ANALYSIS OF THE STATE OF RESEARCH, DEVELOPMENT AND INNOVATION IN THE CZECH REPUBLIC AND THEIR INTERNATIONAL COMPARISON IN 2020

SUMMARY

EXECUTIVE SUMMARY

The 'Analysis of the state of research, development and innovation in the Czech Republic and their international comparison' is produced every year by the Research, Development and Innovation Council (the RDI Council) pursuant to Act No 130/2002 Coll. on support of research, experimental development and innovation. The R&D&I Analysis is drawn up by the RDI Council Department of the Office of the Government of the Czech Republic (OG CR).

The 2020 R&D&I Analysis contains indicators illustrating the situation in Czech R&D&I and their international comparison, including indicators set out in the strategic document National Research, Development and Innovation Policy of the Czech Republic for the period 2016–2020,and it evaluates 9 key topics:

- Financial flows in research and development
- Research and development financing from the state budget
- R&D&I support in CZ from European funding
- Implementation of RIS3 in CZ
- People in research and development
- Research infrastructures
- Research and development results
- Innovation performance of the Czech economy and its international comparison
- International cooperation in R&D&I

Based on the analysis, the RDI Council formulated the strengths and weaknesses of the R&D&I system:

Strengths

+ *Czech economic potential*
+ *Growing private and public R&D&I expenditure*
+ *Research infrastructure built*
+ *Strong publication culture*
+ *Gradually developing internationalisation leading to excellence of some scientific fields*
+ *Qualified people and traditionally strong academia*

Weaknesses

– *Private expenditure in the R&D&I system is consumed mostly in the private sector, which results in a long-term low level of cooperation between the private and the public sector in the R&D&I system*
– *Unsatisfactory participation of Czech research organisations and teams in the framework programme Horizon 2020*
– *The setting of the development of the needed professional competences and skills of researchers and the resulting insufficient utilisation of their potential*
– *Low representation of women in research*
– *Inadequate conditions for effective functioning and development of innovation activities*

– *Insufficient use of the possibilities of intellectual property protection*

Opportunities

The Czech Republic (CZ) has a strong industrial and research base and modern research infrastructures, but the needs of the business sector and the research sector not always match, which reflects in the still low level of cooperation between the two sectors.

CZ must continue to create an environment for the innovation potential development. That includes support for risk capital **investments** and a **higher use of intellectual property protection** in the form of international patents. An opportunity is creating suitable conditions and incentives for investment in start-ups and ensuring an effective use of industrial property protection tools including support for the knowledge base of industrial property protection.

For the system of R&D&I management in CZ, it is essential **to set the instruments of direct and indirect public support** so as to accelerate private R&D&I expenditure and to increase the orientation of research and development on application of R&D results in the society.

The effective setting of public support must go hand in hand with **developing the personnel base of the R&D&I system**. One of the persisting problems in this area is the low representation of women. An opportunity is to create conditions for reconciling research work and parent responsibilities and for women returning to work after maternity and parental leave.

It is essential to build relationships with foreign partners, create long-term links with top-level scientific centres and to **enhance international cooperation** including higher participation of Czech research organisations and teams in the framework programme Horizon 2020 or Horizon Europe (mainly for ERC activities, partnerships and EIC schemes).

For the research capacity to be used effectively, a **functioning legislative environment** is required. The main goal should be to introduce new instruments of purpose-tied aid for innovation and indirect support of R&D, to simplify R&D&I administration and to further improve the evaluation of the situation in R&D&I including a corresponding evaluation of the purpose-tied aid programmes.

For the Czech Republic, it is key to effectively target its R&D&I capacities and to be able to respond to the dynamic developments in the society including the fast development of new technologies, but mainly to major societal challenges. CZ needs to define the priorities for increasing the resilience of the society and to motivate providers to support specifically focused research programmes relevant for the defined threats with a societal impact.

Events associated with the COVID-19 pandemic will have a substantial impact on the orientation of the R&D&I system. The priorities of support for specific fields of research and multidisciplinary teams will be changed so as to avert further threats of this type. The support will not be directed only to medical fields but to a whole range of sectors that can participate in mitigating the consequences of such threats and in their prevention. It appears essential to focus on the key political priorities of the EU, the solution of which is built on disruptive innovation, i.e. mainly the European Green Deal

(EGD), digital transformation and preparedness of the society for pandemics, including solutions for situations induced by COVID-19.

INTERPRETATION PART

The R&D&I environment in CZ has been developing dynamically in the last ten years. Table S.1 illustrates the development of basic financial R&D&I indicators, their year-on-year development and selected macroeconomic indicators.

Table S.1: Expenditure on research and development and its year-on-year changes, compared with basic macroeconomic indicators

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
gross domestic expenditure on R&D (GERD)	CZK billion	53.0	62.8	72.4	77.9	85.1	88.7	80.1	90.4	102.8	111.6	113.4
GERD share in GDP	%	1.33	1.54	1.77	1.88	1.96	1.92	1.67	1.77	1.90	1.93	1.99
Average annual inflation rate	%	1.5	1.9	3.3	1.4	0.4	0.3	0.7	2.5	2.1	2.8	3.2
Share of budgeted R&D&I expenditure from SB in total national SB	%	2.14	2.20	2.24	2.21	2.20	2.21	2.33	2.49	2.55	2.39	2.24
R&D expenditure in the business sector (BERD)	CZK billion	30.0	34.1	38.2	41.5	47.0	48.1	49.0	56.8	63.7	68.8	69.1
Indirect support for private enterprises	CZK billion	1.32	1.84	1.99	2.30	2.27	2.53	2.39	2.52	2.59	2.74	–
R&D personnel	FTE[1]	52,290	55,697	60,329	61,976	64,443	66,433	65,783	69,736	74,969	79,245	80,958
Patents granted in CZ	number	1372	1806	2204	2552	2901	3505	4874	6013	6670	7741	7427
to CZ applicants	number	65	94	149	175	255	369	457	455	415	480	523
to foreign applicants	number	1,307	1,712	2,055	2,377	2,646	3,136	4,417	5,558	6,255	7,261	6,904
Revenue from provided patent licences	CZK billion	1.43	1.52	1.87	2.29	2.73	3.32	3.36	1.93	1.60	2.17	3.05
Foreign trade in high-tech goods												
export of high-tech goods	CZK billion	410.2	476.0	501.8	483.2	559.8	610.0	604.8	687.1	790.2	870.9	920.6
share in the total CZ export of goods	%	16.20	16.53	16.33	15.22	15.43	15.71	15.22	16.19	17.94	19.02	20.72
import of high-tech goods	CZK billion	462.3	473.6	474.1	465.5	546.2	648.3	602.8	706.7	811.9	869.7	934.8
share in the total CZ import of goods	%	19.17	17.62	17.13	16.49	17.07	18.64	17.25	18.59	20.18	21.12	23.66
year-on-year changes			**11/10**	**12/11**	**13/12**	**14/13**	**15/14**	**16/15**	**17/16**	**18/17**	**19/18**	**20/19**
gross domestic expenditure on R&D (total)	%		18.46	15.31	7.59	9.31	4.18	-9.65	12.83	13.68	8.63	1.58
GDP (c.p.)	%		1.74	0.65	1.32	4.90	6.43	3.71	6.54	5.85	7.04	-1.65
export of goods and services	%		9.89	7.43	1.95	13.05	4.74	1.81	6.47	3.15	2.82	-5.42

Source: Czech Statistical Office (CZSO) - Research and development survey, National accounts, Main economic indicators of CZ and State Budget Acts in the years 2009 to 2019 | Note: R&D&I expenditure from the state budget (SB) is indicated excluding expenditure that is to be covered from the EU budget and from financial mechanisms.

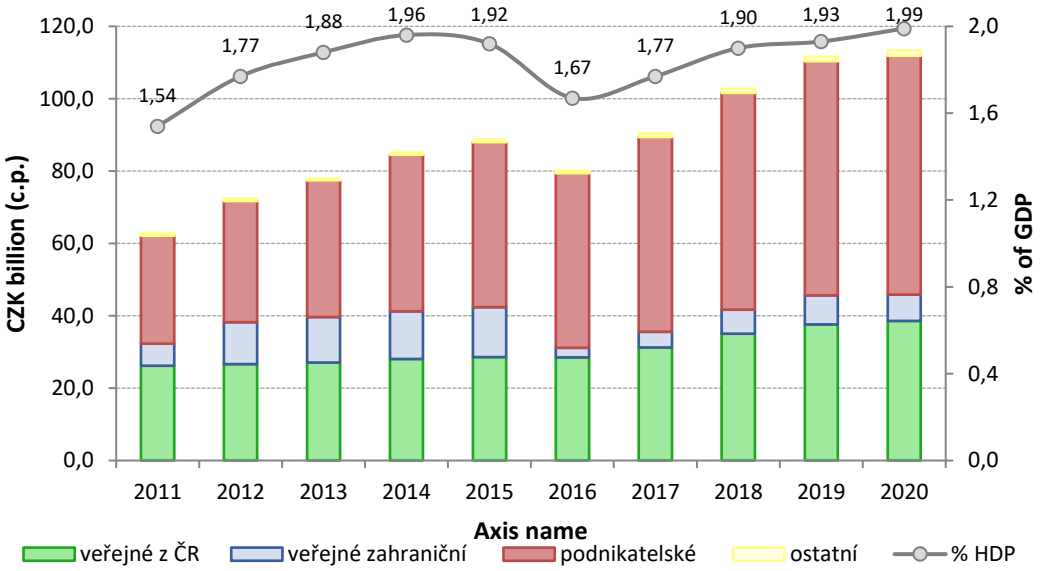
The following text of the summary of the 'Analysis of the state of research, development and innovation in the Czech Republic and their international comparison in 2020' is divided into nine chapters. The monitoring of quantitative indicators of meeting the objectives of the National Research, Development and Innovation Policy 2016-2020 is provided in Annex 1.

[1] FTE (Full-time equivalent) is a unit expressing the level of involvement or the utilisation of the capacity of a worker, converted to 100% capacity (i.e. an equivalent of one worker working full-time).

Financial flows in research and development

The **gross domestic expenditure on R&D in CZ** has been growing in the long term. In the ten-year time line of 2011−2020, the regular year-on-year growth was interrupted only in 2016 when public foreign sources dropped due to the transition to a new programming period. **The absolute amount of total expenditure in 2020 was, for the first time, a record CZK 113.4 billion, i.e. 1.99% of GDP.** The R&D Intensity indicator (i.e. R&D expenditure as a percentage of GDP) has also had a growing trend in the last years, with minute deviations. The long-term growth of gross expenditure on R&D in CZ is mainly due to the steady growth of **business resources, in 2020 those resources reached nearly CZK 66.1 bil**., i.e. nearly 2.2 times more than in 2011.

Gross domestic expenditure on R&D (GERD) in CZ in the period 2011–2020 by source of financing (in current prices)



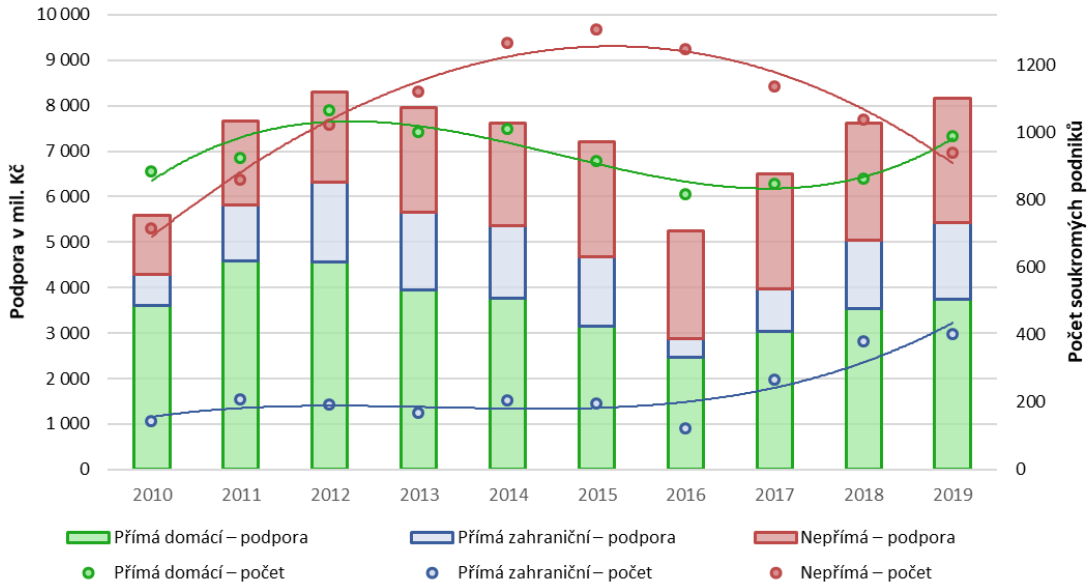
veřejné z ČR	CZ public
veřejné zahraniční	foreign public
podnikatelské	business
ostatní	other
% HDP	% of GDP

Source: CZSO, Annual report on research and development

- R&D expenditure from business sources was CZK 66.1 bil. (i.e. a year-on-year growth by 2%), which is 1.16% of GDP. The largest amount of funds has been spent on R&D in CZ in the long term by the business sector, mainly the automotive industry and ICT. An amount exceeding CZK 0.5 bil. was spent in 2020 on R&D in CZ by 26 enterprises, of which 21 were foreign-controlled.
- Public R&D expenditure reached a record CZK 45.8 bil., of which public domestic sources made up CZK 38.6 bil. and public foreign sources CZK 7.2 bil. In total, R&D expenditure from public sources represented 0.8% of GDP in 2020.

