13. SCIENCE AND TECHNOLOGY, INFORMATION SOCIETY

A. SCIENCE AND TECHNOLOGY

***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 two fundamental forms: (i) tangible: knowledge embodied in physical objects (machinery, equipment, instruments, etc.) or (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 knowledge embodied in an institutional form – i.e. arrangement of activities and relations (organizational structure, management system, standards, regulations, etc.). Hence, while science is concerned about how and why certain things occur, technology is focussed on the means of their implementation.*

Notes on tables

*Tables **13**-1 and **13**-2. **Human resources in science and technology***

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

*– successfully completed **tertiary education**;*

*– not formally qualified as above, but **employed in S&T occupations** where the above qualification is normally required.*

*Human resources in science and technology are monitored within the framework of the HRST system as a **stock** at a certain time (existing labour force with corresponding education and qualifications – see Table **13**-1) and **flows** (potential labour force with corresponding education and qualifications available in the future – see Table **13**-2).*

*Table **13**-1. **Human resources in science and technology (HRST stock): by field of study and occupation***

Data on the HRST national stock are measured in the following three main categories:

*1) persons aged 15+ who completed successfully the **tertiary level of education** (ISCED 5B, 5A and 6) in the following main groups of fields of study: education; humanities and arts; social sciences, business and law (social and behavioural science, journalism and information, business and administration, law); science (life sciences, physical sciences, mathematics and statistics, computing); engineering, manufacturing and construction; health and welfare; agriculture (agriculture, forestry and fishery; veterinary); and other sciences (general education, services, and not known or unspecified). The science and engineering, manufacturing and construction fields of study are considered as the narrowest basis in terms of HRST measurement. Social sciences, business and law, health and welfare, and agriculture are also classified as basic fields of study;*

*2) persons employed in the national economy whose main working activity comes within **scientific occupations** (CZ-ISCO-R major group 2: Professionals) or **technical occupations** (CZ-ISCO-R major group 3: Technicians and associate professionals), which are the main source of their incomes from work;*

*CZ-ISCO-R sub-major groups of occupations 21 (Physical, mathematical and engineering science professionals) and 22 (Life science and health professionals) make up the basic category within the framework of S&T occupations. Persons employed in these professions are referred to as **scientists and engineers**;*

*3) persons who satisfy both the condition of successful completion of tertiary education and the condition of S&T occupation make up the **HRST core** (they are most valuable for the HRST system—they take an active part in scientific and technological development).*

***National stock of HRST, total** comprises all persons who meet at least one of the conditions for being classified to the HRST category. It is calculated as follows: HRST core + persons with completed tertiary education not employed in S&T occupations + persons without completed tertiary education but employed in S&T occupations.*

The presented data come from the labour force sample survey conducted by the CZSO (the tables give averages for a given year).

*Table **13**-2. **Tertiary students and graduates in science and engineering fields of study***

*The table gives the total **number of students and graduates from the tertiary level of education** (ISCED 5B, 5A and 6) in the fields of study 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). These students and graduates are flows (potential in the students and real in the graduates), which enter the HRST system.*

The data have been obtained from data sources of the Institute of Information on Education.

*Table **13**-3 to **13**-9. **Research and development***

*The concept 'research and development' is defined in the Czech Republic by Act No. 130/2002 Sb., on the Support for Research and Development from Public Funds and on Amendments to Certain Related Acts. For the purpose of the Act, 'research and development' is defined as **systematic creative work carried out to obtain new knowledge or to use it**.*

***Research** comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, using methods which allow confirming, supplementing or refuting the knowledge obtained. It includes:*

*– **basic research**, which is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts to explain causes thereof and possible impacts when the observed facts are used, and*

*– **applied research**, which is experimental or theoretical work undertaken to acquire new knowledge directed to future practical uses. The part of the applied research whose results are used through development in new products, technologies and services designed for business under special regulations (e.g. Commercial Code; Act No. 77/1997 Sb., on the State Enterprise, as amended) is referred to as industrial research.*

***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 equipment, introducing new technologies, systems and services, or improving substantially those already produced or introduced, including acquisition and testing of prototypes, pilot plants or demonstration plants.*

The research and development (R&D) data contained in this part of the chapter were obtained from the results of a regular annual statistical survey on research and development (measurement of human and financial resources designed for research and development activities). The survey covers all businesses having R&D as their principal or secondary activity, irrespective of the number of employees. It is fully governed by EU and OECD methodological principles laid down in the Frascati manual (OECD, Paris 2002) and Commission Regulation (EC) No. 753/2004 of 22 April 2004 implementing Decision No. 1608/2003/EC of the European Parliament and of the Council as regards statistics on science and technology.

