

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.). Thus, while science is concerned about how and why certain things happen, technology is focusing 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 organizational 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. the Industrial Property Office of the CR, the Research and Development Council, or the Ministry of Education, Youth and Sports of the CR).

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 education 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 science and engineering professionals, health professionals, and information and communications technology professionals.

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 programme, master programme, and doctoral 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 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:

- Science and engineering professionals (CZ-ISCO sub-major group 21);
- Health professionals (CZ-ISCO sub-major group 22);
- Information and communications technology professionals (CZ-ISCO sub-major group 25).

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 the ISCED 97 (ISCED broad groups 4 and 5).

The data come from data sources of the Ministry of Education, Youth and Sports of the CR, namely from the "SIMS" database (i.e. Union Information from Students' Registers). Since a field of education 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 education), **expert estimates** are given for the breakdown by field of education. The expert estimates are based on data by field of education and a table of correspondence between the CBBE (Classification of Basic Branches of Education), the ISCED 97, and fields of education.

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 education, 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 the revision of the ISCED and the CBBE table of correspondence 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 the 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 individual sectors of R&D performance. The statistical survey fully complies with methodological principles of the EU and the 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 (the 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 public research 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 of 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 the 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 individual reporting units, which are mainly individual faculties of universities but also some 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 are managing 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** – craftsmen, secretarial and clerical staff participating in R&D activities or involved in such activities; included are also managers and administrative 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 originates 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 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 (the 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 from the state budget in the given year and not amounts approved in the Act on the State Budget of the CR.

Tables 22-11 and 22-12. Innovating enterprises

Data on innovations contained in this chapter have been obtained based on a statistical survey on innovations in enterprises, which is carried out in order to map innovation potential of enterprises doing their business in the Czech Republic. The methodology of collection and processing of data results from the Oslo Manual of the OECD, the Council Decision 94/78/EC, Euratom of 24 January 1994 and it is fully in accordance with the methodology and recommendations of Eurostat. The universe population of the statistical survey contains reporting units of the business enterprise sector with 10+ employees in selected key branches according to the Industrial Classification of Economic Activities (OKEČ) Rev. 1.1 and starting from 2008 according to the CZ-NACE Rev. 2 classification.

The statistical survey measures technological innovation activities (product innovation, process innovation) and non-technological innovation activities (marketing innovation, organisational innovation).

Product innovation – products or services, which are either absolutely new or have substantially better basic characteristics, higher technical quality, implemented software or other intangible elements, wider usage, higher satisfaction of a customer.

Process innovation – new and significantly improved production technologies, new and substantially improved ways of providing of services and offering of goods.

Marketing innovation – it is the implementation of a new marketing method containing important changes in the design of a product or packaging, product placement, product promotion or pricing.

Organizational innovation – it is the implementation of a new organizational method in the business practices of an enterprise, workplace organization or external relations with the aim to improve quality of the innovation capacity of the enterprise or its performance characteristics.

Innovating enterprises are enterprises, which were during the reference period implementing technological or non-technological innovation.

Tables 22-13 and 22-14. **Expenditure on product and process innovations**

Total innovation expenditure related to product and process innovations in the reference period comprise: intramural research and development, acquisition of results from extramural research and development, acquisition of machinery and equipment (progressive machinery, computer hardware bought especially for implementation of new or substantially 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 in order to use them in innovations of the enterprise).

Tables 22-15 and 22-16. **Sales of enterprises with product innovation**

Total sales of enterprises with product innovation are sales at innovating enterprises, which implemented product innovation. Unchanged or marginally modified products are products and/or services, which lack the characteristics of a “novelty” and they are not considered to be innovated.

Table 22-17. **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 national granted patents 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 so-called 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 institutional sector (business enterprise, government, and higher education) defined in accordance with the methodology of sector of research and development performance (see definitions in the notes on Tables 22-5 to 22-10. Research and development). Private persons are a separate category.

Table 22-18. **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 of licences 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 2007, mathematical and statistical methods have been used to make estimates for non-response (i.e. data for reporting units, which have not submitted the questionnaire in the determined term).

Data on provided patent licences are available in the breakdown by institutional sector (business enterprise, government, and higher education) defined in accordance with the methodology of sector of research and development performance (see definitions in the notes on Tables 22-5 to 22-10. Research and development).

Table 22-19. 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 also in the methodological part of Chapter 11 External Trade.

Table 22-20. 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 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 (the Extended Balance of Payments Services Classification) as follows:

- Royalties and licence fees (code 266);
- Acquisition/disposal of non-produced, non-financial assets (code 480);
- Computer services (code 263);
- Architectural, engineering and other technical services (code 280);
- Research and development (code 279).

Tables 22-21 and 22-22. 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 the CZ-NACE:

High-tech manufacturing industries (Table 22-21):

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 22-22):

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, however, available with a greater time delay. In the case of the 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 annual SBS, 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 Products 2012 in the thematic group SCIENCE, IT, subgroup – Research and Development:

- 9601-12 “Research and Development Indicators (2011)” (Czech-English) – December 2012
- 9605-12 “Innovation activities of enterprises in the Czech Republic (2008–2010)” (Czech-English) – April 2012

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

- www.czso.cz/eng/redakce.nsf/i/science_and_research_veda