- In terms of GERD converted to GDP share, CZ slightly lags behind the European average, between 2010 and 2019, the R&D Intensity (GERD as a % of GDP) grew in CZ by 0.60 p.p., which was the third highest increase out of all EU Member States.
- Business sources are used nearly exclusively to finance R&D in the business sector. The volume of support for public R&D from domestic business sources is still relatively low, but year on year it grew by CZK 1.2 bil. – it reached almost CZK 3.5 bil. in 2020 in the higher education and government sector. Business entities obtained public support at CZK 6.6 bil., which is historically the highest amount over the last 5 years.
- Public domestic financial resources were directed mainly to R&D implemented in the government and higher education sector, in total the sector spent CZK 33.7 bil. from public sources.
- In the business sector, the majority (63%) of R&D funding was spent in 2020 by private foreign-controlled enterprises, in the government sector it was the institutes of the Czech Academy of Sciences (CAS) (75%) and in the higher education sector it was higher education institutions (94%).
- In terms of the volume of finance, there are 4 strong groups of research organisations in the Czech R&D system – private foreign-controlled companies (CZK 43.7 bil.), higher education institutions (CZK 23.1(?) bil.), followed by private domestic companies (CZK 23.1 bil.) and, with a relatively large gap, the CAS institutes (CZK 14.6 bil.).
- Private companies in CZ are supported from the state budget directly (in 2020, the state budget support amounted to around CZK 4 bil.) as well as indirectly through items deductible from the corporate tax base (CZK 2.7 bil. in 2019). A higher volume of indirect support has been used in the long term by large enterprises, mainly those under foreign control.
- CZ uses only one type of indirect support tool (tax deduction) while abroad the indirect public R&D support of activity carried out in the business sector is usually provided through a combination of multiple instruments.

Development of direct and indirect public support for R&D in private enterprises in CZ



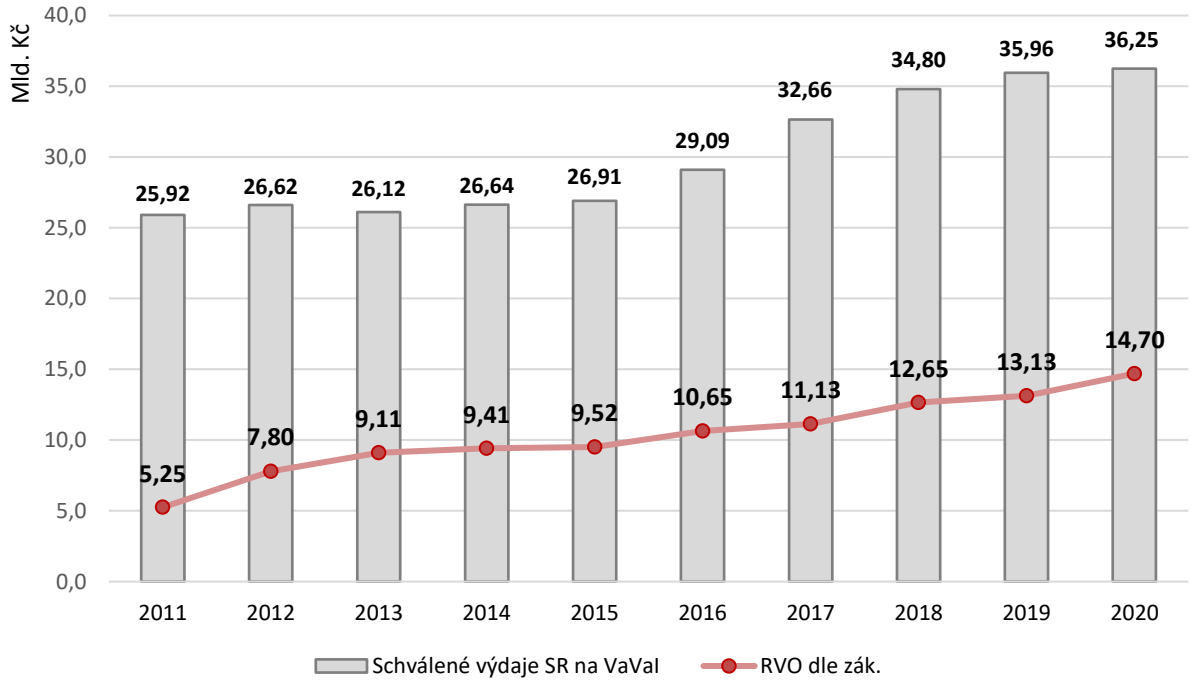
Podpora v mil. Kč	**Aid in CZK mil.**
Počet soukromých podniků	**Number of private enterprises**
Přímá domácí – podpora	Direct domestic - aid
Přímá domácí – počet	Direct domestic - number
Přímá zahraniční – podpora	Direct foreign - aid
Přímá zahraniční – počet	Direct foreign - number
Nepřímá – podpora	Indirect - aid
Nepřímá – počet	Indirect - number

Source: CZSO | Note: Average annual indirect support for public enterprises was CZK 5 mil. in the reporting period and it was used annually by up to 10 enterprises.

Research and development financing from the state budget

The preparation of the proposal of state budget expenditure on R&D&I is continuous and complex. Pursuant to Section 35 par. 2 letter k) and l) of Act No 130/2002 Coll. on support for research, experimental development and innovation, the RDI Council annually draws up a proposal of the total R&D&I expenditure under specific budget chapters and its mid-term outlook.

Development of total budgeted expenditure of the state budget on R&D&I (in CZK bil.)



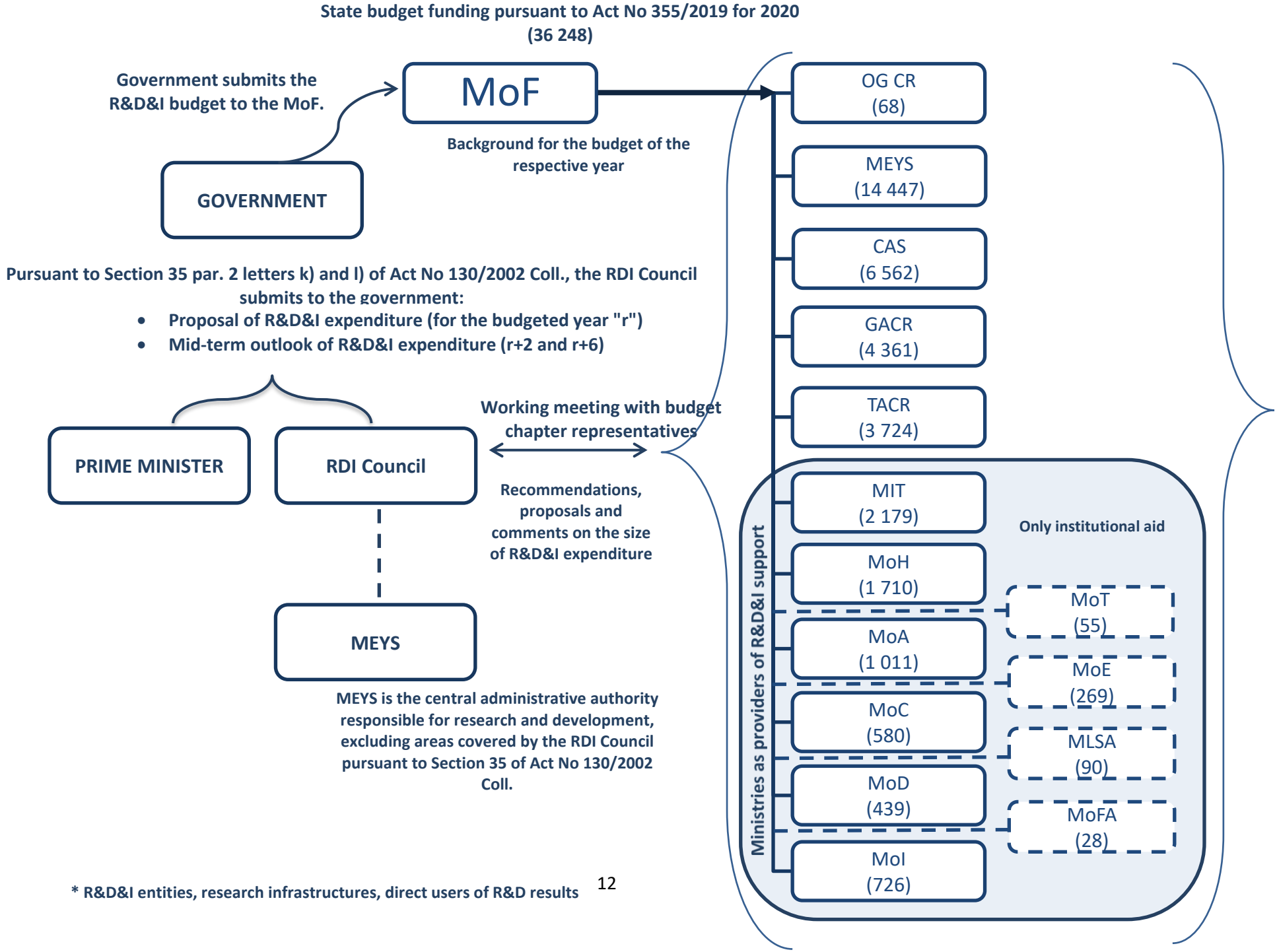
Mld. Kč	CZK bil.
Schválené výdaje SR na VaVaI	Approved SB expenditure on R&D&I
RVO dle zák.	RO development by law

Source: State Budget Acts in the relevant years

- Public domestic resources intended for research, development and innovation in CZ are made up primarily of the state budget for R&D&I, which reached CZK 36.25 bil. in 2020.
- Drawing up the proposal of state budget expenditure on R&D&I and its mid-term outlook is the responsibility of the RDI Council. Since 2017, the proposal has been structured in 15 budget chapters, the funding budgeted for their "operation" was CZK 2,389 mil. in 2020, i.e. 6.6% of the budgeted expenditure.
- The institutional expenditure increased year on year by CZK 1.03 bil., on the contrary the purpose-tied expenditure decreased by CZK 0.75 bil. According to data of the R&D&I Information System, higher education institutions (HEIs) drew support from the state budget in 2020 (excluding support from operational programmes) at CZK 16 bil., the CAS institutes CZK 8.3 bil., the business sector entities almost CZK 5 bil. and the other research organisations CZK 3.5 bil.