Since the year 2001, mathematical and statistical methods have been used to make estimates for reporting units that failed to supply completed questionnaires by the deadline (estimates for non-response).

The R&D indicators are measured in the following four key sectors, where R&D activities are carried out, derived from institutional sectors and sub-sectors used in national accounts:

– ***business 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 authorities of central government and self-government at all levels, except for publicly managed higher professional and university education;*

– ***higher professional and university education sector,*** *which comprises universities, colleges of technology, 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 professional and university education establishments or they are associated with them. This sector is no separate institutional sector of national accounting, but was separately identified by the OECD for its important role in research and development;*

– ***non-profit institutions serving households sector*** *(NPISH sector), which comprises private institutions, including private persons and households, whose primary goal or function is not to make profits, but provide non-market services to households. They include, e.g., associations of research organizations, societies, trade and other unions, movements, federations, foundations, religious societies, etc.*

The R&D indicators are measured by fields of science, in which the reporting unit largely pursues its research and development activities. The fields of science, as defined by the Frascati manual, are:

– ***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, and other engineering sciences and technologies (chemical, aeronautical and space, mechanical, food, metallurgical, clothing, etc.);*

– ***medical sciences****: basic medicine, clinical medicine, health sciences and allied fields;*

– ***agricultural sciences****: agriculture, forestry, fisheries and allied sciences; veterinary medicine;*

– ***social sciences****: psychology, economics, educational sciences (education and training and other allied subjects), and other social sciences (anthropology, ethnology, demography, geography, town and country planning, management, law, linguistics, political sciences, sociology, etc.);*

– ***humanities****: history, languages and literature, other humanities (philosophy, arts, art history, religion, etc.).*

Since 2001, the R&D data are also measured ***by region****, according to R&D workplaces of reporting units.*

Table ***13****-3.* ***Main research and development aggregates***

R&D employees *are research workers directly engaged in R&D, as well as auxiliary workers, technicians, administrators and other persons working at R&D workplaces of the reporting units. They also include employees in charge of providing direct services for R&D activities. Their formal job attachment is contract of employment, contract for work or contract of service.*

The way of measuring and recording R&D employees:

– ***the registered number of employees as of 31 December*** *in terms of actual persons (headcount) refers to the number of persons active, fully or in part, in R&D activities (human resources in research and development). Before 2001 the number also included contracts for work and contracts of service in R&D in force as of the end of a reference year;*

– ***the number of contracts for work or contracts of service in R&D*** *concluded during a reference year (this indicator was measured in 2001 to 2004); since 2005 the number of persons under R&D contracts for work or contracts of service;*

– ***the average registered number of R&D employees, in terms of full-time equivalent*** *(FTE).One FTE equals one-year (full-time) work of an employee who is 100% engaged in R&D activities. For employees also engaged in other activities than R&D, only the R&D-related working time is counted in, so that overestimation of the number of employees engaged in R&D will be avoided. The FTE indicator also takes account of the number of persons working for the reporting unit under contracts for work or contracts of service, adjusted as the FTE methodology dictates. Before 2005, the CZSO derived FTE from the reporting units' records where employees were divided into intervals 0-30%, 30-70%, 70-100% of working time devoted to R&D; since 2005 FTE is calculated directly by the reporting units according to time devoted to R&D.*

Intramural expenditures on R&D *(R&D expenditures) are all expenditures for R&D performed within a reporting unit or sector of the economy, irrespective of the source of funds. Expenditures made outside the reporting unit or sector but in support of intramural R&D (e.g. purchase of supplies for R&D) are included. The intramural R&D expenditures consist of:*

– non-investment R&D expenditures*, further split into:*

– ***total wages*** *of registered R&D employees, whose volume corresponds to the share of the working time spent on R&D activities and includes health and social insurance contributions paid by employers for their employees;*

