services (code 280);

Research and development (code 279).

*Tables **22**-15 and **22**-16. **Basic indicators of enterprises in high-tech sector***

*The group of industries with high technology intensity (hereinafter only **high-tech sector**) comprises economic activities using for their production advanced technologies in a large extent and the development of outputs of these activities is accompanied by high costs either for innovation and/or for research and development. These economic activities at the same time generate a higher value added.*

The high-tech sector consists of group of activities belonging to high-tech manufacturing and high-tech services. A list of activities, which belong to the high-tech sector, was updated by Eurostat in 2010 by means of the Statistical classification of economic activities NACE Rev. 2 valid since 2008. Those businesses are classified to the high-tech sector the prevailing activity of which belongs to the following divisions and groups of CZ-NACE:

***High-tech manufacturing industries** (Table **22**-15):*

Manufacture of pharmaceuticals:

division 21 – Manufacture of basic pharmaceutical products and pharmaceutical preparations

Manufacture of computers and electronic components:

group 26.1 – Manufacture of electronic components and boards

group 26.2 – Manufacture of computers and peripheral equipment

Manufacture of consumer electronics and optical instruments:

group 26.3 – Manufacture of communication equipment

group 26.4 – Manufacture of consumer electronics

group 26.7 – Manufacture of optical instruments and photographic equipment

group 26.8 – Manufacture of magnetic and optical media

Manufacture of scientific electronic equipment:

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

Manufacture of aircraft and related machinery:

group 30.3 – Manufacture of air and spacecraft and related machinery

High-tech service industries *(Table **22**-16):*

Media activities:

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

division 60 – Programming and broadcasting activities

Telecommunications:

division 61 – Telecommunications

IT activities:

division 62 – Computer programming, consultancy and related activities

Information service activities:

division 63 – Information service activities

Research and development:

division 72 – Scientific research and development

*Indicators in these tables, except for R&D expenditure (source: R&D annual survey), were obtained from the annual structural survey of business entities from selected production industries (**SBS – Structural business statistics**) providing a more detailed range of final data, which are available with a greater time delay. In the case of SBS the first reference period for data processing according to the new classification CZ-NACE was the year 2008. Data for 2005–2007 are based on the retroactive conversion of structural data. More detailed information about the data from the SBS, including definitions of individual indicators, is available in Chapter **15**. Industry and in Chapter **18**. Trade, Hotels, Restaurants and Tourism.*

*   *   *

More detailed information on science and research is available in other CZSO publications published in accordance with the Catalogue of Publications 2011 in the thematic group SCIENCE, IT, subgroup – Research and Development:

– 9601-11 "Research and Development Indicators 2010" (Czech-English) – October 2011

Further data can be found on a web page of the Czech Statistical Office at:

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