- Research and development institutions are financed from multiple sources - out of the total support in 2020, the purpose-tied component of the aid has a significantly higher share only for enterprises, the other types of research organisations show a visible trend of gradual increase in the share of institutional aid. For business sector entities, the strong prevalence of purpose-tied aid can be seen as desirable, but for public entities it would indicate a higher risk of year-on-year instability in financing.
- The largest volume of institutional aid for long-term conceptual development of research organisations is provided in CZ from the budget chapters of the Ministry of Education, Youth and Sports (MEYS) and CAS. In 2020, public and private HEIs drew funding for their long-term conceptual development at nearly CZK 7.7 bil. and the CAS institutes used CZK 4.16 bil.
- HEIs receive aid for specific HEI research (CZK 1.2 bil.) from the MEYS chapter and the aid is of institutional aid nature. The CAS institutes receive aid under the CAS chapter as the so-called activity costs (CZK 2 bil.), used mostly for activities associated with R&D&I. This item provides contributions to ELI Beamlines at CZK 210 mil. a year (from 2022, it will be transferred to MEYS to cover a part of the membership fee for the ELI ERIC consortium).
- Purpose-tied aid is provided mainly by the Grant Agency of the Czech Republic (GACR) - used mostly by HEIs and CAS institutes, and the Technology Agency of the Czech Republic (TACR) - supporting mostly enterprises and HEIs. The purpose-tied aid of other ministries is used by the entities funded by them, and successfully also by HEIs.
- The purpose-tied aid provided from the MEYS chapter is specific in that it covers subsidy schemes for Projects of Large R&D&I Infrastructures, and for Specific Higher Education Research, but the support under those schemes is rather institutional as it is not provided through a public tender procedure. Moreover, the funding from programmes National Sustainability Plan I and II, ended in 2020, was gradually transferred to the item Support for long-term conceptual development of research organisations.
- In terms of fields, the purpose-tied aid in CZ is channelled to the field groups Industry (CZK 4.6 bil.), followed by Social Sciences and Humanities (CZK 1.7 bil.), Biosciences (CZK 1.6 bil.) and Medical sciences (CZK 1.3 bil.). Financial aid exceeding CZK 1 bil. was also absorbed by the groups Chemistry and Physics and mathematics.
- Since 2017, the data for newly launched projects have been uploaded to the R&D&I Information System in the structure of OECD Fields of Research and Development. The conversion of the code list into the OECD structure was necessary for implementing the national level of evaluation of research organisations according to Methodology 2017+.
- At present, the institutional aid cannot be reliably broken down by field due to missing data on distribution inside the research organisations (mainly HEIs).
- According to OECD statistics, the most R&D expenditure in the public sector in CZ was directed to Natural Sciences (50%), in the other States, the share of R&D funding in this field ranges between 14 and 40%. The share of public-sector R&D expenditure, spent on the Medical and

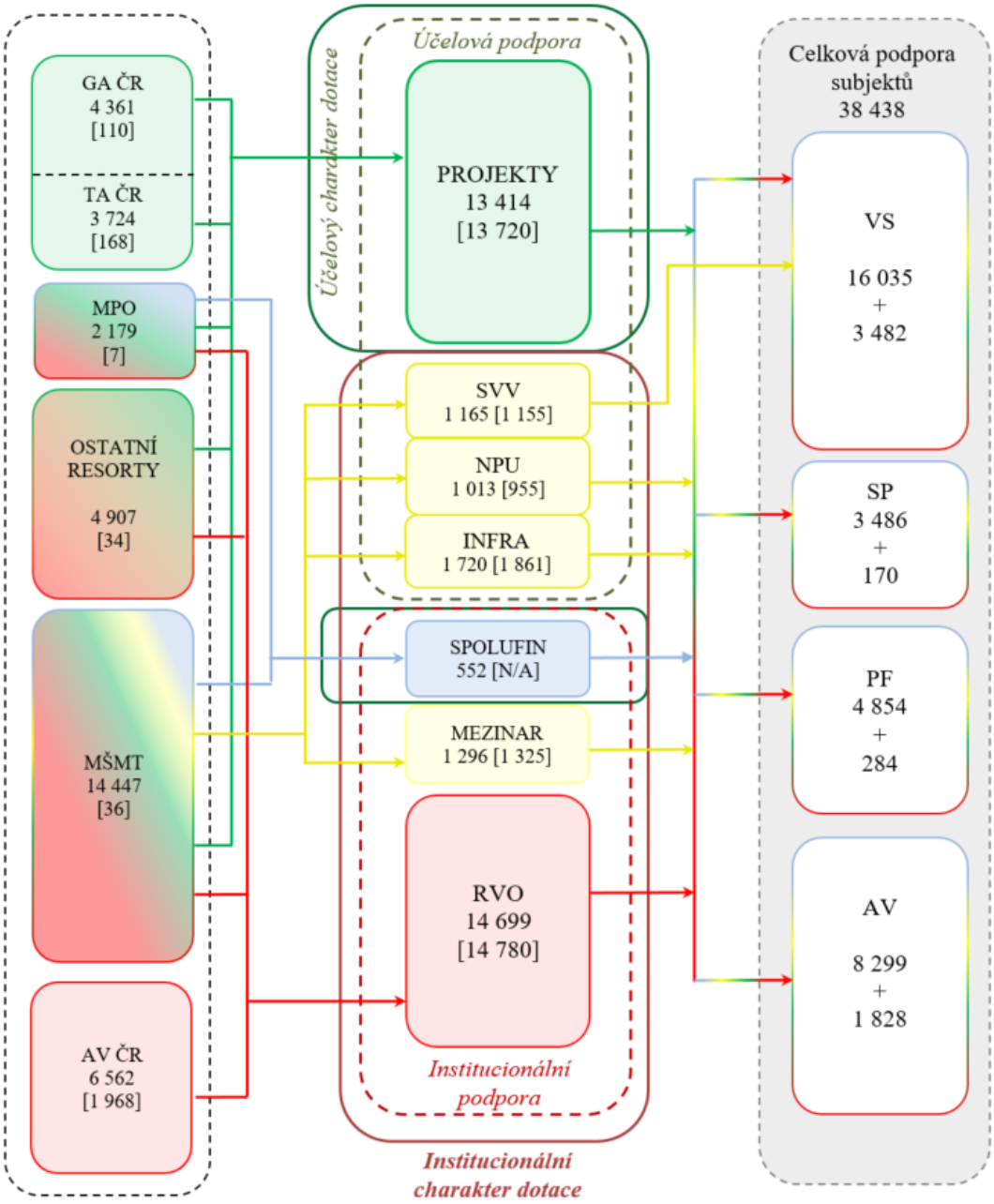
Health Sciences field, reached 11% in CZ, which is a significantly lower share than in Denmark or the Netherlands, as analyses have shown. In the business sector, the dominating field is Engineering and Technology.



* R&D&I entities, research infrastructures, direct users of R&D results

How R&D is financed from the state budget, with volumes of funding spent in 2020 (in CZK mil.)

Providers	Categories of aids	Entities implementing R&D&I
Budgeted expenditure of the state budget (SB) 36,180	Budgeted expenditure of SB 33,859	SB aid used 32,675 + OP and CO-FIN 5,764 + FOREIGN 1,134
of that the activity cost, evaluation of projects etc. [2 321]	Total SB aid used [33 796]	



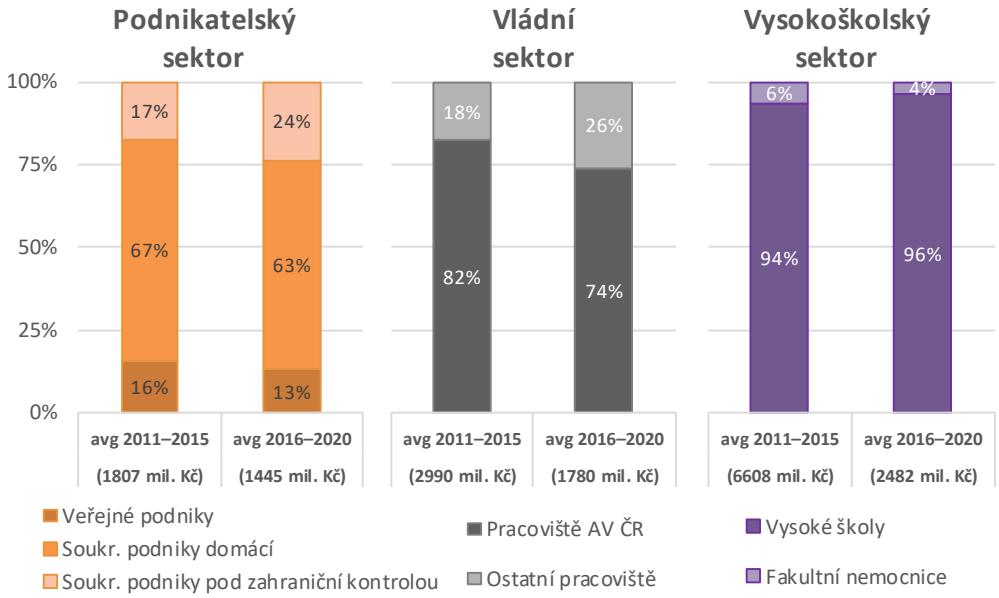
***CAS** – public research institutions established by CAS pursuant to Act No 341/2005 Coll.; **HEIs** – higher education institutions (public, state and private); **SC** – state contributory organisations, organisational units of the state and public research organisations excluding CAS institutes and state HEIs; **LNP** – legal and natural persons, individuals and institutions not falling under any of the above groups, e.g. public and private limited liability companies, public benefit societies, foundations, civic associations, **FOREIGN** – foreign entities, **MIT**- Ministry of Industry and Trade*

***PROJECTS** – grant or programme projects; **SHER** – specific higher education research; **INFRA** – projects of large research infrastructures; **NSP** – National Sustainability Programme I and II; **CO-FIN** – co-financing of OPs; **INTERNAT** – international cooperation; **ROD** – long-term conceptual development of ROs*

R&D&I support in CZ from European funding

The EU Structural Funds, channelled through operational programmes, are one of the key public foreign sources providing financial support of R&D&I activities. From the perspective of Czech R&D, currently the most significant are the Operational Programme Enterprise and Innovation for Competitiveness and the Operational Programme Research, Development and Education, and partly also the Operational Programme Prague - Growth Pole of the Czech Republic. Other public foreign sources include other support from the EU budget (mainly framework programmes - currently Horizon 2020) and international, governmental or public organisations outside the EU (e.g. CERN, ILL, ESA, NATO, OECD, UN, WHO, Norway Grants/EEA etc.).

Figure: 3.1: R&D expenditure from foreign sources by type of beneficiary in the period 2011-2020

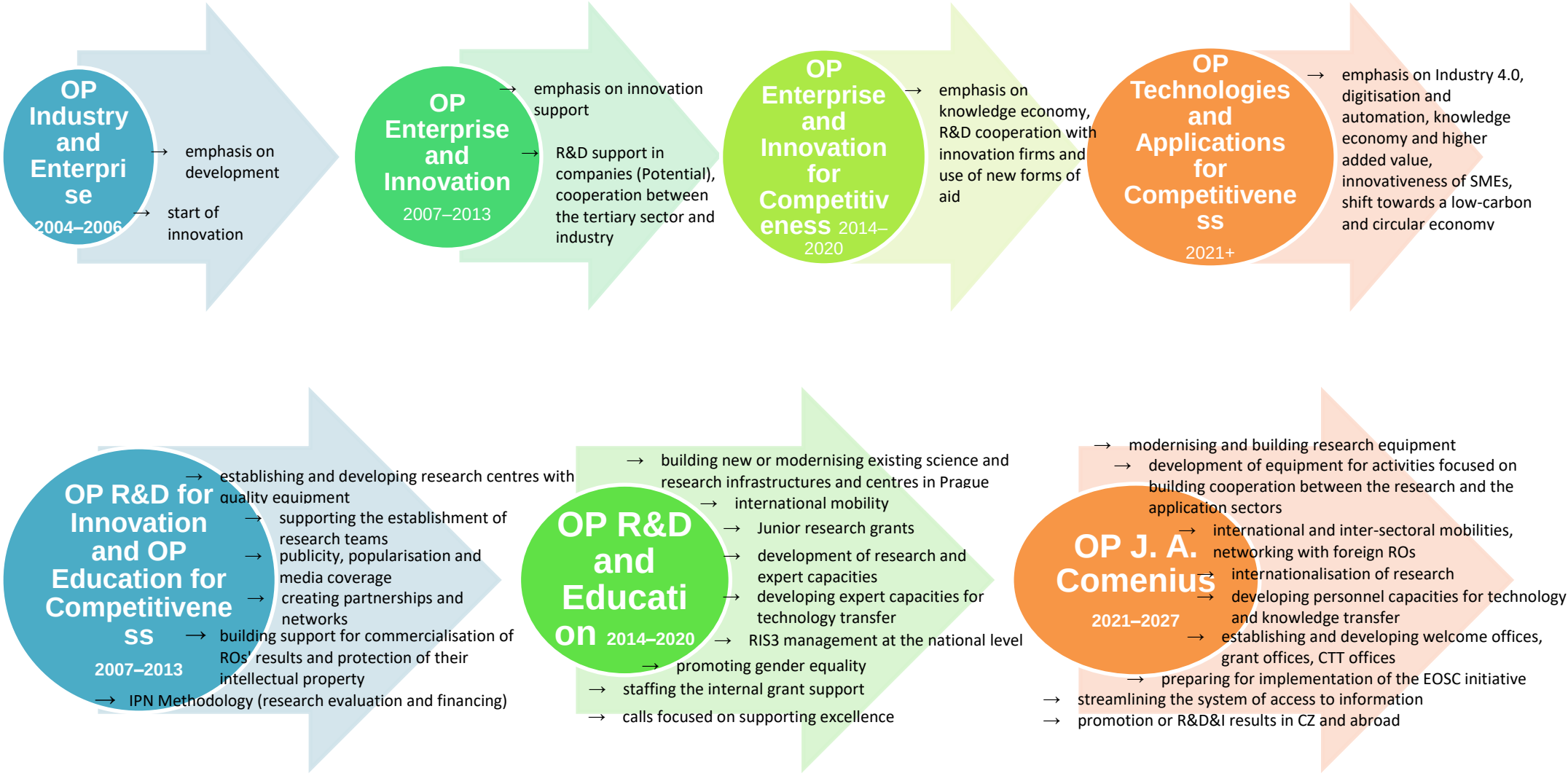


Podnikatelský sektor	**Business sector**
Vládní sektor	**Government sector**
Vysokoškolský sektor	**Higher education sector**
Veřejné podniky	Public enterprises
Soukr. podniky domácí	Private enterprises domestic
Soukr. podniky pod zahraniční kontrolou	Private enterprises foreign-controlled
Pracoviště AV ČR	CAS centres
Ostatní pracoviště	Other centres
Vysoké školy	Higher education institutions
Fakultní nemocnice	University hospitals

Source: CZSO, own processing

The highest volume of public foreign sources for R&D&I activities was spent in the higher education sector, specifically by higher education institutions. Other significant beneficiaries in terms of the volume of aid are the CAS centres and private domestic enterprises.