– ***remuneration for work or service as laid down in contracts for work and contracts of service*** *in the area of R&D performed outside the employment relationship;*

– ***other non-investment expenditures*** *(on material, supplies and equipment to support R&D activities of the reporting unit and on services hired or purchased for R&D). Depreciation of buildings, machinery and mechanical equipment is not included in the statistical measurement of intramural R&D expenditures;*

– acquisition of intangible and tangible fixed assets *for R&D, further split into:*

– ***land, buildings and structures*** *– expenditures on land acquired for R&D needs (e.g. experimental laboratories) and buildings either built up or purchased, expenditures on technical improvement of buildings, etc.;*

– ***other intangible and tangible fixed assets*** *– expenditures on technical and other equipment necessary for R&D activities (devices, machinery and equipment including software, computers, transport equipment, etc.).*

Table ***13****-5.* ***Employees engaged in research and development: by occupation, educational attainment and field of science***

By occupation*, R&D employees are split into:*

– ***research workers*** *– professionals engaged in outlining and creating or producing new knowledge, products, processes, methods and systems and/or in managing such projects. They are mostly scientific and professional intellectual workers and heads of research and development departments;*

– ***technicians*** *(technicians and associate staff) – persons who participate in R&D by performing scientific and technical tasks, by applying concepts and operational methods, usually under supervision of researchers;*

– ***others*** *(other supporting staff) – craftsmen and secretarial and clerical staff who participate in R&D activities or are directly associated with them; managers and administrators insofar as their activities are directly serving to R&D are included.*

By highest educational attainment*, R&D employees are split into:*

– *R&D employees with* ***doctoral education*** *– they reached level V (Doctoral education attained by completion of a doctoral study programme, extension study or scientific education resulting in the Czech degree "Ph.D.", "Dr.", "Dr.Sc." or "CSc.") according to the national classification* „Klasifikace kmenových oborů vzdělávání", KKOV *(Classification of Basic Fields of Education);*

– *R&D employees with **university education** – they reached level T (University education attained by completion of masters, engineering and medical study programmes of universities) or level R (University education attained by completion of bachelors study programmes of universities) according to the* KKOV*;*

– *R&D employees with **higher professional education** – they reached level N (Higher professional education attained by completion of the educational programmes of higher professional schools, performing arts schools and dancing schools; specialization and innovation post-secondary study) according to the* KKOV*;*

– *R&D employees with **upper secondary education and secondary technical education** (hereinafter referred to as the secondary education) – they reached levels H, J, K, L, and M according to the* KKOV*;*

– *R&D employees with **other lower education** – they reached levels A, B, C, D, and E according to the* KKOV.

*Table **13**-6. **Research and development expenditures: by source of funding and sector of performance***

*There are five basic sectors as sources of funding the performance of research and development activities (R&D-funding sectors) in four sectors of R&D performance. Both the former and the latter include the business sector (own funds or funds of other businesses), the government sector (public funds allocated from the state budget chapter for R&D, regional budgets, etc.), the higher education sector (own revenues), and the private non-profit sector. The remaining fifth sector is **the rest-of-the-world sector**.*

*The **rest-of-the-world sector** comprises all institutions and individuals outside the political borders of the country. Belonging to this sector are also all international organizations (European Commission, NATO, etc.), including their facilities and plants within the country.*

*Table **13**-10. **Government budget appropriations or outlays for R&D by socio-economic objectives (GBAORD)***

*The data on **government budget appropriations or outlays for R&D broken down by socio-economic objectives** presented in this chapter have been obtained from administrative sources, namely from the Government Council for Research and Development and the Ministry of Education, Youth and Sport of the CR. Complementary data were then directly acquired from individual providers of state support for R&D. The methodology for data collection and processing is based on the OECD Frascati manual, data security is governed by Commission Regulation (EC) No. 753/2004. The classification of socio-economic objectives is contained in NABS - Nomenclature for the Analysis and Comparison of Science Programmes and Budgets (Eurostat, Rev. 1992).*

*Table **13**-11. **External trade in highly advanced technology (high-tech) goods***

*In the framework of the OECD, **highly-advanced technology (high-tech) goods were defined** according to the Standard International Trade Classification (SITC) Rev. 3 and divided into the following nine basic groups:*

– *Aviation engineering*

– *Computer technology*

– *Electronics and telecommunications*

– *Pharmaceutics*

– *Scientific instruments and apparatus*

– *Electrical engineering*

– *Chemistry*

– *Non-electrical machinery*

– Other high-tech

The data on exports and imports of high-tech goods broken down by SITC have been obtained from data sources of the Directorate General of Customs and, since May 2004, from the CZSO's data sources (Intrastat).