Diagram 3.1: Focus of the MEYS and MIT operational programmes



Source: own processing based on MEYS and MIT information

OP Research, Development and Education

- Registering 601 R&D&I projects, implemented by 158 entities. The aid for R&D&I projects, used up to 2020, exceeds CZK 28 bil. Aid exceeding CZK 1 bil. was granted to entities from 5 regions: City of Prague, South Moravian Region, Central Bohemian Region, Moravia-Silesia Region and Olomouc Region. The highest share of the aid was received by HEIs and, with a gap, by CAS institutes. In total, 11,463 results have been registered, of which 8,192 are peer-reviewed articles, and 95% of those articles were published in periodicals indexed in the WoS or Scopus databases. The results were produced by more than 9,500 researchers, of which one fifth are foreign researchers. Men represented 67% of the participating scientists.

OP Enterprise and Innovation for Competitiveness

- Registering 1,175 R&D&I projects, implemented by 407 entities. The aid for R&D&I projects registered in the R&D&I Information System, granted up to 2020, exceeds CZK 1.4 bil. Aid exceeding CZK 250 bil. was granted to entities from the South Moravian Region (CZK 251 mil.). The highest share of the aid was received by enterprises, as expected. A total of 1,443 results are registered, of which 90% are applied results (non-publication results). The results were produced by more than 2,460 researchers, of which 4% are foreign researchers. Men represented nearly 90 % of the participating scientists.

H2020

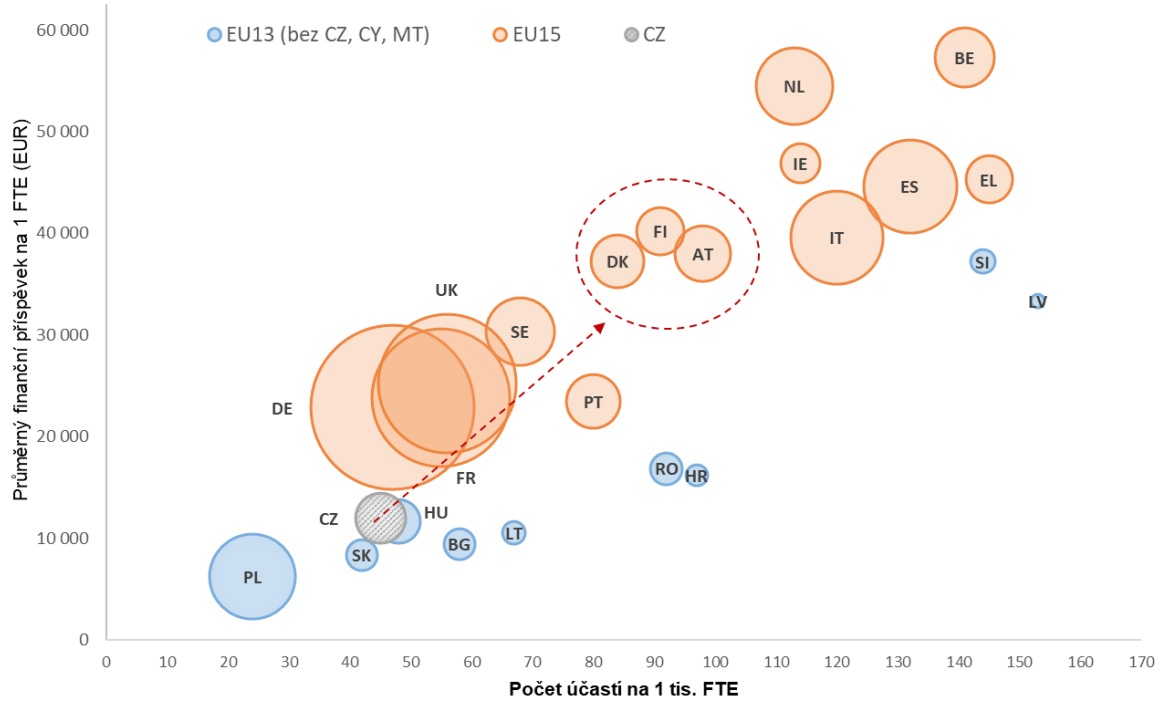
- The highest share of projects was submitted by institutions based in the City of Prague, as expected, followed by the Central Bohemian and the South Moravian Regions. The largest volume of funding was allocated to higher education and secondary schools, the second largest volume was obtained by private sector entities and the third place is held by other research organisations.
- The highest amounts of aid were won by the following organisations: Masaryk University, Charles University, Czech Technical University in Prague and Honeywell international.
- An analysis of the financial and project success rate of CZ in H2020 compared CZ, Austria, Slovakia, Germany and France. The success rate of CZ in obtaining grants is comparable to the other states (i.e. 15.17%).
- It results from analytical studies by EC and the CAS Technology Centre that CZ is among EU Member States with a very low activity of researchers in H2020, but it reaches a good project success rate.

ERC

- The CZ activity in ERC grants and the success rate of CZ applications has grown markedly, mainly in the areas of Starting Grant and Consolidator Grants.
- To support the ERC initiative, GACR launched in 2016 a programme "Support for ERC Applicants", in 2020 GACR financially supported 16 EXPRO projects and 30 JUNIOR STAR projects.

- The MEYS with its ERC CZ programme supports excellent research in CZ, by implementing projects submitted to calls of the European Research Council (ERC) that were included in categories A or B in the international peer review evaluation carried out by ERC expert panels in the second round and did not obtain European funding support. 17 projects were supported in 2020, spending approximately CZK 107.8 mil.

Activity and financial contribution of EU Member States in Horizon 2020



EU13 (bez CZ, CY, MT)	EU13 (excluding CZ, CY, MT)
EU15	EU15
CZ	CZ
Průměrný finanční příspěvek na 1 FTE (EUR)	**Average financial contribution per 1 FTE (EUR)**
Počet účastí na 1 tis. FTE	**Number of participations per 1 thousand FTE**

Source: H2020 Dashboard (as of 05.10.2021), EUROSTAT

Implementation of RIS3 in CZ[2]

The National RIS3 represents one of the implementation tools of the National R&D&I Policy of CZ in the area of oriented and applied research in CZ and must, at the same time, meet the enabling condition for implementing interventions of the EU regional policy in the area of R&D&I. The NRIS3 focuses on support for promising sectors and their transformation towards higher added value, among other things by emphasising support for digitisation and other key technologies and knowledge.

Based on long-term monitoring (01.2015–10.2020) of the RIS3 impacts, the NRIS3 is implemented through 5,971 projects from operational programmes, 1,608 projects of TACR, and 1,594 projects under the programmes of ministries. The total financial support of NRIS3 is CZK 148.0 bil. in operational programmes (EU support 61%) and CZK 45.91 bil. in national programmes (of that SB support is 75%).

In the operational programmes, the most supported specific objective of NRIS3 is strengthening the R&D&I capacities of enterprises (30% of the total support; CZK 44.85 bil.) - the highest share comes from private sources (59% of the total support; CZK 27.40 bil.).

- The national programmes in NRIS3 place a stronger emphasis, as opposed to operational programmes, on supporting cooperation of ROs and firms (44% of the total support, CZK 20.10 bil.) and on addressing societal challenges through R&D&I (22% of the total support; CZK 10.13 bil.).
- In the sectoral specialisation, the operational programmes supported the most the Digital economy and digital content (21% of the total support; CZK 30.84 bil.) and Mechanical engineering - mechatronics (13% of the total support; CZK 19.02 bil.).
- A positive result is the prevailing support of SMEs - SMEs are supported from OP Enterprise and Innovation for Competitiveness with 70% of the European funding (CZK 25 bil.) and 58% of non-public (private) funding (CZK 26 bil.).
- In terms of distribution of the support among places of NRIS3-related projects in the operational programmes, the highest support per 1 inhabitant of the region goes to the South Moravian Region (13%, CZK 21,475/capita) where also the EU support is the highest (13%, CZK 12,021/capita).
- In terms of contributing to the physical indicators of NRIS3 in operational programmes, it is possible to highlight support for deploying innovations (1,382 innovations), support for SME internationalisation (3,995 participations in exhibitions and fairs abroad), strengthening research personnel capacities (5,573 supported researchers and academics), support for cooperation between ROs and firms (1,224 supported cooperations), support for new or modernised research-focused study programmes accredited also for being taught in a foreign language (159 programmes) and support for increasing the employment rate in ICT enterprises (3,733 FTE).

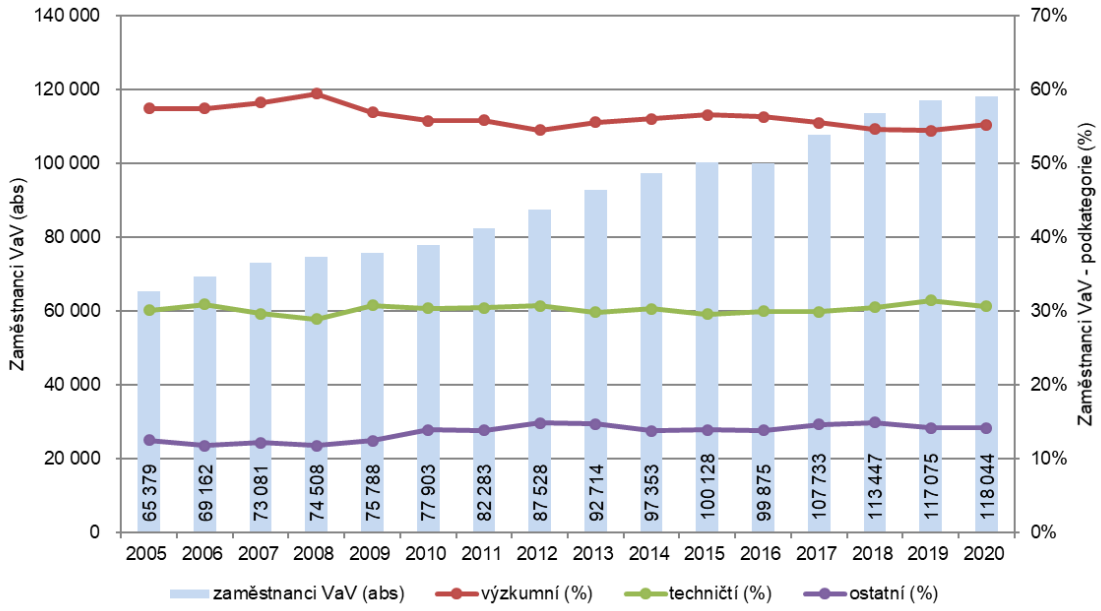
[2] For more see https://www.mpo.cz/cz/podnikani/ris3-strategie/

Another important contribution to the NRIS3 comes from the TACR national programmes that appear to be very successful, at least in terms of the implemented projects and the applied results (3,147) produced in those projects.

People in research and development

One of the most substantial inputs of all activities is the people. Also R&D activities cannot do without them and their personal and professional qualities determine the intensity and quality of R&D, and consequently the success of the whole process of transforming the R&D results into new knowledge in practice. The R&D staff does not consist only of researchers but also of technical and specialised workers in R&D and other support personnel without which the R&D activities cannot be implemented effectively.

The trend in the number of R&D employees (head count) and their shares in work activities (2005–2020)



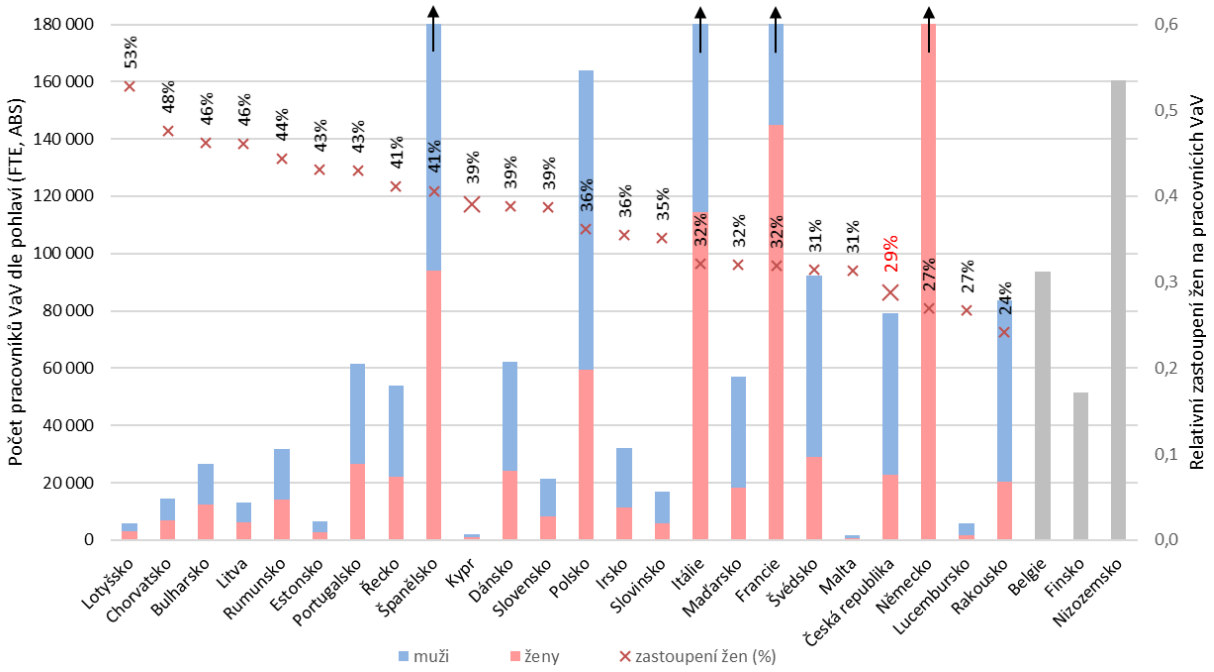
Zaměstnanci VaV (abs)	**R&D employees (abs)**
Zaměstnanci VaV – podkategorie (%)	**R&D employees - sub-categories (%)**
zaměstnanci VaV (abs)	R&D employees (abs)
výzkumní (%)	researchers (%)
techničtí (%)	technical (%)
ostatní (%)	other (%)

Source: own processing based on CZSO data

- In 2020, over 118 thousand persons worked part-time or full-time in R&D. Converting that into the full-time equivalent, nearly 81 thousand employees worked in R&D.
- The majority of R&D employees are researchers (approx. 55%), followed by technical staff (around 31%) and other staff (around 14%).
- The highest number of R&D employees is reported by the business sector (the share of the business sector in the total R&D employment keeps growing). On the contrary, the most researchers work in the higher education sector, closely followed by the business sector.
- In a comparison of the number of R&D employees in the EU-27 countries, CZ moves around the 10th place (between Austria and Denmark) as in the previous years. When comparing the number of researchers among the EU-27 states, CZ ranks 12th.

- The number of researchers in the business sector grew mostly in large foreign-controlled enterprises. The second most important group are domestic small and medium-sized enterprises.
- The most researchers in the business sector work in the manufacturing industry, information and communications activity, and in professional, scientific and technical activity.
- Out of the newly employed young researchers, more than half have a master's degree. In the higher education sector, those employees most often head for public and state HEIs, public enterprises and CAS centres.
- The gender imbalance among researchers persists in all sectors. The share of women in CZ researchers ranged only around 27%. The greatest gap between male and female researchers is in the business sector (women make up only around 13%). On the contrary, the highest representation of women among researchers is in the government sector (40%).
- In the group of newly employed young researchers, women are represented only in 30%. More than a half of the newly employed young researchers in the government sector are women, while in the business sector their share is only 18%.
- In terms of representation of women in R&D workers and in researchers, CZ holds very low positions in the EU-27 ranking (21st position, 24-29%).

Representation of women among R&D workers in an international comparison (FTE, 2019)



Počet pracovníků VaV dle pohlaví (FTE, ABS)	Number of R&D workers by gender (FTE, ABS)
Relativní zastoupení žen na pracovnících VaV	Relative representation of women among R&D workers
Lotyšsko	Latvia
Chorvatsko	Croatia
Bulharsko	Bulgaria
Litva	Lithuania
Rumunsko	Romania
Estonsko	Estonia
Portugalsko	Portugal

Řecko	Greece
Španělsko	Spain
Kypr	Cyprus
Dánsko	Denmark
Slovensko	Slovakia
Polsko	Poland
Irsko	Ireland
Slovinsko	Slovenia
Itálie	Italy
Maďarsko	Hungary
Francie	France
Švédsko	Sweden
Malta	Malta
Česká republika	Czechia
Německo	Germany
Lucembursko	Luxembourg
Rakousko	Austria
Belgie	Belgium
Finsko	Finland
Nizozemsko	Netherlands
muži	men
ženy	women
zastoupení žen (%)	representation of women (%)

Source: Eurostat | France – data for 2018; Belgium, Finland and the Netherlands – values in total (not indicating the representation of women); ABS Germany – 735 584, ABS France – 452 970, ABS Italy – 355 854, ABS Spain – 231 413

Research infrastructures

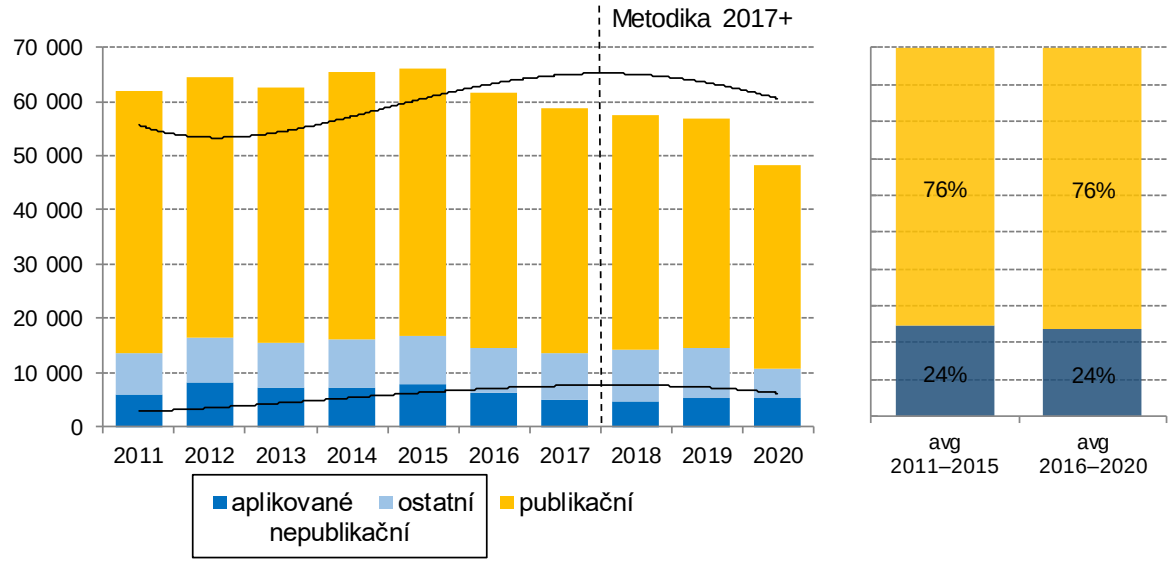
Research infrastructures have a significant impact on the development of national research systems and other groupings of the macro-regional or global dimension. Their state-of-the-art and mainly specialised equipment facilitates a unique opportunity for the other researchers to implement their exceptional scientific experiments and investigations. With the help of open access, it is possible to address more effectively the socio-economic challenges of our society.

- Research infrastructures are intended to effectively interconnect all segments of the innovation chain and to enable interaction of entities involved in education, public research and the business sector, with the final effect in the form of goods and services with a high added value. They usually do not have legal personality, they are established, developed and operated most often by research organisations and they can be considered a basic component of the R&D&I base in CZ.
- In CZ, they are financed from multiple sources, mainly from public funds, both domestic and foreign. In 2020, research infrastructures were supported from the state budget through national grant and programme projects of purpose-tied aid at the total of CZK 4.2 bil. and through OP Research, Development and Education at CZK 1.7 bil.
- MEYS acts as the supervisor of international cooperation of CZ in R&D and supports also internationalisation of large research infrastructures or international cooperation and involvement in international legal groupings, mainly legal entities of ERIC. The total amount paid for ERIC from the CZ state budget was nearly CZK 215 mil. in 2020.
- A specific type of research infrastructures are infrastructures operating as part of international cooperation of the Czech Republic. In 2020, the total Czech fee for participating in international R&D organisations was nearly CZK 833 mil.
- MEYS issued in 2019 an update of the "Roadmap of large research infrastructures of the Czech Republic for the period 2016-2022", presenting the involvement of the scientific community in various calls and opportunities in the area of research infrastructures. The Roadmap covers 48 large research infrastructures; the core of public support for large research infrastructures and their operation in CZ is the subsidy scheme: 'Projects of large research infrastructures', in 2020 the state budget provided CZK 1.9 bil.
- In 2020, large research infrastructures were involved in the production of 2.46 thousand results. The share of publication results was 83%, i.e. 7 p.p. more than the Czech Republic average. In terms of non-publication applied results, the most frequent results were of two types: Software (29) and Patent (18).

Research and development results

Results are an important proof of research and development activity implementation. The data on results from the R&D&I Information System, graphically presented in this chapter, provide a comprehensive view of the R&D&I system productivity in CZ. Based on the character of the R&D&I support (institutional or purpose-tied, for more details see Chapter 2 - Research and development financing from the state budget), it is possible for the RDI Council to partially evaluate the financial instruments of public support for R&D&I as part of the Evaluation of Results of Completed R&D&I Programmes. The R&D&I results significantly reflect in the evaluation of research organisations in CZ. Since 2018, the RDI Council has performed that evaluation at the national level pursuant to Methodology 2017+, which is uniform for the whole R&D&I system.

Numbers of publication and non-publication results in CZ in the period 2011-2020 and their average relative representation in the periods 2011–2015 and 2016–2020



Metodika 2017+	Methodology 2017+
aplikované	applied
ostatní	other
nepublikační	non-publication
publikační	publication

Source: R&D&I IS, database as of 30.06.2021, data exported on 31.07.2021

- The total number of results has been decreasing in the last five years but still the total number of produced results is high - in the period 2016-2020, over 56 thousand results were produced annually on average.
- The highest share of results is produced in CZ in the FORD groups Natural Sciences, Engineering and Technology, and with a slight gap, in Social Sciences. The transfer to the FORD code list will make it possible to monitor the production of results in that breakdown in the future. In 2020, the most results were produced in the field group Natural Sciences, followed by Engineering and Technology, and Social Sciences.

- The share of publication results was 76% - in 2020, over 26 thousand articles were published in specialised periodicals. Nearly 80% of them were published in journals indexed in the Web of Science or Scopus databases.
- As expected, the highest share of articles published in periodicals indexed in WoS or Scopus was produced by CAS institutes, while the lowest share by LNP (i.e. enterprises).
- After Methodology 2017+ was introduced, the production of D-type results (articles in conference proceedings) has been decreasing. The production of results has also decreased in the category of non-publication results, mainly those marked as V - research report and N - certified methodology, medical procedure, specialised map.
- The share of non-publication results in the total number of results has been low in the long term unfortunately. Despite the growing number of patents in the past, the share of results with special legal protection, specifically patents (the P category), was very low in the monitored period 2011-2020.
- The largest producer of non-publication applied results are higher education institutions, mainly thanks to producing results in the V category - research report. The second largest producer are the LNP entities (mostly enterprises). Those focused most on producing results of the G category - a prototype and a functional model. The CAS institutes created the fewest non-publication applied results in absolute terms. Their production focused on two types of results: G - prototype, functional model (28%), P - patent (20%).
- In the long term, the highest share of non-publication results has been in CZ in the field groups Agricultural Sciences and Engineering and Technology, while in the groups Natural Sciences and Medical and Health Sciences the share has been lower.
- When evaluating the quality of publications, it is useful to monitor the structure of the publications in terms of the citation impact of the periodicals and the related publication strategy that can differ from field to field. There are indications that the number of journals, in which Czech authors have published, has grown in all six field groups. In all groups except for Social Sciences, the share of journals with their article influence score (AIS) in quartile 1 (Q1) has increased. The number of Czech journals (CZE) almost did not change - only small increases are recorded, moreover, most of the journals fall in the two bottom quartiles (Q3 and Q4).
- An international comparison of the developments in the normalised citation index for each field group shows that CZ ranks among states lagging behind the EU-15 average. Only in the case of the Medical and Health Sciences group, CZ exceeded the EU-15 average. From the perspective of the Normalised Citation Impact (NCI) trend, CZ has gone down in the Social Sciences group. The citation rate can be boosted also by membership of scientists in international consortia, which can be monitored in the fields from the Medical and Health Sciences group. This typically concerns publications with 30 authors and more.
- The rate of publication with international participation ranged above the EU-15 average in all field groups. The highest rate of cooperation of Czech authors was in the Natural Sciences field

group, which corresponds to the finding that this field group has the highest number of articles with the number of authors exceeding 100.