*Table **13**-12. **Innovating businesses: 2003-2005***

The data on innovations presented in this chapter have been obtained from a statistical sample survey. The survey was conducted for the period of 2003-2005 on a sample of reporting units coming under the business sector. Its aim was to map out the innovation potential of businesses operating in the Czech Republic. The methodology of data collection and processing is based on the Oslo Manual by OECD and Council Decision 94/78/EC, Euratom of 24 January 1994 establishing a multi-annual programme for the development of Community statistics on research, development and innovation, and it is in harmony with the methodology and recommendations of Eurostat. The population of the survey comprised reporting units with 10+ employees belonging to chosen areas of production and services (both financial and non-financial).

*The statistical survey was mainly focussed on **technical innovations** (i.e. on the creation of new or improvement of the existing products and rendered services, production technologies and processes). An innovation in this concept is thus a process of implementing continuous changes (in the technical design of products, in production technology, materials used, etc.) and includes:*

– ***product innovation:** refers to goods or services either new or with much better basic properties, a higher technical quality, introduced software or other intangible features, a wider use, and provide higher satisfaction of the customer. A product innovation must be new for the enterprise, but does not have to be necessarily new for the market. It is not important whether a product innovation was developed by the given or another enterprise. Mere aesthetic changes, as well as mere sale of innovations produced and developed solely by other institutions, are not counted in;*

– ***process innovation**: refers to new and significantly improved production technologies and new and substantially improved methods of providing services and offering goods. Resulting effects must be significant with regard to the size and quality of the output or production and distribution costs. A process innovation must be new for the enterprise, but does not have to be necessarily new for the market. The enterprise observed does not have to be the first to have introduced such a process. Changes of merely organizational or management nature are not counted in.*

Businesses with innovation activity (innovating businesses) are businesses which were introducing technically new or improved products or processes during the reference period.

*Table **13**-13. **Innovation costs and the share of innovated and new products in sales: 2005***

*Total innovation costs in 2005, which were caused by innovation activities in businesses in the reference period, comprise **intramural research and development, acquisition of results of extramural research and development, acquisition of machinery and equipment** (advanced machines, computer hardware especially purchased to introduce new or significantly improved products and/or processes), **acquisition of other extramural knowledge** (purchases of patent rights and non-patent inventions, licences, know-how, trademarks, software and other forms of knowledge from other entities, made to be used for company innovations), **training** (internal and external vocational training of employees, directly intended for research and development), and **design and other forms of preparation for production/supplies** (procedures and technical preparation leading to implementation of products and process innovations not included elsewhere).*

*Table **13**-14. **Patent applications and patents granted originating in the Czech Republic***

The numbers of patent applications and patents granted are traditionally considered as one of the indicators measuring the success of research, development and innovation activities.

*The **invention** is a solution to a technical problem, which is new compared to the state of the technology in the world, contains an inventive step, does not clearly result for an expert from the*

known state of technology, and finds industrial use. The patent granting procedure commences by filing an invention application with the Industrial Property Office of the Czech Republic (IPO). By filing an application concerning an invention the applicant acquires the right of priority. The application is filed in all countries in which the potential patent holder requires protection.

*The **patent** is defined by Act No. 527/1990 Sb., as amended. It is a public deed issued by a national or international patent office (by the Industrial Property Office (IPO) in the Czech Republic), which provides legal protection of the invention for up to 20 years on the territory for which the patent was issued.*

The data have been obtained from data sources of the Industrial Property Office of the CR. They are sorted out by date of the publishing of patent application or granted patent in the IPO bulletin according to the methodology laid down in the Patent Manual (OECD, Paris, 1994).

The data on patents broken down by region of inventor are classified by the fractional method (e.g., if four inventors from different regions complete together a patent application, one fourth of the patent is assigned to each of the regions). The data are also split by section of the International Patent Classification (IPC). Where more IPC codes are assigned to a single patent, the indication of the patent is assigned to the first IPC code. The applications and patents are then classified, on the basis of the IPC, in the framework of high-tech products or groups of high-tech products.

*Tables **13**-15 and **13**-16. **Purchased and sold licences***

*A **licence** is one of the possibilities to use industrial rights and intellectual property on a commercial basis. Since 2003 the data have been collected by means of a separate annual statistical survey designed as a 100% survey. The survey is taken in all reporting units in which a purchase or a sale of a licence for some of industrial property protections was found.*

*A **licence agreement** refers to granting the right to acquisition (purchase) or disposal (sale) in an agreed scope and territory. Licence agreements are concluded in writing for patented inventions or utility models, industrial designs, topography of semi-conductor products, new varieties of plants and animal breeds or trademarks, etc. The licensor entitles the licensee to exercise industrial property rights within the scope and on the territory agreed, and the licensee undertakes to provide certain payment or other property value. A licence agreement becomes operative towards third persons on its recording in the register of the Industrial Property Office of the CR.*

*Tables **13**-17 and **13**-18. **Technology balance of payments: receipts and payments***

*Data on **receipts and payments** obtained in the framework of the **technology balance of payments** (TBP) indicate the technological level of the economy, more specifically the volume of external trade in industrial property and knowledge connected with advanced technologies. 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.*

The data listed in these tables come from data sources of the Czech National Bank (CNB), namely from the current account of the balance of payments. The individual TBP items are defined according to individual receipt and payment items and corresponding international codes (BPM5).

The TBP data, receipts and payments, are further broken down by country. The CNB does not assign country codes to all TBP transfers and these data are pooled under 'Unspecified'.

*Table **13**-19. **Main indicators on a group of manufacturing industries high in technological intensity (the high-tech sector)***

The table gives a group of manufacturing industries with high technological intensity as far as research and development results are concerned. On the one hand, they produce high-tech products (information technologies, biotechnologies, nano-technologies, etc.) and, on the other hand, they themselves are users of these products. In 1997, OECD developed a classification of industries by their technological intensity (four different categories of technological intensity: high technology, medium-high technology, medium-low technology and low technology) based on the International Standard Industrial Classification of all Economic Activities - ISIC Rev. 3 (CZ-NACE in the CR). This split

resulted from the evaluation of the ranking of the following three technological intensity indicators reflecting views of the technology producer and the technology user:

– R&D expenditures divided by value added;

– R&D expenditures divided by output;

– R&D expenditures plus technology incorporated into intermediate products and capital goods, divided by products.

*The group of **high technology** manufacturing industries is composed of 'manufacture of pharmaceuticals, medicinal chemicals and botanical products' (CZ-NACE 24.4), 'manufacture of office machinery and computers' (CZ-NACE 30), 'manufacture of radio, television and communication equipment and apparatus' (CZ-NACE 32), 'manufacture of medical, precision and optical instruments, watches and clocks' (CZ-NACE 33), and 'manufacture of aircraft and spacecraft' (CZ-NACE 35.3).*

The data (the average registered number of employees, book value added and turnover) on the group of manufacturing industries high in technological intensity were obtained from a regular annual structural survey on businesses in chosen production industries.

The data in the tables are comparable with the data published in the statistical yearbooks of previous years.

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Other information on science and technology is available in the CZSO publications brought out according to the CZSO Catalogue of Publications 2006 (thematic group 9 – SERVICES, subgroup 96 – Research and Development):

– "Research and Development Indicators for the Czech Republic in 2005" (Czech-English) – September 2006

– "Innovation in the Czech Republic in 2005" (Czech-English) - November 2006

– "Licences in the Czech Republic in 2005" (Czech-English) - December 2006

– "Government Budget Appropriations or Outlays for R&D (GBOARD) in the Czech Republic in 2005" (Czech-English) – November 2006

– "Statistical Yearbook of Science and Technology 2006" (Czech and English) - December 2006

Further data are published on the following web pages of the Czech Statistical Office:

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