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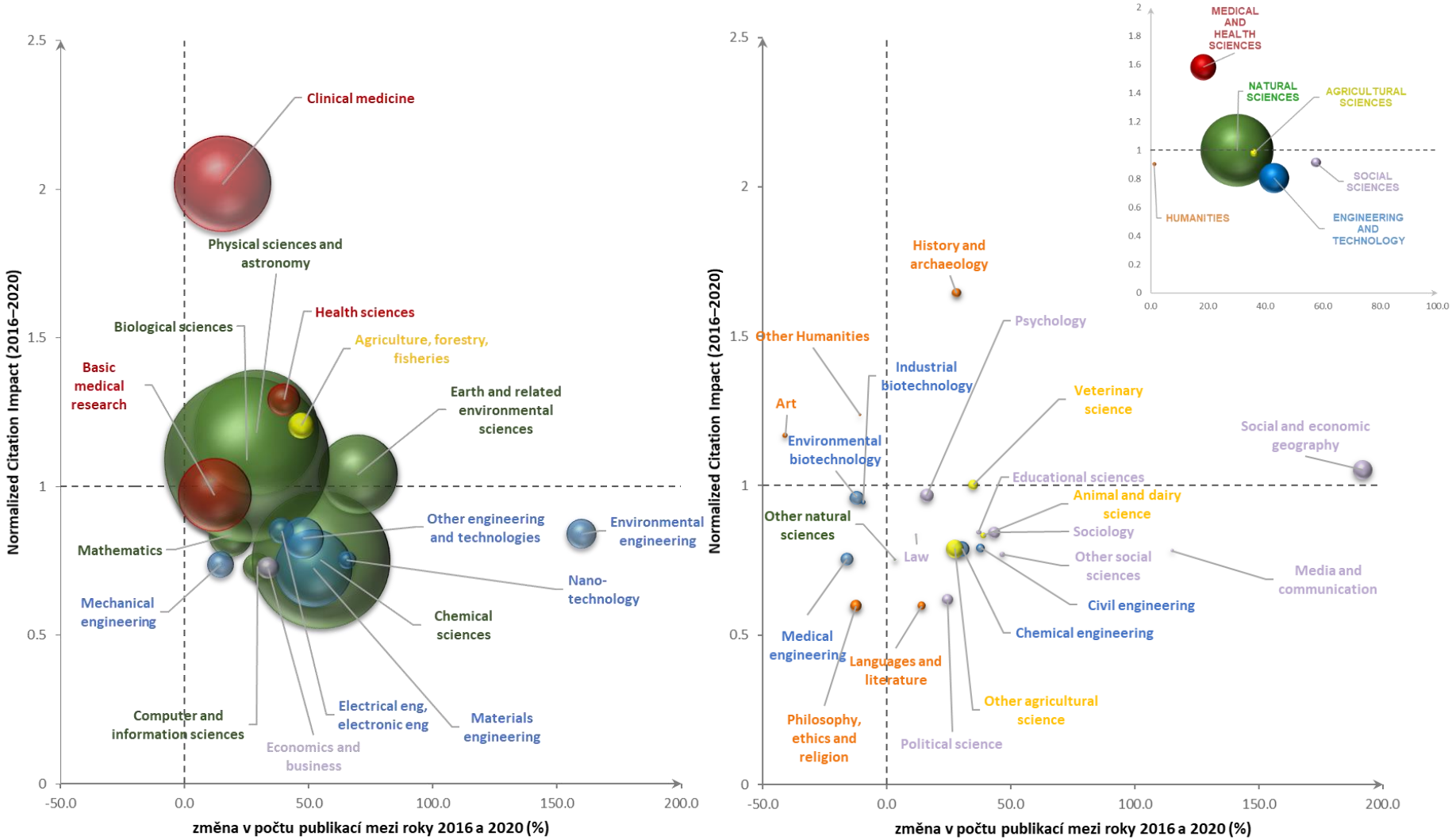
Numbers of publications by Czech authors in WoS in the fields and their citation rate



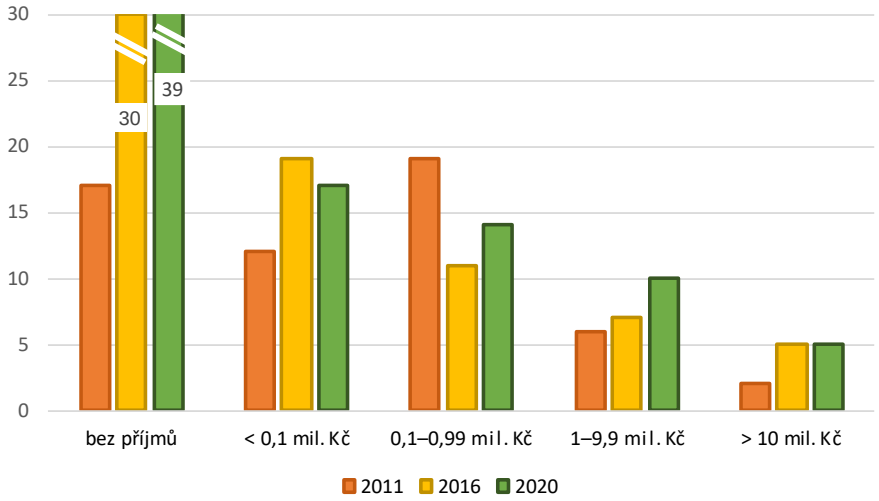
Změna v počtu publikací mezi roky 2016 a 2020 (%)	Change in the number of publications between 2016 and 2020 (%)

Source: WoS, includes publications of article and review type for the period 2016–2020 in WoS Core periodicals, fields divided according to OECD (Frascati Manual) | Publications in which at least one author has „Czech" written in the address are included (co-authorship not taken into account). The left part of the figure includes field groups for which the database had at least 1,500 publications for the monitored period. Horizontal axis: Index of change in the number of publications in 2016 and 2020: (2020–2016)/2016 in %. | Vertical axis: Normalized Citation Impact as of

30.06.2021 (normalized at the field level with subsequent aggregation of the index; if the publication covers more fields, an arithmetic average is used); value y = 1 corresponds approximately to the world average. The size of the bubbles shows the number of publications in the period 2016-2020.

- Over the recent years, the share of quality publications created by international teams of authors has increased, compared to exclusively Czech publications. The structure of countries collaborating with Czech scientists in publication activity is favourable. The largest number of international publications was created in the 2016-2020 period by Czech authors in cooperation with authors from Germany, followed by collaboration with colleagues from the USA and the UK. The collaboration of Czech authors with colleagues from Spain produces articles that have a relatively high NCI (between 3 and 4). Publications with the lowest NCI are produced in cooperation with colleagues from Slovakia.
- The number of patent licence providers, same as the number of granted licences, is growing - the increasing interest in patenting of results in CZ can be viewed as a positive trend that should be, ideally, accompanied by growing income from royalties.

Number of patent licence providers and amount of received royalties (in CZK mil.)



bez příjmů	without income
< 0,1 mil. Kč	< CZK 0.1 mil.
0,1-0,99 mil. Kč	CZK 0.1-0.99 mil.
1-9,9 mil. Kč	CZK 1-9.9 mil.
> 10 mil. Kč	> CZK 10 mil.

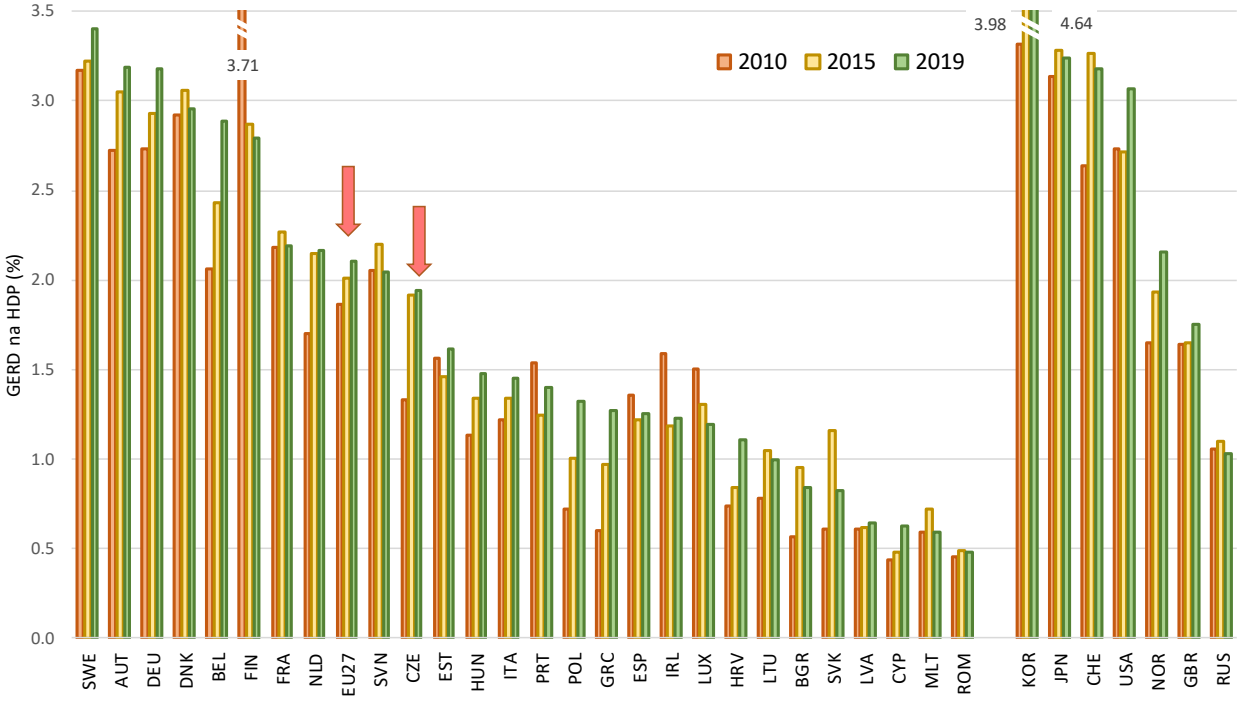
Source: CZSO, own processing

- It appears that a significant number of licence providers (39 out of 85, i.e. 46%) had zero received royalties in 2020.
- Over the last 10 years, the patent activity of Czech inventors grew sharply against the previous period. However, the growing patent activity goes hand in hand with an increase in the offshoring of patents achieved by Czech originators in CZ R&D centres. The patent offshoring is most often directed to the USA and Germany.

Innovation performance of the Czech economy and its international comparison

Innovation activities are a key element in the long-term, sustainable economic growth and competitiveness of economies. Innovation is also often seen as a means to eliminate impacts of economic and other crises. Innovation activities have become important recently also thanks to the worldwide pandemic situation. The impact of the COVID-19 pandemic has not yet fully reflected in most of the indicators in this chapter. The full impact of that effect will be observable only in later data.

Knowledge intensity of the Czech economy and its international comparison



GERD na HDP (%)	GERD share in GDP (%)

Source: Eurostat; OECD – MSTI database | For CHE, the data for 2019 are in fact data for 2017 and the data for 2010 are in fact data for 2008.

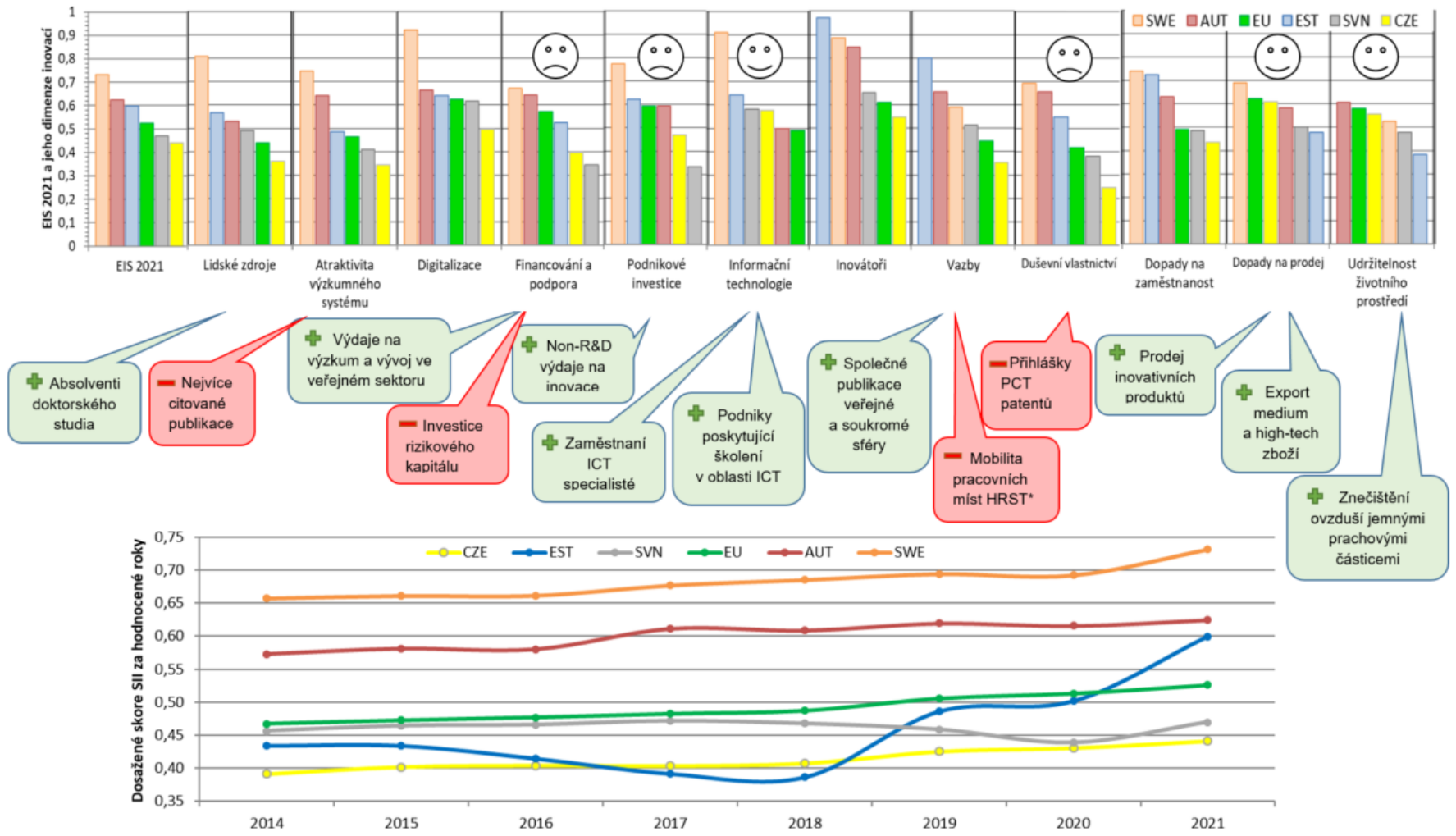
- In the international comparison of knowledge intensity for 2019, CZ ranks 10th but it is still behind the EU-27 average.
- According to the Bloomberg agency, CZ holds the 26th place among the sixty most innovative economies of the world. In this comparison, CZ stands out mainly in the Industry Value Added. The most innovative economies are South Korea, Singapore and Switzerland.

- Based on the composite indicator of the Summary Innovation Index (SII)[3], CZ belongs to the group of 'moderate innovators'. CZ shares the group with e.g. Italy, Slovenia, Spain or Greece. CZ markedly lags behind countries such as Sweden, Finland, Denmark and Belgium. In the individual indicators, CZ outstrips the EU average the most in indicators such as Enterprises providing ICT training, Medium and high tech goods exports, Air emissions by fine particulate matter. On the contrary, CZ reports strongly below-average values compared to the EU average e.g. in indicators Venture capital investment, Patent Cooperation Treaty (PCT) patent applications, Most cited publications, Job-to-job mobility of human resources in science and technology (HRST).
- According to the Global Innovation Index (GII), CZ ranked 24th out of the 132 economies evaluated. The first ranks in the GII 2021 were taken by Switzerland, Sweden, and the United States of America. In general, CZ has its strengths mostly in innovation outputs. Specific indicators with excellent values include Creative goods export, High-tech manufacturing, GERD[4] financed from abroad, Knowledge impact, ISO 9001 quality certificates, Creative goods and services. On the contrary, CZ has weaknesses mostly in innovation inputs. The weaknesses include Ease of starting a business, Investment, Redundancy costs, Risk capital beneficiaries, Joint venture.
- Enterprises with innovation activities see the most limiting factors in the area of innovation in the lack of own funding, lack of qualified staff in the company, lack of financial sources outside the company and low or uncertain return on investment due to small purchasing power or size of the market. CZSO survey shows that enterprises with innovation activities are able to perform innovation activities in terms of creativity and interaction with customers but they lack financial sources and qualified staff.
- Based on innovation capacity mapping, the prevailing firms are those focusing on optimisation of manufacturing processes together with firms performing partial functions of their group. On the contrary, CZ has very few firms in the position of global innovation leaders and pioneers who shape markets. That is directly related to the fact that domestic companies more often take lower positions in the global value chains. The main barriers to higher innovation performance in companies include, in comparison with developed European countries, smaller business ambitions and lower levels of accepted risk in deciding on the size of R&D investment.

[3] For more see https://ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/european-innovation-scoreboard_cs.

[4] Gross domestic expenditure on R&D

European Innovation Scoreboard (EIS) 2021 and its innovation dimension, comparing CZ and selected countries, development of SII values



EIS 2021 a jeho dimenze inovací	EIS 2021 and its innovation dimension

EIS 2021	EIS 2021
Lidské zdroje	Human resources
Atraktivita výzkumného systému	Attractive research systems
Digitalizace	Digitisation
Financování a podpora	Finance and support
Podnikové investice	Firm investments
Informační technologie	Use of information technologies
Inovátoři	Innovators
Vazby	Linkages
Duševní vlastnictví	Intellectual assets
Dopady na zaměstnanost	Employment impacts
Dopady na prodej	Sales impacts
Udržitelnost životního prostředí	Environmental sustainability
Absolventi doktorského studia	Doctorate graduates
Nejvíce citované publikace	Most cited publications
Výdaje na výzkum a vývoj ve veřejném sektoru	R&D expenditures in the public sector
Investice rizikového kapitálu	Venture capital expenditures
Non-R&D výdaje na inovace	Non-R&D Innovation expenditures
Zaměstnaní ICT specialisté	Employed ICT specialists
Podniky poskytující školení v oblasti ICT	Enterprises providing ICT training
Společné publikace veřejné a soukromé sféry	Public-private co-publications
Mobilita pracovních míst HRST*	Job-to-job mobility of HRST*
Přihlášky PCT patentů	PCT patent applications
Prodej inovativních produktů	Sales of innovative products
Export medium a high-tech zboží	Medium and high tech goods exports
Znečištění ovzduší jemnými prachovými částicemi	Air emissions by fine particulate matter
Dosažené skóre SII za hodnocené roky	**Achieved SII score for the evaluated years**

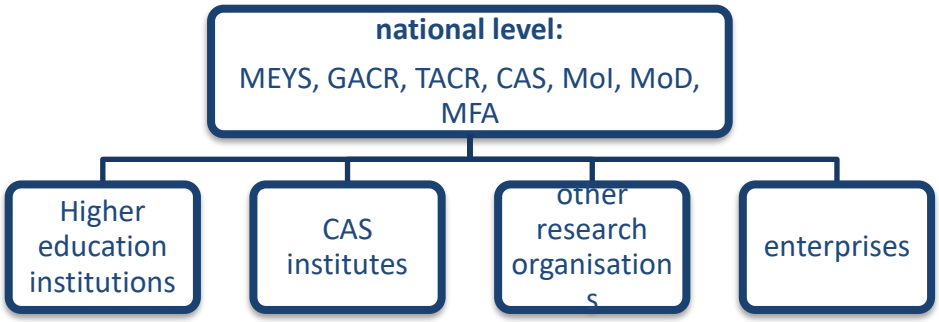
*Source: own processing according to EIS 2021; *Human resources in science and technology (HRST)*

International cooperation in R&D&I

International cooperation in research, development and innovation in all its forms contributes to increasing excellence, competitiveness and development of domestic R&D&I capacities. International R&D&I cooperation serves as a tool for addressing complex scientific and technical topics and global challenges. In the case of operation of a large infrastructure or of multilateral R&D&I projects, international cooperation enables synergy and the sharing of risk and resources with foreign partners. A broader concept of international R&D&I cooperation at the national level is represented by science diplomacy wherein research and development become an instrument of diplomacy and foreign relations building. From the viewpoint of HEIs, CAS institutes and research organisations, international R&D&I cooperation is a tool for ensuring access to foreign tangible and non-tangible resources, to new knowledge, human resources and higher foreign prestige. An increasingly important topic is that of inter-regional and cross-border cooperation of firms, mainly of SMEs, geared towards moving the firms up in European value chains.

The central body responsible for international R&D&I cooperation is, pursuant to Act No 130/2002 Coll., the Ministry of Education, Youth and Sports (MEYS). The key providers of support for international cooperation include GACR and TACR that arrange cooperation with similar foreign agencies and provide purpose-tied aid to international cooperation projects. International R&D&I cooperation at the national level is developed also by other actors such as the Czech Academy of Sciences (CAS), the Ministry of Interior (MoI) or the Ministry of Defence (MoD). The Ministry of Foreign Affairs (MFA) through its embassies searches for new opportunities of international R&D&I cooperation, it mediates new partnerships, projects and arrangements in close cooperation with the responsible ministries, other providers and the actual R&D&I institutions. Since 2020, the RDI Council has operated a steering group tasked to improve coordination among the actors. The scheme illustrates the dimension of international R&D&I cooperation.

Dimension of international R&D&I cooperation



- The body responsible for international R&D&I cooperation is MEYS. The other stakeholders in international R&D&I cooperation include GACR, TACR, CAS, the Ministry of Foreign Affairs, the Ministry of Defence and the Ministry of Interior. Public support from those providers (except for

MFA) is directed to the public and private sectors, specifically to HEIs, CAS institutes, other research organisations and enterprises. An important actor is also the Ministry of Foreign Affairs which manages the foreign service of diplomats responsible for the development of international relations in R&D&I.

- The umbrella document for the R&D&I area, including the theme of international cooperation, is the National R&D&I Policy. In July 2020, the government approved the National R&D&I Policy 2021+, targeted directly at the international cooperation development through a number of specific objectives and measures. With regard to the importance of bilateral cooperation and new possibilities of cooperation, including the cross-border and regional level, arising, among other things, from new calls and initiatives such as the national recovery and resilience plans of EU countries, the drafts of bilateral R&D&I cooperation should be developed for strategically important countries.
- The R&D&I system remains relatively closed from the international cooperation perspective despite the indisputable progress in recent years, which is due to the low involvement of Czech entities in framework EU programmes and to the limited number of research teams involved in international cooperation. In 2020, international R&D&I programmes and activities were affected by the COVID-19 pandemic. The expenditure reimbursed from the state budget decreased significantly in projects of researcher mobilities, implemented by MEYS and CAS.
- The highest volume of expenditure on purpose-tied aid for international cooperation in 2020 was spent on projects of large research infrastructures (CZK 1.9 bil.) and on the INTER-EXCELLENCE programme (CZK 760 mil.). In the INTER-EXCELLENCE programme, the highest share of funds was spent in 2020 by projects of bilateral and multilateral cooperation under the sub-programmes INTER-ACTION (CZK 288 mil.) and INTER-COST (CZK 134 mil.). An important share of the purpose-tied aid was directed to international bilateral projects of GACR (CZK 141 mil.) and the DELTA 2 programme implemented by TACR (CZK 77 mil.).
- The core part of the expenditure under institutional support for international cooperation is made up of expenditure on CZ membership in international R&D&I organisations and ERIC consortia (CZK 1.1 bil). Here, we must also mention other MEYS programmes that received significant funding from the state budget in 2020. They include the programme Joint Technology Initiative ECSEL (CZK 68 mil.), the programme Eurostars-2 (CZK 30 mil.) and expenditure on the European Metrology Programme for Innovation and Research (CZK 22 mil.).

CONCLUSION

Based on its analyses, the Research, Development and Innovation Council formulated the strengths and weaknesses of the R&D&I system. The minimisation or even elimination of weaknesses and the reinforcement of strengths through exploitation of opportunities should help to stabilise the R&D&I system and, in the future, contribute to effective functioning of the R&D&I system as a whole. For the Czech Republic, it is key to effectively target its R&D&I capacities and to be able to respond to the dynamic developments in technologies, but mainly to major societal challenges.

It is apparent that some areas require more detailed analyses, the production of which is often, unfortunately, hindered by the missing or insufficient data base and limited personnel capacities for producing this R&D&I Analysis for 2020. For that reason, some recommendations focus on the data base (see the Technical Recommendations). The monitoring of quantitative indicators of meeting the objectives of the National Research, Development and Innovation Policy 2016-2020 is provided in Annex 1.

STRENGTHS AND WEAKNESSES AND OPPORTUNITIES:

+ *The economic potential of CZ together with the growing private and public expenditure on R&D&I and the built research infrastructure*

- In supporting R&D&I from the state budget, placing more emphasis on research and development in major/breakthrough areas of the fields of science, the results of which will be suitable for international protection.
- In preparing the budget proposal, continuing to stabilise research organisations by strengthening the share of the institutional component of the state-budget R&D&I support (indicator Long-term conceptual development of research organisations) against the purpose-tied aid, in a link to the evaluation of research organisations.
- Analysing the benefits of the financial aid instruments and using the analysis outputs for their optimisation, which can be achieved through consistent implementation of the evaluation of research organisations and evaluation of programmes providing purpose-tied R&D&I aid.
- Setting the instruments of direct and indirect public support so that private expenditure is accelerated and the private-public cooperation is increased.
- Monitoring the level of public support additionality, because the aim and purpose of public support for R&D should be mainly to complement, not to replace private resources.
- Using public foreign sources for the development of the R&D&I system and so exploit the potential of excellent R&D centres and large research infrastructures as a base for long-term cooperation in applied research.
- Placing emphasis on the institutional support component in planning the funding for operation and further development of research infrastructures, the aim of which is to implement significant and excellent research plans, and so to continue to promote and expand international cooperation.

– *Private expenditure in the R&D&I system is consumed mostly in the private sector, which results in a long-term low level of cooperation between the private and the public sector in the R&D&I system*

- Motivating the private and public sectors to increase cooperation by providing more funding to purpose-tied programmes focused on applied research.
- Developing the culture of private-public cooperation.
- Promoting the involvement of public research organisations in the research activities of the private sector through various incentives, higher tax deductions and other instruments of indirect support.
- Focusing the analyses on links between business entities and public research entities (HEIs, CAS institutes, research centres of ministries), with special regard to the societal and economic growth (including employment in technologically advanced fields with a corresponding growth of real wages).

– *Unsatisfactory participation of Czech research organisations and teams in the framework programme Horizon 2020*

- Making such interventions that will motivate Czech research organisations (scientific teams) to participate more in European and other international R&D&I programmes, mainly in the framework EU programmes (Horizon Europe).
- Creating conditions for stimulating the interest of Czech organisations in engaging in international R&D&I programmes, which can produce significant benefits for the Czech R&D&I system as a result of the high participation success rate of CZ in the Horizon 2020 framework programme.

\+ *Qualified people and traditionally strong academia*

- Motivating Czech researchers to engage in foreign projects through new or existing tools for establishing, maintaining and developing foreign cooperations (e.g. MEYS and CAS mobilities, the INTER-EXCELLENCE programme, international bilateral projects of GACR, "Lead Agency" International grant projects, DELTA 2, economic diplomacy projects etc.).
- Using domestic knowledge capacity (excellent internationally connected teams), excellent R&D centres and large research infrastructures and developing in a targeted way the international project cooperation, mutually advantageous long-term partnerships in R&D&I and scientific mobility, both bilaterally and multilaterally, with priority countries or regions (Israel, Germany, USA, EU countries, Southeast Asia), especially with respect to new needs and opportunities.

– *The setting of the development of the needed professional competences and skills of researchers and the resulting insufficient utilisation of their potential*

- Focusing on removal of deficiencies in R&D personnel management, supporting sustainability of scientific careers by improving conditions for reconciling family and professional life, creating conditions for women so that they remain in research, motivating graduates to continue in scientific activity.

- Focusing on effective internationalisation of Czech scientists and their teams with foreign scientists through R&D&I, or on international cooperation and involvement in international legal groupings.
- Preventing so-called precarisation[5] of researchers as, due to the financing from short-term projects, some employees are employed mostly on short-term contracts for a definite period of time, which may lead to ending the science career in extreme cases.

– *Low representation of women in the CZ research environment*

- Setting the conditions for higher motivation of women to get involved in research activities and remain in the scientific career path:
  - formulating recommendations arising from the evaluation of completed programmes, addressed to the support providers,
  - formulating requirements for research organisations to support reconciliation of professional and family life (e.g. motivation and support for women already during their doctoral studies, which will increase the representation of women in the scientific career).

\+ *Strong culture of publication activity and a gradually developing internationalisation leading to excellence of some scientific fields*

- Implementing measures to increase the quality of publication outputs and internationalisation mainly in basic research.
- As part of the evaluation of research organisations and evaluation of programmes, implementing measures motivating research organisations to carry out applied research, which should lead to a balanced ratio of publications and applications, which is specific for each field and changes over time. This requires a functional legislative environment and a detailed elaboration of the method and criteria for evaluating the applications.
- Supporting the building of relationships with foreign partners and establishing long-term links to top-level science centres.
- Maintaining and developing existing tools to support a broader involvement in ERC activities and so foster the ambition to become one of the excellent scientific teams in Europe.
- Continuing to support and motivate researchers and research organisations to record all achieved results in the R&D&I Information System.

– *Inadequate conditions for effective functioning and development of innovation activities and insufficient use of the possibilities of intellectual property protection*

- Continuing to remove the main barriers to innovation progress in CZ, such as the low investment of risk capital, low use of intellectual property protection through international patents, or deficiencies in the area of human resources, and subsequently supporting the use of other forms

[5] Precarisation is a term describing the replacement of a full-fledged employment contract with part-time jobs or contracts on the purchase of services from self-employed traders, it tends to be associated with lower income and absence of benefits and advantages, e.g. the social insurance.

of financial instruments, including guarantees, soft loans etc. for the development of innovation activities.

- Creating suitable conditions and incentives for investment in start-ups.
- Ensuring an effective use of intellectual property protection tools including support for the knowledge base of industrial property protection.
- Exploring the issue of intellectual property and setting the conditions for research organisations or scientific centres so that they are sufficiently motivated to apply an effective licence policy, and so contribute in the future to a growing yield from the sale of patent licences, in which CZ lags behind significantly.
- Through the development and support of innovation activities, shifting business entities from the role of "performing partial functions of their group" to the role of "global innovation leaders and pioneers who shape markets".
- With the help of suitable tools promoting higher business ambitions and a higher level of risk taken in deciding on the amount of investment in R&D. The purpose of the support for innovation activities in enterprises is the shift of those entities from the lower tiers of the global value chains to higher tiers.

TECHNICAL RECOMMENDATIONS:

- In the R&D&I Information System, continuing to build a robust, up-to-date and accessible data base. The starting point for developing the data base used for R&D&I analyses is the data storage created and maintained by the RDI Council. This solution will enable the interconnection of data in the R&D&I IS with data from various databases and registers relevant for R&D&I analyses (e.g. PATSTAT, E-Corda, Web of Science, the CZSO Annual R&D Report, the CZSO Economic Entities Register, ETER, OECD MSTI, databases of providers, registers of the Czech Social Security Administration or the General Financial Directorate - see also Annex 2).
- Continuing to align the code lists of fields in the R&D&I IS and field groups used in CZ with the OECD FORD structure (part of the Frascati Manual).
- Ensuring that institutional aid for R&D&I is recorded in the R&D&I Information System by supported field, and in the case of HEIs, ensuring the records are made down to the level of faculties or departments.
- Keeping records of the R&D&I aid from all public foreign sources in the R&D&I Information System, for operational programmes recording the aid also in a breakdown into the EU part and the state budget part (SB co-financing).
- Introducing a regular monitoring of employing the research infrastructures in applied research for the needs of important sectors of the Czech national economy, thereby making a full use of the records of results produced using the research infrastructure.
- Ensuring records of information on the use of R&D results at the national level.
- Ensuring records of researchers and their participation in projects, including the records of FTEs.

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Annexes:

P1. The monitoring of quantitative indicators of meeting the objectives of the National Research, Development and Innovation Policy of the Czech Republic 2016-2020
Drawn up in cooperation with the Technology Centre of CAS

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ANNEXES

P.1 The monitoring of quantitative indicators of meeting the objectives of the National Research, Development and Innovation Policy of the Czech Republic 2016-2020

The National Research, Development and Innovation Policy of the Czech Republic 2016-2020 (National R&D&I Policy) as an umbrella strategic document for R&D&I includes a system of indicators. The set indicators enable an evaluation of progress in achieving the goals associated with implementation of the strategy. The National R&D&I Policy implementation should include a regular monitoring of indicators and their analysis. The **interim evaluation of the National R&D&I Policy** was made in line with the key milestones of its Specific Objective 1.3: Enhancing the strategic intelligence for the R&D&I policy in **2018 under the responsibility of OG CR - the RDI Council Department**.

As part of launching the regular monitoring, the current **values of quantitative indicators were set** (in most cases for 2016 where possible). The indicator system proposed in the National R&D&I Policy contains qualitative and quantitative indicators that were relevant at the time of its design. Table P.1 shows the values of the indicators usually for 2020 (where values for that year were not available, the value from the last year with available data is shown). The table **specifies some indicators** to improve their explanatory power. As some data used to determine the quantitative indicator values are updated continuously and modified retrospectively by their providers (e.g. numbers of publications or patent applications), the values of some indicators were determined retrospectively for previous years. Other information on determining the indicator values is provided in the notes below the table.

Table P.1: Values of quantitative indicators for evaluating the progress towards the objectives of the National Research, Development and Innovation Policy of the Czech Republic 2016-2020

	Indicator	Baseline value when drafting the National R&D&I Policy (year)	Baseline value for monitoring the achievement against objectives (year)	Current value of the indicator (year)
1	Number of doctoral graduates aged 25-34 years per million of inhabitants of the same age group	1,114 (2013)	1,134 (2016)	1,140 (2019)
2	Share of women in the total number of researchers (%)	25 % (2013)	23.1 % (2016)	23.9 % (2019)
3	Share of scientific publications in co-authorship of domestic and foreign researchers (%) [1]	35.6 % * (2012)	39.7 % * (2016)	49.6% (2019) 57.0% (2020)
4	Share of foreign researchers in the total number of researchers in the government and HEI sector (%) [2]	6 % (2011)	9.5 % (2015)	12.6 % (2019)

	Indicator	Baseline value when drafting the National R&D&I Policy (year)	Baseline value for monitoring the achievement against objectives (year)	Current value of the indicator (year)
5	Number of participations in Horizon 2020 per thousand researchers (FTE)	-	18.4 (2016)	37.0 [3] (2021)
6	Financial contribution obtained in Horizon 2020 per € 1 bil. of GDP	-	-	2.06 [4] (2021)
7	Total number of publications registered in the WoS database per million inhabitants [1]	1,970 * (2014)	2,224 * (2016)	2,246 (2019) 2,023 (2020)
8	Number of PCT applications per million inhabitants	16.7 (2012)	18.1 * (2014)	13.6 ** (2017)
9	Yield from the sale of patent licences (including national) in CZK mil.	2,726 (2014)	3,356 (2016)	2,170 (2019)
10	Share of highly cited publications (share of publications included among 10 % of the most cited publications in the total number) [1]	9.2 % * (2012)	10.0 % * (2015)	9.6 % (2019) 9.7% (2020)
11	Total number of ERC grants per thousand researchers in the government and HEI sector	0.17 (2013)	0.33 (2016)	1.70 [5] (2021)
12	Share of publications produced in public-private co-authorship in the total number of publications (%) [1]	2.1 % * (2013)	2.5 % * (2016)	2.6% (2019) 2.3% (2020)
13	Share of the business sector resources in the R&D expenditure of the government and HEI sector (%)	6.8 % (2013)	9.2 % (2016)	5.6 % (2019)
14	Share of employment in high- and medium-high-tech manufacturing industry (%)	11.2 % (2014)	11.5 % (2016)	11.5 % (2020)
15	Share of employment in knowledge-intensive services (%)	32.6 % (2013)	32.9 % (2016)	34.5 % (2020)
16	Share of business sector resources in GERD (%)	48.6 % * (2013)	60.2 % (2016)	58.0 % (2019)
17	Early-stage investment of risk capital (% of GDP) [6]	0.002 % * (2013)	0.003 % * (2016)	0.005 % (2020)
18	Share of domestic added value in total export (%)	61.3 % (2011)	60.3 % (2014)	62.3 % ** (2016)

**The baseline value of the indicator was modified using current data.*

*** The data were not updated in the OECD database.*

Notes on the indicators:

[1] Data taken from Web of Science InCites for publication types 'article', 'review', 'letter', 'proceedings paper'. After the database was updated, the indicator values were calculated retrospectively for the previous years using the new data. As the data from 2020 are not yet complete, the table shows data for 2019.

[2] The indicator name was reformulated to match the definition in the National R&D&I Policy.

[3] The value was set as the number of participations in H2020 to date from the eCORDA database data of May 2021. The calculation included running and completed projects (i.e. excluding projects under preparation and suspended

projects). The data do not include participants involved in the projects as third parties. The indicator value grows in time as the total number of projects implemented in H2020 increases. Therefore, the value should be compared with the sum for all EU Member States (the indicator value for EU-28 in May 2021 was 61.2).

[4] The value was set as the contribution from the EC obtained by CZ teams under H2020 to date, from the eCORDA database data of May 2021. The calculation included running and completed projects (i.e. excluding projects under preparation and suspended projects). The data do not include contribution obtained by participants involved in the projects as third parties. The indicator value grows in time as the total number of projects implemented in H2020 increases. Therefore, the value should be compared with the sum for all EU Member States (the indicator value for EU-28 in May 2021 was 3.50).

[5] The value was set as the number of ERC grants obtained under H2020 to date, from the eCORDA database data of May 2021. The indicator value grows in time as the total number of projects implemented in H2020 increases. Therefore, the value should be compared with the sum for all EU Member States (the indicator value for EU-28 in September 2020 was 6.37).

[6] The data were taken from Invest Europe reports of June 2021. The early-stage investments are understood as "seed" and "start-up" investments.